Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

The Faculty of Natural Resources and Agricultural Sciences

Ley management

– a means to improve forage quality and production

Vallmanagement

– ett sätt att förbättra vallproduktionen

Cecilia Nilsson

Department of Agricultural Research for Northern Sweden
Master´s thesis • 30 hec • Second cycle, A2E
Agriculture Programme - Soil/Plant 2012

Ley management

Vallmanagement

Cecilia Nilsson

Supervisor:	Anne-Maj Gustavsson, Swedish University of Agricultural Sciences, Department of Agricultural Research for Northern Sweden
Assistant Supervisor:	Federico Cuellar, Hushållningssällskapet Rådgivning Nord AB,
Examiner:	Cecilia Palmborg, Swedish University of Agricultural Sciences, Department of Agricultural Research for Northern Sweden

Credits: 30 hec
Level: Second cycle, A2E
Course title: Independent project in Biology - Master's thesis
Course code: EX0565
Programme/education: Agriculture Programme - Soil/Plant

Place of publication: Umeå
Year of publication: 2012
Picture Cover: Joakim Årbro
Title of series: Examensarbete / Sveriges lantbruksuniversitet, Institutionen för norrländsk jordbruksvetenskap **no:** 2012: 1
Online publication: http://stud.epsilon.slu.se

Key Words: ley management, strategy, ley farming, forage production, forage quality and yield, lean production

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

The Faculty of Natural Resources and Agricultural Sciences
Department of Agricultural Research for Northern Sweden

Preface

With the goal of reinforcing the forage production, the present study was carried out to develop a model, the concept of ley management. The model enables a systematic approach that structures the farmer's decision-making and supports the prioritization of important issues in the production. This is an initial attempt to crystallize a working method that farmers and advisers can use; from setting the targets of the forage production, through planning and implementation to evaluation of crop performance.

The study is a result of collaboration with Hushållningssällskapet Rådgivning Nord AB (i.e. the Rural Economy and Agricultural Societies in the counties of Norrbotten and Västerbotten) and the Swedish University of Agricultural Sciences. It was funded by the Royal Swedish Academy of Agriculture and Forestry (KSLA), the Regional Agricultural Research in Northern Sweden (RJN) and Hushållningssällskapet Rådgivning Nord AB.

This study has evolved during a long process that involved the knowledge and experience of scientists, advisors and farmers. I would especially like thank my supervisors; Anne-Maj Gustavsson at the Department of Agricultural Research for Northern Sweden in Umeå, and Federico Cuellar at Hushållningsällskapet Rådgivning Nord in Luleå, for your support and commitment during the process of conducting this study. I would also like to thank the participating farmers who shared their time, experiences and information of their farms' with me. In addition, I would also like to thank those of you who have contributed to the development of the study through interesting discussions, valuable comments, enthusiasm and support.

It is my hope that this study will give you as a reader an interest in and understanding of the concept of ley management and its potential to improve and clarify the dairy firms' strategies in order to achieve better results, based on each business' unique point of view.

15 June, 2012

Cecilia Nilsson

Sammanfattning

För att klara den ökade konkurrensen med högre krav på effektivitet blir dagens mjölkföretag allt större, med större arealer, mer kapital och mer omfattande logistik. Målet är att få stordriftsfördelar som sänker produktionskostnaden per enhet, men ökad omfattning exponerar gården för ökad risk där små avvikelser snabbt kan radera fördelarna. Denna utveckling ställer höga krav på lantbrukarens förmåga att samordna, planera och leda sin vallodlingskedja fram till lagring av önskad kvalitet och mängd till rätt pris. Syftet med denna studie var att ta fram en modell som lantbrukare och rådgivare kan använda sig av för att identifiera och prioritera strategiska beslut i vallodlingen utifrån uppsatta mål. En viktig del var också att studera lantbrukares beslutsfattande och jämföra det med resultatet i vallodlingen.

Därför gjordes en gårdsstudie på nio mjölkgårdar i Norr- och Västerbotten, utvalda för att ge en geografisk och storleksmässig spridning. Frågeställningarna till dem kan sammanfattas i: Hur tänker ni? Hur gör ni? Hur gick vallodlingsåret 2011? Data samlades in genom intervjuer och besök samt genom fältstudier och att prover togs ut under säsongen 2011. Informationen från gårdsstudien samt diskussioner med rådgivare på Hushållningssällskapet Rådgivning Nord och tre modeller (hushållningsprincipen, företagspyramiden och benchmarking, se avsnitt 2.2), utgjorde sedan basen för utvecklingen av vallmanagementmodellen. Modellerna bidrar med prioriteringen av beslut utifrån olika tidshorisonter i beslutsfattandet och planeringen, tillsammans med processens resursutnyttjande och jämförbarhet mellan lantbrukarna.

Lantbrukarna i studien hade ganska olika förutsättningar att arbeta med. De utmaningar de måste hantera och verktygen de kan använda var dock ganska lika. Åtgärderna är däremot olika eftersom de måste anpassas till gårdens specifika förutsättningar. Lantbrukarnas fokus skiljde sig åt delvis beroende på intresse och vilka problem de har ställts inför på gården. Ett fokus var att sköta marken för att få en bra och hållbar grund för produktionen. Andra fokuserade på att hålla en jämn och hög kapacitet på maskinkedjan eller att ha tillgång på mark i närområdet. Flera av lantbrukarna pekade på hur viktigt det är att se på hela vallkedjan, att allt måste fungera och hänga ihop från jord till utfodring för att det ska gå att producera ett bra vallfoder.

De viktigaste faktorerna för att lyckas under säsongen 2011 för dessa lantbrukare var att ha en genomgående strategi och en förmåga att skörda i tid. Att skörda första skörden i tid gav inte bara en hög kvalitet på vallfodret, utan resten av säsongen fortsatte också bättre. De lantbrukare som däremot var för sent ute i första skörd fick en lägre kvalitet och resten av säsongen gick sämre.

Skördeökningspotentialen i området är stor, eftersom de flesta gårdarna i studien hade en betydligt högre skörd än de fyra ton ts per hektar som är den officiella genomsnittsskörden i området. Beräkningarna av produktionskostnaden visade också att det är möjligt att producera ensilage med hög kvalitet (t.ex. 11.0 MJ, 168 g RP/kg ts) kombinerat med en hög skörd (upp till 10 ton ts per hektar) till en låg kostnad (1.20 kr per kg ts). De lantbrukare som uppnådde dessa goda resultat under säsongen var bättre på att beskriva sin strategi och hur de jobbar med växtodlingen på sin gård. Studien undersökte bara en säsong, men en tydlig strategi bör öka chansen att lyckas med vallodlingen

eftersom det ger en bättre förberedelse för störningar i produktionen. Lantbrukare måste därför ha en strategi för hur de ska nå de uppsatta målen i produktionen för att kunna lyckas, där målen måste anpassas till lantbrukarens förmågor och intressen, gårdens förutsättningar och andra förutsättningar som konkurrens med andra lantbrukare, regler, certifieringar (t.ex. IP Sigill och KRAV) etc.

Vallmanagement definieras som konsten att utforma och leda sin vallodlingskedja fram till lagring av önskad kvalitet och mängd. Begreppet uppfinner inget nytt, men pekar på vikten av strategiskt beslutsfattande, målsättning och resultatuppföljning som nödvändiga delar i lantbrukarens styrning av vallkedjan. Vallmanagementmodellen (se figur 24) delar upp vallodlingssystemet i tre delar: resursbas, verksamhet och värde. Resursbasen är de tillgångar som finns i vallodlingen och utgörs av mark, insatsmedel, maskiner och personal. Kvaliteten i resursbasen (t.ex. kunskap, maskinkapacitet, markens bördighet och arrondering) anger förutsättningarna för verksamheten. I verksamheten ingår lantbrukarens förmåga att utforma logistik, bemanning och att utföra rätt åtgärd vid rätt tidpunkt. Genom resurserna och verksamheten skapas ett värde, i det här fallet en viss skördad mängd av en viss kvalitet till ett visst pris. Verksamheten måste även se till att resursbasen underhålls. Lantbrukaren, samt rådgivare, måste sedan avgöra om det producerade värdet överensstämmer med de resurser som lagts ner i verksamheten, vilket bara kan göras om man kan definiera värdet dvs. har satt ett mål för produktionsresultatet.

Utifrån vallmanagementmodellens tre delar har några grundläggande frågor listats som lantbrukaren kan ställa sig för att utvärdera vallodlingen och prioritera sådant som behöver förändras:

<u>Resursbasen</u>

- Matchar och räcker resurserna till för att producera vallfoder av rätt kvalitet och mängd?
- Upprätthålls markens långsiktiga bördighet och produktionsförmåga?

<u>Verksamheten</u>

- Hur ska verksamheten organiseras och hur samordnas resurserna på bästa sätt?
- Kan dagens verksamhet göras effektivare?

<u>Värdet</u> (är ett resultat av hur väl man hanterat hela vallodlingskedjan)

- Produceras rätt foder, till rätt djur, till rätt pris?
- Fungerar vallfodret bra i utfodringen och ger det en bra utväxling hos korna?

Den enkla modellen ger en karta som lantbrukare och rådgivare kan utgå ifrån för att få en överblick av produktionen och därmed hitta kostnadseffektiva vägar för hela vallkedjan fram till målet.

Det finns flera tillgängliga verktyg för att hjälpa till att svara på de ovanstående frågorna, för att få den nödvändiga kontrollen och översikten av produktionen. Växtodlingsplanen och näringsbalanser är exempel på verktyg som lantbrukarna redan måste ta fram uppgifter till för att uppfylla reglarna i IP Sigill. Kostnadsberäkningar görs för många andra delar i företaget, men alltför sällan för det hemmaproducerade fodret. Arbetskraften i organisationen och dess kompetens är ett annat verktyg som måste beaktas för att kunna optimera användningen av den. Dessa verktyg används dock inte fullt ut idag och för att öka användningen behövs tydliga ekonomiska incitament som kan visa hur odlingsresultatet beror på de beslut och åtgärder som lantbrukarna fattat tidigare under året. Lantbruksföretaget skulle därmed kunna förbättra sin lönsamhet och samtidigt minska sin

miljöpåverkan genom att använda gårdens befintliga resurser mer effektivt med hjälp av att använda de tillgängliga verktygen fullt ut.
För att kunna beräkna sådana incitament krävs det dock en stor databas med jämförelsedata, men för norra Sverige finns det ett litet dataunderlag idag i jämförelse med södra Sverige. Projekt som Greppa Näringen i södra Sverige kan vara en lösning för att systematiskt samla in data. Miljöskatter är en del av finansieringen av Greppa Näringen och därför bör alla svenska lantbrukare kunna få dra nytta av den konkurrensfördel som den fria rådgivningen i Greppa ger. Följaktligen har beslutsfattare, forskning och rådgivning en stor utmaning att ta itu med för att ta fram en databas också för norra Sverige. För att säkerställa en hög kvalitet på rådgivning och forskning framöver som gagnar lantbrukare måste nätverk av forskare, rådgivare, lantbrukare samt beslutsfattare som länsstyrelsen och jordbruksverket utvecklas, för att gemensamt kunna driva kunskapsutvecklingen framåt. Med bättre kommunikation mellan alla instanser kan förutsättningarna för lantbruksföretag förbättras, genom till exempel regelförenklingar. Det bör också bli lättare för lantbrukare att efterfråga kunskap och för forskare att kommunicera resultaten av den forskning som görs, samt för rådgivare att sortera och sammanställa befintlig information för att ge jordbrukarna en bra grund för diskussion och beslut.

Vallmanagementmodellen är enkel, vilket är en av dess styrkor eftersom den är relativt lätt att förstå. Kärnan i den är att få lantbrukarna att bli mer medvetna om sitt nuvarande produktionssystem från ett helhetsperspektiv och därmed få en bättre överblick och kontroll på vallodlingen. Formuleringen av vallmanagementbegreppet i denna studie var också en början på arbetet med att samla in data för att ge lantbrukarna jämförelsedata. Då är det lättare att identifiera och prioritera de delar av vallodlingssystemet som kan behöva ändras eller förbättras och hur det kan göras. Vallmanagementmodellen behöver dock utvecklas mera för att kunna användas på ett bra sätt i rådgivningen och det arbetet kommer att genomföras kontinuerligt under de kommande åren.

Den viktigaste slutsatsen av detta arbete är att lantbrukaren måste ha en strategi för att få tillräcklig kontroll över och kunskap om sitt produktionssystem och dess sammanhang för att kunna lyckas med att genomföra rätt åtgärd vid rätt tidpunkt och samtidigt leda företaget i rätt riktning. Vallmanagementmodellen kan här ge lantbrukare och rådgivare ett verktyg för att undersöka och hitta kostnadseffektiva och miljövänliga sätt att nå gårdens mål.

Abstract

Higher demands of competitiveness and efficiency have led to increasing sizes of farms, with more land, more capital and more comprehensive logistics. The aim is to gain benefits of scale economies that reduce the production cost per unit. However, a greater extent of the business exposes the farm of increased risk where small deviations rapidly can erase the benefits. A modern dairy farm thus put high demands on the farmer's ability to coordinate, plan and manage the forage production through the whole process until storage to obtain silage of the desired quality and quantity at the right price.

The objective of this study was to design a simple model, i.e. the concept of ley management, that farmers and advisers can use to identify and prioritize strategic decisions in the forage production based on the farmer's targets. An important part was to study the farmers' decision-making and compare it with their results in the forage production. The study thus consists of two parts, the farm study and the formulation of the concept of ley management. The farm study was conducted on nine dairy farms in the counties of Norrbotten and Västerbotten. Information about the farms and their forage production was collected through interviews and visits. This was combined with objective data points to evaluate the results of the farmers' management during the season of 2011. The concept of ley management is based on three management models and the results of the farm study combined with experiences from the extension service. The models add the prioritizing of decisions from different time horizons of decision-making and planning, together with the resource utilization of the process perspective and comparability between the farmers.

The farm study showed that there is a potential to produce higher forage yields than what is done today. Calculations of forage production cost showed that it is possible to produce high quality combined with high yield at a low cost. The farmers who achieved these good results during the season could better describe their strategy and how they managed the crop production on their farms.

An important factor that influenced the outcome of the whole season was to harvest the first cut in time, not only to obtain high quality but also for the rest of the season to continue well.

By using existing tools in a larger extent the use of the available resources would be more efficient, thus improving the forage production and serve the profitability of the firm and the environment. Financial incentives are needed to present clear alternatives, however such calculations require a large data base to provide a benchmark and in northern Sweden there is none today. To secure a high quality counselling and research that benefits farmers a network of researchers, advisers and farmers has to be developed, in order to jointly drive the development of knowledge forward.

The farmer must have a strategy for obtaining adequate control and knowledge of the production system and its context to be able to successfully execute the right operations at the right time and at the same time lead the firm to meet its goals. The concept of ley management provides the farmers and advisors with a tool to examine and find cost-effective ways to achieve the farm's goals. The concept is simple and tangible, where the main point is to make the farmers more aware of their present production system from a more holistic point of view and hence what parts of the forage production system that may need to be changed or improved.

Table of contents

1 Why is there a need of ley management?

Higher demands of competitiveness and efficiency have led to increasing sizes of farms, with more land, more capital and more comprehensive logistics. The aim is to gain benefits of scale economies that reduce the production cost per unit. However, a greater extent of the business exposes the farm of increased risk where small deviations rapidly can erase the benefits.

High quality forage can constitute up to 60 % of the feed ration in a high yielding dairy herd in northern Sweden and constitute half of the energy and protein intake (pers. com., Åkerström, 2012). Forage is also already produced on dairy farms and the physiologically most appropriate feed to cows (Sjaastad, et al., 2003). A palatable, nutritional forage with a balanced mineral content leads to an increase in the cow's consumption of forage, which provides the following benefits (Ericson, 2011):

- The milk yield increases due to a higher utilization of the cows' performance character.
- The consumption of concentrates per litre of milk is reduced, thus the net profit milk income minus feed cost can increase.
- Animal health is improved by a higher proportion of forage compared to concentrates in the feed ration, where health is crucial in order to get durable cows and a decreased replacement rate.

Although all dairy farmers are aware of the above aspects and that researchers and extension services have spent much time to convey knowledge and benefits of forage production, there are still far too many dairy firms that do not utilize the full potential of forage production (Eriksson, 2007).

A lack of quantity and quality forces the farmers to compensate with purchased feed, which results in a double cost for the firm; firstly as a direct cost of the purchased feed, secondly as an indirect cost (often fixed costs of machinery and storage) of underutilized resources. Compensation with higher concentrate proportions also increases the risk of a negative impact on the cows' health and thus may not give the expected milk yield. (Solheim, 2007).

A cause of underperforming forage production is that it is managed according to intuition and routine based on old tradition. A modern dairy farm however put high demands on the farmer's ability to coordinate, plan and manage the forage production through the whole process until storage to obtain silage of the desired quality and quantity at the right price (pers. com., Cuellar, 2012).

Definitions

Ley

"Temporary pastureland ⁄ grassland that is integrated in a crop rotation" (Allen, et al., 2011).

Temporary pastureland⁄grassland

"Land on which vegetation is composed of annual, biennial, or perennial forage species kept for a short period of time (usually only a few years)" (Allen, et al., 2011).

Ley management

The art of designing and leading the process of forage production to storage of the desired quality and quantity (section 4.2).

Therefore the business leader has to strive to overview and control the production process, where an important part of creating control and overview is to introduce a more systematic approach built on strategy and clear objectives. Then the resources can be used more efficiently in order to achieve the best results at the lowest cost (pers. com., Cuellar, 2012). That is why there is a need of ley management.

1.1 Objective

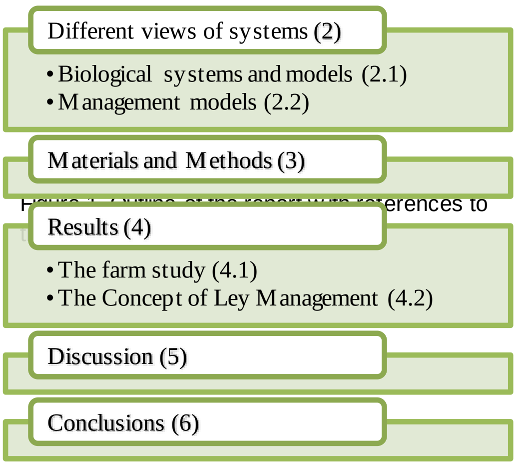
The objective of this study was to design a simple model, i.e. the concept of ley management, that farmers and advisers can use to identify and prioritize strategic decisions in the forage production based on the farmer's targets. An important part was to study the farmers' decision-making and compare it with their results in the forage production.

1.2 Outline

The outline of the report is based on three main questions:

1. How can the forage production system be described with biological models?
2. How can processes be structured and prioritized in management models?
3. How do farmers manage the forage production system?

An overview of the report is shown in figure 1, where the two first questions are answered in the literature review (section 2, Different views of systems). In the first part (2.1) an overview of methods to study the forage production and dairy production systems from different points of view are presented.



In the second part (2.2) some management models are presented, which provides tools to structure processes to be able to prioritise decisions and compare results.

To answer the third question a farm study was conducted, where most of the methods presented in the literature review was used (section 3), with the results presented in section 4.1. The focus was to determine the farmers' goals of the forage production, their strategy to attain them and how they operate and compare the results.

The combined answers of the three main questions constitute the basis of formulating the concept of ley management (4.2). The report is completed with a discussion of key issues (section 5) and conclusions (section 6).

2 Different views of systems

The ecosystem is very complex with a huge number of interacting and interrelated processes, an example of this is figure 2 which shows a schematic overview of the most important conditions and interactions that affect growth and development of leys. This complexity makes it difficult to study the whole system and to be able to overview and manage the ecosystem it is easier to simplify it in varying degrees to understand how different subsystems operate.

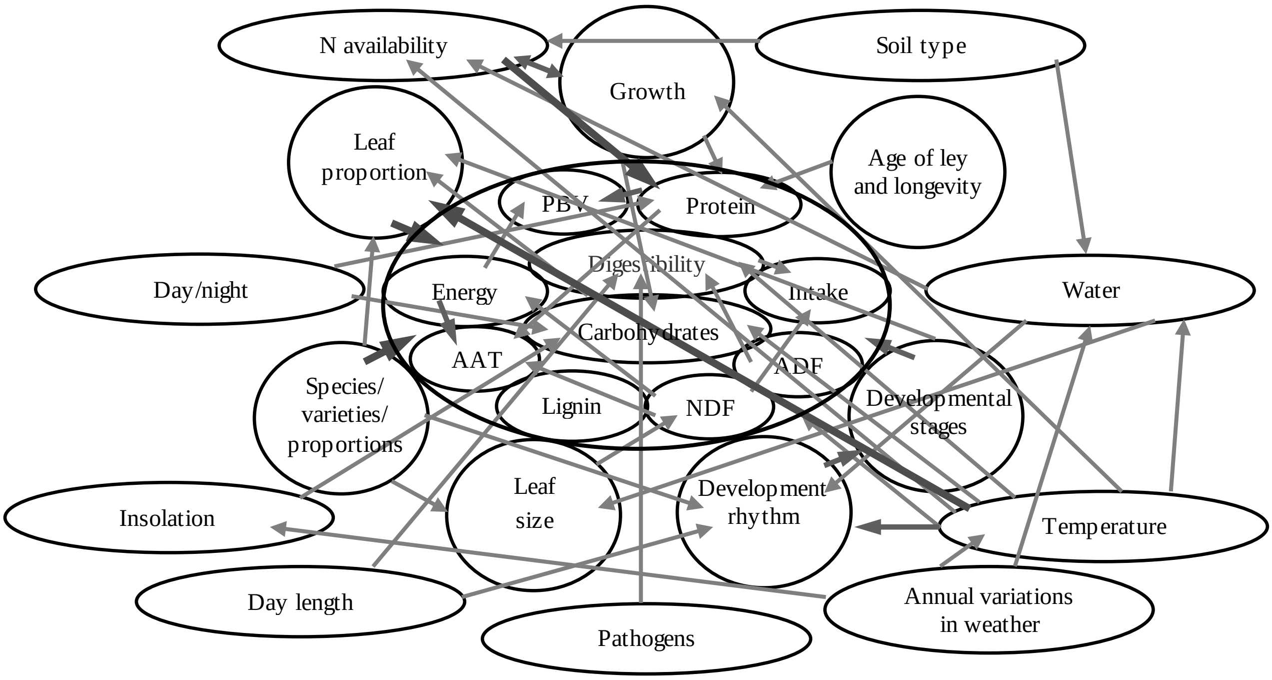


Figure 2. Schematic overview of the complexity of conditions (the outer ellipses) and interactions (arrows) that affect the growth and development of leys (the intermediate circles) and hence the quality (the inner ellipse) (after Johansson, 1993).

2.1 Biological systems and models

In this section several examples of models and trials that describe and evaluate the systems of forage and dairy production will be presented.

The different system descriptions cover different levels and focuses. A schematic overview is shown in figure 3, where each method is placed in the figure according to which levels and subject it covers.

The literature review begins with methods of an environmental aspect followed by production and finally methods of a financial focus, since a profitable business is essential for long term survival and sustainability.

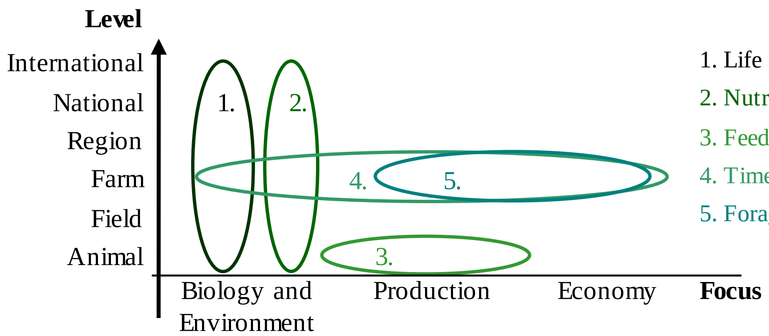


Figure 3. A schematic overview of the different levels and focuses that the models presented in the literature review covers.

2.1.1 Life cycle assessment

Life cycle assessment (LCA) is a methodology to assess the environmental impact of a product, service or process from the cradle to the grave (SIK, n.d), which is estimated by e.g. the emissions of greenhouse gases (GHG), often measured as carbon dioxide equivalents (CO_2e).

The framework of the LCA-methodology is standardized by the International Organization for Standardization (ISO 14040 and ISO 14044) and the structure for a life cycle assesment is shown in figure 4.

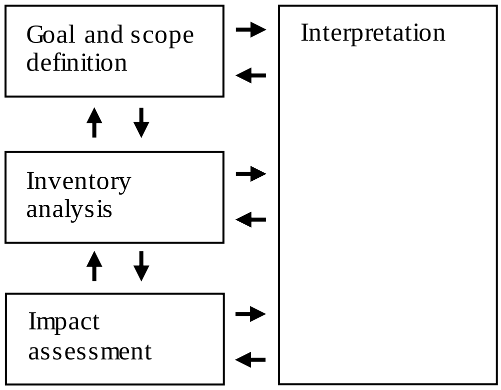


Figure 4. Structure of a life cycle assessment (ISO 14040, 2006).

There has been several LCAs conducted during the last decade to assess the impact of GHG emissions from milk production (Basset-Mens, 2008; Casey & Holden, 2005; Cederberg, et al., 2007; Cederberg & Flysjö, 2004; Cederberg & Mattsson , 2000; Flysjö, et al., 2008; Haas, et al., 2001; Hospido, 2005; Thomassen, et al., 2008; Williams A.G., et al., 2006). But as the International Dairy Federation (2010) concludes, for all these LCAs it were difficult to identify a certain area where meaningful reductions of GHG could be made, since the authors used different methods of calculating the emissions in the milk life cycle.

Cederberg et al. (2011) investigated the uncertainties of estimations of the agricultural carbon footprint. They identified these three key uncertainties:

- Uncertainties in model calculations.
- Uncertainties in measurement data.
- Variations due to different methods of production and management on farms.

The uncertainties can be very large, e.g. the difficulties to estimate and model emissions of methane and nitrous oxide which derives from complicated biological processes. These gases are very potent greenhouse gases and they have therefore a large impact on the carbon footprint. Based on this Flysjö, et al. (2011) argues that climate labelling of food products with exact figures of GHG emissions is questionable due to the uncertainties of emission factors used when calculating the carbon footprints.

An example of uncertainties in measurement data is harvest estimations. Milk production is based on the production of grasslands and the statistics, at least in Sweden, is based on farmers' subjective estimates of yield levels. There are few who weigh their yield and also determines the dry matter concentration (DM). The yield level is important for the size of the carbon footprint, since it is based on the amount (kg) of the product. It is therefore important to secure a high and consistent yield (Cederberg, et al., 2011). Cederberg et al. (2011) also concluded that a high proportion of forage with high quality in the dairy production has benefits not only to the climate but also for other environmental effects such as nitrogen leaching.

The variation between farms' practices can be illustrated by the feed efficiency on Swedish farms, investigated by Henriksson, et al. (2011). They found that the variation of the carbon footprint of milk due to management differences was as large as ±17 % of the average value of 1.1 kg per CO_2e kg energy corrected milk (ECM). The authors also concluded that the actual variation most likely is higher, since the data used in the study were obtained from dairy farms with higher production than the average Swedish farm.

In a life cycle assessment of locally produced feed for dairy cows the energy and land use, environmental impact, eutrophication and acidification were investigated on a fictional farm in the county of Västra Götaland, Sweden (Wallman, et al., 2010). The result showed that it was not possible to identify one of the five tested feed rations that were best for all aspects. The energy consumption was the issue that was affected most by the choice of feed, where the two rations with the highest forage proportion had the lowest consumption. However, both these rations had a higher risk of contributing to eutrophication and a higher demand of land than the other examined feed rations. The ration with highest forage proportion had a high potential of acidification, partly due to a higher manure rate than the other feeds. A conclusion is that feed rations with locally produced protein feeds and silage of nitrogen fixating leys have environmental advantages by a lower energy use and environmental impact than the control, i.e. a normal feed ration for the area, used in the study (Wallman, et al., 2010).

Cederberg et al. (2007) concludes in a LCA of milk in northern Sweden that the environmental issue for the dairy production in northern Sweden is the use of resources rather than eutrophication and acidification. Hence, an important hotspot of the environmental impact of northern Sweden is the large dependence of imported feedstuffs from southern Sweden and abroad (Cederberg, et al., 2007). The energy use was lower on the farms in the study that produced cereals at the farm and thus reduced the imported feedstuffs. The authors concluded that an increased feed production in northern Sweden would decrease the use of energy in the dairy life cycle and increase the use of open land, which supports the Swedish environmental goals of 'a varied agricultural landscape' and 'a rich diversity of plant and animal life'. The authors also requests additional annual fodder plants in the crop rotations that would give several positive effects in the ley dominated crop rotations.

2.1.2 Nutrient balances

Nutrient balances views the agricultural system from a nutrient perspective at different levels, from field, farm, regional and the national levels (figure 3)(Swensson, 2003). The balance can be used to increase the awareness of the risk of negative environmental impact from agriculture.

Wachendorf and Golinski (2006) have pointed out that improved nutrient management and reduced environmental pollution are a part of moving the intensive dairy farming in Europe towards sustainability, where the production systems aim at the integration of social, production and environmental goals. However, the information of nutrient flows and management in grassland agriculture at a whole-farm or a systems scale is limited, as much of the research has been focused on arable cropping systems. Therefore Wachendorf and Golinski (2006) investigated the nitrogen and energy use efficiency in forage production systems based on data from two experimental farms, Karkendamm and De Marke in the Netherlands. They concluded that an intensified production results in more productive grasslands, but the intensification also increases the risk of nutrient losses with negative environmental impact. However if the right knowledge and management are applied, grasslands have the capacity to reduce the negative environmental effects if they are included in a crop rotation of an intensified production.

Öborn, et al. (2003) have examined the merits and limitations of elemental balances. Nutrient management is mainly affected by the type of agro-ecosystem and its state, but also of nutrient balances if there is set agronomic and/or environmental targets (figure 5).They concluded that a simple farm level nutrient balance has many advantages since it is relatively easy tool for nutrient management and it gives an indication of the farms performance.

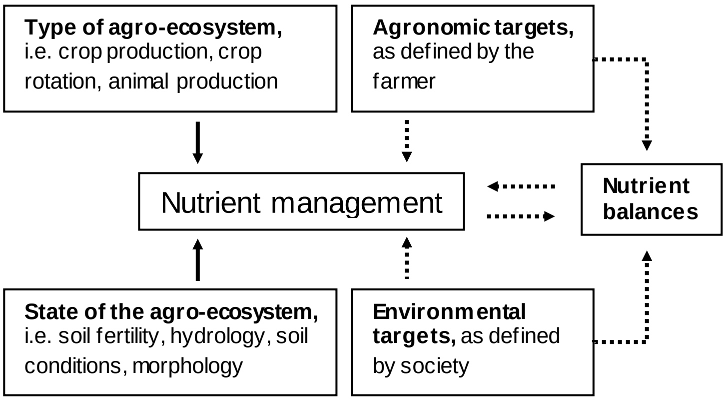


Figure 5. The figure shows the relationship between factors that affect nutrient management. The role of nutrient balances in nutrient management depends partly on the existence of agronomic and environmental targets where a balance is a tool to measure the targets (Öborn, et al., 2003).

However, the balances at best provide a nutrient loss potential, since there is not always a clear reletionship between nutrient management, surplusses, losses and environmental impact (Öborn, et al., 2003).

Calculations of farm level nutrient balances in Sweden often rely on the STANK model (STallgödsel - Näring i Kretslopp), which is the official model for input/output accounting on farm level in Sweden (Linder, 2001). The STANK model was developed as an advisory tool to provide a good support for a better nutrient utilization (Swedish Board of Agriculture, 2008). The program contains a comprehensive tool for managing manure, with calculations on quantity, nutrient content and ammonia losses (Linder, 2001). The inputs of N, P and K are related to the different crop's requirement of nutrients for individual years and also the requirement in the rotation. Increased mineralization due to supply of manure, removal of residues and to the value of the previous crop is also taken into account (Swedish Board of Agriculture, 2008).

An example where nutrient balances are used to reach environmental goals is one project 'Focus on Nutrients' (i.e. Greppa Näringen). The campaign was launched in 2001 in southern Sweden by the Swedish board of agriculture, the federation of Swedish farmers and large number of companies in the agricultural sector and it has expanded to include the region of Götaland, Svealand and the county of Gävleborg. The aims are to reduce nutrient surpluses, promote a safer management of pesticides and to reduce climate impact. Farm visits by advisors are the primary means to meet the goals, where the advisor and the farmer evaluate and discuss the management on the farm. The agreed upon measures that should be taken are also followed up during several years (Focus on Nutrients, 2011).

The calculated balances used by Focus on Nutrients (n.d.) account for estimations of nitrogen fixation and the nitrogen surplus consists of losses by leaching, ammonia emissions and denitrification and also a contribution to soil humus supply in the short to medium term. Based on the participating dairy farms Focus on Nutrients (n.d.) states that an average farm with 1.0 livestock units per hectare has a surpluse around 130 kg N per ha. The 20 % of the farms with lowest nitrogen efficiency have surpluses of 200 kg N per ha and the 20 % highest performing farms have surpluses of 70 kg N per ha. (Focus on Nutrients, n.d.).

In a review of the repeated nutrient balances the surpluses of nitrogen had decreased with 6.4 kg N per ha in 2008 on the participating dairy farms, compared to 140 kg N per ha in 2001 (Linge, et al., 2010).

In a study of 23 dairy farms in the county of Västerbotten the average nitrogen surplus for 16 conventional farms was calculated to 114 kg N per ha and 52 kg N per ha on seven organic dairy farms (Cederberg, et al., 2007). A similar pattern of lower nitrogen surpluses for northern dairy farms was calculated in the Öjebyn project, where the conventional system had surpluses of 94 and 86 kg N per ha and rotation and the organic system 28 and 25 kg N per ha and rotation (Jonsson, 2004).

2.1.3 Feed evaluation systems

The next step in nutrient management on farm level is to evaluate the nutritive value of the produced forage to be able to use it as efficiently as possible in the feed ration. There are several different feed evaluation systems. Two of them will be presented in this section, the Cornell Net Carbohydrate and Protein System and the Nordic Feed Evaluation System, NorFor.

CNCPS - Cornell Net Carbohydrate and Protein System

The Cornell Net Carbohydrate and Protein System (CNCPS) is a part of the Cornell University Nutrient Management Planning System (cuNMPS) that was developed to improve environmental and economic sustainability of dairy farms (Fox, et al., 2002). The aim of CNCPS was to design a nutritional accounting system using inputs that can be measured or observed in a production setting in order to use it as a nutritional diagnostic and diet evaluation tool (Fox, et al., 1995). The model uses a combination of mechanistic and empirical approaches to account for the effects on animal performance, to accurately predict nutrient requirements and utilization with wide variations in animal factors, feed and environmental conditions (Fox, et al., 1995). By accounting for farm-specific management, environmental and feed characteristics a more accurate prediction is made that improves productivity, reduces the use of resources and the negative impact on the environment (Fox, et al., 2004).

The CNCPS model is used in teaching, in commercial computer programs and by nutritional consultants and feed firms to better understand the system and to optimize the use of home-grown feeds and decrease the need for purchased supplements. Evaluations of the model have shown that it in a variety of production settings accurately can predict nutrient requirements, feed utilization and nutrient excretion. By using that information the formulation of diets can be more economical and environmentally friendly (Fox, et al., 2004).

NorFor – Nordic Feed Evaluation System

The Nordic Feed Evaluation System (NorFor) is developed by the farmers' dairy cooperatives in Denmark, Norway, Iceland and Sweden. The aim is to develop a common feed evaluation system to be able to communicate and compare between farmers, consultants and feed industry representatives. A new version of Norfor is under development to give a more comprehensive description of the feed than is done today. Hence, an advantage is a more dynamic evaluation of the forage quality, both in terms of the nutritional and hygienic quality. Consequently it is easier to optimize feed ratios due to the more complex model that more adequately describes the turnover of the feed in the cow

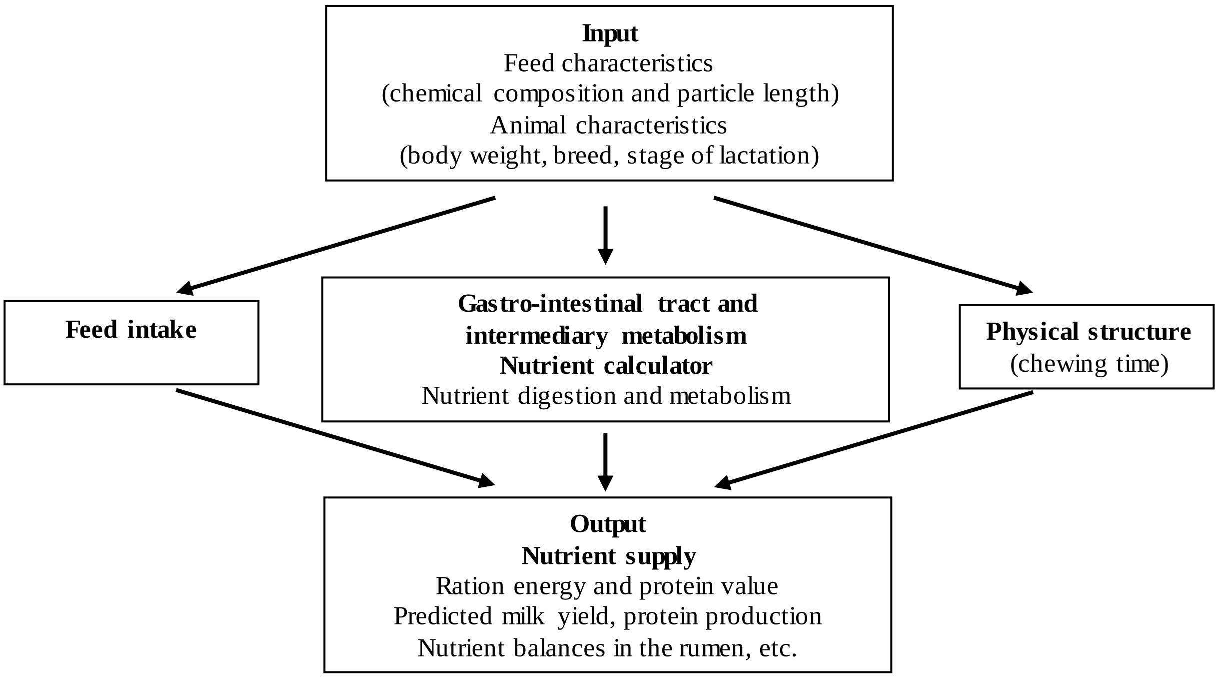


Figure 6. Overview of the NorFor model with the three main parts: feed intake, gastro-intestinal tract and intermediary metabolism and physical structure (Volden, 2011).

(Mehlqvist, et al., 2005b).The used model is semi-mechanistic, static and science-based, with focus on predicting nutrient supply and requirements for maintenance, milk production, growth and pregnancy in cattle (Volden, 2011).

The model consists of three main parts: feed intake, gastro-intestinal tract and intermediary metabolism and physical structure (figure 6). The input of the model consists of data on feed and livestock. From these data a series of calculations are done in the model that describes the nutrients uptake of the animal in relation to its needs. The cow's feed intake, i.e. how much she can eat of a given diet and if the diet can provide sufficient structure are also calculated and linked in the model to provide the output (Mehlqvist, et al., 2005a).

2.1.4 Timeliness

Timeliness costs are the economic consequences of performing a field operation at a non-optimal time (Gunnarsson, 2008). These costs are partly due to how well the planning of field operations is done and on the total capacity of the machinery. What also affect the timeliness cost are farm-specific parameters such as transport distances to the fields, labour availability, non-productive time and length of working day. These factors and weather conditions have a large effect on the time of field operations. Timeliness costs for a specific area or operation are normally calculated using timeliness factors expressing the loss for each day’s delay of an operation (Gunnarsson, 2008). An optimal work and machine organization can reduce the time and thus the cost (Sörensen, 2003). In forage production the timing is very important for the forage quality, voluntary intake and consequently the milk yield (Bertilsson, 1983; Kuoppala, 2008; Bernes, 2008).

Gunnarsson (2008) have developed a method to calculate timeliness costs for forage harvest. The method values forage for milk production with respect to how much a delayed harvest would increase the yield and decrease the feed value. The timeliness cost factors were significantly higher ($p<0.05$) in the first cut compared to the second and third cut. However the timeliness cost per hectare and day’s delay can vary greatly between years due to the annual variations in weather. The most important factor for minimizing high timeliness costs is to avoid delays in harvesting, especially in the first cut (Gunnarsson, 2008).

2.1.5 Forage Production Costs

The forage production cost is a significant part of the feed cost and therefore it is important to monitor it. There are several different methods to calculate the cost, from basic unit contribution to more elaborate calculations that considers a more complex set of factors.

An example of a calculation of unit contribution is an enterprise budget for crop production developed by the Rural Economy and Agricultural Societies (Hushållningssällskapet, 2011). The budget is based on experiences from the Rural Economy and Agricultural Societies for conditions in southern Sweden. It calculates the unit contribution of the production branch based on revenues and variable costs for each individual branch of production. An operating budget can be set up by adding the unit contributions of all production branches and add the overhead costs.

HP-foder is a calculation model that takes more factors into account when calculating farm specific forage production costs (Stark & Ågren, n.d.). The developers' aim of the program was to design a simple model that estimates the magnitude of the production cost as well as being easy to understand and not too time consuming to use. This has led to some simplifications that result in figures that are not as exact as they could be with a more elaborate model (Stark & Ågren, n.d.). But Stark and Ågren (n.d.) argues that there are so many uncertainties in the input figures, that a more exact model would not give a more accurate result. The model is based on costs for machines, purchased services, labour, storage and supplies, which are distributed between the crops based on the requirement of time, supplies and acreage of the crops (Stark & Ågren, n.d). Depending of the nature of the input figures the result will differ, e.g. if the costs are set for different time spans, for the whole forage chain until the feed is served or only until storage (pers. com., Stark, 2011). The result is presented as the cost per kg DM of forage, per hectare and also per MJ (Stark & Ågren, n.d).

Since the middle of the 90s the Rural Economy and Agricultural Society in the region of Västernorrland has conducted several studies where the forage production costs have been calculated on a number of farms in the region using HP-foder (Stark, 2000). The results from the harvest season of 1998 with 60 participating farms show a large variation in forage production cost between the farms, 0.70-2.50 SEK per kg DM. The study also showed a large variation in production cost per MJ which in average was 0.13 SEK per MJ, based on the average energy content of 10.3 MJ per kg DM, but there was no correlation between the cost and energy content. Stark (2000) emphasizes that the production cost per MJ of forage should be contrasted to the price per MJ of cereals and concentrates to give it a comparable value.

A main factor of the variation in production cost was machinery costs, where the potential for improvements was identified as very high. A large part of the machinery costs are fixed, consequently a reduction can be made by increasing the utilization of the machines by e.g. increasing yields both per hectare and total, by machine cooperation and by selling machine services. However, Stark (2000) points at the extensification that is stimulated by EUs payment scheme with lower yields as a result, instead of the intensification with higher yields per hectare that is necessary to reduce the machinery costs. As a consequence Stark (2000) promotes that each individual farm has to weigh practical and financial factors to optimize the firm's profits.

2.2 Management models

Management can be defined as the practice of organizing, directing and developing resources, such as time, knowledge, machinery, employees, co-operations, contacts, land resources, supplies etc., to provide products and services through organisational systems (Bloisi, et al., 2007).

The management theories and models that are presented in this section elucidate important parts of the forage production, by structuring the different parts of the system into processes. The first model, the agricultural business management pyramid, clarifies and describes the time and planning horizons in agricultural businesses (figure 7). The second model, the principle of economising, structures the system into a circuit process that produces a value (figure 8). To evaluate the performance of a system, the concept of benchmarking can be used to set a reference to others.

2.2.1 The agricultural business management pyramid

The management pyramid model (e.g. Samuelsson, 1996) has been adapted to agriculture (pers. com., Karlsson, 2011) to structure planning and decision-making in agricultural firms into three time horizons – strategic, tactical and operational (figure 7). The main point is to elucidate the order of decisions from strategic decisions with effect during several years to operational decisions in the day-to-day work.

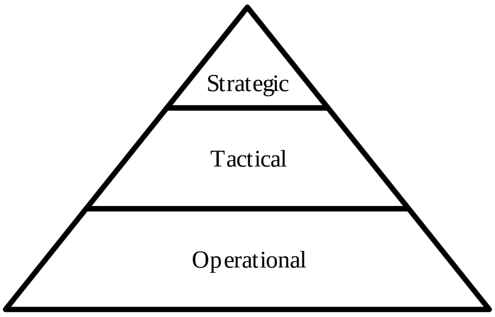


Figure 7. The three time horizons of the agricultural business management pyramid, strategic, tactical and operational; structures planning and decision-making in order to elucidate the order of decisions from strategic decisions with effect during several years to operational decisions in the day-to-day work (pers. com., Karlsson, 2011).

The strategic horizon handles questions of key factors which determine the success of an organization's strategy (up to 20 years), such as personal and business goals, long-term leadership, investments in buildings, machinery, soil fertility etc. The tactical horizon handles questions of a shorter time frame (0-5 years) as management of the business, design of the crop production plan, logistics, manning, maintenance of machinery, evaluation of the harvest season etc. Finally, the operational horizon handles the processes of the day-to-day work required to reach the strategic goals of the business (pers. com., Karlsson, 2011).

The farmer has to be able to handle, combine and balance all parts of the pyramid for maximum competitiveness (pers. com., Karlsson, 2011), where a larger business requires more focus on the two upper horizons to be able to successfully lead the firm towards its goals.

2.2.2 The principle of economising

The principle of economising describes a process with particular attention to resource utilization where the created value does not undermine the sustainability of the process (Bergström, 1998) (figure 8).

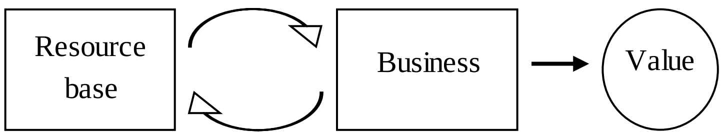


Figure 8. The principle of economising describes a process with particular attention to resource utilization where the created value does not undermine the sustainability of the process (Bergström, 1998).

Economising in a business is a question of how you manage the trade-off of the availability of resources and quality claims, i.e. the production goals. In the model Bergström (1998) defines the business as the focus of interest in a context, where the resource base is the business' identified environment. That is, upon which terms the business exists. Between the resource base and the business there is an exchange which consists of everything that is added to the business and everything that leaves it.

The model thus describes a process where the business uses and affects the resources of the firm while it is producing a value, where everything has to be economised, not just money, and it applies to every level of the firm, from the use of resources to goal attainment. Hence, a sustainable development can be obtained if the idea is applied consistently and systematically (Bergström, 1998).

In forage production the resource base consists of the assets of arable land, machinery and workforce etc. The quality of the resources, e.g. knowledge, soil fertility, land consolidation and machine capacity sets the prerequisites of the business. Maintenance of the resource base is done by e.g. fertilizing, liming, and maintaining machinery and knowledge. The produced value in forage production is a certain forage yield with a certain quality to a certain price.

Lean production, a production practice developed in the car industry, has similar core values as the principle of economising, where the aim is to eliminate waste, thus improving the resource use efficiency (Liker, 2004). There is a project running for implementing lean production on south-western Swedish farms. The aim is to support the participating farms to improve their organisation and the individual learning with the lean methodology in order to reduce waste and increase the profitability of the farm. (The Rural Economy and Agricultural Society in Halland, 2012) . As a part of the project an evaluation of the lean methodology in an agrarian context was conducted, where it was concluded that an implementation of lean can lead to an improved profitability of the agricultural firm (Dyrendahl & Granath, 2011).

2.2.3 Benchmarking

The idea of benchmarking is to learn more from others' experiences. The concept was introduced by the Xerox Group in the end of the 1970s, when they discovered that Japanese manufacturers of copiers were far ahead of them in the development. The term benchmarking was then introduced to get a fixed point, a reference, to compete with. In businesses that have conditions of a planned economy, e.g. within a company, there is an absence of real competition and thus a lack of reference points for efficiency (Karlöf & Lövingsson, 2005), which forage is an example of in the dairy production.

The Global Benchmarking Network'(n.d.) defines benchmarking as:

"…the search for solutions leading an enterprise to better performances, which is based on the best methods and procedures of the industry. The establishment of firm targets on the basis of the optimum methods and procedures of industry is an important success factor of business strategy."

Competition plays an important role in the development by raising the ambition level and creating an interest in learning, which in turn is a prerequisite for efficiency and competitiveness (Karlöf & Lövingsson, 2005) (figure 9). By comparing the business' processes and performance metrics to the best businesses or best practices the development is thus driven forward.

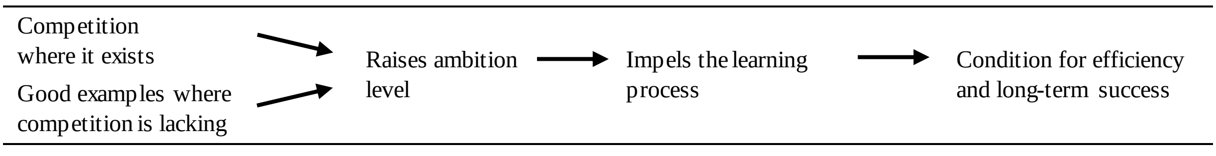


Figure 9. The theory of competition as a mean for efficiency (adapted from Karlöf & Lövingsson, 2005).

However, benchmarking has been trivialized as it has been spread around the world. Gradually it has been interpreted as a simple comparison of key ratios, without reference to causality, learning or progress (Karlöf & Lövingsson, 2005). Karlöf and Lövingsson (2005) refer to genuine benchmarking as standardized key ratios as much as documented procedures with comparable work content or causality. Hence, they mean that benchmarking is a way not only to see that someone performs better, but also why and how. Especially the causality is of great importance, why the performance levels are better, to be able to learnt and thus develop. But it is not only about learning from best practices, it is also about learning from mistakes, your own and others (Karlöf & Lövingsson, 2005). If applied properly, the lessons learn from a benchmarking exercise can facilitate improved performance in critical functions within an organisation or in key areas of the business environment (Riley, n.d.).

The application of benchmarking involves four key steps (Riley, n.d.):

1. Understand in detail existing business processes
2. Analyse the business processes of others
3. Compare own business performance with that of others analysed
4. Implement the necessary measures to close the performance gap

Benchmarking can be used in almost any situation, but the need of quantification varies. The more qualitative the subject is, the more difficult it will be to create quantitative metrics. Hence benchmarking can encompass pure quantitative key ratios to documentation of procedures and inspiration from best practices (Karlöf & Lövingsson, 2005).

3 Materials and methods

The focus of this study was on forage production and the examined parts of the cropping system are in overall defined in figure 10, where they are structured according to the principle of economising (2.2.2) thus sorted under resource base, business and value.

The methods described in the literature review (section 2), except LCA, have been used to varying extent in the study. The LCA method was not used since it demands very comprehensive data and for northern Sweden there is not much available data, e.g. on nutrient leaching (Cederberg, et al., 2007). The LCA methodology is focused on environmental issues, while this study primarily aims to study how the management of forage production can be structured in order to achieve the farmer's goals which to a certain point are driven by financial issues.

Data were collected by several means. A survey and interviews with farmers gave information about the farms and their ley management. This was combined with objective data points to evaluate the results of the farmers' management during the season of 2011. The chosen methods were thus both qualitative and quantitative, which (Eliasson, 2010) means is an advantage in a comprehensive study.

The data of a qualitative character was summarized and the quantitative data processed in Microsoft® Excel, where the average, percentiles were calculated and R^2 and standard error of estimate (SEE) for linear regressions.

The results were compiled in order to ensure the anonymisation of the farmers, since it can be ethically questionable to contrast individuals in research. Although in some cases figures of individual farms are present to elucidate results that cannot be seen in a compilation.

3.1 Selection of farms

The dairy farms participating in this study were selected on the basis that they were spread around the region, i.e. the counties of Västerbotten and Norrbotten, and of different sizes and the farmers had also an extra interest for crop production and especially for forage production. Twelve farmers, six in each region, were initially invited (see invitation appendix I) and contacted during the period of 11 – 25 May 2011. An additional farmer was invited later to assure that an organic farmer would participate in the study. The study is hence based on the nine farmers that decided to participate in the study, four in the county of Västerbotten and five in the county of Norrbotten.

By not selecting the participants randomly and also quite few, the results cannot be expected to be representative for the whole population of dairy farmers. With interest follows most often good results, thus the results of the study can be used to develop the advisory service by giving it a benchmark of achievable results together with strategies that underlie the results.

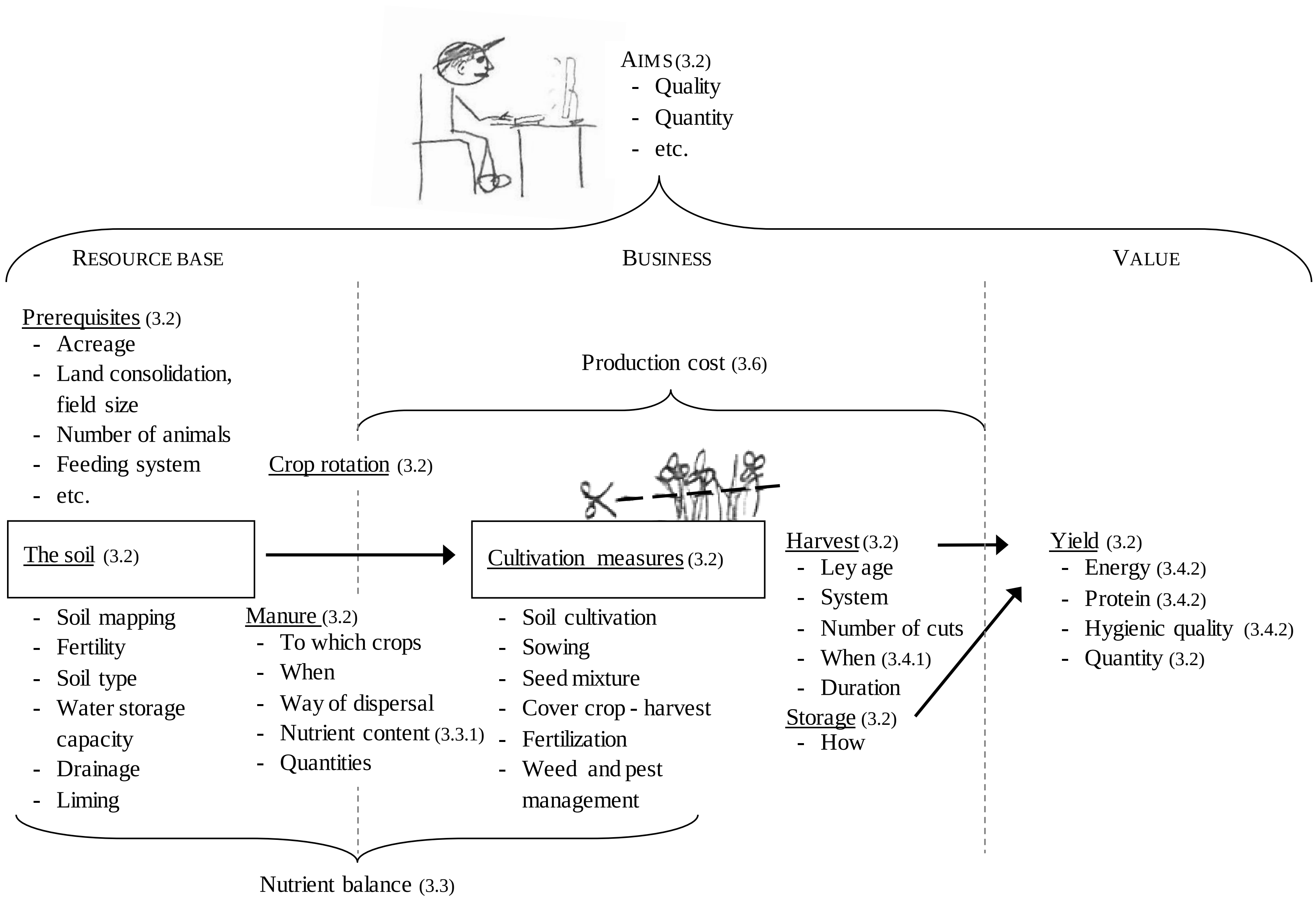


Figure 10. Schematic description of the examined system of forage production structured according to the principle of economising. The farmer at the computer represent how planning and decision-making is done together with goals of the forage production system. The numbers refer to sections where the method used to examine the topic is described.

3.2 Survey and interviews

To be able to know what the farmers think concerning their forage production and how they realize it, information was mainly gathered through a survey and interviews during the farm visits. Contact with the farmers was kept during the season by phone, email and text messages.

The purpose of the survey was to get basic information about the farm before the first interview. For the farm visits and interviews the objective was to determine the farmers' goals of the forage production, their strategy to attain them and how they operate their farms with its prerequisites.

The study followed a few individuals during a period of time and therefore it was considered that possible faults and supplementary questions could be clarified at later occasions, as during the second interview or in other contact with the farmers.

3.2.1 Recommendations

The survey form and interview guides were developed with regard to the following recommendations.

In the beginning of a survey form the purpose should be stated to motivate the farmers to answer it as soon as possible (Eliasson, 2010). Eliasson (2010) recommends that the form is divided into different thematic sections to be easier to overview for the respondents. To ensure the quality of the form Trost (2007) recommends that it is reviewed by a third person.

The interview questions are recommended by e.g. Kvale and Brinkmann (2009) to be structured in an interview guide. Andersson (2001) emphasises the risk of too precisely formulated questions, where the interviewer risks missing essential information since it was not anticipated. In an open interview it is possible to capture perceptions and experiences of important qualities, where the respondent defines the context (Lantz, 2007). That makes it difficult or even impossible to compare quantities between the individual respondents. On the other hand, in a structured interview the interviewer defines what is important, hence Lantz (2007) means that it is decided by the interviewer's pre-understanding or theoretical starting points.

Trost (2010) means that our processing, our analysis and interpretation depends on the individual's personal taste, hence, there are no set rules to follow when processing qualitative data. However Trost (2010) recommends that the responses are structured in the same categories as the interview guide.

3.2.2 Survey

The survey form was sent to the participants when they accepted to join the study. It contained mostly open questions of a quantitative character about basic facts of the farm (appendix II). The form was divided into seven different thematic sections and was reviewed by the supervisors and a farmer. Unanswered questions were completed during the first farm visit.

3.2.3 Farm visits and interviews

Two farm visits and interviews were carried out on each farm during the study. At the first visit the ranking of the leys botanical composition (3.7) was conducted. To be able to do the ranking, the first visit was scheduled two to three weeks after the first harvest, i.e. during the period of 1 July to 4 August. The second visit was carried out between 2 and 19 October.

Prior to the two interviews, interview guides were developed. The first interview guide (appendix III) contained overall research questions and more detailed questions, which were used during the interview. The guide was designed to follow the same themes as the survey form where the questions referred to the survey form's question numbers. Thus, it gave the interview a logical order and missing data in the survey form could easily be supplemented. The interview guide for the second interview (appendix IV) contained questions to follow up the season to further understand how the farmers plan the business and additional questions from the first interview. The content of both guides were developed in discussion with the supervisors.

The chosen manner of the two interviews was based on the semi-structured interview, with elements of an open directed interview, which Lantz (2007) has defined. Consequently, the questions were formulated in short sentences to allow formulation of questions during the interview that followed naturally in the conversation. The open character of the interviews gave a variation of detail in the answers and thus the results from the interviews are not strictly comparable. However, they indicate the diversity of farmers' interests and experienced problems. Another difficulty with the open character was to try to estimate why certain subjects were discussed in one interview and not in another, was it due to the farmer's indifference of the subject, the ability of the interviewer to interpret and ask the right questions at the right time or a combination?

The farmers' responses were noted during the interviews and the annotations were later written out fair and, if any, supplementary questions were noted to be answered at a later occasion.

Data were processed by reducing the dataset to the most important parts from the interviewees' responses and structured by categorizing the data in a similar structure as the interview guide. The first interview, plus the additional questions from the second, were compiled with the results from the survey into a summary, which is presented in the results, sections 4.1.1 to 4.1.4. The compilation of the second interview is presented in sections 4.1.5 and 4.1.6.

3.3 Nutrient balances

Nutrient balances (2.1.2) for the leys were done through NPK-balances based on input from manure (with no regard to the application technique) mineral fertilizers, clover content derived from the botanical composition (3.7) and yields as outputs. Soil mapping data could not be used since only three of the seven farmers who had mapped their soil could provide individual data points, where others only could provide maps with the interpolated data. The soil was hence chosen to be seen as only a recipient which is affected by a surplus or deficit of the nutrients.

3.3.1 Manure analysis

One sample of manure was taken by the farmers and sent for analysis of nutrient content (Agrilab, Uppsala). Information and instructions of how to sample (appendix V), was sent to them with the sampling material and return package. Analysed parameters were dry matter (KLK 1965:1), total and organic nitrogen (SS-ISO 13878), ammonium nitrogen (ISO 11732), total carbon (SS-ISO 10694), phosphorous, potassium, magnesium, calcium, sodium and sulphur (SS 28311).

3.4 Feed evaluation systems

NorFor-input parameters (Volden, 2011) and ensiling evaluation scores (Dairy One, n.d.; DLG, 2006) were used to evaluate the value created in the forage production system (2.1.3). Further evaluation of the silages' value in a feed ration was not done. But the effect of the farms different feed rations were measured by retrieved data of quantity and quality of sold milk.

3.4.1 Fresh matter analysis

Sampling of fresh matter in harvest were done during the first and second cut to be able to see how well the farmers had chosen the optimal harvesting time.

Material and instructions of how to sample the fresh matter were sent to the farmers (appendix VI). The farmers were instructed to take three samples distributed over the field, from the field they reached when half of their acreage was cut. Two of the samples were sent for analyses (Eurofins, Lidköping) of dry matter content (DM), metabolisable energy, crude protein (CP) and neutral detergent fibre (NDF) with NIRS according to Williams and Norris (1987).

The third sample was sent to Umeå where it was sorted into four parts, timothy, fescues, clover and weeds, the grasses in the first cut were also sorted according to developmental stages (Gustavsson, 2011).

3.4.2 Silage quality analysis

One sample of silage from the first harvest was sampled by the farmers and sent in for analysis of quality and hygienic parameters (Eurofins, Lidköping). The samples were analysed with NIRS according to Williams and Norris (1987) for concentration of dry matter, energy, crude protein, soluble crude protein, NDF, ash, sugar and iNDF. pH was analysed chemically (Everitt, 1980) in four samples and in three with NIRS (Williams & Norris, 1987) where the chemical pH-value could not be retrieved. Concentration of lactic, butyric, propionic, acetic and formic acid and ethanol and NH_4-N was analysed chemically according to the methods used at Eurofins pers.com. Bangor, 2012). NorFor input parameters, as chewing index and feed fill value, were calculated by the lab according to (Volden, 2011).

3.4.3 Quantity and quality of sold milk

Data of total quantity of sold milk and its quality; urea, fat, protein, bacteria and cells, were retrieved from the farmers' member page on the dairy's website (Norrmejerier.se). The datasets are from 1 January 2011 to the beginning of October 2011. The quantity of milk was recalculated to energy corrected milk (ECM) with the following equation (Svensk mjölk, 2007):

kg ECM = weigh-in (kg) x 0.25 + fat (kg) x 12.2 + protein (kg) x 7.7

3.5 Timeliness

Factors of timeliness (2.1.4) were examined, e.g. the duration of harvest, and the farmers' view of timeliness and timeliness costs were discussed during the interviews.

3.6 Forage Production Costs

Calculations of the forage production cost (2.1.5) were performed on five of the studied farms. The selection of the farms was made to obtain a geographic distribution and also a distribution in yields and number of harvests.

3.6.1 Forage production diary and machinery

The design of the forage production diary was retrieved from Taurus (2009) and revised to be more lucid and easier to fill in (appendix VII). The farmers filled in the field operations and the time expenditure conducted in the forage production during the season. The purpose was to estimate the time the farmers spent on each operation and the obtained yields as a basis for the production cost calculation. A list of machinery, stock and other costs associated with forage production supplemented the basis for the calculation of production cost (appendix VIII).

Missing data were collected during the second farm visit when the production cost sheet was filled in. For those who had used the ley dairy it was a good basis for an approximation of the time consumed for each operation during the season.

3.6.2 Calculation of production cost

The calculation of the cost of producing forage was done by adapting the enterprise budget of forage (Hushållningssällskapet, 2011) to calculate the unit contribution.

The production cost per kg DM silage was calculated for all operations including storage. Information of which operations, time per operation, acreage, input prices etc. was collected from the forage production diary and at the second farm visit, where the calculation sheet was filled in with the farmer. The yield was estimated as the stored volume. The machinery costs were set to standard values of well-used machines according to Maskinkalkylgruppen (2011) and the cost for the driver was set to 200 SEK/h. The machine cost of establishing a ley is difficult to calculate since it is undersown in a cover crop and therefore it is complicated to divide the costs between the ley and the cover crop. Consequently a standard value was used also for the establishment (800 SEK/ha). The calculations did not take subsidies into account, neither any leaseholds.

The machinery and operations from storage to the intake of the cows differ a lot. The effect of the different feeding systems are however not included in this study.

The production cost is based on standard values and can therefore not give an exact figure, but it gives an order of magnitude of the forage production cost on the farm. A more thorough calculation would require too much time in relation to the increased accuracy, since there are several uncertainties in the calculations, e.g. estimation of yield, time per operation and standard values of machinery costs.

3.7 Botanical composition – the ranking method

The botanical composition of one ley per farm was graded with the dry-weight-rank method ('t Mannetje & Haydock, 1963). The analysed ley was randomised from the farmer's second or third year leys between two and six hectares (the interval of average field sizes of the farms), where every hectare gave one share. A field record was used that included the sown species and the most common weeds (appendix IX). The field was traversed in 20 meters strides, where a quadrat of 0.25 m^2 was randomly put on the ground every 20 m. The species in the quadrat were occcularly estimated to which occupied the largest, second largest and third largest share of the dry matter content above stubble height. Through multipliers the different species' proportions of the fields dry matter content were obtained ('t Mannetje & Haydock, 1963). Evaluations of the method has shown that it is well suited to give good estimates in practise (Neuteboom, Lantinga, & Struik, 1998; Gillen & Smith, 1986). The same method was used by Fagerberg & Sundqvist (1994) and Liedgren (2007).

The species require ample of time to grow after the first cut in order to obtain accurate proportions with the method, which is at least three weeks post harvesting (pers.com. Gustavsson, 2012). The ranking was performed during the first farm visit (1 July to 13 July) which was scheduled to as far as possible give the regrowth enough time. However, on one farm the ranking was carried out too early, only eleven days after cutting, where mainly weeds and some fescues had emerged and almost no timothy. Therefore it was excluded from the data presented in the results. The ranking was not performed on two farms where the farm visit was conducted too late, see section 3.9 for more information.

3.8 Management models

The chosen approach of the study is based on the three management models, presented in section 2.2. They add the prioritizing of decisions, from the different time horizons of decision-making and planning, together with the resource utilization of the process perspective and comparability between the farmers.

Hence, the three models were a basis of structuring and processing the results of the farm study and combined with experiences from the extension service they form the basis of the concept of ley management (section 4.2).

3.9 Data loss

The most difficult thing when deciding methods for data sampling was to weigh the time it takes for the farmer to provide data against the importance it has for the study. The data sampling had to be conducted during the farmer's most hectic period of the year. Therefore some compromises between e.g. sampling quality and time requirement were done, where quality was not prioritised in favour of obtaining results with a simpler or less time consuming method.

But as expected, some data could not be retrieved due to the hectic period and additional problems at the farms with the subsequent shortage of time. Two of the farms had such great problems that they only could contribute to the qualitative part of the study (i.e. survey, farm visits and interviews). However, the problems are also interesting; to see what the origin of the problems are (e.g. poor planning, shortage of available hands or external circumstances that the farmer cannot influence) and how the farmer handles these problems.

To minimize data loss and errors in data, instructions were written and sent to the farmers of how to sample the fresh matter, silage and manure, and signed with a recommendation to make contact if there were any questions of how to do the sampling. Nevertheless, there were some misinterpretations that also caused data loss in addition to lack of time.

The identified sources of error in the results of the analyses are: if the samples were taken as instructed, if they were representative for the field, manure etc. and potential errors in the chemical analysis methods and different analysis methods in pH, where only the NIRS data could be obtained for some of the samples and not data from chemical analyses.

3.10 The seasons weather

To represent the weather in both counties, Umeå was chosen for the county of Västerbotten and Öjebyn for the county of Norrbotten. Data of daily mean temperatures, precipitation and insolation in Umeå and Öjebyn during 1 May to 30 September 2011 were acquired from SMHI (2012). The precipitation was used to illustrate the available harvest windows between the rains and the insolation indicates the potential growth rate. The temperature was used to calculate which date the sum of temperatures reached 250 day degrees, where a ley with mixed species is assumed to have an energy content of 10.8-11.0 MJ (Vallprognos, 2012). The sum of temperatures is based on the daily mean temperature reduced with 5°C, since there is no actual growth below +5ºC. The summation of temperatures starts on the first day of five consecutive days where the daily mean temperature exceeds +5ºC.

4 Results

4.1 The farm study

The nine studied dairy farms are spread in the region of the counties of Västerbotten and Norrbotten, with four respectively five farms. One of the farms is organic (certified according to KRAV) and two of the other farmers have earlier had organic crop production. They now have conventional production mainly since the yields were not high enough in the organic production. The interviewed farmers own and run the business with one or several family members. The average age of the farmers were 48 years, with the youngest of 26 years and the oldest of 60 years. There was a variation in how long experience of farming the farmers had, from five to ten years with no earlier experience to lifelong practice, where most of the farmers had many years of experience. The education level also varied, from self-education to high educations in agriculture and other sciences. Two of the farmers have relatively newly, i.e. during the last 10 years, bought their farm. Five of the other farmers have during the 21st century invested in a new cow house. It is also several of the farmers that have gained access to more arable land during the last years.

4.1.1 The aims and focuses of the farmers

The aim for all farmers was to produce high quality forage with a high feed value, to be able to keep healthy high producing cows. The farmers defined high quality as more than 11 MJ per kg DM and a crude protein concentration of 150-180 g per kg DM, where most aimed at the higher values of the interval. The NDF concentration was not prioritized by all as a quality parameter, but those who did prioritize it had had feeding problems due too low NDF concentrations. The hygienic quality of the silage was also valued as very important by the farmers. As one of them said: There're enough things that can muck up in the cow house anyway.

The yield was another important factor, but as one farmer pointed out, "you can't stare yourself blind on the yield, we did and the harvest became later with every year and the quality dropped." Nowadays that farm harvests three cuts with the same yield as with two cuts, but with a higher quality.

The farmers aimed at as high forage proportion in the feed ration as possible, specified by most as 60 % and higher. One advantage that the farmers saw with a high proportion was e.g. a minimized requirement of concentrates which will reduce the costs of purchased feed combined with a higher degree of self-sufficiency, which in turn gives the farm a more secure access to high quality feed and a better control of how it is produced and treated.

The farmers aimed at keeping the leys for three or in some cases four, harvesting years in order to produce both high quality and high yields.

The focus of the farmers differed due to different interests and farm specific problems. Some of the farmers talked a lot about how important it is to manage the soil to maintain and/or improve fertility, since it is the base of the production. Others discussed more the importance of a smooth chain of machinery with a sufficient capacity for the farm's needs. The third main topic was the importance of availability of land in the neighbourhood. The holistic view of the production system was however strongly expressed by most of the interviewed farmers; that all the steps in the process have to work well together to be able to produce forage of any value. The driving factors for the farmer to keep working was expressed by some as the satisfaction gained when the crops grow well and the fascination of the dynamics of the biological system where one year never is the same as the other.

4.1.2 Resource base

4.1.2.1 Farm-specific prerequisites

The nine farms varied in size, from 25 dairy cows to 170 and from 37 hectares to 320. The herds consist of Holstein and/or Swedish Red Cattle and one herd of Jersey. They produce in average 9 870 kg ECM per cow, but the variation is also large here, from 7 500 to 10 800 kg ECM per cow. Other key figures for the farms regarding animals and acreages are presented in table 1.

The cows are on six of the farms kept in loose-housing systems and on three farms tethered. The milking systems used are automated on three farms, parlour milking on five farms, where one combines both an automated system and parlour milking, and two farms milks the cows where they are tethered.

Three of the farms uses totally mixed ration (TMR) feed, five uses mixed feed with separate concentrate rations, and one uses silage and concentrates. The roughage proportion in the feed rations was around 55-60 % during the visits, except the organic farm that had a higher proportion.

Table 1. Key figures of the nine farms in the study regarding animals and acreages

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Yearly dairy cows	103	25	70	82	150	170
Livestock units (LU)	159	35	110	130	223	260
Yearly dairy cows/LU	*0.65*	*0.41*	*0.64*	*0.68*	*0.71*	*0.73*
Replacement rate (%)	33	17	28	33	40	45
Calving age of heifers (months)	26	23	24	26	27	28
Milk yield (kg ECM/cow year)	9 870	7 500	9 300	9 900	10 600	10 800
Acreage (ha)	181	37	130	199	237	320
Ley and temporary pastures (ha)	124	23	101	132	160	212
Ley acreage (ha)	109	21	95	107	144	184
Stocking rate: total acreage (LU/ha)	*0.90*	*0.55*	*0.77*	*0.93*	*1.04*	*1.22*
*Stocking rate: ley and temporary pasture (LU/ha)**	*1.32*	*0.83*	*1.05*	*1.27*	*1.56*	*1.90*
Stocking rate: yearly cows, total acreage (cows/ha)	*1.17*	*0.35*	*0.51*	*0.61*	*0.68*	*0.76*
Stocking rate: yearly cows, ley acreage (cows/ha)	*0.97*	*0.56*	*0.72*	*0.95*	*1.19*	*1.40*

* Basis for the additional support in the agri-environmental payments for forage production. The support is calculated from the number of livestock units and acreage of ley and temporary pastures in the firm within the support area 1-5. The maximal acreage that can receive the additional support in support area 1-3, where these farms are situated, is calculated by a factor of 1.0 livestock unit per hectare ley and temporary pasture (Swedish board of Agriculture, 2012).

Availability of land

The farmers considered the availability of arable land in the surroundings as an important factor. One reason for that was to be able to plan the logistics in a satisfying way and not be forced to spend too much time on transporting the machinery. Another reason was to be able to meet the pasture regulations. Four of the farmers experienced that there were not enough available land in the nearby area. The other five had enough land for the present farming. One of them even mentioned that the farm had a bit too much land to be able to have as intensive production as they would like. But all the farmers said that they would like to have more land in the neighbourhood. Two of them, who had 18 km or more to the fields furthest away, would in that case dispose of the land furthest away. Only one of the farmers said that it does not matter if the land is close by or further away.

Most of the farmers discussed how far it is economically justifiable to go in order to expand the acreage. Several of them mentioned that in a radius of tens of kilometres there is available land, but it is by most considered as too far and also in many cases that fields are in poor condition.

The formulation of the single payment scheme has affected most of the farmers' acreages. Three of them said that they had less land due to the CAP, since other farmers in the area have optimized the support with larger acreages as a result and/or 'sofa farmers' that lock-in land that otherwise would be available for active production. One farmer pointed out that the 'sofa farming' only builds up a demand of pesticides to the day the land is put into production again due to the propagation of weeds.

Three of the farmers said that the single payment scheme have not affected their acreage since they farm most of the land in the area or competes with other active farmers. The remaining three farmers said that they have more land than they need for the production due to support optimization. Some of the surplus land is fields with size, shape, distance, drainage and/or fertility that make it difficult to farm the fields in a rational way; therefore are these fields not managed as well as the productive fields.

Land consolidation

The land consolidation of the farms differs. The average field size of the farms is three hectares, but it varies between 1.3 and 6.0 ha (table 2). The average distance to the fields varies between two and twelve kilometres. Five of the nine farms have more than 10 km to the fields furthest away, and in many cases, but not all, it is soils with a lower fertility and thus a lower yield. An example of a difficult land consolidation is one farm which has the main acreage spread in several villages around the farm centre. For this farmer it has resulted in a great deal of logistical issues, especially with the transportation of manure to the fields.

Table 2. Land consolidation of the nine studied farms; distance to fields and field sizes

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Average field size (ha)	3	1.3	2.4	2.8	4.6	6.0
Minimum field size (ha)	0.35	0.0	0.1	0.2	0.4	1.0
Maximum field size (ha)	14	3.9	7.0	12.5	23.1	25.0
Average distance to fields (km)	4.3	1.5	2.0	2.5	5.0	12.1
Minimum distance to fields (km)	0.16	0.0	0.0	0.0	0.1	1.0
Maximum distance to fields (km)	20	4.0	6.0	12.0	18.0	90.0

4.1.2.2 Arable land

Soil properties

The soil types on the farms are mainly light silty soils with streaks of very sandy parts, drained lake beds with clay and/or parts with high organic matter. Almost all farmers experience that the variations between fields are large and also that the within field variation can be large on some fields. Some of the farmers have a high proportion of sandy slopes that can be a problem in dry years by causing drought damage to the crop. Damage to plants during winter dormancy can also be a problem, chiefly experienced on humus rich soils, but also where the machines have left tracks in the fields thus hampering the surface run-off. An important measure that several of the farmers take is smoothing the soil surface to facilitate the run-off. For example one of them bought a new harrow that performed better than the old one, thus decreasing the problems with winter damaged leys.

Due to the regulations of IP Sigill (Svenskt Sigill, 2011), which all farms that deliver milk to Norrmejerier have to be certified by (Norrmejerier, n.d.), the farmers have to map the soil (pH, P-AL, K-AL and Mg-AL) of the whole acreage during a period of five years, with some exceptions for e.g. temporary leases and outfields. However, two of the farmers had not mapped any of their soil, but both planned to do it during the autumn 2011. The remaining farmers have mapped the majority of their acreage (table 3), where the field proportions that are not mapped are fields that are newly taken into use and/or are paperless leases.

Some of the farmers expressed how important they think it is to keep record of their land, where soil mapping is an important tool to be able to know which amounts of lime, fertilizer etc. the soil require to maintain fertility and production levels. But some of the other farmers more considered soil mapping as just another formality that has to be done to comply with the regulations.

Table 3. Coverage of soil mapping at the different farms

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Soil mapping coverage	66 %	0 %	60 %	75 %	100 %	100 %

Liming

Liming is considered as a very important measure in the crop rotation for some of the farmers, as the basis of maintaining soil fertility and productivity. For others it was less important, e.g. one farm that has not limed due to old recommendations that there is no profitability in liming, but that farm now considers it again. However, the majority of the farmers lime their fields on a regular basis or a thoroughly liming on single occasions. One farmer pointed out that there was a distinct visual difference between limed and not limed fields on the farm after the latest liming. Another farmer emphasised, that there is economy in updating the soil mapping on a regular basis since the lime requirement alters with time, production and lime application. One farmer that has had organic crop production applied lime to maintain a better soil nutrient balance since that was the only thing they were allowed to apply besides manure, but they nevertheless had the impression that they depleted the soil of nutrients.

Drainage

The main proportion of the farms' fields is drained properly. The acreages that are not drained are for example sandy slopes that are self-draining hence no need of drainage, or leases and in one case too low-lying land that it is not possible to drain it.

4.1.2.3 Crop rotation

The important thing, as several of the farmers pointed out, is to have a good and sufficiently diversified crop rotation that also can be adapted to fit the individual field's different condition. Such a rotation leads to less weeds and a better nutrient supply, which makes the system more sustainable.

Figure 11 shows the crops grown on the farms, where energy crops and permanent pastures are not part of the rotations. The pastures on arable land have on most farms a special rotation, in order to live up to the regulations of condition and acreage (Swedish Board of Agriculture, 2010).

On average 61 % of the acreage of the farms were grown with ley for forage production (figure 11). Most farms only grow one crop between the ley, where the break crop consists of green fodder (oats/pea) or a whole crop (spring wheat, oat, barley) which is undersown with a grass and clover seed mixture. Three of the farms (the three to the left in figure 11) have longer crop rotations that also include one to three years of barley and/or oats for threshing.

Figure 12 shows the distribution of ley ages on the farms. The farmers achieved the goal of three harvest years to a varying extent, as can be seen in the figure where the line marks the proportion of leys that are three years or younger. Some of the farmers however aimed for four years since they had relative high proportions of old leys due to 'old sins' and/or addition of new land.

The strategies for decision-making of when to terminate the leys differed. From a though strategy, where the leys are terminated after three harvesting years, to more flexible strategies where the leys condition is evaluated, as one farmer expressed it; it's unnecessary to terminate a ley that is in a good condition, but you also have to make sure that the logistics works well.

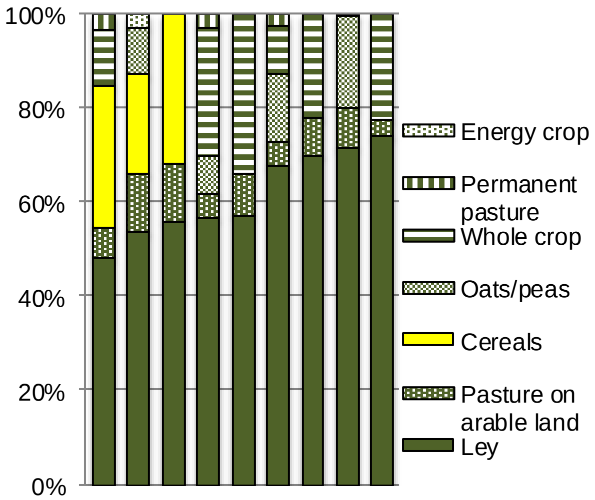


Figure 11. Distribution of the crops grown on the nine farms, sorted according to the proportion of ley. The energy crops and permanent pastures are not part of the crop rotations.

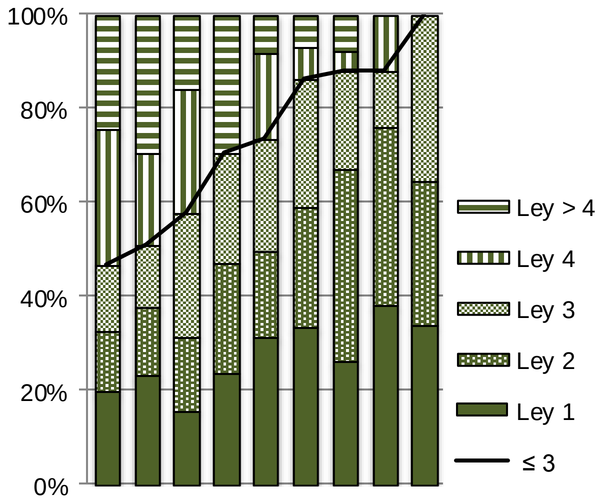


Figure 12. Distribution of ley ages on the nine farms, sorted according to the proportion of leys of three harvesting years or less, which also is marked with the black line.

4.1.2.4 Organisation

Workforce

The farm firms are run by the interviewed farmer and one or a few additional members of the family. If needed further family members can help out on most of the farms. In addition to family members, half of the farms are large enough to have employees, whom mainly work with the animals.

In table 4 the number of full time workers, including the owners, is presented. During the harvest season most of the farms has one seasonal employee, which often is a relative or from the neighbourhood. One of the farmers stressed the importance of taking enough time to take care of the employees to make sure that they enjoy their work and are able to perform their best. With loyal employees it is easier to organize the harvests, e.g. that they agree to take their vacation between the harvests as another farmer concluded.

Table 4. Number of full time workers at normal workforce on the nine farms, number of cows per worker and workforce during the harvest season

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Normal workforce	4	1.5	2.5	3.0	6.0	6.5
Cows per worker	25	17	23	26	27	28
Harvest season*	5	2.5	3.5	4.0	7.0	7.5

* total workforce at the farm during the harvest season, hired entrepreneurs are not included.

Co-operations and hiring of entrepreneurs

The majority of the farmers own most of the required machinery. Machine co-operations have been formed with other farms to utilize the capacity better, to afford a higher capacity and/or to reduce the costs. The prerequisites for a well-functioning co-operation are the availability of other farms that matches both in time, available manning and personal chemistry. The timing factor is a major issue for the farmers that would like to have co-operations, but do not have any at present.

One of the farmers mentioned that you have to be more flexible when you cooperate to make it work. Another farmer, who recently invested in a machine with other farmers, said with humour; “if you don’t cooperate, you don’t have to quarrel”.

Another way to keep the machinery costs down is to have older depreciated machines, but they instead require proper maintenance to function satisfactory for a long time.

Five of the nine farms have machine co-operations with one or several other farms. All farms hire entrepreneurs, mainly for pressing round bales and/or manure application but also for bagging of silage, application of pesticides and sowing. Several of the farmers also sell their machine services to other farms.

Timeliness costs is a subject that was brought up by all farmers when discussing co-operations and entrepreneurs, e.g. what is the cost of having to wait for the round baler or manure spreader? In these discussions timeliness cost is set against owning the machine. One of the farmers, who only have round bales, has solved the problem by only hiring the baler entrepreneur when the development of the fields is even. When they differ in development the own old baler is used to be able to harvest the fields when it is optimal. Another farmer estimated that the timeliness costs were too high and consequently bought an own round baler to be able to bale cereal straw and some hay when it is optimal, since straw is becoming more expensive to buy. A third farmer considered buying a manure spreader, since the spring sowing is delayed due to uneven drying of the soils and that the entrepreneur needs to be able to spread on the whole acreage at the same time. The farmer also saw the advantage of having a smaller spreader than the entrepreneur to reduce the risk of soil compaction.

4.1.3 Business

4.1.3.1 Cultivation measures

Seed mixtures

The seed mixtures that the farmers used are presented in table 5 and 6, where the most common ready-made mixture was SW 934 (SW Seed). Five of the farmers also used mixtures with their own composition (table 6) in addition to the ready-made to be able to compose it as they want. Without exception all mixtures contained timothy (*Phleum pratense* L.) (primarily Grindstad and Jonatan) and red clover (*Trifolium pratense* L.) (primarily Betty and Bjursele). Grindstad is an earlier cultivar than Jonatan, where the difference is used e.g. by one farmer who grows Grindstad on fields close to the farm and Jonatan on fields further away to obtain a higher quality throughout the whole harvest. Another farmer, who has a long duration of harvest, considers Jonatan as the only timothy cultivar that works on the farm.

Meadow fescue (*Festuca pratensis* L.) (primarily Kasper) is used by all farmers but one, who thinks that it grows wild too easily, i.e. it develops too fast with a low quality as a result, and it is considered to not fit the land of the farm. Another farmer was testing a mixture (SW 926) without meadow fescue to see if the ley can produce higher energy concentration in the forage. Other species also occurs in the mixtures, white clover (*Trifolium repens* L.) and smooth meadow grass (*Poa pratensis* L.) primarily in

Table 5. Ready-made seed mixtures used by the nine farmers

Seed mixtures	**%**	**Seed mixtures**	**%**
SW 940		**5912 GEV F 270**	
Timothy Grindstad	55	Timothy Vega*	40
Tall fescue Swaj	35	Timothy Lischka*	20
Red clover SW Torun	10	Meadow fescue Kasper*	10
		Red clover Bjursele 2n*	3
SW 956		Red clover Bjursele 2n	9
White clover Undrom	10	Red clover Ilte 4n	3
Timothy Grindstad	40	Festulolium Hykor*	10
Meadow fescue Kasper	40	White clover Lena*	2
Smooth meadow-grass Sobra	10	White clover Undrom	3
SW 934		**SW 384***	
Timothy Grindstad	75	Timothy Grindstad	55
Meadow fescue Kasper	10	Meadow fescue Kasper	20
Red clover Bjursele	10	Red clover SW Yngve	20
Red clover Betty	5	White clover Undrom	5
SW 926			
Timothy Grindstad	90		
Red clover SW Torun	10		

* allowed in organic farming

Table 6. Seed mixtures composed by the five farmers who used mixtures with their own composition. The proportions of all mixtures were only specified for two of the mixtures

Seedmixtures	%	Seedmixtures
Mixture A		**Mixture D**
Timothy Grindstad	32	Timothy Grindstad
Timothy Jonatan	30	Tall fescue Swaj
Timothy Ragnar	20	Red clover Betty
Meadow fescue Kasper	4	White clover Ramona
Smooth meadow-grass Sobra	2	
Red clover Bjursele	8	**Mixture E**
White clover Ramona	2	Timothy Jonatan
White clover SW Hebe	2	Red clover
Mixture B		**Mixture F**
Timothy Jonatan	70	Timothy Grindstad
Meadow fescue Kasper	15	Timothy Switch
Red clover Bjursele/Red clover Betty	10	Tall fescue Swaj
Alsike clover Frida	5	Red clover Betty
Perennial ryegrass Helmer	0.5	White clover Ramona
Mixture C		**Mixture G**
Timothy Jonatan		Timothy Grindstad
Meadow fescue		Red clover
Red clover		

temporary pastures and alsike clover (*Trifolium hybridum* L.), perennial ryegrass (*Lolium perenne* L.) and tall fescue (*Festuca arundinacea* Schreb.) in leys for forage production. Perennial ryegrass has been used by a few farmers to be able to harvest the ley during the establishment year. One of them reported that the yield was not large at all, but that the ryegrass had a positive effect on yields in the following years since it survived for three years until the termination of the ley.

Ley establishment

Before establishment of a new ley the soil is ploughed, preferably in the autumn. One of the farmers has bought a disc harrow (Carrier Väderstad) to test reduced tillage when the ley is established after cereals. In the spring the fields are harrowed, which several of the farmers have pointed out as a very important operation since the field will not be tilled again until termination. An even surface is the goal in order to avoid soil interspersion in the forage and obtain driving comfort. Some of the farmers also roll the fields to put down protruding stone and one also sows with a BioDrill on the roller.

The leys are undersown in a cover crop, except on one farm that also sows pure swards. Primarily cereals are used as cover crops, where three of the farmers used different crops depending on which crops suits best sequentially and at the location. The organic farmer pointed out that it can be difficult to establish ley in barley, since the cereal empties the soil of easily soluble nutrients. Oats and peas is a better cover crop for the organic farm due to the pea's ability to fix nitrogen.

The oats and peas are harvested first, later the whole crop cereals and the threshed cereals last. A few of the farmers harvest the straw stubble with the established ley in round bales to use as structural feed to e.g. dry cows. They consider it as a good way to utilize as much as possible of the crop and reduce cost and dependence on bought straw for instance.

Weed presence and control measures

The ordinary tillage controls most of the weeds, where some of the farmers cultivate the leys before termination in order to control perennial weeds. One farmer also till with a disc harrow in intervals of a couple of weeks to primarily control couch grass (*Elytrigia repens* L.). One of the farmers has considered converting to organic farming but the weeds at the farm were too problematic. The farmer has instead improved the crop rotation and cultivation measures to improve the weed control.

Four of the farmers regularly use herbicides for weed control at establishment and/or termination of the ley. The application of pesticides is hired when needed. An additional farmer considers using herbicides when cereals are included in the rotation, to control an increasing weed problem at the farm. However, the farmers that obtain agri-environmental payments for forage production are not permitted to use pesticides, other than to terminate the ley (Swedish board of Agriculture, 2012).

None of the farmers have experienced severe problems with diseases in the leys. One of them mentioned a year with some fungi in the timothy, but no action was taken and the farmer has not experienced it again. Another farmer pointed out clover rot as a problem, and the duration of the leys on the farm has been shortened as a consequence.

Botanical composition

In table 7 the botanical composition of the first cut is presented, which is derived from sorted fresh matter samples cut during the first harvest. Table 8 presents the ranked botanical composition after the first cut, graded in a two or three year old ley on each farm. When compared to the seed mixtures the botanical composition reflects the main proportions, with timothy as the main component followed by fescues and clover. The proportion of timothy is in general higher in the first cut together with weeds,

Table 7. Botanical composition of the fresh matter sampled during the first cut (five samples)

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Timothy	*48 %*	*31 %*	*33 %*	*43 %*	*59 %*	*73 %*
Fescues	*17 %*	*0 %*	*0 %*	*18 %*	*34 %*	*35 %*
Total grasses	65 %	33 %	64 %	73 %	77 %	78 %
Total clover	6 %	0 %	1 %	5 %	10 %	13 %
Total weeds	29 %	10 %	21 %	25 %	27 %	63 %

Table 8. Graded botanical composition, in average 22 days, after the first cut in a two or three year old ley (seven samples)

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Timothy	*44 %*	*32 %*	*40 %*	*45 %*	*48 %*	*51 %*
Meadow fescue	*28 %*	*0 %*	*27 %*	*29 %*	*39 %*	*43 %*
Total grasses	73 %	49 %	71 %	74 %	80 %	89 %
Red clover	*6 %*	*1 %*	*2 %*	*5 %*	*10 %*	*14 %*
White clover	*4 %*	*0 %*	*1 %*	*2 %*	*7 %*	*9 %*
Total clover	10 %	4 %	5 %	8 %	12 %	23 %
Grass weeds	*14 %*	*0 %*	*4 %*	*12 %*	*18 %*	*40 %*
Other weeds	*3 %*	*0 %*	*1 %*	*3 %*	*4 %*	*10 %*
Total weeds*	17 %	1 %	6 %	13 %	22 %	44 %

* a large proportion of the grass weeds consisted of couch grass, (*Elytrigia repens* L.) and other weeds of dock (*Rumex* spp. L.).

while fescues and clover have a higher proportion in the second cut. The highest shares of total weeds (63 % and 44 %) mainly consisted of couch grass and dock (*Rumex* spp. L.) who originated from a single field where the establishment of the ley had failed, with a lot of weeds as a consequence.

4.1.3.2 Fertilization

Several of the farmers stressed the importance of sufficient fertilization and liming to activate the microorganisms in the soil. The farmers said that they tried to adapt the application of manure and mineral fertilizers to crop, season, requirement of feed, storage capacity and the soil's bearing capacity. For example, a year with higher yields than normal the farmers often reduces the application rate of mineral fertilizer to the regrowth since the need of feed is secured and mineral fertilizer is expensive. One of the farmers also described that the nitrogen rates has had to be decreased with time on the farm, especially to cereals, due to higher soil fertility hence a higher nitrogen mineralization. Another farmer has experienced that the applied N-rates cannot be too high since the sward does not give a yield response, rather an increase in crude protein concentration that can be hard to match with energy in the feed ration.

All of the farmers have calculated a nutrient balance on farm level, since it is a part of the regulations of IP Sigill (Svenskt Sigill, 2011). But several of them have barely looked at it. However, some of the farmers find the balance quite interesting, to see if the fertilization rates are accurate. One farmer explained that nutrient balances have been calculated for the farm on some occasions, when the farm expanded and/or changed storage system for the manure. These balances have resulted in change in the fertilization strategy, from NPK to only N-fertilizer and a halving of the total amount of mineral fertilizers during the last 30 years.

Several of the farmers discussed the impact of the time of application. One farmer does not apply any manure in the autumn in order to gain higher nitrogen efficiency. Another one, who hires the manure spreading, has to wait until the entrepreneur has time, which at some occasions has resulted in omitted applications after harvest because the regrowth has started too quickly. A third farm, who also hires the manure spreading, has a well-functioning co-operation where the spreader drives almost right behind the harvest machinery. If the farm had done the spreading themselves it would have been done at a less optimal time, due to a long harvest period that ties up the workforce.

Manure and mineral fertilizers

Seven of the farms mainly produce liquid manure, but most of them also have solid and deep litter manure. An additional farmer uses liquid manure from the neighbour and produces solid manure at the own farm, and the last farmer only produces semi-liquid manure. The storage capacity of manure is important, as several farmers mentioned. A sufficient capacity enables applications at an optimal time, thus increasing the nitrogen effect. But there were several of the farmers who had a too low capacity, consequently they have to empty the storage at a less optimal time, most often in the autumn. A farm that rather recently expanded with a new cow-house built a liquid manure tank with overcapacity, since the farmer has experienced that all storages get too small with time.

The proportion of the acreage on each farm that receives manure can be seen in table 9. Some of the farmers use lower manure rates on fields further away than to fields closer to the farm due to the costly and time consuming logistics. Others considered it as very important to apply even rates to the whole acreage.

Table 9. The proportion of the acreage on each farm that receives manure

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Proportion of acreage	85 %	52 %	73 %	90 %	100 %	100 %

All farms except three spreads the manure to almost all leys during the harvest season. Of the three that do not spread to the entire acreage, the first farm band spreads manure only to a small number of the leys, which is the number of fields there is time for between the harvests. The second farm only applies liquid manure in autumn with splash plate. The third does not apply any manure to the leys since the farmer does not want to take the risk of lumps from the semi liquid manure that can ruin the hygienic quality of the forage.

During the harvest season three of the farms band spread the liquid manure, two injects it and one uses splash plate. One of the farms that inject the manure takes three cuts and injects after two of them. Three injections per season have been tried, but did not give good results due to too much damage on roots and from driving. The other farm takes two cuts and hires an entrepreneur to inject the manure after the first cut, and uses a splash plate after the second cut. Both of them have experienced notable higher nitrogen efficiency with the manure injection.

Mineral fertilizer is used by all farms, except the organic that uses Biofer (to the cereals). Another of the farmers who recently had organic crop production said that to be allowed to use mineral fertilizers was a revolution. But the farmer also pointed at the expense of using it and the difficulties to find the right application rate to get an optimal yield response in relation to the cost.

The most common mineral fertilizer used by the farmers is N27. Two of the farmers complement it with NPK 22-3-10, one to fields that are far away that gets little or none manure during the rotation. The other one applies NPK to older leys and also some calcium nitrate (N15.5) to some of the closest fields to give the regrowth a kick-start.

Fertilization of fields at a long distance is often solved with mineral fertilizer since the transportation cost of manure otherwise would be too high. However, most of these fields would benefit from manure application to activate the soil microorganisms, as several of the farmers pointed out. One of the farmers that battle this problem wants to find a not too expensive transportation solution to be able to apply manure to the whole acreage, to let the biology work, as the farmer expressed it. With a cheaper transport of manure the application rates to fields close to the farm, which have been heavily fertilized with manure for a long time, could be reduced in favour for fields with a too low input of organic fertilizers. The measure would also reduce the cost of mineral fertilizer.

Another problem with manure that some illuminated is the risk of soil compaction during application and leaving tracks, due to the increased sizes of manure spreaders. Therefore it has become even more important to drive on the fields only when the bearing capacity is high enough.

Fertilizer rates

Solid and deep litter manure is applied to the fields before ploughing, i.e. when terminating a ley and to annual crops in the rotation. Application of liquid manure to annual crops is done in the spring before sowing. The rates are higher to cereals (25-40 Mg/ha) than to oats and peas (approx. 10 Mg/ha).

Application of manure to the leys is done after harvest, with rates around 20-25 Mg per hectare and application and none of the farmers applies manure before the first cut (table 10). This year one farmer attempted to apply manure in the spring to the leys, but the bearing capacity was too low.

How many applications of manure that is done during the season and per ley year varies between the farms due to the reasons mentioned earlier plus application of mineral fertilizer and distance to the field.

The average total application rates to the leys were 36, 38 and 35 Mg per hectare and year respectively, but there is a large variation (table 10). Table 11 presents the calculated application rates of nitrogen derived from manure and mineral fertilizers. The average application rates were 142, 138 and 139 kg N per hectare and year respectively, where in average 58 % of the nitrogen was derived from mineral fertilizers.

Table 10. Applied rates of ***manure*** *(Mg/ha) to fields close to the farm, per ley year and per cut on the nine farms, stated by the farmers*

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Sum ley 1	**34**	**0**	**20**	**28**	**45**	**75**
spring	0	0	0	0	0	0
after 1st cut	12	0	0	13	23	25
after 2nd cut	19	0	20	23	25	25
autumn	13	0	0	20	20	25
Sum ley 2	**34**	**0**	**20**	**28**	**45**	**75**
spring	0	0	0	0	0	0
after 1st cut	14	0	16	23	25	25
after 2nd cut	14	0	0	10	22	25
autumn	13	15	20	20	24	25
Sum ley 3	**35**	**20**	**25**	**28**	**40**	**75**
spring	0	0	0	0	0	0
after 1st cut	12	0	0	18	25	25
after 2nd cut	14	0	0	20	23	25
autumn	16	0	18	20	23	40

bold – the sum of application rates of each harvest year

Table 11. Calculated application rates of nitrogen from manure and mineral fertilizers (kg N/ha) to fields close to the farm, per ley year and per cut on the nine farms. The nitrogen derived from mineral fertilizers is displayed as the percentage of total nitrogen. The nitrogen effect was assumed to be 1,5 kg N/Mg from liquid manure and 1,25 kg N/Mg from semi-liquid manure (Albertsson, 2010)

	Average		Percentiles									
			0		0.25		0.50		0.75		1.00	
	kg N	min-N	kg N	min-N	kg N	min-N	kg N	min-N	kg N	min-N	kg N	min-N
Sum ley 1	**142**	***60 %***	**41**	***0 %***	**108**	***38 %***	**147**	***68 %***	**165**	***82 %***	**251**	***100 %***
spring	63	*89 %*	0	*0 %*	50	*100 %*	65	*100 %*	81	*100 %*	108	*100 %*
after 1st cut	40	*40 %*	0	*0 %*	34	*0 %*	38	*0 %*	54	*100 %*	80	*100 %*
after 2nd cut	39	*12 %*	0	*0 %*	30	*0 %*	34	*0 %*	38	*0 %*	96	*61 %*
autumn	17	*0*	0	*0 %*	0	*0 %*	23	*0 %*	30	*0 %*	38	*0 %*
Sum ley 2	**138**	***59 %***	**41**	***0 %***	**108**	***38 %***	**147**	***66 %***	**165**	***82 %***	**224**	***100 %***
spring	61	*89 %*	0	*0 %*	50	*100 %*	65	*100 %*	81	*100 %*	99	*100 %*
after 1st cut	43	*35 %*	0	*0 %*	34	*0 %*	38	*0 %*	54	*63 %*	87	*100 %*
after 2nd cut	30	*20 %*	0	*0 %*	30	*0 %*	34	*0 %*	38	*0 %*	50	*100 %*
autumn	17	*0*	0	*0 %*	0	*0 %*	25	*0 %*	30	*0 %*	38	*0 %*
Sum ley 3	**139**	***57 %***	**41**	***0 %***	**119**	***38 %***	**149**	***66 %***	**165**	***80 %***	**186**	***83 %***
spring	61	*89 %*	0	*0 %*	50	*100 %*	65	*100 %*	81	*100 %*	99	*100 %*
after 1st cut	40	*40 %*	0	*0 %*	34	*0 %*	38	*0 %*	50	*100 %*	87	*100 %*
after 2nd cut	30	*20 %*	0	*0 %*	30	*0 %*	34	*0 %*	38	*0 %*	50	*100 %*
autumn	22	*0*	0	*0 %*	0	*0 %*	25	*0 %*	30	*0 %*	50	*0 %*

bold – the sum of application rates of each harvest year
italic – percentages of the nitrogen that is derived from mineral fertilizers

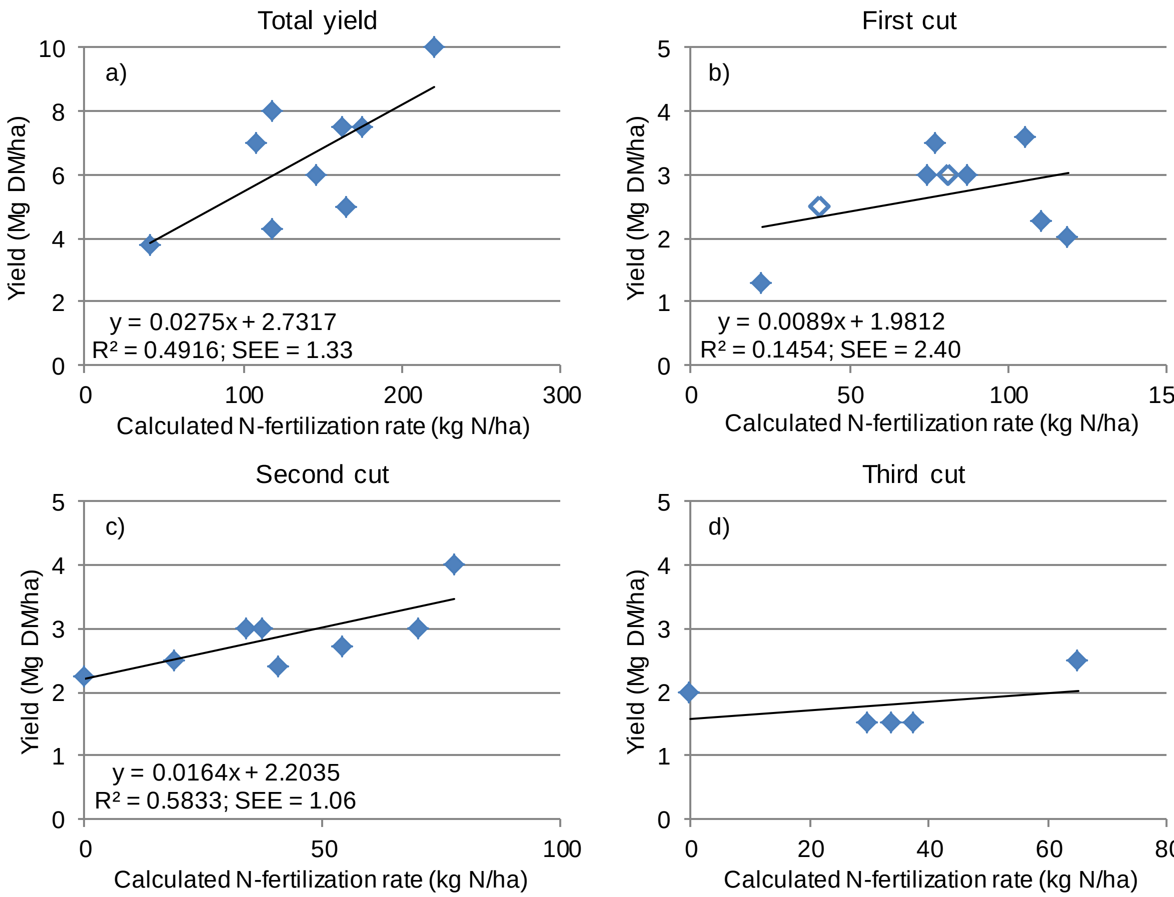


Figure 13. Nitrogen application (from manure and mineral fertilizer) versus a) total yield, b) first, c) second and d) third cut respectively for the nine farms. The linear regression shows the strength of the association between the N-fertilization and the estimated yields of the total, first and second cut for these farms. The SEE-value shows the average deviation from the line in Mg per ha. The calculated N-fertilization rate of the first cut is a summation of the nitrogen applied in the autumn and spring, the open points represent farmers who do not apply manure in autumn to the leys.

In figure 13 the calculated nitrogen rates are compared with the farmers' estimations of their total yield and each cut respectively. The total yields varied rather much, 4-10 Mg DM per ha, and also the yield response per kg applied nitrogen, 30-92 kg DM per kg N.

In figure 14 the recommended rates are compared with the calculated N-rates. The recommended rates differ between the farms due to different yields, stocking rates (LU/ha) and clover content in the leys (Ericson, 2011). The average deviation (SEE-value) from the recommendations was 35 kg N per ha and ranged from -24 to 64 kg N per ha. All points above the line (y = x) indicate a higher application rate than recommended. The dashed line shows that all the farmers in average applied more than recommended, which partly can be

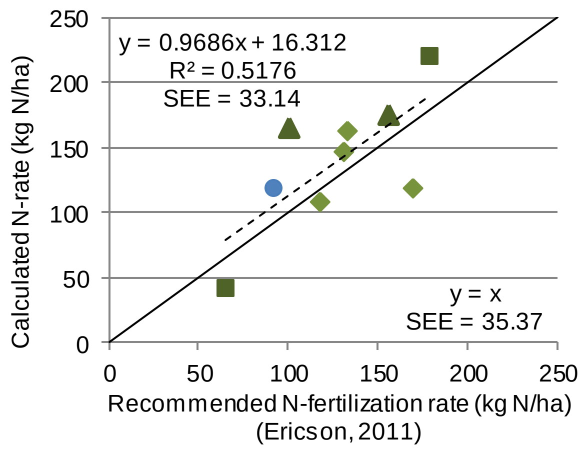


Figure 14.The calculated nitrogen application rate versus application recommendations (Ericson, 2011) for each of the nine farms. The solid line represents an application rate according to recommendations and the dashed line the trendline the calculated application rates. The SEE-value shows the average deviation from the lines in kg N per ha Coding according to application technique of the manure ■ injection, ♦ band spreading, ▲ splash plate, ● only mineral fertilizer.

explained by that several of the farmers said that they calculated with a lower nitrogen effect than 1.5 kg N per Mg liquid manure due to spreading losses. However, there is a trend that the farmers with higher proportions of mineral fertilizer apply total N-fertilization rates that are higher than the recommendations, but the average deviation (SEE) is large with 30 kg N per ha.

Most of the farmers find it difficult to take the clover content into consideration when deciding the fertilizer rates. Several mentioned that they experience that the clover content is more affected by the weather conditioned environment than the management. The association of nitrogen fertilization rates and clover content is however strong (figure 15).

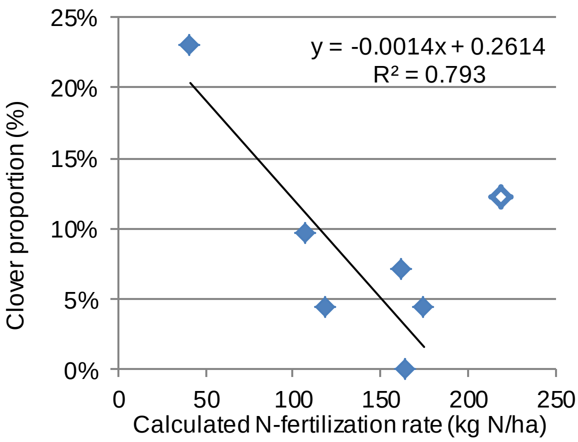


Figure 15. Clover proportion, ranked in a two or three year ley after the first cut, and total nitrogen rate for each of the nine farms. The open point represents a farm that delays fertilization in spring to benefit the clover. It was exempted from the linear regression since it deviates markedly from the others.

In order to benefit the clover in the competition with the grasses one farmer reduces the rate of mineral fertilizer in the spring to first year leys. Another farmer supports the competitiveness of the clover by not fertilizing too early in the spring, since the clover requires higher growth temperatures than the grasses to start growing in the spring. The farmer has over the years seen a marked difference

Table 12. Calculated application rates of phosphorus from manure and mineral fertilizers (kg P/ha) to fields close to the farm, per ley year and per cut on the nine farms. The phosphorous derived from mineral fertilizers is displayed as the percentage of total phosphorus. The phosphorus effect was assumed to be 0,6 kg P/Mg from liquid manure and 1,05 kg P/Mg from semi-liquid manure (Albertsson, 2010)

	Average		Percentiles									
			0		0.25		0.50		0.75		1.00	
	kg P	min-P	kg P	min-P	kg P	min-P	kg P	min-P	kg P	min-P	kg P	min-P
Sum ley 1	**21**	***0 %***	**0**	***0 %***	**15**	***0 %***	**21**	***0 %***	**27**	***0 %***	**45**	***0 %***
spring	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*
after 1st cut	7	*0 %*	0	*0 %*	0	*0 %*	8	*0 %*	14	*0 %*	15	*0 %*
after 2nd cut	11	*0 %*	0	*0 %*	12	*0 %*	14	*0 %*	15	*0 %*	15	*0 %*
autumn	8	*0 %*	0	*0 %*	0	*0 %*	9	*0 %*	15	*0 %*	21	*0 %*
Sum ley 2	**23**	***11 %***	**12**	***0 %***	**15**	***0 %***	**21**	***0 %***	**27**	***0 %***	**45**	***100 %***
spring	2	*11 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	14	*100 %*
after 1st cut	9	*0 %*	0	*0 %*	0	*0 %*	12	*0 %*	15	*0 %*	15	*0 %*
after 2nd cut	8	*0 %*	0	*0 %*	0	*0 %*	12	*0 %*	14	*0 %*	15	*0 %*
autumn	8	*0 %*	0	*0 %*	0	*0 %*	9	*0 %*	15	*0 %*	21	*0 %*
Sum ley 3	**26**	***3 %***	**12**	***0 %***	**15**	***0 %***	**21**	***0 %***	**27**	***0 %***	**56**	***24 %***
spring	2	*11 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	14	*100 %*
after 1st cut	7	*0 %*	0	*0 %*	0	*0 %*	8	*0 %*	15	*0 %*	15	*0 %*
after 2nd cut	8	*0 %*	0	*0 %*	0	*0 %*	12	*0 %*	14	*0 %*	15	*0 %*
autumn	12	*0 %*	0	*0 %*	0	*0 %*	12	*0 %*	15	*0 %*	42	*0 %*

bold – the sum of application rates of each harvest year
italic – percentages of the phosphorus that is derived from mineral fertilizers

with higher clover content in the leys due to the strategy. In figure 15 the farm is represented by the open square, where it has a higher clover proportion than the other farms with a similar N-fertilization rate.

Table 12 presents the calculated application rates of phosphorus derived from manure and mineral fertilizers. The average application rates were 21, 23 and 26 kg P per hectare and year respectively. There was only a small amount of the applied phosphorous that originates from mineral fertilizers, since only one farmer uses mineral P on the fields close to the farm. As mentioned earlier an additional farmer also uses mineral P, but only to the outfields that are not accounted for here.

The regulations (Swedish Board of Agriculture, 2011) states that you may not apply more phosphorous derived from manure than 22 kg per hectare and year, during a five year period and divided on the firm’s total spreading area. Some of the application rates in table 12 are higher or on the edge of being too high to comply with the regulations. However, as shown in table 10, the manure is not spread on the whole acreage and the above rates are the calculated total application rates, including mineral P, to the fields closest to the farm, which means that the farmers comply with the rules when the whole acreage is accounted for.

Table 13 presents the calculated application rates of potassium derived from manure and mineral fertilizers. The average application rates were 134, 139 and 146 kg K per hectare and year respectively, where almost all the potassium was derived from manure.

Table 13. Calculated application rates of ***potassium*** *from manure and mineral fertilizers (kg K/ha) to fields close to the farm, per ley year and per cut on the nine farms. The potassium derived from mineral fertilizers is displayed as the percentage of total potassium. The potassium effect was assumed to be 4,0 kg K/Mg manure (Albertsson, 2010)*

	Average		Percentiles									
			0		0.25		0.50		0.75		1.00	
	kg K	min-K	kg K	min-K	kg K	min-K	kg K	min-K	kg K	min-K	kg K	min-K
Sum ley 1	**134**	***0 %***	**0**	***0 %***	**80**	***0 %***	**110**	***0 %***	**180**	***0 %***	**300**	***0 %***
spring	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*
after 1st cut	47	*0 %*	0	*0 %*	0	*0 %*	50	*0 %*	90	*0 %*	100	*0 %*
after 2nd cut	74	*0 %*	0	*0 %*	80	*0 %*	90	*0 %*	100	*0 %*	100	*0 %*
autumn	47	*0 %*	0	*0 %*	0	*0 %*	60	*0 %*	80	*0 %*	100	*0 %*
Sum ley 2	**139**	***11 %***	**45**	***0 %***	**80**	***0 %***	**110**	***0 %***	**180**	***0 %***	**300**	***100 %***
spring	5	*11 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	45	*100 %*
after 1st cut	58	*0 %*	0	*0 %*	0	*0 %*	80	*0 %*	100	*0 %*	100	*0 %*
after 2nd cut	54	*0 %*	0	*0 %*	0	*0 %*	80	*0 %*	90	*0 %*	100	*0 %*
autumn	47	*0 %*	0	*0 %*	0	*0 %*	60	*0 %*	80	*0 %*	100	*0 %*
Sum ley 3	**146**	***2 %***	**80**	***0 %***	**100**	***0 %***	**110**	***0 %***	**180**	***0 %***	**300**	***22 %***
spring	5	*11 %*	0	*0 %*	0	*0 %*	0	*0 %*	0	*0 %*	45	*100 %*
after 1st cut	49	*0 %*	0	*0 %*	0	*0 %*	50	*0 %*	100	*0 %*	100	*0 %*
after 2nd cut	54	*0 %*	0	*0 %*	0	*0 %*	80	*0 %*	90	*0 %*	100	*0 %*
autumn	62	*0 %*	0	*0 %*	0	*0 %*	80	*0 %*	80	*0 %*	160	*0 %*

bold – the sum of application rates of each harvest year
italic – percentages of the potassium that is derived from mineral fertilizers

Nutrient content of the manure

Only two of the farmers analyses the manure for nitrogen concentration. One of them has three different manure tanks containing liquid manure from milking cows, bulls and cows, and heifers respectively. The nitrogen concentration differs quite much between the tanks, therefore the farmer controls the nitrogen content to be able to optimize the use. One of the farmers that do not analyse the manure pointed out that the value obtained from analysis can be questioned because of the variations due to temperature, water content and spreading technique that strongly affect the obtained nitrogen effect.

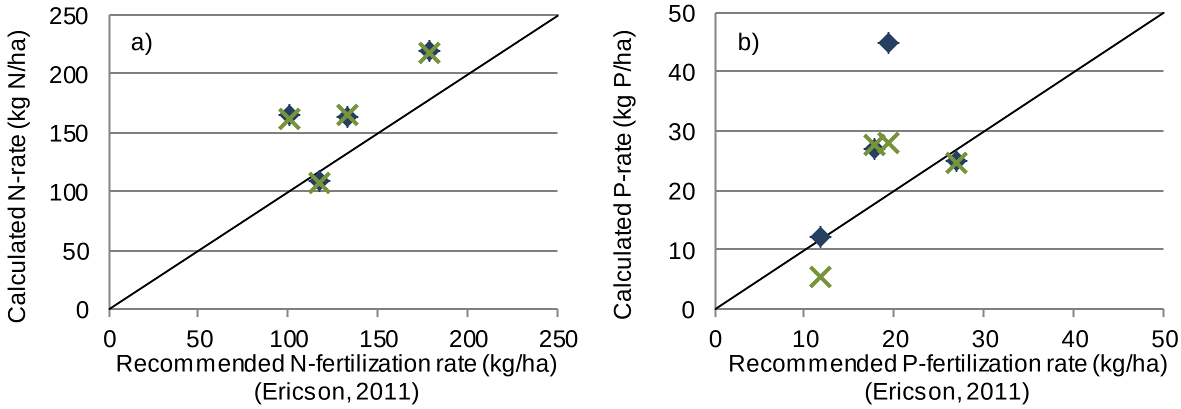
Four samples of liquid manure were analysed and the result is presented in table 14. The content of plant nutrients differed between the farmers and the average is compared to the standard values from the Swedish Board of Agriculture (Albertsson, 2010), which forms the basis for the recommended rates.

The ammonium-N concentration did not differ much between analysed and standard values (4 %). The difference in P and K were however larger (15 % and 26 %). Albertsson (2010) also points out that the concentration of phosphourus and potassium can deviate considerably from the set standard values primarily depending on nutrition standards and the content of phosphorus and potassium in feedstuffs. The differences are also illustrated in figure 16 where the standard value rates of NPK and recalculated NPK-rates based on the analysed samples (table 14), are compared with recommended rates. The standard value NPK-rates deviate more from the recommended rates than the recalculated NPK-rates of the analysed values.

Table 14. Nutrient content of liquid manure from four of the farms, sorted after dry matter content. The average value of the farms is compared with standard values of nutrient content in liquid manure (Albertsson, 2010)

Farm	A	B	C	D	Average	Standard values	Difference*	
Milking system	automatic	parlour	automatic	parlour				
Dry matter. DM	**5.44**	**5.92**	**6.84**	**7.82**	**6.5**	**9.0**	**-2.5**	**-28 %**
Tot-N (kg/Mg)	3.20	3.17	3.62	3.73	3.4			
Organic nitrogen (kg/Mg)	1.17	1.37	1.67	1.81	1.5			
NH_4-N (kg/Mg)	**2.03**	**1.79**	**1.95**	**1.92**	**1.9**	**2.0****	**-0.1**	**-4 %**
Tot-C (kg/Mg)	23.0	26.7	30.9	30.8	27.9			
C/N	19.7	19.4	18.5	17.1	18.7			
Phosphorus (kg/Mg)	**0.42**	**0.41**	**0.62**	**0.59**	**0.5**	**0.6**	**-0.1**	**-15 %**
Potassium (kg/Mg)	**2.56**	**2.54**	**2.63**	**4.17**	**3.0**	**4.0**	**-1.0**	**-26 %**
Magnesium (kg/Mg)	0.50	0.50	0.62	0.99	0.7	1.5	-0.8	-56 %
Calcium (kg/Mg)	0.95	0.77	1.45	1.68	1.2	0.7	0.5	74 %
Sodium (kg/Mg)	0.33	0.28	0.33	1.15	0.5			
Sulphur (kg/Mg)	0.31	0.37	0.41	0.48	0.4	0.6	-0.2	-34 %

* difference between the farmers average value and standard value, and the percentage difference from the standard value.
** the standard value for nitrogen has a specified nitrogen effect to 1.5 kg N/Mg (Albertsson, 2010), here the figure is recalculated to content with an assumed effect of 75 %.



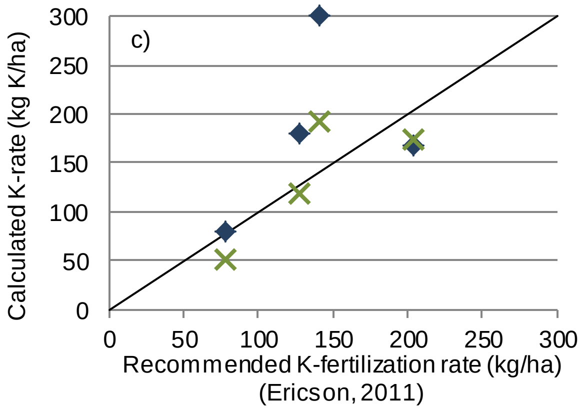


Figure 16. Comparison of calculated a) nitrogen, b) phosphorous and c) potassium rates from the manure's standard values (♦) and analysed content (X) to recommended rates for four of the nine farms. Assumed fertilization effect, N 75%, P and K 100% of content. The line represents an application rate according to recommendations.

4.1.3.3 Harvest

When planning the chain of harvest there are several things to consider, as logistics, developmental differences between fields, machine and reception capacity. With a high machine capacity, the forage is harvested in a short time and then it is mainly logistics and reception capacity that matters. The farmers harvest the closest fields first to be able to start packing in the silo and later the fields further away are harvested as the reception capacity drops as the silo is filled.

If the harvest demands a longer period of time, there is also more time for the development of the leys to change, which should be taken into account. Some of the farmers have thus adapted their choice of cultivars e.g. timothy Jonathan or Grindstad, who is later respectively earlier. One of the farmers, who mainly presses round bales hires the pressing when the development is relatively even between fields. Otherwise, the farmer wants to harvest the fields in the order of development to optimize the quality as much as possible.

Number of cuts

The farmers adjust the number of cuts depending on the production capacity of the land, field size and the length of transportation and also to the requirement of feed. For instance, if the first cut yields well in quality and quantity small fields

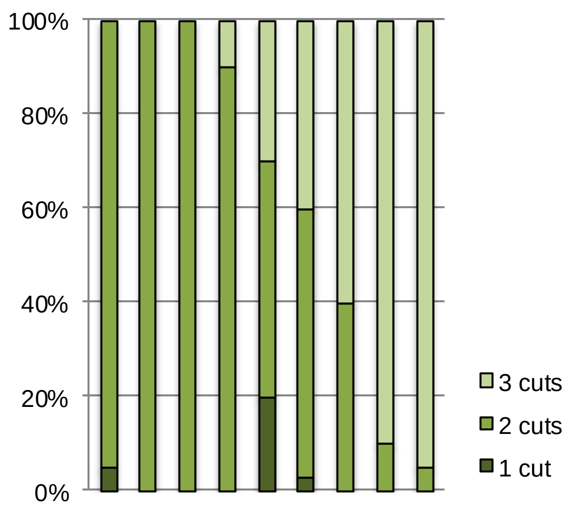


Figure 17. Proportion of the leys that is cut once, twice or three times per season on the nine farms, sorted after increasing number of cuts per season.

and/or fields further away may be cut less frequently to produce rougher forage to e.g. young cattle. Another factor is the weather, e.g. that a third cut can be cancelled due to too wet soils where the risk for damaging the field with the harvesting machinery.

Four of the farmers mainly take two cuts per year and two farmers mainly take three (figure 17). The remaining three have a more even distribution between two and three cuts. As can be seen in figure 17 there is also some fields that are only cut once due to a too long distance to the farm and it being outfields hence with low fertility and production capacity.

Harvest systems

Several of the farmers mentioned the importance of having an adequately high harvesting capacity in the whole chain from cutting the grass to the packing and coverage, to be able to complete the harvest in a couple of days.

Four of the farmers uses precision chop forage wagons and three a pulled or self-propelled forage harvester with transportation wagons, where the chopped forage is stored in bunker or tower silos. Several of the farms also use round bales as an additional storage system for forage of other qualities, if there is not enough storage or from small fields and/or far away. The two remaining farms, which also are the smallest ones, use round balers. Table 15 shows the number of farms using each storage system. In the case of two farms the major proportion of the silage is stored as round bales and the silos a minor part, therefore the round bales are accounted for as primary storage in the table and the silos as secondary.

Silage additives were used by all farms that chop the forage, primarily ProMyr XR 630 and 680 (Perstorp). The two who primarily use round bales have previous years used Kofasil (Addcon). This season neither of them used it because they have not seen an effect of it and one of them is also not satisfied with the control of the application in the baler.

Table 15. The number of farms using each storage system. The primary system stores the largest proportion of the forage yield. Seven of the farms also have secondary storage systems

	Bunker silo	Tower silo	Round bales
Primary storage	4	1	4
Secondary storage	1	1	5

Duration of harvest

As mentioned above, for several of the farms the harvest does not consist of just of one harvest operation, but a few, where the capacity of the secondary systems often are much lower due to e.g. long transportation distances of round bales, thus reducing the total harvest capacity and prolonging the duration of harvest. The harvest systems are run separately except on one farm where both systems are running simultaneously, which the farmer said probably caused a reduction of the capacity of both systems.

The duration of the harvest, i.e. from cutting until storage, varied between 2.5 and 12 days with an average of 6.2 days. The farms that have long harvesting periods and store the forage in silos have adapted by using several silo compartments, thus reducing the time the silo is open (table 16). Figure 18 shows that there is a correlation between the total duration of the harvest and the size of acreage and also with harvest capacity, where both the duration and capacity increase with acreage whereas the capacity has no associative effect on the duration on these farms.

Table 16. Duration of each harvest as an average of all cuts from cutting until storage and capacity on the nine farms. The harvest days per silo are also showed for the seven farms that uses tower and bunker silos

	Number of farms	Average	Percentiles				
			0	0.25	0.50	0.75	1.00
Average duration of harvest (days)	9	6.2	2.5	4.0	6.0	8.5	12.0
Days per silo	7	3.4	1.5	2.3	4.0	4.0	6.0
Harvest capacity (ha/day)*	9	19	7	13	16	22	44

* calculated from the number of harvest days and ley acreage. A farm, represented by open points in figure 18, has invested a lot in high machine capacity which has resulted in a rather short duration of the harvest compared to other farms of the same size.

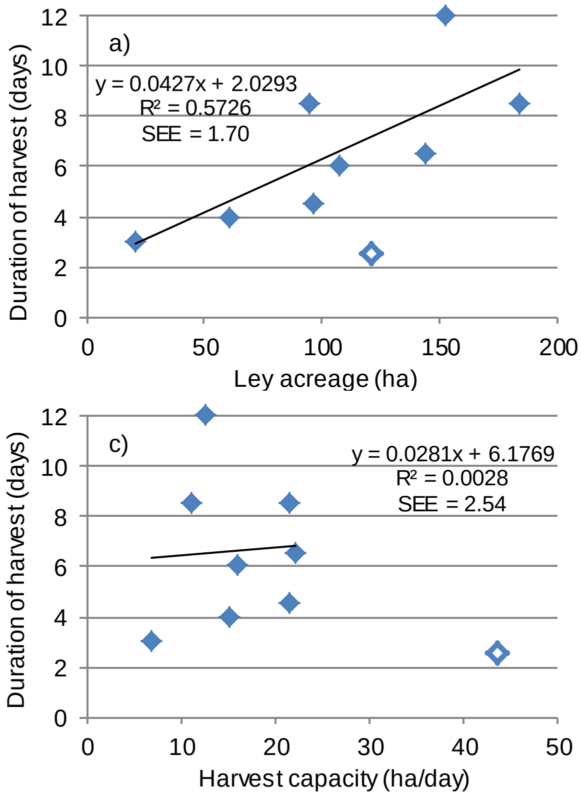


Figure 18. Linear regressions of a) ley acreage and average duration in number of days per harvest, b) ley acreage and harvest capacity on the nine farms, c) harvest capacity and duration of harvest. The open squares represent a farm that differs markedly from the other farms due to high investments. It was thus exempted from the linear regression.

Cutting time

Experience is the most important factor when deciding the time for cutting, where inspections of the fields are essential to see how, especially the timothy, develops and when it will reach the stage of 'inflorescence in flag leaf sheath' which states the right cutting time. A tool to help the decision making is to cut prognosis samples, which five of the farmers do. The samples are analysed (for concentration of energy, crude protein and NDF) and the farmers receive the results together with a prognosis to predict when the crude protein will come down to certain levels based on Gustavsson (1988). Another prediction tool used by some of the farmers is the temperature sum (explained in section 3.10), which is available on vallprognos.se for a large number of sites in the country (Vallprognos, 2012). The webpage also presents the results of analysed harvest prognosis samples.

Five of the farmers managed to harvest the first cut before the rain in June and four after. Figure 19 shows samples from five of the nine farms, whereof four harvested before the rain and one after. The developmental stages and energy content is closely linked, as can be seen in the figure where the latest harvested sample had a high proportion of timothy that had passed the developmental stage of 'inflorescence in flag leaf sheath' and thus had a lower energy content.

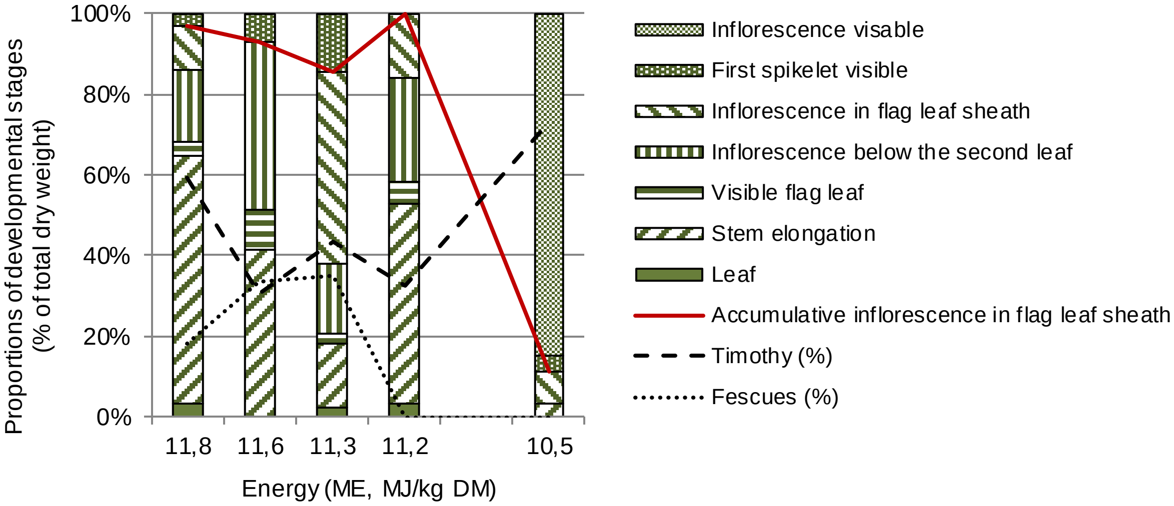


Figure 19. Developmental stages in timothy according to Gustavsson (2011), energy content (ME, MJ/kg DM) and proportions of timothy (dashed line) and fescues (meadow and tall fescue, dotted line) in samples from the first cut from five of the nine farms. The farms are sorted after energy content in the whole sample. The columns represent the proportions of the different developmental stages of timothy on each farm. The red solid line shows the proportion of the samples that has not passed the stage of inflorescence in flag leaf sheath.

Weather

The weather is thus a major issue to consider when deciding the cutting time. The farmers keep track of the weather by studying various weather forecasts to see if they are consistent or not and thus the likelihood that they are correct. Several of the farmers mentioned that they want to see radar images in order to form their own view of the movement of clouds. Two of the farmers also mentioned that they use old weather knowledge, how different wind directions tend to influence the weather. For instance, for one site, rain from the west usually results in less rainfall than forecasted. Another farmer calls colleagues by the coast to hear how the weather is there.

To keep track of the weather is not just a question of harvesting before the rain, as one of the farmers pointed out, it is also a question of how the weather will affect the development of the crop, if it will increase the developmental rate or slow it down. Such observations provide a longer planning horizon to be able to have the harvest machinery ready in time if the development would be faster than usual.

How the farmers handle the decision making related to the weather differs. Some definitely want to harvest before the rain, e.g. the organic farm that, especially in the second cut, wanted to harvest before the rain since the clover content is higher then and the wetter clover will take a long time to dry after a rain. Another farmer said that they want to harvest when it is optimal from a quality perspective thus with little regard to a slight rainfall. Yet another farmer, who has a long duration of the harvest, has a more hardened attitude; it is only to keep on harvesting as long as the soil bears, because it will always rain at least once during harvest.

The season of 2011 started earlier than normal (i.e. the period 1961-1990 (SMHI, 2009)) in the spring, but was followed by a cooler period in the middle of May (figure 21) which slowed down the crop development. This resulted in a first cut that was in average nine days earlier than normal in the region of Västerbotten and Norrbotten (table 17).

Table 17. Normal harvesting date and the predicted date (250 day degrees) of harvest 2011 with the difference between dates for nine locations in Västerbotten and Norrbotten. Data adapted from Vallprognos (2011)

Locations	Normal harvest (1961-1990)	Predicted date	Difference
South Västerbotten	27-jun	16-jun	10.5
North Västerbotten	28-jun	18-jun	10.0
South Norrbotten	27-jun	20-jun	7.3
North Norrbotten	27-jun	17-jun	10.0
Total average	*27-jun*	*18-jun*	*9.2*
Average of coastal	*25-jun*	*18-jun*	*7.0*
Average of inland	*28-jun*	*18-jun*	*9.9*

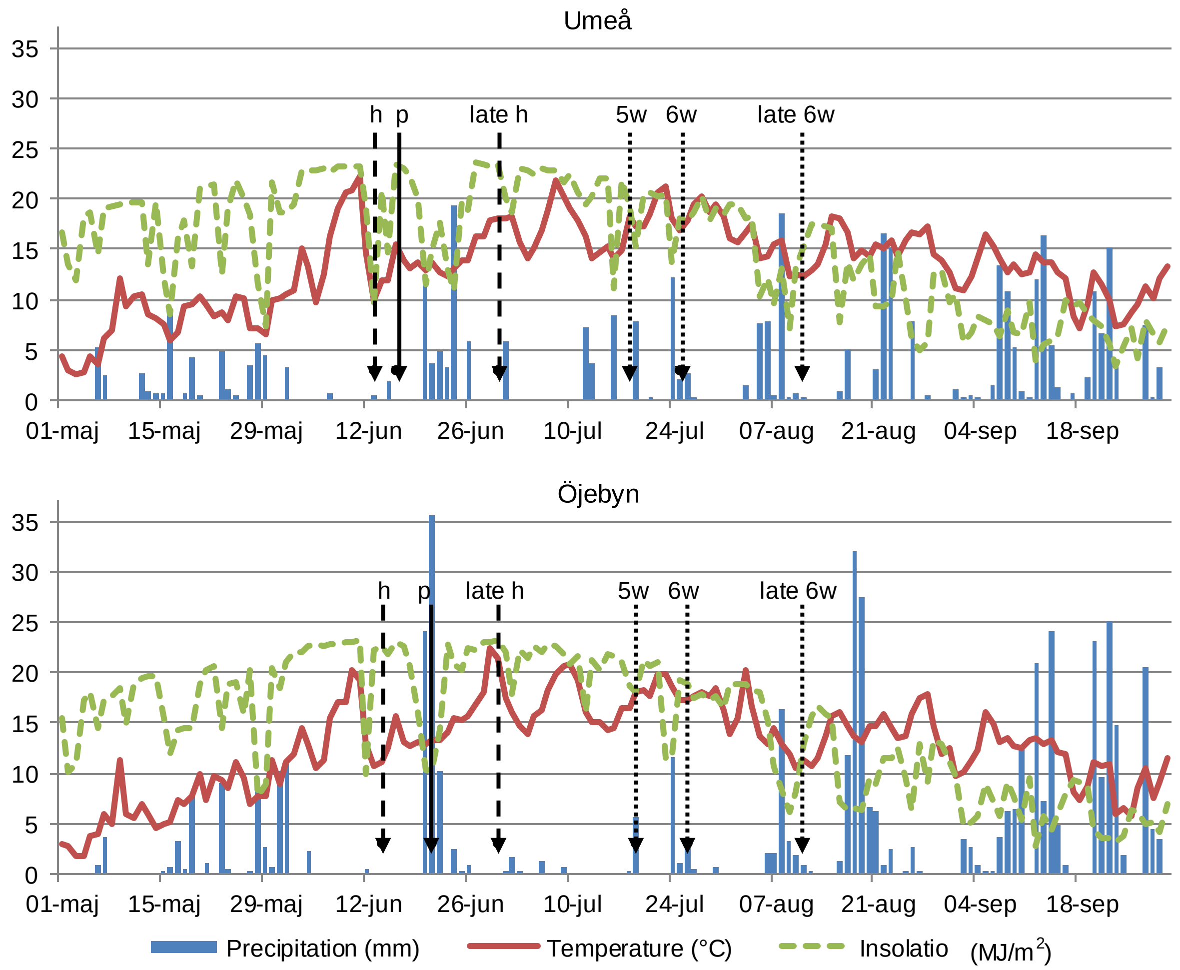


Figure 20. The weather in a) Umeå (south Västerbotten, coastal) and b) Öjebyn (south Norrbotten, coastal) during the harvest season of 2011 (data obtained from SMHI, 2012). The solid arrows point out the predicted harvest dates according to the sum of temperatures, (p) 16 and 21 June for Umeå and Öjebyn respectively. The dashed arrows mark the dates when the farmers in respective county harvested the first cut, before (h) 13 and 14 June and after the rain (late h) 30 June. The dotted arrows mark the dates for the second cut; for three cut systems five weeks after the farmers first cut (5w), for two cut systems six weeks after the first cut harvested in time (6w) and delayed (late 6w).

The predicted dates for harvest (energy at 10.8-11.0 MJ/kg DM) were 16 June for Umeå and 21 June for Öjebyn, and from the 20 June it rained for almost a week in both counties. As can be seen in figure 20 the farms that harvested in time did so 13-14 June and the farmers who were not able to harvest the first cut in time was delayed with two weeks until 30 June due to the rain. After a rather dry June and July, except for the rain at the first cut, the rains came in August, where it was very difficult even for a good planer to find a harvest window between the rains. The delayed first cut resulted in a second cut that was due (six weeks after the first) in the beginning of August in the long period of precipitation which caused the farmers more problems.

4.1.4 Value

4.1.4.1 Yields

The yields are measured by the farmers as the stored volume in the bunker or tower silo and/or number of round bales. Two of the farmers said that they do not measure their yields. The main issue for the farmers is however that the yield shall be sufficient and last during the whole year. Several of them thus had difficulties to estimate the yield in kg DM. Consequently there is an uncertainty in the yields presented in table 18, but it gives an order of magnitude and shows the large variation of yield size. The highest yield was 10 Mg DM per ha from a three-cut system and the lowest was 3.8 Mg DM per ha from the organic two-cut system. The total yields were positively correlated with fertilization (R^2 = 0.49, table 13a) and the number of cuts (R^2 = 0.70). No correlation was found with distance to fields, field size or proportion of leys or annuals in the crop rotation, as indicators of the variation in the rotations.

Three of the farms normally have a deficit of forage, which is solved by buying round bales. Two of them, the farms with lowest yields, pointed out that they want to increase the yields to cover the forage requirement and not expand the acreage. Two other farms also have had deficits, but they have acquired more land or changed the proportions of crops in order to get more acreage of ley. Two additional farmers are balancing on a knife's edge, good years they manage while low yielding years results in too little forage. One of them has solved it by temporarily acquiring harvestable acreages in the area. One farmer had a surplus of forage due to support optimization. A biogas project is under discussion in the area and if it is built the farmer will get a market for the surplus forage. Only one farmer said that they have a balance of supply and demand which is due to a strive to have a month's supply flexibility at normal yield and normal acreage. This gives a margin for yield variations due to different years. The farmer is also of the opinion that an intensive forage production can free acreages that is better used producing grain instead of a surplus of forage.

Table 18. Total yields and per cut (Mg DM/ha) on the nine farms, estimated by the farmers

	Average	Percentiles				
		0	0.25	0.50	0.75	1.00
Total yield	6.6	3.8	5.0	7.0	7.5	10.0
First cut	2.7	1.3	2.3	3.0	3.0	3.6
Second cut	2.9	2.3	2.5	3.0	3.0	4.0
Third cut	1.8	0.0	0.0	1.5	1.5	2.5

4.1.4.2 *Silage quality*

All farmers analyse the silage and most of them considers it as very important. One of them argues that with the obtained values the different silages and feeds can be combined to gain an additive effect, where the sum is greater than the single parts. Some of the farmers experiences that the analyses do not match the results. One of them usually has a high clover content in the silage, which the cows respond better to with higher milk production than the analyses imply. Another farmer experiences that the cows milk less than they are supposed to according to analyses; therefore the farmer now has changed from a positive to a more negative attitude towards analyses.

Three of the farmers were not able to harvest at an optimal time depending on rain and other factors, which can be seen in table 19 on the energy content in the silage from the first cut, where they obtained 10.0-10.3 MJ per kg DM in contrast to the farmers who harvested before the rain, who obtained 10.8-11.2 MJ per kg DM. The concentration of crude protein follows the same pattern, with higher concentration for those who harvested earlier, except for the organic farmer that had the lowest concentration due to the low nitrogen fertilization rate. Additional details of the silage quality are also presented in table 19.

Table 19. The nutrient and hygienic quality of the silage from the first cut, sorted after energy content (for missing values, see section 3.9 Data loss)

Silage	Average	A	B	C	D	E	F	G	Target values *[$]
Dry matter (%)	33	31	31	29	28	24	37	53	> 30*
Energy, ME (MJ/kg DM)	10.6	11.2	11.0	10.8	10.8	10.3	10.1	10.0	> 11.0*
Crude protein (g/kg DM)	153	129	168	176	169	157	143	131	130-160*
NDF (g/kg DM)	500	491	510	465	479	503	543	512	475-525*
AAT (g/kg DM)	71	72	71	71	71		69	69	
PBV (g/kg DM)	31	5	45	53	46		24	13	
Chewing time (min/kg DM)	71		70	66	68	71	77	76	
Feed fill value (FVL/kg DM)	0.50		0.46	0.51	0.50	0.53	0.51	0.51	0.47-0.50[$]
Energy, NEL_{20} (MJ/kg DM)	6.02		6.32	6.27	6.21	6.01	5.78	5.51	> 6.30[$]
Lactic acid (g/kg DM)	62		16	99	89	84	47	36	40-80[$]
Butyric acid (g/kg DM)	<0		<0	1	<0			<0	< 4[$]
Propionic acid (g/kg DM)	<0		<0	<0	0			<0	<2 or 6-12[$]
Acetic acid (g/kg DM)	14		1	19	17	22	13	10	12-30[$]
Formic acid (g/kg DM)	4		5	4	8			<0	<2 or >8[$]
Total VFA	82.2		22	123	114	106	60	46	< 100[$]
Ethanol (g/kg DM)	7		3	5	7			14	< 8[$]
pH	4.3[#]		4.7	3.9	3.9	4.2[#]	4.3	4.6[#]	< 4.2[$]
NH_4-N (g N/kg N)	4.6		3.3	5.8	5	6	3.5	4	<5* < 8.1[$]
VFA score [×]	8.49		7.84	9.62	9.39	9.58	7.29	7.24	[×]
DLG Silage Quality Score [γ]	98		93	100	100	95	100	100	[γ]

*Target values according to Martinsson (2011).

[$] Target values according to Tine Rådgiving (2010). The higher value of propionic acid is normal when additives of propionic or formic acid are used.

[×] VFA - Volatile Fatty Acids, scoring system: 8-10 good, 6-8 satisfactory, 3-6 needs improvement, <3 poor. The score weighs the positive impact of lactic and acetic acids against the negative impact of butyric acid (Sirois, 2011; Dairy One, n.d.).

[γ] DLG - German Agricultural Society. Score: 90-100 very good, 72-89 good, 52-71 needs improvement, 30-51 poor, < 30 very poor. The score is based on contents of acetic and butyric acid and pH, with regard to dry matter content (DLG, 2006).

[#] measured with NIRS (Williams & Norris, 1987) instead of chemical analyses, see section 3.4.2.

4.1.4.3 Production cost

The production costs of the five farms are presented in figure 21 together with associated factors. The production costs per kg DM varied between 1.20 and 1.70 SEK on the conventional farms. On the organic farm the cost was 2.90 SEK per kg DM, which mainly is due to the low yield since the cost per hectare is similar to the others.

A correlation of lower production costs with larger acreages could be expected due to scales of economics. However, the results rather show a tendency of higher costs per kg DM with larger acreages. There is also a tendency of higher costs per kg DM with increased duration of harvest.

As mentioned before, the yield per hectare strongly influences the cost per kg DM. The costs per hectare were relatively similar (approx. 9 100 SEK/ha), except from the second farm from the left who had higher costs (approx. 12 500 SEK/ha). That farm has invested a lot in high capacity, but the farm also has a markedly higher yield than the others which results in a relatively low cost per kg DM.

In figure 22 the production cost per kg DM is compared with the obtained quality and the cost per

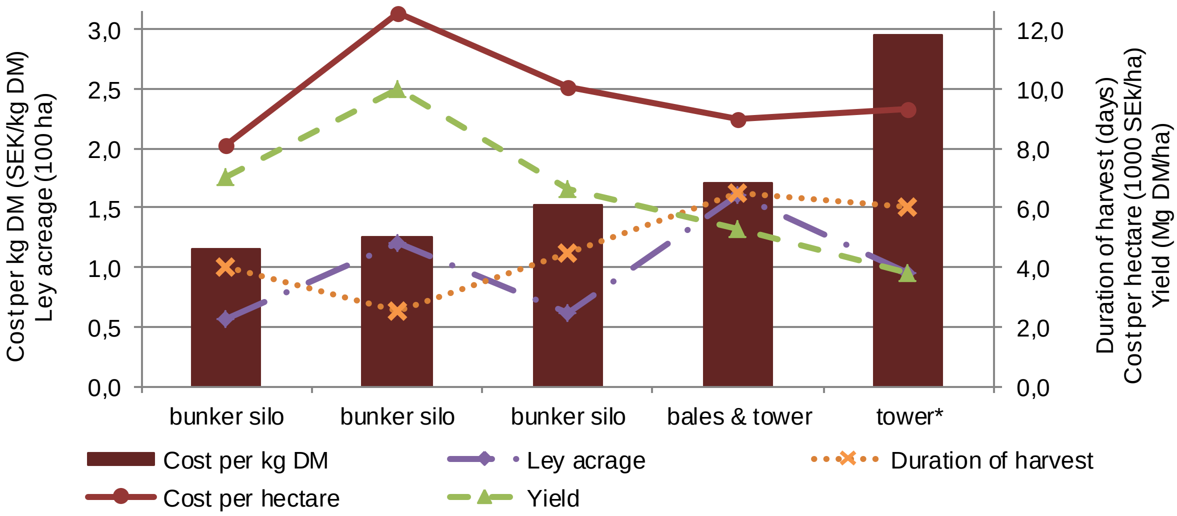


Figure 22. Production cost of forage, per kg DM and per hectare with associated factors as ley acreage, yield and harvest duration for five of the nine farms represented by their storage system. Sorted according to the production cost per kg DM. * Organic farm

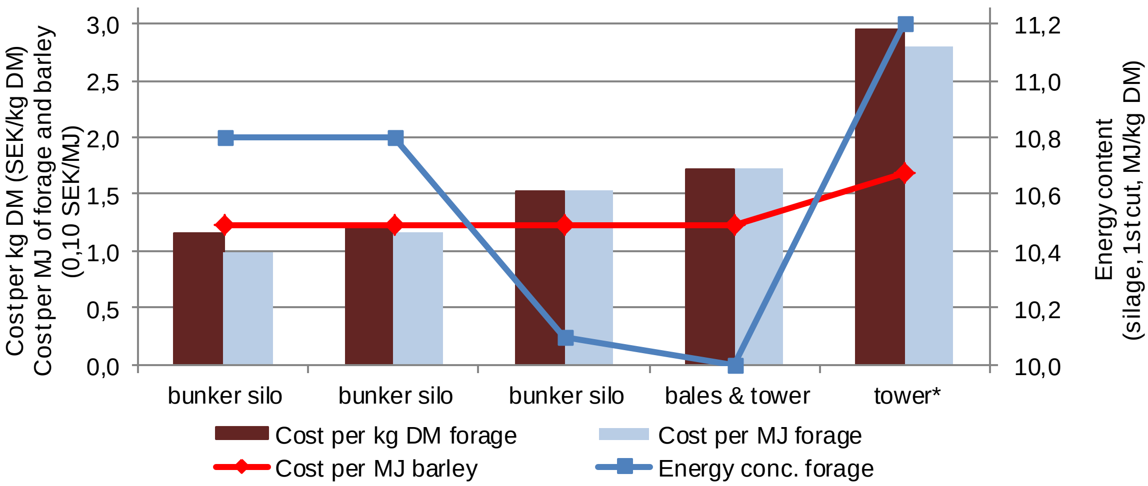


Figure 21. Production cost of forage per kg DM and per MJ, and energy concentration (ME, MJ/kg DM) in silage from the first cut for five of the farms, represented by their storage system. The cost per MJ of barley is based on 13.0 MJ/kg, 1.60 SEK/kg for conventional barley and 2.20 SEK/kg for organic (pers. com., Cuellar, 2012) Sorted according to the production cost per kg DM. * Organic farm

MJ. The cost per MJ varied between 0.10 and 0.28 SEK. For the total economy there is a large difference of paying 1.70 SEK per kg DM for silage with 10.0 MJ per kg DM than 1.20 SEK per kg DM with 10.8 MJ per kg DM. The organic farmer can pay more for high forage quality since there are more factors than the price that are important. The roughage proportion in organic feed rations is regulated to a minimum level of 60 % of the dry matter intake (KRAV, 2011), which limits the use of concentrates. Also the supply of e.g. organic barley can be low which makes it hard to purchase even if the higher price is affordable. Figure 22 also contrast the price per MJ of forage to barley (13.0 MJ/kg, 1.60 SEK/kg for conventional barley and 2.20 SEK/kg for organic, pers. com., Cuellar, 2012). The figure shows that the two farms to the left in the figure can produce energy from forage at a lower cost than purchased barley. For the organic farm it is not only a question of cost, since there are rules for maximum proportions of concentrates in the feed rations but also the availability of certified grain.

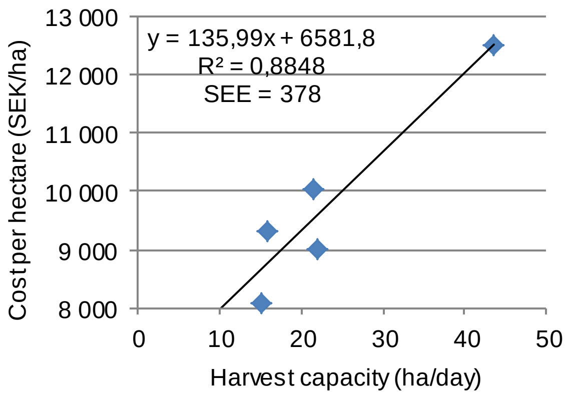


Figure 23. Linear regression of harvest capacity and cost per hectare for the five farms in figure 22 and 23.

For the examined five farms there is a strong association between harvest capacity and cost per hectare (figure 23), where a higher capacity increases the cost per hectare. But as mentioned before, the cost per kg DM can be reduced by increasing the yield.

4.1.4.4 Quantity and quality of sold milk

Table 20. The quantity and quality of sold milk and the production stability on the nine farms, from January to the beginning of October 2011, compared with the price base or ideal value stated by the dairy

	Average	Percentiles					
		0	0.25	0.50	0.75	1.00	Norrmejerier*
Sold milk quantity (kg ECM/cow day)	30.0	26.1	28.8	30.6	31.3	32.6	
Sold milk quantity (kg/cow day)	28.9	21.4	28.3	29.6	31.4	32.3	
Production variation**	309	105	172	246	440	638	
Fat (%)	4.4	4.1	4.1	4.2	4.3	5.5	4.4
Protein (%)	3.4	3.2	3.2	3.4	3.5	3.9	3.5
Cells (1000/ml)***	168	81	129	166	202	259	175
Bacteria (1000/ml)***	12	10.0	10.0	10.0	11.3	20.0	10
Urea (mmol/ml)****	4.5	3.9	4.3	4.5	4.6	5.5	4.6

* Norrmejerier’s price bases and ideal values.

** Measured as standard error estimate (SEE) from a linear regression of the sold quantity of two days during the period.

*** High values mainly originate from a few samples.

**** Target value 3-6 where there is no effect on production or fertility, but the interval may be narrower depending on the time after calving (Svensk mjölk, 2007).

The value produced in the forage production system is decided by how the feed is evaluated by the animals consuming it and their production. Table 20 presents the nine farms’ quantity and quality of sold milk from January to the beginning of October 2011. The lowest yielding farm is the one with Jersey cows and it also had the highest fat content. The production variation (i.e. the average of how much the sold quantity of two days differs from a linear regression) shows a tendency of larger variations of the sold quantity of milk on farms with higher total production (R^2=0,48; SEE=118 kg ECM).

4.1.5 Evaluation of the season

4.1.5.1 Execution of the cultivation measures during the season

Most of the farmers reckoned that the overall season of 2011 was good, as one put it, "it has been some difficulties with the machinery, but less than in a normal season". The weather however, complicated things for most of the farmers in the second and third cut, in particular for the larger farms that have a large organization to coordinate and get going at the right time between the rain showers.

Two of the farmers experienced the harvest season as very difficult. One of the farms, that does not have equipment for mixing forage, could not begin the harvesting the first cut before the rain in June since the concentration of crude protein was too high. Instead the first cut was delayed due to the rain and the second harvest was also disrupted by the variable weather. Thus the farmer had the feeling that the harvests were never entirely completed. A lack of available labour was also a major reason for the long duration of the harvests for the farmer.

The other farm encountered problematic external circumstances during the first cut which prolonged the harvest with more than one week. It was not possible to anticipate the problems and thus no action could be taken to prevent it and it resulted in a lot of extra work and therefore the season begun awry and also remained awry for the whole season.

4.1.5.2 Quality and yield

Six of the farmers judged that they had obtained a good forage quality (approx. 11 MJ/kg DM) in the first cut. Three of the farmers, those who were interrupted or delayed by the rain, thought that the quality was acceptable (approx. 10.3 MJ/kg DM) (table 21). The first harvest yielded well for all farmers except two who had obtained an acceptable or poor yield.

The result of the second cut was somewhat more spread among the farmers, four were satisfied with the quality, one reckoned it as acceptable, one as bad and the three remaining had not analysed the second harvest. Concerning the yield, seven of them were satisfied and two thought it as acceptable. Four of the farmers also harvested a third cut, where the yield was high but very wet due to the constant rain. None of them had analysed the quality, but one of them said that they could be happy if the energy content was higher than 10 MJ.

It can be concluded that those who harvested the first cut at the right time and finished before the rain had a relatively good season. For those who went awry in the beginning of the season, it more or less went awry the whole season, i.e. they were to a greater extent displeased with the outcome. However, most of the farmers had problems because of rain with late and wet second and/or third harvests as a result.

Table 21. The nine farmers rating of quality and quantity of the yields obtained during the season of 2011

	1st cut			**2nd cut**				**3rd cut**			
Rating	Good	Acceptable	Bad	Good	Acceptable	Bad	n.d.*	Good	Acceptable	Bad	n.d.*
Quality	6	3	0	4	1	1	3	0	0	0	4
Quantity	7	1	1	7	2	0	-	4	0	0	-

* not determined

4.1.6 Strategic and tactical planning

4.1.6.1 Evaluation and planning

Most of the farmers evaluate the crop production intuitively during and after the season; the working memory processes the results, as one farmer put it.

The season is evaluated by one farmer by comparing the outcome of the fertilization with the feed analyses to get feedback on why the results turned out the way they did, especially when the results are bad but also when they turned out well. The farmer means, facetiously, that you have to teach yourself something along the way.

The crop production plan is an important part in planning the year and it also have to be done to comply with the regulations of IP Sigill (Svenskt Sigill, 2011) and it is a support when applying to the different support application schemes. It differed between the farmers how the crop production plan is done, by whom and the usage of it. Several of the farmers discuss the plan between themselves on the farm. Advisors and neighbours are also asked to help when putting it together. One of the farmers stated that in practice it is always the same crops, so what remains is to adjust the fertilization rates according to the outcome of the previous year.

All of the farmers know their plan and keep it in their head, but most also keep it on paper or on the computer to be able to check details and note changes. One of the farmers pondered that it would be neat to be able to record and display the history of management of individual fields, but that also requires an effort in time to document all measures carried out on the field. Another farmer, who recently has started to use such a program to organize the crop production plan experienced that it is a useful tool, e.g. it is easier to calculate and order the correct amounts of fertilizer and seeds. However, it takes a lot of time to fill in all the necessary data to get the program going and to learn how to use it in an effective way in order to gain the benefits. Yet another farmer said that the crop production plan at present only is a formality that has to be done, but the farmer also saw the benefits of using it more and reckoned that they should be better at following up the plan, but it has not yet been done due to a lack of time.

A farmer describes the crop production plan as the backbone of the crop production, in order to have control and ensure that measures are taken when they should, e.g. the liming that is carried out in a certain place in the crop rotation. The process of planning for the farmer begins during the season. In the end of the summer the crop production plan is roughly decided, with which fields should be ploughed, which crops should follow which on each field etc. The plan is put on paper in the end of September to be able to order lime, seed and fertilizer in time and to be able to plan measures of ditching and digging. The crop production plan is finalized in the end of February, before the support application and compliance of IP Sigill is to be made.

When speaking of regulations, one of the farmers considered that a certain degree of regulation can be beneficial, when it forces you to document the production which increases the overview and thus improves your farming. However, the general consensus is that there are too many rules, and especially far too many unnecessary rules. A farmer ironically noted that the rules keep you occupied, since there is nothing else to do. The farmer also expressed a dislike of the feeling of being a social security recipient when the farm was organic. A third farmer said with a tired voice when we went through the farm's crop rotation: “and then there is the subsidy, the most profitable crop”.

4.1.6.2 Improvements of the production process

Most of the farmers are quite pleased with their existing production systems, thus the improvements the farmers wanted to implement were mostly measures to optimize it. The nature of the improvements varied depending on the farmers' interests and where they saw problems or potential problems in the business.

The difficulty lies in a constant consideration if you are heading in the right direction, as one farmer expressed it. Another farmer emphasized that nothing in the system is static; hence there is a need of innovation now and then. A farmer has for example tested to thresh the cereals undersown with ley earlier in order to harvest the straw with the grass to get a good structural fodder.

Concerning the resource base one farmer emphasized that it all comes down to learn how the soil responds to different measures and hence the result on production. Several of the farmers wanted to revise drainage, liming and fertilization to improve the soil fertility and productivity. The fertilization was discussed by several of the farmers where the spreading of manure to the whole acreage was an issue. Another goal was to improve the logistics on the farms by acquiring more land closer to the farm by purchase, trade or clearing of land. To improve the land consolidation further, several also wanted to merge fields and/or remove obstacles on the fields. Another logistical issue was the distribution of ley ages, where there were some farmers that were out of phase and wanted to come to terms with that and also reduce the age of the leys to three or four years.

Some of the farmers considered investing in new buildings, primarily storages of forage and cereals. One farmer wanted to add one or two compartments to the existing bunker silo to be able to optimize the mixing possibilities of different batches. Another farmer also pondered on a grand plan of building a new large, rational and cheap cow house at another location where no compromises to existing buildings have to be considered.

To improve the cultivation measures, some farmers wanted to improve the ley establishment, e.g. by choosing a better cover crop, in order to increase the yield and also reduce weeds. Rationalizations of spring tillage and harvest were also topics that were discussed, problems which mainly are to be solved by improving the machine capacity, either by buying machines, cooperate or hiring entrepreneurs. One farmer mentioned that he is going into therapy to dare to cut larger acreages at the same time when harvesting to obtain a high and more uniform forage quality. Another farmer aimed at becoming more self-sufficient in order to have a better control of how the feed is grown and dealt with.

Several of the farmers said that the ultimate goal is to do enough; sufficiently accurate and well enough, but not overdoing it, to make the production successful. One farmer brought up an example of overdoing things; where a system of individual feeding was used before on the farm, but the farmer reckon that it is doubtful if the extra work pays off, since there are too many uncertainties in the calculations. Another farmer questioned whether there is any marginal profit with expanding the business since you have to drive longer distances. Instead the farmer considered it is better to optimize what they already have. Another farmer summarized very well what most of them strived for; that you have to be curious and dare to try new possibilities to be able to find solutions that may work even better with the existing production.

4.1.6.3 Knowledge acquisition

Most of the farmers read a lot to acquire new knowledge and ideas that can be developed to improve the production on the farm. Another large source of information is the contacts with other farmers or stakeholders at meetings, courses etc. to exchange experiences and ideas.

Three of the farmers said that the farmer network in their areas was well developed with social meetings, field walks etc., whilst in other areas there is little or no networking, partly due to that there are very few active farmers in some of the areas.

The farmers were positive to the Focus of Nutrients, but how well they knew the concept varied. One farmer pointed out that it would be very helpful if the campaign was launched also in this region, since it can assist farmers to use the farm's resources more efficiently.

Four of the farmers employ crop production advisors, but in principle only to help with the crop production plan. When asked what kind of services the farmers would like the advisory service to offer, several of the farmers answered that it is difficult to know what you're missing when it does not exist. Some of the farmers however knew what qualifications they wanted from an advisor:

- Back-to-basics, the whole chain of forage production is important, from ploughing to storage and feeding
- Monitor the production to guide the farmer in the right direction when needed
- Very updated on the latest findings
- Work well as a sounding board
- Have basic knowledge of ruminant physiology

Benchmarks as a source of frames of reference were requested from several of the farmers to be able to compare their present production and in which areas and to what extent it can be improved.

4.2 The Concept of Ley Management

The concept of ley management can be defined as the art of designing and leading the process of forage production to storage of the desired quality and quantity. The concept does not invent something new, but it shows how the many processes and decisions in forage production can be structured and prioritized. The concept claims to summarize everything from strategic planning to daily operations in a tangible way. An important part of the strategic work is to evaluate how the farm performs at present in order to identify and prioritize improvements and/or changes in the production. Thus the management of the system can be reinforced to better address critical moments that are crucial for success.

The three models presented in the literature review (section 2.2) and the farm study combined with experiences from the extension service forms the basis of the concept of ley management. The models were chosen since they in a good and sustainable way unites the natural resource base with the requirement for efficiency in an economic process, since the agricultural firm has to plan on long term to be able to maintain production capacity. The concept of benchmarking adds comparative figures with reference to causality in order to learn and develop the business.

A schematic model of the concept of ley management is shown in figure 24, where the principle of economizing is the foundation. The resource base in the model is constituted by the assets in the production. To be able to lead the business in the desired direction the resource base demands long term planning and decision-making of e.g. new investments. The processes in the production constitutes the business, ranging from day-to-day work to several years, e.g. when planning the crop rotation. The value is hence the production result of the combination of the resource base and the business, which is decided by how well the forage production system was managed from planning to execution. The value is however ultimately decided by how the feed is evaluated by the animals consuming it. Therefore it is very important to determine the herd's quality requirements to be able to set up goals and produce according to them.

Thus, the management and result control deal with the set goals (short and long term) of the farm's performance and the strategies of how to meet them. How well the farmer succeeds depends on personal characteristics, such as knowledge and ability to turn it into practice. Another important factor is the ability to delegate responsibilities and duties to others in the organisation or outside it, who can perform the task better and/or more efficiently. Thus the farmer can focus more on the things he/she does best. The extension service is an example of outsiders that can provide useful services for the farmer. But the advisors also have to have the right qualities, to be able to communicate and adapt support according to the farmers' different requirements. The farmers' different demands of the qualifications of advisors (section 4.1.6.3) also reflect that the requirements are different, depending on how far different farmers have come in the development of their strategic planning.

Based on the concept of ley management, a list of a few fundamental issues is presented below with questions that farmers and advisors can use to evaluate the forage production and the management of the system. To pose the questions are almost more important than the answers, because of the need of increasing the awareness of the own production and it is due to the large variation of farm conditions and aims, that will result in very different answers.

<u>Resource base</u> (consists of strategic decisions)

- Do the resources match and are they sufficient for the production of forage of the right quality and quantity?
- Is the long-term soil fertility and productivity maintained?

<u>Business</u> (primarily influenced by tactical and operational decisions)

- How can the business be organized and coordinated to use the resources in the best way?
- Can the business be more effective than it is today?

<u>Value</u> (the result of how well you have managed the forage production)

- Is the right fodder produced, to the right animal at the right price?
- Does the forage work well in the feed rations and do the cows yield well from it?

This model and the posed questions thus give farmers and advisors a tool to evaluate and discuss the possibilities of the present forage production to find cost effective ways to achieve the targets. Here benchmarking can add an important frame of reference for further evaluation of the production, in which areas it can be improved, to what extent and ideas of how it can be achieved.

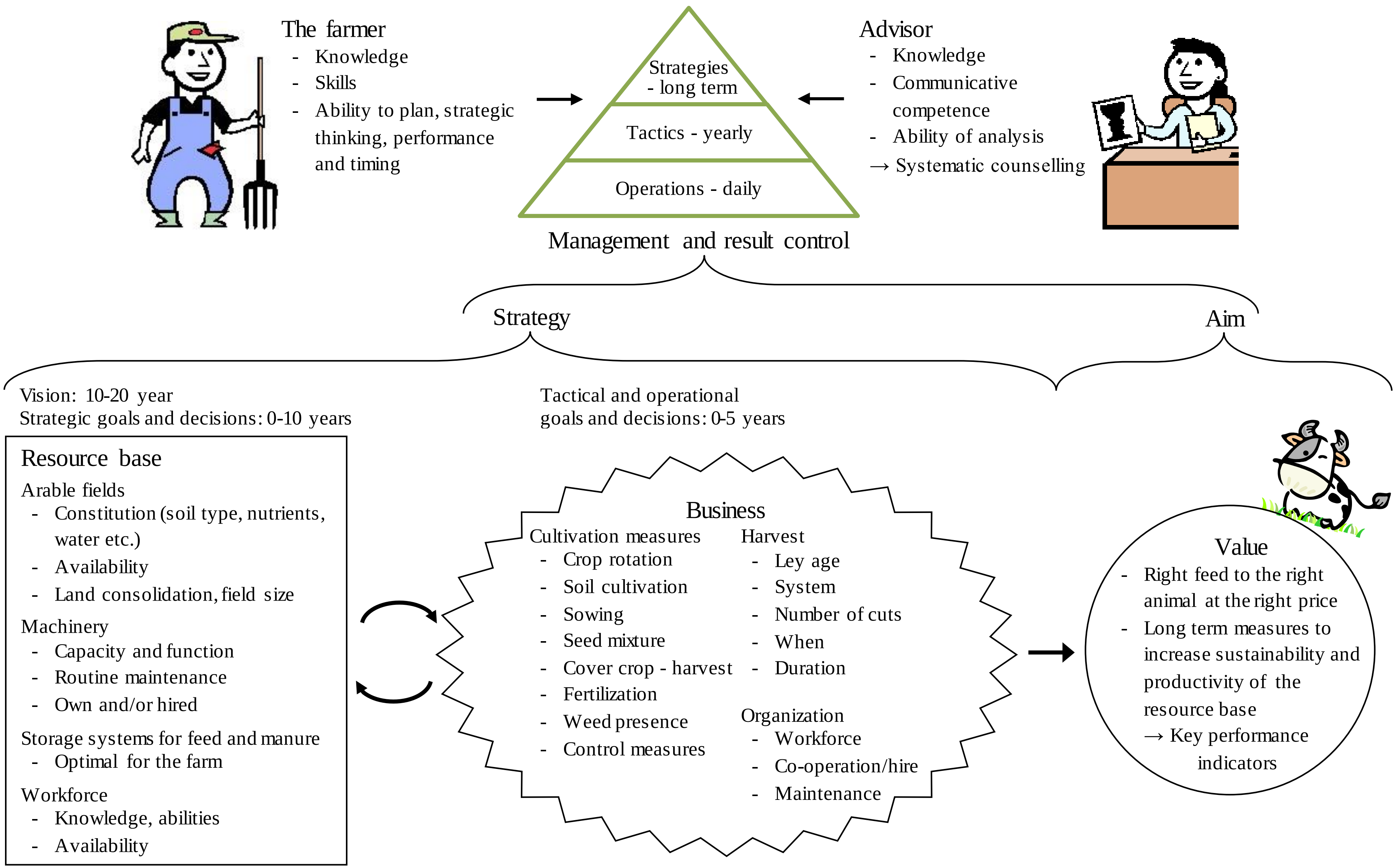


Figure 24. A schematic model of the concept of ley management. The system of forage production is structured into a resource base and business which together creates a value. To be able to achieve a set value, i.e. the aim, the farmer has to have strategies to be able to meet the goals. By combining strategies for the different parts of the forage production, the aims and the three different horizons of planning and decision-making the farmer can improve the management and result control of the forage production. The model provides a tool for farmers and advisors to examine the present forage production and find cost-effective ways to achieve the farm's goals.

5 Discussion

The farmers in this study had quite different prerequisites and resource bases to work with. The challenges they faced were however rather similar, and also the tools that can be used to manage most of them. The measures are nevertheless different, since they have to be implemented according to the farm specific prerequisites, the farmer's abilities and interests, regulations, certifications (e.g. IP Sigill and KRAV) etc. Consequently there are no general ultimate answers or solutions of which measures should be adopted to succeed with the forage production. However, by setting goals for the firm, prioritize the business, do continuous evaluations and have a good overview of the organisation, i.e. develop suitable strategies for the unique farm, the chance of success increases.

5.1 Overview and control

The main issue for the farmers was to have enough overview and control of the system. The discussions with them focused most on machine capacity at harvest, timing of operations mainly at harvest and fertilization, and timeliness costs. These subjects will hence be discussed more thoroughly in the following sections.

5.1.1 Harvest

5.1.1.1 Machine capacity at harvest

The duration of harvest varied a lot between the nine farmers but not only due to different acreages (figure 18). An ideal capacity for a farm would be to be able to finish the harvest, or separate harvest systems, in a few days, but as table 16 shows, only half of the farms meet the ideal. All the farmers wanted to have a high machine capacity, but that requires a lot of investments in machinery and workforce, thus it is a question of costs. Another alternative is to invest in co-operations or hire entrepreneurs, but as several of the farmers have pointed out, that is a question of timing, for the machinery to be available at the right time, with the dependence on others that follows and the potential timeliness cost. The machinery cost also has to be weighed against the alternative cost, i.e. not being able to harvest as high quality forage as a higher machine capacity in a smooth chain of harvest would allow. This might however be difficult to calculate and it is time consuming since it requires a lot of reasonably accurate data of the farm, to be able to calculate a reasonable accurate estimation if the alternative is good or not compared to the present.

5.1.1.2 Cutting time and quality

A solid base of the forage production is a key factor to be able to produce high quality forage, that the day-to-day work is functional. Seasons with more difficult weather conditions at harvest often separates farmers that are good at planning, coordination and performing at the right time from the ones that are not. They have their organisations functional and ready to start at the right time, thereby they can harvest forage of higher quality than a farmer that has not prepared equally well. If the aim is to harvest early there are also more opportunities to obtain acceptable forage even if it rains.

The forage quality is mainly decided by the cutting time where the developmental stage of especially timothy has a large impact. The energy concentration and developmental stage of timothy is correlated, therefore it is a good reference point to use when deciding to harvest the first cut. However, the farmer has to go out and walk in the fields to be able to see the developmental stages.

To obtain a good quality in the first cut Gustavsson (2006) recommends that it should be harvested when the most developed shoots reach stage 45, inflorescence in flag leaf sheat. This is a breaking point, with a low decrease in energy concentration before the break and a rapid decrease after, at approximately 11-11.5 MJ per kg DM depending on the year (Gustavsson, 2006). This was also shown in the sorted samples from the farmers, where higher proportions of the latest developmental stages resulted in a low energy content figure 20.

The sum of temperatures (described in section 3.10) forecasts the date of the first cut, i.e. it predicts the development based on 250 day degrees, when the energy concentration is expected to reach 10,8-11,0 MJ per kg DM (Vallprognos, 2012). Hence, if the aim is set on a higher energy content the harvest has to be started before the forecasted date to be able to finish on the forecasted day. But the development is also influenced by more factors than temperature (figure 2), e.g. day length which accelerates the development even more the further north the farm is located (Gustavsson, 1996). Thus it is even more important to start the harvest before the predicted day.

The weather of this season had a large impact on the obtained quality. The cutting intervals of the "right time" fitted the periods without major precipitation, as illustrated in figure 20. The delayed first cut due to the rain in June, caused a shift of the right time to harvest the following cut. This shift resulted in that when the following cut was due, it rained again. Consequently, the farmers that were able to harvest the first cut in time also succeeded better throughout the whole season and the farmers who cut too late, the rest of the season went more or less awry. If a rain pattern similar to this season can be assumed over years, it stresses the importance of planning e.g. to have available workforce at harvest and preparation of machinery to be able to harvest the first cut in time. Otherwise there is a higher risk of a delay in the following harvests, thus decreasing forage quality in the following yields as well as in the first cut. Consequently, this implies that if you succeed to harvest the first cut at the right time, it is also more likely that the rest of the season will proceed in a better way.

5.1.1.3 Duration of harvest

The longer duration of the harvest the larger the developmental differences in the cut forage will be, with larger variations in the quality. Consequently it is more difficult to harvest at optimum when the harvest takes a long time. There are developmental differences between fields, in particular with distance, and also depending on the species and cultivars, the age and topography of the ley. But the differences are not enough to compensate for a long harvest period. To consider these spatial differences are however a measure to decrease the quality variation of the forage on farms that do not have the capacity to finish the harvest in a few days.

A long harvest period also increases the risk of rain, where e.g. one of the farmers with a long duration of harvest counted with at least one day of rain during the harvest. Thus the risk of wet forage increases which in turn makes it much harder to manage a good conservation (Eriksson, 2007). However to shorten the harvest duration requires investments as discussed earlier (section 5.1.1.1) in machinery, workforce and/or co-operations which may increase the costs of forage production. However, if the costs of purchased feed can be reduced and/or the milk production is increased due to higher forage quality it can be profitable.

5.1.1.4 Yields

The yields were estimated by the farmers, with more or less rough estimations of the stored quantity. Farmers in general do not have to know their yields in Mg DM per se from a short-term feeding perspective, since what matters then is whether the quantity is enough to feed the cows or not. But with a broader and more long-term perspective the quantification of the yield matters since the expected yield should decide the fertilizer rate and also what quantity the total production cost can be split on, i.e. the production cost per kg DM. It is also necessary to quantify the yields to be able to evaluate and compare different fields, seasons, fertilization rates and between farms, i.e. benchmarking.

The average estimated yield of the farms in the study was 6,6 Mg DM per hectare (table 17), which is higher than the official yields of approx. 4 Mg DM per hectare in the counties of Västerbotten and Norrbotten, which also are based on farmers' estimations (Swedish Board of Agriculture, 2012). The official yield thus only matches the organic farm in the study. The large differences between the farms in the study, 4-10 Mg DM per ha, and the harvest statistics hence imply that there is a substantial potential of improving the yields on many farms in the counties. The yields were positively correlated with nitrogen fertilization and number of cuts, but not with factors as field size and distance and proportion of ley or annuals in the crop rotation. A regression however only accounts for one factor, and the size of the yield is affected by a large number of factors. One obvious factor that was not measured in this study is the soil fertility. One of the farmers with the highest yields has worked for a long time to increase the soil fertility with high yields as a result. Another farmer who obtained a relatively low yield explained this by the low fertility of the soils that the farmer now tries to improve.

The farms in the study that normally had a deficit of forage could reduce the gap between supply and demand by increasing the yields. The other farms could with higher yields make land available to grow other crops thus increasing the farm's self-sufficiency of feed and also gain some of the benefits associated with a more diversified crop rotation (Malézieux, et al., 2009). Higher yields would also reduce the production cost per kg DM, as long as it is a result of better management of the available resources in the cropping system, not by just adding more inputs without consideration of other factors that affect yields as timing, bad drainage, low pH etc.

5.1.1.5 Fertilization

The basis when deciding the fertilisation rate is to estimate the nutrient sources; soil fertility, composition and amount of the available manure and mineral fertilizer that is needed, and the output of the system, i.e. the nutrient requirement of the crop at an expected yield level.

Consequently, to be able to optimize the nutrient utilization of the manure it is important to know what you are spreading. But in the study there were only a few of the farmers who analysed their manure before spreading it. The analysed samples showed that the deviation from the standard values can be quite large (table 14). The mineral content in soil, fertilizers and crop has to be monitored to keep a balanced composition. Unbalanced mineral contents can have negative effects on the production, for instance too low potassium content in the soil reduces yield and decreases overwintering (Kjellquist, 1994) and unbalanced mineral content in feed rations can cause health disruptions (Eriksson, 2012). This emphasises the importance of monitoring the nutrient content of the soil and how the application of manure affects it and the uptake of the crop.

When comparing the nitrogen rates with the estimated yields, there was a large difference in yield and especially in yield response per kg N. In average 42 % of the available nitrogen was derived from manure, where the ammonium concentration varies with time, temperature, humidity and pH and also with different spreading techniques, which can result in very different nitrogen effects for the plants. Consequently a part of the variation in yield response can be explained by uncertainties in soil fertility and the estimations of yield and fertilizer rate, but not all.

An example of what might be a timing effect is the higher proportion of clover on one farm with a stated strategy of a later mineral fertilization in spring to benefit the clover (figure 16). However, the difference is not scientifically proved since it is only one sample with a number of factors that may have affected the outcome. But the farmer's observation stresses the importance of choosing not only the right rates but also the right time when applying fertilizers to achieve the best result. Here, farmers as well as the extension service have a major challenge in optimizing the application rates of nitrogen and also the timing. An optimization of fertilizers, both in amounts and timing, will hence serve the profitability of the firm, animal health and the environment.

5.1.2 Timeliness costs

It is rather easy to calculate the cost of a machine, but to quantify the difference e.g. a change in machinery or timing of an operation will make in the production is more complicated since the biological system is complex. The farmers have to know the required input data well enough and most important; take the time to do the evaluation and calculations of an estimate. A striking thing when discussing timeliness costs with the farmers was consequently the lack of actual calculations of what different alternatives might cost through the whole chain of forage production. This is a service that the advisory service should provide, with a large data base to be able to compare different solutions. However, such a data base requires a lot of data, which is discussed in section 5.1.4.

5.1.3 Available tools

The value of being in control is realised when adequate control and knowledge of the production system and its context is achieved. The larger the business is, the more important it is to quantify and document the processes and the results (examples in table 22) to remain in control, since it is difficult to keep all information in the head and there are more people involved in the business. Due to the large amount of information and the financial values at stake it is thus important to use available tools to control the production. In this study, this also was shown since the more successful farms to a greater extent used tools to monitor the forage production from the soil, crop rotation, inputs and economy.

It is mandatory for farms certified by IP Sigill to make a crop production plan every year, a nutrient balance every fifth year and soil mapping every tenth year (Svenskt Sigill, 2011). Hence the farmers should make sure to actually use these tools to their full extent, which is not done today. An incentive is therefore needed where it is exemplified just how much a farmer can earn on implementing a certain measure. Examples of such tools are nutrient balances that can cut unnecessary fertilizer costs and calculations of forage production cost that evaluates the financial outcome and thus give the farmer an incentive to get a better overview of the production.

Another kind of tool is the workforce with their knowledge and skills. However, farmers in general have not become farmers to work with people, which unfortunately in too many cases results in a sub optimization of the competence that the business holds. A part of the problem can be explained with that many farmers started their business on their own, or with a partner with relatively few cows. With time the business has expanded to a size that requires employees. A business with several employees requires good leadership and ample of time for planning, which takes a lot more time than the small business the farmer started up with. The lack of time for planning and structuring routines thus hampers the success of the business (pers. com., Cuellar, 2012). Consequently, there is a requirement of helping farmers to improve the structure of e.g. the day-to-day work with clear routines, which will increase the efficiency of the whole organisation. In addition there is also an increasing problem with recruiting workers with the right qualifications.

5.1.4 Financial incentives

As discussed in the section above, there is a need of putting price tags on different measures to give the farmers additional incentives to develop their production. Then it is easier to show how the results of the cultivation depends on the actions and decisions taken earlier in the year and how the farm can be more profitable by changing parts of the production. For instance, to be able to show the value of harvesting forage of 11.0 MJ per kg DM instead of 10.0 MJ per kg DM and also the cost per MJ. But also how longer term decisions affect the production, such as a crop rotation with three years of ley instead of five, or a more diversified rotation with more crops than ley and one year of break crop.

5.1.5 Lack of data

The agriculture in northern Sweden is hampered by the lack of data, especially in crop production. Due to the data lack it is difficult for e.g. the advisory service to establish and expand properly, since it is difficult to give good advice without the proper support in good and extensive data. However, it is not reasonable for the advisory service to charge the farmers to collect basic data. And since farmers experience that they do not get a financially value in return, they will not employ advisors and it becomes a sort of catch-22. Therefore, it is required that other financial contributions is done to allow a collection of data to build up a data base for northern farmers, to give them an equal knowledge base as the farmers in southern Sweden has today in e.g. Focus on nutrients. ‘Focus on nutrients’ offers free counselling to improve the farms profitability and reduce the environmental impact. The Swedish board of agriculture is responsible for the project and it is funded by the Swedish Rural Development

Programme and environmental taxes (Focus on Nutrients, 2011). Since taxes are a part of the funding of the project, all Swedish farmers should be able to benefit from the competitive advantage of the free counselling that the ‘Focus on Nutrients’ project provides. The four northern counties nevertheless contribute with 7.5 % of the total Swedish arable land (Swedish Board of Agriculture, 2012) and 10 % of the total quantity of delivered milk (Swedish Dairy association, 2012).

Table 22 shows some factors that has been investigated in this study and could be useful to collect in a database in order to evaluate and compare different farms’ forage production system and their performance.

Table 22. Examples of key performance indicators that can be useful when evaluating and comparing dairy farms and their performance in forage production

Resource base	Business	Value
Acreage (ha)	Ley age (years)	Yield (kg DM/ha)
Number of animals, cows	Botanical composition	Nutrient and hygienic quality of silage
Stocking rates	Fertilizer rate (kg NPK/ha)	Production cost (SEK/kg DM, ha etc.)
Soil mapping (K-AL, P-AL, pH)	Manure coverage (% of acreage)	Forage proportion in feed ration (%)
Field distance (min, max, average)	Manure analysis (NPK etc.)	Quantity and quality of sold milk
Field size (min, max, average)	Nutrient balance (NPK etc.)	
Machine chain capacity (ha/day)	Harvest system	
Crop rotation	Number of cuts	
	Cutting time - development	
	Duration of harvest (days, days/silo)	

5.2 Factors difficult to influence

Challenges that however are difficult for farmers to address directly are e.g. the availability of land, regulations, political decisions and prices of inputs.

All farmers in the study requested more land, but the availability in the neighbourhood was low due to that they already farmed most of the land in the area, competed with other active farmers or suffered from the lock-in effect of arable land due to the design of the single payment scheme. There is however a reform underway of CAP, where one of the objectives is to support active farmers (European Commission, 2011) which hopefully will be able to ease the lock-in of land.

Other issues that the farmers are subjected to are all the rules, regulations and certifications they have to comply with on a national level and on EU-level in order to receive the supports that are important for the financial status of most agricultural businesses (pers. com., Cuellar, 2012).

Prices of inputs, primarily mineral fertilizer and fuel as well as the milk price also strongly influence the financial outcome of the business. Farmers can only affect prices of inputs to a certain degree by e.g. negotiation. To avoid unnecessary costs planning is therefore essential, to have the right amounts in storage at the right time.

5.3 A clear strategy provides good results

The study have identified that having a strategy and be able to harvest in time was the most important factors for the success of the season for these farmers. The fertilization strategy is also important, especially in a long term perspective of finances and the environment, as well as machine capacity that strongly affect the forage production cost and thus the net result of milk and feed.

The farm study did not find any correlations between achieved results (in terms of energy concentration in the silage of the first cut and estimated forage yield) and farm size, education or age. Rather it was the degree of interest and curiosity that was the driving factor for good results.

A larger farm size does not automatically equal better results. This is also a part of the problem that initiated this study, that expanding farms in a too large extent fail to achieve better or equal the results of the smaller farm, with a negative economic outcome as a result.

Most of the farmers have worked a long time and gained a lot of experience that can compensate for a lower degree of education. How the farmers use their experience and acquire new knowledge is thus more important than the educational background of middle aged farmers (average age was 48 years), where interest has been shown to have positive effects on knowledge (e.g. Krapp, 1999). The farmers in the study who achieved good results during the season could also describe their strategy and how they managed the crop production on their farms, as well as displaying a high level of interest and knowledge.

What is a successful strategy then? That depends entirely on the specific prerequisites of the farm, as mentioned in the beginning of this chapter. The strategies firstly have to be developed to the farmer’s and the workforce’s abilities and interests, since it is difficult to work successfully with something that is not interesting. Secondly it has to account for all the farm specific prerequisites and regulations and certifications that put up some of the frame work for the production. Finally all these factors have to be weighed against each other to be able to optimize the result, both in terms of quality and quantity of forage and the economical outcome. The overall strategy sets the framework for how the forage production system should be designed. An example of such an overall strategy is organic certification that put extra regulations on the list of prerequisites that the business have to account for in the production. But in return an organic cropping system obtains higher payments and it might correlate better with personal views. More examples of overall strategies for the forage production are intensification to optimise production, extensification to optimize supports from EU, expansion of the business for benefits of economies of scale, optimizing it at the size it is, specialization in animal husbandry on only milking cows, heifer hotel, bulls etc.

Thus the only general strategy that can be adopted by all businesses is to have a strategy with set goals of the production. The chance of success increases by setting goals for the firm, prioritizing the business, do continuous evaluations and have a good overview of the organisation.

This farm study only investigated one season, where short term results as the quantity and quality of the seasons yield were evaluated. However, a long term strategy is required to be able to maintain high and even results over years. Consequently, a clear strategy should increase the chance of success in the forage production over years, since it provides a better preparation for disruptions in the production.

5.4 Future perspectives of the concept of ley management

The management perspective is an approach that has drawn more and more attention in agricultural businesses. The decision-making in agriculture today exposes farms of increased risk since the economic scale is increasing with larger farms. The agricultural businesses also become more knowledgeable and more skilled and with access to web-based information it decreases the adviser's traditional role as a mediator of knowledge (pers. com., Cuellar, 2012). This development further emphasises that the advisory service as well as research has to a greater extent engage in a dialogue with farmers of system solutions and increasingly assist them in evaluation and decision-making of the production system.

The development of the concept of ley management in this study is a first step towards a framework for farmers and advisors to facilitate overview and structuring of the production of today to get a more holistic view and the development of various courses of action for the individual farm. The concept is simple, which is one of its strengths as it is relatively easy to grasp. The main point is to make the farmers more aware of their present production system from a more holistic point of view and hence what parts that may need to be changed or improved. However, the concept needs to be further developed for a successful implementation in the advisory service and that work will be continuously carried out in the coming years.

In a study of sugar beet farmers Berglund, et al., (n.d.) concluded that the farmers results was a combination of training, interest and talent of the practitioner and the quality of the starting material, where the best farmers were better at interpreting the conditions and respond to them with the right measure at the right time. That is what the concept of ley management tries to encompass and achieve, by asking questions to make the farmer more aware of the business and more interested to further explore, utilize and develop the resource base of the farm. Hence the way, the strategy, to a more cost-effective production should be chosen based on the farmer's interests, knowledge, the prerequisites of the farm and the area.

5.4.1 Areas that need further attention

The study has also identified a number of areas that require more attention from the advisory service and research. Lack of data, as discussed earlier (5.1.5), is hampering the forage production and especially in the northern parts of Sweden. Extensive data collection and compilation, e.g. as Focus on Nutrients in southern Sweden, in a database would considerably improve the prerequisites for the advisory service to provide farmers with better counselling and provide the research with a valuable source of information for research projects.

More research and communication of existing knowledge of the chain of forage production and its organization is needed, where the main focus has to be on the system and system solutions. With good solutions and strategies of how the forage production system can be designed, the farms' resources can be used more efficiently which increases the profitability of the firm and reduces the negative environmental impact. The list below exemplifies some of the issues that need more attention.

- How can farmers plan and execute their forage production – in short and long terms
- Methods to evaluate the silage of the year and what effect it has on the cows' production
- More focus on how different batches and cutting times can be used to increase the proportions of home produced protein.

There are also several factors that are difficult to influence directly for farmers, which needs attention from the agricultural sector. Here strategic issues have to be clarified to be able to formulate various courses of actions, e.g. for:

- Changing climate conditions
- More expensive equipment, inputs etc.
- More difficult to employ qualified workers
- Uncertainty of counselling and knowledge development when the government does not prioritise applied research, trials and education.

An important measure to secure a high quality counselling and research that benefits farmers is to build a network of researchers, advisors, farmers and authorities as county administrative boards and the Swedish board of agriculture, in order to jointly drive the development of knowledge forward. Thus a dialog can be held where it is easier for farmers and advisors to request knowledge and for researchers to communicate the results of the research being done. The sorting and collation of information that advisors do will also be facilitated, thus the advisory service can provide the farmers with a good database as a basis for discussion of the present business, its goals and decision-making. A better communication with authorities may simplify and facilitate e.g. the prerequisites for farm firms by simplified regulations, targeting of important projects etc. Consequently, it is important to build up a counselling system in which all organisations are involved.

6 Conclusions

To be able to be successful in the forage production, farmers have to have a strategy for how they should reach the set goals of the production, where the goals have to be adapted to the farmer's abilities and interests, the farm's prerequisites and other prerequisites such as competition with other farmers, regulations and certifications e.g. IP Sigill and KRAV. This study only investigated one season, but a clear strategy should increase the chance of success in the forage production, since it provides a better preparation for disruptions in the production.

The farmers in this study had quite different prerequisites and resource bases to work with. The challenges they faced were however rather similar, and also the tools that can be used to manage most of them. The measures are nevertheless different, since they have to be implemented according to the farm specific prerequisites.

The official yield in the studied region was four tonnes per hectare, which was excelled by all farms in the study, except the organic farm that equalled it. The farm study thus showed that there is potential to produce higher forage yields. The calculations of forage production cost also showed that it is possible to produce high quality (e.g. 11.0 MJ, 168 g CP/kg DM) combined with high yield (up to 10 Mg DM forage per hectare) at a low cost (1.20 SEK per kg DM). The farmers who achieved these good results were able to describe their strategy well and how they managed the crop production on their farms. An important factor that influenced the outcome of the whole season was to harvest the first cut in time, not only to obtain high quality, but also for the rest of the season to continue well. The farmers that were able to harvest the first cut in time succeeded better throughout the whole season and the farmers who cut too late, obtained a lower quality in the first cut and the rest of the season went more or less awry.

There are several available tools to gain the necessary control and overview of the production in order to use the resources as efficiently as possible, e.g. the crop production plan, nutrient balances and calculations of costs, but the tools have to be used to do any good. The workforce in the organisation also has to be considered to optimize the use of the available competence. However, these tools are not used to their full potential today, consequently farmers need clear financial incentives to increase the use. The incentives should be able to show in tangible terms, e.g. profit per hectare, increased yield and quality, reduced use of nitrogen etc., how the results of the cultivation depends on the actions and decisions taken earlier in the year. An optimization of the forage production by using available tools will hence serve the profitability of the firm and the environment.

Calculations of such incentives however require a large data base to provide a benchmark and in northern Sweden there is none today. Projects as 'Focus on nutrients' in southern Sweden could be one solution to systematically collect data. Environmental taxes are a part of the funding of 'Focus on nutrients', hence all Swedish farmers should be able to benefit from the competitive advantage of the free counselling that the 'Focus on Nutrients' project provides. The policy makers, research and advisory service thus have a large challenge to deal with to enable an extensive database for northern Sweden as well. To secure a high quality counselling and research that benefits farmers a network of researchers, advisors, farmers and authorities as county administrative boards and the Swedish board of agriculture has to be developed, in order to jointly drive the development of knowledge forward. With more communication between these organisations the prerequisites for forage production may be improved. Consequently, it is important to build up a counselling system in which all organisations are involved.

The concept of ley management is simple, which is one of its strengths as it is relatively easy to grasp. The main point of it is to make the farmers more aware of their present production system from a more holistic point of view, thus enabling a better overview and control. The formulation of the concept in this study was also a beginning of the work of collecting data to provide farmers with a benchmark. That allows comparison of the own forage production with others, and hence identify parts of the production that may need to be changed or improved and how it can be done. However, the concept needs to be further developed for a successful implementation in the advisory service and that work will be continuously carried out in the coming years.

The most important conclusion, that also summarizes the whole study, is that the farmer must have adequate control and knowledge of the farm's production system and its context, to be able to successfully execute the right operations at the right time and at the same time lead the firm in the desired direction. The concept of ley management provides farmers and advisors with a tool to examine and find cost-effective and environmentally friendly ways to achieve the farm's goals.

References

Albertsson, B., 2010. *Riktlinjer för gödsling och kalkning 2011,* Jönköping: The Swedish Board of Agriculture.

Allen, V. et al., 2011. An international terminology for grazing lands and grazing animals. *Grass and forage science,* 66(1), pp. 2-28.

Andersson, B.-E., 2001. *Som man frågar får man svar – en introduktion i intervju och enkätteknik.* Göteborg: Elander.

Bangor, K., 2012. *Lab Manager, Eurofins.* Personal communication 2012-05-10

Basset-Mens, C., 2008. *Estimating the carbon footprint of raw milk at the farm gate: methodological review and recommendations..* Zurich, Switzerland, pp. 12-14.

Belotti, C. & Spörndly, R., 1992. *Vallfoder eller spannmål till korna?.* Aktuellt från Lantbruksuniversitetet 411, Husdjur. Uppsala: Sveriges Lantbruksuniversitet.

Berglund , K. et al., n.d. *4T – Tillväxt Till Tio Ton.* [Online] Available at: http://4t.sockerbetor.nu [Accessed 8 March 2012].

Bergström, S., 1998. *Hur går det? Introduktion till naturekonomisk företagsanalys.* Lund: Studentlitteratur.

Bernes, G. H. M. &. M. K., 2008. Effects of harvest date of timothy (Phleum pratense) on its nutritive value, and on the voluntary silage intake and liveweight gain of lambs. *Grass and Forage Science,* Volume 63, pp. 212-220.

Bertilsson, J. &. B. E., 1983. Effect of conservation method and stage of maturity upon the feeding value of forage to dairy cows. *Swedish Journal of agricultural Research,* Volume 13, pp. 189-200.

Bloisi, W., Cook, C. & Hunsaker, P. L., 2007. *Management and Organisational Behaviour.* 2 ed. Berkshire: McGraw-Hill Education.

Brandt, M., Haeussermann, A. & Hartung, E., 2010. Invited review: Technical solutions for analysis of milk constituents and abnormal milk. *Journal of Dairy Science,* pp. 427-436.

Casey, J. & Holden, N., 2005. Analysis of greenhouse gas emissions from the average Irish milk production system. *Agricultural Systems,* 86(1), pp. 97-114.

Cederberg , C. & Mattsson , B., 2000. Life Cycle Assessment of milk production—A comparison of conventional and organic farming. *Journal of Cleaner Production,* 8(1), pp. 49-60.

Cederberg, C. & Flysjö, A., 2004. *Life Cycle inventory of 23 dairy farms in South-Western Sweden,* Gothenburg: The Swedish Institute for food and biotechnology.

Cederberg, C., Flysjö, A. & Ericson, L., 2007. *Livscykelanalys (LCA) av norrländsk mjölkproduktion (LCA of milk in northern Sweden),* Gothenburg: SIK – the Swedish Institute for Food and Biotechnology.

Cederberg, C., Wallman, M., Berglund, M. & Gustavsson, J., 2011. *Klimatavtryck av ekologiska jordbruksprodukter,* Göteborg: Swedish Institute for Food and Biotechnology (SIK).

Cuellar, F., 2012. *Farm business adviser at Hushållningssällskapet in the counties of Norrbotten and Västerbotten.*

Dairy One, n.d.. *New Tool for Evaluating Silage Quality.* [Online] Available at: http://www.dairyone.com/Forage/FactSheet/VFA_Score.htm [Accessed 24 October 2011].

DLG, 2006. *Grobfutterbewertung. Teil B - DLG-Schlüssel zur Beurteilung der Gärqualität von Grünfuttersilagen auf Basis der chemischen Untersuchung,* DLG-Information 2/2006.

Dyrendahl, C. & Granath, J., 2011. *Lean för lantbruksföretaget: utvärdering av industriellt managementsystem i agrar kontext ,* Uppsala: Swedish University of Agricultural Sciences.

Eliasson, A., 2010. *Kvantitativ metod från början.* 2 ed. Lund: Studentlitteratur.

Ericson, L., ed., 2011. *Norrländsk växtodling.* LRF Västerbotten i samarbete med Forslundagymnasiet, Institutionen för norrländsk jordbruksvetenskap, SLU, Regionförbundet Jämtlands län.

Eriksson, H., 2007. *Ensilering kräver stor omsorg i alla led - Erfarenheter från en uppföljning av 2001-2005 års ensilagekvalitet på över 550 olika gårdar, varav flertalet belägna inom Norrmejeriers och Milkos verksamhetsområde,* Umeå: Swedish University of Agricultural Sciences.

Eriksson, H., 2012. *Vallfodrets mineralbalans,* Umeå: Swedish University of agricultural Sciences.

European Commission, 2011. *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy. COD(2011)0280,* Brussels: European Commission.

Everitt, B., 1980. *Vallfoderanalyser: metodbeskrivning över provtagning och analysering.* Husdjur 56. Uppsala: Swedish University of Agricultural Sciences.

Fagerberg, B. & Sundqvist, U., 1994. *Öjebynprojektet - Vallarnas botaniska sammansättning 1992-93 samt symbiotiska kvävefixering 1990-93,* Umeå: Sveriges lantbruksuniversitet.

Flysjö, A., Cederberg & Strid, I., 2008. *LCA-databas för konventionella fodermedel - miljöpåverkan i samband med produktion (LCA-database for conventional feed ingredients - environmental impact at production),* Gothenburg: SIK – the Swedish Institute for Food and Biotechnology.

Flysjö, A., Henriksson, M., Cederberg, C. & Ledgard, S. F., 2011. Various parameters effect on the carbon footprint of milk production in New Zealand and Sweden. *Agricultural Systems,* Volume 104, pp. 459-469.

Focus on Nutrients, 2011. *Projektbeskrivning.* [Online] Available at: http://www.greppa.nu/omgreppa/projektbeskrivning.4.32b12c7f12940112a7c800018407.html [Accessed 11 october 2011].

Focus on Nutrients, n.d. Tolkning av växtnäringsbalans på mjölkgården. *Greppa näringens praktiska råd nr 15.3.*

Fox, D., Barry, M., Pitt, . R. & Rosel, D., 1995. Application of the Cornell Net Carbohydrate and Protein Model forCattle Consuming Forages. *Journal of Animal Science ,* Volume 73, pp. 267-277.

Fox, D. et al., 2004. The Cornell Net Carbohydrate and Protein System model for evaluating herd nutrition and nutrient excretion. *Animal Feed Science and Technology,* 112(1-4), pp. 29-78.

Fox, D. et al., 2002. Environmental protection and the Cornell University nutrient management planning system: Future perspectives. *Proceedings of the Cornell Nutrition Conference For Feed Manufacturers,* pp. 79-98.

Gillen, R. L. & Smith, E. L., 1986. Evaluation of the Dry-Weight-Rank Method for Determining Species Composition in Tall-grass Prairie. *Journal of Range Management,* pp. Vol. 39, No. 3, 283-285.

Global Benchmarking Network, n.d. *Glossary and FAQ on Benchmarking.* [Online] Available at: http://www.globalbenchmarking.org/images/stories/PDF/1007_gbn_glossary_and_faq_v01.pdf [Accessed 29 august 2011].

Gunnarsson, C., 2008. *Timeliness costs in grain and forage production systems,* Uppsala: Swedish University of Agricultural Sciences, Acta Universitatis agriculturae Sueciae.

Gustavsson, A.-M., 1988. A method for protein content predictions in leys. *Swedish J. Agric. Res,* Volume 18, pp. 105-111.

Gustavsson, A.-M., 1996. Virkning av klima og vaerforhold på naeringsverdi i grovfor - behov av höstetidsprognoser. *Faginfo ,* Volume 2, pp. 92-98.

Gustavsson, A.-M., 2006. *Morphological aspects of digestibility of timothy.* Akureyri, Island, Nordic Association of Agricultural Scientists (NJF).

Gustavsson, A.-M., 2011. A developmental scale for perennial forage grasses based on the decimal code framework. *Grass and Forage Science,* pp. 93-108.

Gustavsson, A.-M., 2012. *Senior Research Officer, Department of Agricultural Research for Northern Sweden, Swedish University of Agricultural Sciences. Personal communication.*

Gustavsson, A-M., unpubl. Provtagningsanvisningar för skördetidsprognoser i vall. Uppsala: Swedish University of Agricultural Sciences

Haas, G., Wetterich, F. & Köpke, U., 2001. Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment. *Agriculture, Ecosystems and Environment,* Issue 83, pp. 43-53.

Henriksson, M., Flysjö, A., Cederberg, C. & Swensson, C., 2011. Variation in carbon footprint of milk due to management differences between Swedish dairy farms. *Animal,* 5(9), pp. 1474-1484.

Hospido, A., 2005. *Life Cycle Assessment as a tool for analysing the environmental performance of key food sectors in Galicia (Spain): milk and canned tuna,* Santiago de Compostela

Hushållningssällskapet, 2011. *Produktionsgrenskalkyler för växtodling.* Kristianstad: Hushållningssällskapen Kalmar-Kronoberg-Blekinge, Kristianstad, Malmöhus and Växa in the region of Halland.

ISO 14040, 2006. *Environmental management – Life cycle assessment – Principles and framework.* Geneva, Switzerland, International Organization for Standardization.

ISO 14044, 2006. *Environmental management – Life cycle assessment – Requirements and guidelines.* Geneva, Switzerland, International Organization for Standardization.

Johansson, L., 1993. Uppsala: Swedish University of Agricultural Sciences. Unpublished material.

Jonsson, S., 2004. *Öjebynprojektet - ekologisk produktion av livsmedel. Slutrapport (The Öjebyn-project – organic production of food),* Öjebyn: Swedish University of Agricultural Sciences.

Karlsson, O., 2011. *CEO of Hushållningssällskapet in the region of Halland.* Personal communication

Karlöf, B. & Lövingsson, F. H., 2005. *The A-Z of management concepts and models*. London: Thorogood.

Kjellquist, T., 1994. Kaliumgödsling till vall - börja med återväxten!. *Växtpressen* , Volume 2.

Krapp, A., 1999. Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education*, 14(1), pp. 23-40.

KRAV, 2011. *Regler för KRAV-certifierad produktion utgåva 2012*, Uppsala: KRAV ekonomisk förening.

Kuoppala, K. R. M. N. J. &. H. P., 2008. The effect of cutting time of grass silage in primary growth and regrowth and the interactions between silage quality and concentrate level on milk production of dairy cows. *Livestock Science*, 116(1-3), pp. 171-182.

Kvale, S. & Brinkmann, S., 2009. *Den kvalitativa forskningsintervjun*. Lund: Studentlitteratur.

Lantz, A., 2007. *Intervjumetodik*. 2 ed. Lund: Studentlitteratur.

Liedgren, A., 2007. *Utvärdering av skördetidsprognoser i vall*, Dept. of Agricultural Research for Northern Sweden, SLU.

Liker, J. K., 2004. *The Toyota Way - 14 Management Principles from the World's greatest Manufacturer*. New York: McGraw-Hill.

Linder, J., 2001. *STANK - the official model for input/output accounting on farm level in Sweden*. s.l., JTI-rapport Lantbruk & Industri 281, p. 35.

Linge, C., Olofsson, S., Nilsson, H. & Kihlberg, J., 2010. *Resultat av upprepade växtnäringsbalanser, beräknad utlakningsminskning av kväve samt miljömålsavstämningar gjorda vid rådgivningsbesök i Greppa Näringen under perioden 2001-2008*, Greppa Näringen.

Malézieux, E. et al., 2009. Mixing plant species in cropping systems: concepts, tools and models. A review. *Agronomy for Sustainable Development*, 29(1), pp. 43-62.

Martinsson, K., 2011. *Professor NJV, husdjursskötsel*. SLU, Umeå

Maskinkalkylgruppen, 2011. *Maskinkostnader 2011 - Underlag och kalkylexempel på timkostnader för lantbruksmaskiner*. Bjärred: Hushållningssällskapet, HIR Malmöhus, LRF Konsult, Maskin Konsulenterna.

Mehlqvist, M., Volden, H. & Larsen, M., 2005b. Nu kommer vallfodret till sin rätt!. *Husdjur*, Volume 4, pp. 38-40.

Mehlqvist, M., Volden, H., Larsen, M. & Gustafsson, A., 2005a. Mycket att vinna på nytt fodersystem. *Husdjur*, Volume 3, pp. 48-49.

Neuteboom, J. H., Lantinga, E. A. & Struik, P. C., 1998. Evaluation of the dry weight rank method for botanical. *Netherlands Journal of Agricultural Science*, pp. 46, 285-304.

Norrmejerier, n.d. *IP-sigill - En säkerhet för dig som konsument*. [Online] Available at: http://www.norrmejerier.se/ip-sigill [Accessed 16 April 2012].

Riley, J., n.d.. *Benchmarking*. [Online] Available at: http://tutor2u.net/business/strategy/benchmarking.htm [Accessed 4 November 2011].

Samuelsson, L. A. ed., 1996. *Controllerhandboken*. Stockholm: Sveriges Verkstadsindustrier.

SIK – the Swedish Institute for Food and Biotechnology, n.d. *LCA - Livscykelanalyser*. [Online] Available at: http://www.sik.se/default.asp?initid=468&menutree=470&toplinkname=Milj%F6sidor&menuheading=Milj%F6sidor&mainpage=templates/01.asp?sida=372 [Accessed 30 september 2011].

Sirois, P., 2011. *Forage and Soils Lab Manager, Dairy One*.

Sjaastad, Ø., Hove, K. & Sand, O., 2003. *Physiology of Domestic Animals*. Oslo: Scandinavian Veterinary Press.

SMHI, 2009. *Hur beräknas normalvärden?*. [Online] Available at: http://www.smhi.se/kunskapsbanken/meteorologi/hur-beraknas-normalvarden-1.4087 [Accessed 12 June 2012].

SMHI, 2012. *Lantmet väderstationer*. [Online] Available at: http://www.ffe.slu.se/lm/LMHome.cfm?LMSUB=1 [Accessed 12 March 2012].

Solheim, M., 2007. *Hur inverkar olika andel vallfoder i utfodringen på*, Uppsala: Swedish University of Agriculture.

Stark, A.-S., 2000. *Kostnad för hemmaproducerat foder - en sammanställning av material från sextio mjölkföretag i Västernorrland*, Umeå: Swedish University of Agricultural Sciences.

Stark, A.-S., 2011. *Farm business adviser at Hushållningssällskapet in the county of Västernorrland*. Umeå. Personal Communication

Stark, A.-S. & Ågren, M., n.d. *Manual HP-foder 3.02 - För kostnadsberäkning av hemmaproducerat foder*, Härnösand: Firms Fia Stark & Ejeln.

Swedish Board of Agriculture, 2008. *Manual till kalkylprogrammet STANK in MIND (Stallgödsel - näring i kretslopp)*. [Online] Available at: http://www.sjv.se/download/18.6beab0f111fb74e78a78000241/ManualtillSTANKinMIND.zip [Accessed 15 september 2011].

Swedish Board of Agriculture, 2010. *Statens jordbruksverks författningssamling, 2010:15*, Jönköping: The Swedish Board of Agriculture.

Swedish Board of Agriculture, 2011. *Statens jordbruksverks författningssamling, 2011:25, 8§*, Jönköping: The Swedish Board of Agriculture.

Swedish board of Agriculture, 2012. *Villkor för miljöersättningen för vallodling.* [Online] Available at: http://www.sjv.se/amnesomraden/stod/miljoersattningar/vallodling/villkor.4.7c909d4211d6c23487380004800.html [Accessed 7 March 2012].

Swedish Board of Agriculture, 2012. *Åkerarealens användning efter län/riket och gröda. År 1981-2011.* [Online] Available at: http://statistik.sjv.se/Database/Jordbruksverket/Markanvandning/Markanvandning.asp [Accessed 13 June 2012].

Swedish Dairy association, 2012. *Mjölkinvägningens förändring länsvis 2011.* [Online] Available at: http://svenskmjolk.se/Statistik/Mejeri-och-konsumtion/Mjolkinvagningens-forandring-lansvis/Mjolkinvagning-2011/ [Accessed 14 06 2012].

Svensk mjölk, 2007. *Tolkningsguide Kokontrollen.* [Online] Available at: http://www.svenskmjolk.se/Global/Dokument/Dokumentarkiv/Produkter%20och%20tj%C3%A4nster/Produktblad/Tolkningsguide%20f%C3%B6r%20Kokontrollen%204Mb.pdf [Accessed 13 January 2012].

Svenskt Sigill, 2011. *Sigill Mjölk. Standard för kvalitetssäkrad mjölkproduktion inklusive basregler som gäller för alla inriktningar inom IP SIGILL,* Stockholm: Sigill Kvalitetssystem AB.

Swensson, C., 2003. Analyses of mineral element balances between 1997 and 1999 from dairy farms in the south of Sweden. *European Journal of Agronomy,* Volume 20, pp. 63-69.

Sörensen, C., 2003. Workability and Machinery Sizing for Combine Harvesting. *Agricultural Engineering International: the CIGR Journal of Scientific Research and,* Volume 5, pp. 1-19.

't Mannetje, L. & Haydock, K. P., 1963. The dry-weight-rank method for the botanical analysis of pasture. *Journal of the British Grassland Society,* pp. 18, 268-275.

Taurus, 2009. *Valldagboken 2008.* [Online] Available at: http://www.taurus.mu/sitebase/default.aspx?idnr=u5CBFPCcdIqH7EzYfs9GTa6PkFtbFF26BCXT2LeBQ6iNpFibuNbP4eion8u4 [Accessed 14 june 2011].

The International Dairy Federation (IDF), 2010. *A Common Carbon Footprint Approach for Dairy: The IDF Guide to Standard Lifecycle Assessment Methodology for the Dairy Sector.*

The Rural Economy and Agricultural Society in Halland, 2012. Svenska ESF-rådet satsar 9,5 miljoner - Lean lantbruk. Press release 2012-01-19.

Thomassen, M., Dalgaard, R., Heijungs, R. & de Boer, I., 2008. Attributional and consequential LCA of milk production. *The International Journal of Life Cycle Assessment,* 13(4), pp. 339-349.

Tine Rådgiving, 2010. *Forklaring til analysebeviset - Grovfôr,* Moss, Norway: Eurofins.

Trost, J., 2007. *Enkätboken.* 3 ed. Lund: Studentlitteratur.

Trost, J., 2010. *Kvalitativa intervjuer.* 4th ed. Lund: Studentlitteratur.

Wachendorf, M. & Golinski, P., 2006. *Towards Sustainable intensive dairy farming in Europe.* Badajoz, Spain, 3-6 April, 2006, pp. 624-634.

Wallman, M., Cederberg, C., Florén, B. & Strid, I., 2010. *Life cycle assessment of locally produced feed for dairy cows,* Uppsala: Swedish University of Agricultural Sciences.

Vallprognos, 2012. *Vallprognos.* [Online] Available at: http://www.vallprognos.se [Accessed 12 June 2012].

Williams, A., Audsley, E. & Sandars, D., 2006. *Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities,* Bedford: Cranfield University and Defra.

Williams, P. & Norris, K. eds., 1987. *Near-Infrared Technology in the Agricultural and Food Industries..* St. Paul: American Association of Cereal Chemist.

Volden, H., ed., 2011. *NorFor - The Nordic feed evaluation system.* Wageningen: Wageningen Academic Publishers.

Volden, H., 2011. Overall model description. In: H. Volden, ed. *NorFor - The Nordic feed evaluation system,.* Wageningen: Wageningen Academic Publishers, pp. 23-25.

Åkerström, G., 2012. *In charge of feeding at Isaksgården, Älvsbyn. Former milk production adviser.*

Öborn, I. et al., 2003. Element balances as a tool for sustainable nutrient management: a critical appraisal of their merits and limitations within an agronomic and environmental context. *European Journal of Agronomy,* 20(1-2), pp. 211-225.

Appendix

I. Invitation to the study

Vallmanagement – en jämförande studie av vallkedjan på norrländska mjölkgårdar.

Du är en av 12 mjölkproducenter i Norr- och Västerbotten som inbjuds till att delta i en unik studie om vallodling.

Syftet med studien är att följa upp hela vallkedjan på mjölkgårdar, från planering till genomförande och resultat. Detta för att undersöka hur mjölkföretag tänker kring och lägger upp sin vallodling. Kunskapsunderlaget som fås genom studien kommer att delges till deltagare och andra intressenter samt att det ska ligga till grund för att vässa vallrådgivningen i norra Sverige.

Studien genomförs av Cecilia Nilsson som går mark/växt-agronomprogrammet på SLU och utgör hennes examensarbete. Studien handleds och utförs åt Hushållningssällskapets Rådgivning Nord. Vetenskaplig handledare är Anne-Maj Gustavsson, forskningsledare på institutionen för norrländsk jordbruksvetenskap.

Genom att delta får gården ta del av foderanalyser och ett antal ekonomiska nyckeltal som belyser kostnaderna för din vallodling. Sammantaget ger detta dig ett kvitto på hur bra din vallkedja fungerar samt styrkor och svagheter i gårdens vallfoderstrategi. Tillsammans med jämförelsen med de andra gårdarna i studien ger det dig en möjlighet att se var det finns utvecklingsmöjligheter i din vallodling. **Som deltagare i studien kommer du att vara anonym.**

Studiens delar:

- Datainsamling
- Telefonintervju innan vårbruket
- Valldagbok
- Gårdsbesök i juni, innan 1:a skörd
- Provtagning under skörd för näringsanalys
- Avslutande gårdsbesök i augusti
- Utvärdering

Resultatet sammanställs i en populärvetenskaplig skrift som skickas till samtliga deltagare.

Cecilia kommer att kontakta er under slutet av vecka 19 och vecka 20 för att ta emot er anmälan och berätta mer om hur studien kommer att gå till.

Har du några frågor kontakta gärna,
Cecilia Nilsson, tel 070-56 16 425, e-post: ceni0001@stud.slu.se

Ley management – a comparative study of the forage production system on dairy farms in northern Sweden

You are one of 12 milk producers in Norrbotten and Västerbotten who are invited to participate in a unique study on forage production.

The study aims at examining the forage production of dairy farms, from planning to implementation and results. This is to examine how dairy firms think about and manage their forage production. The knowledge base obtained through the study will be communicated to the participants and other stakeholders and it will also form the basis for developing the advisory services in northern Sweden.

The study is conducted by Cecilia Nilsson who is taking the Agriculture Programme - Soil/Plant at SLU and this study will constitute her Master's thesis. The study is supervised and performed on behalf of the Rural Economy and Agricultural Societies in the counties of Norrbotten and Västerbotten. Scientific advisor is Anne-Maj Gustavsson, Senior Research Officer at the Department of Agricultural Research for Northern Sweden.

By participating the farm receive results of feed analyses and a number of economic indicators that illustrate the cost of your forage production. Altogether, this provides you with a receipt of how well your forage production work, with the strengths and weaknesses of the farm's forage strategy. Along with the comparison of the other farms in the study, it gives you an opportunity to identify potential for development in your forage production. **As a participant in the study, you will be anonymous.**

Parts of the study:

- Data collection
- Telephone interview before the spring tillage
- Forage production dairy
- Farm visit in June, before the first cut
- Sampling during harvest for quality analysis
- Concluding farm visit in August
- Evaluation

The results will be compiled in a popular scientific article that will be sent to all participants.

Cecilia will contact you in the end of week 19 and 20 to receive your application and tell you more about how the study will be done.

If you have any questions you are welcome to contact,
Cecilia Nilsson, phone: 070-56 16 425, e-post: ceni0001@stud.slu.se

II. Survey form

ALLMÄNA FRÅGOR / GENERAL QUESTIONS

1. Ditt namn / Your name:______________________________
   Lantbrukets namn / The farm's name:________________________
2. Äger och driver du lantbruket tillsammans med någon? Do you own and operate the farm together with someone? Om ja, med / If yes, with:_____________________
3. Vilket år är du/ni född? / What year were you born? _______________
4. Vilken högsta utbildning har du/ni? / What is your highest education? ______________
5. Markera om gården drivs konventionellt eller ekologiskt /
   Mark whether the farm is operated conventionally or organically
6. Hur många djur finns på gården? / How many animals is there on the farm? ________________ djurenheter / livestock units
7. Antal årskor / number of cows: _______________
8. Mjölkavkastning / milk yield: per ko / cow_________ kg ECM/ko år / cow year,
   totalt / total _________ kg ECM/ år / year
9. Vilket mjölksystem används? / Which milking system is used? ___________________

GRÖDOR / CROPS

10. Hur stor areal brukar du? / How much area do you cultivate? _______________
11. Hur ser din växtföljd ut? / What is your crop rotation? __________________________
12. Vilka grödor odlar du i år? / Which crops do you cultivate this year?
    - Total vallareal / Total ley acrage____ ha, Vall / year I____ ha, Vall / year II____ ha, Vall / year III____ ha, Vall / year IV____ ha, Vall / year V____ ha
    - Spannmål / Cereals: Korn / Barley____ ha, havre / oats____ ha
    - Grönfoder / Green fodder____ ha, vilken sort? / what species?_______________
    - Helsäd / Whole crop____ ha
    - Betesmark / pasture____ ha
    - Övrigt / Other____ ha, nämligen / specified_______________

MARKEN / THE SOIL

13. Hur långt har du till dina fält? / How far away are your fields
    - medel / average_________ km
    - min_________ km
    - max_________ km
14. Hur stora är dina fält? / How large are your fields?
    - medel / average _________ ha
    - min_________ ha
    - max_________ ha

15. Vilken jordart är den dominerande på din mark? / What type of soil is dominating on your fields________________________
Är variationen stor mellan fält? / Is the variation large between fields? ____________
Är variationen stor inom fält? / Is the variation large within fields? _______________

16. Är hela arealen markkarterad? / Is the whole acrage soil mapped?_____________
Om nej, ange andel som är karterad / If no, indicate the percentage that is mapped: __________________
När gjordes markkarteringarna? / When was the mapping conducted? Senast / latest_______, äldsta / oldest_______
Markera den metod som har använts vid kartering. Punktkartering, linjekartering annan, nämligen / Select the method used for mapping. Point mapping, line mapping or other:______________

17. Är all mark dränerad? / Is all the land drained________________________
Om nej, ange andel och varför / If no, indicate the precentage that is mapped and why: ____

VÄXTNÄRING / PLANT NUTRIENTS

18. Markera vilka former av stallgödsel som används. Flyt, klet, fast & urin, djupströ / Select which types of manure that is used. Liquid, semi-liquid, solid and urine, deep litter

19. Hur lagras stallgödseln? / How is the manure stored? __________________________

20. Till vilka grödor sprids stallgödseln, när och vilken mängd? / To which crops is the manure applied, when and at what rates?

21. Gröda / Crop:_________________
stallgödselform / type of manure:__
när / when:___________________
mängd / rate:_________ ton/ha

Gröda / Crop:_________________
stallgödselform / type of manure:__
när / when:___________________
mängd / rate:_________ ton/ha

Gröda / Crop:_________________
stallgödselform / type of manure:__
när / when:___________________
mängd / rate:_________ ton/ha

Gröda / Crop:_________________
stallgödselform / type of manure:__
när / when:___________________
mängd / rate:_________ ton/ha

22. Analyseras N-värdet i gödseln innan spridning? / Is the manure analysed for N-content? ____________
Om ja, vad brukar värdena ligga på? / If yes, what is a common value?
________________________ (per form och djurslag / per type of manure and animal)

23. Använder du handelsgödsel? / Do you use mineral fertilizer? _____________
När sprids den, till vilka grödor och mängd?
/ When do you apply it, to which crops and at what rates?

Gröda / Crop: __________
sort / type: ___________
NPKS:_________

när / when: ___________
mängd / amount: _______ kg/ha

Gröda / Crop: __________ när / when: ___________
sort / type: __________ mängd / amount: _______ kg/ha
NPKS: _________

24. Görs näringsbalanser för gården? / Are nutrient balances calculated for the farm? ____

VALLEN / THE LEY

25. Vilka vallfröblandningar använder du? What seed mixtures do you use?
namn / name:________________________
art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ namn / name:________________________
art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ namn / name:________________________
art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________ art - sort – andel / species – variety - proportion:_______________________________

26. Vilken jordarbetning görs innan sådd? / What kind of tillage is done before sowing?
____

27. Vilken insåningsgröda används? / Which crop is the ley undersown in? ____________
När skördas den? / When is it harvested? _____________________________________

28. Hur länge ligger vallarna i regel? / For how many years are the leys generally harvested?
_______________ år / years

29. Görs någon ogräsbekämpning (kemisk/mekanisk) i vallarna, när och med vad? / Is any weed control (chemical / mechanical) conducted in the leys, when and with what?
____

30. Har ni problem med sjukdomar i vallen, vad gör ni åt dem? / Do you have any problems with diseases of the leys, how do you control them?
____

VALLSKÖRD / FORAGE HARVEST

31. Hur många skördar tas? / How many cuts are harvested?
    1 skörd / cut __________ % av vallarealen / of the ley acreage
    2 skördar / cuts __________ % av vallarealen / of the ley acreage
    3 skördar / cuts __________ % av vallarealen / of the ley acreage
32. Använder du något prognosverktyg för att bestämma skördetidpunkt, vilket? / Do you use any tool of prediction to determine the cutting time, which one? ______________
33. Vilket maskinsystem använder du vid skörd? / Which machine system do you use at harvest?
    ____
    Hur lång tid tar skörden? / How long time do the harvest require? ______ dagar / days
34. Använder du något ensileringsmedel, vilket? / Do you use any silage additives, what kind?
    ____
35. Mäter du skördemängden, hur? / Do you measure the yield, how? ________________
36. Genomsnittsskörd / Aerage yield: totalt / total __________ton ts/ha, Mg DM/ha,
    sk 1 / 1st cut:_________ton ts/ha, Mg DM/ha
    sk 2 / 2nd cut:_________ton ts/ha, Mg DM/ha
    sk 3 / 3rd cut:_________ton ts/ha, Mg DM/ha
37. Analyserar du vallfodrets kvalitet? / Do you analyse the forage quality? ___________

ÖVRIGT / ADDITIONAL QUESTIONS

38. Samarbetar du med någon annan gård? / Do you cooperate with any farm? _______
    Om ja, med vad? / If yes, with what? ______________________________________
39. Anlitar du entreprenörer? / Do you hire entrepreneurs? _______
    Om ja, med vad? / If yes, for what? ______________________________________
40. Vilka tider är du mest tillgänglig? / Which hours are you most available?

    På telefon / on telephone: ____

    E-post / e-mail: ____

Har du några problem med att besvara frågorna eller undrar över något annat får du gärna kontakta mig / If you have any problems answering the questions or have questions concerning something else, feel free to contact me:
Cecilia Nilsson, tel 070-56 16 425, e-post / e-mail: ceni0001@stud.slu.se

III. Interview guide 1

Firstly the overall research questions are presented followed by the more detailed questions, which were used during the interview. The detailed questions are also linked to the survey question number to facilitate supplementation of any missing data in the survey form. The original guide in Swedish is followed by a translation in English.

Forskningsfrågor

Vilken strategi har lantbrukaren för sin vallodling?

- Vilka mål har lantbrukaren med sin vallodling?
- Hur planerar lantbrukaren sin vallodling?
- Växtodlingsplan – växtföljd?
- Gör lantbrukaren någon uppföljning av vallodlingen?

Hur ser de långsiktiga strategierna ut för:

- Markkartering, görs den och följs den?
- Arrondering
- Dränering
- Kalkning
- Maskinkapacitet
- Samarbeten
- Växtföljder

Finns det en generell strategi avseende:

- Omläggning av vallar
- Skördetidpunkt
- Inköp av insatsvaror
- Maskiner, logistik & underhåll
- Samarbeten
- Anställda
- Planering och förberedelser inför säsongen (det organisatoriska)
- Planering och förberedelse inför skörd (Operativa)

Research questions

What strategy does the farmer have for the ley production?

- What are the farmers' goals for the forage production?
- How do the farmer plan the forage production
- Crop production plan and crop rotation?
- Is the farmer evaluating the forage production?

What are the long term strategies for:

- Soil mapping, is it conducted and is it used?
- Land consolidation
- Drainage
- Liming
- Machine capacity
- Co-operations
- Crop rotations

Is there a general strategy for:

- Termination of leys
- Cutting time
- Purchase of inputs
- Machines, logistics and maintenance
- Co-operations
- Employees and organization during the season
- Planning and preparations before the season (tactical questions)
- Planning and preparations before harvest (operational questions)

Allmänna frågor
1-9

Grödor
10-12 När och hur görs växtodlingsplanen?
Mål – vilka: volym, kvalitet, olika för olika skördar/djur? Grovfoderandel?
Hur nå dem? Plan B om det inte går?
Planering

Marken - Hänsyn till: mark, dränering, kalkning
13-17 - Torkkänslighet, utvintringsbenägenhet?

Växtnäring
18-23 Hur tänker du kring användning och spridning av stall- och handelsgödsel (mängder, sammansättning, balans, läckage) och lagringskapacitet

Vallen
24-29 23,24,28 – behov, inköp av gödsel, utsäde, växtskydd

Vallskörd
30-36 Förberedelser?
31 – hur funkar skördetidsbestämning – filosofi?
32 – maskinkapacitet, logistik, underhåll
34 – lagringskapacitet
36 – foderkvalitet, provtagning: när, vad analyseras?
Uppföljning av växtodlingsplan: hur, när, effekter, återkoppling mot mål?

Övrigt
37-38 Samarbete/entreprenör – funkar bra/dåligt, vill ha mer/mindre?
Personal
– behov, kommunikation
– Antal per helår/säsong

Nöjd med ditt system? Vad är bra och vad kan ändras/förbättras?
Hur får du ihop: Mål idag, det här året och 10 års period?

General questions
1-9

Crops
10-12 When and how is the crop production plan done?
Goals – define: quantity, quality, different for different cuts/animals? Proportion of roughage in the feed ration?
How is the goals achieved? Is there a plan B if it does not work?
Planning

Soil - Considerations of soil, drainage, liming
13-17 - Drought sensitivity, overwintering?

Plant nutrients
18-23 What are your thoughts on use and application of manure and mineral fertilizers (rates, composition, balance, leakage) and storage capacity

The ley
24-29 23,24,28 – requirement and purchase of fertilizer, seed and crop protection

Forage harvest
30-36 Preparations?
31 – how do the decision-making of cutting time work – philosophy?
32 – Machine capacity, logistics, maintenance
34 – storage capacity
36 – yield quality, sampling: when, what is analysed?
Follow-up on the crop production plan: how is it done, when, effects, feedback on goals?

Additional questions
37-38 Co-operation/entrepreneurs – how does it work, want more/less?
Employees
– requirements, communication
– number of, per year/season

Satisfied with your system? What is good and what can be changed / improved?
How do you make the goals of today, this year and in 10 years meet?

IV. Interview guide 2

The original interview guide in Swedish is followed by a translation in English.

Utvärdering av säsongen

- Skördad mängd, kvalitet, övrigt – mycket/litet?, bra/dålig, jämför med ett normalt år
- Får du normalt över-/underskott av vallfoder? Om du får för lite, vad gör du då?
- Uppnåddes målen för ensilagekvalitet – vad beror det på?
- Hur fungerar ensilaget i utfodringen? Grovfoderandel? Mjölkmängd? jmf m normalt?
- Har verksamheten flutit på? Om inte – vad hände, varför? – vad göra för att undvika igen?

Strategiska frågor dvs *hur får du ihop: Mål idag, det här året och 10 års period?*

- Hur tacklar du regnperioder? Kollar väder/prenumererar – hur bestämmer du dig?
- Hur förbättrar du på lång sikt dina förutsättningar för att nå målen – åtgärder tex underhålla arealer med dikningar/ kalk etc, inköp av nya maskiner, mer mark etc
- Hur stark efterfrågan har du på areal (nära/långt bort)?
- Hur ser du på EU-stöden? Påverkar de din areal (+/-), hade du haft samma areal utan stöden? Har du andra motiv till att bruka mark än foderproduktion?
- Planeringshorisonter – vo-plan, markkartering och v-näringsbalans – används de och hur?
- Fortbildning, av dig själv och personal – hur gör du/ni, vilka kanaler (kurser, fältvandringar, ERFA-grupp, tidningar, internet, forskningsrapporter etc)?
- Anlitas rådgivare? Till vad? hur mycket? Saknar du någon typ av rådgivning, tex Greppa? Vad skulle du kräva för/av rådgivning för att anlita den?

Kompletterande frågor

- Rekryteringsprocent, inkalvningsålder, medellivslängd?
- Är all areal för utfodring? Halm, strö?
- Vilket fodersystem används (fullfoder, strikt/grupper, kraftfoderstation, toppgiva etc)?
- Mineralanalys? Brukar du göra en, hur ligger du till, tar du hänsyn till den i utfodring?
- Bestäms ts-halt? När, hur, hur ofta? (bla för att veta grovfoderandel)
- Stämmer DE? Vad består övriga djur av (ungdjur, tjurar etc)?
- Hur mkt bete på åker förekommer? Hur stor areal betesmark totalt/på vall? Hur hanteras bete på vall – skörd, gödsling etc?
- Vall långt bort: hur stor, används till?
- Uppskatta skördemängd i % av total skörd, från 3, 2 resp 1-skördesystem?
- Antal dagar för att fylla plan-/tornsilo resp. ta in balar (dvs hur många dagar är resp. silo öppen?)
- Antal knivar i balpressen?
- Hur stor del av total-/vallarealen får stallgödsel?
- Gödslingsstrategi: Hur har du kommit fram till givorna? Vilken N-verkan från stallgödseln räknar du med? Spridningsteknik? hänsyn till klöverhalt, mängd, tidpunkt, antal skördar, markkartering, etc?

Evaluation of the season

- Yield, quality, other – high/low, good/bad, compare with a “normal year”.
- Do you normally get a surplus or deficit of forage? If too little, what do you do?
- Were the goals achieved for the silage quality? – how come?
- How does the silage work in the feeding? Proportion in feed ration? Milk in-weigh? – compare to normal?
- Has the business worked smoothly? If not, what happened, why? – what should you do to avoid it again?

Strategic questions i.e. *How do you make the goals of today, this year and in 10 years meet?*

- How do you handle rainfall? Monitor weather forecasts – how do you decide?
- How do you improve your resources on long term to be able to reach your goals? – measures, e.g. maintain the fields by drainage, liming etc., purchase of machinery, more land etc.?
- How strong is your demand of arable land (close/further away)?
- What do you think about the EU supports? Do they affect your acreage (+/-)? Would you have the same acreage without the supports? Do you have other motives for cultivating land than feed production?
- Planning horizons – crop production plan, soil mapping and nutrient balance – are they used, if how?
- Knowledge acquisition, for yourself and your employees – how do you do it, what kind of channels do you use (courses, field walks, experience groups, journals, internet, research articles etc.)?
- Do you employ advisors? To what, how much? Do you miss any type of counselling, e.g. Focus on nutrients? What would you require from and/or of the advisory service and advisors to employ it?

Supplementary questions

- Replacement rate (%), calving age of heifers (months), average age of milking cows?
- Is all land cultivated for feeding? Straw, litter?
- What kind of feeding system is used (complete rations, separate concentrate rations, individual/groups etc.)?
- Mineral analysis? Do you make one, at what level are you, do you take it into account in the feed recipe?
- Is the dry matter content measured? When, how often? (needed for calculating proportion in feed ration)
- Is the number of livestock units correct? What are the other animals (young cattle, bulls, etc.)?
- How much of the grazing is on arable land/ley? What is the total acreage of natural/permanent pasture? How are grazing on ley managed – cuts, fertilization etc.?
- Ley acreage far away: size, what is it used for?
- Estimate yield in per cent of total that is derived from the different cutting systems, i.e. 3, 2 and 1 cut respectively.
- Number of days to fill bunker or tower silo respectively make and take home round bales (i.e. for how many days are each silo open?)
- Number of knives in the bale press?
- To how large part of the total/ley acreage is manure applied?
- Fertilization strategy: How do you decide your rates? Which N-effect do you expect from the manure? Application technique? Considerations of clover content, yield, timing, number of cuts, soil mapping etc.?

V. Analysis of manure

The original instruction letter in Swedish of sampling manure for analysis is followed by a translation in English.

Analys av flytgödsel

Hej!

Med denna försändelse ska du ha fått material för att skicka in din flytgödsel för analys. Värdena behövs till min studie, och du kommer också att få resultatet skickat till dig så fort analyserna är klara. Så jag hoppas att du kan ta dig tid för att ta provet, det är viktigt att du tar provet i samband med spridning, då flytgödseln är blandad, se noggrannare instruktioner nedan. Har du flera brunnar, så ta provet ur den med gödsel från korna.

De värden som analyseras är:
Torrsubstans (ts)
Total kalium (Tot_K)
Total fosfor (Tot_P)
Total magnesium (tot_Mg)
Total kväve (Tot_N)
Ammoniumkväve (NH4_N)

Vänliga hälsningar, Cecilia

Har du några frågor kan du nå mig på:
Mobil: 070-56 16 425
Mail: ceni0001@stud.slu.se

Provtagningsinstruktioner från Agrilab

- Provtagningen utförs lämpligen i samband med vårspridning eller vid annat tillfälle när behållaren rymmer mycket gödsel och är ordentligt omrörd. Att gödsel är ordentligt blandad är väldigt viktigt för att få ett representativt prov som analyseras.
- Fyll den bifogade behållaren med gödsel.
- Skruva på locket ordentligt och se till att det blir riktigt tätt!
- Stoppa behållaren i en tät plastpåse, paketera i medföljande kartong glöm inte följesedeln.
- Posta behållaren, helst i början av veckan så att provet inte blir stående hos posten över helgen. OBS! det är mycket viktigt att provet skickas samma dag som det tas.
- Svaret kommer till dig inom en vecka.

Analysis of liquid manure

Hi!

With this delivery you should have received materials to send in your liquid manure for analysis. The values are needed for my study, and you will also receive the results as soon as the analyses are done. So I hope that you can take the time to do the sampling, it is important that you take the sample at the time of application, then the liquid manure is mixed, see detailed instructions below. Do you have multiple manure tanks, take the sample from the one with manure from cows.

Samples are analysed for:
Dry matter (DM)
Total potassium (Tot_K)
Total phosphorous (Tot_P)
Total magnesium (tot_Mg)
Total nitrogen (Tot_N)
Ammonium nitrogen (NH4_N)

Kind regards, Cecilia

If you have any questions, please contact me:
Mobile: 070-56 16 425
Mail: ceni0001@stud.slu.se

Sampling instructions from Agrilab

- Sampling is preferably performed in conjunction with application in spring or on another occasion when the tank contains a lot of manure and is properly stirred. That the manure is mixed well is very important to get a representative sample for analysis.
- Fill the supplied container with manure.
- Screw the lid on tightly and make sure it gets tight!
- Put the container in a sealed plastic bag, pack it in the supplied box, do not forget the delivery note.
- Mail the container, preferably early in the week so that the sample will not be standing in line for the weekend. NOTE! it is very important that the sample is sent on the day it is taken.
- You will receive the results within a week.

VI. Fresh matter sampling

The instruction was adapted from Gustavsson's (unpublished) sampling instructions for harvest prognosis of leys. The original instruction letter in Swedish of sampling fresh matter for analysis is followed by a translation in English.

Provtagning i skörd

Syftet med provtagningen är att få en avstämning om hur bra du lyckats med val av skördetidpunkt. **Tre grönmasseprover** ska tas, varav två ska skickas på analys. Det tredje provet ska skickas till mig för att jag ska undersöka utvecklingsstadiet.
Du kommer att få kuvert, påsar och följesedel från Eurofins i dagarna, så att du kan skicka två prover till dem, **märk proverna med dina initialer** 1 och 2, tex CN1 och CN2, märk även följesedeln och det tredje provet till mig.

Gör så här:

1. När du slagit hälften av din totala areal och kommer till nästa fält notera höjd, ev. liggvall, vallålder och ta gärna en bild på beståndet (innan avslagning), skicka förslagsvis allt till mig med sms/mms (070-5616425).
2. När du slagit fältet tar du ut **tre olika prover på minst 3 liter** från tre olika strängar längs en diagonal på det nyslagna fältet. Provplatserna ska väljas slumpmässigt, men linjen bör läggas så att beståndet är jämnt och representerar fältet, notera gärna stubbhöjd.
3. Lägg grönmassan i varsin **ren och torr plastpåse** och se till att de inte utsätts för sol och värme.
4. Sortera två av proverna, på ett **rent underlag**, i gräs och klöver. Om **gräset** är den dominerande arten (> 25 %) så skicka bara in gräsdelen för analys. Om **klövern** dominerar ska båda arterna skickas in för analys i varsin påse. Det **tredje provet ska inte sorteras**.
5. Proverna måste skickas så att laboratoriet får dem **nästa dag om de skickas direkt** (dvs måndag och tisdag). Annars kan du frysa proven och skicka dem senare för analys. Det tredje provet får **inte frysas** utan skickas så fort som möjligt till mig.
6. Skicka de två proven, med **ifylld följesedel**, till analys och det tredje (osorterade, ofrysta) skickas till:
   Anne-Maj Gustavsson
   SLU NJV
   901 83 Umeå
   Märk kuvertet med: Kylen grovlabb och provet med namn så jag vet vems det är.
7. Klar!

Ett enkelt sätt att få ett **rent underlag** är att klippa upp kanten och botten på en ren ny sopsäck av plast och vika ut den. Då får man en lagom stor arbetsyta att hålla till på. Det är viktigt att provet sorteras på ett rent underlag, eftersom inblandning av t ex en liten mängd jord kan störa analyserna kraftigt. För ett **bra analysresultat** är det viktigt att provet kommer fram nästa dag och att det inte utsätts för sol och värme. Det blir enklare att **sortera isär klöver och gräs** om man gör en prydlig bunt av provet när man klipper det, och sedan lägger ner det försiktigt i plastsäcken.

Sampling in harvest

The purpose of the sampling is to obtain a record of how well you succeeded with the choice of cutting time. Three samples of fresh matter green should be taken, two of them is sent for analysis. The third sample is sent to me so that I can examine the developmental stages. You will receive envelopes, bags and delivery notes from Eurofins these days, so you can send two samples to them, marking the samples with your initials 1 and 2, e.g. CN1 and CN2, also mark the delivery note and send the third sample to me.

Proceed as follows:

1. When you have cut half of your total acreage and comes to the next field note height, any lying grass, ley age, and please take a picture of the sward (before cutting), send everything to me with sms / mms (070-5616425).
2. When you have cut the field, take the **three different samples of at least 3 litres** from three different swats along a diagonal on the newly cut field. Sample locations should be selected randomly, but the line should be placed so that the sward is even and representative for the field, please note stubble height.
3. Put each fresh matter sample in a **clean, dry plastic bag** and make sure they are not exposed to sun and heat.
4. Sort two of the samples, on a **clean surface**, in grass and clover. If the **grass** is the dominant species (> 25%) only send in the grass part for analysis. If the **clover** dominates both species should be submitted for analysis in separate bags. **The third sample should not be sorted.**
5. The samples must be sent to the laboratory so they can be **received the day after**, if they are sent directly (i.e. Monday and Tuesday). Otherwise, you can freeze the samples and send them later for analysis. The third sample must not be frozen and should be sent to me as soon as possible.
6. Send the two samples, with **completed delivery note**, to analysis and the third (unsorted, non-refrigerated) is sent to:
   Anne-Maj Gustavsson
   SLU NJV
   901 83 Umeå
   Mark the envelope: Kylen grovlabb and the sample with name so I know whose it is.
7. Finished!

An easy way to get a **clean surface** is to cut up the edge and bottom of a clean new plastic garbage bag and unfold it. Then you get a nice sized workspace. It is important that the sample is sorted on a clean surface, since the admixture of e.g. a small amount of soil can considerably interfere with analysis.
For a **good analysis results**, it is important that the sample arrives the following day and that it is not exposed to sun and heat.
It will be easier to sort clover and grass if you make a neat bundle of the sample when you cut it, and then carefully put it in the plastic bag.

VII. Forage production diary

The design of the forage production diary was retrieved from Taurus (2009) and revised to be more lucid and easier to fill in. The original instructions and diary sheet in Swedish are followed by a translation in English.

Instruktioner till valldagboken

Syftet med valldagboken är att jag ska få en uppfattning om vilken **tid** du lägger ner på de olika momenten i vallodling och skörd.

Du får ut valldagboken i två olika filformat, pdf för utskrift och i excel ifall du vill renskriva och skicka in valldagboken via mail.

Korta instruktioner:

- Ett blad för varje skörd
- Notera datum för varje moment och fyll i tiden för de moment som utförts den dagen samt skördeutfall i balar, lass eller ton.
- Ange antalet maskintimmar för de moment du utfört, saknas något moment så gör en egen kolumn för det.

Transportmomentet fylls i då den sker separat från skördemomentet, tex med bogserad eller självgående hack eller hemtransport av balar. För hackvagn ingår transporten i skördemomentet.

Har du några frågor kan du nå mig på:
Mobil: 070-56 16 425
Mail: ceni0001@stud.slu.se

Instructions for the forage production diary

The purpose of the forage production diary is for me to get an idea of what time you spend on the different operations in your forage production.

You get the forage production diary in two different file formats, pdf to print and in excel if you want to transcribe and send me the forage production diary by email.

Short instructions:

- One paper for each cut
- Note the date for each operation and fill in the time for the operations conducted during that day and yield in number of bales, wagons or tonnes.
- Note the number of machine hours for the executed operations, if any operation is missing make a column for it.

Transportation is filled in when it is done separately from the harvest operation, for example, with trailed or self-propelled harvester or the repatriation of bales. For precision chop forage wagons the transportation is included in the harvest operation.

If you have any questions, please contact me:
Mobile: 070-56 16 425
E-mail: ceni0001@stud.slu.se

Valldagbok för: **insådd** år:
Forage production diary for: **sowing** Year:

Namn / Name: ______________________

Datum	Areal ha	**Timtid per moment**						Anteckningar
		plöjning	kultivering	harvning	sådd	vältning	gödsling	
Date	Acreage ha	**Hours per operation**						Notes
		Ploughing	Shallow tilling	Harrowing	Sowing	Rolling	fertilization	
Summa / Sum								

Valldagbok för: **1a/2:a/3e skörd** år:
Forage production diary for: **1st/ 2nd/ 3rd cut** Year:

Namn / Name: ____________

Datum	Areal ha	**Timtid per moment**							Skördeutfall			Anteckningar
		gödsling	slåtter	strängläggning	skörd	packning	täckning/ inplastning	transport	Balar	Lass	Ton	
Date	Acreage ha	**Hours per operation**							Yield			Notes
		fertilization	cutting	swathing	harvest	packing	covering/ wrapping	transport	Bales	Loads	Tonnes	
Summa / Sum												

VIII. Machines and inputs

The original table in Swedish is followed by a translation in English.

Namn:

Maskiner/lager mm	h tot	h/år	uh kr	uh h	bränsle /olja kr/h
	Mängd	**Pris**	**Areal**		
Vallutsäde (insådd areal)					
Handelsgödsel					
Kalk					
Bekämpningsmedel					
Plast till silo					
Plast och nät till rundbalar					
Tillsatsmedel					
El (kWh)					

Name:

Machines/storage etc.	h tot	h/year	maintenance SEK	maintenance h	Fuel / oil SEK/h
	Amount	**Price**	**Acreage**		
Seed mixture (sown acreage)					
Mineral fertilizer					
Lime					
Pesticides					
Plastic for coverage of bunker silo					
Plastic and nets for round bales					
Additives					
Electricity (kWh)					

IX. Field record of the botanical composition

Mall för gradering av artsammansättning / Field record of ranking of the botanical composition

Namn / Name: Skifte / field: Datum / date:

Nr	Timotej	Ängs-svingel	Röd-klöver	Vit-klöver	Rör-svingel	Ängsgröe	Vitgröe	Tuvtåtel	Kvickrot	Smör-blommor	Baldersbrå	Maskros	Kavle	Övrigt	Anmärkning
No	Timothy	Meadow fescue	Red clover	White clover	Tall fescue	Smooth meadow-grass	Annual Meadow-grass	Tufted Hair-grass	Couch grass	Buttercups	Scentless Mayweed	Dandelion	Foxtail	Other	Notes
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															

I denna serie publiceras examensarbeten (motsvarande 15 eller 30 högskolepoäng) samt större enskilda arbeten (15-30 högskolepoäng) utförda och/eller handledda vid Institutionen för norrländsk jordbruksvetenskap, Sveriges Lantbruksuniversitet.

DISTRIBUTION:

Sveriges Lantbruksuniversitet
Institutionen för norrländsk jordbruksvetenskap
901 83 UMEÅ

www.slu.se/njv
