Farm level approach to manage grass yield variation in changing climate in Jokioinen, Kuopio and St. Petersburg

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Abstract— Cattle's feeding is based on grass silage in Northern Europe, but grass growth is highly dependent on weather conditions. In farms decision-making, grass area is usually determined by the variation of yield. To be adequate in every situation, the lowest expected yield level determines the cultivated area. Other way to manage the grass yield risk is to increase silage storage capacity over annual consumption. Variation of grass yield in climate data from years 1961-1990 was compared with 15 different climate scenario models simulating years 2046-2065. A model was developed for evaluating the inadequacy risk in terms of cultivated area and storing capacity.

Index Terms—grass silage, grass production, risk, yield variation

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1 Introduction

Risk management has become a central concept in many climate change assessments, particularly in light of the projected increases in extreme weather events (Kalaugher et al. 2013). There is need for analysing not only average yield changes, but also the potential frequency of major losses (Yakushev, 2009).

Kalaugher et al. (2013) emphasize resilience in adaptation, but remind that achieving greater resilience may come at the cost of short-term productivity. Further, long-term strategic process including multiple management objectives and climate change scenarios far in the future conflicts the planning horizon amongst farmers.

Lee et al. (2013) defined that tactical adaptation involves modifying the existing production system, using well-known management practices and minimal investment. It includes for example utilizing conserved or stored feed, and purchasing and feeding out additional supplementary feed. Instead, strategic adaptations involve making substantial changes to current production systems. It involves greater risks and more capital investments than tactical adaptations.

Farm-scale adaptive responses in northern Europe could include e.g. greater reliance on conserved feed for housed livestock and feed budgeting for dry seasons (Hopkins and Prado 2007). Graux et al. (2013)

emphasized improving the farm's degree of forage autonomy and security of livestock systems when facing increasingly hazardous climate conditions. Stored forage resource could be redistributed in a new way to deal with increased risk of forage deficits.

This study is based on data of Höglind et al. (2013). They assessed the impact of climate change on two grass species, timothy and ryegrass, at 14 locations in Iceland, Scandinavia, Baltic countries and St. Petersburg. A near-future scenario (2040–2065) was compared with the baseline period 1960–1990. As perennial ryegrass cannot be grown all over the study area today, they limited yield simulations to timothy as the most important forage grass in most of the study area. Timothy is an especially suitable grass species for locations included in the current study, St. Petersburg, Jokioinen and Kuopio. We utilized the simulated annual timothy grass dry matter yields (g/m2) of 15 different Global Climate Models (GCMs) for individual years for Kuopio[1], Jokioinen[2] and St. Petersburg[3]. Data is described more detailed in Höglind et al. (2013).

2 Materials and methods

The model was built to describe a dairy farm's annual feed consumption and to follow the roughage feed production of the farm. The farm has storage for one year of roughage consumption. In addition, there is buffer storage. The whole year's feed use and extra storage is to be used during the harvest season, so that during and straight after the first harvest, silage from the previous season is consumed and new harvest will be fed only after the buffer is empty. Shortage in the buffer storage is possible to be filled, when the yield potential exceeds the target level. In the beginning of a simulation, the buffer is set to be full. 98 simulated yield years are run through the model in order to assess the difference in the risk effect of each climate change scenario.

The model aims to hold farms silage storages full after each harvest season. If yield potential is higher than silage demand and storages are already full, the extra grass area is left unharvested. Usually in multi-harvest grass silage production system this means that harvests that occur later in the growing season are omitted and also no fertilizers are applied to those fields. For risk management, two alternative mechanisms are given: forage buffer and possibility to alter the field area. In order to simulate the management decisions storage handling and harvest rules need to be described.

[1] Kuopio, Finland Alt. 99 Lat. 63.01, Long. 27.80, Environmental zone: Boreal 3
[2] Jokioinen: Finland, Alt. 90, Lat. 60.80, Long. 23.48, Environmental zone: Boreal 4
[3] St. Petersburg: Russia, Alt. 3, Lat. 59.58, Long. 30.18, Environmental zone: Boreal 7

Silage shortage is assumed to be compensated with concentrate feeding. Intensity of concentrate feeding in herd's diet is changed if there is not enough silage. Rate of substitution between roughage and concentrate feeding is assumed to be linear, but the maximum level of concentrate is set to 60 % of feed DM.

The harvest cost function consists of two parts: first part that includes cost of mowing and raking are based on harvest area whereas the latter part that is dictated by transportation, grass collecting with a forage harvester and silage packing depend on amount of harvested silage.

3 *Results*

3.1 *Determining the baseline-scenario*

In the baseline-scenario we describe a typical risk-averse farmer, who chooses to grow grass on bigger field area than needed on average and who maintains a buffer storage to compensate lack of yield. By this strategy the farmer will have adequate silage stock for his cattle in most of the years. Field area and buffer size are determined by the farmer's propensity to risk aversion.

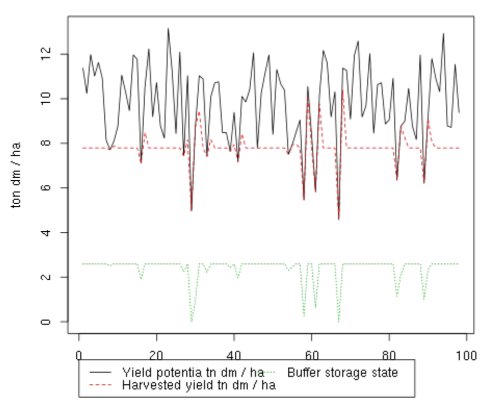

Figure 1 Yield potential, harvested yield and status of buffer storage during the simulation in Kuopio with base scenario.

The baseline scenario used in the analysis is based on a 16 % risk level so that the farmer measures the silage area by assuming 80 % of the target yield level and has 4 months of buffer storage capacity. When the farmer assumes 80 % of the mean yield (approx. 8 ton/ha DM yield), 16 of the years are below the mean in Jokioinen (10 of the years in St. Petersburg and 6 in Kuopio), so that the deficiency must be compensated with extra concentrate feeding, even with utilizing buffer storage. Yield potential above storage capacity cannot be utilized, unless buffer storage is used on previous year it can be filled with yield potential. Example of yearly harvest decisions is presented in Figure 1.

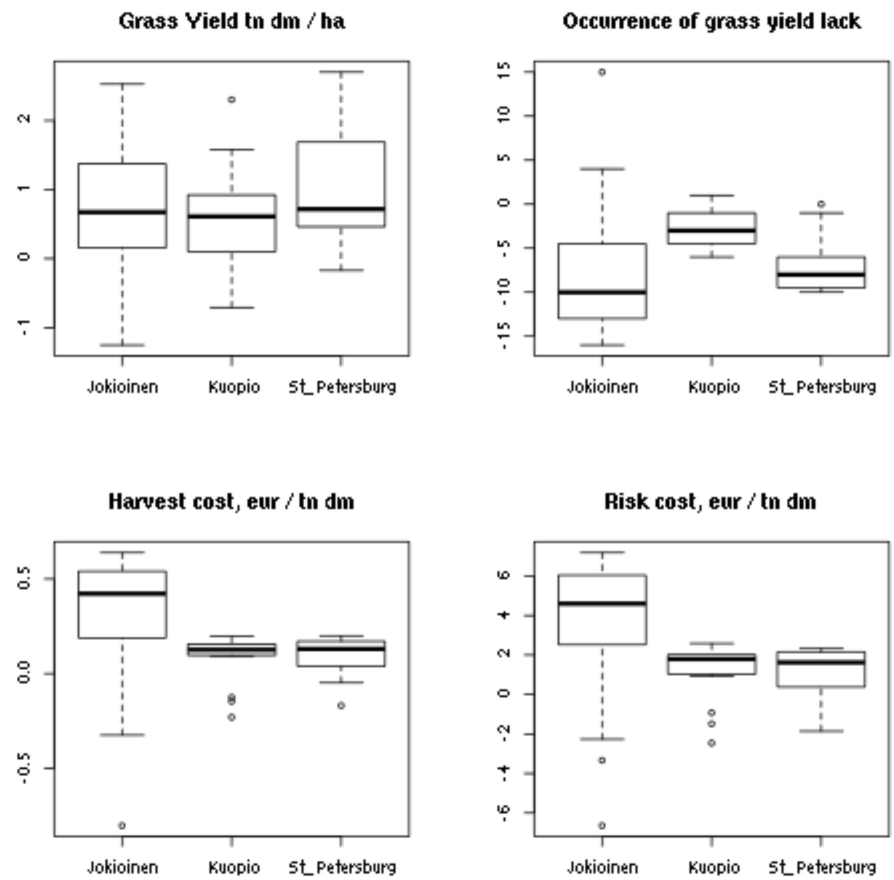

Figure 2 Difference of GCM-scenario mean yield, grass lack occurrence, harvest cost and risk cost, compared to baseline mean.

3.2 *Simulated GCMs yields*

Grass yields with 15 different GCM-scenario were compared to simulated baseline yields in similar manner. Grass yields were slightly improved in climate change scenarios and occurrence of poor harvest years became more seldom, when basing the harvest strategy on mean yield of the baseline. Harvest and risk costs were moderately affected in Kuopio and St. Petersburg, whereas in Jokioinen the effect was larger (Figure 2).

In Kuopio there was not much room for improvement in occurrence of poor grass yield seasons, which leads to small improvement in that variable.

4 Conclusions and discussion

Effect of climate change to grass production has not been analyzed from the farm level point-of-view.

Farms can prepare for exceptional years by adjusting cultivated grass area and having extra storing capacity available. A model was built to analyze these adjusting possibilities.

Yield variation between baseline and average of the GCM-scenarios wasn't affected. Yield average is slightly affected in Jokioinen and St Petersburg whereas in Kuopio the yield is increased by 30 %.

The effect on harvest and risk related costs are somewhat different. Average harvest cost is reduced slightly in all sites due to increased yield. The risk related sum of harvest and extra concentrate cost is more efficiently decreased in Jokioinen and St Petersburg compared to Kuopio. This is because occurrence of unsatisfactory yield is lowered more efficiently in these sites. In fact, in the base scenario the yield risk seems smaller in Kuopio, compared to these two other sites, but the difference is pretty much evened in the GCM-scenarios.

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