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Effect of climate change on growth potential in the mountainous region of southeast Norway

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Abstract—The COUP–ENGNOR ley crop modeling system was calibrated on relevant yield data from field trials in southern Norway. This parameterized version was used to compare the potential ley production at Fokstua (62°N; 970 m a.s.l.) for the period 1961–1990 with that of a Hadley A2 climatic scenario for the period 2071–2100. The impact of a climatic change, which projects a temperature increase by 2–3 °C, and a lengthening of the growing season by approximately 1.5 months, is an appreciable increase in production potential, especially as to fodder quality and feed unit yield. This is due to a new harvesting regime, which favors an early first cut and thus allows two seasonal cuts. The impact of the increased production potential of the mountainous districts of southern Norway towards the end of this century are considered, including the value of ley plant breeding towards optimal combination of late seasonal growth with maximum winter hardiness.

Key-words: climatic scenario, crop model, cultivar, ley, mountainous area, regrowth, timothy, wintering

1. Introduction

A large part of the reclaimable land reserves in Norway lies in the mountainous areas of the southeastern parts at altitudes from 600 to 1000 –1100 m a.s.l. In the marginal agroclimatic zones corresponding to this region, less than 30 percent of the arable soil is so far taken into cultivation for the whole country (*Grønlund*, 1990). In the most marginal zone, corresponding to approx. 900 –1100 m a.s.l. in South Norway, at most some 15 percent of the potentially arable land is cultivated. These areas, in spite of their extremely short growing season, might still give a satisfactory dry matter (DM) yield when used for fodder production by a hardy perennial grass crop. One reason for the low utilization is that a satisfactory (DM) yield depends on one late cut, and thus to the cost of feed quality whether expressed as net energy (feed unit) or protein concentration in harvested DM. Both these quality traits decrease strongly with advancing grass development stage.

As the temperature climate ameliorates, cultivation will be possible and more profitable than today at higher altitudes, thus opening considerable areas in southeast Norway for increased food production. We have explored potentials and possible challenges by extending fodder production to higher altitudes in a future climate.

2. Materials and methods

The analytical tool of this work was the COUP – ENGNOR crop modeling system, in which the COUP model (*Jansson* and *Karlberg*, 2001) simulates soil moisture and crop water uptake based on daily values of global radiation, temperature, precipitation, relative air humidity, and wind speed. These data were the inputs to simulations of plant production by the ENGNOR model (*Baadshaug* and *Lantinga*, 2002), which calculates total and harvestable ley yield from the temperature, radiation, and soil moisture supply. The present model has been calibrated to weekly observations of growth rates of first and second growth of timothy at the University Experimental Farm. This has allowed a reliable description of the reduced regrowth capacity of the extremely hardy timothy cultivar Engmo (*Fig. 1*). In this study, the extrapolations into future climates were based on a regionally downscaled Hadley A2 scenario for the site Fokstua (62^{o}N; 970 m a.s.l.) (*Engen-Skaugen*, 2007).

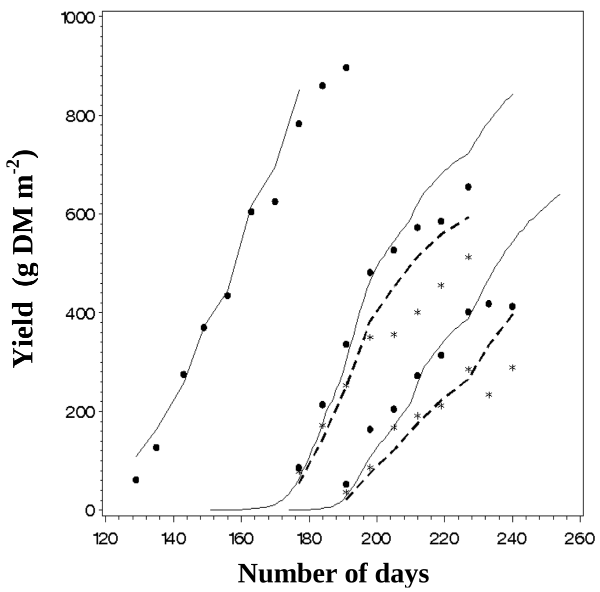

Fig. 1. Calibration of the ENGNOR ley crop model (curves) using first (left), and second growth rate observations (middle and right) at the University Experimental Farm (dots or stars) for two timothy cultivars, Engmo and Grindstad.

3. *Results*

The Hadley A2 scenario indicates only minor changes in the precipitation, whereas the air temperature (*Fig. 2*) will increase by 2 – 3 °C, implying a lengthening of the growing season by approximately 1.5 months. The effect of this change on the yield potential is seen from the comparison between the estimates for the 1961–1990 period and those of the 2071–2100 scenario (*Fig. 3*). The benefit of the climatic change may not be too striking when measured as a mere DM yield increase. The most important gain may be that of fodder quality, since the future climate will make possible two harvests in a season, a management regime which is not practical at this altitude in the present climate. The superior quality of young grass, especially as to net energy concentration, is more than ever appraised by milk and meat producers.

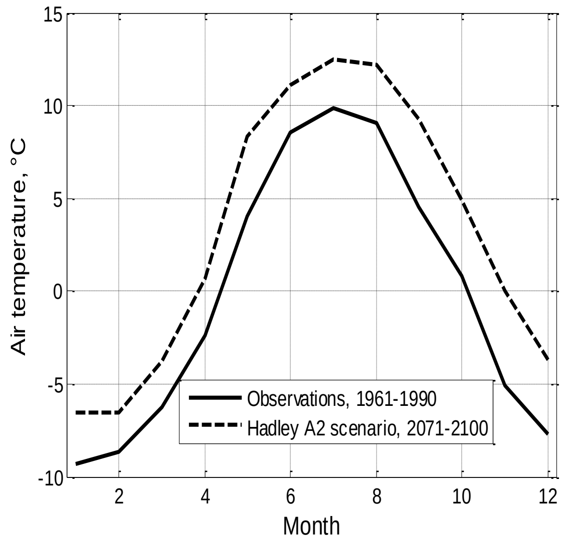

Fig. 2. Air temperature of the Hadley A2 scenario for the period 2071–2100 of Fokstua in southern Norway (62°N; 970 m a.s.l.), as compared with the observations during 1961 to 1990.

The results in *Fig. 3* are relevant for the timothy cultivar Grindstad, which is usually not considered as sufficiently winter hardy for the high altitudes. When choosing a more hardy cultivar, Engmo, to secure maximum winter survival, the yield gain from the warmer climate will be reduced (*Fig. 4*), due to the less vigorous second growth of this cultivar.

4. *Discussion*

The main limiting factors for agriculture in the marginal areas are the length of the growing season and the winter survival of perennial fodder crops, which usually are the only ones which can be grown. The expected increase of the seasonal temperature has a considerable positive effect on future plant production potential. However, the same is not necessarily in the case of wintering conditions. The main problems might be warm spells during the winter, which will be more frequent, and imply increased risks of ice crust formation on the grass fields. Therefore, in the case of timothy ley culture, the hardy cultivar Engmo will still be a highly actual choice, to the cost of reduced seasonal yield (*Fig. 4*), whenever more than one harvest is practiced.

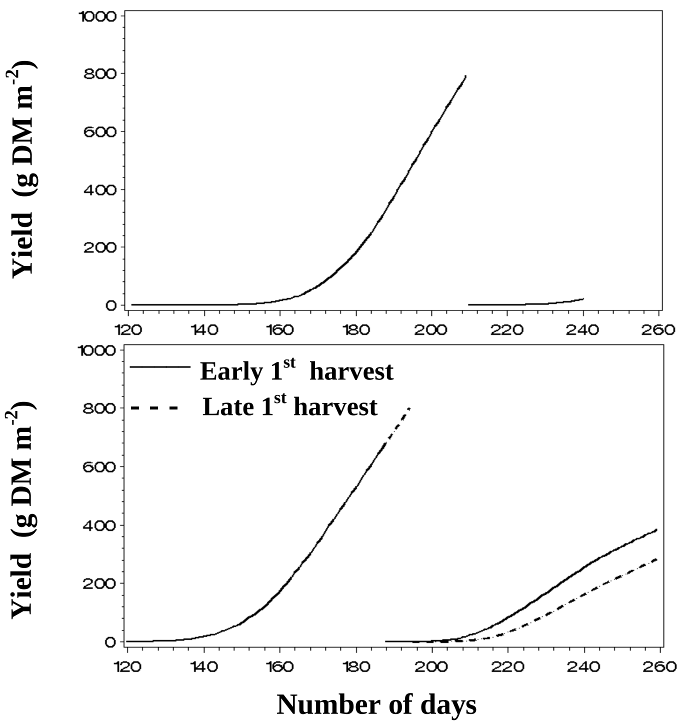

Fig. 3. Estimated yields of the Grindstad timothy ley at Fokstua (62°N; 970 m a.s.l.) for the period 1961–1990 (upper part) and for the scenario period 2071–2100 (lower part), using the ENGNOR crop growth model.

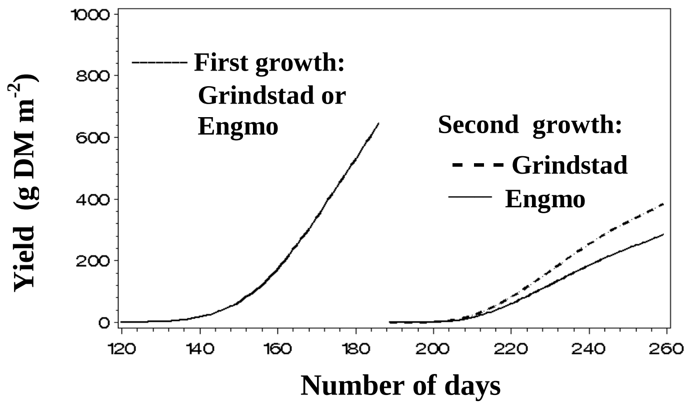

Fig. 4. Estimated yields of a timothy ley at Fokstua (62°N; 970 m a.s.l.) for the period 2071–2100 for the two contrasting timothy cultivars Grindstad and Engmo.

5. *Conclusions*

The projected climatic change will strongly increase the agricultural production potential of the mountainous areas of Norway. But, for a full benefit of the climatic change, the eternal challenge to the grass breeders still remains: to combine vigorous growth in the late growing season (see *Fig. 4*, Grindstad) with maximum winter hardiness (Engmo).

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