Quantification of Ley Yield Increase by Climate Change in Mountainous Regions of South Norway.

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Introduction

A large part of the Norwegian land reserves classified suitable for cultivation, lies in the mountainous regions of the south-eastern parts of the country at altitudes from 600 to 1100 m a.s.l (*Grønlund* 1990) (Figs 1 and 2). Prospective climate change may make it more profitable than today to cultivate new arable land at these altitudes. Thus, considerable new areas in southeast Norway may be available for increased food production.

Materials and methods

The analytical tool of this work has been the COUP – ENGNOR crop modelling 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 temperature, radiation, and soil moisture supply. The model was calibrated to observations of growth rates of the two Norwegian timothy cultivars Grindstad and Engmo at the Norwegian University of Life Sciences (59.7°N, 80 m a.s.l.). From recent Norwegian field experiment data herbage net energy concentration in milk production (FEm kg^{-1} DM) was estimated (*Bakken et al.*, 2009). The projected future climate of the site Fokstua (62°N, 970 m a.s.l.) in this study is from downscaling the atmosphere-ocean general circulation model HadCM3H (from the Hadley Centre) with emission scenario A2 (*Engen-Skaugen*, 2007).

Results and discussion

The Hadley A2 scenario shows an air temperature increase of 2-3 °C, and a lengthening of the growing season by some 1½ months (Fig. 3). This, combined with a slightly lower summer precipitation (Fig. 3), indicates a higher frequency of summer droughts. However, the effect of the combined change on yield potential is still appreciable, as seen from Fig. 4. The total yearly DM yield gains in the "new" climate were 41 and 49 percent for early and late first harvests, respectively. The corresponding gains in total yearly FEm yield were somewhat lower, 37 and 32 percent. So, the superior quality obtained by an early first cut, more than outweighed the loss in DM yield. In modern milk production practice, an early cut is most important, to meet the high net energy concentration demand of a high-yielding dairy cow. In addition, an early first harvest favours a maximum yield of digestible protein, the concentration of which will decrease rapidly with developmental stage of the ley crop.

The results in Fig. 4, upper part, apply to the timothy cv. Grindstad, which, however, is usually not sufficiently winter-hardy for high altitudes. For Engmo, a most hardy cultivar, the yield gain from the warmer climate will be somewhat reduced due to the less vigorous second growth of this far-north adapted cultivar (Fig. 4, lower part). The gain in yearly DM yield when choosing this cultivar, was reduced from the 41 percent of Grindstad to 26 percent, and that of FEm yield from 37 to 23 percent. Such a choice can be necessary even in the future, since the climatic change may lead to impaired wintering conditions for perennial ley crops. The main problem to be expected is probably warm spells during the winter, which may occur in a more variable climate. They may imply ice crust formation on the grass fields. Therefore, in the case of timothy ley cropping, hardy cultivars will still be needed, to the cost of reduced seasonal yield whenever more than one harvest is practiced.

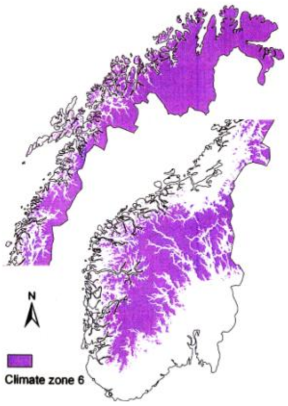

Figure 1. Areas in agroclimatic zone 6, in Norway with long term means of April and July temperatures below -1 and 12 °C, respectively.

Figure 2. An example of land for cultivation at the lake Yddin in the Valdres valley, South Norway, at about 900 m a.s.l.

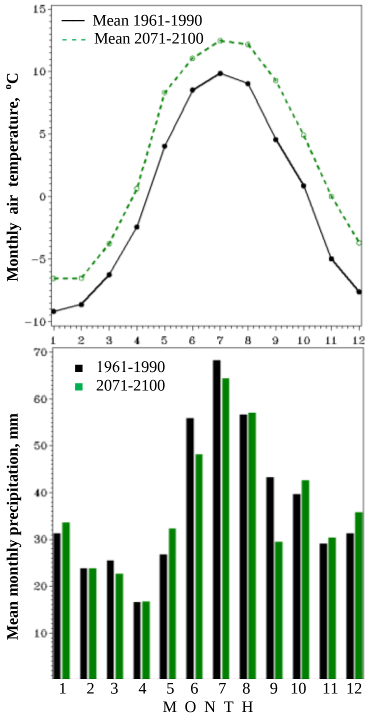

Figure 3. Monthly air temperature during the period 1961-1990 at Fokstua, Norway (62°N, 970 m a.s.l.) and the Hadley A2 temperature scenario for 2071-2100 at the same site (top), and the corresponding data for the mean monthly precipitation (bottom).

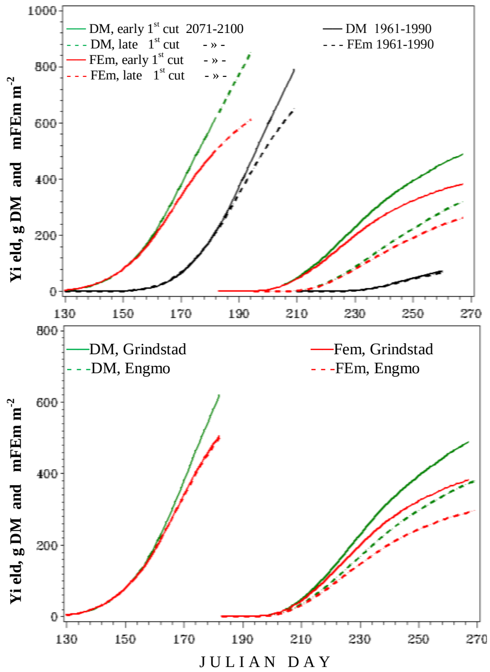

Figure 4. Top: Estimated yields of DM and net energy (FEm), cv. Grindstad, from the ENGNOR crop growth model, 1st and 2nd growths, at Fokstua (62°N, 970 m a.s.l) for the period 1961-1990 and for the 2071-2100 scenario. Bottom: DM and FEm yields of first and second growths by early first cut of the timothy cultivars Grindstad and Engmo for the period 2071-2100.

Conclusion

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 (e.g. Grindstad, see Fig. 4) with maximum winter hardiness, as that of extremely high latitude cultivars.

References

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