THE EFFECT OF PHYTOTOXIC SUBSTANCES IN PERMANENT GRASSLAND

E. Haugland[1] and R. Elven[2]
[1]The Norwegian Crop Research Institute, Plant Protection Centre, N-1432 Aas, Norway
[2]University of Oslo, Botanical Garden & Museum, Trondheimsvn. 23B, N-0562 Oslo, Norway

ABSTRACT
The concentration of phytotoxic substances in permanent grassland was studied and related to botanical composition in a two year study. Species that were negatively correlated to growth retardation varied between the two years. This may have been caused by variation in growth conditions between the two years, but may also indicate that single plant species are not the main source for the phytotoxic substances. Dead decomposing tissue may instead be the main source of phytotoxic substances in permanent grassland.

KEYWORDS
Allelopathy, phytotoxicity, grassland, bioassay, renovation

INTRODUCTION
In permanent grassland it can be desirable to change the botanical composition due to high amounts of low-yielding or poor quality species. But, in permanent grassland it is very often not possible to plough due to shallow soil depth or risk of loss of nutrients and soil erosion. Direct drilling can be the alternative, but trials with direct drilling have often failed, probably due to competition from the established species, damage by pests and pathogens and release of phytotoxic substances. The aim of the present study was to relate species composition in permanent grassland to the concentration of phytotoxic substances.

MATERIALS AND METHODS
The study was undertaken in permanent grassland which mainly had not been ploughed in the last 40 years. Management of the grass fields varied in intensity. All sites were cut once or twice each year, with a variation in fertilisation between sites. One to three samples were taken at each site and year at the end of May/beginning of June. A circular piece of the grass sward of diameter 21 cm and approximately 7 cm thick was cut with the use of a metal cylinder and a large hammer. The sample was fitted into a circular bucket. This bucket was put into another bucket to collect the extract. 600 ml of tap water was carefully poured onto the sample, which filtered through the vegetation and the top soil. 300-500 ml of the water was usually retained in the sample while the rest was collected in the bottom bucket. The collected extract (100-300 ml) was made up to 600 ml with tap water and then poured onto the sample again. This procedure was repeated twice. In the end approximately 600 ml of extract was filtered through cheese cloth and coffee machine filter and frozen at -20½C. Botanical composition of each sample was registered as visual estimates of the biomass proportion of each species. Number of samples were 49 and 50 in 1994 and 1995, respectively. The concentration of phytotoxic substances was assessed by using a bioassay method described by Haugland and Brandsaeter (1996). Radish (*Raphanus sativus* L.) was used as the test species and root length was measured. Root growth in distilled water was used as control. The data were analysed by Partial Least Square (PLS)-analysis, with relative root length as the dependent variable and per cent of species as independent variables. Rare species were not included in the analysis.

RESULTS AND DISCUSSION
In 1994 the relative root length of radish in the bioassay varied between 27 and 131% of the control, while in 1995 the figures varied between 33 and 122%. The PLS analysis for 1994 indicated that *Phalaris arundinacea* L., *Alopecurus pratensis* L., *Elymus repens* (L.) Gould., *Ranunculus repen*s L., *Taraxacum officinale* (Web.) Marss. and Alchemilla species, together with total per cent of grasses were negatively correlated to root length (Figure 1). In 1995 *Dactylis glomerata* L., *T. officinale, R. repens, Trifolium repens* L. together with total per cent of grasses was negatively related to root length of radish in the bioassay. Most of these species have been identified as producers of allelopathic agents (Wardle, 1987). The species that were negatively correlated to root length, were different in the two years. A species like *Rumex acetosa* L. showed a positive correlation to root length in the first year but a negative effect in the second year. This may have been caused by the variation in growth conditions between years. Newbery (1979) found that *R. acetosa* caused growth reductions when soil water was close to field capacity, while under drier conditions no such effects were found. However, the present results may also indicate that single species are not the origin of the phytotoxic substances. Instead the amounts of decaying organic matter may be important as studied by Gussin and Lynch (1981). The negative correlation with total per cent of grasses in both years also indicates such a relationship, because high percentage of grasses probably will produce denser and higher amounts of dead organic matter. *Holcus mollis* L. has a growth pattern and vegetative reproduction system similar to *E. repens* and forms dense, monoculture-like stands. It is known that phytotoxic components can be released from decaying rhizomes of *E. repens* (e.g. Whitehead et al., 1982) and the difficulty of other species to establish in the dense stands of *H. mollis* could have such a cause. The present study, however, did not indicate such a relationship (Figure 1).

Although there was a variation in botanical composition between samples within sites, the results from the bioassay were rather similar within sites. This indicates that factors related to each site, rather than botanical composition is important for the amount of phytotoxic substances. From a renovation point of view, it could be interesting to predict the amounts of phytotoxic components and hence the likely problems with direct drilling a year in advance of renovation. But, the correlation in growth reduction between the two experimental years were rather poor ($r=0.39$, $p=0.051$), which probably makes such a strategy difficult to carry out.

In the present study the proportion of each species was estimated. But, if the amount of decaying organic matter is important for the release of phytotoxic substances, measurements on actual biomass of dead organic matter should be taken together with the actual amount of each species in the samples.

CONCLUSION
Although the ecological importance of the concentrations of phytotoxic substances found in the present study is not shown, these substances most likely could interfere with newly sown and germinated species in a permanent grass sward, hindering their establishment. The present results showed rather poor relationship between single plant species and growth retardation. The amount of decaying organic matter is more likely to be important for the concentration of phytotoxic substances in grassland.

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REFERENCES

Gussin, E. J. and J. M. Lynch. 1981. Microbial fermentation of grass residues to organic acids as a factor in the establishment of new grass swards. New Phytologist **89:** 449-457.

Haugland, E. and L. O. Brandsaeter. 1996. Experiments on bioassay sensitivity in the study of allelopathy. Journal of Chemical Ecology **22:** 1845-1859.

Newbery, D. M. 1979. The effect of decomposing roots on the growth of grassland plants. Journal of Applied Ecology **16:** 613-622.

Wardle, D. A. 1987. Allelopathy in the New Zealand grassland/ pasture ecosystem. New Zealand Journal of Experimental Agriculture **15:** 243-255.

Whitehead, D. C., H. Dibb and R. D. Hartley. 1982. Phenolic compounds in soil as influenced by the growth of different plant species. Journal of Applied Ecology **19:** 579-588.

Figure 1

The first and the second Partial Least Square (PLS)-components in 1994 and 1995 relating species composition to relative root length (RELROOT).