TOWARDS A MODEL FOR NITROGEN APPLICATION TO SEED CROPS OF TIMOTHY (*PHLEUM PRATENSE*)

T.S. Aamlid
The Norwegian Crop Research Institute, Division Landvik, N-4890 Grimstad, Norway

ABSTRACT
In seed production experiments with timothy (*Phleum pratense* L.) split application of 25 kg N ha^{-1} as early as possible in spring (mean date 17 April) plus 50 kg ha^{-1} at the start of tiller elongation (mean date 19 May) increased seed yields compared to only one application of 75 or 100 kg N ha^{-1} in mid-May. On plots not receiving nitrogen until mid-May, the seed yield increase resulting from an additional application of 25 kg N ha^{-1} at heading (mean date 19 June) could be related to the ratio between measured and critical per cent nitrogen in plant dry matter at that stage. The optimal amount of nitrogen was related to tiller density in spring and rainfall in July, but not to soil mineral nitrogen.

KEYWORDS
Nitrogen, *Phleum pratense*, plant analysis, soil mineral nitrogen, split application, tillers, timothy, seed yield

INTRODUCTION

With about 2000 ha harvested annually, timothy (*Phleum pratense*) is the most important herbage seed crop in Norway. The national average seed yield of this species is about 580 kg ha^{-1}, but more than 800 kg ha^{-1} is not uncommon.

In accordance with earlier trials (Torskenæs, 1986) Norwegian seed crops of timothy seldom receive any nitrogen in autumn. Spring applications usually amount to 80 kg N ha^{-1} in compound NPK fertilzers. Delaying the spring application from early April to May resulted in higher timothy seed yields in Norwegian (Torskenæs, unpublished) as well as in Danish (Nordestgaard, 1981) experiments, and common Norwegian practice has therefore been to apply the total amount of fertilizer in mid-May.

For the past five years, split applications of nitrogen have become more common in Norwegian grain production. The main application in early spring is often reduced depending on analyses of soil mineral nitrogen, and additional applications at jointing and/or heading are adjusted for meteorological data, visual crop appearance and/or plant analyses.

The objectives of the present research were (1) to clarify if there is any advantage of splitting nitrogen applications to Norwegian seed crops of timothy; and (2) to provide data for adjusting fertilizer nitrogen to soil and/or plant analyses during the growing season.

MATERIALS AND METHODS

In the early spring of 1994 and 1995 four experimental fields were laid out in first year crops of timothy 'Grindstad' at various locations in SE Norway (58-61°N). Treatments included various combinations (see Table 1) of an early application of 25 kg N ha^{-1} given as $Ca(NO_3)_2$ as soon as the field was trafficable in spring (mean date 17 April), a main application of 50-100 kg N ha^{-1} (50 kg as compound NH_4+NO_3; remaining $Ca(NO_3)_2$) in mid-May (approximately at the start of tiller elongation, mean date 19 May), and a late application of 25 kg N ha^{-1} as $Ca(NO_3)_2$ at heading (mean date 19 June). Plots with no N application were included as controls. Soil (for NH_4+NO_3 down to 40 cm depth) and plant (for vegetative and reproductive tiller number, dry matter yield and Kjeldahl-N) samples were taken at regular intervals during the growing season. Plant nitrogen status was expressed by the ratio N_a/N_c, where N_a and N_c are actual and critical nitrogen concentrations in plant dry matter, respectively. N_c was calculated by the function $N_c = 1.33 + e^{(1.4 - 0.26W)}$, where W is the dry matter yield in tonnes ha^{-1} (Greenwood et al., 1991).

The experiments were harvested directly with field plot combines in August. Data are available from four harvests in first year crops, four harvests in second year crops and two harvests in third year crops.

RESULTS

Analysis of soil mineral nitrogen before the main application of fertilizer in mid-May showed values ranging from 18 to 142 with an average of 46 kg N ha^{-1} (data not shown in tables or figures). Levels after seed harvest were similar with an average of 42 kg N ha^{-1}. Various nitrogen regimes had no significant effect on these characters. A stepwise linear regression based on treatments receiving fertilizer in mid-May only (treatments 1-4) showed no relationship between soil mineral nitrogen and the estimated optimal economic input of fertilizer nitrogen (which ranged from 44 to 17 kg N ha^{-1} assuming a price per kg of timothy seed equivalent to the price per kg N in $Ca(NO_3)_2$ multiplied by 2.3). In this regression, tiller number per m^2 in spring was the character most strongly correlated with optimal economic nitrogen input ($r = -0.69$, $p<0.05$).

On average for ten crops, the highest seed yield was obtained with a combination of 25 kg N ha^{-1} in early spring + 50 kg N ha^{-1} in mid-May (Table 1). With only one exception, this combination produced more seed than 75 or 100 kg N ha^{-1} given as one application in mid-May. The superiority of the 25 + 50 kg N ha^{-1} combination was due to a higher number of reproductive tillers, while vegetative tiller number at harvest was lower than for most other treatments (Fig. 1). Weight per unthreshed inflorescence tended to be higher in treatments receiving early nitrogen, but thousand seed weight was lower than in all other treatments except the unfertilized control (Table 1). Lodging on plots receiving early nitrogen did not differ from plots receiving the same total amount of nitrogen in one application (data not shown).

As an overall average, the higher seed yield after an early nitrogen application was associated with more tillers, higher plant dry weight and higher nitrogen concentration in mid-May (Table 1). However, after having applied 25 kg N ha^{-1} in April , the decision whether to apply 50 or 75 kg N ha^{-1} in mid-May could not be assisted by knowledge about soil available nitrogen, tiller density or plant nitrogen ratio at that stage. Raising the input from 25+50 to 25+75 kg N ha^{-1} (treatment 6 vs. 5) was advantageous to seed yield only when the rainfall in July was below 35 mm (regression significant at $p<0.05$).

On plots which had not received nitrogen until in mid-May, application of an additional 25 kg N ha^{-1} at heading elevated seed yield (treatment 7 vs. 2 and treatment 8 vs. 3) if plant nitrogen ratio (N_a/N_c) at that stage was lower than 0.8 (regression significant at $p<0.01$). No similar relationship could be detected for plots which had received early nitrogen (treatment 9 vs. 5).

DISCUSSION

The present research provides no justification for adjusting nitrogen inputs to grass seed crops to soil mineral nitrogen. At the early stages of plant ontogeny, it also seems difficult to relate optimal inputs to various measures of plant nitrogen status. Tiller density and rainfall during the growing season (especially in July) appear to be the most important factors determining optimal nitrogen amount to timothy seed crops.

Compared with crops which did not receive nitrogen until mid-May, crops which had been fertilized in April were earlier and had more and heavier tillers at heading in June. While the development of a high seed yield potential in the former crops still depended on plant nitrogen status at heading, the seed yield potential in crops with an early nitrogen input was probably already determined at that stage. This explains why the effect of additional nitrogen at heading could be related to plant nitrogen ratio only in crops which had not been fertilized until mid-May.

Based on these experiments, the Norwegian recommendations for nitrogen application to timothy seed crops have now been changed from one application in mid-May to a split application with 20-30 kg ha^{-1} in early spring and 40-60 kg ha^{-1} in mid-May.

REFERENCES

Greenwood, D.J, F. Gastal, G. Lemaire, A. Draycott, P. Millard and J.J. Neeteson, 1991. Growth rate and %N of field grown crops. Theory and experiments. Annals of Botany **67**: 181-190.

Nordestgaard, A. 1981. Different times of nitrogen application in the spring in seed production of cocksfoot (*Dactylis glomerata*), red fescue (*Festuca rubra*), smooth-stalked meadowgrass (*Poa pratensis*), timothy (*Phleum pratense*) or small timothy (*Phleum bertolonii*). Tidsskrift for Planteavl **85**: 357-388. (In Danish, with English abstract).

Torskenæs, E. 1986. Nitrogen fertilization of timothy grown for seed. Forskning og forsøk i landbruket **37**, 89-94. (In Norwegian, with English abstract).

Figure 1

Vegetative and reproductive tiller number at seed harvest after various combinations of nitrogen application to timothy seed crops. Average of two experiments in 1994, four experiments in 1995 and three experiments in 1996.

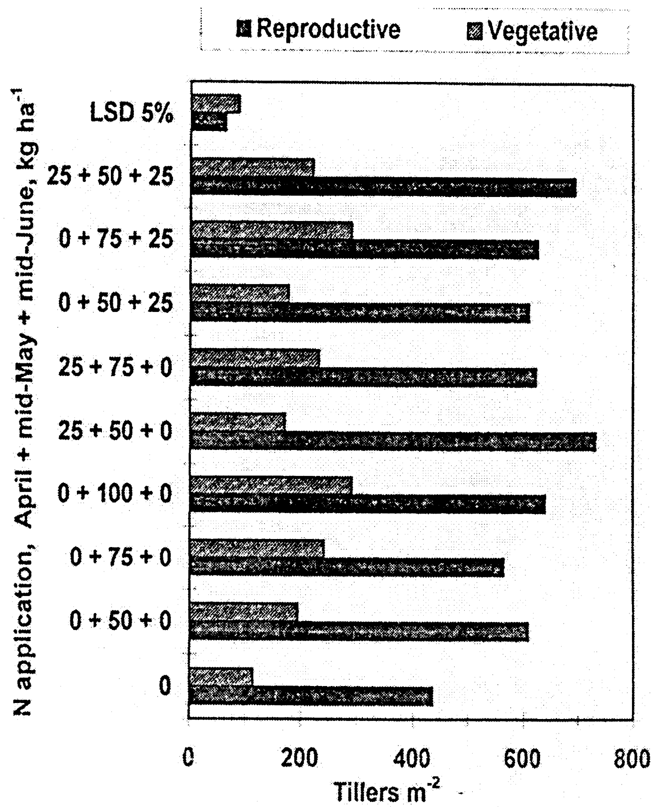

Table 1

Effect of various nitrogen regimes on tiller number, total plant dry weight and nitrogen concentration at various developmental stages and on seed yield, weight per unthreshed inflorescence and thousand seed weight at seed harvest. (Means of ten harvests except for tillers at the start of tiller elongation and heading, which were not counted in the two crops harvested in 1994.)

Nitrogen application, kg ha^{-1}				At the start of tiller elongation (13 - 29 May)			At heading (13-25 June)			At seed harvest (5 -26 Aug)			
Treatment ment. no	As early as [possible 22 Mar-	Late jointing (10-18	Heading (13-20 June)	Tillers, m^{-2}	Dry weight kg ha^{-1}	% N in dry matter	Tillers, m^{-2}	Dry weight kg ha^{-1}	% N in dry matter	Dry wieght, kg ha^{-1}	Seed yield kg ha^{-1}	Weight per unthreshed inflorescence	Thousand seed weight
1	0	0	0	1093	1385	2.1	776	3393	1.3	6554	631	292	663
2	0	50	0	1093	1385	2.1	1045	5025	1.6	9555	871	298	698
3	0	75	0	1093	1385	2.1	1042	5309	1.8	9476	950	284	692
4	0	100	0	1093	1385	2.1	1162	5857	1.9	10554	952	313	698
5	25	50	0	1269	1642	2.6	1107	6080	1.7	10689	1026	309	662
6	25	75	0	1269	1642	2.6	1174	5935	1.8	10750	1003	328	664
7	0	50	25	1093	1385	2.1	1045	5025	1.6	10210	948	287	701
8	0	75	25	1093	1385	2.1	1042	5309	1.8	10856	950	299	691
9	25	50	25	1269	1642	2.6	1107	6080	1.7	11651	1023	305	671
LSD 5%				92	147	0.5	113	630	0.1	1199	72	25	18