Yields, plant characteristics, total N and fibre composition of timothy cultivars grown at two latitudes

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Timothy (*Phleum pratense* L.) cultivars of southern (45°N) and northern (≥60°N) origin were grown in Charlottetown, Prince Edward Island, Canada (46° N) and Jokioinen, Finland (61° N) in two years. Timothy was harvested twice a season and nitrogen applied at 100 or 150 kg/ha. Dry matter yields were higher in Charlottetown than in Jokioinen and northern cultivars outyielded southern cultivars. Nitrogen at 150 kg/ha increased total yields an average of 1.4 t/ha over the 100 kg N/ha rate. The stems and panicles of timothy were longer in Charlottetown. Northern cultivars had longer panicles. The leaf content of cultivars ranged from 139 to 230 g/kg. Northern cultivars had greater N concentrations (22.1 g/kg) in cut 2 than southern timothies (19.7 g/kg). Concentrations of neutral detergent fibre (NDF) and acid detergent fibre (ADF) in cut 1 were lower in Jokioinen. In conclusion, northern cultivars performed well in Charlottetown but there were differences in yield stability among cultivars. Nutritional quality of timothy cultivars varied among the sites and the significance of differences in NDF and ADF in relation to animal performance require further study.

Key words: fibre content, leaves, nitrogen fertilizer, panicle, *Phleum pratense* L., stem

Introduction

Timothy (*Phleum pratense* L.) is a widely grown forage grass in the humid, microthermal regions including northeastern part of north America and Nordic countries. Reasons for timothy's importance include its adaptability as it can be grown successfully under a wide range of soil and climatic conditions. Timothy is winterhardy and under proper management it can persist for several years in its area of adaptation (Pulli 1980, Bélanger et al. 1989). Timothy is usually grown for hay or silage for on-farm feeding and it is also grown for export markets which may have specific requirements for hay quality.

Previous studies on timothy cultivars originating from different latitudes have dealt with
plant growth, digestibility of dry matter, persistence and plant characteristics. In Scotland (55.5°N), Hay (1989) noted that timothy cultivars originating from high (>61°N) latitudes had lower annual dry matter production than cultivars from low latitude (52°N). Winter survival of timothy in Alaska (61.6°N) was the best for cultivars originating from northern, high latitude regions in the Nordic countries (Klebesadel and Helm 1986). Schjelderup et al. (1994) suggested that these high latitude cultivars of timothy are genetically heterogenous for genes governing winter survival. Deinum et al. (1981) found that contrasting timothy cultivars, harvested at the same morphological stage, were more digestible grown at high latitudes than those grown at lower latitudes. The digestibility of early maturing timothy cultivars tends to be greater than that of late maturing cultivars at the same morphological stage (Koch 1976, Mika 1983).

Several factors, such as nitrogen fertilization and harvest management, influence the growth and composition of timothy. Fertilizing timothy with nitrogen increases dry matter production and tissue N concentration (Kunelius et al. 1976, Hunt et al. 1979, Kline and Broersma 1983, Kunelius et al. 1987, Lindgren and Lindberg 1988, Bélanger et al. 1989). A two-cut system for timothy, with harvest at full heading, resulted in high yields and good persistence but N concentration and dry matter digestibility were low in Atlantic Canada (Kunelius et al. 1976, Kunelius and McRae 1987). In Northern Sweden (64°N) Lindgren and Lindberg (1988) concluded that timothy harvested two to four days after heading and fertilized with 100 kg N/ha in spring resulted in herbage with 11.5 MJ ME/kg and 160 g CP/kg in organic matter.

In recent years demand for timothy hay for various uses including export markets has increased. Management systems including timely harvesting and adequate fertilization with nitrogen are required for producing timothy that meets specific criteria for hay quality and appearance. Location can have a significant influence on timothy cultivars (Surprenant et al. 1993) but relatively little is known about plant characteristics and composition of timothy cultivars grown in contrasting environments. Accordingly, the objective of this study was to determine, at two latitudes, the yields, plant characteristics, fibre composition and total N concentration of timothy cultivars of diverse origin and maturities fertilized at two rates of nitrogen.

Material and methods

Experiments were established in Charlottetown, Prince Edward Island, Canada (46°N), and Jokioinen, Finland (61°N). The growing season in Prince Edward Island is about 180 days (>5°C) and it is characterized by a wet, cool spring and fall, and a warm, moist summer with occasional periods of drought (Table 1). The soil in Charlottetown was fine sandy loam, an Orthic Humo-Ferric Podzol, with a pH of 6.4. This soil has a poorly structured fragipan-like subsoil below 60 cm depth which impedes drainage. The growing season in Jokioinen is about 150 days (>5°) with a cool and dry spring, a moist and warm summer and a cool autumn (Table 1). The soil in Jokioinen was sandy clay with a pH of 6.5.

In Charlottetown N, P and K were applied at 25, 44 and 83 kg/ha before seeding in mid-June 1991 and in mid-August at 45, 7 and 37 kg/ha, respectively. In Jokioinen the respective N, P and K rates were 48, 21 and 39 at the time of sowing in mid-July 1991. Timothy was sown at 12 kg/ha with small-plot drill (Wintersteiger, Reid, Austria). Weeds were controlled by clipping in mid-August. The plots measured 1.5 x 5.0 m. The experimental design was a factorial arranged as a randomized block with four replications. The timothy cultivars and their origins are listed in Table 2.

In early May of both production years, P and K were applied at 35 and 66 kg/ha, respectively, in Charlottetown. After cut 1, K was applied at 66 kg/ha. In Jokioinen the respective P and K rates were 45 and 85 kg/ha in May and 35 and
Table 1. Mean monthly temperatures and total precipitation during the first (1992) and second (1993) production years in Charlottetown, Prince Edward Island, Canada and Jokioinen, Finland.

| Month       | Charlottetown Year 1 | Charlottetown Year 2 | Jokioinen Year 1 | Jokioinen Year 2 |
|-------------|----------------------|----------------------|------------------|------------------|
| April       | 13                   | 28                   | 13               | 33               |
| May         | 9.1                  | 8.0                  | 11.4             | 13.6             |
| June        | 14.2                 | 13.8                 | 15.7             | 11.4             |
| July        | 15.8                 | 13.8                 | 16.0             | 15.6             |
| August      | 18.5                 | 13.8                 | 14.3             | 12.9             |
| September   | 14.9                 | 13.7                 | 11.3             | 5.7              |
| October     | 7.5                  | 6.0                  | -0.6             | 3.0              |
| November    | 0.9                  | 2.2                  | -1.8             | -3.6             |

66 kg/ha after cut 1. Nitrogen, as ammonium nitrate, was applied at two rates: 60 in spring and 40 kg/ha after cut 1 (low N) or 90 in spring and 60 kg/ha after cut 1 (high N) at the two sites.

A day before harvest, twenty random stems were cut from each plot for determining panicle length and stem length of timothy cultivars. Green leaves (blade), stems and dead matter were separated and dried at 80°C. Timothy in the primary (cut 1) and secondary growth (cut 2) was harvested with a Haldrup 1500 forage plot harvester (J.Haldrup, Løgstør, Denmark) at the growth stage R 2 – R3 (Moore et al. 1991) when the panicle had emerged. The dates of harvest are given in Table 3. Samples of chopped forage were dried at 90°C to constant weight in a forced air drier. A separate sample was freeze dried and ground through a 1-mm screen for tissue analyses. Total nitrogen concentration was determined by the combustion method (Association of Official Analytical Chemists 1989). Neutral and acid detergent fibres were sequentially fractionated using the procedure outlined by Van Soest (1982).

Table 2. Timothy cultivars and their regions of origin.

| Cultivar     | Latitude, °N | Region          |
|--------------|--------------|-----------------|
| **Southern** |              |                 |
| Climax       | 45           | Ontario, Canada |
| Drummond     | 43           | Quebec, Canada  |
| Glenmor      | 45           | Minnesota, USA  |
| Itasca       | 45           | Minnesota, USA  |
| Richmond     | 44           | Ontario, Canada |
| Timfor       | 45           | Minnesota, USA  |
| Toro         | 45           | Po Valley, Italy|
| Wimnor       | 45           | Minnesota, USA  |
| **Northern** |              |                 |
| Alma         | 61           | Finland         |
| Bottnia II   | 64           | Sweden          |
| Korpa        | 65           | Iceland         |
| Tiiti        | 60           | Finland         |

Table 3. Mean harvest dates of timothy cultivars at full heading stage in the two production years.

| Year | Cut | Cultivar group | Location |
|------|-----|----------------|----------|
| 1    | E†  | L              | 29 June  |
|      |     |                | 8 July   |
| 2    | E   | L              | 27 August|
|      |     |                | 4 September|
| 2    | E   | L              | 3 July   |
|      |     |                | 9 July   |
| 2    | E   | L              | 25 August|
|      |     |                | 7 September|

†E = Itasca, Richmond, Timfor, Toro
L = Climax, Drummond, Glenmor, Wimnor, Alma, Bottnia II, Korpa, Tiiti
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Table 4. Mean dry matter yields (t/ha) of timothy cultivars, yield differences between years and effect of nitrogen fertilizer on yields.

| Cultivar    | Cut 1 Charlottetown | Cut 1 Jokioinen | Cut 2 Charlottetown | Cut 2 Jokioinen |
|-------------|---------------------|-----------------|---------------------|-----------------|
|             | Yield   | Difference † | Yield   | Difference | Yield   | Difference | Yield   | Difference |
| Southern    |          |              |          |            |          |            |          |            |
| Climax      | 7.1     | -2.6         | 2.7     | 1.7        | 3.0     | 0.2         | 2.7     | 2.2         |
| Drummond    | 6.9     | -1.0         | 2.5     | 1.7        | 3.4     | -0.3        | 2.7     | 3.1         |
| Glenmor     | 7.1     | -1.7         | 2.1     | 1.8        | 3.6     | 0           | 2.9     | 3.0         |
| Itasca      | 5.9     | 1.4          | 2.5     | 1.5        | 3.5     | -0.3        | 3.2     | 3.4         |
| Richmond    | 5.4     | 0.8          | 2.8     | 1.8        | 3.7     | -1.0        | 3.5     | 3.5         |
| Timfor      | 5.6     | 1.4          | 2.4     | 1.3        | 3.4     | -0.1        | 3.1     | 3.2         |
| Toro        | 5.1     | 0.5          | 2.4     | 1.3        | 3.4     | -0.4        | 3.4     | 3.5         |
| Winmor      | 6.4     | 0            | 2.4     | 1.7        | 3.1     | 0.3         | 3.0     | 3.1         |
| Northern    |          |              |          |            |          |            |          |            |
| Alma        | 7.6     | -2.7         | 3.3     | 1.5        | 3.1     | 0           | 2.3     | 1.7         |
| Bottn II    | 6.9     | -1.9         | 3.2     | 1.5        | 3.1     | -0.3        | 2.5     | 1.7         |
| Korpa       | 8.0     | -4.2         | 2.6     | 1.7        | 2.6     | 0.1         | 1.7     | 1.2         |
| Tiiti       | 7.1     | -1.2         | 3.5     | 1.1        | 2.9     | 0.1         | 2.9     | 2.1         |
| Mean        | 6.6     | -0.9         | 2.7     | 1.6        | 3.2     | -0.1        | 2.9     | 2.7         |
|             | 0.22    | 0.48         | 0.22    | 0.48       | 0.14    | 0.23        | 0.14    | 0.23        |

N rate, kg/ha

|       | Cut 1 | Cut 2 |
|-------|-------|-------|
| 100   | 6.2   | 2.7   |
| 150   | 6.9   | 3.8   |
|       | 0.19  | 0.06  |
|       | 0.09  | 0.09  |

† Minus (−) denotes lower yield in year 2 than year 1.

Analysis of variance was performed on two-year combined data for each cut. Selected orthogonal contrasts for comparing selected cultivars were calculated using the statistical program GENSTAT 5 (Genstat 5 Committee 1993).

Results

Selected contrasts were calculated and reference is made to significant (P<0.05) site effects between Charlottetown and Jokioinen and for cultivars of southern vs northern origin.

The dry matter (dm) yields of cut 1 were greater in Charlottetown than in Jokioinen (Table 4). The yields in Jokioinen were also considerably greater in year 2 than year 1. Timothy cultivars of northern origin outyielded those of southern origin in cut 1 while in cut 2 the reverse was true. There were significant site x cultivar interactions for dry matter production. In cut 1, dry matter yields among the cultivars ranged from 5.1 to 8.0 t/ha in Charlottetown and from 2.1 to 3.5 t/ha in Jokioinen. Dry matter yields of cut 2 in Charlottetown were from 2.6 to 3.7 t/ha and in Jokioinen from 1.7 to 3.5 t/ha. Yield differences in cut 1 between years varied in Charlottetown; dry matter yield of Winmor was 6.4 t/ha in both years while Korpa, Alma and Climax yielded 2.6 to 4.2 t/ha less in year 2 than 1. In Charlottetown yield differences of cultivars in cut 2 were small but in Jokioinen yields of cut 2 were 1.2 to 3.5 t/ha greater in year 2 than year 1. The dry matter yields of cuts
Table 5. Mean length and differences in length of panicle and stem of timothy at the time of cut 1.

| Cultivar | Panicle. mm | Stem. cm |
|----------|-------------|----------|
|          | Charlottetown | Jokioinen | Charlottetown | Jokioinen |
|          | Length | Difference † | Length | Difference | Length | Difference | Length | Difference |
| Southern | Climax | 71 | 6 | 51 | 1 | 83 | 5 | 64 | -1 |
|          | Drummond | 71 | 5 | 48 | 10 | 80 | 7 | 57 | -1 |
|          | Glenmor | 64 | 11 | 44 | -2 | 85 | 1 | 60 | -4 |
|          | Itasca | 64 | 2 | 41 | 4 | 77 | 3 | 59 | 0 |
|          | Richmond | 64 | 7 | 41 | 5 | 79 | -1 | 65 | 9 |
|          | Timfor | 62 | 16 | 42 | 0 | 75 | 8 | 60 | 0 |
|          | Toro | 61 | 17 | 40 | 3 | 80 | 4 | 64 | 3 |
|          | Winmor | 69 | 9 | 44 | 1 | 83 | 9 | 59 | -4 |
| Northern | Alma | 72 | 7 | 53 | 11 | 82 | 6 | 63 | 1 |
|          | Bottniall | 65 | 9 | 48 | 10 | 84 | 3 | 64 | 0 |
|          | Korpa | 69 | 5 | 45 | 7 | 77 | 6 | 54 | -5 |
|          | Tiiti | 75 | 0 | 51 | 8 | 79 | 6 | 64 | -1 |
| Mean | 67 | 8 | 46 | 5 | 81 | 5 | 61 | 0 |
| sem, n = 8, df = 138 | 2.0 | 3.3 | 2.0 | 3.3 | 1.1 | 2.3 | 1.1 | 2.3 |

N rate, kg/ha

| 100 | 64 | 6 | 45 | 5 |
| 150 | 71 | 10 | 46 | 5 |
| sem, n = 48, df = 138 | 0.8 | 1.3 | 0.8 | 1.3 |

† Minus (−) denotes shorter length in year 2 than year 1.

1 and 2 were 0.4 to 1.1 t/ha greater for the 150 than 100 kg/ha rate of N in two sites (Table 4). Yield increase, due to applied N at 150 kg/ha over 100 kg/ha rate, was greater in Charlottetown than in Jokioinen.

The panicles of timothy were longer in Charlottetown than in Jokioinen (Table 5). Yearly differences in stem lengths of cultivars were small. There was a significant site x cultivar interaction with Drummond, Glenmor, Winmor and Korpa showing greater differences in stem length between the sites than other cultivars. Rates of nitrogen had little effect on the stem length.

Mean leaf content of timothis was similar in Charlottetown and Jokioinen (Table 6). Leaf content among cultivars varied less in Jokioinen than in Charlottetown where the leaf content ranged from 230 g/kg for Timfor to 139 g/kg for Alma. Difference in leaf content between the years was least for Korpa and largest for Timfor. Nitrogen rate did not affect leaf content.

Dead material content of cultivars in Charlottetown ranged from a low of 23 to a high of 48 g/kg for Richmond and Alma, respectively.
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Table 6. Mean leaf and dead matter contents (g/kg) of timothy cultivars at cut 1 and differences in the contents between the years.

| Cultivar       | Charlottetown Leaves | Difference † | Jokioinen Leaves | Difference | Charlottetown Dead matter | Difference |
|----------------|----------------------|--------------|------------------|------------|---------------------------|------------|
| **Southern**   |                      |              |                  |            |                           |            |
| Climax         | 146                  | 4            | 148              | -16        | 42                        | -18        |
| Drummond       | 167                  | -11          | 191              | -40        | 43                        | -21        |
| Glenmor        | 162                  | 4            | 165              | -12        | 39                        | -12        |
| Itasca         | 199                  | -57          | 186              | -30        | 40                        | 12         |
| Richmond       | 199                  | -22          | 171              | -50        | 23                        | -13        |
| Timfor         | 230                  | -78          | 170              | -39        | 34                        | 19         |
| Toro           | 204                  | -29          | 178              | -60        | 24                        | 2          |
| Winmor         | 182                  | -17          | 179              | -1         | 33                        | -13        |
| **Northern**   |                      |              |                  |            |                           |            |
| Alma           | 139                  | -5           | 143              | -35        | 48                        | -21        |
| Bottnia II     | 142                  | -1           | 162              | -31        | 40                        | -18        |
| Korpa          | 151                  | 1            | 156              | -2         | 46                        | -24        |
| Titi           | 153                  | 1            | 160              | -42        | 37                        | -16        |
| Mean           | 167                  | -18          | 167              | -30        | 37                        | -10        |
| sem, n = 8, df = 138 | 7.9  | 12.0   | 7.9              | 12.0       | 3.0                       | 5.6        |
| N rate, kg/ha  |                      |              |                  |            |                           |            |
| 100            | 172                  | -16          | 167              | -28        | 37                        | -9         |
| 150            | 173                  | -20          | 168              | -32        | 37                        | -11        |
| sem, n = 48, df = 138 | 3.2  | 4.9    | 3.2              | 4.9        | 1.2                       | 2.3        |

† Minus (−) denotes lower content in year 2 than year 1.

(Table 6). Dead material of most cultivars was lower in the second year. Southern timothy cultivars had lower dead material content (35 g/kg) than northern cultivars (43 g/kg).

The N concentrations of most timothy cultivars in cuts 1 and 2 were considerably greater in Jokioinen than in Charlottetown (Table 7). In cut 1, total N concentration of timothy cultivars ranged from 9.5 to 12.7 g/kg in Charlottetown and from 13.4 to 16.8 g/kg in Jokioinen. Total N concentrations in cut 2 were from 13.1 to 17.1 g/kg in Charlottetown while in Jokioinen the concentrations were from 18.8 to 26.4 g/kg. Total N in cut 1 was similar in both years. In cut 2 there were, however, large differences in Jokioinen where total N concentrations were greater in year 1. Northern cultivars had greater total N concentrations (22.1 g/kg) in cut 2 than southern timothes (19.7 g/kg). Significant site x N rate interaction in cut 1 was due to greater increase in the N concentration between 100 and 150 kg N/ha rates in Charlottetown than in Jokioinen while in cut 2 the reverse occurred.

Neutral detergent fibre (NDF) concentrations of timothy cultivars in cut 1 were lower in Jokioinen than in Charlottetown while in cut 2 the reverse was true (Table 8). In cut 1, Richmond and Toro were lowest in NDF at both sites. It is also noted that in Jokioinen the southern cultivars in cut 1 were lower in NDF than northern timothy cultivars. In cut 2, there were large differences in NDF of cultivars in Charlottetown where northern cultivars were lowest in NDF. Nitrogen at 150 kg/ha, compared with 100 kg/ha rate, decreased NDF in cut 1 and increased in cut 2 in Charlottetown but not in Jokioinen.
Table 7. Mean nitrogen concentration (g/kg) of timothy cultivars in cuts 1 and 2 and differences in N concentrations between the years.

| Cultivar | Cut 1 | Cut 2 |
|----------|-------|-------|
|          | Charlottetown | Jokioinen | Charlottetown | Jokioinen |
|          | N conc. | Difference † | N conc. | Difference | N conc. | Difference | N conc. | Difference |
| Southern |        |           |        |           |        |           |        |           |
| Climax   | 10.2   | -2.1      | 16.8   | 3.5       | 14.6   | -3.4      | 21.1   | -14.1     |
| Drummond | 11.3   | -0.3      | 15.7   | -0.7      | 14.6   | -3.8      | 19.9   | -17.4     |
| Glenmor  | 10.6   | -0.7      | 15.0   | 0.6       | 13.8   | -3.3      | 18.8   | -14.9     |
| Itasca   | 12.5   | -1.9      | 15.7   | -1.1      | 14.1   | -3.1      | 19.7   | -17.7     |
| Richmond | 12.7   | -1.7      | 13.4   | -1.0      | 14.4   | -0.2      | 18.5   | -17.1     |
| Timfor   | 12.5   | -2.8      | 15.3   | -0.9      | 14.3   | -4.2      | 18.8   | -14.3     |
| Toro     | 12.6   | -1.6      | 14.6   | -2.2      | 14.4   | -1.0      | 20.2   | -18.3     |
| Northern |        |           |        |           |        |           |        |           |
| Winmor   | 10.3   | 0.8       | 14.5   | 0         | 13.1   | -3.7      | 19.1   | -15.5     |
| Alma     | 10.8   | -0.4      | 14.9   | -0.7      | 14.9   | -4.7      | 22.6   | -15.8     |
| Bottnia II | 10.5 | -0.5      | 15.2   | -2.2      | 15.1   | -4.0      | 23.0   | -17.4     |
| Korpa    | 10.8   | -1.0      | 16.0   | 1.1       | 17.1   | -3.2      | 26.4   | -17.3     |
| Tiiti    | 9.5    | -0.4      | 14.7   | 1.0       | 14.6   | -3.9      | 21.0   | -14.8     |
| Mean     | 11.2   | -1.1      | 15.2   | -0.2      | 14.6   | -3.2      | 20.8   | -16.2     |
| sem, n = 8, df = 138 | 0.44 | 0.95 | 0.44 | 0.95 | 0.44 | 0.85 | 0.44 | 0.85 |
| N rate, kg/ha |        |           |        |           |        |           |        |           |
| 100      | 10.2   | -1.8      | 14.6   | -0.7      | 14.3   | -3.8      | 19.6   | -15.5     |
| 150      | 12.2   | -0.3      | 15.7   | 0.3       | 14.9   | -2.6      | 22.0   | -16.9     |
| sem, n = 48, df = 138 | 0.18 | 0.36 | 0.18 | 0.36 | 0.18 | 0.35 | 0.18 | 0.35 |

† Minus (−) denotes lower concentration in year 2 than year 1.

Acid detergent fibre (ADF) of timothy in cut 1 was lower in Jokioinen than in Charlottetown (Table 9). Differences among cultivars within sites and between the years were up to 38 g/kg. In cut 2, ADF of Toro and Timfor varied more among the sites than ADF of other cultivars. Northern cultivars were consistently low in ADF in both sites.

Hemicellulose concentration of timothy was greater in Jokioinen than in Charlottetown (Table 10). The rates of N had little effect on hemicellulose concentration in timothy. Toro in cut 1 was low in hemicellulose in both sites while Drummond and Tiiti were high in hemicellulose. In cut 2, Toro and Alma were the lowest in hemicellulose in Charlottetown. In Jokioinen the four northern cultivars were higher in hemicellulose than southern timothies.

Discussion

Timothy is adapted to the growing conditions of microthermal regions such as Atlantic Canada and Nordic countries. In this study all timothy cultivars persisted in Charlottetown and Jokioinen where the overwintering conditions were quite severe with minimum air temperatures exceeding -20°C. Under harsh overwintering conditions in Alaska, Klebesadel and Helm (1986) found that wintersurvival of timothy was correlated with the latitude of cultivar origin, with northernmost cultivars being superior to those of more southern origin. In our study there were, however, differences in the dry matter yields of timothy cultivars; dry matter yields of the primary growth were much greater in Charlottetown.
Table 8. Mean neutral detergent fibre (NDF) concentration (g/kg) of timothy cultivars in cuts 1 and 2 and differences in NDF between the years.

| Cultivar | Charlottetown Cut 1 | Jokioinen | Charlottetown Cut 2 | Jokioinen |
|----------|----------------------|-----------|----------------------|-----------|
|          | NDF | Difference † | NDF | Difference | NDF | Difference | NDF | Difference |
| Southern |      |            |      |            |      |            |      |            |
| Climax   | 692 | 53         | 613 | 22        | 594 | 22         | 633 | -4        |
| Drummond | 703 | 54         | 637 | 58        | 604 | 14         | 637 | -19       |
| Glenmor  | 697 | 36         | 609 | -14       | 616 | 29         | 637 | -31       |
| Itasca   | 690 | 44         | 608 | 37        | 621 | 28         | 633 | -16       |
| Richmond | 680 | 34         | 597 | 27        | 628 | 21         | 632 | -56       |
| Timfor   | 696 | 50         | 612 | 6         | 628 | 28         | 641 | -16       |
| Toro     | 679 | 40         | 586 | 13        | 625 | 31         | 631 | -14       |
| Winnmor  | 696 | 33         | 614 | -5        | 605 | 11         | 638 | -46       |
| Northern |      |            |      |            |      |            |      |            |
| Alma     | 684 | 49         | 630 | 54        | 578 | 14         | 643 | -14       |
| Bottnia II | 674 | 62        | 619 | 63        | 580 | 15         | 629 | -21       |
| Korpa    | 695 | 57         | 617 | 38        | 577 | 8          | 619 | -33       |
| Tiiti    | 689 | 57         | 625 | 58        | 570 | 0          | 644 | 1         |
| Mean     | 690 | 47         | 614 | 30        | 602 | 18         | 635 | -22       |
| sem, n = 8, df = 138 | 4.6 | 8.6 | | | 5.0 | 10.5 | | |
| N rate, kg/ha |      |            |      |            |      |            |      |            |
| 100      | 697 | 47         | 615 | 29        | 590 | 0          | 633 | -32       |
| 150      | 683 | 48         | 612 | 31        | 615 | 37         | 637 | -13       |
| sem, n = 48, df = 138 | 1.9 | 3.5 | | | 2.1 | 4.3 | | |

† Minus (−) denotes lower concentration in year 2 than year 1.
two sites with differences in dry matter yields of cut 1 being greater in Charlottetown than in Jokioinen. Niemeläinen and Rinne (1992) reported that in several experiments in southern Finland Tiiti, a northern cultivar, outyielded Climax, a southern cultivar, particularly in the first cut. In this study we did not observe such differences. In Scotland (55.5° N) high-latitude timothy (origin 69° N) had lower yields in early spring and autumn than low-latitude (52°N) timothy while in late spring the reverse was true (Hay 1989). It is noted that the most stable cultivars, with the least difference in the dry matter yields between the two years, were Winmor in Charlottetown and the four northern timothy in Jokioinen. Klebesadel and Helm (1986) noted similar differences in the adaptation of southern and northern timothies in Alaska. Nitrogen applied at 90 kg/ha increased the dry matter yields over the 60 kg/ha rate concurring with previous findings (Kunelius et al. 1976, Lindgren and Lindberg 1988).

Plant characteristics varied considerably between Charlottetown and Jokioinen. The panicles were longer and applied N had greater effect on panicle length under shorter days in Charlottetown than in Jokioinen which is in agreement with Ryle and Langer (1963). Tiiti, Alma and Climax had longest panicles at both sites. The stem length was also greater in Charlottetown than in Jokioinen but nitrogen rate had little effect on stem length. Balasko and Smith

Table 9. Mean acid detergent fibre (ADF) concentration (g/kg) of timothy cultivars in cuts 1 and 2 and differences in ADF between the years.

| Cultivar | Cut 1 | Cut 2 |
|----------|-------|-------|
|          | Charlottetown | Jokioinen | Charlottetown | Jokioinen |
|          | ADF | Difference † | ADF | Difference | ADF | Difference | ADF | Difference |
| Southern | | | | | | | |
| Climax   | 391 | 19 | 271 | 17 | 301 | 23 | 291 | 47 |
| Drummond | 396 | 31 | 276 | 17 | 300 | 12 | 302 | 19 |
| Glenmor  | 400 | 12 | 264 | 0 | 315 | 10 | 303 | 12 |
| Itasca   | 395 | 38 | 265 | 18 | 329 | 13 | 302 | 17 |
| Richmond | 383 | 26 | 260 | 12 | 333 | 7 | 297 | 12 |
| Timfor   | 390 | 33 | 263 | 5 | 335 | 24 | 289 | 34 |
| Toro     | 388 | 27 | 252 | 17 | 339 | 20 | 294 | 34 |
| Winmor   | 399 | 19 | 268 | 1 | 317 | 22 | 315 | 5 |
| Northern | | | | | | | |
| Alma     | 377 | 30 | 281 | 12 | 287 | 7 | 282 | 2 |
| Bottnia II | 373 | 33 | 267 | 23 | 288 | 14 | 290 | 29 |
| Korpa    | 382 | 26 | 273 | 10 | 285 | 11 | 258 | 16 |
| Tiiti    | 387 | 27 | 268 | 17 | 284 | 10 | 287 | 1 |
| Mean     | 388 | 27 | 267 | 11 | 309 | 15 | 292 | 2 |
| sem, n = 8, df = 138 | 3.4 | 6.4 | 3.4 | 6.4 | 5.8 | 11.3 | 5.8 | 11.3 |
| N rate, kg/ha | | | | | | | |
| 100      | 392 | 28 | 269 | 11 | 290 | 2 | 290 | 0 |
| 150      | 384 | 26 | 266 | 11 | 295 | 27 | 295 | 4 |
| sem, n = 48, df = 138 | 1.4 | 2.6 | 1.4 | 2.6 | 2.4 | 4.6 | 2.4 | 4.6 |

† Minus (−) denotes lower concentration in year 2 than year 1.
Table 10. Mean hemicellulose concentration (g/kg) of timothy cultivars in cuts 1 and 2 and differences in hemicellulose concentrations between the years.

| Cultivar       | Cut 1          | Cut 2          |
|----------------|----------------|----------------|
|                | Charlottetown  | Jokioinen      | Charlottetown  | Jokioinen      |
|                | Hemi-          | Difference †  | Hemi-          | Difference    |
|                | cellulose     |                | cellulose     |                |
| Southern       |               |                |               |                |
| Climax         | 281           | 11             | 329           | 20             |
| Drummond       | 298           | 21             | 351           | 44             |
| Glenmor        | 285           | 16             | 330           | 6              |
| Itasca         | 291           | 19             | 326           | 23             |
| Richmond       | 285           | 4              | 325           | 13             |
| Timfor         | 290           | 1              | 330           | 6              |
| Toro           | 283           | 8              | 317           | 5              |
| Winmor         | 285           | 2              | 329           | 3              |
| Northern       |               |                |               |                |
| Alma           | 289           | 1              | 337           | 41             |
| Bottnia II     | 286           | 20             | 346           | 48             |
| Korpa          | 297           | 13             | 335           | 32             |
| Tiiti          | 290           | 15             | 348           | 36             |
| Mean           | 288           | 11             | 334           | 22             |
| sem, n = 8, df = 138 | 3.1        | 6.5            | 3.1           | 6.5            |

| N rate, kg/ha | 100  |                | 150  |                |
|               | 292  | 12             | 285  | 10             |
| sem, n = 48, df = 138 | 1.3  | 2.7            | 1.3  | 2.7            |

† Minus (−) denotes lower concentration in year 2 than year 1.

(1971) found that N fertilization increased both panicle length and stem length of timothy. Among cultivars Itasca and Bottnia II had least difference in stem length in the two years.

In this study the leaf content of timothies was similar in the two sites but leafiness among cultivars varied less in Jokioinen than in Charlottetown. These results concur partially with the findings by Heide et al. (1985) who showed that long-day stimulation, in comparison with very short (8 h) day conditions, increased the plant height and leaf area of high latitude timothy (origin 69°N). Nitrogen fertilization has been shown to increase the leaf area of timothy (Balasko and Smith 1971) but in this study the nitrogen rates had no effect on leaf content.

It is noted that differences in plant maturity were negligible in Jokioinen while maturity differences were up to 10 days in Charlottetown. There is limited information on the maturity of timothy cultivars grown at different latitudes but field observations indicate small differences in maturity of timothy cultivars at northern latitudes (>60°N). Phytotron studies of Hay and Pedersen (1986) suggest that under long-day conditions timothy cultivars of varying latitudinal origin responded to photoperiodic stimulation of dry matter production in a similar way. There were, however, differences in stem apex development as low latitude cultivars S48 and Motim had more uniform reproductive development than high latitude cultivar Engmo. In Alaska
Klebesadel (1970) found that anthesis progressed earliest on northernmost-adapted strains of timothy and bromegrass (*Bromus inermis* Leyss.), and followed on successively later dates with progressively more southerly adapted strains. In Jokioinen the day length is about 19 hours in June during the period for primary growth and there were no marked differences in maturity of the timothy cultivars included in this study.

The fibre concentrations of timothy cultivars varied between the two sites. The NDF concentrations of timothy cultivars in cut 1 were, on average, 76 g/kg lower in Jokioinen than in Charlotte-town. Similarly, mean ADF concentration was 121 g/kg lower in Jokioinen than Charlotte-town. These effects are large enough to have influence on the performance of animals consuming such forages. Previous work on forage species grown at different latitudes has demonstrated differences in the composition of timothy. Deinum et al. (1981) found that digestibility of organic matter of timothy declined faster at higher latitudes but, at similar morphological maturity, digestibility of the whole crop was greater at high than low latitude sites.

This study indicates that dry matter yields, plant characteristics and fibre composition were site dependent for the cultivars. Both southern and northern cultivars grew well in Charlotte-town particularly in primary growth but there were large differences in yield stability among cultivars. In Jokioinen locally developed northern cultivars outyielded southern cultivars in primary growth. The significance of observed differences in NDF and ADF in relation to the performance of ruminants (Mason and Flipot 1988) and horses (Maeta et al. 1992) require further study.

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Pohjoista (≥ 60°N) ja eteläistä (46°N) alkuperää olvia timotei (Phleum pratense L.) lajikkeita tutkittiin Jokioisissa ja Prinssi Edwardin Saarella Kanadassa. Timotei niitettiin kahdesti kasvukauden aikana typpilannouksen ollessa 100 tai 150 kg/ha.

Kuiva-ainesadot olivat suuremmat Kanadassa ja pohjoiset lajikkeet olivat satoisampia. Typpilannousitus lisäsi satoa 1 400 kg/ha. Timotein korret ja tähkät olivat pitempiä Kanadassa, ja molemmissa tutkimuskohteissa pohjoisten lajikkeiden tähkät olivat pitkäistä. Lehtipitoisuus vaihteli 139 g/kg ja 230 g/kg välillä. Pohjoiset lajikkeet olivat typpipitoisempia (22,1 g/kg) kuin eteläiset lajikkeet (19,7 g/kg). Ensimmäisessä niitossa NDF- ja ADF-pitoisuudet olivat alhaisempia Jokioisissa, missä myös eteläisten lajikkeiden NDF oli alhaisempi. Suurimmat lajikkeiden väliset erot ADF-pitoisuudessa olivat 29 g/kg ensimmäisessä nitossa ja 57 g/kg toisessa nitossa.

Tämä tutkimus osoittaa, että pohjoista alkuperää olevat timoteilajikkeet olivat satoisia myös huomattavasti eteläisemmällä leveysasteella. Pohjoismaiden kasvinjalostajilla voisi siten olla mahdollisuksia kehittää nurmiheinälajikkeita esimerkiksi Pohjois-Amerikan alueille, missä ilmastolliset olosuhteet ovat samanlaisia.