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

H. Tapani Kunelius

Research Centre, Agriculture and Agri-Food Canada, Charlottetown, Prince Edward Island, Canada, C1A 7M8

Pertti Pärssinen

Boreal Plant Breeding, Myllytie 10, FIN-31600 Jokioinen, Finland

Seppo K. Pulli

Agricultural Research Centre of Finland, Institute of Crop and Soil Science, FIN-31600 Jokioinen, Finland

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 adabtability 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

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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 occassional 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

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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.

	Mean temperature, °C						Precipitation, mm					
	Charlottetown			Jokioinen			Charlottetown			Jokioinen		
	Year 1	Year 2	30 yr mean	Year 1	Year 2	30 yr mean	Year 1	Year 2	30 yr mean	Year 1	Year 2	30 yr mean
April	1.3	2.8	2.7	1.3	3.3	2.4	49	147	88	48	29	31
May	9.1	8.0	9.2	11.4	13.6	9.4	60	102	90	7	7	35
June	14.2	13.8	14.8	15.7	11.4	14.3	81	99	88	25	56	47
July	15.8	16.3	18.8	16.0	15.6	15.8	162	89	78	47	107	80
August	18.5	18.3	18.4	14.3	12.9	14.2	160	28	90	107	136	83
September	14.9	13.7	14.0	11.3	5.7	9.4	32	70	92	59	13	65
October	7.5	6.0	8.6	–0.6	3.0	4.7	146	162	112	64	51	58
November	0.9	2.2	3.1	–1.8	–3.6	–0.5	94	93	115	63	3	55

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, Løgstor, 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
Winmor	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: Charlottetown	Location: Jokioinen
1	1	E †	29 June	29 June
		L	8 July	29 June
	2	E	27 August	4 September
		L	4 September	4 September
2	1	E	3 July	23 June
		L	9 July	23 June
	2	E	25 August	9 September
		L	7 September	9 September

†E = Itasca, Richmond, Timfor, Toro
L = Climax, Drummond, Glenmor, Winmor, Alma, Bottnia II, Korpa, Tiiti

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				Cut 2			
	Charlottetown		Jokioinen		Charlottetown		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	3.1	3.2
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
Bottnia 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
sem, n = 8, df = 138	0.22	0.48	0.22	0.48	0.14	0.23	0.14	0.23
N rate, kg/ha								
100	6.2	–0.8	2.5	1.3	2.7	–0.6	2.5	2.4
150	6.9	–1.0	2.9	1.8	3.8	0.3	3.2	2.9
sem, n = 48, df = 138	0.09	0.19	0.09	0.19	0.06	0.09	0.06	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

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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
Bottnia II	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	81	5	61	0
150	71	10	46	5	80	4	61	0
sem, n = 48, df = 138	0.8	1.3	0.8	1.3	0.4	0.9	0.4	0.9

† 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). Tiiti had the longest panicles and Toro the shortest panicles. The largest year to year difference of 17 mm in panicle length was for Toro in Charlottetown. Northern cultivars of timothy had slightly longer panicles at 59 mm than southern cultivars at 55 mm. There was a significant site x N rate interaction; panicles were 7 mm longer in Charlottetown, and only 1 mm longer in Jokioinen for the 150 than 100 kg N/ha rate.

The stems of timothy in cut 1 were, on average, 20 cm taller 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 timothies 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

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		Jokioinen		Charlottetown	
	Leaves	Difference †	Leaves	Difference	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
Tiiti	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 timothies 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 Charlottettown 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 timothies (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 occured.

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 timothies. 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.

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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	Cut 1				Cut 2			
	Charlottetown		Jokioinen		Charlottetown		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	629	–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
Winmor	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	4.6	8.6	5.0	10.5	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	1.9	3.5	2.1	4.3	2.1	4.3

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

than in Jokioinen. The dry matter yields in Jokioinen were also low in comparison with annual timothy yields of over 9 t/ha in trials conducted in several sites in southern Finland (Niemeläinen and Rinne 1992). A likely reason for low dry matter yields in Jokioinen was low precipitation, particularly, in the spring of year 1 (Table 1) which reduced the growth of timothy. In year 2, rainfall in May was again low in Jokioinen and temperature in June was below normal resulting in slow growth of all timothy cultivars of southern and northern origin. Björnsson and Helgadottir (1988) estimated the temperature effects on annual dry matter yield of cool season grasses at 644 kg/ha/°C. In previous studies timothy has usually had greater dry matter production at high than low latitudes (Deinum et al. 1981). The period for primary growth of timothy in Charlottetown and Jokioinen is between mid-May and late June. During long daylight conditions, requirements for the photoperiodic stimulation of all the cultivars at the primary growth were likely met (Heide 1982, Ryle and Langer 1963) as the daylengths in the middle of May and June are 17.2h and 19.1h in Jokioinen, and 14.9h and 15.7h in Charlottetown, respectively. It appears that low precipitation and lower than normal temperature during this period reduced the growth of timothy in Jokioinen.

Timothy cultivars of northern and southern origin had similar dry matter yields on average. Cultivars responded, however, differently at the

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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	1	301	23	291	4
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	–1
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.

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 timothies 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 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-cellulose	Difference †	Hemi-cellulose	Difference	Hemi-cellulose	Difference	Hemi-cellulose	Difference
Southern								
Climax	281	11	329	20	280	2	316	–19
Drummond	298	21	351	44	288	2	304	–28
Glenmor	285	16	330	–6	283	14	296	–41
Itasca	291	19	326	23	275	11	307	–34
Richmond	285	4	325	13	276	1	297	–30
Timfor	290	1	330	6	279	8	299	–22
Toro	283	8	317	5	272	4	307	–18
Winmor	285	2	329	3	283	5	295	–31
Northern								
Alma	289	1	337	41	273	4	330	0
Bottnia II	286	20	346	48	275	1	329	–18
Korpa	297	13	335	32	276	5	332	–2
Tiiti	290	15	348	36	276	–5	326	17
Mean	288	11	334	22	278	3	311	–19
sem, n = 8, df = 138	3.1	6.5	3.1	6.5	3.1	6.7	3.1	6.7
N rate, kg/ha								
100	292	12	333	20	278	–2	310	–22
150	285	10	333	24	278	9	312	–15
sem, n = 48, df = 138	1.3	2.7	1.3	2.7	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 neglible 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 amd Motim had more uniform reproductive development than high latitude cultivar Engmo. In Alaska

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(61.5°) 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 Charlottetown. Similarly, mean ADF concentration was 121 g/kg lower in Jokioinen than Charlottetown. 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 compositon of timothy. Deinum et al. (1981) found that digestibility of organic matter of timothy declined faster at higher latitudes but, at similar morphological maturities, 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 Charlottetown 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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SELOSTUS

Timoteilajikkeiden sadot, kasvuominaisuudet sekä typpi- ja kuitupitoisuus kahdella leveysasteella

H. Tapani Kunelius, Pertti Pärssinen ja Seppo K. Pulli
Agriculture and Agri-Food Canada, Boreal Suomen Kasvinjalostus ja Maatalouden tutkimuskeskus

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

Kuiva-ainesadot olivat suuremmat Kanadassa ja pohjoiset lajikkeet olivat satoisampia. Typpilannoitus lisäsi satoa 1 400 kg/ha. Timotein korret ja tähkät olivat pitempiä Kanadassa, ja molemmissa tutkimuskohteissa pohjoisten lajikkeiden tähkät olivat pitempiä. 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 niitossa ja 57 g/kg toisessa niitossa.

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