Seasonal Distribution of Forage Yield and Winter Hardiness of Grasses from Diverse Latitudinal Origins Harvested Four Times Per Year in Southcentral Alaska

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Summary

Objectives were to compare under intensive utilization (high fertility, four harvests per year, supplemental irrigation) total forage production, seasonal distribution, and winter hardiness among 12 subarctic-adapted and three mid-temperate-adapted strains of Kentucky bluegrass (*Poa pratensis* L.); four subarctic-adapted strains of red fescue (*Festuca rubra* L.); two mid-temperate-adapted cultivars of red fescue, one of chewings fescue (*F. rubra* var. *commutata* Gaud.) and one of hard fescue (*F. ovina* var. *duriuscula* [L.] Koch); and three tall-growing, northern-adapted forage grass cultivars: Polar hybrid bromegrass (predominantly *Bromus inermis* Leyss. x *B. pumpellianus* Scribn.), Garrison creeping foxtail (*Alopecurus arundinaceus* Poir.), and Engmo timothy (*Phleum pratense* L.).

The study was conducted over three years at the Matanuska Research Farm (61.6°N) near Palmer in subarctic, southcentral Alaska. Mean harvest dates during the two years were 11 June, 9 July, 14 August, and 25 September.

- The seven mid-temperate-adapted cultivars of fescue and Kentucky bluegrass were inadequately winter-hardy, producing low yields during the first year and none during the second year; the sole exceptions were Troy Kentucky bluegrass and Durar hard fescue which produced some forage during the second harvest year, but those yields were very low also.

- Of the tall-growing grasses, Polar bromegrass and Garrison creeping foxtail were more winter-hardy than Engmo timothy; the latter sustained severe winter injury during the second winter. Polar bromegrass showed slightly poorer winter survival than the most winter-hardy strains of Kentucky bluegrass.

- Considerable differences in winter hardiness were noted among the subarctic-adapted strains of Kentucky bluegrass and red fescue, and the best of those produced higher yields with more even distribution than the commonly used taller-growing forage grasses.

- Yield distribution of Polar was uneven; it produced high yields in the first and third harvests, but was the least productive of all northern-adapted grasses in the second (early July) harvests.

- All grasses were low yielding at the fourth harvest (late September) in both years, despite the final growth period being longer than the others.

- The winter-hardy subarctic-adapted strains of Kentucky bluegrass and red fescue produced evenly distributed, high yields of forage under intensive utilization.

Introduction

Relatively short growing seasons at subarctic latitudes require maximum efficiencies in production of forages during the brief growing period. This is necessary to provide adequately for livestock feeding requirements both during the growing season and for preserved forages for use during the relatively longer infeeding period. As elsewhere, forages in Alaska are utilized in several ways; these include (a) usually two harvests per year for preservation as silage, haylage, or hay, (b) more frequent harvests for green-chop feeding, and (c) pasturing rotationally or continuously. Various crop species utilized for forage differ in growth characteristics as well as in their responses to various harvest procedures and schedules; therefore it is understandable that a number of species can be advantageously employed for forage production in Alaska, each to fulfill ideally one of the several ways that forages are utilized.

Another limitation affecting forage production in the far north is the modest number of useful perennial legume and grass species and strains adequately winter-hardy to persist dependably under northern climatic constraints (Klebesadel 1970, 1971, 1985; Klebesadel et al. 1964; Wilton et al. 1966).

Tall-Growing Grasses

Grass species differ considerably in growth form. Tall-growing grasses are defined as those that when full grown have elevated many to most of their leaves well above the base of the plants on tall-growing culms (stems). When tall-growing grasses are harvested, all or most of the photosynthetic capability (leaves and leaf sheaths) is removed as harvested forage (Smith and Nelson 1985). Tall-growing grasses used in this study were smooth bromegrass, creeping foxtail, and timothy.

Bromegrass

Smooth bromegrass (*Bromus inermis* Leyss.), native to Eurasia, is a tall-growing species that spreads by underground stems, called rhizomes, to form a sod. It is the perennial grass currently most used for forage production in southcentral Alaska. The very winter-hardy cultivar Polar, developed in Alaska, traces predominantly to smooth bromegrass, but it also incorporates some germplasm derived from native North American pumpelly bromegrass (*B. pumpellianus* Scribn.) (Hodgson et al. 1971a).

Bromegrass is utilized as pasture and is harvested for green feeding or preserved forage. With two harvests per year, the most winter-hardy cultivars of bromegrass usually persist dependably. However, with more frequent harvests, as is typical with green-chop operations, bromegrass stands can be weakened and predisposed to subsequent winter injury or to total winter kill, especially if the winter stresses are unusually severe (Unpublished data, Alaska Agricultural and Forestry Experiment Station).

Creeping Foxtail

Creeping foxtail (*Alopecurus arundinaceus* Poir.) is a tall-growing, strongly rhizomatous perennial grass native to Europe and Asia (Stroh et al. 1978). It is closely related to meadow foxtail (*A. pratensis* L.), a more commonly known bunch-type grass that somewhat resembles timothy in appearance. Due to some similarity in their common names, creeping foxtail may also be confused with the very unpalatable grass called foxtail barley (*Hordeum jubatum* L.), a prolific and weedy species that occurs commonly along roadsides and on other disturbed areas in Alaska.

Garrison, a cultivar of creeping foxtail selected from naturalized stands in North Dakota (Stroh et al. 1978), has been compared with various grasses in other tests in this area of Alaska; some data on its performance in other tests have been discussed in previous reports (Klebesadel and Dofing 1990; Mitchell 1982, 1986, 1987).

Timothy

Timothy (*Phleum pratense* L.), a species introduced into North America from Europe, also is classed as a tall-growing grass. Unlike the rhizomatous (sod-forming) growth of smooth bromegrass and creeping foxtail, however, timothy is a bunch-type grass.

Many timothy cultivars have been developed and released to growers by plant breeders in North America and in Europe (Hanson 1972). North American cultivars generally produce tall growth for both the first and second harvests in two-cut management in Alaska; however, the far-northern-adapted Norwegian cultivar Engmo used in this study produces tall growth only in the first crop of the season. After the first cutting, Engmo does not produce another crop of elongated heading culms but instead produces mostly a dense, low-growing, very leafy aftermath (Klebesadel and Helm 1986).

Short-Growing Grasses

In contrast to the taller-growing grasses, adapted cultivars of shorter-growing grasses such as Kentucky bluegrass (*Poa pratensis* L.) and red fescue (*Festuca rubra* L.), when maintained as turf, can be clipped as often as weekly and persist well locally. These grasses, with most leaves arising from the basal area of the plant, retain an abundance of leaves below the height of defoliation, enabling them to continue uninterrupted photosynthetic activity throughout the growing season despite frequent, close clipping.

Kentucky Bluegrass

Kentucky bluegrass is considered a valuable pasture grass in North America, although usually it is not seeded artificially but appears and spreads as a volunteer in forage stands (Duell 1985; Hanson 1972; Smith et al. 1986). It ordinarily is not utilized as a machine-harvested forage, except as included as a volunteer element in tall-grass mixtures. Artificially dried and pelletized Kentucky bluegrass clippings produced as a by-product during the development of sod for market are utilized as a poultry feed (Duell 1985). A major drawback to utilization of this species as a harvested forage or pasture in much of the United States is its characteristically low mid-season productivity where hot, dry weather induces summer dormancy (Duell 1985; Smith et al. 1986).

Various strains and cultivars of Kentucky bluegrass differ considerably in winter hardiness in Alaska (Klebesadel et al. 1964; Klebesadel 1984); the most winter-hardy generally are adapted at northern latitudes and derive from areas where winter stresses tend to be severe. The Kentucky bluegrass cultivar Nugget was selected and released by the Alaska Agricultural Experiment Station (Hodgson et al. 1971b); it is extremely winter-hardy but is semi-dwarf in growth form. There has been some conjecture that taller-growing, longer-leaved forms of Kentucky bluegrass might be superior to Nugget in forage production.

Red Fescue

Red fescue is used principally as a turf or soil stabilization grass in the U.S. and Canada and it is not considered a major forage crop (Buckner 1985; Hanson 1972). However, this species can be productive of forage (Elliott and Baenziger 1973), and the cultivar Arctared is winter-hardy in Alaska (Hodgson et al. 1978; Klebesadel 1985; Mitchell 1982). Mitchell (1972) at this location reported that red fescues and bluegrasses ranked high in herbage production among 19 grasses grown in rows and clipped five times vs. twice per year.

In forage breeding and management programs at this station, numerous grasses have been collected and evaluated for agronomic potential for turf, forage, and conservation purposes. Seed increased from several lines of Kentucky bluegrass and red fescue earlier determined to be winter-hardy, disease-resistant, and productive of herbage was used to establish those grasses in this study. Often it is impossible to determine whether grasses collected in Alaska, that prove to be well adapted and winter-hardy, are truly native or were introduced and have become naturalized (Hodgson et al. 1971b, 1978; Mitchell 1972, 1982). Taxonomists (Hulten 1968; Porsild and Cody 1980; Welsh 1974) are in general agreement that Kentucky bluegrass was introduced into Alaska but that red fescue is native here and elsewhere in the circumpolar region.

This Study

The objective of this investigation was to compare winter hardiness, total forage production and yield distribution of subarctic versus mid-temperate-adapted strains of Kentucky bluegrass and red fescue, and local standard varieties of tall-growing forage grasses. The experiment was conducted under conditions of intensive management (high N fertility, four cuttings per year, and supplemental irrigation applied when precipitation was judged to be inadequate for optimum grass growth). The study was conducted at the University of Alaska's Matanuska Research Farm (61.6°N) in the Matanuska Valley of southcentral Alaska.

Experimental Procedures

Soil in the experiment site was Knik silt loam (coarse-silty over sandy or sandy-skeletal, mixed, nonacid Typic Cryochrept). Commercial fertilizer disked into the plowed seedbed prior to planting supplied nitrogen (N), phosphorus (as P_2O_5), and potassium (as K_2O) at 32, 128, and 64 lb/acre, respectively.

All grasses were broadcast-seeded 19 June 1974 without a companion crop in individual field plots measuring 5 x 20 ft. in a randomized complete block experimental design with four replications. Fifteen Kentucky bluegrasses seeded at 18 lb/acre included subarctic-adapted cultivars Nugget from Alaska, Atlas from Sweden, one unnamed, numbered line (412) from Iceland, and nine numbered lines collected within Alaska (bearing "AK" prefix); three mid-temperate-adapted cultivars were Delta from Canada, and Troy and Merion from the conterminous United States.

Six red fescues, also seeded at 18 lb/acre, included cultivars Arctared, Boreal, and Pennlawn, and three numbered Alaska selections. Two other fine-leaved fescue cultivars were Highlight chewings fescue (*F. rubra* var. *commutata* Gaud). and Durar hard fescue (*F. ovina* var. *duriuscula* (L.) Koch). Three tall-growing cultivars planted for comparison purposes were Polar bromegrass at 22 lb/acre, Engmo timothy at 6 lb/acre, and Garrison creeping foxtail at 16 lb/acre.

Four forage harvests were taken in both 1975 and 1976 on dates indicated in Table 1. In all harvests, yields were derived from a 2.5 x 17.5-ft. swath harvested from the centerline of each plot and leaving a two-inch stubble. Small, bagged samples from each plot were dried to constant weight at 140°F; all yields are reported on the oven-dry basis.

Fertilizer applied as spring top dressing on 23 April

1975 and 7 April 1976 supplied N, P_2O_5, and K_2O at 126, 96, and 48 lb/acre, respectively, each year. Ammonium nitrate applied 13 June and 10 July 1975 and 11 June and 13 July 1976, shortly after the first and second forage harvests each year, supplied N at 85 lb/acre at each application.

During the growing period May through September, precipitation in 1974 and 1975 was 6.1 inches and 9.6 inches, respectively; normal for that period is 9.8 inches. Two sprinkler irrigations in 1974 (24 June and 24 Aug.) and one in 1975 (10 July) supplied supplemental water to bring totals to approximately 10 inches both years.

Results and Discussion

The relatively late seeding date resulted in low seeding-year forage yields of all grasses (Table 1). As a group, the subarctic-adapted red fescues were lower in yield than the other categories of entries.

Winter Hardiness

Considerable differences in winter injury were noted each spring, both among and within species and adaptation groupings (Table 2). A considerable range of hardiness was noted within both subarctic-adapted groups of short-growing grasses and also among the three tall grasses. Two subarctic-adapted bluegrasses, AK-69-3 and AK-69-28, were extremely winter-hardy and showed no indication of winter injury either spring. The most-injured northern-adapted Kentucky bluegrass was Atlas from Sweden, a northern country but one with relatively mild winter stresses.

The red fescue line AK-67-52-2 was extremely winter-hardy, with a tendency toward less winter injury than the very winter-hardy cultivar Arctared, although the differences were not statistically significant (Table 2). The other two Alaska lines of red fescue showed considerably greater winter injury than AK-67-52-2 or Arctared.

Estimated winter injury of Polar bromegrass and Garrison creeping foxtail was modest during both winters and the grasses differed little. In contrast, Engmo timothy, a grass with more exposed over-wintering tissues than smooth bromegrass and creeping foxtail (Klebesadel 1977), sustained 55% stand loss in the 1974-75 winter (Table 2) and was so badly injured during the following winter that no further forage yields were obtained.

Although Engmo timothy is from a far-northern area above the Arctic Circle in Norway and is one of the most winter-hardy timothy cultivars in the world (Klebesadel and Helm 1986), it is not as winter-hardy in this area as many other grasses. These include most indigenous Alaskan grasses and many introduced, relatively winter-hardy grass strains with more subterranean over-wintering tissues than timothy (Klebesadel 1977).

All temperate-adapted cultivars of Kentucky bluegrass and red fescue sustained serious injury during both winters and Pennlawn red fescue winter-killed completely during the first winter. Winter injury resulted in very low yield in the 1975 first cutting from Troy Kentucky bluegrass and no harvestable yield from either Merion Kentucky bluegrass (Figure 1) or Highlight chewings fescue (Table 1). Durar hard fescue, Boreal red fescue, and Delta Kentucky bluegrass (Figure 2) sustained considerable winter injury as well but were the most winter-hardy of the temperate-adapted cultivars. Merion and Highlight recovered to produce low but measurable yields for the following three harvests in 1975.

During the winter 1975-76, the previously injured but somewhat recovered stands of Delta, Merion, Troy, Boreal, Highlight, and Durar again sustained severe winter injury. Troy produced no harvestable yield in the first cutting of 1976 and during all of 1976 Troy and Durar produced only very low yields at each harvest. These results confirm the relatively poor winter hardiness in southcentral Alaska of grasses introduced from more southern latitudes, even though winters in their area of origin may be at least as cold as those of southcentral Alaska (Klebesadel 1970, 1971, 1985; Klebesadel et al. 1964). A previous study (Klebesadel 1971) showed that the poor survival of more southern-adapted introductions is attributable to a considerable extent to inadequate physiologic preparation for winter in this unaccustomed northern environment.

Total Forage Yields

Of the subarctic-adapted grasses, considerable differences were found among species in 2-year mean total forage yields (Table 1, Figure 3). In general, the shorter-growing grasses, Kentucky bluegrass and red fescue, surpassed the three tall-growing species. These results with four harvests per year differ somewhat from the rankings obtained with two harvests per year (Klebesadel and Dofing 1990; Mitchell 1982, 1986); with two cuttings, total forage yields of grasses of the two growth types were more nearly equal and, in some tests, the yields of bromegrass and timothy surpassed those of Kentucky bluegrass and red fescue.

In the present study, the Kentucky bluegrasses produced highest total yields; all 12 strains averaged 3.33 tons/acre while the three highest-yielding bluegrass strains averaged 3.60 tons/acre. Although strains AK-68-132, AK-68-134, and AK-68-135 produced much longer leaves than the dwarf-type Nugget, they were no more productive than Nugget.

The mean of total yields of the four subarctic-

Table 1. *Seeding-year and subsequent oven-dry forage yields of Kentucky bluegrass and red fescue strains from diverse latitudinal origins and three tall-growing forage grasses harvested four times per year at the Matanuska Research Farm. Planted 19 June 1974.*

Species, adaptation,	1974	1975					1976				
and strain	9 Oct	11 June	9 July	14 Aug	26 Sep	Total	11 June	9 July	13 Aug	24 Sep	Total
	Tons per acre										
Kentucky bluegrass											
Subarctic-adapted:											
Nugget (Alaska)	0.18 e-i [1]	1.05 c-f	1.19 ab	1.45 ab	0.38 c-g	4.07 ab	0.24 hi	1.22 a	1.43 a	0.30 abc	3.19 ab
AK-69-3 [2]	0.04 i	1.82 a	0.83 d-h	0.99 e-h	0.09 hi	3.73 abc	2.25 a	0.52 h	0.62 gh	0.08 fgh	3.47 a
412 (Iceland)	0.29 d-h	1.17 b-e	1.23 a	1.48 a	0.34 d-g	4.22 a	0.24 hi	1.09 ab	1.32 a	0.25 a-e	2.90 bcd
AK-68-134	0.35 b-f	1.53 abc	0.96 c-f	1.31 a-d	0.23 fgh	4.03 ab	0.82 de	0.99 bcd	1.03 bcd	0.18 c-g	3.02 abc
AK-69-28	0.11 ghi	1.61 ab	0.77 gh	1.23 a-e	0.23 fgh	3.84 abc	1.05 cd	0.85 def	1.12 b	0.15 d-h	3.17 ab
AK-68-132	0.43 bcd	1.48 abc	0.94 c-g	1.22 a-e	0.21 gh	3.85 abc	0.86 de	1.00 bcd	1.08 bc	0.20 b-g	3.14 ab
AK-69-18	0.03 i	0.85 efg	0.98 cde	1.39 ab	0.39 c-g	3.61 abc	0.84 de	1.04 b	1.09 bc	0.15 d-h	3.12 ab
AK-68-135	0.33 c-g	1.11 c-f	1.02 bc	1.28 a-e	0.30 e-h	3.71 abc	0.78 de	1.05 b	0.99 b-e	0.18 c-g	3.00 abc
AK-69-32	0.44 bcd	0.83 e-h	0.99 cd	1.16 b-e	0.56 a-d	3.54 abc	0.41 gh	1.06 b	0.99 b-e	0.34 ab	2.80 bcd
AK-68-81	0.43 bcd	0.93 def	1.05 bc	1.08 d-g	0.40 c-g	3.46 abc	0.70 efg	1.02 bc	0.89 c-f	0.22 a-f	2.83 bcd
AK-68-66	0.38 b-e	0.88 ef	0.88 c-g	1.14 c-f	0.32 efg	3.22 bcd	0.73 def	0.87 cde	0.79 efg	0.14 e-h	2.53 cde
Atlas (Sweden)	0.36 b-f	0.71 e-h	0.80 e-h	1.09 c-f	0.51 b-e	3.11 cd	0.43 fgh	0.81 efg	0.72 fg	0.32 abc	2.28 ef
Mean	0.28	1.16	0.97	1.24	0.33	3.70	0.78	0.96	1.01	0.21	2.95
Mid-temperate adapted:											
Delta (Ontario)	0.33 c-g	0.37 g-j	0.32 kl	0.78 g-j	0.63 ab	2.10 e	Tr [3]	Tr	Tr	Tr	Tr
Merion (Pennsylvania)	0.16 e-i	Tr	0.24 lm	0.54 jk	0.41 b-g	1.20 fg	Tr	Tr	Tr	Tr	Tr
Troy (Montana)	0.15 e-i	0.03 j	0.16 lmn	0.43 k	0.28 fgh	0.90 g	Tr	0.18 i	0.21 hi	0.09 fgh	0.48 g
Mean	0.21	0.13	0.24	0.58	0.44	1.40	Tr	0.06	0.07	0.03	0.16
Red fescue											
Subarctic-adapted:											
Arctared (Alaska)	0.08 hi	1.38 a-d	0.76 gh	1.27 a-e	0.45 b-f	3.86 abc	0.97 cde	0.71 fg	0.81 efg	0.33 ab	2.82 bcd
AK-67-52-2	0.03 i	1.40 a-d	0.66 hi	0.79 g-j	0.34 d-g	3.19 bcd	1.64 b	0.70 g	0.66 h	0.09 fgh	3.09 ab
AK-344	0.01 i	0.65 f-i	0.79 fgh	0.85 f-i	0.73 a	3.02 cd	0.44 fgh	0.45 h	0.85 def	0.35 a	2.09 ef
AK-343	0.02 i	0.20 ij	0.41 jk	0.66 ijk	0.45 b-f	1.72 efg	0.37 h	0.45 h	0.74 fg	0.28 a-d	1.84 f
Mean	0.04	0.91	0.66	0.89	0.49	2.95	0.86	0.58	0.77	0.26	2.46
Mid-temperate-adapted:											
Boreal (Alberta)	0.68 a	0.22 ij	0.30 kl	0.67 ijk	0.59 abc	1.78 ef	Tr	Tr	Tr	Tr	Tr
Pennlawn (Pennsylvania)	0.13 f-i (WK) [4]	—	—	—	—	—	—	—	—	—	—
Highlight [5] (Holland)	0.55 abc	Tr	0.10 mn	0.41 k	0.39 c-g	0.90 g	Tr	Tr	Tr	Tr	Tr
Durar [6] (Wash.-Oregon)	0.02 i	0.78 e-h	0.42 jk	0.43 k	0.38 c-g	2.01 e	0.10 hi	0.25 i	0.13 i	0.11 e-h	0.59 g
Mean	0.35	0.25	0.21	0.38	0.34	1.17	0.03	0.06	0.03	0.03	0.15
Tall grasses:											
Polar brome (Alaska)	0.58 ab	0.61 f-i	0.24 klm	1.00 d-h	0.09 hi	1.94 ef	1.21 c	0.08 j	1.07 bc	0.05 gh	2.41 de
Garrison cr. foxtail (N. Dakota)	0.33 c-g	0.95 def	0.40 jk	0.77 g-j	0.37 d-g	2.49 de	1.00 cde	0.54 h	0.51 h	0.13 e-h	2.18 ef
Engmo timothy (Norway)	0.36 b-f	0.36 hij	0.52 ij	0.73 hij	0.33 efg	1.94 ef	Tr	Tr	Tr	Tr	Tr
Mean	0.42	0.64	0.39	0.83	0.26	2.12	0.74	0.21	0.53	0.06	1.53

1 Within each column, means followed by the same letter are not significantly different (5% level) using Duncan's Multiple Range Test.

2 AK prefix indicates experimental line in Alaska agronomy research program.

3 Trace amount of herbage insufficient for harvestable yield.

4 No further yields; stand winter-killed completely.

5 Chewings fescue = *F. rubra* var. *commutata*.

6 Hard fescue = *F. ovina* var. *duriuscula*.

Table 2. *Visual estimates of winter injury of broadcast-plot stands of Kentucky bluegrass and red fescue strains from diverse latitudinal origins, and three tall-growing forage grasses, following two winters at the Matanuska Research Farm.*

	Winter of	
	1974-75	1975-76[1]
	% winter kill[2]	
Kentucky bluegrass:		
Subarctic-adapted:		
AK-69-3[3]	0 a[4]	0 a
AK-69-28	0 a	0 a
Nugget (Alaska)	1 a	9 a-d
AK-69-18	6 a	1 ab
412 (Iceland)	6 a	14 bcd
AK-68-134	9 ab	16 cd
AK-68-132	11 abc	9 a-d
AK-68-135	13 abc	15 bcd
AK-69-32	30 cde	45 ef
AK-68-81	31 cde	14 bcd
AK-68-66	40 def	20 d
Atlas (Sweden)	43 ef	69 g
Mean	16	18
Mid-temperate-adapted:		
Delta	70 gh	92 h
Troy	90 i	75 g
Merion	94 i	91 h
Mean	85	86
Red fescue:		
Subarctic-adapted:		
AK-67-52-2	4 a	4 abc
Arctared (Alaska)	5 a	18 cd
AK-344	43 ef	43 e
AK-343	54 fg	56 f
Mean	27	30
Mid-temperate-adapted:		
Durar[5] (Washington-Oregon)	31 cde	70 g
Boreal (Alberta)	83 hi	94 h
Highlight[6] (Netherlands)	97 i	96 h
Pennlawn (Pennsylvania)	100 i	—
Mean	78	87
Tall grasses:		
Garrison cr. foxtail (N. Dak.)	21 a-d	11 a-d
Polar brome (Alaska)	29 b-e	13 bcd
Engmo timothy (Norway)	55 fg	94 h
Mean	35	39

1 Percent winter kill during winter 1975-76 of grass stand alive in autumn of 1975.

2 Visual estimates on 6 June 1975 and 25 May 1976 (means of four replicates).

3 AK prefix indicates experimental line in Alaska agronomy research program.

4 Within each column, means not followed by a common letter are significantly different (5% level) using Duncan's Multiple Range Test.

5 Hard fescue (*F. ovina* var. *duriuscula*).

6 Chewings fescue (*F. rubra* var. *commutata*).

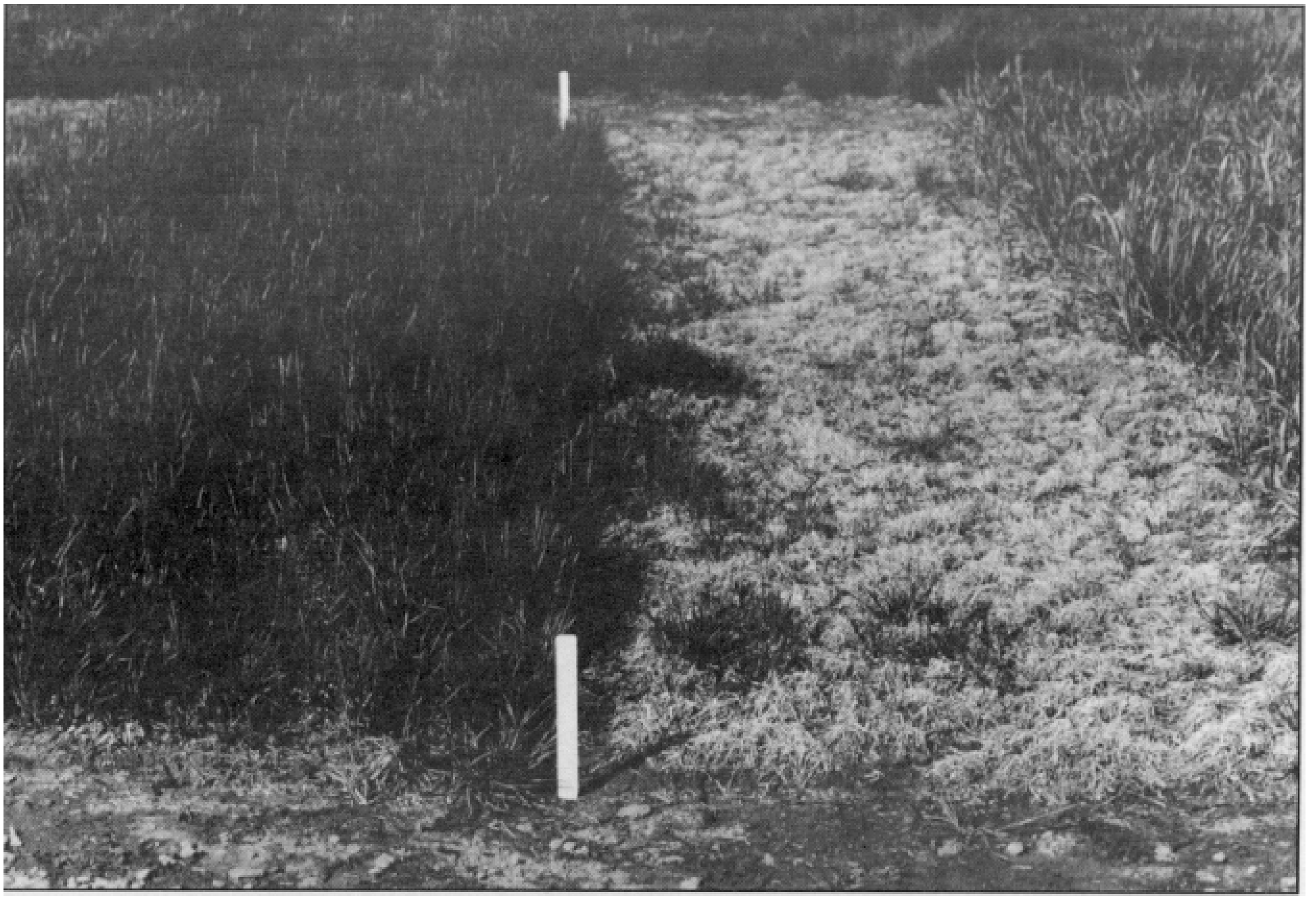

Figure 1. *Comparative winter hardiness of two Kentucky bluegrass cultivars of dissimilar latitudinal adaptation: (left) subarctic-adapted Atlas from Sweden and (right) mid-temperate-adapted Merion from the USA. Plots planted 19 June 1974; photo 5 June 1975.*

adapted red fescue strains was intermediate between the Kentucky bluegrasses and the tall-growing species. The two most winter-injured of the red fescue strains (Table 2), however, produced lower yields than Arctared and AK-67-52-2 which more closely approximated the yields of the Kentucky bluegrasses.

The three tall-growing grasses did not differ significantly in total yields in 1975, and Polar brome and Garrison foxtail were similar in 1976 when the badly winter-injured Engmo timothy produced no harvestable yields (Table 1).

The mid-temperate-adapted strains of Kentucky bluegrass and fescue produced only modest yields in 1975 and little or none in 1976 (Table 1).

Yield Distribution

Beyond the restrictions imposed by winter injury on forage yield of individual grasses, there were quite different patterns of yield distribution among harvests associated with the different grass species.

In general, all subarctic-adapted Kentucky bluegrass and red fescue strains, Garrison creeping foxtail, and Engmo timothy (in 1975) produced appreciable yields in each of the first three harvests each year. Polar bromegrass, in contrast, produced relatively more in the first and third harvests (42% and 48%, respectively, of total-year yield) but only 7% in the second harvest. This unevenness of herbage production by bromegrass was noted previously at this location by Brundage and Sweetman (1964). In utilizing bromegrass as a pasture species, they found its heavy initial herbage growth during June was followed by a period of slow regrowth and low production which could not be hastened by either N fertilization or irrigation.

That behavioral response derives from intrinsic growth characteristics of smooth bromegrass; when the first growth of culms (aerial stems) is severed and removed before axillary basal tillers are in readiness to begin new growth, regrowth of the grass is delayed (Smith and Nelson 1985; Smith et al. 1986). Eastin et al. (1964) in Indiana stated that appearance of new basal tillers in spring growth of bromegrass ceased when culms began to elongate and did not resume until after anthesis (flowering or pollen-shedding stage). They

Figure 2. *Comparative winter hardiness of two Kentucky bluegrass strains of dissimilar latitudinal adaptation: (left) mid-temperate-adapted Delta from southern Canada and (right) subarctic-adapted strain "412" from Iceland. Plots planted 19 June 1974; photo 5 June 1975.*

postulate that auxins (growth regulators) within the plant suppress the development of basal tillers during the time of rapid culm elongation; they found high growth-regulator activity at the early jointing (culm elongation) stage and a significant drop in growth-regulator activity just prior to anthesis and preceding the period when active tiller growth resumed.

The first harvest of bromegrass in the present study (11 June both years) was at the late boot stage (a very few heads just emerging in 1975, none visible in 1976) and the topmost leaves were at a height of 26 to 28 inches in 1975, and at 20 to 22 inches in 1976. The "boot stage" is during the period of rapid culm elongation; it refers to the developmental stage when the gradually elevating seed head is still enclosed within the topmost leaf sheath (or boot) of the culm, just prior to emerging and becoming visible. With reference to the report of Eastin et al. (1964), the very slow regrowth of bromegrass after harvest at boot stage in the present study conforms to normal bromegrass behavior.

Moreover, perennial grasses undergo cycles of utilization (through growth) and replenishment (via photosynthetic activity) of carbohydrate reserves that therefore are closely associated with growth stages. When Reynolds and Smith (1962) harvested bromegrass on 3 June in Wisconsin, where grasses begin spring growth earlier than in Alaska, the grass was at early heading stage and new growth after harvest was slow there also; they attributed that slow recovery growth to low levels of carbohydrate reserves and as yet inactive basal buds that must provide for the new growth. They found regrowth to be more rapid when a first cutting was taken on 27 June at a more advanced stage of grass growth (green seed); at that stage, the grass had stored a higher level of carbohydrate reserves and basal buds were in readiness to put forth new growth.

The subarctic-adapted bluegrasses produced the most uniform distribution of herbage over the first three harvests, averaging 29%, 29%, and 34% of total-season yields in those harvests, respectively. This is in marked contrast with Kentucky bluegrass behavior in more southern latitudes. There the greater heat and often droughty conditions during mid-summer characteristically induce non-productive summer dormancy until growth resumes with advent of cooler temperatures and increased precipitation in late summer and autumn (Duell 1985; Smith et al. 1986).

All of the grasses produced relatively small yields in the fourth harvest each year (Table 1), despite the fact that the growth period prior to that harvest was the longest (mean = 42 days) of all. Hamilton et al. (1969) in Wisconsin also obtained very low yields from three perennial grasses, including smooth bromegrass and timothy, in the final of four harvests per year. This reduced late-season herbage production probably is attributable to the seasonal pattern of gradually shortening photoperiods and lowering temperatures, resulting in reduced photosynthetic activity and slower metabolic activity.

Moreover, perennial species characteristically grow less actively during the late portion of the growing season, diverting photosynthetic product increasingly into stored food reserves (Smith and Nelson 1985; Smith et al. 1986). It is unlikely that either inadequate fertility or deficient soil moisture imposed limitations on late-season herbage production because high levels of fertilization were employed in this test and natural precipitation plus supplemental irrigation totaled about 4.7 inches for August + September in each harvest year.

Rate of Dry-Matter Production

Another way of viewing the productivity of the various grasses, in addition to the actual yields on each harvest date, is to calculate mean pounds of forage dry matter produced per acre per day (lb/acre/day) during the different growth periods prior to each harvest (Figure 3). This calculated value more accurately compares the rate of dry-matter production of the grasses during the different periods than the actual harvested yields indicate, because the growth periods differed in length. Using 10 May as a somewhat arbitrary, but reasonably approximate, date for the start of spring growth, the two-year mean consecutive growth periods prior to each harvest (Figure 3) were 32, 28, 36, and 42 days in duration, respectively. This value is recognized as a mean of the productivity rate for each entire growth period and therefore is not indicative of actual production for each individual day; this is because on the first days after harvest, usually very little growth is produced, while in the days just prior to harvest, daily dry-matter production is substantially greater than at the beginning of the growth period.

Using this measure of productivity, it is seen that the severe winter injury of Engmo timothy during the winter of 1974-75 (estimated at 55%, see Table 2) resulted in a very low rate of dry-matter production (23 lb/acre/day) during the initial growth period of 1975 (Figure 3). In contrast, the average of the other four lesser-injured species showed near-similar (and considerably greater than timothy) 2-year mean rates of dry-matter production during that initial growth period of 58 lb/acre/day (Figure 3).

The maximum rate of dry-matter production for all species and growth periods was the mean of the 12 subarctic-adapted strains of Kentucky bluegrass (69 lb/acre/day) during the growth interval 11 June to 9 July. This very active growth (almost equaled during the immediately following growth period = 62 lb/acre/day) is during the time that Kentucky bluegrass normally is very unproductive at lower latitudes due to high summer temperatures, and sometimes moisture deficit, that limit its growth there, resulting in a condition referred to as summer dormancy (Duell 1975; Smith et al. 1986). However, in southcentral Alaska, that very active productivity of this species occurs when temperatures are relatively much cooler, precipitation normally is increasing, and when very long photoperiods (daylight hours) favor maximum photosynthetic activity.

As noted in the foregoing discussion of yield distribution, Polar bromegrass was very unproductive during the second growth period; rate of dry-matter production was only 12 lb/acre/day.

Productivity of all grasses was least, ranging from 3 lb/acre/day (Polar brome) to 18 lb/acre/day (4 subarctic-adapted red fescues), during the final growth period, 14 August to 25 September (= two-year mean dates). Although that growth period was the longest of the four (42 days) and was well supplied with precipitation, it also had the disadvantages for grass productivity of (a) shortening photoperiods, resulting in less photosynthetic activity, (b) seasonally lowering temperatures that cause slowing of metabolic activities and growth processes, and (c) gradually increased diversion of photosynthetic products in perennial species away from active growth and into food-reserve storage (Raese and Decker 1966; Smith and Nelson 1985; Smith et al. 1986).

Conclusions

Mid-temperate-adapted cultivars of Kentucky bluegrass (Delta, Merion, Troy), red fescue (Boreal, Pennlawn), as well as Highlight chewings fescue and Durar hard fescue are inadequately winter-hardy for dependable use as cropland forages in this area. Moreover, several of the strains of Kentucky bluegrass and red fescue considered to be subarctic-adapted sustained considerably greater winter injury, and therefore produced generally lower forage yields, than the most winter-hardy, northern-adapted strains.

Northern adaptation, however, does not guarantee winter hardiness, for Engmo timothy from northern Norway (69° to 70°N) sustained considerable winter

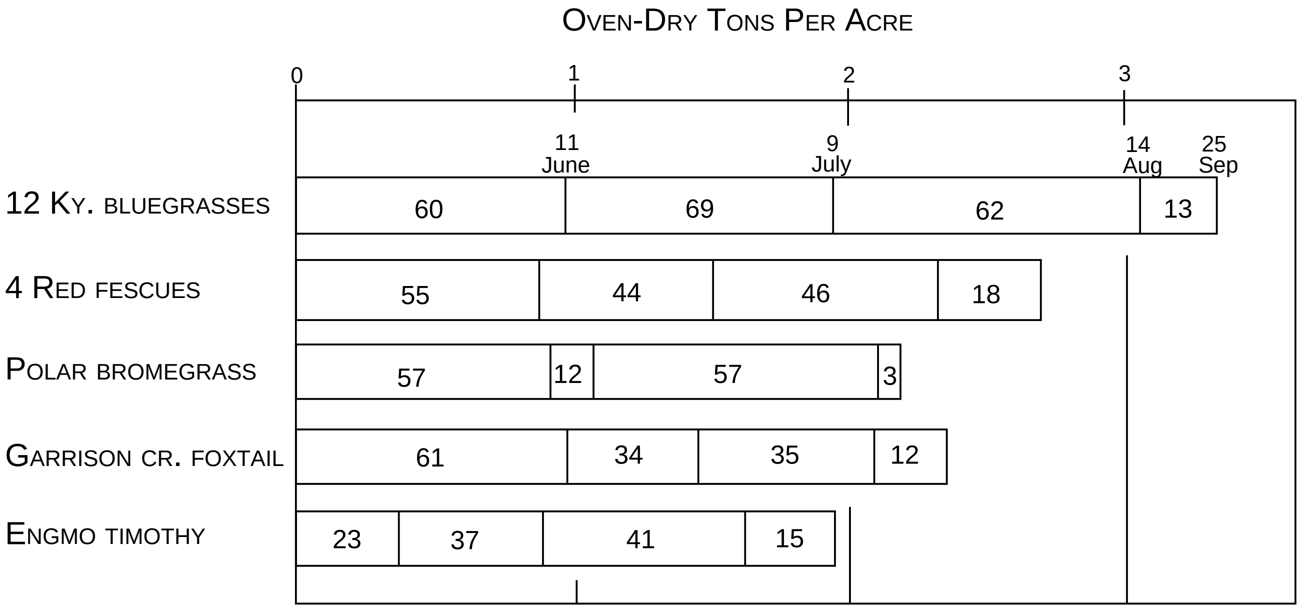

Figure 3. *Two-year mean cumulative forage dry-matter yields of 12 subarctic-adapted strains of Kentucky bluegrass, 4 subarctic-adapted strains of red fescue, and Polar bromegrass, Garrison creeping foxtail, and Engmo timothy (timothy = 1 year only) harvested four times each year. Numbers within bar segments are mean pounds dry matter per acre per day accumulated by the grasses during each growth period prior to harvest (the somewhat arbitrary but approximate date of 10 May was used for start of spring growth to permit calculating a duration for the first growth period). Two-year mean harvest dates for bar segments shown above top bar only.*

injury during the first winter, and even more during the second winter to the extent that no harvestable yields were produced during the final year. The marginal winter hardiness of far-northern-adapted Engmo in comparison with the hardiest Kentucky bluegrasses, red fescues, smooth bromegrass, and creeping foxtail used in this test probably is due at least in part to plant morphology. The over-wintering crown tissues of timothy are relatively superficial and therefore more exposed to winter stresses (direct cold, freeze-thaw effects, dehydration) than those of the other species. Over-wintering tissues of the other species consist of subterranean rhizomes and tillers that are better protected from harmful winter stresses (Klebesadel 1977; Klebesadel and Helm 1986; Smith 1964).

The non-productive mid-summer dormancy common in Kentucky bluegrass at lower latitudes, where hot, dry summers are common (Duell 1985; Smith et al. 1986), is not a problem in this area of cool summer growing conditions. The subarctic-adapted Kentucky bluegrass strains produced evenly distributed, high yields in each of the first three harvests that spanned the mid-summer period.

The higher total forage yields of Kentucky bluegrass than those of bromegrass in the present study are opposite of the results of Jung et al. (1974) in the Allegheny Highlands of West Virginia; there smooth bromegrass produced more forage than Kentucky bluegrass with three or five cuttings per year at a high level of N fertility and "under conditions of minimal temperature and moisture stress." Bird (1943), in Quebec, reported that even though smooth bromegrass produced less total forage with three to six harvests per year than with two, the more-drought-resistant bromegrass produced more forage with frequent harvests than Kentucky bluegrass.

From a practical viewpoint, the low yields in the fourth cutting of the present study suggest that a fourth harvest probably should not be taken, at least not with the harvest schedules used in this study. These results suggest that if four harvests per year are desired, dates of the first three harvests should be advanced somewhat, with grasses suited to that scheduling, to permit an even longer growth period before the fourth harvest. Conversely, if season-long herbage production is to be fully utilized in three harvests per year, dates of the first three harvests should be somewhat later than those used in this study. Preferred harvest dates then probably should be about mid-June + mid-July + mid-September.

Hardy, productive Kentucky bluegrasses or red fescues should serve well for green-chop forage or pasturage throughout most of the growing season. When these perennials become less productive in September, they could be supplemented effectively in this environment by utilizing annual ryegrasses (*Lolium* sp.) for late-season forage throughout September and during October until severe frosts or snow preclude further utilization. Annual ryegrasses typically continue more active herbage production than perennial grasses through the late portion of the growing season.

The considerable range of winter hardiness and good forage yields within the subarctic-adapted strains evaluated indicates that very reliable and productive grasses exist for intensive management; these could be utilized solely for green-chop harvest, for rotational grazing, or combinations of both. However, utilization of herbage from the short-growing bluegrasses or fescues probably would be more effectively accomplished by livestock; recovery would be more difficult with farm-scale forage harvest equipment than was accomplished by plot mowers and hand-raking in this study.

Subarctic-adapted strains of Kentucky bluegrass and red fescue harvested four times per year were more productive than the taller-growing bromegrass, timothy, and creeping foxtail. Bromegrass was comparatively poor in total forage production under the four-cut harvest schedule in this study, but compares more favorably with other grasses when harvested twice per year (Klebesadel and Helm 1986; Klebesadel and Dofing 1990; Mitchell 1982, 1986). Those results suggest that this species is best utilized with two harvests per year for preserved forage with the first harvest taken later in June and at a more advanced stage of growth than in this study. That schedule would circumvent the poor recovery growth of bromegrass after a mid-June harvest at boot stage. The poor productivity of bromegrass at a time of ideal growing conditions tends to ill-suit that grass to utilization for green-chop feeding or pasture, systems that require a more constant supply of herbage than bromegrass provided.

These promising results with a small and somewhat random selection of subarctic-adapted Kentucky bluegrass and red fescue strains suggest that more extensive collections and evaluations may be warranted. Within the strains evaluated, considerable differences were noted not only in winter hardiness and productivity but also in growth types.

Kentucky bluegrass strain AK-69-3 excelled in markedly earlier spring growth than all other grasses, in high initial and total forage yields (see especially first-cut yields, Table 1), and in excellent winter hardiness (Table 2). Foliage of that strain was free of disease in 1974 and 1975; however, during later seed increase it displayed considerable susceptibility to two foliar diseases and it was therefore discarded.

Nugget and AK-69-18 are relatively short dwarf types, while AK-68-132, AK-68-134, and AK-68-135 produced longer, more lax leaves than all other strains of Kentucky bluegrass compared. Additional collections and evaluations that seek taller types well suited to machine harvest, along with demonstrated high levels of winter hardiness, herbage production, and disease resistance should be worthwhile.

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Explanatory Note

This report summarizes research completed several years ago. During its completion, the investigator/author assumed time-consuming research supervisory responsibilities that delayed more timely publication. It is published now because it represents heretofore unpublished information that augments Alaska's agronomic research data base; moreover, publication can circumvent the need to repeat this already completed research.

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