Winterhardiness and Agronomic Performance of Wildryes (*Elymus* species) Compared With Other Grasses in Alaska, and Responses of Siberian Wildrye to Management Practices

Leslie J. Klebesadel
Emeritus Professor of Agronomy
Agricultural and Forestry Experiment Station
Palmer, Alaska

UNIVERSITY OF ALASKA FAIRBANKS

Agricultural and Forestry Experiment Station
School of Agriculture and Land Resources Management

Bulletin 97 December 1993

Table of Contents

List of Tables and Figures

SUMMARY

This report summarizes eight field experiments involving both native and introduced wildrye grasses (*Elymus* species) conducted over a span of several years at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska. Objectives were to (a) evaluate winterhardiness, persistence, forage yield, and other aspects of agronomic performance of numerous strains within several species of wildrye, (b) assess their potential for forage use or conservation plantings in Alaska, and (c) determine the effects on Siberian wildrye (*E. sibiricus*) of seeding-year management options (time of planting and time of harvest) on seeding-year forage production, subsequent winter survival, and on second-year forage production.

Experiment I (Individual plants in rows)

- All 9 strains of Siberian wildrye evaluated (7 from the U.S.S.R., 1 from Mongolia, 1 from Alaska) showed excellent winter survival, most at 100%, none less than 94%.
- Percent winter survival was excellent also in Alaska collections of beach wildrye (95%) and downy wildrye (96%).
- Three strains of Russian wildrye (Mayak, Sawki, P-9012) were near-similar in winter survival, averaging 87%.
- Altai wildrye and the Volga cultivar of mammoth wildrye were intermediate in winter survival; Altai survival was 72% and Volga 37%.
- One strain each of Canada wildrye (P-3355), basin wildrye (P-5797), and antarctic wildrye were nonhardy; winter survival of all three was 0%.
- Other grasses that winterkilled totally were Hattfjelldal and Va-BL-67 orchardgrass, and Vagones and Loken meadow fescue, all from Norway.
- Non-*Elymus* grasses that survived the winter at 100% were Polar and pumpelly bromegrass, Garrison creeping foxtail, and native Alaskan arctic wheatgrass.

Experiment II (Broadcast-seeded plots for forage)

- Seeding-year forage yields of all nine strains of wildrye within seven species and pumpelly bromegrass were low, compared with yields of timothy, meadow fescue, orchardgrass, creeping foxtail, and smooth bromegrass.
- Numbered strains of Canada wildrye (P-3355) and basin wildrye (P-5797) were the least winterhardy of the 20 grass strains compared; both winterkilled completely the first winter. Other relatively nonhardy grasses that sustained over 90% winterkill during the first winter were mammoth wildrye (cultivar Volga), Altai wildrye, Loken and Vagones meadow fescue from Norway, and Hattfjelldal and Va-BL-67 orchardgrass from Norway.
- Intermediate in winterhardiness during the first winter (all rated at 60% winterkilled) were Russian wildrye cultivars Sawki and Mayak from Saskatchewan and strain P-9012 from Washington state.
- Grasses with no apparent winter injury during the first winter were native Alaskan beach and Siberian wildryes, Polar and native pumpelly bromegrass, native arctic wheatgrass, Garrison creeping foxtail, and Engmo and Bodin timothy cultivars from Norway; stands of Va-BL-60 timothy from Norway were rated 10% winterkilled.
- Grasses that were severely injured during the first winter, produced little or no harvestable forage during the second year, and winterkilled totally during the second winter were Altai wildrye, Loken and Vagones meadow fescue, and Hattfjelldal and Va-BL-67 orchardgrass.
- The only wildryes from sources outside of Alaska that persisted and produced a forage yield for the full 4-year term of the experiment were Sawki and Mayak Russian wildrye; however, those yields were less than one-third of the highest yielding grasses in other species.
- Native Alaskan Siberian and beach wildryes were more winterhardy, and Siberian wildrye produced more forage than all wildryes from elsewhere. The very open character of the beach wildrye stands, however, permitted weed ingress into those plots to the extent that no forage yields were obtained from that grass in the fourth year.
- Seven non-*Elymus* grass strains surpassed all wildryes derived from sources outside Alaska in winterhardiness, persistence, and forage yields, averaging over 3 tons of dry matter per acre; those were three strains of timothy from Norway, Garrison creeping foxtail, Polar bromegrass, and native Alaskan pumpelly bromegrass and arctic wheatgrass.

Experiments IIIa, IIIb, IIIc, IIId (Siberian wildrye compared with other grasses in broadcast-seeded plots for forage)

- In four similar experiments, each six years in duration, total yield of native Alaskan Siberian wildrye was about three-quarters that of Polar bromegrass, but more than twice as much as Sawki Russian wildrye. Total yield of Sawki was similar to that of Engmo timothy.
- Stands of Siberian wildrye showed evidence of senescence in the fifth and sixth years of the experiments, becoming less productive then than stands of the longer-lived Polar bromegrass; Polar stands were fully productive for the full 6-year term of all four experiments.
- Stands of Sawki winterkilled totally before completion of three of the four experiments; Engmo timothy stands winterkilled about midway through two of the experiments, but persisted for the full term of the other two tests.

Experiment IV
(Broadcast-seeded plots for forage)

• Grasses in this experiment were favored by above-average precipitation during the seeding year, but were under considerable moisture-deficit stress during the following two years when two harvests were taken each year.

• Highest seeding-year yields were produced by two Siberian wildryes from Asia, Signal smooth bromegrass, seven timothy cultivars, and Frontier reed canarygrass; these averaged 2.46 tons oven-dry forage per acre.

• Relatively mild winters permitted some typically nonhardy grass strains to survive (e.g., Climax timothy) for the full term of the experiment; Frontier reed canarygrass, the only grass that did not persist for the full term, sustained severe injury during the first winter and winterkilled totally during the second.

• Of the 29 grass strains harvested over a 3-year period, the two strains of Siberian wildrye from Asian sources ranked first and second; the third strain of Siberian wildrye, from Alaska, ranked 20th.

• As a group, four cultivars of smooth bromegrass generally ranked second in yields to the Asia-origin Siberian wildryes, and seven timothy cultivars ranked generally below those bromegrasses.

• Arctared red fescue, quackgrass, and Nugget Kentucky bluegrass were intermediate in total yield.

• Under the drought-stress conditions of the last two years of this experiment, all native Alaskan grasses were generally low yielding; these included pumpelly bromegrass, Norcoast hairgrass, six strains within four species of wheatgrasses, and American sloughgrass.

Experiment V
(Seeding-year management effects on Siberian wildrye)

• Seeding-year forage yields from plantings on 19 May and 6 June averaged 2.81 and 2.49 T/A, respectively, and were little influenced by six different harvest dates from 20 August to 6 October.

• Seeding-year forage yields from grass planted 24 June were much reduced from those of the earlier two planting dates, and generally increased with successively later harvest dates from 20 August (0.46 T/A) to 6 October (1.43 T/A).

• Second-year first-cut forage yields from Siberian wildrye that had been planted 19 May or 6 June were uniformly high, averaging 2.58 and 2.57 T/A, respectively, and showed no harmful effects from any of the seeding-year harvests.

• With grass planted later (on 24 June), however, seeding-year harvest near mid-September predisposed the grass to severe winter injury; the thinned and weakened stands produced very low forage yields in the first cutting of the second year. Seeding-year harvests were less injurious to the grass as they were taken increasingly earlier or later than mid-September.

• These results indicate that the youngest (latest-planted) seedlings were more susceptible to inappropriate seeding-year harvest dates than older, earlier planted seedlings that had a longer growth period for development and physiological preparation for winter.

General

• To derive full benefit in Alaska from broad-based, unselected genetic reservoirs, plant introductions (such as wildryes) from Eurasia should be drawn not only from the northernmost areas of their natural ranges on that continent, but also should be brought directly to Alaska for evaluation and selection.

• Bringing to Alaska plant strains that have originated in northern areas but were introduced into North America at lower latitudes for evaluation and selection (thereby selecting within and narrowing their gene base for ideal performance under environmental conditions at those lower latitudes) discards valuable genetic elements that confer optimal physiologic harmony with far-northern climatic peculiarities common to both Alaska and the origin of the plants.

INTRODUCTION

The wildrye grasses (*Elymus* species) in North America are represented by several species; with some exceptions, most are native in western areas of the U.S. and Canada, and a few species are native in Alaska. Hitchcock (1950) lists 23 species as native in the conterminous 48 states; all are cool-season perennials with either a tufted (bunch type) or rhizomatous (spreads by rhizomes = underground stems) growth habit (Table 1).

Wildryes are relatively coarse grasses with slender elongated seedheads called spikes. The various species differ considerably in palatability, are adapted to a wide range of soil conditions, and are useful for revegetation as well as forage (Hafenrichter *et al*. 1968; Hanson 1972; Hoover *et al*. 1948).

Wildrye Species in Alaska

Hulten (1968) lists five species of wildrye as occurring in Alaska. Beach wildrye is a coarse, rhizomatous, tall-growing grass (Fig. 1) that occurs in all coastal areas of the state (Hulten 1968); it has been utilized for forage, for a wide variety of human uses, and its vigorous rhizome growth stabilizes coastal sands (Klebesadel 1985a).

Blue wildrye and northern wildrye are native in coastal southeastern Alaska, and downy wildrye occurs widely in interior and northern areas of the state.

Siberian wildrye occurs in southcentral and central Alaska (Hulten 1968; Klebesadel 1969) where it is most often encountered in disturbed areas such as along roadways (Fig. 2). This species is found also in a limited area in northwestern Canada (Bowden and Cody 1961; Porsild and Cody 1980). This report treats it as native to Alaska, but recognizing, however, the possibility that it was introduced (Hulten 1968; Porsild and Cody 1980) and has become naturalized.

Taxonomy

Although the wildrye grasses traditionally have been grouped within the genus *Elymus* (Aamodt and Savage 1949; Hafenrichter *et al*. 1968; Hanson 1972; Hitchcock 1950; Hoover *et al*. 1948; Hulten 1968; Porsild and Cody 1980), a recently proposed taxonomic revision (Dewey 1983) of *Elymus* and related grass genera proposes new scientific nomenclature for many of the wildrye grasses (Table 1). Although some recent reports have adopted the revised system (e.g., Voigt and MacLauchlan 1985), this report adheres to the traditional scientific names to assist in relating species discussed herein to earlier literature and floras; Table 1 provides cross-referencing of the two systems.

Early Evaluations in Alaska

Irwin (1945) summarized evaluations of many grasses and legumes at seven experiment stations in Alaska from 1898 to 1945. An unnamed species of native wildrye was seeded in 1906 at the Kenai station but failed to germinate. All other recorded seedings of wildryes were at the Matanuska station and were reported as follows:

Blue wildrye—Seeded 1940

Stand poor and scattering; medium growth; light foliage. Winter-killed the first winter.

Beardless wildrye—Seeded 1940

Good stand; very little foliage. A good soil binder for side hills, but of little forage value. Very hardy; spreads rapidly by underground rhizomes.

Siberian wildrye—Seeded 1941

Germinates quickly with good stands; very hardy. Foliage very scant; seeds early and heavily. A good

Table 1. Common and scientific names (two systems) of wildrye grasses native to Alaska or utilized in experiments reported here.

Common name	Scientific name: Traditional	Scientific name: Proposed[1]	Growth habit	Native: To Alaska	Native: Elsewhere in North America
Siberian wildrye	*Elymus sibiricus*	*Elymus sibiricus*	Bunch	Yes(?)	Yes(?)
Canada wildrye	*Elymus canadensis*	*Elymus canadensis*	Bunch	No	Yes
Blue wildrye	*Elymus glaucus*	*Elymus glaucus*	Bunch	Yes	Yes
Northern wildrye	*Elymus hirsutus*	*Elymus hirsutus*	Bunch	Yes	Yes
Beach wildrye	*Elymus mollis*	*Leymus mollis*	Spreading	Yes	Yes
Mammoth wildrye	*Elymus giganteus*	*Leymus racemosus*	Spreading	Introduced from Asia	
Altai wildrye	*Elymus angustus*	*Leymus angustus*	Spreading	Introduced from Asia	
Basin wildrye	*Elymus cinereus*	*Leymus cinereus*	Bunch	No	Yes
Beardless wildrye	*Elymus triticoides*	*Leymus triticoides*	Spreading	No	Yes
Downy wildrye	*Elymus innovatus*	*Leymus innovatus*	Spreading	Yes	Yes
Giant wildrye	*Elymus condensatus*	*Leymus condensatus*	Bunch	No	Yes
Russian wildrye	*Elymus junceus*	*Psathyrostachys juncea*	Bunch	Introduced from Asia	

[1]See Dewey reference (1983).

soil-binder and produces early pasture, but of little forage value after seed stalks form.

Russian wildrye—Seeded 1940, 1941, 1942

Excellent stands; good growth first season and thereafter; exceptionally-heavy foliage; sparse seeder. Does best in grass and legume mixtures for hay and pasture; very hardy and recommended. Best perennial grass yet tried at Matanuska Station. No commercial source of seed available.

Canada wildrye—Seeded 1940, 1941, 1942

Fair stand and growth the first season. 1940 seeding killed completely the first winter. 1941 seeding made excellent growth and came through the winter in vigorous condition. An excellent leafy hay-type grass.

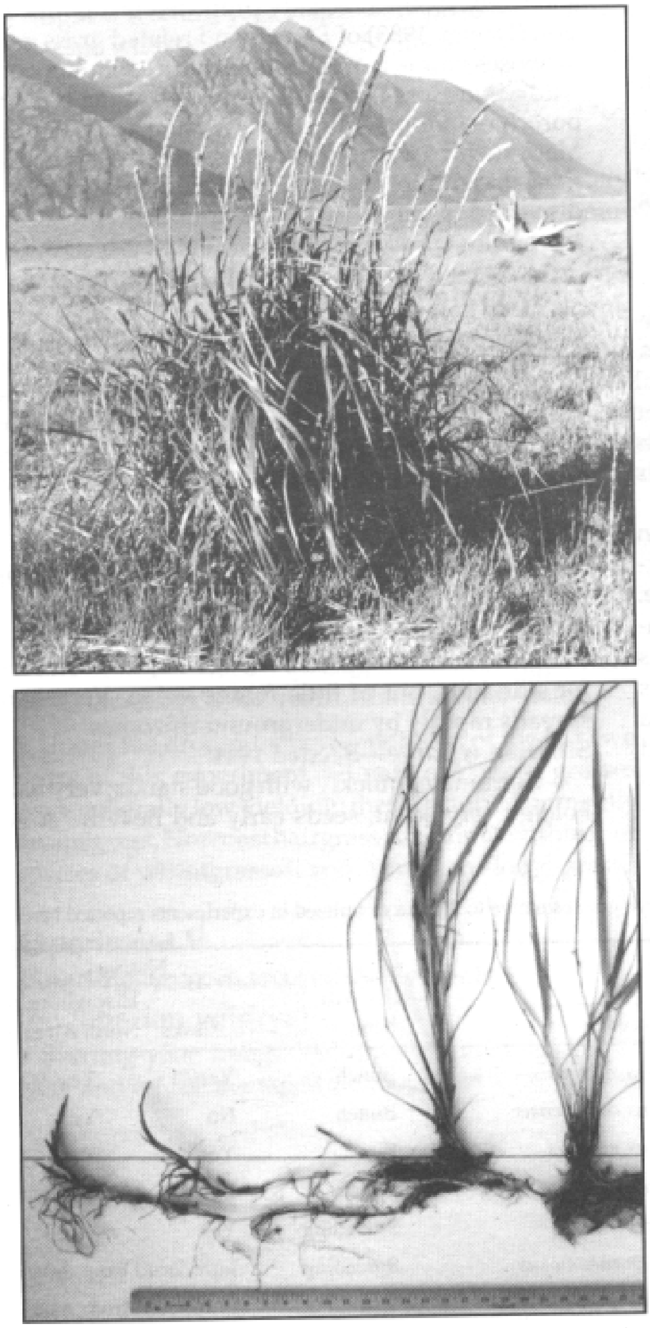


Figure 1. (Top) A plant of beach wildrye growing on moist tidal flat near Girdwood, Alaska. (Lower) Rhizomes (underground stems) of beach wildrye showing two plants (right) that arose from those rhizomes, and (left) growing points of rhizomes that have emerged above the soil surface which is indicated by black horizontal line; numbers on yardstick below plant indicate inches.

Wildryes Little-Studied in Alaska

Except for the above very limited comments on wildryes by Irwin (1945), a few by Aamodt and Savage (1949), and some published data on characteristics and agronomic performance of Alaskan Siberian wildrye (Klebesadel 1969; Klebesadel and Helm 1992) and beach wildrye (Klebesadel 1985a), apparently no experimental information is available on general suitability of other species of wildrye for use in Alaska for forage or other purposes.

Background to Experiments I and II

Several species of wildrye native to North America (basin, blue, beardless, Canada) have been utilized as harvested forage, as range grasses, and for permanent grass cover in conservation plantings (Hafenrichter *et al*. 1968; Hanson 1972; Hoover *et al*. 1948; Voigt and MacLauchlan 1985).

In addition to the native species, Russian, mammoth, and Altai wildryes have been introduced from Asia and evaluated for use in various areas of North America (Hafenrichter *et al*. 1968; Hanson 1972; Heinrichs and Lawrence 1956; Lawrence 1967, 1977, 1978; Lawrence and Ratzlaff 1985; Lawrence *et al*. 1960; Lawrence and Troelsen 1964; Rogler and Schaaf 1963; Voigt and MacLauchlan 1985).

Despite the considerable number of evaluations and uses in both Canada and the western U.S. referred to above, wildryes have been evaluated in Alaska to a very limited extent (Irwin 1945; Klebesadel 1969, 1985a). Experiments I and II of this report were conducted to compare several native and introduced wildryes with other species of grasses for winterhardiness and forage production.

Background to Experiments IIIa, IIIb, IIIc, and IIId

Irwin's (1945) statement concerning Russian wildrye evaluations in 1940-42, "Best perennial grass yet tried at Matanuska Station," indicated that more extensive comparisons were merited between this wildrye and other forage grasses that have been generally adopted for forage production in Alaska.

Russian wildrye, since its most significant early introduction into the U.S. and Canada about 1926-27, has become widely used in western areas of both countries, primarily as a pasture grass (Hanson 1972; Heinrichs and Lawrence 1956; Rogler and Schaaf 1963).

Though recognized as somewhat slower to establish than many other grasses, Russian wildrye is long-lived, nutritious, makes rapid recovery growth after grazing, and is better suited to pasture utilization than

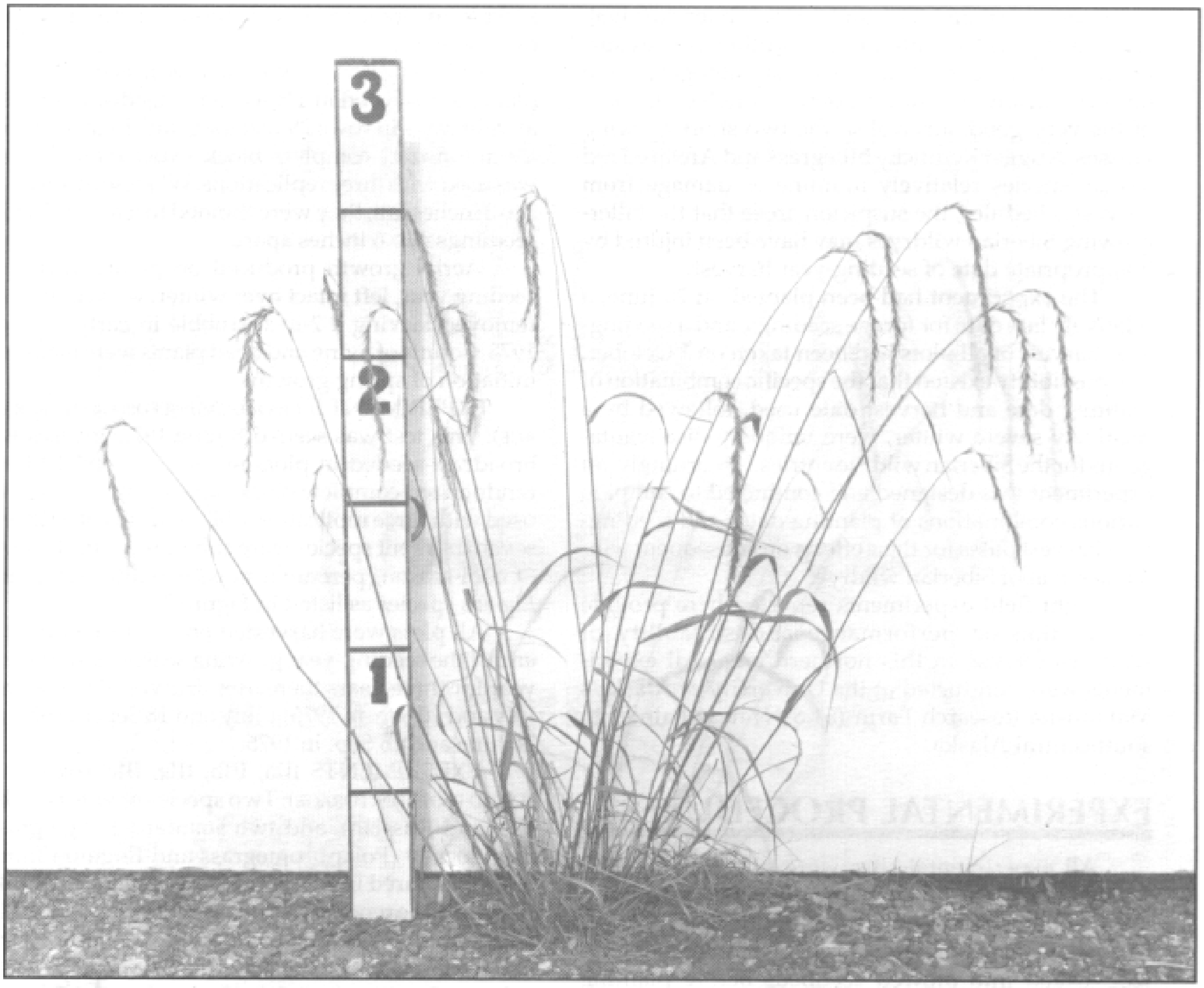


Figure 2. A plant of Siberian wildrye growing in roadside gravel. Seed in the pendulous seed heads is near maturity in this 13 August photo. The non-leafy character of this plant growing in infertile substrate contrasts sharply with the very leafy Siberian wildrye when grown under high soil-fertility conditions in Figure 4. Numbers on stake indicate height in feet.

harvested forage because of its abundance of basal leaves. Rogler and Schaaf (1963) describe it as "exceptionally resistant to cold and drought." Cultivars released in North America include Mayak, selected at Swift Current, Saskatchewan; Sawki at Saskatoon, Saskatchewan; and Vinall at Mandan, North Dakota (Hanson 1972).

Background to Experiment IV

Little is known about the relative forage productivity or other agronomic comparisons between Alaskan and Asiatic ecotypes of Siberian wildrye. Seed of one strain of Asiatic origin, increased at the Alaska Plant Materials Center, and another strain composited at this station and consisting of several lines of Asiatic origin, were seeded for comparison with an Alaska strain of Siberian wildrye and grasses within several other species.

Background to Experiment V

After displaying excellent winterhardiness in several experiments over many years, several strains of Siberian wildrye inexplicably sustained inordinate injury during the first winter in a large, broadcast-seeded plot experiment that also included grasses within 14 other species. Eight accessions of Siberian wildrye from the U.S.S.R., that had been very winterhardy in earlier trials, averaged only 26% estimated winter survival over three replicates. Native Alaskan Siberian wildrye, a grass that had seldom showed any winter injury previously, was estimated at only 38% winter survival.

In contrast to the poor survival of the Siberian wildryes, five cultivars of northern-adapted smooth bromegrass averaged 70% survival, the five other native Alaskan grasses in the experiment averaged 84% survival, and Nugget Kentucky bluegrass and Arctared

red fescue averaged 83% and 100% winter survival, respectively. Thus, with numerous other grasses surviving well, it seemed unlikely that pathogens were involved to any significant extent. Moreover, in view of the very good survival of the two short-growing grasses, Nugget Kentucky bluegrass and Arctared red fescue, species relatively immune to damage from harvest schedules, the suspicion arose that the taller-growing Siberian wildryes may have been injured by inappropriate date of seeding-year harvest.

The experiment had been planted on 20 June, a relatively late date for forage seedings, and a seeding-year harvest of all plots had been taken on 1 October. The possibility existed that the specific combination of planting date and harvest date used, followed by a relatively severe winter, were uniquely disadvantageous for the Siberian wildrye entries. Accordingly, an experiment was designed and conducted to compare various combinations of planting dates and seeding-year harvest dates for their effects on subsequent winter survival of Siberian wildrye.

Eight field experiments reported here provide information on performance and suitability of wildryes for use in this northern area. All experiments were conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska.

EXPERIMENTAL PROCEDURES

All experimental sites were selected for good surface drainage and all were fully exposed to maximum winter stresses occurring locally. Soil type was Knik silt loam (Typic Cryochrept). Commercial fertilizer disked into plowed seedbeds before planting each experiment supplied nitrogen (N), phosphorus (as P_2O_5), and potassium (as K_2O) at 32, 128, and 64 lb/A, respectively.

In each of the years after establishment in Experiments II, III, and IV, commercial fertilizer topdressed in late March or early April and before initiation of spring growth of grasses supplied N, P_2O_5, and K_2O at 126, 96, and 48 lb/A, respectively. In Experiments II, III, and IV (in years when two harvests per year were taken), ammonium nitrate supplying N at 80 lb/A was topdressed one to three days after the first-cutting forage harvest each year.

All forage harvests were made with a sickle-equipped plot mower leaving approximately a 2-inch stubble. Yields were derived from a swath 2.5 feet wide mowed from the centerline of each plot after a 1.25-foot strip was mowed and discarded from both ends of all plots to remove border effects. Small, bagged samples from each plot were dried to constant weight at 140°F to derive percent dry matter in herbage at harvest; all yields are reported on the oven-dry basis.

Any regrowth after second forage harvests was clipped and raked shortly before freeze-up in all ongoing forage experiments. This left a uniform 2-inch stubble to prevent uneven snow retention on plots over winter.

EXPERIMENT I (INDIVIDUAL PLANTS IN ROWS): The plant strains listed in Table 2 were seeded 8 June 1972 at light rates in rows 29 feet long and 18 inches apart; a randomized complete block experimental design was used with three replications. When seedlings were 2 to 3 inches tall, they were thinned to leave individual seedlings 4 to 6 inches apart.

Aerial growth produced on plants during the seeding year, left intact over winter, was clipped and removed leaving a 2-inch stubble in early spring of 1973. Counts of living and dead plants were made after initiation of spring growth.

EXPERIMENT II (BROADCAST-SEEDED PLOTS FOR FORAGE): This test was seeded 8 June 1972; grasses were broadcast-seeded in plots measuring 5 by 18 feet; a randomized complete block experimental design was used with three replications. Nine strains of wildrye in seven different species were compared with 11 strains of cool-season, perennial grasses within seven non-*Elymus* species as listed in Figure 3.

All plots were harvested on 13 October near the end of the seeding-year growing season and twice per year for three years thereafter. Harvest dates were 11 July and 10 Sep. in 1973, 1 July and 18 Sep. in 1974, and 26 June and 25 Sep. in 1975.

EXPERIMENTS IIIa, IIIb, IIIc, IIId (BROADCAST-SEEDED PLOTS FOR FORAGE): Two species of wildrye (Siberian and Russian), and two standard forage grasses used locally (Polar bromegrass and Engmo timothy) were compared in four large experiments, the bulk of which will be reported elsewhere. The Siberian wildrye was a composite strain composed of collections from native stands in Alaska; the Russian wildrye was the cultivar Sawki selected in Saskatchewan. The four experiments, identified here as Experiments IIIa, IIIb, IIIc, and IIId, were spring-seeded without a companion crop in consecutive years, 1967, 1968, 1969, and 1970, respectively. Randomized complete block experimental designs were used with three replications in all four tests; individual plots were five feet wide and 15 to 20 feet long in the various experiments.

A seeding-year forage harvest was taken near the end of the growing season in the year of establishment; two harvests were taken per year for the subsequent five years in each experiment (mean harvest dates for the four experiments appear in Table 3).

EXPERIMENT IV (BROADCAST-SEEDED PLOTS FOR FORAGE): The 29 grass strains in 15 species shown in Table 3 were broadcast-seeded 25 May 1984 in plots measuring 5 by16 feet; a randomized complete block experimental design was used with four replications. Forage harvests were taken near the end of the seeding year growth period and twice during each of the two subsequent years on the dates given in Table 3.

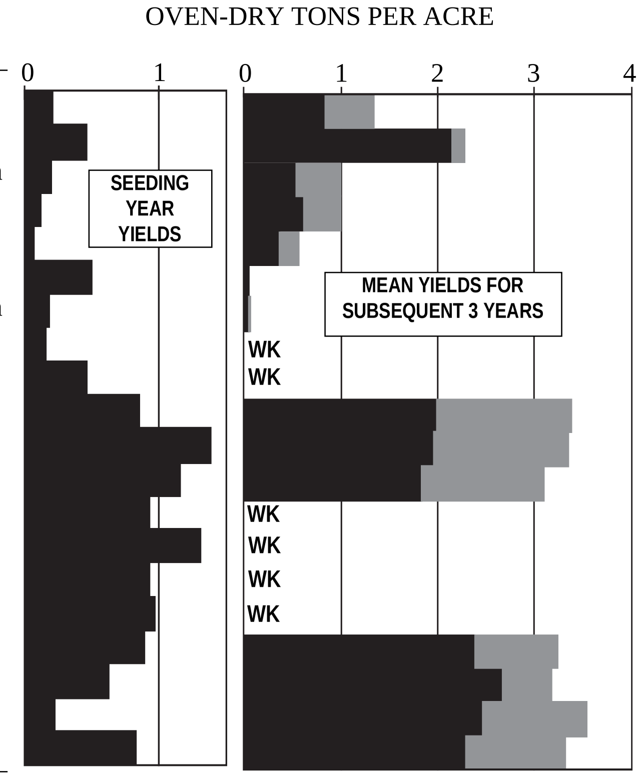
EXPERIMENT V (SEEDING-YEAR MANAGEMENT OF SIBERIAN WILDRYE): This experiment involved only Siberian wildrye; a composite bulked from several Asiatic

Table 2. Comparative winter survival of native Alaskan and introduced wildryes and northern-adapted strains within non-*Elymus* grass species grown as individual plants in rows. (Exp. I, planted 8 June 1972, three replications.)

Common name	Scientific name	Cultivar or strain	Identification no. PI[1]	Identification no. AFA[2]	Species origin	Seed source	Mean percent winter survival[3]
Siberian wildrye	*Elymus sibiricus*	Buriatia	315427	1859	U.S.S.R.	RPIS[4]	100
" "	" "	Amurskij	326266	1863	"	"	100
" "	" "	Guaran	326267	1864	"	"	99
" "	" "	—	326268	1865	"	"	100
" "	" "	—	315428	1860	"	"	100
" "	" "	—	325315	1862	"	"	100
" "	" "	—	314619	1769	"	"	94
" "	" "	—	315429	1861	Mongolia	"	100
" "	" "	—	—	1833	Alaska	Alaska	100
Downy wildrye	*Elymus innovatus*	—	—	1756	Alaska	Alaska	96
Beach wildrye	*Elymus mollis*	—	—	1754	Alaska	Alaska	95
Russian wildrye	*Elymus junceus*	Mayak	—	1932	U.S.S.R.	Saskatchewan	91
" "	" "	Sawki	—	1901	"	"	86
" "	" "	P-9012	—	1761	"	SCS[5]	84
Altai wildrye	*Elymus angustus*	—	—	1933	U.S.S.R.	Saskatchewan	72
Mammoth wildrye	*Elymus giganteus*	Volga	—	1759	U.S.S.R.	SCS	37
Canada wildrye	*Elymus canadensis*	P-3355	—	1757	N. Amer.	SCS	0
Basin wildrye	*Elymus cinereus*	P-5797	—	1758	N. Amer.	SCS	0
Antarctic wildrye	*Elymus antarcticus*	—	286201	1857	Chile	RPIS	0
Other grasses:							
Orchardgrass	*Dactylis glomerata*	Hattfjelldal	—	1939	Europe	Norway	0
"	" "	Va-BL-67	—	1940	"	"	0
Meadow fescue	*Festuca pratensis*	Vagones	—	1941	Europe	Norway	0
" "	" "	Loken	—	1942	"	"	0
Creeping foxtail	*Alopecurus arundinaceus*	Garrison	—	1867	Eurasia	SCS	100
Smooth bromegrass	*Bromus inermis*	Polar[6]	—	1925	Eurasia/ N. Amer.	Alaska	100
Pumpelly bromegrass	*B. pumpellianus*	—	—	1920	Alaska	Alaska	100
Arctic wheatgrass	*Agropyron sericeum*	—	—	1819	Alaska	Alaska	100

[1]Identification number from national Plant Introduction system.
[2]Identification number from Alaska Forage Accession record.
[3]Mean percent of surviving plants (3 replications) in spring of 1973.
[4]Regional Plant Introduction Station, Pullman, WA, supplied by A.M. Davis.
[5]Soil Conservation Service, U.S.D.A., Plant Materials Center, Pullman, WA, supplied by Frank H. Webb.
[6]Predominantly of hybrid origin (*B. inermis* of Eurasian origin x *B. pumpellianus* from N. America).

Common name	Species	Cultivar or strain	Species origin	Seed source
Beach wildrye	*Elymus mollis*	(None)	Alaska	Alaska
Siberian wildrye	*E. sibiricus*	"	"	"
Russian wildrye	*E. junceus*	Sawki	U.S.S.R.	Saskatchewan
" "	“ “	Mayak	"	U.S.S.R.
" "	“ “	P-9012	"	SCS[1]
Mammoth wildrye	*E. giganteus*	Volga	"	"
Altai wildrye	*E. angustus*	(None)	Mongolia	Saskatchewan
Canada wildrye	*E. canadensis*	P-3355	N. America	SCS
Basin wildrye	*E. cinereus*	P-5797	N. America	"
Timothy	*Phleum pratense*	Engmo	Europe	Norway
"	" "	Bodin	"	"
"	" "	Va-BL-60	"	"
Meadow fescue	*Festuca pratensis*	Loken	"	"
" "	" "	Vagones	"	"
Orchardgrass	*Dactylis glomerata*	Hattfjelldal	"	"
"	" "	Va-BL-67	"	"
Creeping foxtail	*Alopecurus arundinaceus*	Garrison	Eurasia	SCS
Arctic wheatgrass	*Agropyron sericeum*	(None)	Alaska	Alaska
Pumpelly brome	*Bromus pumpellianus*	(None)	"	"
Smooth brome	*B. inermis*	Polar[2]	Eurasia/Alaska	"



[1]Soil Conservation Service, U.S.D.A., Plant Materials Center, Pullman, WA., supplied by Frank H. Webb.

[2]Predominantly of hybrid origin (*B.inermis* from Eurasia x *B. pumpellianus* from N. America).

Figure 3. Background information on wildryes and other grasses in Exp. II, and forage yields produced over four years from broadcast-seeded plots at the Matanuska Research Farm. Left graph shows seeding-year yields harvested 13 October. Right graph shows mean yields for first-cuttings (solid portion of bars) and second-cuttings (shaded portion of bars) for three harvest years after establishment, except beach wildrye yield bar is mean of only two years. (WK) = Winterkilled first winter. Mean harvest dates: first = 3 July; second = 18 Sep.

Table 3. Mean forage yields of native Alaskan Siberian wildrye, Sawki Russian wildrye, Polar bromegrass, and Engmo timothy in four, 6-year experiments at the Matanuska Research Farm. Plots were harvested once near the end of the seeding-year growing season and twice each year thereafter for five years; harvest dates are means for the four experiments (Exps. IIIa, IIIb, IIIc, and IIId).

	Seeding year	Years after establishment										6-year total
		First		Second		Third		Fourth		Fifth		
	29 Sep	5 July	29 Sep	3 July	4 Oct	6 July	21 Sep	6 July	19 Sep	1 July	17 Sep	
	Oven-dry tons/acre											
Native Siberian wildrye	0.41	2.52	0.90	1.90	0.78	1.69	0.65	2.03	0.12	1.46	0.03	12.49
Sawki Russian wildrye[1]	0.21	0.50	0.42	0.76	0.68	0.99	0.76	0.46	0.43	0.41	0.16	5.78
Polar bromegrass	0.69	1.48	1.20	1.31	1.20	2.02	1.23	2.48	0.89	2.59	1.09	16.18
Engmo timothy[2]	0.86	1.01	1.25	0.38	0.89	0.29	0.23	0.76	0.05	0.40	0.36	6.48

[1]Stands of Sawki winterkilled totally during the 5th winter in Exp. IIIa, and during the 4th winter in Exps. IIIc and IIId.
[2]Stands of Engmo winterkilled totally during the 4th winter in Exp. IIIa, and during the 3rd winter in Exp. IIIb.

lines was used. A split-plot experimental design was used with four replications. Three main plots seeded on three different dates (19 May, 6 June, 24 June) in 1975 were each divided into six subplots that measured 5 by 18 feet. Subplots were harvested in the seeding year on six different dates (20 Aug., 29 Aug., 12 Sep., 19 Sep., 30 Sep., 6 Oct.). At the 6 Oct. harvest, all other plots were also clipped short and raked leaving a uniform 2-inch stubble to prevent uneven snow retention over winter.

All plots were harvested on the same date (15 June) in 1976 to provide a uniform quantitative measure of the effects of seeding-year treatments on subsequent winter survival and on forage production in the year after establishment.

RESULTS AND DISCUSSION

EXPERIMENT I (INDIVIDUAL PLANTS IN ROWS): A great range in winter survival was apparent among the wildryes and other grasses grown as individual plants in rows. Most of the Siberian wildryes (from both Alaska and Asia) survived at 100% and none less than 94%. These results agree with the assessment of Siberian wildrye by Denisov and Netrebov (1976) who described the species as the “champion of winter hardiness” in Siberia.

The three strains of Russian wildrye survived somewhat less well than the Siberian group, averaging 87%. Altai wildrye survived at 72% and mammoth wildrye at 37%. Three wildryes, Canada, basin, and antarctic winterkilled totally.

These results are at variance with results reported by Lawrence and Troelsen (1964) in Saskatchewan. They reported good winter survival for basin, Altai, and Russian wildryes, but poor survival for Siberian wildrye. The poor agreement of these Alaska results with those in Saskatchewan could possibly be due to different strains (with different adaptation and therefore winterhardiness).

EXPERIMENT II (BROADCAST-SEEDED PLOTS FOR FORAGE): Seeding-year forage yields of all nine strains of wildrye within seven species were low, compared with yields of timothy, meadow fescue, orchardgrass, creeping foxtail, and smooth bromegrass (Fig. 3); seeding-year yield of native pumpelly bromegrass was low, also.

Numbered strains of Canada wildrye (P-3355) and basin wildrye (P-5797) were the least winterhardy of the 20 grass strains compared; both winterkilled completely the first winter. Relatively nonhardy grasses that sustained over 90% winterkill during the first winter were mammoth wildrye (cultivar Volga), Altai wildrye, meadow fescue cultivars Loken and Vagones from Norway, and orchardgrass cultivars Hattfjelldal and Va-BL-67 from Norway.

Intermediate in winterhardiness during the first winter (all rated at 60% winterkilled) were Russian wildrye cultivars Sawki and Mayak from Saskatchewan and strain P-9012 from Washington state.

Grasses that showed no evidence of winter injury during the first winter were native Alaskan beach and Siberian wildryes, Polar and native pumpelly bromegrass, native arctic wheatgrass, Garrison creeping foxtail, and Engmo and Bodin timothy cultivars from Norway; the Va-BL-60 strain of timothy from Norway was rated at 10% winterkilled.

The following grasses (all severely injured during the first winter) produced little or no harvestable forage during the second year and sustained total winterkill during the second winter: Altai wildrye, Loken and Vagones meadow fescue, and Hattfjelldal and Va-BL-67 orchardgrass.

The only wildryes from sources outside of Alaska that persisted and produced a forage yield for the full 4-year term of the experiment were Sawki and Mayak Russian wildrye; however, those yields were less than one-third of the highest yielding grasses in other species.

Native Alaskan Siberian and beach wildryes were more winterhardy, and Siberian wildrye produced more forage than all wildryes from elsewhere. However, the very open character of the beach wildrye stand permitted weed ingress into those plots to the extent that no forage yield was obtained from that grass in the fourth year.

Seven non-*Elymus* grass strains surpassed all wildryes derived from sources outside Alaska in winterhardiness, persistence, and forage yields, averaging over 3 tons of dry matter per acre; those were three strains of timothy from Norway, Garrison creeping foxtail, Polar bromegrass, and native Alaskan pumpelly bromegrass and arctic wheatgrass.

These results and those of Experiment I indicate that the evaluated strains of Russian, mammoth, Altai, Canada, and basin wildrye are poorly adapted for use as forage or conservation plantings in this area of Alaska. These results apply, however, only to the strains evaluated. Other experimental studies in Alaska have demonstrated that a great range of winterhardiness can exist among the cultivars, regional strains, and latitudinal ecotypes within a species (Klebesadel 1984, 1985b; Klebesadel and Helm 1986, 1992; Klebesadel and Dofing 1991). If strains of the above introduced wildryes can be obtained from more northern origins and evaluated in Alaska, they may be found to be better adapted to Alaskan conditions.

EXPERIMENTS IIIa, IIIb, IIIc, IIId (BROADCAST-SEEDED PLOTS FOR FORAGE): These results summarize the performance of a single strain within each of two species of wildrye and compare them with two of the major forage cultivars recommended for use in this area. The results reported here summarize only the winterhardiness, persistence, and forage production of those four grasses from four large experiments that included many other grasses and legumes; the total results will be reported in a separate bulletin.

The two wildryes were native Alaskan Siberian wildrye and Sawki Russian wildrye; the commonly used forages were Polar bromegrass and Engmo timothy. The data in Table 3 are means of forage yields for the four experiments that were each harvested once near the end of the seeding-year growing season and twice per year for the subsequent five years. Harvest dates in Table 3 are mean dates for the four experiments.

Averaged over the 6-year durations of four experiments (24 harvest-years), Polar bromegrass ranked first of the four grasses and Siberian wildrye second in total forage yield (Table 3). With considerably lower total yields, Engmo timothy ranked third and Sawki Russian wildrye fourth.

The relatively poor performance of Sawki (Sawki stands winterkilled in three of the four tests) contrasts with Irwin's (1945) praise for Russian wildrye in earlier evaluations at this station. The discrepancy may lie in differing adaptation of the different strains of Russian wildrye evaluated in Irwin's (1945) report versus the Sawki cultivar utilized in these experiments.

Lawrence (1967) reported that source material from which Sawki was selected was of uncertain origin, but "probably came from introductions from the Western Siberian Experiment Station at Omsk" (= 55°N). Having (probably) originated at that more southern latitude than this area of Alaska, then undergoing selection within that gene pool for genotypes that exhibited superior performance at even more southern latitudes (ca. 49° to 52°N) in Saskatchewan, it is not altogether surprising that Sawki performed poorly when grown at this much higher latitude.

Irwin (1945) provided no information on the origin of the Russian wildrye strain evaluated here in the 1940's. A greater array of ecotypes within this species should be evaluated here; Rogler and Schaaf (1963) describe its natural range in Eurasia as very extensive. Ecotypes from more northern origins on that continent likely would fare better in southcentral Alaska than Sawki, which was selected for superior performance at much lower latitudes in Canada. This argues strongly that germplasm from northern areas of Eurasia should be brought directly to Alaska for evaluation, instead of drawing upon stocks that have been selected for superior adaptation at lower latitudes in Canada or the 48 conterminous states. That selection process logically narrows the gene base of plant populations for optimal suitability at those lower latitudes but, during that selection, discards genetic elements that confer best adaptation to higher latitudes as in Alaska.

Another discrepancy is found between Irwin's (1945) report and the present results in his description of Siberian wildrye as "Foliage very scant." That assessment is hardly accurate for the appearance of Siberian wildrye grown in experiments reported here (Fig. 4). The discrepancy probably is due to differences in soil fertility. When growing in low-fertility substrates such as roadside gravels, Siberian wildrye is quite non-leafy (Fig. 2). Irwin (1945) does not refer to any fertilizers applied but they probably were minimal in the 1940's, resulting in relatively non-leafy growth. However, with relatively high rates of the major nutrients supplied in the present experiments, Siberian wildrye produces an abundance of foliage (Figs. 4, 7).

EXPERIMENT IV (BROADCAST-SEEDED PLOTS FOR FORAGE): Three strains of Siberian wildrye, one from Alaska and two from Asia, were compared with 26 other grass strains within several species in a 3-year experiment (1984-86). The intended objective—to compare strains for winterhardiness and productivity under average rainfall and winter conditions—was generally thwarted by abnormal weather conditions. Amounts and distribution of precipitation imposed marked influences on the forage productivity of the grasses, and two relatively mild winters permitted several strains to survive that ordinarily would have sustained severe winter injury or total winterkill.

Concerning winter conditions, relatively little stress was imposed on strains; Climax timothy, for example, a cultivar that ordinarily is severely injured

Figure 4. Comparative spring growth photographed 21 June of one-year-old plots of (left) Sawki Russian wildrye (est. 50% winterkill) and (right) native Alaskan Siberian wildrye (no apparent winter injury) in Experiment IIIa. Numbers on white stakes indicate height in feet.

in field locations exposed to maximum winter stresses as Exp. IV was, survived well and ranked seventh in productivity. The only grass that winterkilled completely was Frontier reed canarygrass; it sustained severe injury during the first winter and was killed totally during the second.

Good establishment and high seeding-year forage yields were obtained (Table 4), due to precipitation being above normal and well distributed during the seeding year (Table 5). Seven timothy cultivars averaged 2.45 T/A, five strains of bromegrass averaged 2.09 T/A, and Frontier reed canarygrass produced at 2.48 T/A.

The following two growing seasons were below normal in rainfall, especially during the first halves (Table 5), leading to modest forage yields. Accordingly, forage yields during the years 1985 and 1986 were more a comparison of the grasses for forage-producing capabilities under drought stress than a measure of comparative production under good growing conditions.

The two Siberian wildryes from Russia ranked first and second in total forage yield, while the Alaska strain of the same species ranked 20th. While no climatological data are available for the original habitats of the Asiatic strains, it is probable that they are adapted to conditions of greater drought stress than the Alaska strain. Other experiments during years of moisture deficit at this station showed poorer tolerance of moisture stress by native Alaska wheatgrasses than introduced strains from arid areas in the western U.S. (Klebesadel and Helm 1992).

Three of the four bromegrass cultivars ranked high (third, fourth, fifth) in total forage production; however, native Alaskan pumpelly brome (at 11th) and the cultivar Lofar (14th) from Norway ranked well below the other strains.

The group of seven timothy cultivars ranked in the upper half of the 29 grass strains, but generally below the bromegrasses; timothy as a species is recognized to be less tolerant of moisture deficit than smooth bromegrass (Smith *et al*. 1986).

Table 4. Forage yields of three strains of Siberian wildrye and other native and introduced grasses harvested once near the end of the seeding year and twice during the subsequent two moisture-deficient years at the Matanuska Research Farm. (Exp. IV, broadcast-seeded plots planted 25 May 1984, 4 replications).

Grass species and strain	1984	1985			1986			3-year total	Overall rank
	24 Sept	28 June	10 Sept	Total	30 June	8 Sept	Total		
	-Oven-dry tons/acre-								
Siberian wildryes *(Elymus)*:									
E. sibiricus (USSR) (AFA-2201-PMC)	2.47 abc[1]	2.55 a	1.46 bc	4.01 a	1.32 bcd	1.75 efg	3.07 b-f	9.55 a	1
E. sibiricus (USSR) (AFA-2144)	2.40 abc	2.46 a	1.46 bc	3.92 a	1.32 bcd	1.85 b-g	3.17 bcd	9.49 ab	2
E. sibiricus (Alaska) (AFA-1996)	0.96 ijk	1.91 bc	1.07 d	2.98 bcd	1.17 cde	1.11 jk	2.28 gh	6.22 fgh	20
Wheatgrasses *(Agropyron)*:									
A. repens (Quackgrass)	1.85 def	1.54 c-f	1.45 bc	2.99 bcd	1.18 cde	2.16 a-d	3.34 a-d	8.18 cd	8
A. boreale (AFA-2202-PMC)	1.60 e-h	1.41 c-f	1.07 d	2.48 c-g	0.62 g-j	1.19 ij	1.81 hi	5.89 ghi	21
A. subsecundum (AFA-2204-PMC)	1.20 hij	1.62 cde	0.57 ef	2.19 e-h	0.74 fgh	1.00 jkl	1.74 i	5.13 h-k	23
A. yukonense (AFA-2206-PMC)	1.41 f-j	1.33 def	0.52 efg	1.85 ghi	0.39 ij	1.21 hij	1.60 i	4.86 i-l	24
A. subsecundum (AFA-2203-PMC)	1.56 e-h	0.52 i	0.66 ef	1.18 j	0.51 hij	1.06 jkl	1.57 ij	4.31 j-m	25
A. violaceum (AFA-2205-PMC)	1.15 hij	1.12 e-h	0.39 fg	1.51 ij	0.28 jk	1.13 j	1.41 ij	4.07 k-n	26
A. violaceum (AFA-2171-AFES)	0.90 jk	1.25 d-g	0.25 gh	1.50 ij	0.67 f-i	0.74 l	1.41 ij	3.81 lmn	27
Smooth bromegrasses *(Bromus inermis)*:									
Signal	2.59 ab	1.48 c-f	1.40 bc	2.88 cd	1.38 bc	2.20 abc	3.58 ab	9.05 abc	3
Manchar	2.19 bcd	1.43 c-f	1.61 b	3.04 bc	1.69 ab	2.09 b-e	3.78 a	9.01 abc	4
Polar[2]	2.01 cde	1.71 cd	1.29 bcd	3.00 bcd	1.50 abc	1.96 b-f	3.46 abc	8.47 a-d	5
Pumpelly[3]	1.84 def	1.49 c-f	1.38 bcd	2.87 cd	1.40 bc	1.73 efg	3.13 b-e	7.84 cde	11
Lofar	1.80 d-g	1.37 def	1.17 cd	2.54 c-f	1.41 bc	1.88 b-g	3.29 a-d	7.63 de	14
Timothy *(Phleum pratense)*:									
Climax	2.39 abc	0.70 hi	1.93 a	2.63 cde	0.76 fgh	2.50 a	3.26 a-d	8.28 bcd	7
Kampe II	2.88 a	0.63 hi	1.89 a	2.52 c-f	0.54 hij	2.07 b-e	2.61 efg	8.01 cde	9
Engmo	2.43 abc	1.04 fgh	1.31 bcd	2.35 d-h	1.42 bc	1.79 d-g	3.21 bcd	7.99 cde	10
Bottnia II	2.63 ab	0.72 hi	1.29 bcd	2.01 e-i	1.00 def	2.21 ab	3.21 bcd	7.85 cde	12

Table 4 (continued).

Grass species and strain	1984 24 Sept	1985 28 June	1985 10 Sept	1985 Total	1986 30 June	1986 8 Sept	1986 Total	3-year total	Overall rank
	-Oven-dry tons/acre-								
Timothy *(Phleum pratense)* continued:									
Korpa	2.38 abc	0.73 hi	1.24 cd	1.97 f-i	1.36 bcd	1.77 efg	3.13 bcd	7.48 de	15
Bodin	2.20 bcd	0.77 ghi	1.29 bcd	2.06 e-i	1.31 cd	1.82 c-g	3.13 bcd	7.39 def	16
Adda	2.25 bcd	0.80 ghi	1.28 bcd	2.08 e-i	1.35 bcd	1.50 ghi	2.85 def	7.18 def	18
Reed canarygrass *(Phalaris arundinacea)*:									
Rovik	1.30 g-j	0.75 ghi	0.75 e	1.50 ij	0.95 efg	1.61 fg	2.56 fg	5.36 hij	22
Frontier	2.48 abc	Tr[4]	0.46 efg	0.46 k (WK)[5]	—	—	—	2.94 n	29
Other grasses:									
Arctared red fescue *(Festuca rubra)*	1.34 f-j	2.33 ab	1.39 bcd	3.72 a	1.82 a	1.55 gh	3.37 a-d	8.43 a-d	6
Nugget Kentucky bluegrass *(Poa pratensis)*	1.47 f-i	1.42 c-f	1.58 b	3.00 bcd	1.40 bc	1.88 b-f	3.28 a-d	7.75 cde	13
Norcoast hairgrass *(Deschampsia beringensis)*	1.80 d-g	1.52 c-f	2.04 a	3.56 ab	0.29 jk	1.61 f-g	1.90 hi	7.26 def	17
Garrison creeping foxtail *(Alopecurus arundinaceus)*	1.22 hij	1.36 def	1.17 cd	2.53 c-f	1.25 cde	1.76 efg	3.01 c-f	6.76 efg	19
American sloughgrass *(Beckmannia syzigachne)*	0.56 k	1.50 c-f	0.25 gh	1.75 hij	0.31 jk	0.77 kl	1.08 j	3.39 mn	28

[1]Within each column, means not followed by a common letter differ significantly (5% level) using Duncan's Multiple Range Test.
[2]Predominantly hybrid *(B. inermis x B. pumpellianus)*.
[3]Native Alaskan *Bromus pumpellianus*.
[4]Trace amount of herbage inadequate for harvestable yield.
[5]Stand winterkilled totally; no further yields.

Table 5. Monthly departures (inches) from normal precipitation recorded at the Matanuska Research Farm during the course of forage-production Experiments II, IIIa, IIIb, IIIc, IIId, IV, and V.

Experiment	Year	Apr	May	June	July	Aug	Sep	Net departure
Exp. II:	1972	+ .18	+ .49	+ .05	- .64	-1.85	+2.54	+ .77
	1973	+ .69	- .36	+ .32	-2.04	+1.66	-1.50	-1.23
	1974	+ .12	+ .06	- .94	-1.28	-1.43	- .09	-3.56
	1975	+1.34	- .49	+ .71	- .13	-1.33	+1.02	+1.12
Exps. IIIa, IIIb, IIIc, and IIId:[1]	1967	+ .46	+ .19	+ .06	+ .46	- .04	+ .78	+1.90
	1968	+ .08	+1.80	+ .36	- .50	-2.23	-1.57	-2.06
	1969	- .37	+ .28	- .90	+1.04	-2.08	-1.93	-3.95
	1970	- .05	- .66	+ .06	- .36	- .75	-1.55	-3.31
	1971	+ .59	- .47	+ .49	- .14	+2.00	+ .09	+2.56
	1972 through 1975 appear above (for Exp. II).							
Exp. IV:	1984	+ .17	+ .10	+ .19	+ .26	+ .08	- .50	+ .30
	1985	- .53	- .28	- .71	-1.02	+ .61	+1.26	- .67
	1986	- .57	- .56	-1.11	+1.66	- .48	+1.00	- .06
Exp. V:	1975	+1.34	- .49	+ .71	- .13	-1.33	+1.02	+1.12
	1976	+ .94	- .11	-1.34	- .63	-2.06	- .99	-4.19
Normal		.63	.74	1.59	2.50	2.38	2.33	

[1]Some supplemental irrigation was applied at times of critical moisture deficit, but generally applied after moisture stress was conspicuous; thus yields were lower than would have occurred with more adequate and timely precipitation.

Five strains of native Alaskan wheatgrasses, and one from Canada, within four species ranked near the bottom in yields. Similarly, other low yielders among native Alaskan species were Norcoast hairgrass (17th) and American sloughgrass (28th); foliage of the latter grass was severely infected with a mildew pathogen, especially during the latter part of each growing season.

Quackgrass differed from the other *Agropyron* species in producing higher forage yields and ranked eighth overall. Similarly, Arctared red fescue produced well (sixth in rank) while Nugget Kentucky bluegrass (13th) and Garrison creeping foxtail (19th) were somewhat lower.

Rovik reed canarygrass, from Norway, ranked 22nd and was more winterhardy than Frontier from Canada, paralleling earlier results with those strains at this location (Klebesadel and Dofing 1991).

These results indicate that Siberian wildrye from Asia, at least under conditions of drought stress, is a somewhat better forage producer than many other grass species, including strains of commonly used, highly productive forage cultivars.

EXPERIMENT V (SEEDING-YEAR MANAGEMENT OF SIBERIAN WILDRYE): Seeding-year forage yields from plots seeded 19 May differed little as affected by harvest date (Fig. 5); yields for the six harvest dates from 20 August to 6 October averaged 2.81 tons oven-dry forage per acre. The absence of increase in yield from 20 August to 6 October, a span of 47 days, was somewhat surprising.

Plots seeded 6 June averaged only slightly less in forage yield (2.49 T/A) across the six seeding-year harvest dates, but there was slightly more indication of increasing yield from the first cut (20 Aug. = 2.18 T/A) to the last (6 Oct. = 2.66 T/A).

Seeding-year forage yields from plots seeded 24 June were considerably lower than from the earlier two planting dates. Average yield across all six harvests was 1.14 T/A, and an increase in yield from first cut (20 Aug. = 0.46 T/A) to last (6 Oct. = 1.43 T/A) was much more evident (Fig. 5).

In spring of the following year, considerable differences were apparent in winter survival and vigor of spring growth among plots that had been harvested on different dates in the seeding year; however, those differences were confined to plots that had been planted on the latest (24 June) planting date (Fig. 6).

When all plots were harvested on the same date (15 June) the following year, seeding-year harvest dates were noted to have had little influence on winter survival and second-year forage production of the grass seeded on the earliest two dates (Figs. 7, 8). Over all seeding-year cutting dates, plots that had been planted 19 May averaged 2.58 T/A in the second-year first cutting while those planted 6 June averaged 2.57 T/A.

With plots that had been planted 24 June, however, different dates of seeding-year harvest had a profound influence on winter survival and second-year first-cutting yield (Figs. 6, 8). Plots that had been harvested 20 August in the seeding year yielded well the following spring at 2.43 T/A. Plots harvested 29 August or 6 October were somewhat adversely affected, yielding 1.92 and 1.86 T/A, respectively. Harvest on 30 September resulted in somewhat more injury to plots with a second-year first-cut yield of 1.44 T/A.

The most harmful effect on plots planted 24 June resulted from seeding-year harvests on 12 and 19 September. Effects of those two harvest dates were about equal; both predisposed stands to severe winter injury (Figs. 6, 8). The thinned and weakened stands that had been harvested on 12 and 19 September produced very low forage yields of 0.62 and 0.64 T/A, respectively, a 74% reduction in yield compared to plots planted at the same time but harvested on 20 August (Fig. 8).

These results indicate that two advantages can accrue from planting Siberian wildrye earlier than early June: (a) in a year of favorable growing conditions (as occurred in 1975, Table 5), a seeding-year forage yield in excess of 2.5 T/A can be obtained (Fig. 5), and (b) the time of seeding-year harvest should have little effect on subsequent health of the stand.

The damaging effect of the combination of late seeding (24 June) and seeding-year harvest near mid-September in this experiment helps considerably to explain the poor performance of Siberian wildrye in an earlier experiment (seeded 20 June, seeding-year harvest on 1 October) described in "Background to Experiment V" in the introduction of this report. The inappropriate combination of planting date and seeding-year harvest date were probably causal in the poor winter survival of Siberian wildryes in that experiment.

The injurious effects of certain seeding-year harvest dates in this experiment parallel some results found with other forage species. Smith and Graber (1948) reported that a seeding-year harvest in mid-September in Wisconsin was much more injurious to biennial yellow sweetclover (*Melilotus officinalis*) than harvests earlier (in mid-August) or later (in mid-October).

Similarly, various seeding-year harvest dates were found to have considerably different effects on subsequent winter survival and second-year forage yield of smooth bromegrass (*Bromus inermis*) at this location (Klebesadel 1993) and biennial white sweetclover (*Melilotus alba*) in Alaska's Tanana Valley (Unpublished information, Alaska Agricultural and Forestry Exp. Sta.).

CONCLUSIONS

A few species of wildrye are native in Alaska, more in Canada and the 48 conterminous states, and still other species have been introduced into North America from Old World sources and are utilized both for forage and for soil stabilization.

Experiments reported here indicate that with one

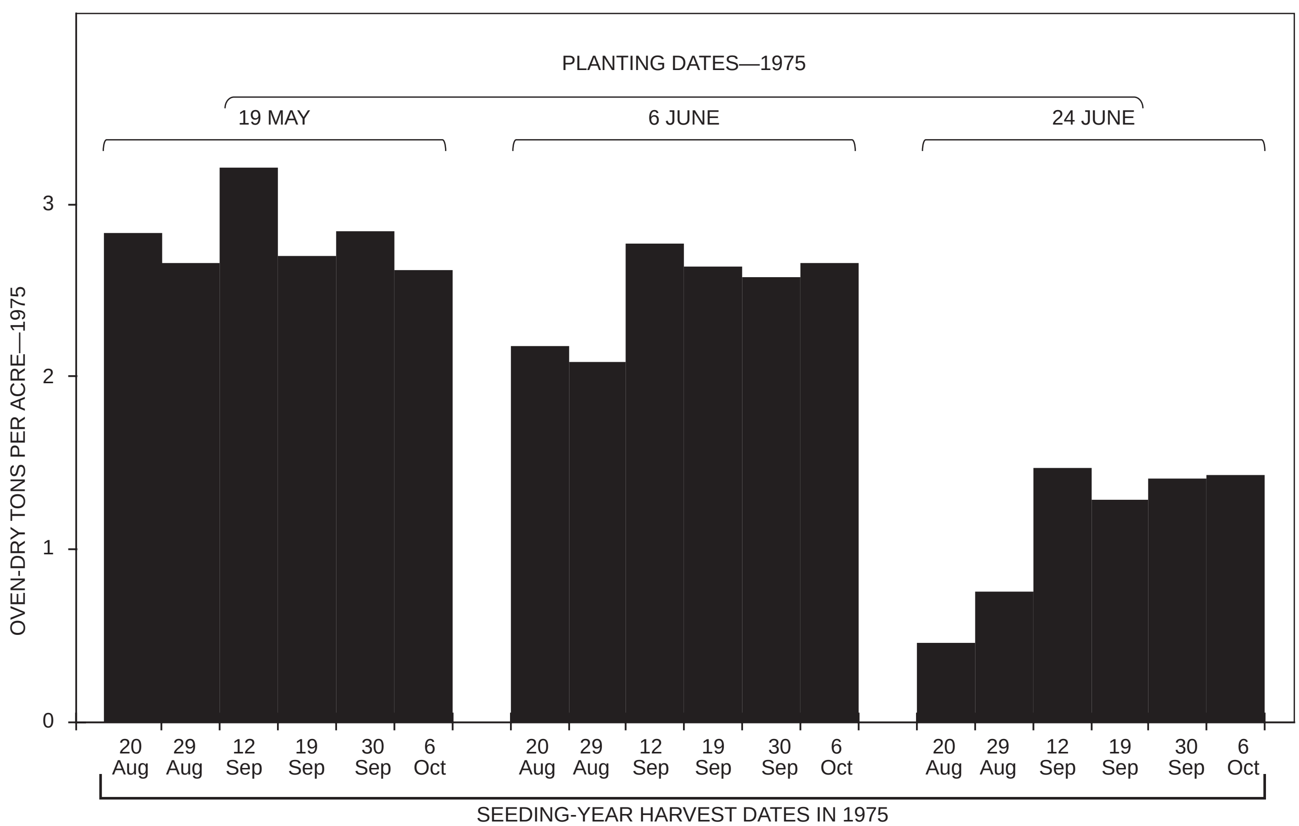


Figure 5. Seeding-year forage yields of Siberian wildrye as influenced by three planting dates in 1975 and six different seeding-year harvest dates (Exp. V).

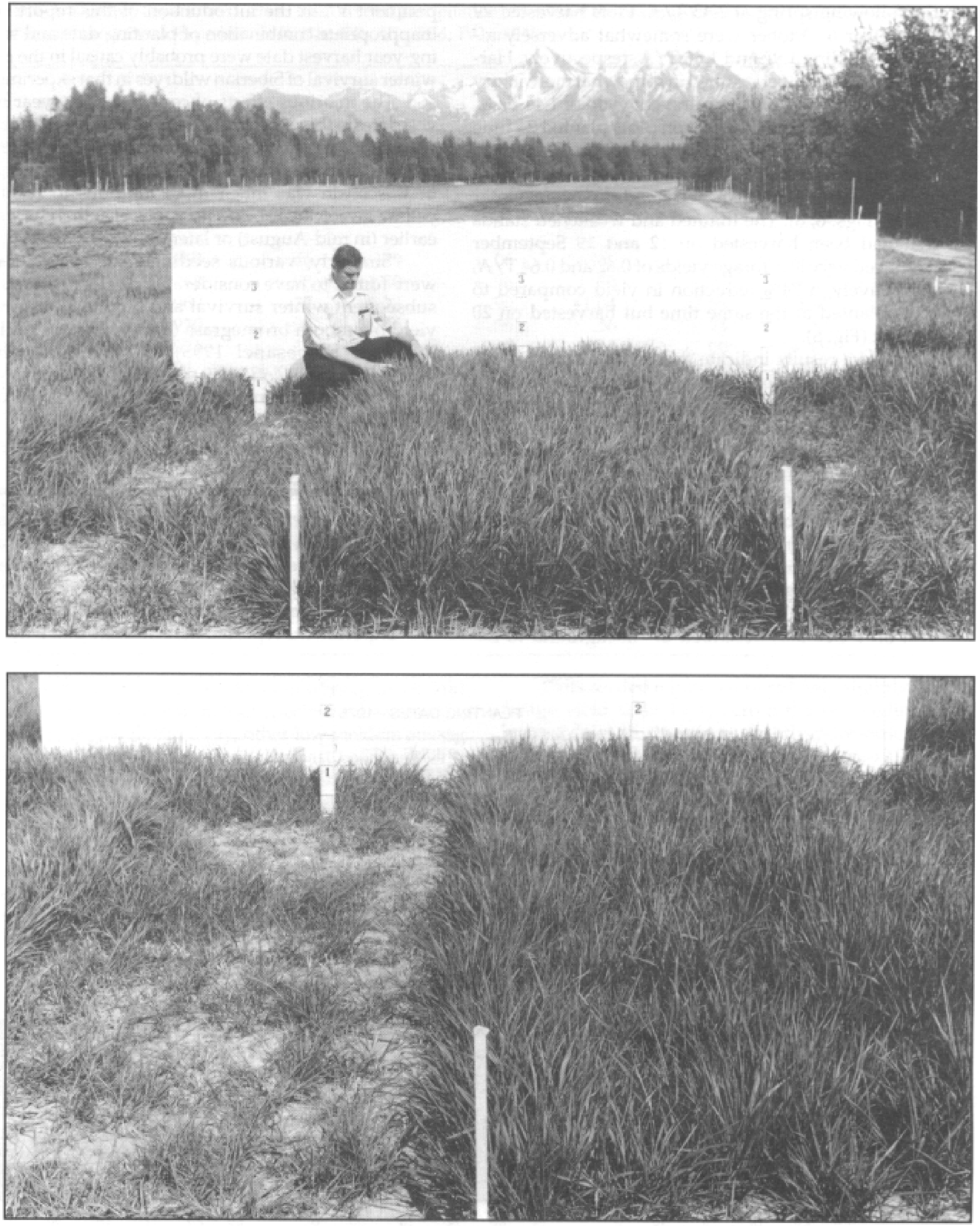


Figure 6. Comparative injury to plots of Siberian wildrye as influenced by different seeding-year harvest dates of the grass

Figure 7. Appearance of Siberian wildrye at the uniform evaluation harvest of all plots on 15 June of the second year of Experiment V, showing the excellent growth produced by the grass in a portion of the experiment seeded early the prior year and therefore undamaged by various dates of seeding-year harvest.

exception (Asiatic Siberian wildrye) the evaluated strains of wildryes introduced from elsewhere in North America and Eurasia hold little viable potential for dependable use in Alaska either as forage crops or for non-forage uses such as revegetation, soil stabilization, etc. This conclusion derives from both their marginal to poor winterhardiness and modest forage yields.

It is recognized that the forage-plot experiments reported here subjected grasses to considerable stresses (aerial growth removed twice per year, plants exposed to maximum winter stresses with only a short stubble, resulting in no retention of protective, insulating snow cover against the removal force of winter winds). Those conditions impose greater stresses on grasses than would be encountered in unharvested conservation plantings. Nonetheless, there are other, more dependably winterhardy grasses available for such uses in Alaska; these include the Alaska cultivar Polar and native pumpelly bromegrass, Arctared red fescue, Nugget Kentucky bluegrass, and introduced Garrison creeping foxtail, and Sodar streambank wheatgrass.

All of these last-mentioned grasses have demonstrated good winterhardiness and persistence in trials in Alaska (Klebesadel 1984, 1985b; Klebesadel and Helm 1986, 1992). Moreover, all possess subterranean overwintering tissues and all spread vegetatively by underground rhizomes (some more vigorously than others) to fill gaps in stands and to bind soils against erosional forces.

Native Alaskan beach wildrye has been utilized as a forage crop where harvestable natural stands existed near livestock operations in Alaska (Klebesadel 1985a). However, despite its winterhardiness, some agronomic deficiencies augur against its use as a seeded cropland forage grass; these include (a) modest forage yields compared with other currently used grasses, (b) a relatively open stand that permits weed invasion, and (c) the coarseness of the grass that does not affect its use as silage but could detract from its use as dried hay.

Beach wildrye serves a valuable role in nature as a vegetative cover and stabilizer of coastal sands (Klebesadel 1985a). It can be artificially employed in that role when seed supplies are available or if propa-

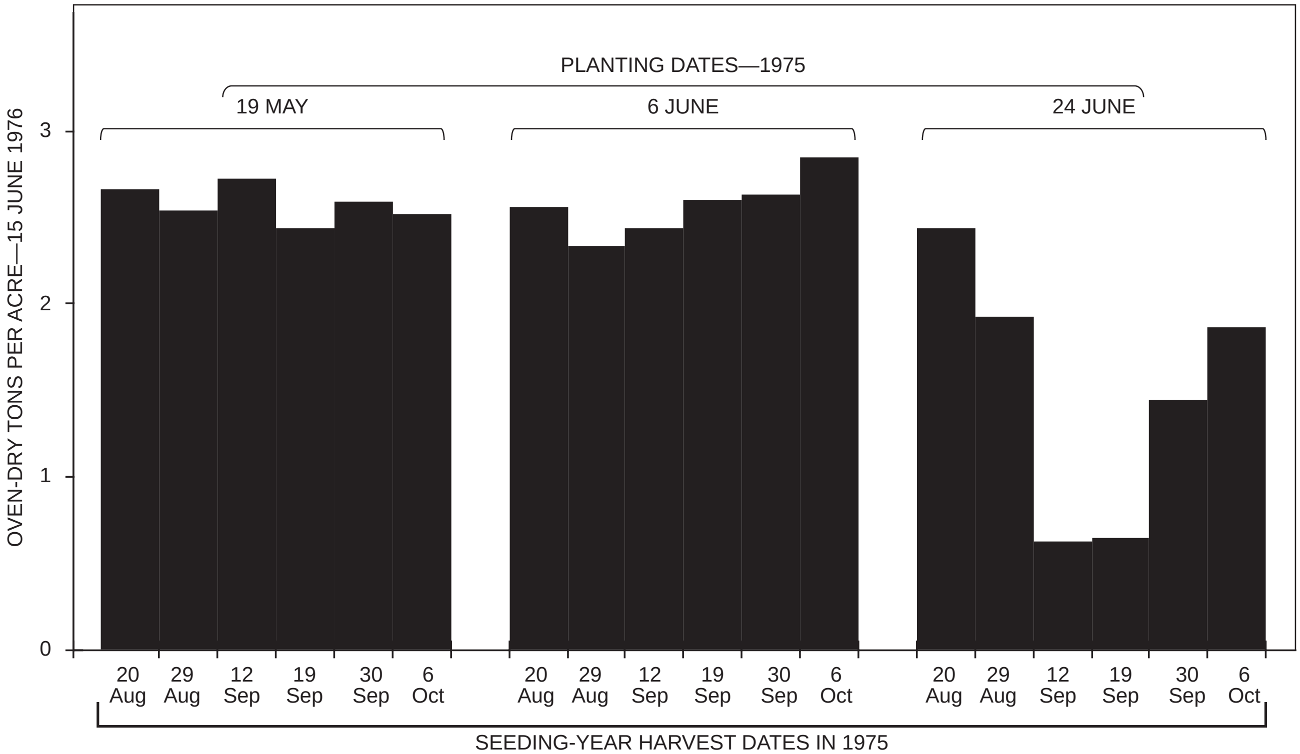


Figure 8. Forage yields of Siberian wildrye on 15 June 1976 as influenced by three different planting dates in 1975 and six different seeding-year harvest dates in 1975 (Exp. V).

Figure 9. Siberian wildrye produces an abundance of seed heads and high yields of seed. However, forage quality of a fully headed crop as shown here would be poor as the bristly awns on the seed heads (Fig. 10) could cause feeding problems.

Figure 10. This photo taken 9 July shows the very drooping or pendulous aspect of the seed heads of Siberian wildrye. The immature, green seed head on the left is healthy while the whitened one on the right, which shows the bristly awns more distinctly, will produce no seed. The stem tissues below the seed head on the right were injured by an insect, resulting in this sterile condition called "silvertop" or "whitehead."

gated vegetatively. This grass also has been utilized historically in many other non-forage avenues (Klebesadel 1985a); one of the most valuable continues today wherein it serves as a fiber source for masterfully crafted basketry by Alaska Natives.

Of all the wildryes evaluated in the experiments reported here, Siberian wildrye represents the best combination of winterhardiness, forage productivity, and excellent seed yields (Fig. 9; Klebesadel and Helm 1992). It was apparent from Exp. IV that accessions of Siberian wildrye from Asiatic sources exhibited better productivity under drought stress than the bulk lot from Alaska sources.

The experiment comparing seeding-year management options (Exp. V) demonstrated clearly that stands of this grass can be injured by an inappropriate combination of planting and harvest dates; late-planted Siberian wildrye should not be harvested near mid-September.

A Cautionary Consideration Concerning Use of Siberian Wildrye as a Forage Crop

Despite its considerable potential for forage production, a significant characteristic of Siberian wildrye that must be taken into account before its use as a forage crop is the abundance of rough, sharp awns that are borne as projections from structures within the seed heads (Fig. 10). If dried as hay after the seed heads emerge, these then-brittle awns could invade the soft mouth tissues of livestock to become a serious problem. It is not known at this time whether the awns would present a feeding hazard if this grass were harvested for a hay crop before emergence of the seed heads; this important question should be investigated.

Limitations of These Findings

It should be recognized that these results apply only to the wildrye strains evaluated and their performance only in this area of Alaska. Accordingly, these findings do not apply to all strains or ecotypes within the species from which they were drawn, nor do they apply to other areas of Alaska where growing or winter conditions may differ from those of the Matanuska Valley.

Many studies at this location have revealed that a great diversity can exist in adaptation (and thus performance in this area of Alaska) among various ecotypes, regional strains, and cultivars within a given species; this has been found to be especially true in plant species that either occur naturally, or have become cultivated, across many degrees of latitude (a considerable north-south dimension) and that occupy a range that includes northern areas (Klebesadel 1984, 1985b, 1985c; Klebesadel and Helm 1986, 1992; Klebesadel and Dofing 1991).

Several of the wildryes evaluated in this report represent named cultivars or numbered strains selected for superior performance at more southern latitudes in Canada or within the 48 conterminous states. Future evaluations of wildryes should include ecotypes drawn from the northernmost limits of their natural ranges. Such introductions should be brought directly to Alaska for evaluation, circumventing selection for good performance at lower latitudes that logically discards genotypes ideally adapted to subarctic latitudes. Wildrye germplasm introduced directly into Alaska from other high-latitude areas should retain ideal physiological adaptation to northern latitudes and therefore should fare better under Alaska conditions than some of the more southern-adapted strains evaluated in experiments reported here.

ACKNOWLEDGMENTS

Early work contributing to this investigation was supported in part by grants RF58108 and RF61036 from The Rockefeller Foundation concerning the collection and evaluation of native Alaskan grasses. These investigations were conducted cooperatively with the Agricultural Research Service, U.S. Department of Agriculture.

I thank Darel Smith for technical assistance, Stoney Wright of the Alaska Plant Materials Center for supplying all seed lots designated "PMC" in Experiment IV, other individuals who supplied requested seed lots, Bobbi Kunkel for calculations, Dr. D.J. Helm for statistical analyses of data, and Peg Banks for manuscript typing. I am grateful also to Keith Swarner for bulletin compositing and graphic contributions, and Stephen Lay for editorial oversight.

LITERATURE CITED

Aamodt, O.S., and D.A. Savage. 1949. Cereal, forage, and range problems and possibilities in Alaska. p. 87-124. (In) Report on exploratory investigations of agricultural problems in Alaska. U.S. Dep. Agric. Misc. Pub. 700. U.S. Government Printing Office, Washington, DC.

Bowden, W.M., and W.J. Cody. 1961. Recognition of *Elymus sibiricus* L. from Alaska and the District of Mackenzie. Bull. Torrey Botanical Club 88:153-155.

Denisov, G.V., and V.P. Netrebov. 1976. (1984 Translation) Growth and development of fodder plants cultivated in the Kolyma Basin. p. 100-135. (In) L.G. Elovskaya (ed.). Biology of fodder plants in the Permafrost Zone. Academy of Science of the U.S.S.R. Siberian Div., Novosibirsk, U.S.S.R.

Dewey, D.R. 1983. Historical and current taxonomic perspectives of *Agropyron*, *Elymus*, and related genera. Crop Sci. 23:637-642.

Hafenrichter, A.L., J.L. Schwendiman, H.L. Harris, R.S. MacLauchlan, and H.W. Miller. 1968. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin states. U.S. Dep. Agric. Soil Conservation Service Handbook 339. U.S. Government Printing Office, Washington, DC.

Hanson, A.A. 1972. Grass varieties in the United States. U.S. Dep. Agric. Handbook No. 170. U.S. Government Printing Office, Washington, DC.

Heinrichs, D.H., and T. Lawrence. 1956. Russian wild rye grass. Canada Dep. Agric. Pub. 991.

Hitchcock, A.S. 1950. Manual of the grasses of the United States (2nd. ed. rev. by A. Chase). U.S. Dep. Agric. Misc. Pub. 200. U.S. Government Printing Office, Washington, DC.

Hoover, M.M., M.A. Hein, W.A. Dayton, and C.O. Erlanson. 1948. The main grasses for farm and home. p. 639-700. (In) Grass. U.S. Dep. Agric. Yearbook. U.S. Government Printing Office, Washington, DC.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA.

Irwin, D.L. 1945. Forty-seven years of experimental work with grasses and legumes in Alaska. Alaska Agric. Exp. Sta. Bull. 12.

Klebesadel, L.J. 1969. Siberian wildrye (*Elymus sibiricus* L.): Agronomic characteristics of a potentially valuable forage and conservation grass for the North. Agronomy Jour. 61:855-859.

Klebesadel, L.J. 1984. Far-north-adapted bluegrasses from areas with rigorous winter climate perform best in southcentral Alaska. Agroborealis 16:37-42.

Klebesadel, L.J. 1985a. Beach wildrye: Characteristics and uses of a native Alaskan grass of uniquely coastal distribution. Agroborealis 17(2):31-38.

Klebesadel, L.J. 1985b. Hardening behavior, winter survival, and forage productivity of *Festuca* species and cultivars in subarctic Alaska. Crop Sci. 25:441-447.

Klebesadel, L.J. 1985c. The critical importance of north-latitude adaptation for dependable winter survival of perennial plants in Alaska. Agroborealis 17(1):21-30.

Klebesadel, L.J. 1993. Bromegrass in Alaska. III. Effects of planting dates, and time of seeding-year harvest, on seeding-year forage yields and quality, winter survival, and second-year spring forage yield. Alaska Agric. and Forestry Exp. Sta. Bull. 96.

Klebesadel, L.J., and D. Helm. 1986. Food reserve storage, low-temperature injury, winter survival, and forage yields of timothy in subarctic Alaska as related to latitude-of-origin. Crop Sci. 26:325-334.

Klebesadel, L.J., and D.J. Helm. 1992. Relationship of latitude-of-origin to winter survival and to forage and seed yields of wheatgrasses (*Agropyron* species) in subarctic Alaska. Alaska Agric. and Forestry Exp. Sta. Bull. 88.

Klebesadel, L.J., and S.M. Dofing. 1991. Reed canarygrass in Alaska: Influence of latitude-of-adaptation on winter survival and forage productivity, and observations on seed production. Alaska Agric. and Forestry Exp. Sta. Bull. 84.

Lawrence, T. 1967. Sawki Russian wild ryegrass. Canadian Jour. Plant Sci. 47:612-613.

Lawrence, T. 1977. Altai wild ryegrass. Agriculture Canada Pub. 1602.

Lawrence, T. 1978. An evaluation of thirty grass populations as forage crops for southwestern Saskatchewan. Canadian Jour. Plant Sci. 58:107-115.

Lawrence, T., and D.C. Ratzlaff. 1985. Evaluation of fourteen grass populations as forage crops for southwestern Saskatchewan. Canadian Jour. Plant Sci. 65:951-957.

Lawrence, T., D.H. Heinrichs, and R.B. Carson. 1960. An evaluation of Altai wild rye, *Elymus angustus* Trin., as a forage crop. Canadian Jour. Plant Sci. 40:295-305.

Lawrence, T., and J.E. Troelsen. 1964. An evaluation of 15 grass species as forage crops for southwestern Saskatchewan. Canadian Jour. Plant Sci. 44:301-310.

Porsild, A.E., and W.J. Cody. 1980. Vascular plants of continental Northwest Territories, Canada. National Museums of Canada, Ottawa, Ontario.

Rogler, G.A., and H.M. Schaaf. 1963. Growing Russian wildrye in the western states. U.S. Dep. Agric. Leaflet 524. U.S. Government Printing Office, Washington, DC.

Smith, Dale, and L.F. Graber. 1948. The influence of top growth removal on the root and vegetative development of biennial sweetclover. Jour. Amer. Soc. Agron. 40:818-831.

Smith, Dale, R.J. Bula, and R.P. Walgenbach. 1986. Forage management. (5th ed.) Kendall/Hunt Publishing Co., Dubuque, IA.

Voigt, P.W., and R.S. MacLauchlan. 1985. Native and other western grasses. p. 177-187. (In) M.E. Heath *et al*. (eds.). Forages—the science of grassland agriculture. (4th ed.) Iowa State University Press, Ames, IA.