

Effects of Planting Date and Latitude-of-Adaptation on Seeding- Year Development, Winter Survival, and Subsequent Seed and Forage Production Potential of Grasses and Legumes in Subarctic Alaska

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Summary

Three to four cultivars from diverse latitudinal origins within each of five species were planted in rows on seven dates from late May to late July in three separate, similar experiments during three different years. Species included were timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), red clover (*Trifolium pratense* L.), and alfalfa (*Medicago sativa* L.). After emergence, rows were thinned to individual plants. Observations and data are reported for (a) seeding-year development, (b) subsequent winter survival, and (c) seed and forage production potential of surviving plants during the second year of growth.

- Seeding-year plants of Kentucky bluegrass and red fescue developed into leafy tufts that produced no elongated culms or seed heads.
- With all planting dates that resulted in production of seed heads during the seeding year by timothy cultivars, fewer heads were produced by the northernmost-adapted cultivar Engmo than by the more southern-adapted Climax and Clair.
- With early planting dates, northern-adapted ecotypes of red clover and alfalfa generally produced seedlings with fewer flowers and fewer elongated stems by freeze-up than did the more southern-adapted ecotypes within each species.
- Early-planted northern-adapted seedlings of timothy, Kentucky bluegrass, and red fescue survived winters better, and produced more seed heads and herbage per plant the following year than the more southern-adapted ecotypes within each species.
- Differences in winter survival between the northernmost-adapted cultivar and those from more southern origins were greater within timothy than within Kentucky bluegrass or red fescue.
- The more southern-adapted ecotypes of Kentucky bluegrass and red fescue survived winters better than similar-origin timothy and alfalfa.
- Subarctic-adapted alfalfa planted in early July tended to survive winters better than when planted earlier or later.
- All red clover cultivars winterkilled regardless of origin or planting date. Even the northernmost-adapted red clovers succumbed to total winterkill under the conditions of these experiments.
- The extreme exposure of all seedlings to winter stresses in these experiments (seedlings clipped short in autumn retained no protective, insulating snow cover against the evacuation force of winter winds) demonstrates the generally poorer winter survival in this area of even the hardiest strains of the two legume species compared with the northern-adapted grasses.
- These results confirm the desirability of utilizing only northern-adapted cultivars of these species for best winter survival and for maximum seed or forage production in southcentral Alaska.
- These findings also confirm the general desirability of early planting for maximum seedling development, and for best winter survival and second-year productivity of both seed and forage.

Introduction

Timing of cultural practices can have considerable influences on desired objectives with forage crops (Elliott and Baenziger 1973; Klebesadel 1969, 1970; Langer and Ryle 1959). Time-of-planting was found to have a marked effect on winter survival and on seed production during the subsequent year in latitudinal strains of two forage grasses at this location (Klebesadel 1970). Planting dates also strongly influenced winter survival and spring forage yields of winter rye (*Secale cereale* L.) cultivars (Klebesadel 1969).

Beyond the above studies, little information is available on comparative development and subsequent winterhardiness of various-aged seedlings of forage grasses and legumes in subarctic Alaska. Further, little is known of the influences of time-of-planting on the potential for herbage or seed production of many grasses and legumes during the year following planting.

Objectives of the present study were to compare effects of several planting dates on seeding-year development, winter survival, and second-year herbage and seed production potential of cultivars from three diverse latitudinal sources within three grass species and four latitudinal sources within two legume species. Three two-year field experiments were conducted over a four-year period at the University of Alaska's Matanuska Research Farm (61.6°N) in southcentral Alaska.

Experimental Procedure

Three similar field experiments were planted during three consecutive years in Knik silt loam (coarse-silty over sandy or sandy-skeletal, mixed, nonacid Typic Cryorthent). All three experimental sites were selected for good surface drainage. Commercial fertilizer disked into each plowed seedbed supplied nitrogen (N), phosphorus (P), and potassium (K) at 32, 56, and 54 lb/A, respectively. Cultivars from diverse latitudinal sources were utilized within three grass and two legume species as listed in Table 1. Randomized complete block experimental designs were used with three replications. Each cultivar or strain was seeded in rows 18 to 22 feet long and 18 inches apart on seven dates about 10 days apart in each experiment as listed in Table 2. Departures from mean dates in

individual years were ± 0 to 3 days.

Seedlings were thinned early by hand-pulling to leave individual plants 6 to 8 inches apart. Seeding-year plant development data were taken in mid-October (after killing frost) in the first two tests. In the first experiment, every plant was examined for number of visible seed heads (grasses), flower and bud clusters (red clover), flowering or budded racemes (alfalfa), and elongated culms or stems exceeding 6 inches in length. In the second and third experiments, 10 representative plants per row were examined for the same criteria. After data collection, all plants were clipped to about a 2-inch stubble and clipped growth was removed from the experimental area to prevent uneven snow retention during the winters.

In mid-to-late April of the year following planting, each experiment was topdressed uniformly with commercial fertilizer supplying N, P, and K at 64, 32, and 46 lb/A, respectively. Each spring of the first year following planting, living and dead plants were counted in each row to calculate winter survival percentages. Seed heads were counted in August on all living grass plants. All herbage of surviving grass plants was clipped (leaving a 2-inch stubble) in August and dried to constant weight at 140°F to calculate oven-dry weight of herbage per plant to provide an estimate of plant vigor and forage production potential.

Results

Seeding-year Development

Timothy: Phenological and morphological differences in seeding-year growth were apparent in October among cultivars from different latitudinal origins (Figure 1, Table 2). Engmo from northern Norway generally produced fewer seed heads and fewer culms taller than six inches than Climax and Clair from more southern latitudes. Climax, from an intermediate latitudinal origin, and Clair, from the southernmost source, did not differ significantly in number of seed heads or culms per plant.

All cultivars produced fewer seed heads and culms on the progressively smaller and younger plants from successively later planting dates. Heide (1982) in Norway reported that heading proceeded earlier on seedlings of timothy ecotypes from south-

ern Norway than on ecotypes from northern Norway.

Kentucky bluegrass and **red fescue**: None of the plants of either species produced seed heads or elongated culms during the seeding year. Plants of both species were progressively smaller leafy tufts with successively later planting dates (Figure 2).

Red clover: Both Alaskland and Altaswede, more northern-adapted than the other two red clover cultivars, are of the “mammoth” type. Both produced very few flowers or stems per plant in the seeding year (Table 2). As is typical of the mammoth type (Smith 1963), seeding-year plants consisted mostly of leafy rosettes. Kenland and Nolins Red are “medium” type cultivars from increasingly more southern origins, respectively, and both produced several stems and numerous

flowers by freeze-up on plants seeded before mid-June.

With all four cultivars, the most flowers and stems were produced on the largest and oldest seedlings from plantings in late May and early June. Fewer stems and flowers were produced on plants that developed from successively later seeding dates.

Alfalfa: There was a tendency toward fewer flowering and budded racemes per plant with northernmost-adapted A-Syn.B than with the three more southern-adapted cultivars, and differences were apparent only for the earliest planting dates (Table 2). Essentially no racemes were visible on plants from seedings made after mid-June. There were no differences among strains for numbers of elongated stems produced per plant during the seeding year.

Species	Cultivar or strain	Place of origin	Latitude of origin (°N)
Timothy: (<i>Phleum pratense</i> L.)	Engmo	Norway	69-70
	Climax	Ontario	44-46
	Clair	Kentucky	38-39
Kentucky bluegrass: (<i>Poa pratensis</i> L.)	Nugget	Alaska	61-62
	Delta	Ontario	44-46
	Merion	Pennsylvania	40-42
Red fescue: (<i>Festuca rubra</i> L.)	Arctared	Alaska	61-62
	Boreal	Alberta	55-56
	Ranier	Oregon	44-45
Alfalfa: (<i>Medicago sativa</i> L.)	A-Syn.B	Alaska	61-65
	Rambler	Saskatchewan	45-55
	Vernal	Wisconsin	42-44
	Caliverde	California	38-39
Red clover: (<i>Trifolium pratense</i> L.)	Alaskland	Alaska	61-65
	Altaswede	Alberta	45-55
	Kenland	Kentucky	35-38
	Nolins Red	Louisiana	28-32

Table 1. Species, cultivars or strains, and places and latitudes of origin of grasses and legumes compared.

Species and cultivars or strains	Planting dates						
	24 May	4 June	12 June	24 June	4 July	13 July	22 July
Timothy	----- Seed heads per plant -----						
Engmo	2.7 b*	2.5 b	1.4 b	0.2 b	0.0	0.0	0.0
Climax	9.9 a	6.5 a	4.0 a	1.4 a	0.6 a	0.1 a	0.0
Clair	8.2 a	5.7 a	3.8 a	1.3 a	0.4 a	0.1 a	0.0
	----- Culms longer than 6 inches per plant -----						
Engmo	4.5 b	4.3 b	2.8 b	1.0 b	0.1 b	0.0	0.0
Climax	10.9 a	7.5 a	5.3 a	2.6 a	1.2 a	0.7 a	0.1 a
Clair	9.5 a	7.0 a	4.9 a	2.5 a	1.0 a	0.6 a	0.3 a
Red clover	----- Flower or bud clusters per plant -----						
Alaskland	0.1 b	0.0	0.0	0.0	0.0	0.0	0.0
Altaswede	0.6 b	0.2 b	0.1 b	0.0	0.0	0.0	0.0
Kenland	8.3 a	6.5 a	4.6 a	0.6 a	0.0	0.0	0.0
Nolins Red	9.2 a	7.1 a	5.6 a	1.4 a	0.0	0.0	0.0
	----- Stems longer than 6 inches per plant -----						
Alaskland	1.0 b	0.5 b	0.3 b	0.0	0.0	0.0	0.0
Altaswede	1.8 b	1.3 b	0.7 b	0.0	0.0	0.0	0.0
Kenland	4.6 a	4.3 a	3.8 a	2.1 a	0.4 a	0.0	0.0
Nolins Red	4.4 a	4.4 a	3.8 a	2.4 a	0.5 a	0.3	0.0
	24 May	2 June	10 June	21 June	1 July	12 July	20 July
Alfalfa	----- Flowering or budded racemes per plant -----						
A-Syn.B	2.4 b	0.5 c	0.5 a	0.0	0.0	0.0	0.0
Rambler	8.1 a	7.2 a	2.7 a	0.0	0.0	0.0	0.0
Vernal	7.7 a	2.8 bc	3.7 a	0.0	0.0	0.0	0.0
Caliverde	5.8 ab	5.8 ab	1.0 a	0.1	0.0	0.0	0.0

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

Table 2. Seeding-year developmental characteristics attained by autumn freeze-up by timothy, red clover, and alfalfa strains from diverse latitudinal origins when planted on various dates in southcentral Alaska's Matanuska Valley. Planting dates and values are means of two years except alfalfa data are for one year.

Winter Survival

Timothy: Winter survival of Engmo plants was near 100% for all plantings prior to mid-July, but survival of plants from seedlings made near 22 July dropped sharply to only 67% (Figure 3-A). Climax, of intermediate latitudinal adaptation, was intermediate between Engmo and the more southern-adapted Clair in winter survival, but closer to that of Clair, as is its latitudinal origin.

Planting dates had little consistent influence on winter survival of Climax or Clair, and neither surpassed 22% survival for any date of planting. Over all planting dates in all three tests, mean winter survival percentages of Engmo, Climax, and Clair were 94%, 17%, and 4%, respectively.

These winter-survival differences between Engmo and the more southern-adapted Climax and Clair over all planting dates agree with earlier visual estimates of winter survival in solid-seeded rows (Klebesadel 1970). The differences noted among these three cultivars parallel patterns in winter survival noted earlier (Klebesadel and Helm 1986) among many timothy strains from a wide range of latitudinal origins.

Kentucky bluegrass: Winter survival of Nugget, the northernmost-adapted Kentucky bluegrass in this study, was excellent for all planting dates prior to July (Figure 4-A). Nugget exhibited slight reductions in survival for the three July planting dates but even the poorest winter survival surpassed 80% following mid- and late-July plantings.

Winter survival of Delta from Canada and Merion from the conterminous USA was quite similar with all planting dates. Both survived better than 80% with seeding dates prior to July, but survival declined rapidly with later plantings. Survival of both was significantly less than Nugget with the two latest July plantings. During more stressful winters at this location, winter survival differences between Nugget and Delta have been greater than occurred in this study (Klebesadel 1984).

Red fescue: Planting dates had little influence on the excellent winter survival rates of Arctared, and prior to late June did not affect winter survival of Boreal or Ranier plants (Figure 5-A). When planted progressively later in July, survival of Boreal and Ranier became progressively poorer until they averaged only 56% and 41%, respectively, with late-July planting.

Differences in winter survival among cultivars generally were not great except for the two latest planting dates. The relative survival rates of the three cultivars for most planting dates were consistent with Arctared best, Boreal intermediate, and Ranier poorest; however, the generally poorer survival of Ranier was seldom significantly different from Boreal. The general pattern of survival among these cultivars parallels earlier results at this location (Klebesadel 1985a; Klebesadel et al. 1964).

Red clover: No plants of any red clover cultivar survived any of the three winters. In other tests at this location (unpublished information, Alaska Agric. and Forestry Exp. Sta.), winter survival has been better with northern-adapted mammoth-type cultivars (that ordinarily do not flower in the seeding year) than with mid-temperate-adapted cultivars that do flower as seedlings. Smith (1963) in Wisconsin reported that red clover plants that flowered during the seeding year winterkilled more than non-flowering plants. Moreover, cultivars that flowered least were more winterhardy than those that flowered profusely during the seeding year.

Winter survival of red clover in the Matanuska Valley usually is much improved when it is seeded with a cereal companion crop and a tall stubble is left at harvest (unpublished information, Alaska Agric. and Forestry Exp. Sta.). A 10- to 12-inch cereal companion-crop stubble effectively holds an insulating snow cover in place against the evacuation force of winter winds (Klebesadel 1974). Protective snow cover generally contributes to much better winter survival of red clover (Figure 6).

Alfalfa: No plants of Caliverde survived in any of the three tests, and none of the other three alfalfa strains survived the winter in one test. In the other two tests, survival of Alaskan A-Syn.B was considerably better with all planting dates than were Rambler or Vernal (Figure 7). The superior winterhardiness of A-Syn.B was acquired through several generations of natural selection for improved adaptation to northern climatic effects (Klebesadel 1971b). Rambler survival was slightly but not significantly better than that of Vernal with all planting dates, and planting dates had essentially no effect on winter survival of Rambler and Vernal.

In contrast, planting dates did affect winter

survival of A-Syn.B plants. Poorest survival (20%) occurred with both earliest and latest planting dates. Essentially similar winter survival (about 30%) occurred with planting on three June dates or in mid-July. However, strikingly better winter

survival (mean = 56%) occurred with planting in early July. That winter survival was significantly better than the survival of plants from the May or later July plantings but did not differ significantly from that of the three June plantings.



PLANTING DATES

Figure 1. Representative individual plants of three timothy cultivars of diverse latitudinal adaptation photographed on 12 October near end of the growing season, showing growth and heading as influenced by seven dates of planting during the same year. Cultivars: A = Engmo from northern Norway (69° to 70°N), B = Climax from Canada (44° to 46°N), C = Clair from Kentucky (38° to 39°N). Horizontal lines are 8 inches apart.

Seed and Forage Production Potential in Second Year

No seed harvests were made but seed heads were counted to give comparative estimates of seed-production potential of the different grass strains and as influenced by planting dates. Late harvest of plant herbage in August permitted full expression of seed-heads and served to measure comparative vigor of plants and forage-production potential. In practice, however, harvest for forage would have been at an earlier and more appropriate time for better-quality first-cutting herbage.

Timothy: The trends of numbers of seed heads produced per surviving plant, and amount of herbage per plant, followed generally the same pattern and relationships for all three cultivars as was noted for winter survival; Engmo was highest, Climax was intermediate, and Clair was lowest (Figure 3). However, differences between Climax and Clair were seldom significant.

With Engmo, production of seed heads and herbage per plant was highest and relatively similar with the three earliest planting dates and there was little difference among planting date effects. With planting dates successively later than mid-June there were progressively fewer seed heads and lower herbage yield per plant. Engmo plants

seeded in late July produced about one-third the numbers of seed heads and amounts of herbage as those from early-June seeding.

Numbers of seed heads and herbage yields of surviving plants of both Climax and Clair were consistently low, reflecting severe winter injury in surviving plants of both cultivars. Planting dates showed no consistent influence on heading or herbage yields of Climax or Clair.

Kentucky bluegrass: Nugget averaged 38 seed heads per plant for the earliest planting in late May, markedly more than the other two cultivars and more than twice as many heads as produced by Nugget plants with the next best planting date (only 11 days later) in early June (Figure 4-B). In contrast to Nugget, both Delta and Merion produced slightly more seed heads per plant when seeded in early June than with the earliest planting in late May. All three cultivars produced progressively fewer seed heads with planting dates successively later than early June, until virtually none were produced on plants of any cultivar with the latest planting date in July. When differences were significant with planting dates in June, Delta plants produced more seed heads than Merion plants.

Nugget plants produced the most herbage, and significantly more than Delta and Merion,

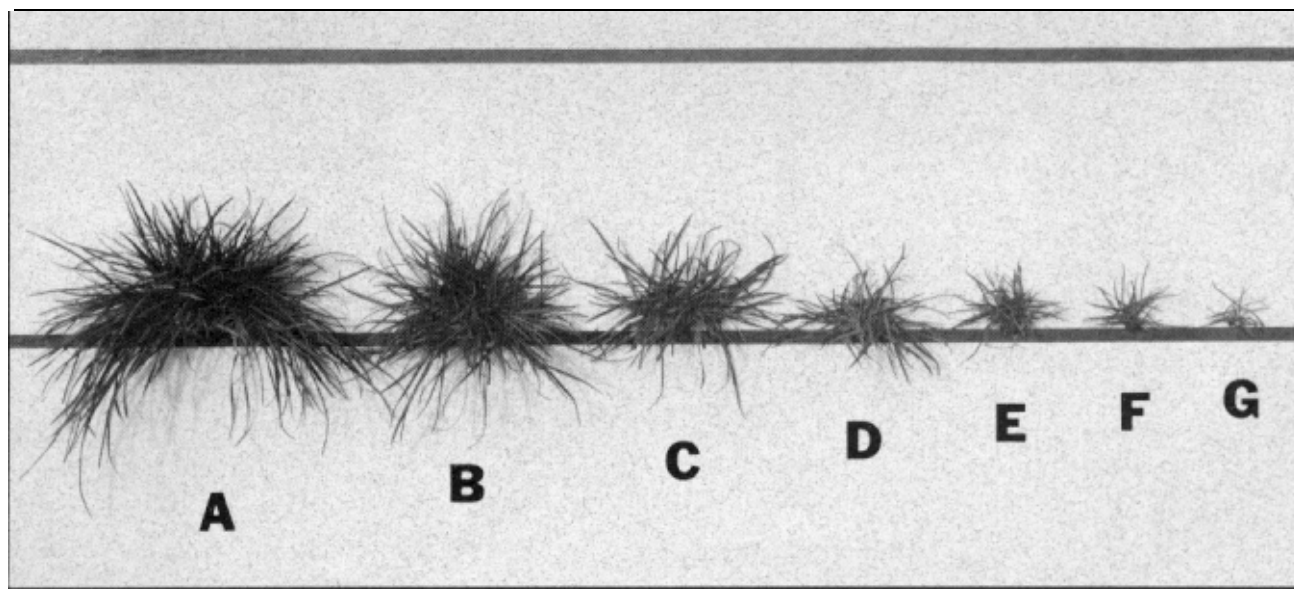


Figure 2. Seedling-year development of representative Nugget Kentucky bluegrass plants as influenced by seven different seeding dates. Photo taken on 3 October near freeze-up and at the end of the growing season. Black lines are 12 inches apart. Seeding dates: A = 21 May, B = 31 May, C = 11 June, D = 21 June, E = 2 July, F = 12 July, G = 23 July.

with the earliest plantings in late May and early June. Nugget produced progressively less with each later planting date (Figure 4-C). The more southern-adapted Delta and Merion were virtually identical in herbage yield per plant with all seven planting dates. Dates of planting prior to July had little influence on herbage yields of Delta and Merion. With late June and later plantings, all three cultivars produced gradually less but virtually identical herbage yield per plant with each later planting date during the previous year.

Red fescue: Seed and forage-production potential of the three red fescue cultivars was related to latitudinal adaptation and followed the same relative pattern over all planting dates as occurred with winter survival (Figure 5); Arctared was best, Boreal intermediate, and Ranier poorest. However, differences in heading and herbage per plant between Arctared and the other two cultivars were much greater than the differences in winter survival, especially for the first four planting dates.

The trends of seed-head numbers and herbage yield per plant were the same with all three cultivars, becoming progressively less with each later planting date during the previous year. However, amounts of heading and herbage per plant were much higher initially, and the decline with later plantings much more precipitous, with Arctared than with Boreal or Ranier. Boreal and especially Ranier headed very sparsely.

Alfalfa: The very few and generally non-vigorous plants of Rambler and Vernal, in the two tests where some winter survival occurred, were destroyed prior to flowering to prevent interpollination with A-Syn.B plants left for seed increase. No counts of floral racemes or stems were made on surviving A-Syn.B plants.

Discussion

The northernmost-adapted strains of timothy, Kentucky bluegrass, red fescue, and alfalfa generally were superior to those of intermediate (Canadian) latitudinal adaptation in winterhardiness, and in seed and forage production potential. In turn, the Canadian cultivars often were superior in all three criteria to the more southern-adapted cultivars from the conterminous USA. Differences among cultivars usually were greatest for earliest dates of planting, except that winter survival differences among cultivars of Kentucky

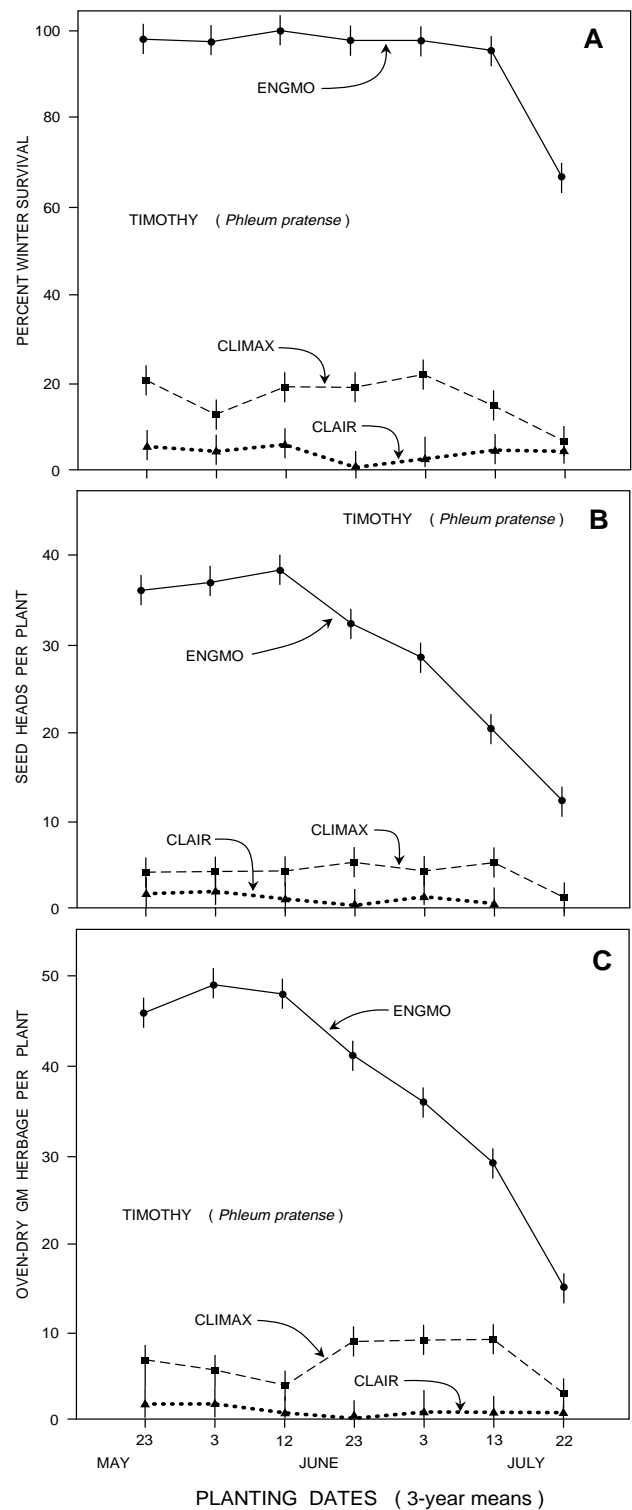


Figure 3. Influence of seven planting dates on winter survival and on seed and forage production potential of three timothy cultivars of diverse latitudinal adaptation; values are means of three separate experiments. For each date, means not connected by a common vertical line are significantly different (5% level) using Duncan's Multiple Range Test.

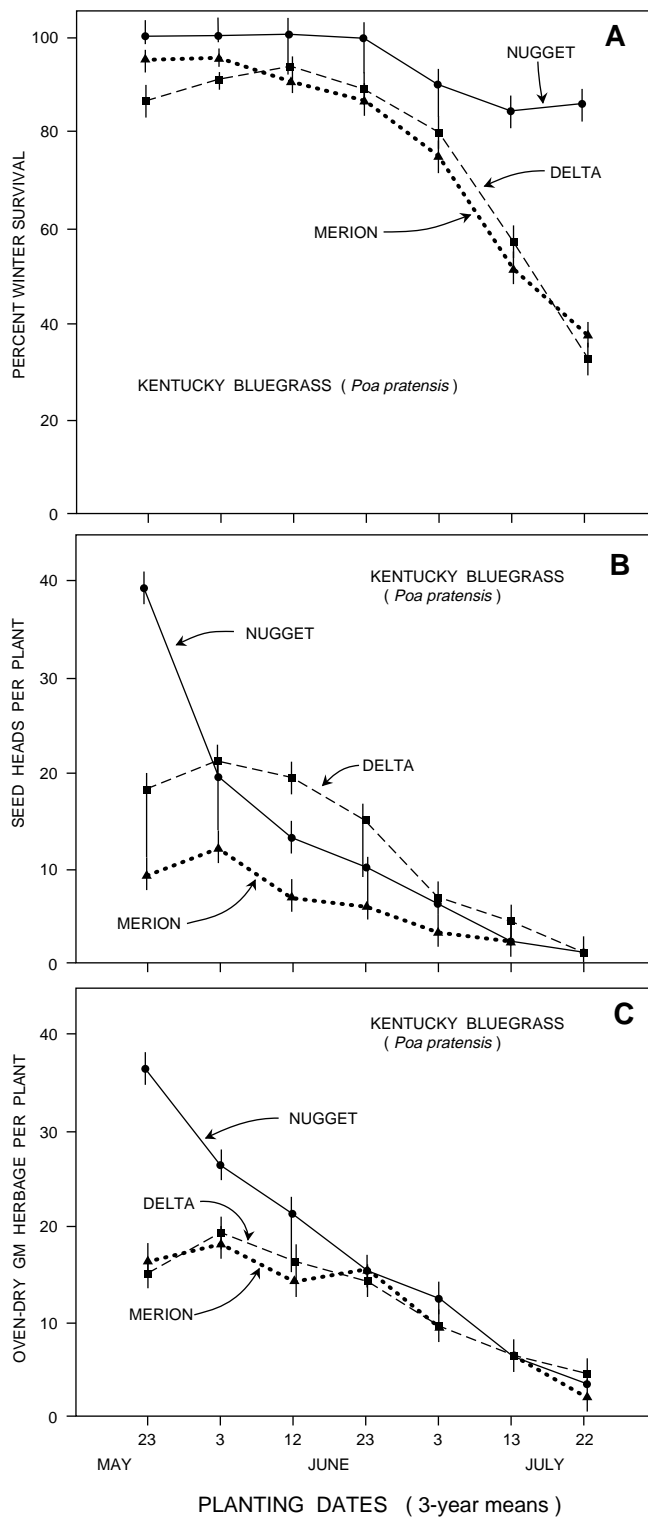


Figure 4. Influence of seven planting dates on winter survival and on seed and forage production potential of three Kentucky bluegrass cultivars of diverse latitudinal adaptation; values are means of three separate experiments. For each date, means not connected by a common vertical line are significantly different (5% level) using Duncan's Multiple Range Test.

bluegrass and red fescue were greatest for latest planting dates. Planting in May resulted in maximum production of seed heads or herbage per plant during the year after planting with the most winter-hardy grasses; both yield factors generally were progressively lower with successively later planting dates through late July.

An exception to the above patterns was the superior winter survival of Alaskan A-Syn.B alfalfa with early July planting over earlier or later planting. The cause of the unusual pattern of winter survival in A-Syn.B alfalfa is poorly understood. Seedlings from early July plantings may have benefited by being larger, better developed plants at onset of winter than those from later plantings. Arakeri and Schmid (1949) reported poor winter survival of alfalfa seeded later than 1 August in Minnesota where the autumn growing period is longer than in Alaska. A-Syn.B seedlings planted in early July also may have benefited by escaping exposure to very long mid-summer photoperiods (19.5 hours at this latitude at summer solstice) that may have deleteriously predisposed earlier-planted seedlings to poorer winter survival.

This pattern of markedly better alfalfa survival with early July planting than with dates earlier or later could be dismissed as a random anomaly were it not for a very similar pattern of winter survival vs. planting dates noted in experiments with another species, annual bluegrass (*Poa annua* L.) (unpublished information, Alaska Agric. and Forestry Exp. Sta.). Annual bluegrass behaves both as a true annual and as a winter annual; in the latter instance, winter survival is necessary to complete the life cycle. The relative similarity of winter survival patterns of the two species, as influenced by planting dates, lends credibility toward these results having a logical basis.

The generally poor winter survival of grasses with progressively later planting in this study contrasts with acceptable survival and standard practice of much later seeding of grasses in more southern latitudes (Van Keuren and Canode 1963). The generally longer growing seasons at more southern latitudes, followed by shorter, often less-stressful winters, result in good winter survival of late-planted grasses.

Northern-adapted grasses in these tests were markedly more winterhardy than Alaskan strains

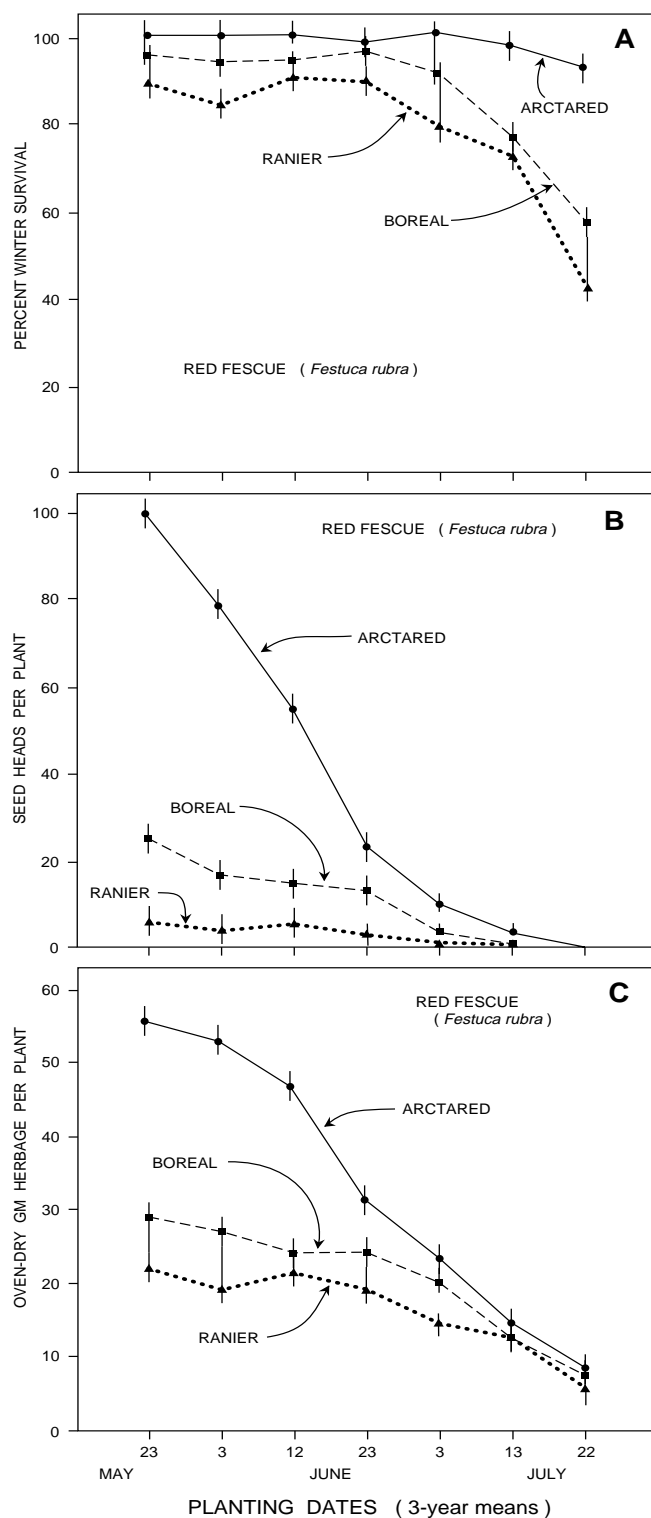


Figure 5. Influence of seven planting dates on winter survival and on seed and forage production potential of three red fescue cultivars of diverse latitudinal adaptation; values are means of three separate experiments. For each date, means not connected by a common vertical line are significantly different (5% level) using Duncan's Multiple Range Test.

of alfalfa and red clover. Cultivars of Kentucky bluegrass and red fescue from both mid-latitude and more southern origins were more winterhardy than timothy and alfalfa cultivars from similar origins. Mid-temperate-adapted timothy in turn was more winterhardy than the temperate-origin alfalfas and more hardy than any of the red clover cultivars, regardless of latitudinal adaptation.

Previous work (Klebesadel 1971a, 1985b) at this location has demonstrated that mid-temperate-adapted grass ecotypes grown in subarctic Alaska are predisposed to poor winter survival and low subsequent seed production by unaccustomed photoperiod-growing season interrelationships during late-summer and autumn. Moreover, Hodgson (1966) noted that induction and initiation of floral primordia commonly occur during autumn at this latitude in several subarctic-adapted grasses. Poor adaptation to subarctic photoperiodic pattern near termination of the growing season undoubtedly is responsible for the poorer winter survival and lowered seed and forage production potential of the mid-temperate-adapted cultivars used in this study.

These results confirm the importance of using northern-adapted strains of forage grasses and legumes in this area. Moreover, time-of-planting governs the extent of development achieved by seedlings before winter. That developmental status, in turn, exerts considerable influence on subsequent winter survival and seed and forage production potential during the following growing season.

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Literature Cited

- Arakeri, H.R., and A.R. Schmid. 1949. Cold resistance of various legumes and grasses in early stages of growth. *Agronomy Jour.* 41:182-185.
- Elliott, C.R., and H. Baenziger. 1973. Creeping red fescue. *Agriculture Canada Pub.* 1122. Ottawa, Ontario.

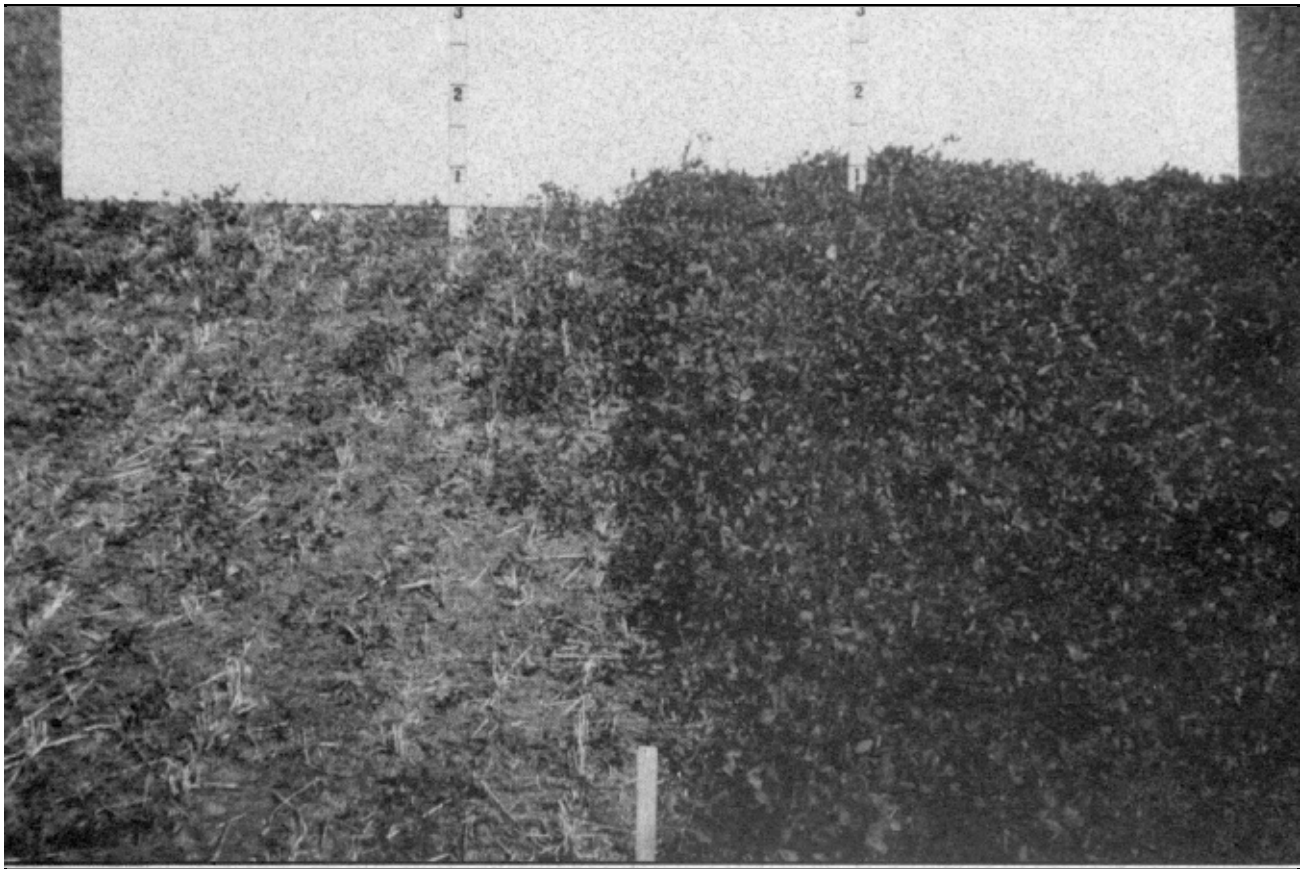


Figure 6. This photo on 22 June of two plots (from an experiment not a part of the present study) illustrates the importance of insulating snow cover for winter survival of red clover. Entire area of photo was planted 12 June of the previous year; Alaskland red clover was broadcast-seeded with a barley companion crop drilled in rows 6 inches apart. At barley harvest for grain, a short (2 to 2 1/2-inch) stubble left on the plot left of center could not hold insulating snow cover in place against the evacuation force of occasionally strong winter winds; accordingly, most of the unprotected red clover seedlings in that plot winterkilled. A tall (10 to 12-inch) barley stubble left in the right plot held protective snow in place resulting in good red clover survival.

- Heide, O.M. 1982. Effects of photoperiod and temperature on growth and flowering in Norwegian and British timothy cultivars (*Phleum pratense* L.). *Acta Agriculturae Scandinavica* 32:241-252.
- Hodgson, H.J. 1966. Floral initiation in Alaskan Gramineae. *Botanical Gazette* 127:64-70.
- Klebesadel, L.J. 1969. Winter survival and spring forage yield of winter rye varieties in subarctic Alaska as influenced by date of planting. *Agronomy Jour.* 61:708-712.
- Klebesadel, L.J. 1970. Influence of planting date and latitudinal provenance on winter survival, heading, and seed production of bromegrass and timothy in the Subarctic. *Crop Science* 10:594-598.
- Klebesadel, L.J. 1971a. Nyctoperiod modification during late summer and autumn affects winter survival and heading of grasses. *Crop Science* 11:507-511.
- Klebesadel, L.J. 1971b. Selective modification of alfalfa toward acclimatization in a subarctic area of severe winter stress. *Crop Science* 11:609-614.
- Klebesadel, L.J. 1974. Winter stresses affecting overwintering crops in the Matanuska Valley. *Agroborealis* 6(1):17-20.
- Klebesadel, L.J. 1984. Far-north-adapted blue-grasses from areas with rigorous winter climate perform best in southcentral Alaska. *Agroborealis* 16(1):37-42.

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

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

Klebesadel, L.J., A.C. Wilton, R.L. Taylor, and J.J. Koranda. 1964. Fall growth behavior and winter survival of *Festuca rubra* and *Poa pratensis* in Alaska as influenced by latitude-of-adaptation. *Crop Science* 4:340-341.

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 Science* 26:325-334.

Langer, R.H.M., and G.J.A. Ryle. 1959. The effect of time of sowing on flowering and fertile tiller production in S.48 timothy. *Jour. Agricultural Science* 53:145-150.

Smith, D. 1963. Reliability of flowering as an indicator of winter survival in red clover. *Canadian Jour. Plant Science* 42:386-389.

Van Keuren, R.W., and C.L. Canode. 1963. Effects of spring and fall plantings on seed production of several grass species. *Crop Science* 3:122-125.

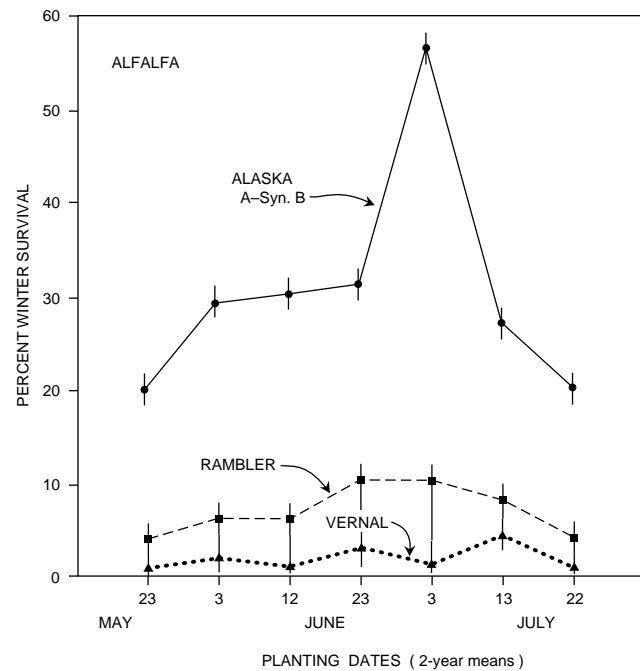


Figure 7. Influence of seven different planting dates on winter survival of three alfalfa strains from diverse latitudinal origins; values are means of two tests. Winter survival of Caliverde (the most southern-adapted cultivar) was zero with all planting dates in both tests. For each date, means not connected by a common vertical line are significantly different (5% level) using Duncan's Multiple Range Test.