RYEGRASSES IN ALASKA:

Grazing Preference, Forage Yields, Digestibility, and Other Comparisons Among Four Types of Ryegrass, and Responses of Different Types and Cultivars to Various Management Options.

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

Holstein dairy cows grazing late-season regrowth of tetraploid annual ryegrass.

University of Alaska Fairbanks
Agricultural and Forestry Experiment Station
School of Agriculture and Land Resources Management

SCHOOL OF AGRICULTURE & LAND RESOURCES MANAGEMENT
AGRICULTURAL & FORESTRY EXPERIMENT STATION

Bulletin 108

February 2000

Contents

Figures

Tables

Summary

This report summarizes experiments with different species[1], types, and cultivars of ryegrass. Experiments were conducted to determine growth habits, productivity, digestibility and other characteristics of herbage, responses to management options, and grazing preference with dairy stock.

Objectives were to assess usefulness of ryegrasses for incorporation into forage-production systems on Alaska farms, exploring their annual forage-production potential to supplement the main perennial-grass forage base, and especially to extend the effective grazing period maximally and with high-quality pasturage or green-chop forage during the late portion of the growing season.

Perennial forage grasses become relatively unproductive and poorer in nutritional quality during the latter portion of the growing season, resulting in reduced milk production. Moreover, perennials ideally require freedom from utilization pressures during late summer/early autumn in order to undergo needed and adequate physiological preparation for successful winter survival.

All experiments were conducted at the University of Alaska Agricultural and Forestry Experiment Station's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska.

Experiment I: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats vs. Ryegrass + Oats + Peas, Harvested Twice, One Planting Date, Three Different Mid-Season Harvest Dates.

- Ryegrass regrowth after the two earliest mid-season harvests was more abundant than the initial growth of the season, the amount of regrowth largely dependent on time of mid-season harvest (which determines duration of the regrowth period).
- Ryegrass grown alone produced smaller first-cutting yields than oats or the two mixtures but, due to high regrowth yields, produced more total yield with any of the three mid-season harvest dates (mean total yield = 3.10 T/A) than oats grown alone (mean total yield = 2.16 T/A) and almost as much as the two mixtures.
- First-cutting yields, second-cutting yields, and total yields were virtually identical with all three different mid-season harvest dates with ryegrass + oats and ryegrass + oats + field peas (mean total yield = 3.33 T/A).
- Total two-cut forage yields of oats grown alone with three different mid-season harvest dates averaged 2.16 T/A, about 1 T/A less than total yields of ryegrass alone or either of the two crop mixtures that included ryegrass.
- Regrowth of oats, after mid-season harvests, was intermediate between that of ryegrass and peas. Oat regrowth was considerable (mean = 1.40 T/A) following mid-season harvest on 21 July, 50 days after planting, when oats were at early to late boot stage. With mid-season harvest on 31 July and 10 August (60 and 70 days after planting, respectively, when oat development was more advanced), oat regrowth yields were markedly and progressively less.
- With two harvests per year, no benefit in total forage yield accrued from including field peas in mixture with oats and common ryegrass; pea plants exhibited very little or no regrowth after cutting and removal of the main stem at a mid-season harvest. Comparing the three dates of mid-season harvest over three years, visual estimates of the percentage of dry-matter yield represented by peas in the regrowths ranged from 0% to 20%.
- Total (two-cuttings) crude protein yields per acre were highest when field peas were included with oats and ryegrass, and lowest with oats grown alone. With oats grown alone, or oats with ryegrass, total crude protein yields per acre decreased as mid-season harvests were later; time of mid-season harvest had little effect on total crude protein yields from ryegrass alone (mean = 675 lb/A) or from the mixture of ryegrass + oats + peas (mean = 784 lb/A).

Experiment II: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats, Three Planting Dates, Harvested Twice, Four Different Mid-Season Harvest Dates.

- In general, higher total (2 cuttings) forage yields were obtained from ryegrass alone or ryegrass with oats than with oats alone, as occurred in Experiment I. Again those differences were due principally to the greater regrowth yields of ryegrass.
- With mid-June planting, mid-season harvests of ryegrass on 19 and 27 July (30 and 40 days after planting, respectively) were very low and impractical, less than ½ T/A. Ryegrass planted alone in mid-June and cut in mid-July did not produce a recoverable yield.
- Ryegrass that was harvested on the earliest mid-season dates, and then produced the highest-yielding regrowths, was fully headed, stemmy, and badly lodged in late September, representing generally poor pasturage.
- Oats in mixture with ryegrass tended to reduce

[1]Diploid and tetraploid annual ryegrass = *Lolium multiflorum*, Westerwold ryegrass = *L. multiflorum* var. *westerwoldicum*, and perennial ryegrass = *L. perenne*.

lodging in the regrowth, due to the presence of the stronger, more lodging-resistant oat stems; only with the earliest planting and earliest mid-season harvest, resulting in a rank regrowth with about 80% ryegrass in the mixture, did severe lodging of the regrowth occur.

• Oats regrowth was markedly suppressed when mid-season harvest was taken later than the fully headed/pre-anthesis stage of oat development, regardless of planting date or mid-season harvest date.

• In contrast, ryegrass regrowth yields were more influenced by duration of the regrowth period than by stage of plant development at the mid-season harvest.

Experiment III: Seasonal Distribution of Forage Yields of Several Ryegrass Types, Strains, and Cultivars as Influenced by Two Different Times of Mid-Season Harvest.

• The annual strains, and NK "Tetrablend" (a commercial blend of annual and perennial strains), yielded considerably more in first cuttings than the perennials.

• Most of the annual ryegrasses and the annual + perennial blend produced more forage in two cuttings than any of the six perennial ryegrass strains in both years.

• First-cutting yields of the six perennial strains were very low; first-cutting yields of the perennials more than doubled in the 12 to 14 days between the two mid-season harvest dates.

• Marked differences in forage yield were evident among the annual strains compared. Six strains were outstanding with two-cut yields between 3.5 and 4.2 T/A in 1967. Those included both 'Westerwold' entries; Mommersteeg's 'Tewera'; Northrup, King's 'NO-8H' and 'Tetrablend'; and the Oregon-grown "common" diploid annual from a local seed supplier.

• Although the perennial strains generally were somewhat inferior in total two-harvest yields to the annuals, herbage of the perennials consisted entirely of dense growths of leaves. In contrast, herbage of the annuals at harvest of both the first growth and the regrowth consisted mostly of elongated stems bearing leaves and seed heads.

• Total two-cut yields generally were affected little by date of mid-season harvest. However, the distribution of yield in first vs. second cuttings was influenced considerably with all ryegrass strains, as well as with oats, by the different mid-season harvest dates.

• Oats harvested when fully headed but prior to anthesis (the earlier of two mid-season harvests) was followed by a significant regrowth harvested in late September. In contrast, oats harvested about two weeks later at early milk stage was followed by a very sparse regrowth.

• The few annual and perennial ryegrass strains evaluated differed substantially in amount of heading and in total annual herbage yield; thus, further comparisons may well be justified inasmuch as there exist, worldwide, several hundred named cultivars of annual and perennial ryegrass.

Experiment IV: Common Ryegrass Regrowth Yields in Response to Six N Rates After Mid-Season Forage Harvest of Ryegrass + Oats + Field Peas. (Three-year mean dates: planted 28 May, mid-season harvest = 19 July, final harvest = 23 Sep.).

• N rates topdressed immediately after mid-season harvest were 0, 40, 60, 80, 100, or 120 lb/A. Oven-dry yield of ryegrass regrowth in late September was 1.42 T/A with no N, and 2.26 T/A with 40 lb N/A.

• N rates of 60, 80, 100, and 120 lb/A did not increase ryegrass regrowth yields above those obtained with the 40 lb/A N rate; mean yield for those four rates was 2.30 T/A.

• At the highest N rates, lodging of the regrowth was increasingly pronounced, resulting in incomplete harvest recovery of some of the severely lodged ryegrass.

• Failure of the ryegrass regrowth to respond favorably to N rates above 40 lb/A may have been due to low rates of P_2O_5 and K_2O applied at planting.

• Some N fixed by the field peas may have been released from root nodules after pea harvest to become available to the ryegrass, accounting in part for the absence of response of ryegrass regrowth to the higher N rates.

Experiment V: Relative Grazing Preference Among Four Different Types of Ryegrass.

Four types of ryegrass seeded in early June in each of three growing seasons were harvested at mid-season (mean date = 29 July); regrowths were compared for late-season dairy-cow grazing preference at progressively advanced stages of development with four successive, two-day grazing sessions spaced regularly from early September to early October. Also compared were digestibility (in vitro dry-matter disappearance), crude protein, percent dry matter in herbage (succulence), heading, and other characteristics. Ryegrasses compared were (a) common diploid annual, b) tetraploid annual, (c) Westerwold, and (d) perennial.

• Percent dry matter in herbage of the four ryegrasses differed most in late September and early October when common annual and Westerwold were profusely headed and stemmy, and the perennial and tetraploid annual remained leafy; percent dry matter at those two samplings ranked the grasses: common annual > Westerwold > perennial > tetraploid annual.

• Crude protein concentrations from first to last grazing dates decreased gradually in herbage of all four strains; however, percent crude protein in the virtually non-heading and very leafy perennial and tetraploid annual generally was higher than in the common annual and Westerwold.

• Digestibility remained near constant during late summer and early autumn in the very leafy, non-heading tetraploid annual and perennial, but declined considerably with increased heading in Westerwold and common.

• Digestibility at all grazing sessions ranked: tetraploid annual > perennial > Westerwold > common.

• Grazing preference over three years clearly favored the tetraploid annual, and differences were greatest in late September and early October when both of the profusely heading grasses (common and Westerwold) were headed most fully.

• Perennial ryegrass, although finer-leaved, was otherwise very similar in several characteristics to the most-grazed tetraploid annual (very leafy, succulent, non-heading, and high in crude protein and almost as high in digestibility); however, the perennial surprisingly was little grazed. This suggests that some factor(s) other than those listed above influenced grazing preference for the tetraploid annual over the perennial.

• In seeking to achieve high-quality late-season ryegrass pasturage (as opposed to forage for harvest), concern should be directed not solely at total herbage availability (yield) but, more importantly, at herbage productivity coupled with characteristics that influence grazing preference; those characteristics include leafiness, lack of heading and lodging, and high levels of protein, digestibility, and succulence.

Cultural and Use Considerations

Practical experience gained while conducting these experiments and peripheral, non-experimental information on ryegrasses that could be helpful to growers are summarized at the end of this report.

Introduction

This report discusses certain investigations and uses of ryegrasses elsewhere, reviews earlier published work with ryegrasses in Alaska, and reports some previously unpublished work with ryegrasses at this station.

The Ryegrasses

The ryegrasses belong to the taxonomic genus *Lolium*. Terrell (1968) in a revision of the genus distinguished eight species of ryegrass. The ryegrasses are believed native to Europe, temperate Asia, and northern Africa. Two species have become economically important throughout the world in areas with cool temperate climates. They are perennial ryegrass (*L. perenne*), also referred to as English ryegrass, and annual ryegrass (*L. multiflorum*), often called Italian ryegrass.

Westerwold (or Westerwolth) ryegrass (*L. multiflorum* var. *westerwoldicum*), used in some experiments of this report, is an annual, rapid-growing and early maturing selection or cultivar of annual ryegrass that originated in the Westerwolde area of the Netherlands (Jung *et al.* 1996).

In the seed trade, the term "common" or "common annual" ryegrass refers to a mixture of predominantly annual ryegrass with usually very small percentages of perennial ryegrass and hybrids of the two (Hafenrichter *et al.* 1979; Schoth and Hein 1940).

History

Perennial ryegrass is believed to be the first of all perennial grasses grown in pure stand for forage; it was mentioned in agricultural literature in England in 1611 (Hoover *et al.* 1948).

Italian ryegrass was grown in meadows in northern Italy in the thirteenth century (Frakes 1973), was recognized in France in 1818, in Switzerland in 1820, and was introduced into England in 1831 (Nelson *et al.* 1997; Hoover *et al.* 1948).

Both ryegrasses are believed to have been introduced into North America during the Colonial Period (Evers *et al.* 1997; Nelson *et al.* 1997). Their several positive attributes as forage and pasture species have promoted their spread throughout temperate regions and they now are used extensively in Europe, Australia, New Zealand, Japan, and North and South America (Hannaway *et al.* 1997; Jung *et al.* 1996).

Species Characteristics

Both annual and perennial ryegrass are cool-season, bunch-type grasses with conspicuously shiny leaves. Leaf blades of perennial are narrower than those of annual, and seeds of annual ryegrass typically possess a short awn while perennial seeds have none. Annual plants generally grow taller than those of perennial, and several other plant characteristics differentiate the two species (Jung *et al.* 1996.)

Both species are considered self-incompatible, but the two readily cross-pollinate and both hybridize with fescues (*Festuca* species) (Balasko *et al.* 1995; Jung *et al.* 1996; Riewe and Mondart 1985).

Perennial ryegrass is only moderately winterhardy, and is a short-lived perennial in mild-winter temperate regions. Only occasionally do a very few plants survive winters in Alaska and then only in the most protected sites; thus it can serve only as an annual crop here.

Both species are valued for several characteristics including rapid establishment, vigorous growth, rapid recovery after defoliation, a long growing season, generally excellent palatability (for sheep, dairy and beef cattle, horses, and wildlife including deer), tolerance to a wide range of environmental conditions and management practices, excellent persistence under close grazing, high digestibility, high productivity in mild-to-cool, wet climates or with irrigation, and weed suppression (Balasko *et al.* 1995; Hannaway *et al.* 1997; Jung *et al.* 1996; Rouquette *et al.* 1997). Also, the ryegrasses grow well on a wide range of soil types (Evers *et al.* 1997; Frakes 1973). Those desirable characteristics have led to extensive use of both species for pasture, hay, silage, soil conservation, green manure, and turf (Frakes 1973).

Vernalization by cold temperatures, prior to occurrence of photoperiods in excess of 13 hours, is necessary to cause heading in perennial ryegrass (Balasko *et al.* 1995; Jung *et al.* 1996); therefore, with spring-seeding in Alaska most perennial strains produce a profusion of leaves with little or no heading.

In contrast, annual ryegrass (including Westerwold) does not require cold temperatures prior to initiation of inflorescences so, when spring-seeded in Alaska, it heads profusely in both the first growth of the year and again in regrowth produced after a mid-season harvest.

Ryegrass Improvement

Breeding work and selection for improved cultivars of ryegrass started in Holland around 1935 (Barenbrug 1979). An innovative step toward increasing productivity and diversity in ryegrasses was the discovery in 1937 that tetraploids (strains with twice the normal diploid chromosome number) could be created; the first such cultivars were released by Dutch plant breeders in the early 1960s (Barenbrug 1979).

Creation of tetraploids, with subsequent selection, has resulted in several superior and desirable characteristics; compared with diploids, tetraploids have larger seeds and leaves, higher soluble carbohydrate (sugar) content leading to enhanced palatability, greater succulence, and higher herbage yields (Barenbrug 1979).

Breeding objectives for improvement of ryegrasses are discussed at length by Hannaway *et al.* (1997) and Nelson *et al.* (1997).

Importance and Uses

"Ryegrass . . . probably is the most widely used of all grasses," according to Riewe and Mondart (1985). Jung *et al.* (1996) state that annual and perennial ryegrass ". . . are among the most important pasture/forage/turf grasses in the world." Balasko *et al.* (1995) relate that "Perennial ryegrass is considered the premier quality forage grass species throughout the world."

The two primary areas of perennial ryegrass production for forage in the U.S., each with about 124,000 acres, are the Northeast and the Pacific Northwest, principally Oregon and Washington (Balasko *et al.* 1995; Hafenrichter *et al.* 1979).

In contrast, annual ryegrass is grown much more extensively in the U.S., on about three million acres. About 90% of that acreage is devoted to winter pasture (fall planted for winter grazing) in the southeastern U.S. (Balasko *et al.* 1995). That area extends from eastern Texas and Oklahoma to the Atlantic Coast, and from the Gulf Coast north to the southern edge of the North Central and Northeast regions (Balasko *et al.* 1995; Rouquette *et al.* 1997).

Practically all of the seed of both perennial and annual ryegrasses is produced in the Pacific Northwest, mostly in western Oregon (Balasko *et al.* 1995; Hafenrichter *et al.* 1979; Young and Barker 1997).

Both species of ryegrass are sometimes grown in association with legumes for pasture or green manure (Hafenrichter *et al.* 1979; Kunelius and Narasimhalu 1983; Rouquette *et al.* 1997). Annual ryegrass is most commonly fall-seeded in dormant warm-season grasses for winter pasture in the South, but also is pastured in mixture with small grains such as oats, wheat, or rye (Rouquette *et al.* 1997).

Another common use of ryegrass is seeding in mixture with other species to provide quick and effective ground cover for lawns or soil stabilization while other perennial species are becoming established. This practice is common in the other states (Hafenrichter *et al.* 1979), as well as in Alaska, on a great variety of non-agricultural, disturbed soils including roadsides and medians, airports, etc.

Early Evaluations in Alaska

Irwin (1945) summarized early evaluations of ryegrasses at several widely separated federal experiment stations in Alaska. Perennial ryegrass seeded from 1902 to 1906 at the Sitka, Kenai, Copper Center, and Rampart stations, and at the Matanuska station in 1919, 1932, and 1938 made "poor" to "good" growth in the year of seeding, but usually died during the first winter. Annual ryegrass seeded in 1919 and 1938 at the Matanuska station made "fair growth". Only visual observations were recorded and no yields were reported; moreover, those early trials probably had little or no benefit of added fertilizer nutrients.

More Recent Ryegrass Evaluations in Alaska

Brundage *et al.* (1963) studied yield of four grasses: common ryegrass, orchardgrass (*Dactylis glomerata*), timothy (*Phleum pratense*), and tall oatgrass (*Arrhenatherum elatius*), each grown alone as well as each in association with non-winterhardy alfalfa (*Medicago sativa*) for annual forage. Relative grazing preference was determined using dairy stock. Ryegrass was superior in herbage production, orchardgrass second, and timothy and tall oatgrass lowest. Alfalfa competed poorly with the vigorous ryegrass. Grazing preference favored tall oatgrass in 1961, but ryegrass was preferred in 1962 until it headed.

Several experiments with ryegrass grown alone or in mixtures contributed to other early reports with recommendations for ryegrass use in Alaska (Klebesadel 1968; Klebesadel *et al.* 1963).

Brundage and Branton (1967) compared annual ryegrass and orchardgrass–alfalfa with first harvest on different mid-season dates during July and early August. Yields were consistently higher from ryegrass while crude protein level in herbage was higher with orchardgrass-alfalfa. With both grasses, first-cutting yields were progressively higher, and aftermath yields lower, with successively later dates of mid-season harvest. That study, too, found a strong grazing preference for ryegrass in early heading stage, no difference between choices one to two weeks later, but a decided preference for the non-heading orchardgrass with alfalfa two to four weeks later when the ryegrass was stemmier, fully headed, and past anthesis.

Mitchell (1984) conducted 14 different trials in Alaska evaluating and comparing different strains of ryegrasses (24 in total) from 1976 to 1983. Experiments were conducted at Palmer, Point Mackenzie, Delta Junction, and two locations near Homer on the Kenai Peninsula. Some cultivars were evaluated more extensively than others, with samplings of herbage at successive developmental stages and analyses for crude protein, digestibility, phosphorus, potassium, calcium, and magnesium as influenced by different rates of fertilization and different harvest frequencies. He concluded that, with proper management, ryegrass can serve as a useful annual forage in different agricultural areas in Alaska, and that two to four harvests can be taken per year in the better farming areas.

Shortcomings of Smooth Bromegrass For Uniform Season-Long Forage Production: Can an Annual Such as Ryegrass Serve as a Useful Supplement to Bromegrass?

Smooth bromegrass (*Bromus inermis*) is the dominant perennial forage species on Alaska farms; it is harvested and stored as dried hay, haylage, or silage, harvested as green-chop forage for drylot feeding, or pastured.

Thus, adapted, winterhardy bromegrass is versatile, very productive with adequate fertilization and soil moisture, nutritious and very palatable to dairy stock (Klebesadel 1999), dependable and long-lived if not mismanaged (Klebesadel 1994a, 1997).

Despite its valuable desirable characteristics, smooth bromegrass is not a perfect supplier of forage, and other crops have been evaluated to supplement bromegrass shortcomings. In dense older stands, bromegrass tends to become "sod-bound" and early spring growth for pasturage is slow. One strategy for providing earlier grazing, while preventing undesirable grazing pressure on new spring growth of bromegrass, is provision of alternate early spring grazing with hardy winter rye (Klebesadel 1969b).

Dr. A. L. Brundage recognized early with pasture studies in Alaska that smooth bromegrass is characterized by a decidedly uneven production of herbage throughout the growing season (Brundage and Branton 1967; Brundage and Sweetman 1964; Brundage *et al.* 1963).

Productivity of uninterrupted growth of bromegrass (with adequate soil moisture and fertility) is phenomenal during the month of June (Klebesadel 1994a, 1997), a characteristic that meshes well with two harvests per year — a heavy forage harvest in late June or early July, followed by another harvest of a somewhat lower-yielding crop of regrowth near early September. However, if the initial growth of bromegrass is interrupted by harvest or pasturing in early to mid-June, a conspicuous lag in productivity occurs until new growth is put forth by activation of basal tillers in early July (Brundage and Sweetman 1964; Klebesadel 1992, 1994a, 1997; Fig. 1).

The third time in the growing season when bromegrass falls short of being the ideal, all-purpose forage source in Alaska, and the one addressed in this report, is the several-week period prior to onset of winter when bromegrass becomes unproductive for late-season pasturage (Fig. 1), and declining nutritional quality of its herbage typically results in seasonal depression of milk production(*)[2]. Kunelius and Calder (1978) report similar reduced

[2] This symbol(*) throughout this report indicates information derived from personal communication with Alaska dairy scientists Dr. A. L. Brundage and the late W. J. Sweetman.

late-season productivity and quality of perennial grasses in eastern Canada.

Perennial grasses such as smooth bromegrass become less productive of herbage late in the growing season as shortening photoperiods and cooler temperatures stimulate a diversion of photosynthetic product away from herbage production and instead toward storage of food reserves required for development of winterhardiness, survival over winter, and production of early growth the following spring (Smith 1964).

A productive, palatable, and nutritious alternative species for pasture or green-chop forage could circumvent that milk-production slump as well as relieve bromegrass from utilization pressures during the critical weeks when it undergoes physiological preparation for winter.

Answers Were Sought to the Following Questions:

Experiments reported herein were directed toward answering several questions, especially the following:

(1) Should ryegrass be seeded alone? With oats? With oats and peas?

(2) When should ryegrass be planted for maximum utility? With a given date of planting, when should mid-season harvest be accomplished for optimum distribution of yields in first growth and in the regrowth, and so that the regrowth develops best to serve ideally in yield, quality, and acceptability for grazing or green-chop use late in the growing season?

(3) Can time of mid-season harvest influence not only herbage yield but also the amount of heading in the regrowth, a factor that could affect desirability for grazing stock?

(4) Which ryegrass to use? Common? Annual? Westerwold? Perennial? Diploid? Tetraploid? Which cultivar or strain? Do different types and strains react alike to different management approaches?

(5) Should mid-season harvest be followed by nitrogen topdressing? If so, how much?

(6) How palatable are different types of ryegrass to grazing dairy stock? Abundant grass growth with poor acceptability cannot promote needed high levels of intake.

(7) Can offer of different types of ryegrass in free-choice, cafeteria-style experiments reveal differences in actual grazing preference? If so, can those preferences be related to grass characteristics?

(8) Would oats or an oats + ryegrass mixture harvested for forage serve well as a companion crop for the establishment of small-seeded, perennial forage crops such as bromegrass, timothy, alfalfa, clovers, etc.?

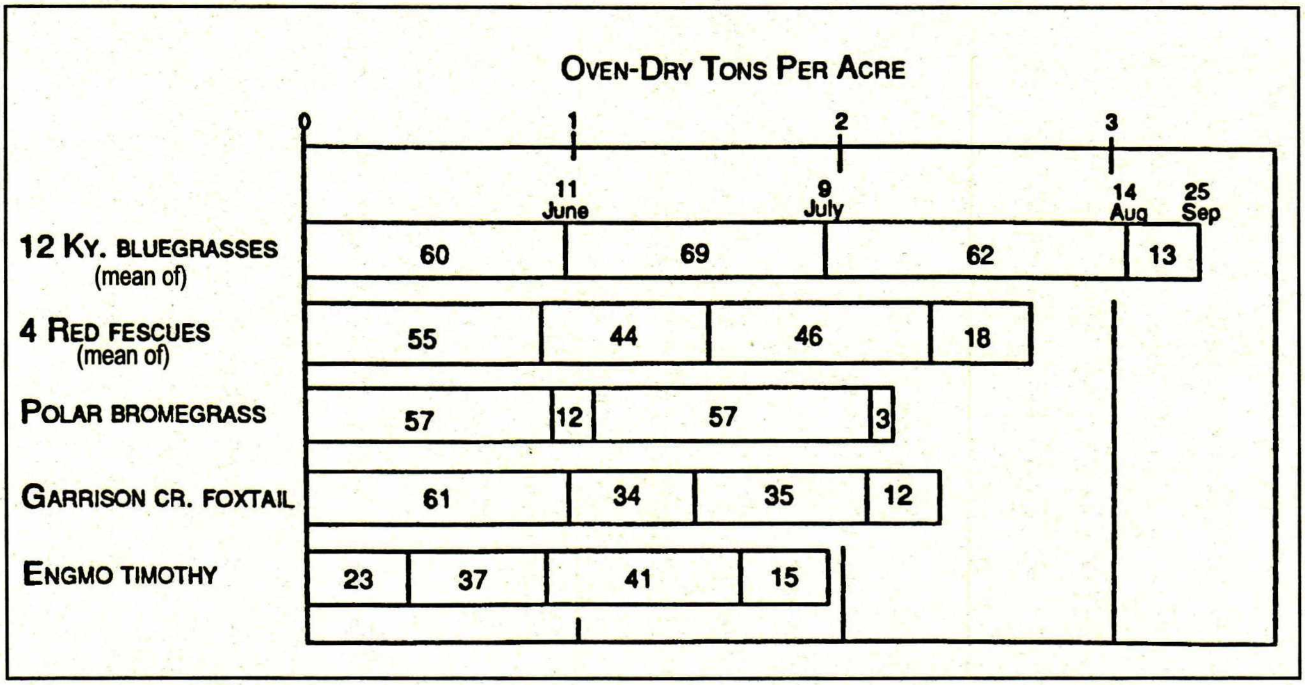

Figure 1. Graph illustrating the diminishing production of herbage by perennial forage grasses late in the growing season, a period when ryegrasses could provide supplemental forage. The number within each bar segment is the mean pounds of dry matter produced per acre per day for each growth period; harvest dates appear above the top graph bar only, but apply to all bars. The final bar segment for the 42-day growth period from 14 August to 25 September shows clearly the diminished rate of herbage production for all grasses, especially bromegrass. Data are two-year means for all grasses, except one year for timothy. (From Klebesadel 1992).

Experimental Procedure

All experiments reported here were conducted at the University of Alaska's Matanuska Research Farm (61.6°N) near Palmer in southcentral Alaska. All experiments were conducted in Knik silt loam (Typic Cryochrept). Pre-plant commercial fertilizer disked into each plowed seedbed supplied N, P_2O_5, and K_2O at 32, 128, and 64 lb/A, respectively, unless otherwise stated. Randomized complete block experimental designs with four replications were used in all experiments.

. Oats (*Avena sativa*) sown in Experiments I through III was the cultivar Rodney. Peas (*Pisum arvense*) used in Experiment I were identified as "Canadian field peas" with no cultivar designated. Oats and the oats + peas mixture were planted with a small tractor-mounted drill that placed seed in 10 rows six inches apart and about 2 ½ inches deep. The only ryegrass used in Experiments I, II, and IV was Oregon-grown "common". Ryegrass was broadcast-seeded in all experiments and all plantings were firmed and seed buried shallowly with a corrugated-roller implement immediately after planting. Commercial ammonium nitrate was used for nitrogen topdressings after mid-season harvests in all experiments.

In the small-plot experiments, plot size was 5 by 16, 5 by 18, or 5 by 20 feet in the various experiments. Forage yields were derived from a swath 2½ feet wide mowed and weighed from the centerline of each plot, leaving about a 2–inch stubble, after a 1¼–foot-wide 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 calculate yields on an oven-dry basis. Dried samples were ground finely and analyzed for crude protein (N x 6.25) by the Kjeldahl method. All forage yields and crude protein levels are reported on the oven-dry basis (140°F).

Experiment I: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats vs. Ryegrass + Oats + Peas, Harvested Twice, One Planting Date, Three Different Mid-Season Harvest Dates.

The above single species and mixtures were compared over three years for forage production. Each plot was harvested twice, once near mid-season and once in late September. Ryegrass was planted at 15 lb/A, oats at 100 lb/A where used alone or with ryegrass only, and at 50 lb/A in mixture with ryegrass + peas. Sowing rate for Canadian field peas was 50 lb/A with appropriate bacterial inoculant mixed with seed at planting. Plots were topdressed immediately after each mid-season harvest to supply N at 50 lb/A. Dates of planting, mid-season harvests, and final harvests were (numbers in parentheses are number of days between procedures):

		Harvests			
		Mid-Season			
Year	Planted	Early	Mid	Late	Final
1964	1 June (49)	20 July (10)	30 July (11)	10 Aug (49)	28 Sep
1966	4 June (47)	21 July (11)	1 Aug (11)	12 Aug (45)	26 Sep
1967	31 May (51)	21 July (12)	2 Aug (7)	9 Aug (49)	27 Sep
Means:	2 June (49)	21 July (11)	1 Aug (9)	10 Aug (48)	27 Sep

Experiment II: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats, Three Planting Dates, Harvested Twice, Four Different Mid-Season Harvest Dates.

The above single species and the mixture were planted on 17 May, 29 May, and 16 June in 1967. Each crop or mixture, from each planting date, was harvested twice, the first cutting on one of four different mid-season harvest dates —18 July, 27 July, 4 August, or 14 August. Plots harvested on each mid-season date were topdressed immediately to supply N at 60 lb/A. Final harvest (second cutting) of all plots was on 29 September.

Experiment III: Seasonal Distribution of Forage Yields of Several Ryegrass Types, Strains, and Cultivars as Influenced by Two Different Times of Mid-Season Harvest.

To evaluate the performance and productivity of ryegrasses from diverse sources, seed was obtained from N.V.H. Mommersteeg's, a seed firm in Holland, also from the Welsh Plant Breeding Station near Aberystwyth, Wales, and from Northrup, King and Co., a U.S. seed firm. These are abbreviated as "Momm.", Aberyst.", and "NK", respectively. Ryegrass strains from those sources were compared with Oregon-grown common diploid ryegrass that has been used by some local farmers in recent years.

All ryegrass strains and Rodney oats were planted on 23 May 1967 (Exp. IIIa) and 5 June 1968 (Exp. IIIb). All ryegrasses were planted at 15 lb/A and oats at 100 lb/A. Immediately after mid-season harvests, each plot was topdressed to supply N at 60 lb/A. Two dates of mid-season harvest were compared, 21 July and 2 August in 1967, and 23 July and 6 August in 1968. Each plot was harvested twice per season but each grass strain was evaluated under two different dates of mid-season harvest. Regrowth on all plots was harvested 29 September in 1967 and 25 September in 1968.

Experiment IV: Common Ryegrass Regrowth Yields in Response to Six N Rates After Mid-Season Forage Harvest of Ryegrass + Oats + Field Peas.

Preplant fertilizer disked into the seedbed each year supplied N, P_2O_5, and K_2O at 30, 60, and 30 lb/A, respectively. Oats, field peas, and ryegrass were planted at the rates given in Experiment I. Dates of planting, mid-season harvests, and final harvests were (numbers in parentheses are the number of days between operations):

			Harvests		
Year	Planted		Mid-Season		Final
1961	23 May	(57)	19 July	(61)	18 Sep
1963	5 June	(43)	18 July	(67)	23 Sep
1964	26 May	(56)	21 July	(69)	28 Sep
Means:	28 May	(52)	19 July	(66)	23 Sep

Immediately after mid-season harvest each year, plots were topdressed with ammonium nitrate to supply N at one of the following rates: 0, 40, 60, 80, 100, or 120 lb/A.

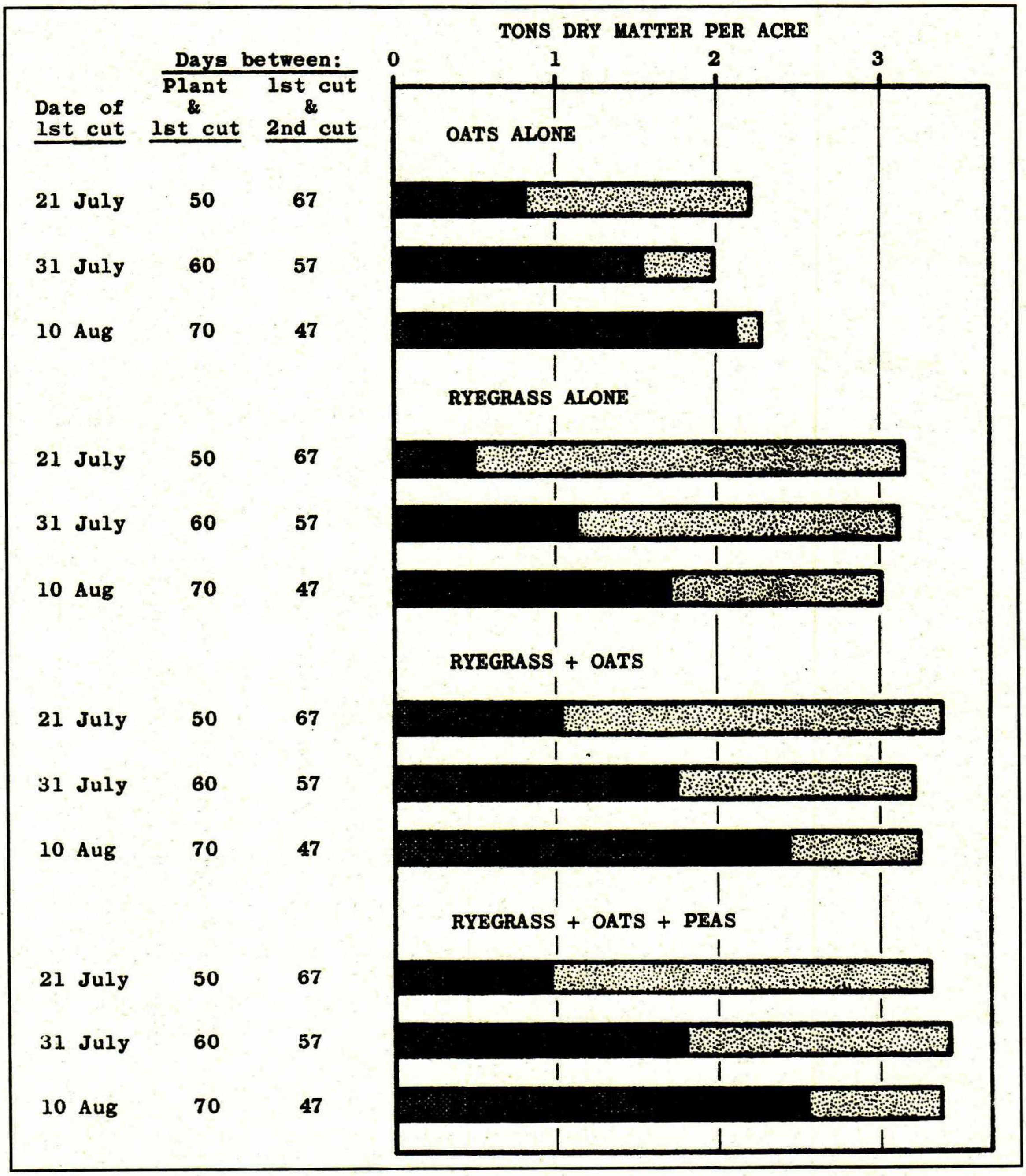

Figure 2. Three-year mean oven-dry forage yields and yield distribution from (a) oats grown alone, (b) common ryegrass alone, (c) ryegrass + oats grown together, and (d) ryegrass + oats + field peas, as influenced by three dates of mid-season harvest. Dark portion of each graph bar is mid-season harvest yield; stippled portion is added yield from regrowth harvested in late September. Mean planting date = 1 June; second harvest (of regrowth) on all plots taken on or about 27 September each year. (Experiment I).

Experiment V: Relative Grazing Preference Among Four Different Types of Ryegrass.

Four types of ryegrass, diploid annual (Oregon-grown "common"), Westerwold (cv. 'Billion' from Northrup, King), a tetraploid annual (cv. 'Tetrone' from Northrup, King), and a perennial (Northrup, King '100') were spring-seeded in four consecutive years (1968-69-70-71) for grazing-preference comparisons of ryegrass regrowth by dairy stock at four, 2–day sessions, about 10 days apart, from early September to early October. Unusually dry conditions in spring of 1969 resulted in poor seed germination and uneven stands inadequate for meaningful comparisons so that experiment was terminated.

Fertilizer topdressed after the mid-season harvest supplied N at 60 lb/A in 1968 and 80 lb/A in 1970 and 1971. Dates of planting, mid-season harvest, harvest of 20-foot sample strips prior to each grazing comparison, and each of the four, 2–day grazing comparisons each year were:

	1968	1970	1971	Mean
Planted	10 June	3 June	3 June	5 June
Mid-season harvest	6 Aug	23 July	28 July	29 July
N topdressed	13 Aug	24 July	30 July	31 July
Sample strips harvested	4 Sep	2 Sep	1 Sep	2 Sep
	16 Sep	14 Sep	13 Sep	14 Sep
	25 Sep	25 Sep	27 Sep	26 Sep
	7 Oct	6 Oct	7 Oct	7 Oct
Two-day grazings	5+6 Sep	2+3 Sep	2+3 Sep	3+4 Sep
	16+17 Sep	14+15 Sep	14+15 Sep	15+16 Sep
	26+27 Sep	25+26 Sep	27+28 Sep	26+27 Sep
	7+8 Oct	6+7 Oct	8+9 Oct	7+8 Oct

Samples for in vitro digestibility determinations were dried at 90°F.

Grasses were grazed on a free-choice basis with four mature Holstein cows assigned at random to each of two replicates of the four grasses (confined by relocatable electric fences) on two consecutive days at each of the four successive grazing comparisons each year. Each replicate consisted of 16 paddocks, each

Table 1a. (Above double line): Development of oats, common ryegrass, and field pea plants grown alone and in mixtures at the *earliest* of three mid-season harvests. (Below double line): Development of the regrowths of those three species at the second and final harvest in late September. (Experiment I - Identical experiment conducted in 1964, 1966, and 1967).

Date of mid-season harvest	Development of initial growth at earliest of three mid-season harvests					
	Oats		Ryegrass		Peas	
	Height	Development	Height	Development	Vine length	Development
20 July 1964	26 – 28"	early boot	12 – 14"	late boot to early head	28 – 30"	bud, pre-flower
21 July 1966	14 – 16"	early boot	12 – 14"	late boot to early head	28 – 30"	bud, pre-flower
21 July 1967	22 – 24"	late boot to early head	20 – 22"	fully headed, pre-anthesis	24 – 26"	very early flower

Regrowth (after first harvest on):	Development of regrowths at final harvest in late September		
	Oats	Ryegrass	Peas
20 July 1964	Alone: 32 – 40", milk stage	Alone: 34 – 40", stemmy, badly lodged	
	w/RG: 30 – 40", est.50% of mixture	w/Oats: 34 – 40", fully headed, some anthesis, est.50% of mixture	
	w/RG+P: 34 – 38", est.30% of mixture	w/O+P: 34 – 38", fully headed, est. 50% of mixture	24 – 32", early bloom, est. 20% of mixture
21 July 1966	Alone: 28 – 32", fully headed, pre-anthesis	Alone: 34 – 36", fully headed, pre-anthsis	
	w/RG: 22 – 24", est.5% of mixture	w/Oats: 32 – 34", est.95% of mixture	
	w/RG+P: 22 – 24", est.3% of mixture	w/O+P: 32 – 34", est.95% of mixture	34 – 36", flowering, est.2% of mixture
21 July 1967	Alone: 32 – 36", standing well	Alone: 30 – 36", badly lodged	
	w/RG: 28 – 32", est.30% of mixture	w/Oats: 30 – 36", lodged, est. 70% of mixture	
	w/RG+P: 28 – 32", est.30% of mixture	w/O+P: 30 – 36", est.70% of mixture	est.<1% of mixture

paddock measuring 40 by 50 feet. A different block of four contiguous, previously ungrazed paddocks (of the four ryegrasses) in each replicate was used for each 2-day grazing comparison. Thus, each successive 2-day grazing comparison was on previously ungrazed grass regrowth about 10 days more advanced phenologically than the previous comparison.

The animals were not fed prior to being driven to the experimental area shortly after 8:00 AM each grazing day. Grazing activity was recorded from an elevated vantage point using binoculars at each five-minute interval from the beginning of the grazing period until satiation, when cows were removed from the experimental area, usually about 10:00 to 10:30 AM each day. Each observed cow grazing a specific grass was multiplied by five to calculate total "cow minutes" of grazing time.

Results and Discussion

Experiment I: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats vs. Ryegrass + Oats + Peas, Harvested Twice, One Planting Date, Three Different Mid-Season Harvest Dates.

Five main findings were apparent in the results graphed in Figure 2: (a) oats was the dominant contributor to mid-season harvest yields, (b) ryegrass was the dominant contributor to second-harvest yields in late September, (c) delaying mid-season harvest about three weeks (from about 50 to about 70 days after planting) more than doubled mid-season harvest yields, (d) although time of mid-season harvest had a marked effect on the proportion of the total two-cut yield that was obtained in the first

Table 1b. (Above double line): Development of oats, common ryegrass, and field pea plants grown alone and in mixtures at the *intermediate* of three mid-season harvests. (Below double line): Development of the regrowths of those three species at the second and final harvest in late September. (Experiment I - Identical experiment conducted in 1964, 1966, and 1967).

Date of mid-season harvest	Development of initial growth at the intermediate of three mid-season harvests					
	Oats		Ryegrass		Peas	
	Height	Development	Height	Development	Vine length	Development
30 July 1964	34 – 36"	fully headed, pre-anthesis	(alone) 20 – 22" (w/oats) 14 – 16"	fully headed late boot to early head	44 – 46"	early flower
1 Aug 1966	24 – 28"	very late boot to early head	24 – 30"	late boot to early head	42 – 48"	0–5 flowers per plant
2 Aug 1967	38 – 40"	anthesis to ¼groat	28 – 30"	fully headed, mostly in anthesis	42 – 46"	flowering with early small pods

Regrowth (after first harvest on):	Development of regrowths at final harvest in late September		
	Oats	Ryegrass	Peas
30 July 1964	Alone: 10 – 22", late boot to early head	Alone: 22 – 28", some lodging	
	w/RG: 10 – 20", very sparse regrowth	w/Oats: 20 – 26", est.80% of mixture	
	w/RG+P: 10 – 20", very sparse regrowth	w/O+P: 20 – 26", est.85% of mixture	none
1 Aug 1966	Alone: 20 – 22", fully headed, pre-anthesis	Alone: 26 – 28", fully headed	
	w/RG: 22 – 24", est.15% of mixture	w/Oats: 22 – 24", headed, est. 85% of mixture	
	w/RG+P: 22 – 24", est.1% of mixture	w/O+P: 24 – 26", est.98% of mixture	10 – 12", est. 1% of mixture
2 Aug 1967	Alone: 16 – 24", fully headed, pre-anthesis	Alone: 28 – 34", a few lodged areas	
	w/RG: 16 – 24", est.15% of mixture	w/Oats: 24 – 30", est.85% of mixture	
	w/RG+P: 16 – 24", est. 15% of mixture	w/O+P: 26 – 32", est.85% of mixture	none

Table 1c. (Above double line): Development of oats, common ryegrass, and field pea plants grown alone and in mixtures at the *latest* of three mid-season harvests. (Below double line): Development of the plants in the regrowths of those three species at the second and final harvest in late September. (Experiment I - Identical experiment conducted in 1964, 1966, and 1967).

Date of mid-season harvest	Development of initial growth at latest of three mid-season harvests					
	Oats		Ryegrass		Peas	
	Height	Development	Height	Development	Vine length	Development
10 Aug 1964	46 – 48"	¼–½ groat formed	(alone) 32 – 36" (w/oats) 26 – 30"	anthesis anthesis	56 – 58"	flowering + pods forming
12 Aug 1966	32 – 36"	fully headed	28 – 32"	fully headed, anthesis	42 – 46"	5–7 flowers per plant
9 Aug 1967	40 – 42"	late milk stage	32 – 36"	just past anthesis	38 – 40"	flowering, 2–3 pods per plant,small peas in oldest pods

Regrowth (after first harvest on):	Development of regrowths at final harvest in late September		
	Oats	Ryegrass	Peas
10 Aug 1964	Alone: 10 – 16", late boot to early head	Alone: 18 – 22", late boot to headed, stemmy	
	w/RG: 10 – 16", est.10% of mixture	w/Oats: 12 – 16", late boot, est.90% of mixture	
	w/RG+P: 10 – 16", est. 10% of mixture	w/O+P: 12 – 16", late boot, est.90% of mixture	none
12 Aug 1966	Alone: 14 – 16", late boot to early head	Alone: 18 – 20", fully headed	
	w/RG: 12 – 14", est.1% of mixture	w/Oats: 16 – 18", fully headed, est.99% of mixture	
	w/RG+P: 12 – 14", est. 1% of mixture	w/O+P: 16 – 18", fully headed, est. 99% of mixture	none
9 Aug 1967	Alone: 10 – 18", very sparse	Alone: 18 – 24", fully headed, no lodging	
	w/RG: 10 – 16", est.5% of mixture	w/Oats: 18 – 22", est.95% of mixture	
	w/RG+P: 10 – 16", est.5% of mixture	w/O+P: 18 – 22", est.95% of mixture	none

(mid-season) versus the second (late September) harvests, total yields for the two cuttings were affected little by timing of the mid-season harvest, and (e) field peas (in mixture with ryegrass and oats) did not increase forage yields above those realized with oats plus ryegrass without peas.

Ryegrass alone yielded approximately as much in total-season yields as ryegrass + oats, despite the fact that first-cutting yields of ryegrass alone were less than those where oats were included (Fig. 2). However, despite the less abundant regrowth of oats, a ryegrass + oats combination should be preferred to ryegrass alone. This is because the oat tiller regrowth in the ryegrass + oats mixture was seen to contribute valuable physical support and lodging resistance to the finer-stemmed ryegrass. Rains during September can cause heavy regrowth of ryegrass alone to become badly lodged.

The lesser regrowth of oats, compared with ryegrass, illustrates why oats alone or oats + peas are better than oats + ryegrass as companion crops to use when establishing perennial forage seedings such as bromegrass or timothy. The extremely vigorous regrowth of ryegrass after mid-season harvest is too competitive for adequate growth and establishment of the slower-growing perennial grass seedlings[3] (See additional discussion on this in final section of this report).

There was minimal to absent regrowth of field peas after the mid-season harvests (Tables 1a, 1b, 1c); however, it should be noted that field peas in a mixture can contribute beneficial nutritional components to the forage, especially elevated levels of crude protein (Fig. 3), digestibility, calcium, and magnesium (Brundage and Klebesadel 1970; Brundage *et al.* 1979; Klebesadel 1969a).

The nutritional benefits added by peas would accrue primarily to forage harvested at mid-season

[3]Not studied in these experiments, but known from earlier studies and from unpublished data, Alaska Agric. and Forestry Exp. Sta.

for, as noted, peas regrew poorly after mid-season harvest and contributed little or no herbage to the regrowth. However, it was noted that, after mid-season harvest, regrowth of ryegrass in the mixture where peas were included was darker green and obviously benefited from N fixed by bacteria in pea-root nodules prior to mid-season harvest.

Field peas are indeterminate in growth and continue vine extension, flowering, and pod development and filling throughout Alaska's relatively short growing seasons (Brundage and Klebesadel 1970; Klebesadel 1969a); thus, their contribution is greater in an oat + pea mixture (without ryegrass) that is grown for a longer period and harvested once for silage when oats is near late milk to early dough stage of development (Hodgson 1956). Development in Alaska of 'Weal', a "hooded" cultivar of barley (*Hordeum vulgare*) (hooded means without scabrous awns in the seed head — common in most barleys — that can cause feeding problems), has led to a recent trend toward an oats + barley combination for silage in place of an oats + peas mixture; the high cost of field-pea seed and the desired higher energy levels in oats + hooded barley silage have contributed to this change (Brundage *et al.* 1981).

Total crude protein yields per acre (for mid-season + late Sep. harvest) were highest when field peas were included with oats and ryegrass, lowest with oats grown alone and intermediate for ryegrass grown alone or with oats (Fig. 3).

With oats grown alone, or oats with ryegrass, total crude protein yields per acre decreased as mid-season harvests were later; time of mid-season harvest had little effect on total crude protein yields from ryegrass alone (mean = 675 lb/A) or from the mixture of ryegrass + oats + peas (mean = 784 lb/A).

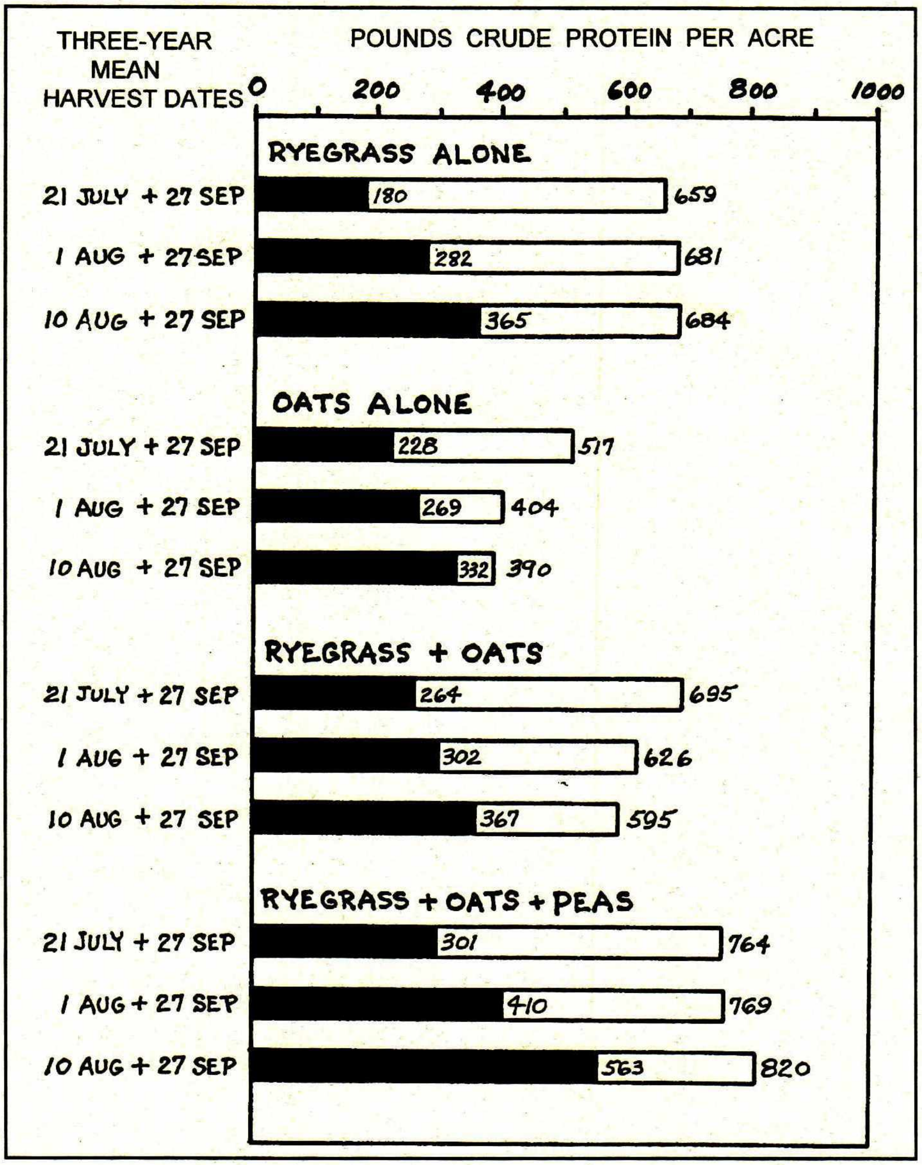

Figure 3. Three-year means of pounds of crude protein per acre produced by common ryegrass grown alone, oats alone, ryegrass + oats grown together, and ryegrass + oats + field peas, as influenced by three dates of mid-season harvest. Black portion of each graph bar and adjacent number are for first cutting; open portion of bar represents crude protein added in second cutting in late September. Number at right of each bar is total pounds crude protein per acre for both cuttings. (Experiment I).

Experiment II: Ryegrass Alone vs. Oats Alone vs. Ryegrass + Oats, Three Planting Dates, Harvested Twice, Four Different Mid-Season Harvest Dates.

This experiment was designed to determine when ryegrass or ryegrass + oats should be planted for maximum usefulness. Additionally, with a given time of planting, when should a mid-season harvest be taken for desired distribution of yields in first growth and in the regrowth?

Planting dates, mid-season harvest dates, duration of growth periods, and forage yields appear in Figure 4.

Early to mid-May generally is the earliest that field plantings can be made in Alaska, although different agricultural areas, and individual farms, fields, and years differ in characteristics that affect and determine when earliest field operations can be accomplished each year.

On most farms, cereals grown to maturity for grain and straw necessarily are given priority over annual forage for earliest planting because the grains require most of the growing season to mature. This tends to shift planting time for annual forages to late May or early June. Mid-June is about as late as planting would be practical for annual forage crops intended for two harvests or a mid-season harvest plus appreciable pasturage before the end of the growing season.

Date of: Plant	Date of: 1st cut	Approximate days between: Plant & 1st cut	Approximate days between: 1st cut & 2nd cut
17 MAY	18 July	60	75
	27 July	70	65
	4 Aug	80	55
	14 Aug	90	45
29 MAY	18 July	50	75
	27 July	60	65
	4 Aug	70	55
	14 Aug	80	45
16 JUNE	18 July	30	75
	27 July	40	65
	4 Aug	50	55
	14 Aug	60	45
17 MAY	18 July	60	75
	27 July	70	65
	4 Aug	80	55
	14 Aug	90	45
29 MAY	18 July	50	75
	27 July	60	65
	4 Aug	70	55
	14 Aug	80	45
16 JUNE	18 July	30	75
	27 July	40	65
	4 Aug	50	55
	14 Aug	60	45
17 MAY	18 July	60	75
	27 July	70	65
	4 Aug	80	55
	14 Aug	90	45
29 MAY	18 July	50	75
	27 July	60	65
	4 Aug	70	55
	14 Aug	80	45
16 JUNE	18 July	30	75
	27 July	40	65
	4 Aug	50	55
	14 Aug	60	45

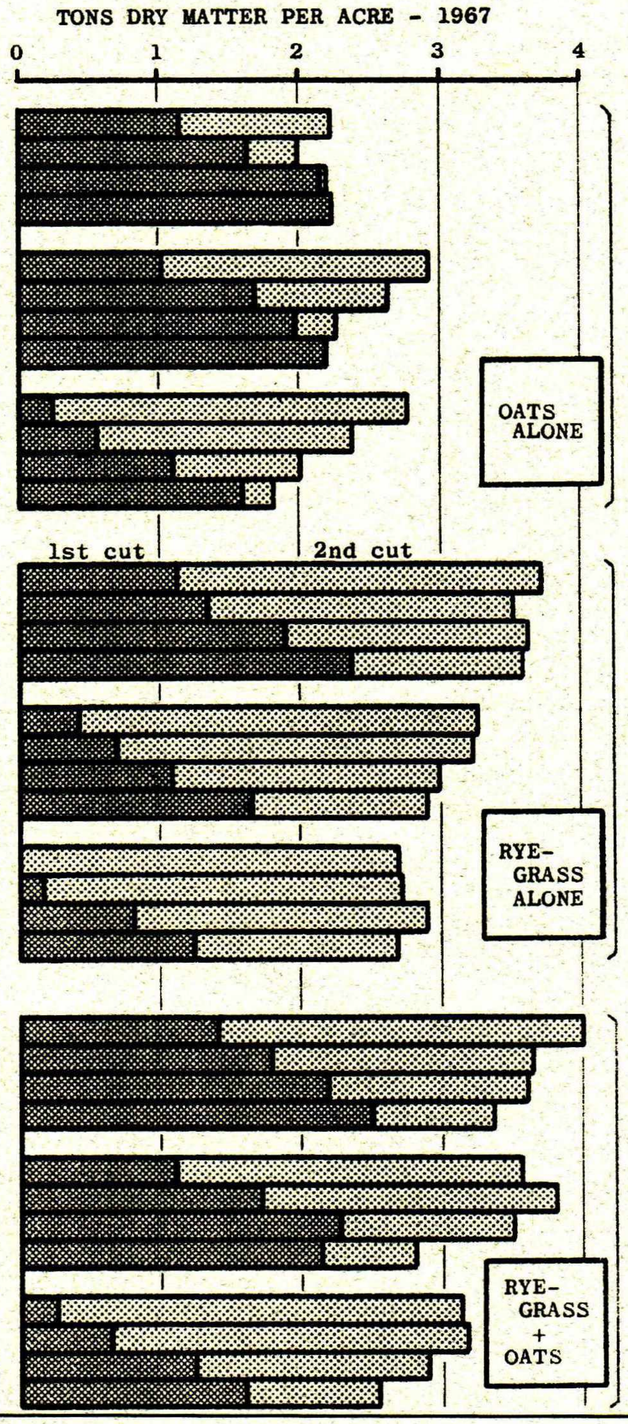

Figure 4. Oven-dry forage yields and yield distribution of oats grown alone, common annual ryegrass grown alone, and ryegrass + oats grown together, as influenced by three dates of planting and four dates of mid-season harvest; data are for one year. (Experiment II).

Table 2a. Development of oats and common ryegrass, grown alone and in mixture, at four different mid-season harvest dates, as influenced by three different planting dates in 1967. (Experiment II).

		Dates of mid-season harvest							
		18 July		27 July		4 Aug		14 Aug	
Planted	Crop	Height	Development	Height	Development	Height	Development	Height	Development
17 May	Oats	30 – 32"	fully headed, pre-anthesis	36 – 38"	¼ groat	36 – 38"	milk stage	36 – 38"	early to mid-dough
	Ryegrass	28 – 30"	fully headed, early anthesis	28 – 30"	mid-anthesis	36 – 38"	late anthesis	38 – 40"	past anthesis
29 May	Oats	22 – 24"	late boot to early heading	32 – 34"	fully headed, pre-anthesis	38 – 40"	very early milk stage	38 – 40"	late milk stage
	Ryegrass	16 – 18"	fully headed, pre-anthesis	34 – 36"	early to mid-anthesis	36 – 38"	late anthesis	38 – 40"	past anthesis
16 June	Oats	10 – 12"	pre-boot stage	20 – 22"	early boot stage	24 – 26"	late boot to early heading	34 – 36"	fully headed, pre-anthesis
	Ryegrass	3 – 6"	3 – 5 leaves	10 – 12"	pre-boot stage	16 – 18"	late boot to early heading	30 – 32"	fully headed, very early anthesis

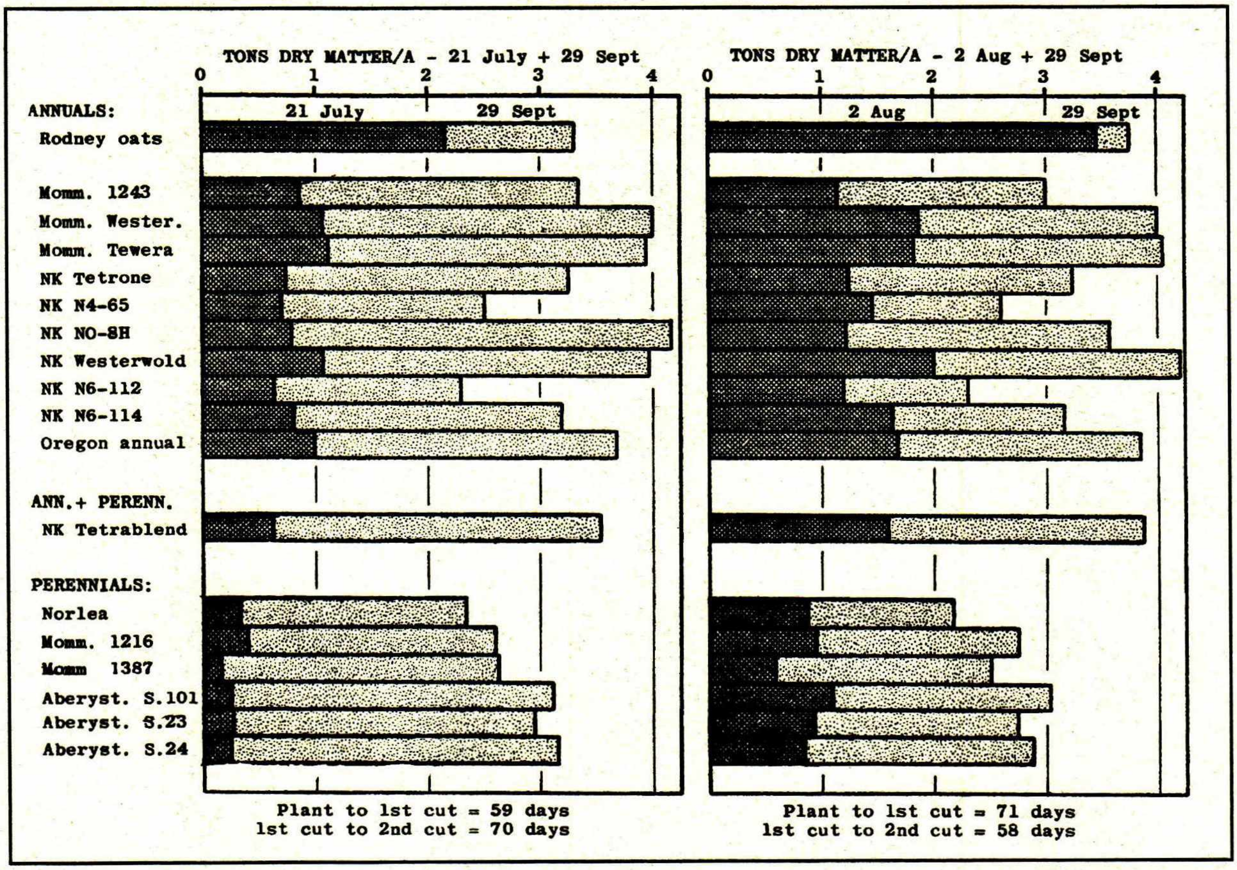

Figure 5. Seasonal distribution of forage yields of oats and several annual and perennial ryegrasses as influenced by two different dates of mid-season harvest. All planted on 23 May 1967; data are for one year (Experiment III a).

Table 2b. Development of oats and common ryegrass, grown alone and in mixture, at the time of the 29 September 1967 harvest of the regrowths after four different dates of mid-season harvests of crops planted on three different dates. (Experiment II).

Crop	Planted	Dates of mid-season harvest							
		18 July		27 July		4 Aug		14 Aug	
		Height	Development	Height	Development	Height	Development	Height	Development
Oats: (no lodging in any plots of oats alone)	17 May	26 – 30"	late milk stage, fairly sparse stand	16 – 26"	pre-milk stage, sparse stand	6 – 20"	very sparse, non-leafy culms	4 – 10"	virtually no regrowth
	29 May	32 – 38"	pre-to early milk, fairly dense stand	24 – 30"	near anthesis, not dense stand	10 – 24"	quite sparse, most culms headed, non-leafy	4 – 10"	virtually no regrowth
	16 June	36 – 42"	milk stage, dense stand	30 – 38"	late anthesis, fairly dense stand	20 – 26"	leafy culms, mostly boot to early head, fair stand	10 – 16"	pre-to early boot, only fair stand
Ryegrass:	17 May	34 – 38"(L)[1]	badly lodged, 100% headed	28 – 34"	standing well, fully headed	24 – 30"	boot to fully headed, standing well (**)[2]	18 – 22"	boot to early head
	29 May	34 – 38"(L)	badly lodged, 100% headed	30 – 36"	slight lodging, fully headed	24 – 30"	late boot to headed, standing well	18 – 22"	boot to early head, standing well
	16 June	30 – 36"(L)	badly lodged, 90% headed	30 – 36"(L)	fairly badly lodged	22 – 28"	mostly headed, slight lodging	20 – 22"	boot to early head, standing well
Oats + ryegrass mixture:	17 May	Est. 80% ryegrass, badly lodged, 100% headed		Est. 80% ryegrass, slight lodging		Est. 95% ryegrass		10 – 16"	est. 99% ryegrass
	29 May	34 – 38"	est. 50% ryegrass, standing well (**)	Est. 60% ryegrass, standing well		Est. 85% ryegrass		10 – 14"	est. 95% ryegrass
	16 June	Est. 40% ryegrass, oats standing well, ryegrass weak		Est. 40% ryegrass, standing well(**)		Est. 60% ryegrass		12 – 16"	est. 85% ryegrass

[1](L) = lifted, height measurement when plants lifted erect.
[2](**) indicates plots that looked exceptionally good.

In general, higher total (2 cuttings) forage yields were obtained from ryegrass grown alone, or ryegrass grown in mixture with oats, than from oats grown alone (Fig. 4), as occurred in Experiment I. Again those differences were due primarily to greater regrowth yields of ryegrass than of oats.

Though not totally consistent, there was also a trend toward lower total, two-harvest yields with progressively later mid-season harvests (Fig. 4). Later mid-season harvests shortened the regrowth period, and amount of ryegrass regrowth was more affected by duration of the regrowth period than by stage of development at the mid-season harvest.

In contrast, regrowths of oats were reduced markedly when mid-season harvests were taken later than the fully-headed/prior-to-anthesis stage. The greatest oat regrowth (2.52 T/A, Fig. 4) occurred with the latest planting (16 June) and earliest mid-season harvest (18 July), taken when oats were 10 to 12 inches tall and prior to boot stage (Table 1a); however, that mid-season harvest was very low in yield (0.25 T/A).

Oats grown alone therefore is much less useful than ryegrass for late-season pasture or forage following a mid-season harvest, unless development stage of the initial growth is taken into account at the mid-season harvest (Fig. 4, Tables 2a, 2b).

Alternately, oats planted in May and grown as a companion crop in the establishment of small-seeded perennial forage seedings can provide a considerable yield in a mid-season forage harvest in late July or early August, then produce a sparse, relatively non-competitive regrowth during the remainder of the growing season. This affords the perennial seeding a long period for establishment with minimal competition between forage harvest and freeze-up.

Invariably, when ryegrass was seeded alone and harvested on either of the two earliest mid-season dates (18 July or 27 July), the regrowths produced high yields in late September (Fig. 4) but were badly lodged (Table 2b).

Where oats were grown in mixture with ryegrass, the regrowths tended to lodge much less due to the greater strength (lodging resistance) of the oat stems compared with ryegrass (Table 2b). An exception was when the mixture was planted earliest (17 May) with early mid-season harvest (18 or 27 July); there the heavy regrowth, consisting mostly of ryegrass, could not be adequately supported by the limited oat regrowth and lodging was considerable (Table 2b).

Experiment III: Seasonal Distribution of Forage Yields of Several Ryegrass Types, Strains, and Cultivars as Influenced by Two Different Times of Mid-Season Harvest.

Since only common diploid annual ryegrass was used in Experiments I and II, a wider selection of ryegrass cultivars and strains was selected for evaluation and comparisons in experiments planted

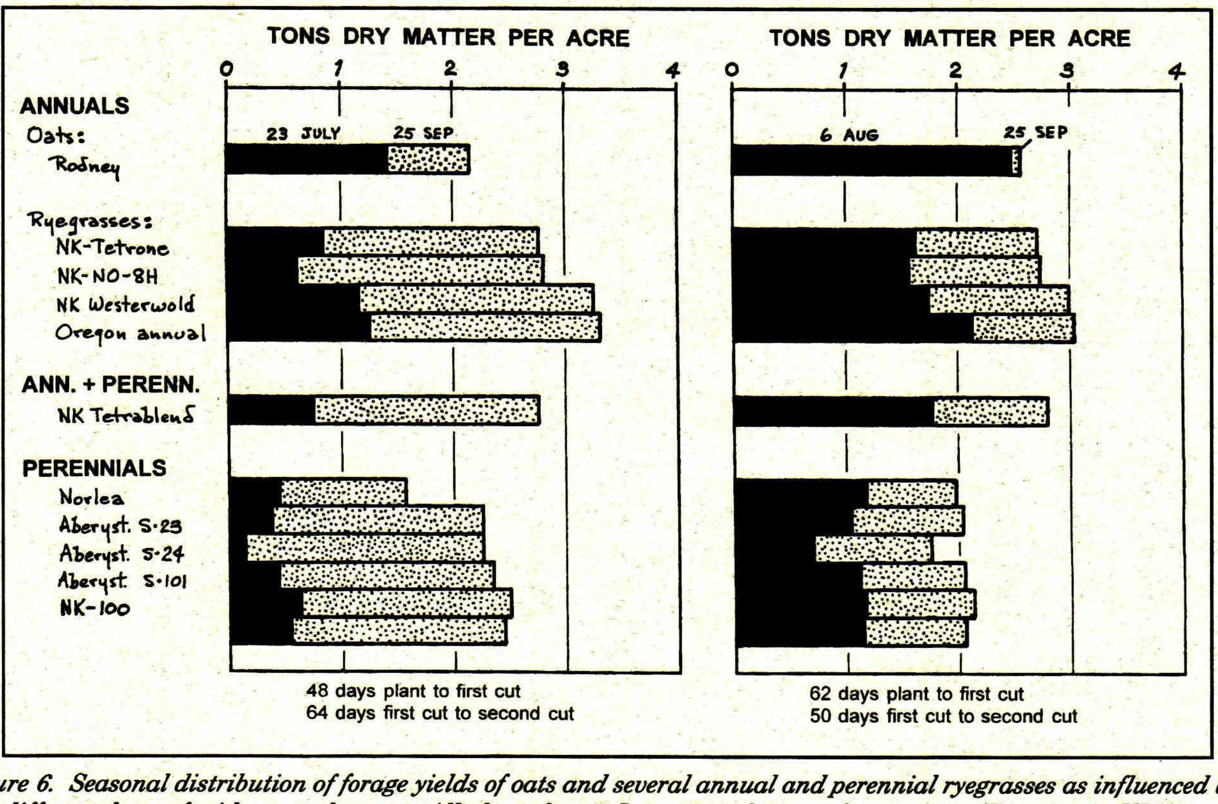

Figure 6. Seasonal distribution of forage yields of oats and several annual and perennial ryegrasses as influenced by two different dates of mid-season harvest. All planted on 5 June 1968; data are for one year. (Experiment III b).

Table 3. Some characteristics of Rodney oats and various annual and perennial ryegrass strains evaluated for forage on two harvest schedules at the Matanuska Research Farm (Experiment IIIa).

ANNUALS:	Percent dry matter When cut on 7/21	Percent dry matter On 9/27 (plots cut 7/21)	Estimated no. heads on 9/27 per 5 by 16-ft plot	Percent dry matter When cut on 8/2	Percent dry matter On 9/27 (plots cut 8/2)	Estimated no. heads on 9/27 per 5 by 16-ft plot	Characteristics of regrowth in late September
Rodney oats	19.0	23.7	800	24.5	20.7	400	
Ryegrasses:							
Momm.[1] 1243	14.1	20.9	200	18.2	20.0	100	Broad leaves, few heads
Momm. Wester.	17.6	25.0	5000	22.4	19.4	4000	Tall, stemmy, fairly leafy
Momm. Tewera	16.1	21.1	7000	18.9	18.0	3000	Tall, stemmy, fairly leafy
NK[2] Tetrone	14.1	18.1	200	15.8	17.0	40	Broad leaves, few heads
NK N4-65	22.3	30.1	5000	30.8	25.9	5000	Stemmy, short, non-leafy
NK NO-8H	12.6	20.1	300	14.9	16.4	60	Very broad leaves, few heads
NK Wester.	17.0	23.5	8000	21.4	18.4	4000	Tall, stemmy, fairly leafy
NK N6-112	19.5	24.6	3000	23.6	20.1	3000	Tall, stemmy, non-leafy
NK N6-114	17.1	23.5	5000	21.2	20.1	4000	Tall, stemmy, non-leafy
Oregon annual	17.9	24.5	5000	24.8	20.3	3000	Tall, stemmy, some lodged
ANN. + PERENN. (Mixture):							
NK Tetrablend	15.1	20.5	1000	17.3	19.3	1000	2 types : Tall headed stems + shorter plants w/broad lvs.
PERENNIALS:							
Norlea	16.9	25.8	0	17.4	22.0	0	Fine leaves, very short
Momm. 1216	17.3	21.3	0	16.8	19.8	20	Medium leaf width
Momm. 1387	20.7	21.5	50	16.1	19.6	100	Fine leaves
Aberyst.[3] S.101	19.4	20.7	0	16.7	19.6	0	Fine leaves
Aberyst. S.23	17.6	23.8	0	16.0	19.4	40	Fine leaves, very leafy
Aberyst. S.24	18.5	21.9	200	16.7	18.3	200	Fine leaves

[1] Mommersteegs
[2] Northrup, King
[3] Aberystwyth, Wales, UK

in 1965, 1966, 1967, 1968, 1969, and 1970, each comparing a different group of strains. The 1969 test was terminated early due to poor germination resulting from extreme moisture deficit in late 1968 and early 1969 growing seasons. Only the two for 1967 (Experiment IIIa, Fig. 5) and 1968 (Experiment IIIb, Fig. 6), which included the most strains, are reported here.

The objective was to assess the performance (forage yields, heading, etc.), with two different mid-season harvest dates, of a broad range of genetic material within annual and perennial species from the U.S. and Europe. Oats were grown alone as a standard for comparing with the ryegrass strains.

As in Experiment I, total yields for the two cuttings of the season generally were not affected greatly by date of mid-season harvest. The distribution of yield in first versus second cutting, however, was influenced considerably with all ryegrass strains and with oats by the different mid-season harvest dates (21 July vs. 2 Aug. in 1967; 23 July vs. 6 Aug. in 1968)

With mid-season harvest on 21 July 1967 (59 days after planting) when oats were fully headed but prior to anthesis, 35% of total-season yield of oats was obtained in the second cutting in late September (Fig. 5); in contrast, with mid-season harvest on 2 August (71 days after planting) when oats were in early milk stage, only 8% of the total-season yield was obtained in the second cutting, illustrating the limited regrowth potential of oats after a late mid-season forage harvest. With both mid-season harvests, and especially the later one, oats regrowth was markedly less than any of the 17 ryegrasses. A similar pattern of oat yields occurred in 1968 (Fig. 6).

The annual ryegrasses and oats generally outyielded the perennials although certain of the perennial strains surpassed the lowest-yielding annuals in 1967 (Fig. 5); in 1968 all of the annual ryegrasses surpassed all of the perennials in yield (Fig. 6).

The annual ryegrasses and NK "Tetrablend" (a commercial blend of annual and perennial strains), generally yielded more in first cuttings than the perennials in both years.

First-cutting yields of the perennial strains were very low with the earlier mid-season harvest in both years. First-cutting yields of perennial ryegrasses more than doubled in the 12 to 14 days between the two mid-season harvest dates.

The following tabulation of yields and time intervals compares annual and perennial ryegrasses as groups (oats yields not included):

1967 (Experiment IIIa):	Plant to mid-season harvest	Mid-Season harvests 21 July	2 Aug	Mid-Season harvest to final harvest	Final harvest 28 Sep	Total yield
	(days)	(T/A)	(T/A)	(days)	(T/A)	(T/A)
10 annuals + 1 blend	(59)	0.85		(70)	2.59	3.44
10 annuals + 1 blend	(71)		1.53	(58)	1.91	3.44
6 perennials	(59)	0.27		(70)	2.53	2.80
6 perennials	(71)		0.87	(58)	1.81	2.68
1968 (Experiment IIIb):		23 July	6 Aug	24 Sep		
4 annuals + 1 blend	(48)	0.93		(64)	2.05	2.98
4 annuals + 1 blend	(62)		1.77	(50)	1.08	2.85
6 perennials	(48)	0.43		(64)	1.88	2.31
6 perennials	(62)		1.06	(50)	0.94	2.00

Regrowth yields in late September of 1968 were lower than in 1967 due to considerably less precipitation in July, August and September of 1968. Precipitation received at the Matanuska Research Farm during those three months was 4.30 inches below the normal of 7.53; during August and September only 0.67 and 0.82 inches were received, versus normals of 2.90 and 2.39 inches, respectively. In contrast, the much more abundant precipitation received in July, August, and September of 1967 was 2.70, 2.86, and 3.17 inches, respectively, 1.20 inches above normal for those three months.

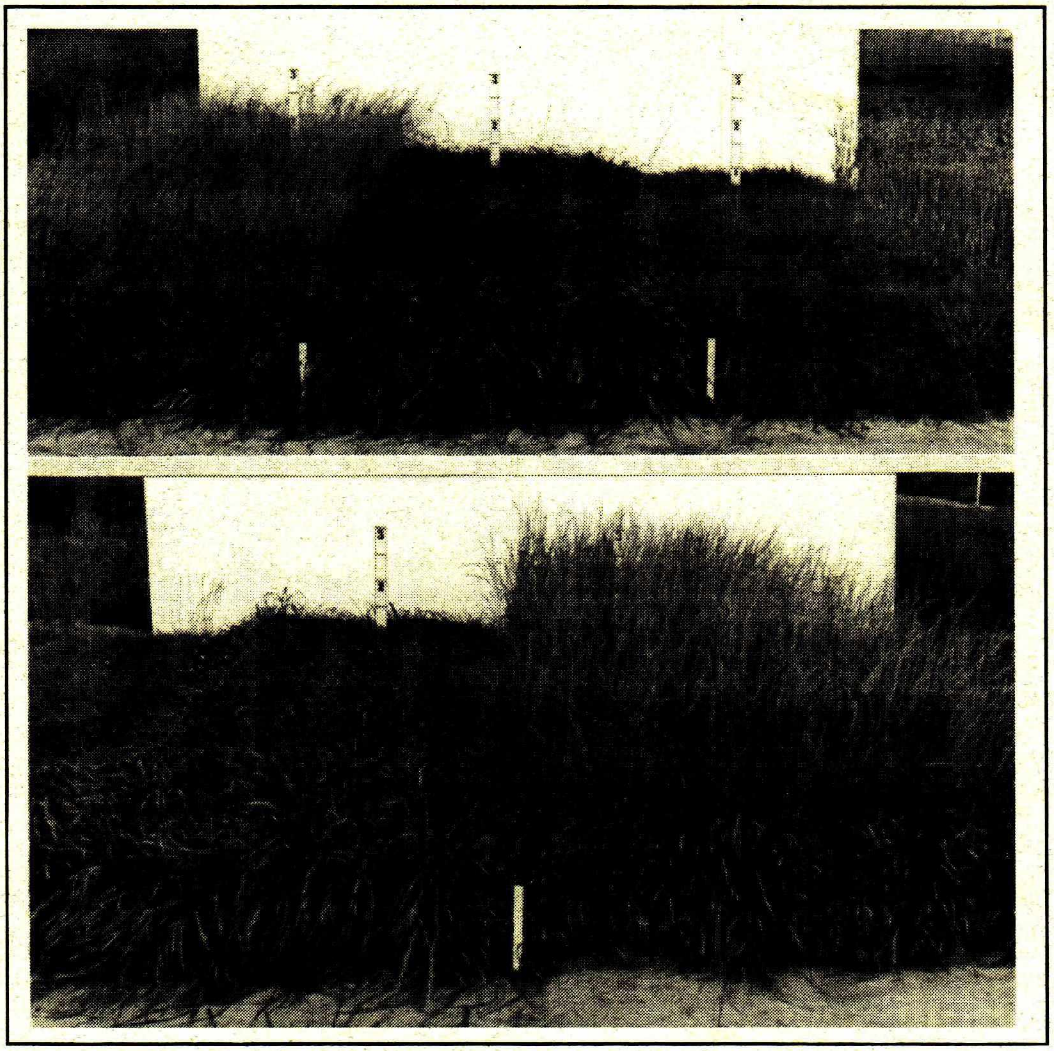

Figure 7. (Upper photo): Left plot = common diploid annual, center plot = tetraploid annual (cultivar Tetrone), right plot = perennial (cultivar Norlea). (Lower photo): Left plot = tetraploid annual (cultivar Tetrone), right plot = Westerwold (cultivar Billion). All plots planted 5 June 1968, mid-season harvest 23 July, photo 19 September. Numbered stake in center of each plot indicates height in feet. (Experiment III b).

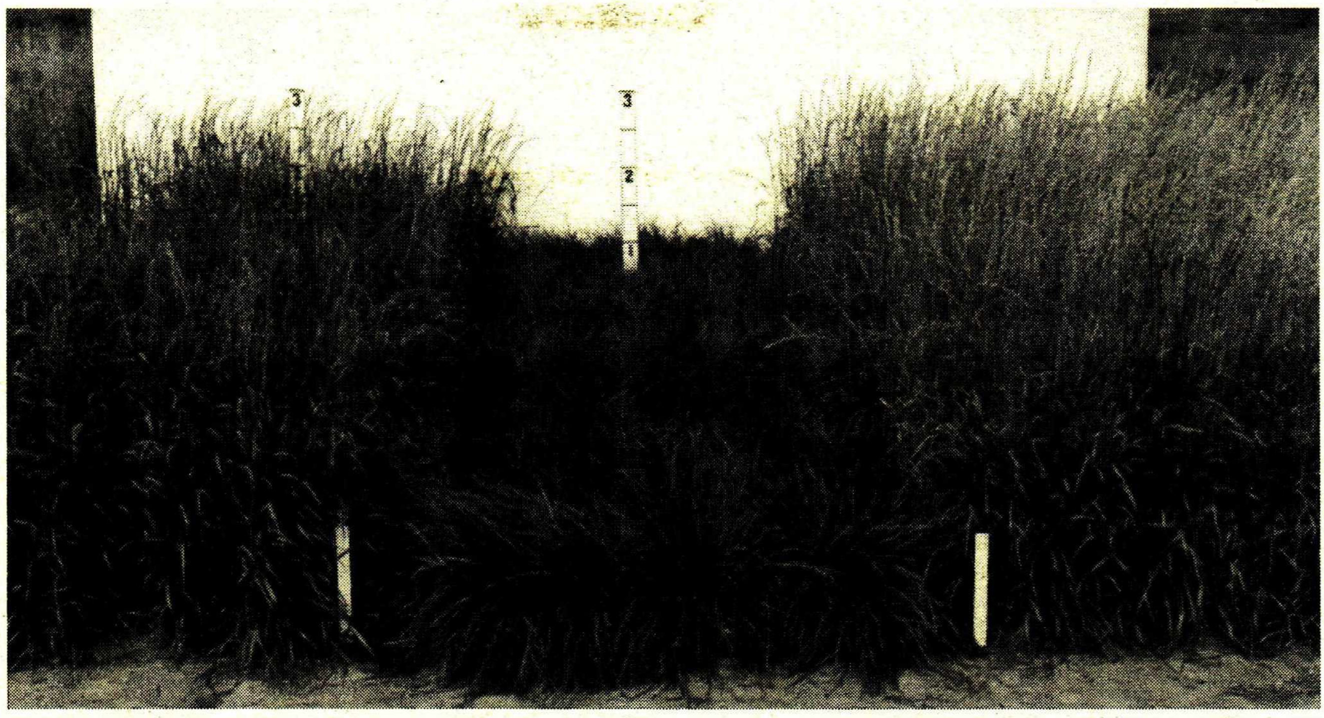

Figure 8. Left and right plots are Westerwold (cultivar Billion) annual ryegrass, center plot is perennial (strain NK 100). Plots were planted 5 June 1968, mid-season harvest of right plot was 23 July, center and left plots were harvested 6 August, photo taken 19 September. Note considerably reduced heading in left plot of Westerwold with 14-day later mid-season harvest than right plot. Numbered stake in center of each plot indicates height in feet. (Experiment III b).

Marked differences in forage yields were evident in 1967 among the annual strains compared (Fig. 5). Six were outstanding with total-season yields between 3.5 and 4.2 T/A. Those included both 'Westerwold' entries, Mommersteeg's 'Tewera', Northrup, King's 'NO–8H' and 'Tetrablend', and the Oregon-grown common annual from a local seed supplier.

Although yields of the perennial strains generally were somewhat inferior to the annuals, herbage of the perennials consisted almost entirely of dense growths of leaves. In contrast, herbage of most of the annuals consisted largely of elongated stems bearing leaves and seed heads in both the first growth and in the regrowth (Table 3).

Other studies at this station found that dairy stock readily consumed the very leafy early initial growth of annual ryegrass, and similar herbage in the early regrowth, but later increasingly rejected the herbage in the field as it headed and became more stemmy (Brundage and Branton 1967; Brundage *et al.* 1963). Dairy research specialists discovered that relatively stemmy annual ryegrass that was virtually rejected by cattle grazing in the field found good acceptance when harvested daily and fed as "green chop" to the same animals in dry-lot(*).

Observations on the considerable differences in the amounts of heading (Table 3) led to speculation that perennial ryegrass, or the virtually non-heading tetraploid annual, might be more acceptable to grazing animals than the increasingly heading common annual and Westerwold ryegrasses as the regrowth period lengthens (see Experiment V).

The very considerable differences in growth and heading in the late-September regrowths of the different ryegrass types are shown in Figures 7 and 8. Note also in Figure 8 the effect of timing of the mid-season harvest on the amount of late-season heading of the Westerwold cultivar Billion also used in Experiment V.

Moreover, the few annual and perennial ryegrasses evaluated in Experiment III revealed that cultivars differed substantially in yielding ability. Further cultivar comparisons may well be justified inasmuch as there exist, on a worldwide basis, hundreds of named cultivars of annual and perennial ryegrasses (Alderson and Sharp 1995; Barenbrug 1979; Hannaway *et al.* 1997).

Experiment IV: Common Ryegrass Regrowth Yields in Response to Six N Rates After Mid-Season Forage Harvest of Ryegrass + Oats + Field Peas.

The effects of six N rates (0,40,60,80,100,120 lb/A), applied immediately after mid-season harvest of oats + common ryegrass + field peas, on amount of regrowth (predominantly ryegrass) produced by late September appear in Figure 9.

The three-year-mean yields of regrowth with no N applied after the mid-season harvest was 1.42 T/A. Application of N at 40 lb/A increased the regrowth yield considerably to 2.26 T/A. The four higher rates of N did not increase regrowth yields (mean of those 4 rates = 2.30 T/A) above those obtained with the 40 lb/A rate.

Kunelius and Calder (1978) and Kunelius (1980) evaluated different N rates and harvest schedules for Italian (annual) and Westerwold ryegrasses in eastern Canada. They reported that their intermediate rate (72 lb/A) applied after seedling emergence and after first and second harvests (total = 216 lb N/A) with three harvests annually was a suitable management scenario.

Mitchell (1984) in Alaska recommended a complete fertilizer at planting supplying N at 60 to 70 lb/A, followed by 70 to 90 lb/A after the first harvest.

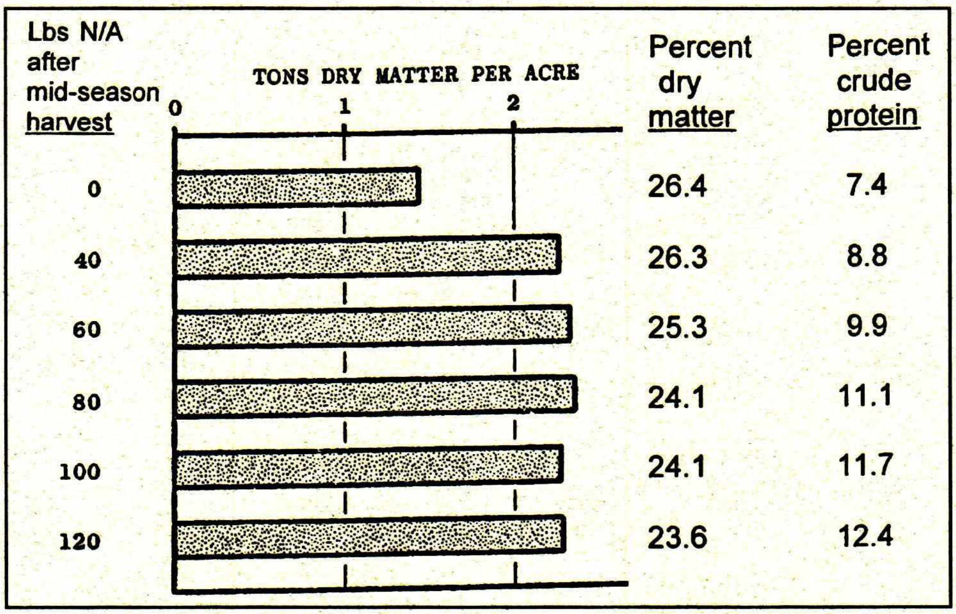

Figure 9. Effects of six different rates of N topdressing (applied immediately after first cutting of a common ryegrass + oats + field pea mixture) on regrowth yields consisting predominantly of ryegrass harvested in late September. All values are means for three years, except crude protein values were determined for two years. Mean dates were: Planting = 28 May, mid-season harvest = 19 July, second and final harvest = 23 September, for which yields and data are shown in graph above. Mean growth period between planting and mid-season harvest = 52 days, between mid-season and final harvest = 66 days.

Thus, the above reports recommend much higher N rates than were found effective in Experiment IV. A possible rationalization for the limited response of the ryegrass regrowth to N rates may have been inadequate levels of other major nutrients; the pre-plant application supplied P_2O_5 at only 60 lb/A and K_2O at 30 lb/A.

Another possible explanation contributing to the poor response of the ryegrass regrowth to higher N rates may lie in the fact that the crop association in this study

Table 4. Forage yield, percent dry matter, and percent crude protein in herbage of the four ryegrasses at the mid-season harvest each year; regrowths after mid-season harvests were compared for grazing preference (Exp. V).

	1968	1970	1971	Mean
Days between planting and mid-season harvest:	57	50	54	54
Mid-season harvest date:	6 Aug	23 July	28 July	29 July
Forage yield at mid-season harvest:	Oven-Dry Tons Per Acre			
Common diploid annual	1.61	1.12	1.01	1.25
Westerwold	2.00	1.04	1.03	1.36
Tetraploid annual	1.63	0.98	0.87	1.16
Perennial	1.30	0.47	0.52	0.76
Dry matter in herbage at mid-season harvest:	Percent			
Common diploid annual	21.1	13.6	17.9	17.5
Westerwold	19.0	12.7	14.6	15.4
Tetraploid annual	15.0	13.0	14.2	14.1
Perennial	18.2	15.0	16.5	16.6
Crude protein in herbage at mid-season harvest:	Percent			
Common diploid annual	11.8	18.0	14.4	14.7
Westerwold	10.4	19.8	14.8	15.0
Tetraploid annual	14.6	22.0	16.6	17.7
Perennial	15.6	24.1	20.5	20.1

included field peas, a very effective N-fixing legume. Following mid-season harvest of the oats + ryegrass + field pea mixture, decomposing field pea root nodules probably released some N into the soil system that supplemented N supplied in the commercial fertilizer topdressing (effect of this was visibly obvious in the darker-green, more robust ryegrass regrowth where peas had been grown in a mixture in Experiment I). If so, regrowth from a seeding of oats + ryegrass, or ryegrass alone (without the legume), probably would show greater response to higher mid-season N rates than was found in Experiment IV.

Pre-plant seedbed fertilizer application in this experiment each year was 10–20–10 at 300 lb/A. Thus total N applied from planting to final harvest for maximum production of the regrowth was only 30 + 40 = 70 lb/A.

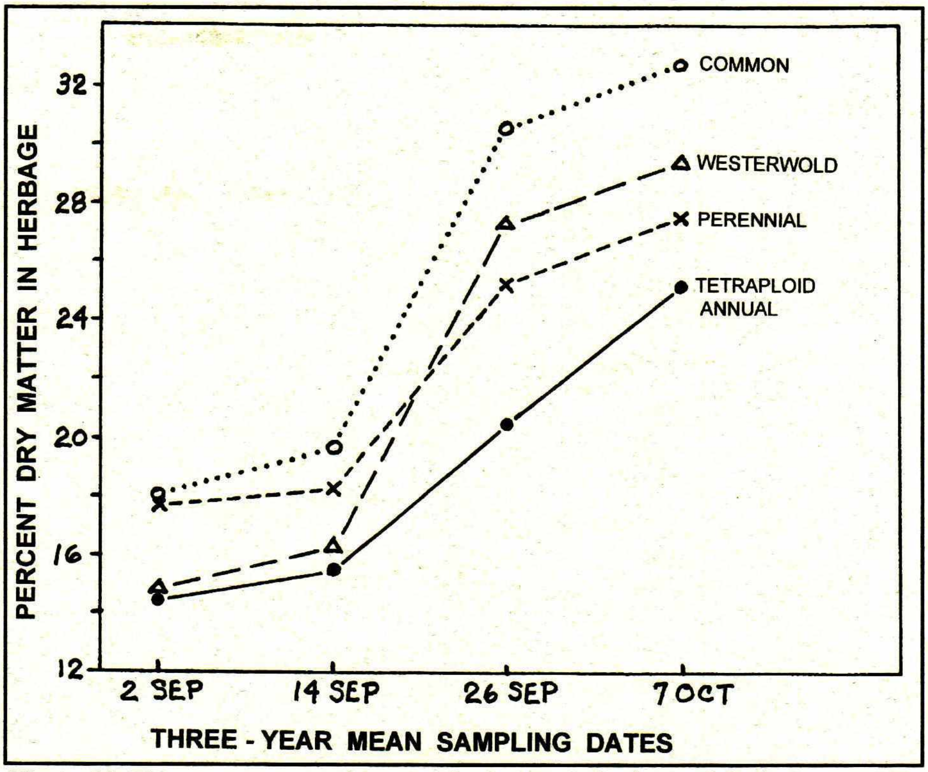

Figure 10. Three-year means of percent dry matter in herbage of the four ryegrasses in Experiment V, sampled just before each of the four successive two-day grazing comparisons. Although lines connect the four values of each ryegrass, each value is the mean from a previously ungrazed pair of paddocks of each ryegrass, one from each of two replicates.

Experiment V: Relative Grazing Preference Among Four Different Types of Ryegrass.

Herbage available for grazing: Three-year means of the quantities of grasses available in paddocks (as sampled by mowed strips prior to grazing) at each of the four (early Sep. to early Oct.) grazing comparisons were 1.38, 1.70, 1.84, and 1.74 T/A. Differences among the four grasses at each sampling were minor. However, difference among years was considerable due to low precipitation in 1968; mean values for all four grasses over all four grazing comparisons in 1968, 1970, and 1971 were 0.84, 2.02, and 2.13 T/A, respectively.

Percent dry matter in herbage: Three-year mean percent dry matter in herbage of the four grasses at the mid-season harvest in late July did not differ greatly, ranging from a low

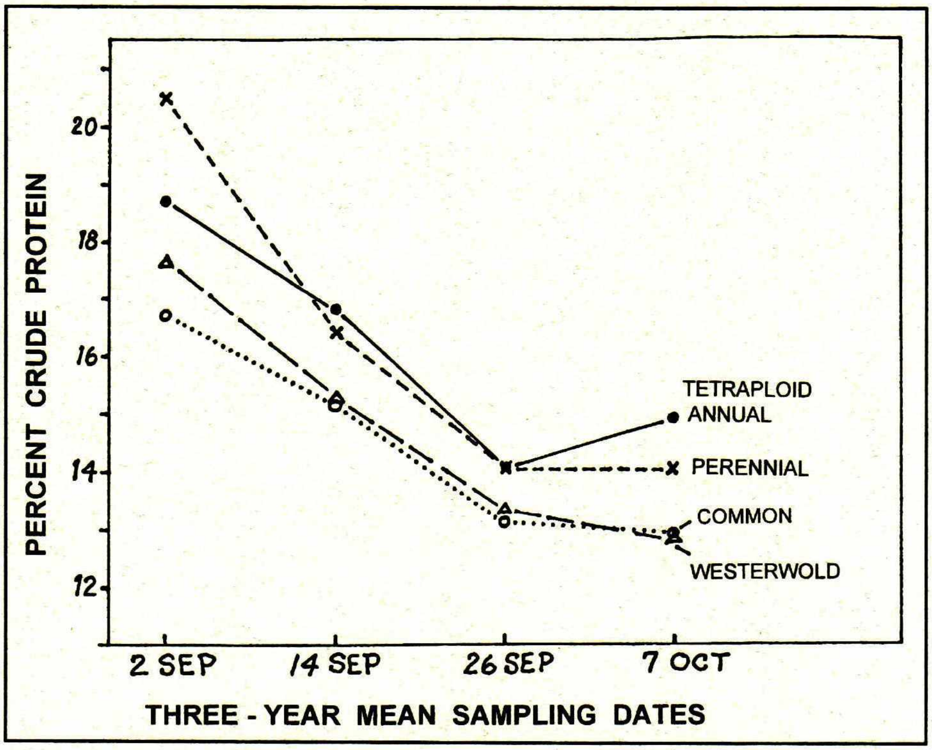

Figure 11. Three-year means of percent crude protein in herbage of the four ryegrasses in Experiment V, sampled just before each of the four successive two-day grazing comparisons. Although lines connect the four values of each ryegrass, each value is the mean from a previously ungrazed pair of paddocks of each ryegrass, one from each of two replicates.

of 14.1% for the tetraploid annual to a high of 17.5% for Oregon common (Table 4). At the four samplings (3-year means) of the regrowths just before each of the September and October grazing comparisons, all four grasses increased in percent dry matter from first sampling (range = 14.5% to 18.0%) to last (range = 25.1% to 32.8%) with the most rapid increases after mid-September (Fig. 10).

The common annual was highest at each sampling and the tetraploid annual lowest in percent dry matter (i.e., the most succulent). Differences among grasses were greatest in late September and early October when common annual and Westerwold were the most headed and stemmy. At the final two samplings they ranked: common annual > Westerwold > perennial > tetraploid annual.

Two other reports note that tetraploid ryegrass herbage tends to be lower in percent dry matter and more palatable to grazing livestock (Barenbrug 1979; Dent and Aldrich 1963). Marten (1970) cites several investigators who have reported a positive correlation between herbage succulence and palatability (grazing preference).

Crude Protein: At the mid-season harvest (mean date = 29 July), the two profusely headed ryegrasses were quite similar in percent crude protein as shown in Table 4. Although crude protein levels in the mid-season harvests differed considerably among years (4-grass mean in 1968 = 13.1%, in 1970 = 21.0%, in 1970 = 16.6%), the four ryegrasses were always quite similar in relative ranking; three year means were: Oregon common 14.7%, Westerwold 15.0%, tetraploid annual 17.7%, and perennial 20.1%.

At the successive samplings of the regrowth just prior to each two-day grazing comparison there was a decline in percent crude protein in all four grasses from 2 September (range = 16.8% to 20.5%) to 26 September (range 13.1% to 14.1%);

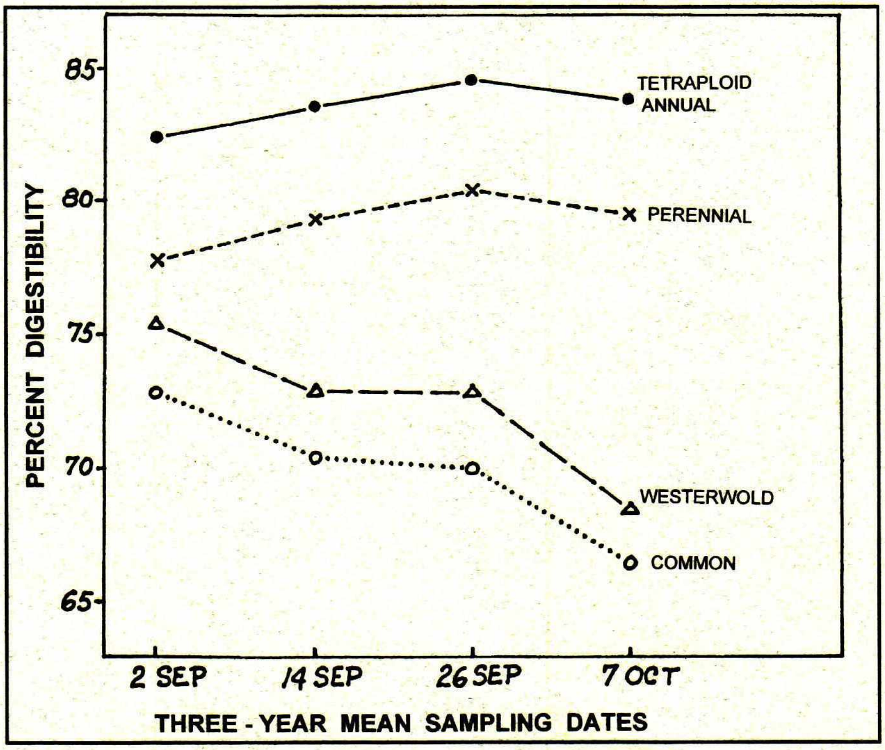

Figure 12. Three-year means of percent digestibility (in vitro dry-matter disappearance) of herbage of the four ryegrasses sampled just before each of the four successive two-day grazing comparisons. Although lines connect the four values of each ryegrass, each value is the mean from a previously ungrazed pair of paddocks of each ryegrass, one from each of two replicates.

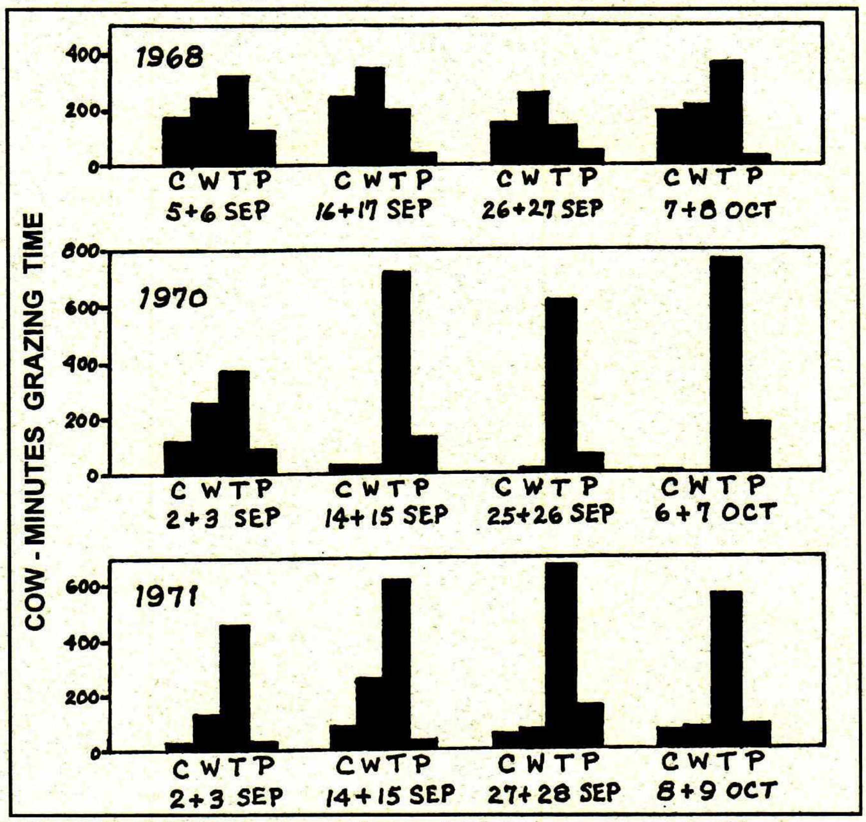

Figure 13. Relative grazing preference for late-season regrowth of four different ryegrasses at four successive two-day grazing comparisons. Data are expressed as cumulative two-day "cow minutes" grazing time for three individual years. Key to ryegrasses: C = common diploid annual, W = Westerwold, T = tetraploid annual, P = perennial. (Experiment V).

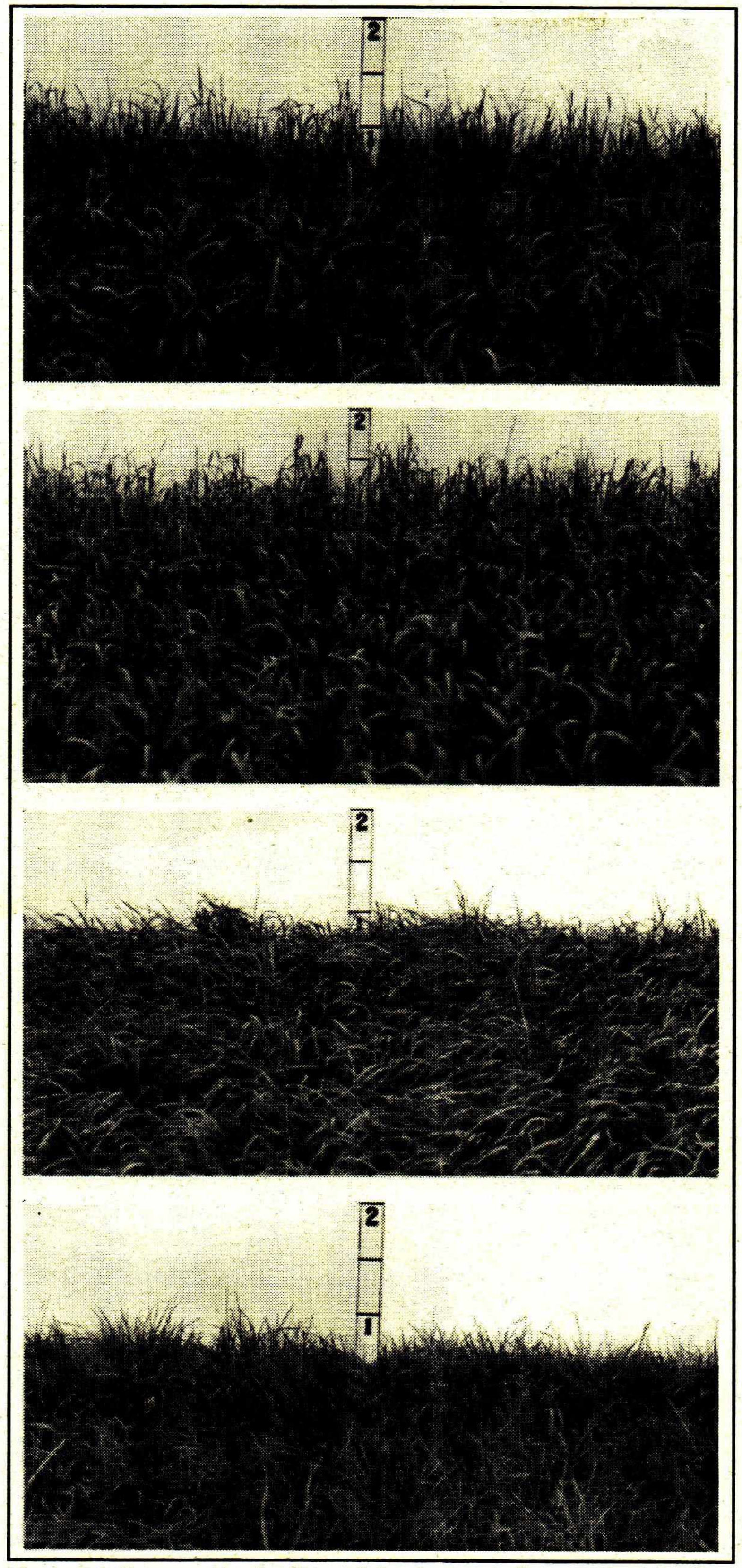

Figure 14. Comparative height and development of regrowth of the four ryegrasses in Experiment V on 16 September, 41 days after the mid-season harvest and just before the second two-day grazing comparison (16 + 17 Sep.) in 1968. Top to bottom: common diploid annual, Westerwold, tetraploid annual, perennial. Note the absence of heading in the top two grasses in mid-September of 1968. Numbers on stake indicate height in feet.

from the latter date to the final sampling (mean date = 7 Oct.) percent crude protein remained relatively constant in all four ryegrasses (Fig. 11).

Digestibility: The four ryegrasses differed considerably in digestibility (in vitro dry-matter disappearance) at the four successive samplings of regrowths (Fig. 12). Percent digestibility for the two non-heading types remained relatively constant over the four sampling dates (3-year mean of 4 samplings for tetraploid annual = 83.6%, perennial = 79.5%), and they were considerably higher in digestibility at all samplings than the two types that headed profusely; the latter two declined rapidly between first and last samplings. Westerwold decreased from 75.4% on 2 September to 68.3% on 7 October, while common annual, always the lowest in digestibility, declined from 72.9% to 66.4% over the same period.

Grazing Preference: Differences in grazing preference among the four ryegrasses were less consistent in 1968 than in 1970 and 1971 (Fig. 13). Perennial was the least grazed in all four comparisons in 1968 but, while tetraploid annual was most grazed in the first and last comparisons, Westerwold was grazed most during the two middle grazing comparisons. Common annual was always intermediate between the most and least grazed in 1968.

The difference in grazing preferences between 1968 and the two later years apparently was due to differences in plant development, primarily heading. Only 30 days had elapsed in 1968 between the mid-season harvest (6 Aug.) and the first two-day grazing comparison (versus 41 days in 1970 and 35 days in 1971), and all four of the grasses were leafy and nonheaded at the early September grazing in 1968 (Fig. 14). Thus, common and Westerwold were more acceptable to the cows in 1968 as shown in Figure 13. Moreover, a highly unusual and sustained droughty period in July, August, and September of 1968, detailed in discussion of Experiment III, tended to slow grass growth and development including heading.

In contrast to 1968, common annual and Westerwold were taller and headed at the first grazing comparison in 1970 (Fig. 15) and 1971, probably the reason those two grasses tended to be grazed much less in those two years (Fig. 13). In 1968 common and Westerwold were only beginning to head at the second grazing comparison in mid-September (Figs. 14, 16).

The pattern of grazing preferences in 1970 and 1971 were generally similar for the two years but markedly different from the somewhat indistinct and changing preferences seen in 1968 when heading was delayed. In 1970 and 1971, cows displayed a clear and unequivocal preference for the tetraploid annual at all four comparisons in both years (Fig. 13). Others have noted higher levels of palatability and intake of tetraploid ryegrasses than diploids by cattle (Dent and Aldrich 1963; Hageman *et al.* 1993; Jung *et al.* 1996).

With the first grazing comparison in 1970, and the first two in 1971, the second choice was Westerwold but, with later grazings in both years, Westerwold fared no better than common annual, both of which headed, became more stemmy, and were much less grazed than the leafy and virtually non-heading tetraploid annual and perennial.

With the last three grazing comparisons in 1970 and the third in 1971, perennial was slightly more grazed than common annual and Westerwold, but much less than the tetraploid. The perennial was very leafy, finer leaved than the tetraploid (Fig. 16), roughly equivalent to the tetraploid in crude protein (Fig. 11), and only slightly lower in digestibility than the tetraploid (Fig. 12). Yet on several occasions it was noted that a cow would enter one margin of a perennial paddock, walk slowly through it with muzzle "brushing" the tops of the leaves, and leave that paddock without ever "tasting" the grass.

Comparative deterioration of herbage in autumn: With increasingly severe frosts, sometimes in late September but especially in October, the erect growth of common and Westerwold ryegrass stems and leaves became conspicuously more bleached and progressively less attractive from a forage standpoint than the very leafy, lower-growing, and obviously less affected tetraploid annual and perennial ryegrasses. This visual impression of a trend toward poorer quality paralleled the rapid increases in percent dry matter (= declines in succulence, Fig. 10) and digestibility (Fig. 12) noted in both of the heading, stemmier ryegrasses.

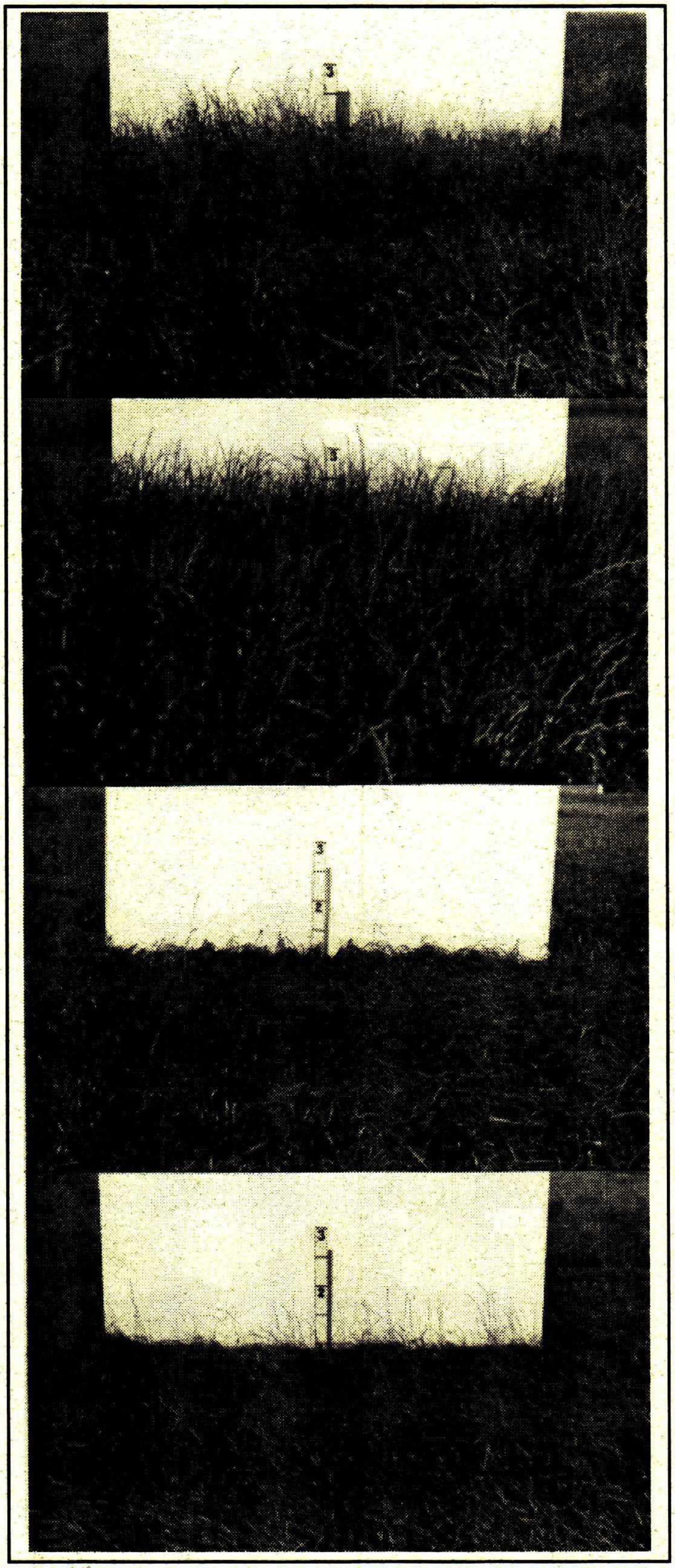

Figure 15. Comparative height and development of regrowth of the four ryegrasses in Experiment V on 2 September, 41 days after the mid-season harvest and just before the first two-day grazing comparison (2 + 3 Sep.) in 1970. Top to bottom: common diploid annual, Westerwold, tetraploid annual, perennial. Note the profuse early heading in the top two grasses in very early September of 1970. Numbers on stake indicate height in feet.

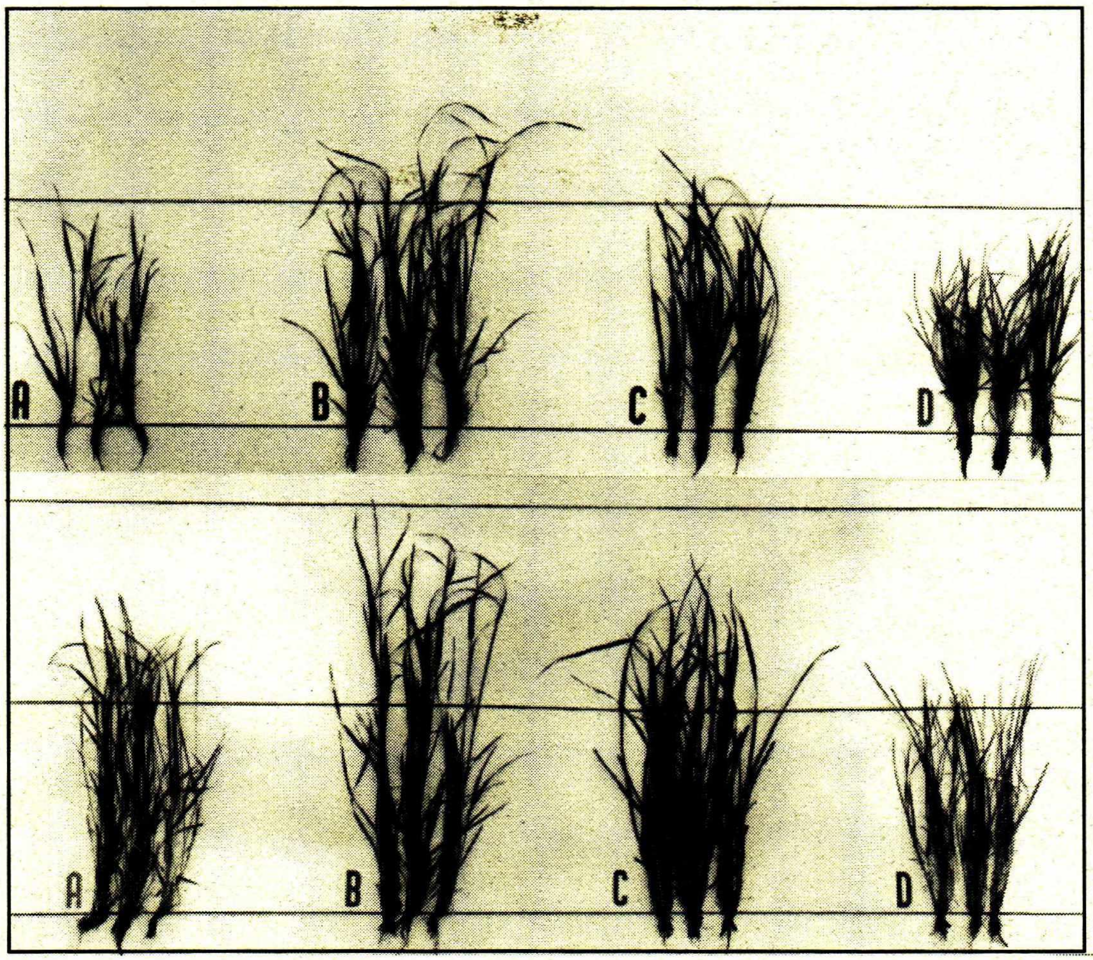

Figure 16. Representative three-plant groups of regrowth of the four ryegrasses used in Experiment V, photographed on two different dates in 1968 following mid-season harvest on 6 August. Upper photo taken 5 September just before first 2-day grazing comparison; lower photo taken 16 September just before second grazing comparison. A = common diploid annual, B = Westerwold, C = tetraploid annual, D = perennial. Note profuse tiller development in all grasses, very early heading in common and Westerwold in lower photo, broader leaf blades in Westerwold and tetraploid annual, finest leaves in perennial. Distance between horizontal lines = 12 inches.

This visually apparent slower deterioration of herbage quality in the tetraploid annual and perennial ryegrasses with late-season frosts serves to extend their pasture usefulness period appreciably beyond that offered by common diploid annual or Westerwold. Extension of the grazing season in autumn with annuals is important in this high-latitude area of (a) relatively short growing seasons, (b) long winter infeeding demands, and (c) the need to free perennial grasses from utilization pressures in September and October when they become less productive, of poorer nutritional quality, and as they undergo physiological preparation for winter (Klebesadel 1992, 1994a, 1994b, 1997).

Specific Cultivar or Strain versus Type

The grazing-preference findings raise certain questions: Would all tetraploid annual strains be more preferred to grazing dairy stock than any perennial strains? Would any tetraploid annual strain be preferred to all diploid annuals or Westerwold strains? Would managing common and Westerwold to keep them from heading (i.e., more frequent defoliation) make them as acceptable to grazing stock as the tetraploid annual?

Only a single strain of each of the four ryegrasses compared was used in this experiment. Would all cultivars of tetraploid annual be preferred to grazing stock (as Tetrone was) over the other three ryegrasses? Would other cultivars or selections of perennial ryegrass be preferred for grazing over the one evaluated in this test?

Just as different species of forages can differ in palatability or grazing preference (Klebesadel 1999; Marten 1970), it is known also that different selections, strains, or cultivars within a plant species can differ in acceptance to grazing animals (Dent and Aldrich 1963; Marten 1970). The results reported here perhaps should be interpreted as indicative of comparative grazing preference for the specific strains used, as opposed to referring to the broader categories of type or species of ryegrass, until future investigations with other strains within each category may corroborate these findings.

Conclusions

Results presented in this report add to an expanding base of knowledge for using ryegrass to its fullest potential to meet forage requirements in this northern area.

Both ryegrass species, and all of the types and cultivars evaluated established quickly and grew well for annual forage purposes in these experiments (except in one year –1969– when unusually dry conditions resulted in poor seed germination and failure of two experiments). The various strains evaluated exhibited some considerable differences in growth habit, especially heading, as well as in percent crude protein and digestibility of herbage, and marked differences in grazing preferences by dairy stock.

Management options compared (time of planting, time of mid-season harvest) established guidelines for optimum use of ryegrasses as a mid-season-harvested forage and also for a productive regrowth of palatable, and nutritious late-season pasturage or green-chop forage conducive to maintaining milk production at higher levels than occurs with reliance on perennial grasses. The latter (a) become less productive late in the growing season (Klebesadel 1992, 1994a, 1994b, 1997), (b) become poorer in nutritional quality and less capable of supporting high levels of milk production during the late portion of the growing season(*), and (c) should not undergo utilization pressure during the pre-winter period needed for unfettered physiological preparation for best winter survival and vigorous growth the following spring.

Although certain bromegrass harvest schedules can leave an abundance of herbage for pasturing during September and early October (Klebesadel 1997, Figs. 9, 13), such harvest schedules do not provide for maximum forage recovery or optimum management of that perennial.

Ideal management of bromegrass in Alaska for maximum forage production and harmony with its growth patterns and physiological processes involves two cuttings, the first in late June or very early July and the second in late August or early September (Klebesadel 1997). With that timing of the second harvest, virtually no grazable regrowth occurs during the remainder of the growing season (Klebesadel 1997, Fig. 9). That deficiency identifies a critical need growers face for a supplemental forage source that can extend the forage-production season with abundant pasturage or green-chop during the weeks prior to freeze-up. Experiments reported here illustrate how ryegrass can fulfill that need.

Ryegrass regrowth yields were influenced more by duration of the regrowth period than by stage of plant development at the mid-season harvest. In contrast, regrowth of oats was greatly influenced by stage of development at the time of mid-season harvest.

Oat regrowth was greatest when the first harvest was taken prior to heading (though that first-cut yield was very low, Fig. 4). Oat regrowth was reduced markedly when mid-season harvest was taken later than the fully headed but prior to anthesis stage of oat development, regardless of planting date or mid-season harvest date.

Most but not all of the annual ryegrasses evaluated surpassed the perennial strains in total two-cut forage yields, the superior total yields of the annuals due primarily to higher yields at the mid-season harvest.

The non-heading tetraploid annual and perennial ryegrasses surpassed the common diploid annual and Westerwold during late season in crude protein and digestibility. The similarities of those two did not carry over to uniformly equivalent grazing preference, however, as the tetraploid was favored markedly over perennial as well as the other two ryegrasses in virtually all of the twelve, two-day grazing comparisons from early September to early October during the three years.

Herbage characteristics of the tetraploid annual that were associated with favored grazing preference were extreme leafiness, non-heading, succulence (low percent dry matter), and high levels of digestibility and crude protein. Inasmuch as the perennial ryegrass was generally similar to the tetraploid in these characteristics, but was little grazed, some other factor(s) (taste, odor?) more obvious to cows than to agronomists, served to influence the disparate grazing preference between those two grasses.

Many other factors in addition to those listed above have been identified or theorized by other investigators as influencing palatability or grazing preference; see Klebesadel (1999) for a summary list of about three dozen of those factors.

Dent and Aldrich (1963) reported higher soluble carbohydrate levels in tetraploid than in diploid ryegrasses in England and Wales (including the tetraploid annual cultivar Tetrone used in this study) and speculated that this could enhance palatability and grazing preference for tetraploids.

Wilson and Dolby (1969) and Hannaway *et al.* (1982) reported superior nutritional quality of grass and better dairy cow performance with ryegrass grazed more intensively at short (6 to 10 inches) rather than taller (10 to 15 inches) growth. Hannaway *et al.* (1982) also recommend stocking rates sufficient to provide intensive utilization of ryegrass, keeping it in a short, leafy status.

None of the experiments in this report involved more than two harvests of ryegrass per year. Rouquette *et al.* (1997) state "Annual ryegrass is very tolerant of frequent and severe defoliation." Mitchell (1984) reported harvesting as many as four times per year in Alaska, Kunelius and Calder (1978) in eastern Canada found four harvests per year to be satisfactory, and Dent and Aldrich (1963) reported a harvest frequency of eight times per year. More frequent harvests or grazing could maintain the strains that head profusely (e.g., common and Westerwold) in a leafy condition that should be more acceptable to grazing animals.

This suggests that a considerable field of experimentation is open and desirable for future studies on ryegrass management in Alaska, balancing herbage production and quality with needs. Studies should evaluate various schedules and frequencies of harvest or pasturing, fertilizer (especially N) studies, stocking rates on pastures, and the complex integrating and balancing of forage and pasture production from perennial and annual species for optimum production, quality, use, and efficiencies.

The general performance of ryegrasses evaluated in this study suggests that they (especially the tetraploid annual) can serve ideally as a supplement to the primary perennial-grass dairy forage base, especially as pasture or green-chop forage late in the growing season. That grass, seeded in late May to very early June:

(a) produced a mid-season forage yield of 1.6 T/A with about 18% crude protein
(b) produced a vigorous, very leafy, virtually non-heading regrowth that was:
    1) high in crude protein,
    2) consistently highest in digestibility and succulence of four ryegrasses, and
    3) most avidly grazed of the four ryegrasses.

Ryegrass regrowth for September and October pasturage or green chop:

(a) can be used to the fullest extent desired because there is no concern for subsequent winter survival,
(b) frees perennial grasses from utilization pressure during September and October, permitting unfettered physiological preparation for winter, and
(c) can maintain higher levels of milk production in dairy stock than can be supported by the characteristically decreasing yields and lowering nutritional quality of perennial grasses in late summer and early autumn.

Experiments I through IV evaluated procedures to maximize yields of herbage of ryegrass, oats, or mixtures, planted and harvested on various dates as shown in Figures 2, 4, 5, 6, and 9. Information on how to maximize herbage yield is useful if the crops are to be harvested for storage or for green-chop feeding in drylot. However, it is clear that more than just the amount of herbage available must be considered if the regrowth is intended for ideal pasture. Factors such as amount of heading, leafiness, lodging, and other quality characteristics that may influence acceptability to grazing animals are important, as shown convincingly in Experiment V; some of that plant-development information and quality characteristics are summarized in Tables 2a, 2b, and 3, and Figures 10, 11, and 12.

Cultural and Use Considerations

During the course of these experiments, some experience and observations worthy of mention are appended here for the practical benefit of ryegrass growers.

Plant ryegrass at about 15 to 20 pounds per acre in the grass attachment of the grain drill or in a packer-type seeder with corrugated rollers. Try to plant no deeper than one inch. Ryegrass will not emerge if seed is planted too deep. Pull a packer-roller behind the grain drill.

Ryegrass requires a firm, well prepared seedbed for best establishment. Substantially more care is required to obtain good establishment of ryegrass and other small-seeded crops than with larger-seeded crops such as oats, other cereals, and field peas. The important packing of soil after seeding slows drying of the soil surface, assures intimate soil-seed contact, and promotes upward movement of moisture from lower levels of soil, via capillary action, to accelerate seed germination.

The sequence of procedures from tillage through other seedbed-preparation activities to packing the soil after seeding should be accomplished as rapidly as possible to minimize moisture loss from the disturbed soil because of the paucity of spring precipitation in Alaska's agricultural areas. Brundage *et al.* (1963) suggest sprinkler irrigation to ensure optimum seed germination of small-seeded forages.

Another method of seeding ryegrass is with a cyclone-type broadcast seeder. If ryegrass seed is broadcast on the soil surface, a very light harrowing should precede packing to cover the seed slightly.

Ryegrass, except at very advanced stages of growth, is high in moisture content. Some hay or silage should be fed along with ryegrass pasture or green-chop forage because of a decided laxative effect on the animals when ryegrass is consumed as the only roughage(*).

Forage available at mid-season on spring-seeded ryegrass is best utilized as pasture, fed as green chop, or ensiled. A mid-season cutting of common ryegrass, put up as excellent-appearing, field-cured hay, surprisingly was rejected by dairy cows and bulls in the Experiment Station herd(*). Similar crops of ryegrass, fed as green-chop forage or ensiled, found good animal acceptance.

• Twice-harvested annual forages control weeds: Mid-season harvest of ryegrass or ryegrass + oats mixture interrupts growth of troublesome and prolific annual weeds, thereby greatly reducing seed production and dispersal. Then the vigorous, highly competitive ryegrass regrowth suppresses weed growth during the remainder of the growing season. Annual forage crops harvested once late in the growing season permit many weeds to produce seed to contaminate croplands.

• Availability of ryegrass forage for use during the late portion of the growing season frees perennial grasses from use during late season (September and October), contributing to their better winter survival.

• The ryegrasses regrow rapidly after mid-season harvest and continue active growth during cool September weather that (usually, but not in 1968) is well supplied with precipitation. Non-heading ryegrass herbage remains acceptable until very hard frosts in October.

• Spring-seeded ryegrass must be harvested at least once in mid-season to remove the initial growth and stimulate tiller development which then becomes a vigorous regrowth of leafy, succulent forage. Spring-seeded common ryegrass grown without mid-season harvest evolves into a poor forage crop after mid-season, becoming very rank, stemmy, and relatively non-leafy, high in percent dry matter, and unpalatable.

• Although grazing animals readily consume the very leafy early initial growth and regrowth of common annual and Westerwold ryegrasses, they later display an increasing rejection of the herbage in the field as it gradually becomes headed and more stemmy.

• Annual (common) ryegrass seed, grown in Oregon, is modest in cost and regularly available.

• Ryegrass regrowth herbage can be used for pasture or green-chop forage to the fullest extent desired or necessary, with none of the concerns for relief necessary for perennials, for these annuals do not prepare for winter but continue growing actively until killed by frost.

Comparative Merits of Oats versus Oats + Ryegrass as Companion Crops For Establishing Small-Seeded Perennial Forage Seedings:

Though not a procedure studied in the course of the experiments reported here, small-seeded perennial forage species such as bromegrass, timothy, and legumes often are seeded with, and become established in association with, an annual cereal crop harvested at an immature stage for forage or at maturity for grain and straw.

A vigorously growing, rapidly developing cereal companion crop can help somewhat to suppress weed growth but also greatly impedes the growth of the slower-growing perennial seedlings as the dominant, taller-growing companion crop competes with the forage seedlings for light and soil moisture (Klebesadel and Smith 1959, 1960).

On the basis of observations in the studies reported here, and experience with other establishment studies with small-seeded perennial forages in association with cereal companion crops, any mixture that uses ryegrass to obtain a vigorous regrowth for late-season pasturage or green-chop forage would undoubtedly be much too competitive for small, establishing perennial forage seedlings.

The very vigorous regrowth of ryegrass would be most competitive during the late portion of the growing season when establishing perennial seedlings need absence of competition to achieve growth and preparation for winter. Others also have reported annual ryegrass to be extremely competitive with other associated species (Blaser *et al.* 1956; Hafenrichter *et al.* 1979; Jung *et al.* 1996; McKell *et al.* 1969).

Thus, of all treatments evaluated here, oats grown alone would be the best choice as a companion crop for establishing perennial forage seedlings. Those seedlings would be subjected to less competition for light and soil moisture if the oats were harvested once or twice for forage as opposed to growing to maturity for grain and straw (Klebesadel and Smith 1960). Moreover, leaving a tall (6- to 10-inch) stubble at the final harvest can be very effective in retaining a protective, insulating covering of snow during winter against the removal force of strong winter winds common in the Matanuska Valley.

Lawn-seed mixtures routinely include ryegrasses as a component for rapid germination, vigorous seedling growth, and early green appearance (Schery 1975). However, due to the rapid, aggressive, and highly competitive growth of ryegrasses, their proportion in mixtures with more winterhardy lawngrass species in Alaska should not exceed about 10% to 20% or they will be so dominant and competitive that the ryegrass (desired only during establishment) will adversely affect seedling growth and ultimate stands of the slower-growing, desired perennials.

Acknowledgments

I thank Darel Smith and Arthur Berglund for technical assistance, Dr. A. L. Brundage for providing dairy stock used in the grazing study, Vivian Burton for determinations of N (for crude protein calculations) and in vitro digestibility of herbages, Kelly Munyon for manuscript typing, and Jan Hanscom for bulletin layout. This research was conducted cooperatively with the Agricultural Research Service of the U.S. Department of Agriculture.

Literature Cited

Alderson, J., and W.C. Sharp. 1995. Grass varieties in the United States. U.S. Dep. Agric. Handbook 170. U.S. Government Printing Office, Washington. DC.

Balasko, J.A., G.W. Evers, and R.W. Duell. 1995. Bluegrasses, ryegrasses, and bentgrasses. p.357–371. (In) R.F. Barnes et al. (eds.) Forages (5th ed.) Vol. 1: An Introduction to Grassland Agriculture. Iowa State University Press, Ames, IA.

Barenbrug, J.T. 1979. Barenbrug addresses participants at ryegrass symposium. Seed World July: 10–11,20.

Blaser, R.E., T. Taylor, W. Griffeth, and W. Skrdla. 1956. Seedling competition in establishing forage plants. Agronomy Jour. 48:1–6.

Brundage, A.L., and C.I. Branton. 1967. Ryegrass and orchardgrass-alfalfa for annual forage and pasture in south-central Alaska. Jour. Dairy Science 50:856–862.

Brundage, A.L., and L.J. Klebesadel. 1970. Nutritive value of oat and pea components of a forage mixture harvested sequentially. Jour. Dairy Science 53:793–796.

Brundage, A.L., R.L. Taylor, and V.L. Burton. 1979. Relative yields and nutritive values of barley, oats, and peas harvested at four successive dates for forage. Jour. Dairy Science 62:740–745.

Brundage, A.L., R.L. Taylor, and V.L. Burton. 1981. A changing pattern in small-grain silage mixtures in Alaska. Agroborealis 13:4–5.

Brundage, A.L., and W.J. Sweetman. 1964. Comparative utilization of irrigated bromegrass under rotational and strip grazing. Jour. Dairy Science 47:528–530.

Brundage, A.L., W.J. Sweetman, L.J. Klebesadel, N.E. Michaelson, and C.I. Branton. 1963. Grasses and alfalfa for annual forage and pasture in southcentral Alaska. Jour. Dairy Science 46:1260–1265.

Dent, J.W., and D.T.A. Aldrich. 1963. Soluble carbohydrate content of varieties of tetraploid ryegrass. Nature 198:905.

Evers, G.W., G.R. Smith, and C.S. Hoveland. 1997. Ecology and production of annual ryegrass. p.29–43. (In) F.M. Roquette, Jr., and L.R. Nelson (eds.) Ecology, production and management of Lolium for forage in the USA. Crop Science Soc. America Special Pub. 24, Madison, WI.

Frakes, R.V. 1973. The ryegrasses. p.307–313. (In) M.E. Heath, et al. (eds.) Forages—the science of grassland agriculture (3rd ed.) Iowa State University Press, Ames, IA.

Hafenrichter, A.L., J.L. Schwendiman, H.L. Harris, R.S. MacLauchlan, and H.W. Miller. 1979. Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin states. U.S. Dep. Agric. Handbook 339. U.S. Government Printing Office, Washington, D.C.

Hageman, I.W., E.A. Lantinga, and H. Schlepars. 1993. Herbage intake, digestibility characteristics and milk production of a diploid and two tetraploid cultivars of perennial ryegrass. p.459–460 (In) M.J. Baker et al. (eds.) Proceedings 12th Int. Grassland Congress, Wellington. N.Z.

Hannaway, D.B., H.W. Youngberg, and W.S. McGuire. 1982. Growing annual ryegrass for forage. Oregon State Univ. Ext. Serv. Pub. FS-291.

Hannaway, D.B., G.W. Evers, S.L. Fales, M.H. Hall, S.D. Fransen, D.M. Ball, S.W. Johnson, I.H. Jacob, M. Chaney, W. Lane, and W.C. Young. 1997. Perennial ryegrass for forage in the USA. p.101–122. (In) F.M. Rouquette, Jr., and L.R. Nelson (eds.) Ecology, production, and management of Lolium for forage in the USA. Crop Science Soc. America Special Pub. 24, Madison, WI.

Hodgson, H.J. 1956. Effect of seeding rates and time of harvest on yield and quality of oat-pea forage. Agronomy Jour. 48:87–90.

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 of Agriculture. U.S. Government Printing Office, Washington, DC.

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

Jung, G.A., A.J.P. Van Wijk, W.F. Hunt, and C.E. Watson. 1996. Ryegrasses. p.605–641. (In) L.E. Moser, et al. (eds.) Cool-Season Forage Grasses. American Society of Agronomy, Madison, WI.

Klebesadel, L.J. 1968. Getting the most out of ryegrass in Alaska. Alaska Agric. Exp. Sta. Forage Research Report 4A.

Klebesadel, L.J. 1969a. Chemical composition and yield of oats and peas separated from a forage mixture at successive stages of growth. Agronomy Jour. 61:713–716.

Klebesadel, L.J. 1969b. 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. 1992. Seasonal distribution of forage yield and winterhardiness of grasses from diverse latitudinal origins harvested four times per year in southcentral Alaska. Alaska Agric. and Forestry Exp. Sta. Bull. 90.

Klebesadel, L.J. 1994a. Bromegrass in Alaska. IV. Effects of various schedules and frequencies of harvest on forage yields and quality and on subsequent winter survival of several strains. Alaska Agric. and Forestry Exp. Sta. Bull. 102.

Klebesadel, L.J. 1994b. Comparative winterhardiness of cultivated and native Alaskan grasses, and forage yield and quality as influenced by harvest schedules and frequencies, and rates of applied nitrogen. Alaska Agric. and Forestry Exp. Sta. Bull. 99.

Klebesadel, L.J. 1997. Bromegrass in Alaska. VI. Effects of a broad array of harvest schedules and frequencies on forage yield and quality and on subsequent winter survival of cultivars Manchar and Polar. Alaska Agric. and Forestry Exp. Sta. Bull. 104.

Klebesadel, L.J. 1999. Relative grazing preference, herbage yield, in vitro digestibility, and other comparisons among seven perennial grasses at various times of the year in southcentral Alaska. Alaska Agric. and Forestry Exp. Sta. Bull. 107.

Klebesadel, L.J., A.L. Brundage, and W.J. Sweetman. 1963. Cash in on a new late-summer forage source — common ryegrass seeded with early-harvested oats and peas. Alaska Agric. Exp. Sta. Forage Research Report 1.

Klebesadel, L.J., and Dale Smith. 1959. Light and soil moisture beneath several companion crops as related to the establishment of alfalfa and red clover. Botanical Gazette 121(1):39–46.

Klebesadel, L.J., and Dale Smith. 1960. Effects of harvesting an oat companion crop at four stages of maturity on the yield of oats, on light near the soil surface, on soil moisture, and on the establishment of alfalfa. Agronomy Jour. 52:627–630.

Kunelius, H.T. 1980. Effects of nitrogen rates and harvest schedules on yield and quality of Westerwolds ryegrass grown as a summer annual. Canadian Jour. Plant Science 60:519–524.

Kunelius, H.T., and F.W. Calder. 1978. Effects of rates of N and regrowth intervals on yields and quality of Italian ryegrass grown as a summer annual. Canadian Jour. Plant Science 58:691–697.

Kunelius, H.T., and P. Narasimhalu. 1983. Yields and quality of Italian and Westerwolds ryegrasses, red clover, alfalfa, birdsfoot trefoil, and Persian clover grown in monocultures and ryegrass-legumes mixtures. Canadian Jour. Plant Science 63:437–442.

Marten, G.C. 1970. Measurement and significance of forage palatability. Minnesota Agric. Exp. Sta. Scientific Jour. Series Paper no. 7117. P. D1-D55. (In) Proceedings National Conf. On Forage Quality Evaluation and Utilization, Lincoln, NE, Sep. 1969. Nebraska Center for Continuing Education, Lincoln, NE.

McKell, C.M., C. Duncan, and C.H. Muller. 1969. Competitive relationships of annual ryegrass (*Lolium multiflorum* Lam.). Ecology 50:653–657.

Mitchell, W.W. 1984. Ryegrasses: An option for an annual forage crop in Alaska. Alaska Agric. Exp. Sta. Bull. 64.

Nelson, L.R., T.D. Phillips, and C.E. Watson. 1997. Plant breeding for improved production in annual ryegrass. p.1–14 (In) F.M. Rouquette, Jr., and L.R. Nelson (eds.) Ecology, production, and management of Lolium for forage in the USA. Crop Science Soc. America Special Pub. 24, Madison, WI.

Riewe, M.E., and C.L. Mondart, Jr. 1985. The ryegrasses. p.241–246. (In) M.E. Heath, et al. (eds.) Forages—the science of grassland agriculture. Iowa State University Press, Ames IA.

Rouquette, F.M., Jr., D.I. Bransby, and M.E. Riewe. 1997. Grazing management and use of ryegrass. p.79–99. (In) F.M. Rouquette, Jr., and L.R. Nelson (eds.) Ecology, production, and management of Lolium for forage in the USA. Crop Science Soc. America Special Pub. 24, Madison. WI.

Schery, R.W. 1975. Rally 'round the ryegrasses. Seed World 113:44–45.

Schoth, H.A., and M.A. Hein. 1940. The ryegrasses. U.S. Dep. Agric. Leaflet 196. U.S. Government Printing Office, Washington, DC.

Smith, Dale. 1964. Winter injury and the survival of forage plants. Herbage Abstracts 34:203–209.

Terrell, E.E. 1968. A taxonomic revision of the genus Lolium. U.S. Dep. Agric. Tech. Bull. 1392. U.S. Government Printing Office, Washington, DC.

Wilson, G.F., and R.M. Dolby. 1969. Ryegrass varieties in relation to dairy cattle performance: IV. Milk production from cows grazing ryegrass pastures at two stages of growth and receiving two levels of nitrogen fertilizer. New Zealand Jour. Agric. Research 12:489–500.

Young, W.C., and R.E. Barker. 1997. Ryegrass seed production in Oregon. p.123–138. (In) F.M. Rouquette, Jr., and L.R. Nelson (eds.) Ecology, production, and management of Lolium for forage in the USA. Crop Science Soc. America Special Pub. 24, Madison, WI.