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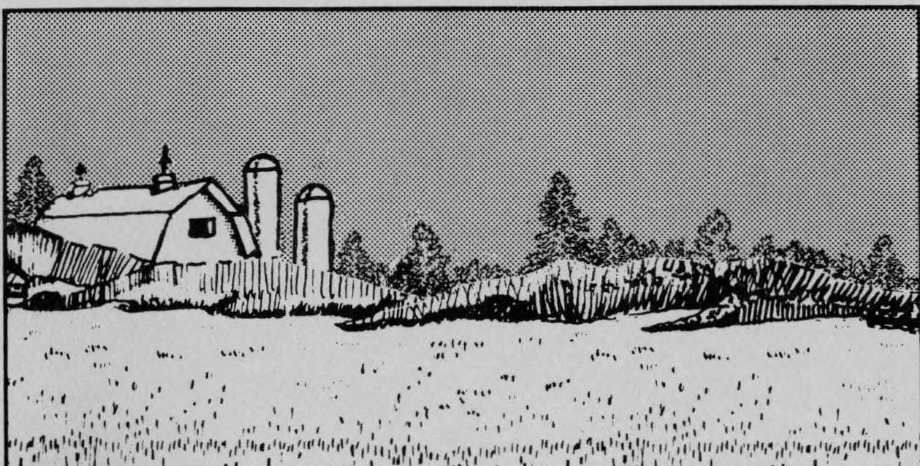

Agricultural Experiment Station
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INTRODUCTION

Annuals are often planted for a forage crop in Alaska, often on land that is being renovated or on newly cleared land, thus providing a longer opportunity for working the soil before seeding a perennial. Oats (*Avena sativa*) and barley (*Hordeum vulgare*), sometimes seeded with a legume, are the most important annuals used for forage in Alaska. Cereals can provide a high-yield, late-summer forage crop, stored as hay or silage. Ryegrass (*Lolium*), another annual not now in significant use in Alaska, affords an option that merits consideration in forage programs.

Ryegrasses are a major forage in various regions of the world. They comprise a majority of the forages sown in the United Kingdom (National Seed Development Organization Limited n.d.) and other western European nations (Barenbrug 1979). Ryegrasses constitute the major winter annual forage in southeastern United States (Oregon State University Extension Service 1982, Arnold et al. 1980) and serve for temporary pasture in other areas of the United States (Frakes 1973).

Probably the most abundant use of ryegrass in Alaska is in groundcover seedings. It often is included with other grasses in revegetation and turf plantings to provide a quick, first-year cover. It is not utilized to a significant extent as a forage grass, although some previous research resulted in recommendations for its use (Klebesadel et al. 1963, Klebesadel 1968). Klebesadel et al. (1963) recommended the inclusion of ryegrass in seedings of oats and peas, with the oats and peas to be harvested sufficiently early to permit ample regrowth of the ryegrass for late-summer grazing. About 2 tons per acre of regrowth was produced by September 18 after a July 19 first harvest from a May 23 seeding. In more extensive work, Klebesadel (1968) demonstrated the possible use of oats and ryegrass or ryegrass alone with different seeding and harvest dates, eliminating peas from the recommended mixture. By taking a first harvest in late July to early August and a second harvest in late September, over 4 tons per acre of total yield were obtained with some treatments and varieties.

Brundage et al. (1963) and Brundage and Branton (1967) investigated yield, palatability, and quality characteristics of ryegrass under grazing and different harvest regimes in southcentral Alaska. Grazing animals readily accepted common annual ryegrass when the heads were emerging from the boot, preferring it to an orchardgrass/alfalfa mixture, and continued to graze ryegrass for 1 to 2 weeks thereafter. However, after the ryegrass had headed and approached flowering (anthesis), the animals rejected ryegrass in favor of the orchardgrass/alfalfa mixture. Protein content of ryegrass declined from above 20 per cent to nearly 10 per cent during this period. Protein content of regrowth after the initial harvest, though declining over a 44-day regrowth period, fell little below 15 per cent.

This bulletin presents information from a number of trials conducted in the Palmer, Pt. MacKenzie, Delta, and Homer areas over a period of years. It provides yield and quality data for certain varieties selected from a number tested under one-, two-, three-, and four-harvest systems. Some of the varieties had not previously been tested in Alaska.

KINDS OF RYEGRASSES

In a taxonomic treatment of genus *Lolium*, Terrell (1968) recognized eight species of ryegrasses. Those important as forage grasses are annual ryegrass, also known as Italian ryegrass (*L. multiflorum*), and perennial ryegrass (*L. perenne*). Species distinctions and separations are not iron clad, however. For instance, under some circumstances annual ryegrass will survive the winter and renew growth in the second season, thus behaving as a short-lived perennial. In Alaska, perennial ryegrass rarely survives the winter, therefore behaving as an annual. Furthermore the two species are interfertile and can produce hybrids that reproduce naturally. This, of course, blurs distinctions between the two. Their ability to hybridize has been utilized in developing varieties of ryegrasses (National Seed Development Organization Limited n.d.).

A multitude of ryegrass varieties have been developed, particularly in Europe. These are derived by selecting superior-performing individuals, by crossing individuals or strains or species, and by another means involving manipulation of chromosomes that has proved particularly fruitful with the forage ryegrasses (Barenbrug 1979).

A species of plant or animal is generally characterized by a particular number of chromosomes, though plants do not adhere to this rule as rigidly as do animals. Normally, each cell in a plant of annual or perennial ryegrass has fourteen chromosomes, which is termed the diploid number. With the use of the chemical "colchicine" it is possible to double the number of chromosomes, thus producing plants with twenty-eight chromosomes in their cells, termed tetraploid plants. Though doubling the number of chromosomes may induce problems in reproductive fertility, tetraploid ryegrasses have been developed that reproduce themselves satisfactorily. Tetraploidy in ryegrass generally results in larger plant parts and may produce other differences, such as higher digestibility and different growth rates, thus stimulating the development of a large number of tetraploid varieties (Barenbrug 1979).

Ryegrasses also differ in their requirements for heading. Some will head profusely in the year of seeding. Others require vernalization for heading to occur to any extent and therefore remain leafy with relatively few heads produced in the year of seeding.

EXPERIMENTAL PROCEDURES

This bulletin presents the results and interpretations from fourteen different trials with ryegrasses conducted over a period of years from 1976 through 1983. Six different sites, or soil types, were involved at five different locations. Some trials included cereals in addition to ryegrasses. A total of twenty-four different ryegrass entries or varieties were tested over the course of the trial period, though most trials involved ten or fewer entries.

Trials were conducted on Bodenburg silt loam at Palmer, on Homestead and Flathorn silt loam at Pt. MacKenzie, on Kachemak and Mutnala silt loam near Homer, and on Beals silt loam near Delta Junction.

Most trials were established by broadcast seedings in plots 4'x14' or 5'x15' replicated four times in a randomized complete block design. Two trials contained three replications; one trial was seeded in rows 6 inches apart and 12 feet long, six rows per plot. Harvests were taken with a sickle-bar mower, which cut sections 2'x10' or 2'x12' from the center portion of each plot at about 2.4 inches height. Fresh weights were obtained in the field for yield data, and about 1000- to 1500-gram samples were retained to be dried at 60 °C for dry-matter determination and laboratory analyses.

Broadcast seedings of ryegrass were at 25 to 34 lbs seed per acre. The seed was raked in and the plot tamped after raking. Row plantings were seeded at 20 lbs per acre. Cereals were seeded at 100 to 125 lbs per acre. Plots generally were fertilized when seeded with 18-18-18 or 20-20-15 at 400 to 500 lbs per acre, and, when two or more harvests were taken during the season, they were generally refertilized with urea at 200 lbs per acre after the first harvest. Exceptions will be noted in the presentation of the data.

Plant samples from many of the trials were analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) and for digestibility as measured by in vitro dry matter disappearance (IVDMD) in a test that employs rumen fluid in a test tube.

In one trial conducted at Palmer in plots 3'x15', three ryegrasses were cut at progressively later stages to determine the effect of different stages of maturity on quality of the grass. Another trial conducted at Pt. MacKenzie tested the effect of applying 18-18-18 fertilizer at four rates, from 200 to 500 lbs per acre.

Twenty-four different annual ryegrasses were entered in the various trials, but many were included in only one or two experiments. For the purposes of this publication, detailed data are presented for five ryegrasses that are representative of the different types. The five ryegrasses are common, 'Gulf ', 'Aubade', 'Tetila', and 'Tetrelite'. Common annual ryegrass is that which is generally available from retail seed dealers in Alaska. It is not a named variety and therefore does not stem from particular breeding stock. Nevertheless, it appears to be fairly predictable in its characteristics. Each of the others is a named variety based on particular breeding stock which assures each a genetic identity.

Common ryegrass is a diploid annual having fourteen chromosomes in its cells. A stand of common annual ryegrass heads out profusely and becomes stemmy after heading. The variety Gulf is another diploid annual ryegrass similar to common in its characteristics (fig. 1). Aubade is a tetraploid with twenty-eight chromosomes, also heading profusely but with heavier stems and wider leaves than common (fig. 1). Aubade is one of a group of ryegrasses known as the Westerwold type and can be termed Aubade Westerwold ryegrass. The variety Tetila (fig. 1) is a tetraploid annual ryegrass that heads only sparingly in the year of seeding and therefore, having less stem tissue relative to leaf tissue, is leafier than the three ryegrasses already discussed. Tetrelite is a tetraploid hybrid between annual and perennial ryegrass. It resembles Tetila in growth habit, producing a leafy growth with few stems (fig. 1). It does not persist as a perennial under Alaska's conditions.

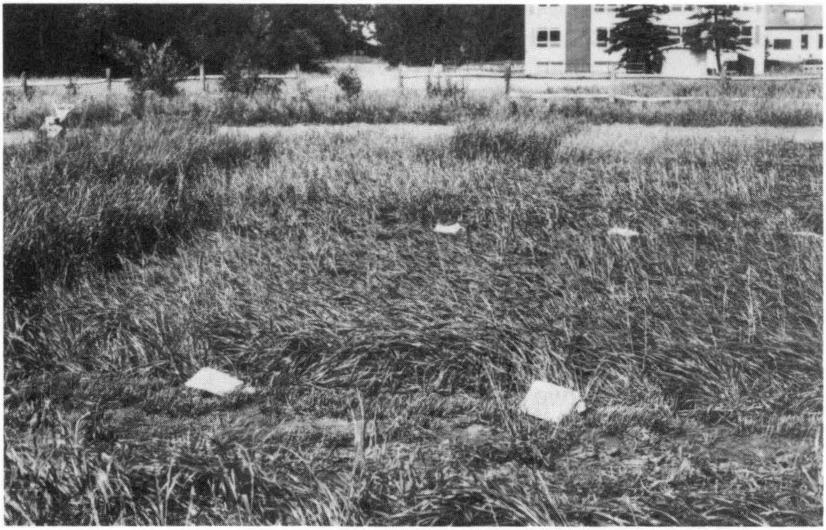

Figure 1. The different growth forms of annual ryegrass are evident in this trial at the Palmer Research Center. The tall-growing ryegrasses in the two plots by the left margin are the profusely heading Westerwold types—tetraploid varieties Billion in front and Aubade behind it. The tall ryegrasses in the center plots in the background are Billion on the left and the diploid variety Gulf on the right. Gulf is very similar to common annual ryegrass. In the center foreground between the bags is Tetila, a tetraploid leafy type, and to its left is Tetrelite, a tetraploid hybrid between annual and perennial ryegrass.

FORAGE YIELDS

Ryegrass plantings can be managed for one, two, or more harvests, which may be obtained by mechanical means, by grazing, or by a combination of both. Depending on the length of the growing season and time of establishment, the highest yields probably will be obtained from stands managed for two or three mechanical harvests. In some areas only one mechanical harvest may be taken with some regrowth enabling late grazing. Yield comparisons will be made with common annual ryegrass, which has been used to the greatest extent in Alaska.

Palmer Trials

In five trials conducted in different years at the Palmer Research Center on Bodenburg silt loam, yields of common annual ryegrass ranged from 2.98 to 4.13 tons per acre (oven-dry weight), averaging about 3.5 tons per acre (table 1). With seedings conducted in the second to third weeks of May, three harvests were taken per season in four of the trials and four harvests were taken in one of the trials. Under the three-harvest system, harvests generally were obtained first about mid July, second in the third week of August, and third in early October. About 2.50 to 2.75 tons of dry matter were produced per acre in two harvests, with over 0.5 to 1.0 ton of regrowth occurring from late August through September.

The more profusely and earlier heading common, Gulf, and Aubade produced higher first-harvest yields than the leafy Tetila and Tetrelite ryegrasses, but the latter two generally equaled or exceeded the other three in second- and third-harvest yields (table 1). Gulf ryegrass was decidedly inferior to the other four in regrowth ability after the second harvest. Aubade generally was superior to common ryegrass in the production of late-season regrowth. Thus, the tetraploids sustained growth better than the diploids through the season. The sparsely heading and leafier Tetila and Tetrelite were best at sustaining growth in the late

Table 1. Averages and ranges of forage yields, for selected ryegrasses and cereals under three-harvest and four-harvest systems for various trials conducted at the Palmer Research Center.

Entry	No. of trials	First harvest	Second harvest	Third harvest	Fourth harvest	Total
		---------------------(tons per acre[1])---------------------				
Ryegrasses						
Common	4	1.53	1.26	0.73		3.52
		(1.10-1.94)	(0.80-1.68)	(0.57-0.92)		
	1	1.36	0.75	0.70	0.51	3.32
Gulf	4	1.46	1.00	0.40		2.86
		(0.90-1.88)	(0.56-1.55)	(0.22-0.52)		
Aubade	4	1.42	1.35	0.96		3.73
		(0.79-1.98)	(0.08-1.79)	(0.81-1.24)		
	1	1.52	0.79	0.76	0.62	3.69
Tetila	4	1.02	1.44	0.92		3.38
		(0.74-1.25)	(1.06-1.87)	(0.82-1.07)		
	1	1.45	0.92	0.81	0.81	3.98
Tetrelite	3	1.00	1.39	1.07		3.46
		(0.64-1.37)	(0.90-1.80)	(0.91-1.17)		
Cereals						
Toral Oats	1	1.60	0.82	0.04		2.46
Weal barley	1	1.88	0.16	0.04		2.08
	1	1.72	0.08	0.42	0	2.22

[1]Oven-dry matter (ODM); hay yield=ODM × 1.136 (12 per cent moisture basis).

stages of the growing season (fig. 2). The highest yield was obtained with Aubade Westerwold ryegrass in 1983, which produced 4.5 tons of dry matter per acre in three harvests (=5.1 tons on a 12 per cent moisture hay basis.).

In two trials that contained cereals as well as ryegrasses, 'Toral' oats and 'Weal' barley outproduced the ryegrasses in the first harvest but yielded substantially less than most of the ryegrasses in the succeeding harvests (table 1).

Pt. MacKenzie Trials

Common, Gulf, and Aubade ryegrasses yielded substantially more than the slower-starting Tetila and Tetrelite ryegrasses in the first harvest

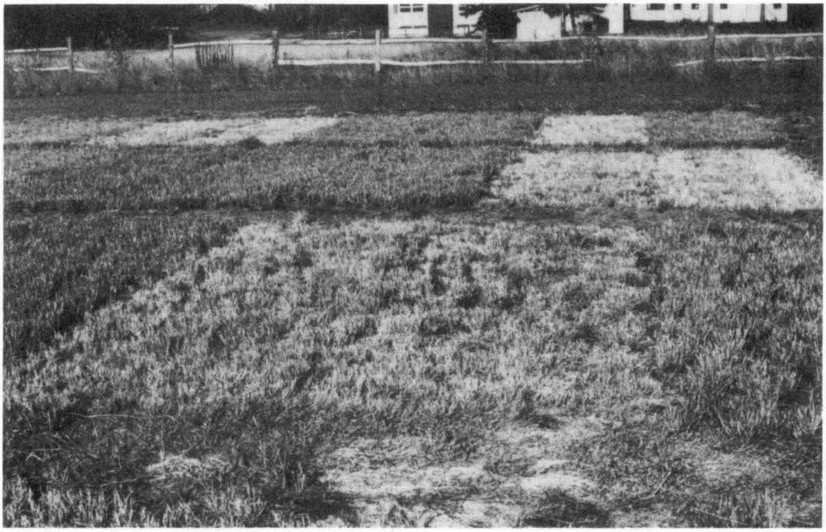

Figure 2. Late in the growing season, after the third harvest had been taken on the ryegrass plots of Figure 1, only the tetraploid leafy types regrew to any extent. Those that failed to produce any appreciable growth included all the profusely heading types, common, Gulf, Aubade, and Billion.

at Pt. MacKenzie on Homestead and Flathorn silt loams (table 2). They about equaled each other in yield in the second harvest. With the second harvest taken at the end of August, very little regrowth developed for a third harvest. The two diploids, common and Gulf, were the poorest for late-season growth . The leafier tetraploids, Tetila and Tetrelite, outproduced Aubade, a more stemmy tetraploid, in late season. With seedings conducted in the third to fourth week of May, about 2.5 to 3.0 tons of dry-matter production (2.8 to 3.4 tons on hay basis) were indicated for two harvests of ryegrasses at Pt. MacKenzie. The results suggested, however, that a late-August, second harvest permitted too little time for good, late-season regrowth.

Homer Area—Lookout Mountain

Seedings were generally made about mid June on Kachemak silt loam at this coastal, subalpine site (about 1500 ft. elevation) and a single

Table 2. Forage yields, by harvest, of ryegrass entries at Pt. MacKenzie in 1982 and 1983.

Ryegrass entry	Yr. of trial	First harvest	Second harvest	Third harvest	total
		(tons per acre[1])			
Common	'82	1.04	1.87		2.93
	'83	1.78	1.42	0.03	3.23
Gulf	'82	1.00	1.99		2.99
	'83	1.72	1.18	0	2.90
Aubade	'82	0.93	1.97		2.90
	'83	1.83	1.16	0.08	3.08
Tetila	'82	0.51	2.21		2.72
	'83	0.96	1.17	0.15	2.27
Tetrelite	'82	0.23	1.70		1.92
	'83	0.92	1.29	0.16	2.37

[1]Oven-dry matter (ODM); hay yield=ODM × 1.136 (12 per cent moisture basis).

harvest taken from late August to mid to late September. Two harvests were taken in one of the four trials. Dry-matter yields of 1.5 to over 2.0 tons per acre were obtained with a growing period of about 70 to 80 days after seeding (table 3). The single trial with two harvests utilized 99 days of the growing season but produced lower total yields than the one-harvest trials. Gulf and Aubade produced over 2.5 tons per acre in one trial with a growing period of 91 days after seeding.

In trials containing both cereals and ryegrasses, Toral oats substantially outproduced the ryegrasses under the single-harvest system (table 3.). Under the two-harvest system, most ryegrasses surpassed the cereals because of superior regrowth ability.

Homer Area—Fritz Creek

In a trial established on Mutnala silt loam at about 450 ft. elevation in the Homer area, common and Gulf ryegrass produced almost 2.5 tons per acre and Toral oats over 2.7 tons per acre with a 77-day growing period (table 3). Weal barley was no better than the ryegrasses on this strongly acid soil (pH 4.9). Production of Tetila and Tetrelite was substantially less than that of the other ryegrasses, but selective grazing of these grasses by moose influenced the data.

Table 3. Averages and ranges of forage yields, by harvest, for selected ryegrasses and cereals for various trials conducted on subalpine site (Lookout Mt.) and at coastal forest site (Fritz Creek) near Homer.

Entry	No. of trials	Lookout Mt. First harvest	Lookout Mt. Second harvest	Lookout Mt. Total	Fritz Ck. First harvest
		(tons per acre[1])			
Ryegrasses					
Common	1	1.91		1.91	2.45
	1	1.04	0.46	1.50	
Gulf	3	2.09 (1.76-2.59)		2.09	2.42
	1	0.90	0.42	1.32	
Aubade	3	2.24 (1.80-2.68)		2.24	2.18
	1	0.83	0.51	1.34	
Tetila	3	1.77 (1.41-2.28)		1.77	1.40
	1	0.76	0.47	1.23	
Tetrelite	3	1.32 (1.16-1.43)		1.32	1.26
	1	0.66	0.47	1.13	
Cereals					
Toral oats	2	3.13 (2.53-3.72)		3.13	2.74
	1	0.99	0.13	1.12	
Weal barley	1	2.23		2.23	2.39
	1	0.69	0.11	0.80	

[1]Oven-dry matter (ODM); hay yields=ODM × 1.136 (12 per cent moisture basis).

Delta Junction Area

In a single trial conducted on Beals silt loam in the Delta Junction area, Aubade, Gulf, and common produced about 1.8 tons per acre in the first harvest after a growing period of 69 days (table 4). Tetila and Tetrelite were substantially less productive. These results were affected by droughty conditions that hindered establishment. No fertilizer was applied after the first harvest, and lower yields than were expected were obtained in the second harvest. Besides insufficient fertilization, graz-

Table 4. Forage yields, by harvest, of ryegrasses in 1983 at Delta Agricultural project area.

Ryegrass entry	First harvest	Second harvest	Total
	(tons per acre[1])		
Common	1.78	0.06	1.84
Gulf	1.82	0.05	1.87
Aubade	1.83	0.07	1.90
Tetila	1.17	0.10	1.27
Tetrelite	0.97	0.17	1.14

[1]Oven-dry matter (ODM); hay yield=ODM × 1.136 (12 per cent moisture basis).

ing by small mammals and harvest timing may have influenced results further. The first harvest was taken after the ryegrasses were fully headed. An earlier first harvest would have resulted in better regrowth, albeit a lower first-harvest yield.

FORAGE QUALITY

Forage quality is influenced by a number of factors. Among these are plant maturity, rate of growth, soil-nutrient status, and other growing conditions. Crude protein and digestibility (IVDMD) percentages are summarized in Table 5 for a number of the Palmer trials. The much wider range of values on a percentage basis for crude protein than for IVDMD suggests that crude protein is more subject than digestibility to the factors influencing quality. The results suggest that, by cutting these ryegrasses in mid July and again in the second to third week of

Table 5. Ranges of crude protein and in vitro dry matter disappearance (IVDMD) values for ryegrass forage, by harvest, for various trials conducted at the Palmer Research Center.

Ryegrass entry	No. of trials	Harvest	Crude Protein	IVDMD
			(%)	
Common	4	1st	13.2-21.8	59.1-76.5
	4	2nd	15.6-20.7	63.1-73.7
	4	3rd	13.3-20.1	64.9-79.0
	1	4th	24.9	82.1
Aubade	4	1st	11.9-22.0	60.0-75.8
	4	2nd	13.9-21.3	65.7-73.4
	4	3rd	13.6-20.2	60.4-79.7
	1	4th	24.9	82.8
Tetila	4	1st	17.9-25.6	79.1-84.4
	4	2nd	17.1-24.8	79.0-82.8
	4	3rd	11.6-25.6	68.1-86.6
	1	4th	23.3	86.3
Tetrelite	3	1st	18.8-23.3	78.2-80.7
	3	2nd	16.8-19.0	74.7-82.3
	3	3rd	13.6-15.5	74.2-87.7

August, crude protein can be maintained at 12 per cent or better and IVDMD at about 60 per cent or better. Digestibility of the leafy tetraploids Tetila and Tetrelite remained particularly high, generally over 70 per cent. The stemmier ryegrasses were usually above 60 per cent in IVDMD.

In the Palmer trials percentages of phosphorus, potassium, calcium, and magnesium also varied widely (table 6). These values were generally adequate or above for beef-animal nutrition (National Research Council 1976).

A trial conducted at Palmer in 1983 demonstrated the effect of stage-of-harvest on forage quality. The diploid common and tetraploid Aubade, both profusely heading ryegrasses, and the tetraploid 'Ninak', a sparsely heading entry, were harvested at four different stages with cutting dates set a week apart. The cutting dates spanned the head emergence through anthesis (pollen shedding) stages for the profusely heading grasses, and the leaf to heading stages for Ninak. Crude protein declined about 40 per cent for common and Aubade and about 35 per cent for Ninak over

Table 6. Ranges in concentrations of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) of ryegrass forage, by harvest, for trials conducted in various years at the Palmer Research Center.

Ryegrass entry	No. of trials	Harvest	P	K	Ca	Mg
			(%)			
Common	4	1st	.26-.41	1.9-4.2	.39-.64	.18-.75
	4	2nd	.19-.33	1.8-2.7	.43-.73	.24-.40
	4	3rd	.22-.37	1.5-3.0	.30-.69	.21-.39
	1	4th	.33	3.4	.41	.36
Aubade	4	1st	.21-.52	1.9-3.8	.41-.50	.15-.52
	4	2nd	.21-.33	1.8-2.7	.38-.67	.18-.47
	4	3rd	.21-.42	1.6-3.0	.31-.62	.16-.51
	1	4th	.31	3.4	.45	.40
Tetila	4	1st	.20-.47	2.1-3.6	.29-.58	.19-.59
	4	2nd	.15-.29	2.0-2.8	.32-.53	.23-.62
	4	3rd	.19-.34	1.7-3.1	.29-.51	.14-.47
	1	4th	.23	3.0	.28	.33
Tetrelite	3	1st	.23-.49	2.4-3.5	.35-.60	.14-.34
	3	2nd	.23-.28	1.9-2.6	.39-.57	.21-.44
	3	3rd	.20-.34	1.7-2.3	.27-.64	.15-.37

this 3-week period (fig. 3). Digestibility was more stable, declining 15 to 19 per cent for common and Aubade and only 6 per cent for Ninak (fig. 4). Phosphorus and potassium also showed definite declines in concentrations for the profusely heading grasses but much less so for Ninak (table 7). Results were variable for calcium and magnesium.

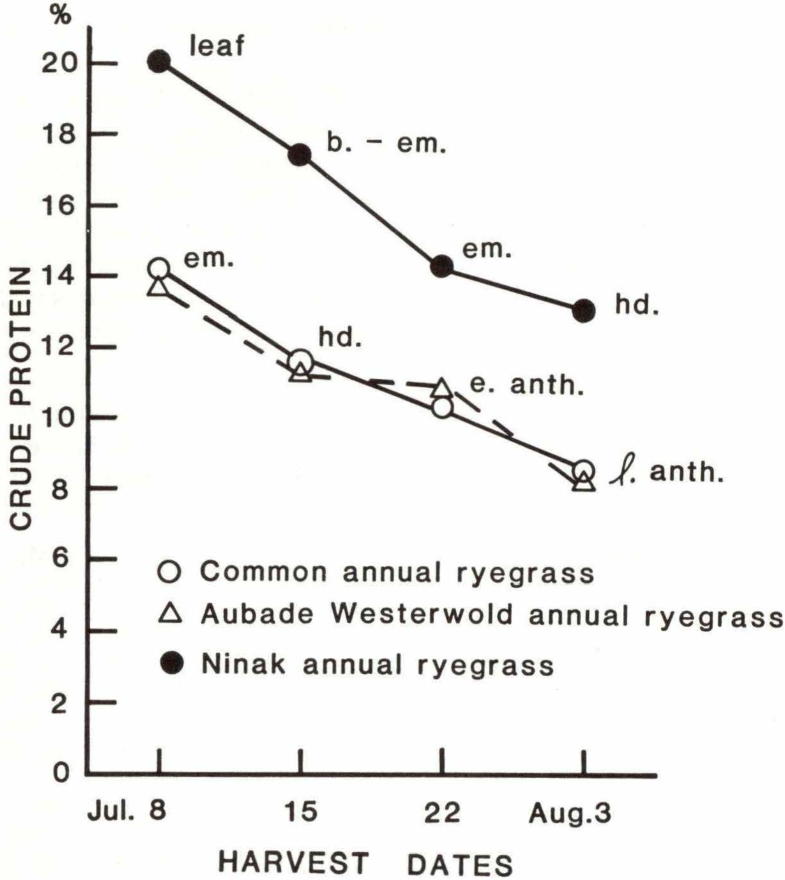

Figure 3. The effect of stage of maturity on crude-protein content of three ryegrasses cut at successively later stages of development can be seen above. Stages of development at harvest dates: leaf = preboot stage; b. em. = boot to head emergence stage; em. = head emergence stage; hd. = fully emerged or headed stage; e. anth. = early anthesis; ℓ. anth. = late anthesis. Common and Aubade are profusely heading types; Ninak is a leafy type.

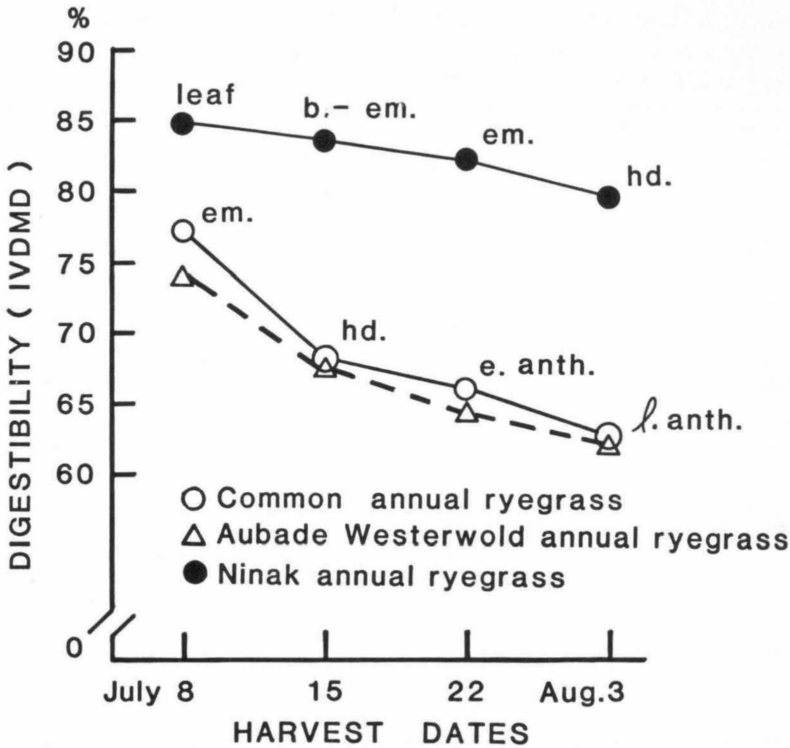

Figure 4. The effect of stage of maturity on in vitro dry matter disappearance (IVDMD) of three ryegrasses cut at successively later stages of development is shown above.

This trial suggests that decline in quality is influenced by the heading process in ryegrasses. Thus, those that remain leafy are apt to experience less decline. The leafy tetraploid ryegrass maintained particularly high IVDMD values through the early heading period.

A high rate of growth can influence forage quality by diluting the contents of various quality factors. Because of this, high-producing forages may have lower quality readings than those with slower rates of growth. The growth rate of the leafy ryegrasses prior to the first harvest, lower than that of the profusely heading ryegrasses, probably contributes to their higher quality. However, because of their good regrowth ability, the leafy ryegrasses have yielded as much or more than common and Aubade ryegrasses for the second and third harvests

Table 7. Effects of harvest date (maturity) on concentration of phosphorous (P), potassium (K), calcium (Ca), and magnesium (Mg) in ryegrass forage at Palmer Research Center.

Ryegrass entry	Date of harvest	P	K	Ca	Mg
		(%)			
Common	Jul 8	0.21	2.4	0.57	0.16
	15	0.18	2.1	0.58	0.13
	22	0.15	1.6	0.62	0.12
	Aug 3	0.12	1.2	0.46	0.13
Aubade	Jul 8	0.19	2.5	0.50	0.14
	15	0.15	2.1	0.52	0.13
	22	0.14	1.8	0.57	0.14
	Aug 3	0.10	1.5	0.51	0.13
Ninak	Jul 8	0.19	3.3	0.54	0.18
	15	0.19	3.1	0.56	0.15
	22	0.17	2.8	0.36	0.14
	Aug 3	0.18	3.0	0.52	0.20

at Palmer and still maintained higher-quality forage; this further implicates the heading process with its buildup of stem tissue as affecting quality in ryegrasses.

A relatively high moisture content is associated with the high ratio of leaf tissue to stem tissue in the sparsely heading ryegrasses. The moisture content of common and Aubade decreased from above 80 per cent at head emergence to 71-72 per cent at late anthesis, whereas the moisture content of the leafy Ninak decreased from about 84 per cent at the leaf stage to 82 per cent at the heading stage. Of course, a high moisture content renders the material more difficult to condition for storage as hay, thus emphasizing provision for storage as silage.

Crude-protein values of ryegrass forage from the Pt. MacKenzie area were low to high (table 8). The low values reflect the fact that the first harvest of one of the trials and both second harvests were taken after the material was fully headed. Digestibility, as measured by IVDMD, in general remained in the good to high range—above 60 per cent (table 8). Some low phosphorus percentages (table 9) probably reflected the

Table 8. Ranges of crude protein and in vitro dry matter disappearance (IVDMD) values of ryegrass forage, by harvest, for trials conducted in 1982 and 1983 at the Pt. MacKenzie agricultural project area.

Ryegrass entry	No. of trials	Harvest	Crude Protein	IVDMD
			(%)	
Common	2	1st	6.3-14.3	63.3-72.0
	2	2nd	10.9-11.3	59.4-64.9
	1	3rd	17.5	75.6
Aubade	2	1st	6.6-16.2	64.0-74.6
	2	2nd	11.1-11.6	59.5-67.4
	1	3rd	17.9	76.5
Tetila	2	1st	9.7-20.8	81.8-82.5
	2	2nd	12.4-14.1	83.0-87.0
	1	3rd	12.8	84.1
Tetrelite	2	1st	10.5-21.5	78.7-82.1
	2	2nd	11.8-16.2	80.3-81.3
	1	3rd	13.2	83.0

Table 9. Ranges in concentration of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) of ryegrass forage, by harvest, for trials conducted in 1982 and 1983 at Pt. MacKenzie agricultural project area.

Ryegrass entry	No. of trials	Harvest	P	K	Ca	Mg
				(%)		
Common	2	1st	.21	1.5-2.3	.23-.33	.10
	2	2nd	.14-.15	1.6-1.8	.28-.44	.12-.14
	1	3rd	.28	2.1	.43	.16
Aubade	2	1st	.10-.24	1.4-2.7	.18-.31	.10
	2	2nd	.14-.17	1.7-1.7	.17-.42	.12
	1	3rd	.30	1.9	.51	.17
Tetila	2	1st	.10-.17	1.8-2.9	.17-.32	.08-.11
	2	2nd	.11-.14	1.9-2.0	.22-.53	.13-.17
	1	3rd	.21	1.2	.50	.16
Tetrelite	2	1st	.14	2.2-2.7	.22-.38	.09-.15
	2	2nd	.12-.18	1.8-1.8	.34-.40	.13-.16
	1	3rd	.22	1.6	.36	.16

stage of harvest and low availability of P in the soil. Magnesium content was low.

Crude-protein values of ryegrass forage from the subalpine site (Lookout Mt.) north of Homer (table 10) also varied much more than digestibility. The variation is an expression of different lengths of growing periods, and environmental conditions that affect growth rates and stage of development. Growing periods, as measured from dates of seeding to harvest dates, extended from 63 days to 91 days. Phosphorus and potassium concentrations were adequate to good (table 11). Calcium content varied a great deal, with the very high contents associated with the shortest growing period. Magnesium, characteristically, was low.

In the single trial at a low elevation site (Fritz Creek) east of Homer, the penalty for harvesting ryegrass forage after heading and flowering have occurred is evidenced by the very low crude protein and phosphorus values (table 12). Laboratory-determined digestibility was less affected by the late harvest. The cereals differed little from most of the ryegrasses in measures of forage quality.

Table 10. Ranges of crude protein and in vitro dry matter disappearance values of ryegrass and cereal forages, by harvest, for trials conducted in various years at subalpine site (Lookout Mt.) near Homer.

Entry	No. of trials	Harvest	Crude protein	IVDMD
			---------------(%)---------------	
Ryegrasses				
Common	2	1st	9.7-20.7	69.0-77.6
	1	2nd	18.6	77.1
Aubade	4	1st	5.5-20.8	51.4-74.0[1]
	1	2nd	19.2	76.7
Tetila	4	1st	8.6-23.9	60.5-79.6[1]
	1	2nd	19.5	85.8
Tetrelite	4	1st	11.6-25.8	70.5-82.7[1]
	1	2nd	17.3	78.6
Cereals				
Toral oats	3	1st	5.1-19.5	48.6-74.6[1]
	1	2nd	26.9	78.6
Weal barley	2	1st	12.5-25.9	70.2[1]
	1	2nd	26.8	78.6

[1] Data for one less trial than indicated at left.

Table 11. Ranges in concentrations of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in ryegrass and cereal forage, by harvest, for trials conducted at subalpine site (Lookout Mt.) near Homer.

Entry	No. of trials	Harvest	P	K	Ca	Mg
			(%)			
Ryegrasses						
Common	2	1st	.24-.32	1.6-2.9	.28-.65	.09-.19
	1	2nd	.28	2.1	.56	.20
Aubade	4	1st	.22-.38	1.5-3.4	.17-.57	.11-.19
	1	2nd	.28	2.1	.53	.20
Tetila	4	1st	.24-.29	2.0-3.4	.22-.65	.14-.21
	1	2nd	.27	2.3	.42	.19
Tetrelite	4	1st	.25-.30	2.1-3.5	.21-.81	.14-.25
	1	2nd	.22	1.7	.51	.19
Cereals						
Toral oats	2	1st	.22-.38	2.2-3.4	.14-.52	.11-.17
	1	2nd	.41	3.1	.49	.23
Weal barley	1	1st	.19-.26	2.6-3.4	.31-.73	.12-.21
	1	2nd	.34	2.7	.68	.23

Table 12. Contents of crude protein, digestible dry matter (IVDMD), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in ryegrass and cereal forages from trial at low-altitude site near Homer.

Entry	Protein	IVDMD	P	K	Ca	Mg
			(%)			
Ryegrasses						
Common	5.9	62.3	.10	1.6	.20	.14
Aubade	5.8	61.2	.08	1.6	.16	.13
Tetila	7.8	83.2	.08	2.0	.17	.15
Tetrelite	9.3	81.2	.11	2.0	.19	.19
Cereals						
Toral oats	5.7	60.5	.11	1.4	.12	.13
Weal barley	6.1	54.3	.08	1.5	.14	.11

FERTILIZER TREATMENTS

Only one trial was conducted with ryegrasses in which fertilizer was applied as a treatement variable. The fertilizer 18-18-18 was applied at 200, 300, 400, and 500 lbs per acre to common and Aubade ryegrasses in a 1983 seeding at Pt. MacKenzie on Flathorn silt loam. The initial treatment was followed by an overall application of 200 lbs per acre of urea after the first harvest.

Droughty conditions that prevailed during much of the 1983 growing season may have influenced results. Increasing fertilizer amounts from 200 to 300 lbs per acre, supplying 36 and 54 lbs N, respectively, produced a substantial increase in yield in the first harvest (table 13); yield increases were small, however, at the two highest fertilizer levels, which supplied 72 and 90 lbs N per acre.

In the second harvest, the 500-lb treatment, which supplied a total of 180 lbs N including the follow-up urea application, produced a significantly higher yield than the other treatments.

The 200-lb treatment produced significantly less in total yield than the other treatments. The 500-lb treatment produced significantly more than the 300-lb treatment in total yield. The 300-lb treatment, supplying 144 lbs N with refertilization, produced over 3.5 tons of forage per acre. In fertilizer trials with forage oats at Pt. MacKenzie, good responses were obtained to fertilizer applications that supplied up to 120 lbs of N per acre (Michaelson et al. 1984).

Fertilizer treatments influenced crude-protein percentages of the ryegrasses. The first harvest was taken when the plants were in the flowering stage after heading, thus crude-protein values were low (table 14). However, crude protein showed a positive response to the amount of fertilizer applied, whereas digestibility showed a decline. Fertilizer treatment appeared to have little effect on mineral uptake. Phosphorus was low for all treatments. Values for the second harvest generally were higher than for the first harvest. The application of 90 lbs N per acre after the first harvest had a leveling effect on crude-protein contents

Table 13. Forage yield of ryegrass fertilized at different rates of 18-18-18 (N-P_2O_5-K_2O) at time of seeding at Pt. MacKenzie.

Fertilizer treatment	First harvest	Increase (decrease)[1]	Second harvest[3]	Increase (decrease)	Total	Increase (decrease)
(lb/acre)	(T/ac.)	(%)	(T/ac)	(%)	(T/ac)	(%)
200	1.50 b[2]	--	1.37 b	--	2.87 c	--
300	2.04 a	36	1.50 b	9	3.54 b	23
400	2.24 a	10	1.48 b	(1)	3.72 ab	5
500	2.41 a	8	1.68 a	14	4.09 a	10

[1] % increase or decrease over or below preceding figure.
[2] Figures within a column followed by the same letter do not differ significantly (confidence level = 95%).
[3] All plots received 90 lbs of N per acre after the first harvest.

Table 14. Concentrations of crude protein, digestible dry matter (IVDMD), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in ryegrass forage from plots fertilized at seeding at different rates of 18-18-18 (N-P_2O_5-K_2O) at Pt. MacKenzie.

Fertilizer treatment[1]	Crude protein[2]	IVDMD	P	K	Ca	Mg
(lbs/acre)	(%)					
First Harvest						
200	4.4	66.3	.11	1.32	.38	.09
300	4.9	63.1	.11	1.46	.40	.09
400	5.9	62.7	.11	1.64	.50	.11
500	6.8	62.0	.12	1.62	.38	.09
Second Harvest[3]						
200	12.8	76.1	.15	2.26	.50	.15
300	11.6	74.9	.15	2.12	.48	.14
400	13.0	75.3	.18	2.06	.54	.15
500	13.0	74.1	.20	2.05	.54	.15

[1] Amount of 18-18-18 applied.
[2] Plots were seeded 2 June and harvested 57 days later with grasses in an advanced heading stage, which helps account for low crude protein values.
[3] All plots received a treatment of 90 lbs of N per acre as urea after the first harvest. Second harvest was taken 40 days after first harvest in early heading stage.

of the second harvest. Phosphorous increased at the higher treatments.

Fertilizers generally employed in the Palmer and Pt. MacKenzie trials consisted of 20-20-15 or 18-18-18 supplying about 70 to 90 lbs N per acre at the time of seeding, followed by urea supplying 90 lbs N per acre applied after the first harvest. In the Homer area under the single harvest system either 20-20-15 or 18-18-18 was applied at rates supplying about 50 to 72 lbs N per acre.

Some of these applications have been barely adequate or have been insufficient to supply the amount of nitrogen removed in the forage. The amount removed is the product of yield x per cent N in the forage. The 160 to 180 lbs N applied in the three-harvest system employed at Palmer about equaled the amount removed (table 15). In the four-cut trial, 238 lbs N was applied, which equaled the N requirement for common annual ryegrass but was less than the requirement for Aubade and

Table 15. Average amounts of nitrogen removed in ryegrass forage, by harvest, at three research locations.

Ryegrass entry	No. of trials	Harvest				Total
		1st	2nd	3rd	4th	
		--------------------(lbs per acre)--------------------				
Palmer						
Common	3	77	63	42		182
	1	96	50	44	41	231
Aubade	3	69	62	48		179
	1	105	54	49	50	259
Tetila	3	69	79	41		189
	1	119	73	66	60	318
Pt. MacKenzie						
Common	1	47	68			105
	1	36	50	1		87
Aubade	1	48	70			118
	1	37	43	5		85
Tetila	1	34	100			134
	1	30	46	6		82
Homer, Subalpine (Lookout Mt.)						
Common	1	60				60
	1	69	27			96
Aubade	3	66				66
	1	55	31			86
Tetila	3	70				70
	1	58	29			87

Tetila. The leafy tetraploid Tetila maintained a high N concentration while yielding 4 tons of forage per acre, resulting in over 300 lbs N being removed per acre. The Pt. MacKenzie trials removed less than the 160 to 180 lbs N applied. When cut in the emergence to early-heading stage, about 50 to 70 lbs were removed in each of the first and second harvests at Pt. MacKenzie. At the low fertilizer rates used in the Lookout Mt. trials, more nitrogen was removed than was applied.

DISCUSSION AND SUMMARY

Ryegrasses provide an option for an annual forage crop with good regrowth potential under proper management. In trials at the Palmer Research Center, a number of different varieties of ryegrasses have produced from 2.5 to 4.5 tons of dry matter per acre under three-harvest and four-harvest systems. In 2 years of trials at the Pt. MacKenzie agricultural project area, different varieties have produced about 3 tons per acre and, with heavy fertilization, up to 4 tons under two-harvest and three-harvest systems. At a subalpine grassland site near Homer, yields have ranged from about 1.5 to 2.5 tons of dry matter per acre under one-cut and two-cut systems. At Delta, about 1.8 tons per acre were obtained in a late harvest with negligible regrowth for a second harvest.

The choice between growing a cereal or a ryegrass for an annual forage depends upon management objectives. In trials that have provided comparisons of cereals with ryegrasses, the cereals generally have outproduced the ryegrasses in the first harvest. This is particularly true when harvest was delayed until late in the season, as at the subalpine site near Homer. Where a single harvest is contemplated, ryegrasses offer no advantage in yield and little or no advantage in quality. However, cereal regrowth after harvest is much less than that of ryegrass (also previously demonstrated by Klebesadel 1968). Under a multiple-harvest system, with adequate fertilization, ryegrass can provide good-quality forage for storage or grazing. If managed properly, it can afford grazing late in the season when perennial stands should be rested to prepare for winter.

In the Matanuska Valley and Pt. MacKenzie areas, two harvests have been taken by mid to late August, each providing about 1.0 to over 1.5 tons of dry matter per acre, with late regrowth providing from a small amount to more than 1 ton of forage. Much more late-summer regrowth has been produced at Palmer, with the second cut taken near mid August, than at Pt. MacKenzie, where the second cut was taken at the end of August. A second cut taken earlier than late August may be necessary to enable more regrowth for the September-October period.

Little research has been done on fertilization of annual ryegrass in Alaska. In the Atlantic Provinces in eastern Canada, three applications of about 70 lbs of nitrogen per acre—for establishment and after the first and second harvests—were recommended for ryegrass (Kunelius and Calder 1978). Four-week intervals were allowed between harvests in a four-harvest system. This appears to fit results obtained here, but our shorter growing season must be taken into consideration. At least 60 to 70 lbs N in a mix such as 20-20-15 or 18-18-18 are recommended at seeding followed by 70 to 90 lbs N after the first harvest. The higher N rate would be desired if a third harvest is contemplated, either by grazing or mechanical means. Higher rates with the addition of more P and K may be required to sustain heavy production. Seeding rates of 25 to 35 lbs per acre appear appropriate, depending upon seed-bed conditions. The tetraploid ryegrases have heavier seeds than the diploids and should be seeded at heavier rates.

Time of harvest is critical to plant quality. Harvests should be taken when heads are emerging to the fully emerged stage. Harvest should not be delayed beyond the initial fully headed stage because of serious loss of protein content and loss of acceptability for grazing purposes (Brundage and Branton 1967). The ryegrasses maintain relatively high IVDMD values, generally near or above 70 per cent for the stemmy types and above 80 per cent for the leafy types when harvested prior to the fully headed stage. A disadvantage to cutting ryegrass when quality is high is its low dry-matter content at this stage. Dry-matter content increases as the plant ages, but quality decreases. Because of its low dry-matter content when cut in the boot- to head-emergence stage, ryegrass can be difficult to condition for haying purposes. Ryegrass is best preserved as wilted silage for a stored forage. Animals in the Palmer Research Center dairy research program have been reported as rejecting ryegrass stored as hay while readily accepting that stored as silage or fed as green chop (Klebesadel 1968), but other reports refer to the use of ryegrass as hay (Frakes 1973). Acceptability as hay may depend on its maturity stage at harvest.

Because of their taller, stemmier growth, the diploid common annual ryegrass and tetraploid Westerold type, such as Aubade, are better adapted for mechanical harvest than the leafier, sparsely heading tetraploids. The leafy types provide vigorous, mid- to late-season growth and are better adapted for grazing purposes than the stemmy types. Where both mechanical harvest and late grazing are the objectives, a seed mix could be used that includes both a stemmy type and a leafy type. The diploid common annual ryegrass is subject to lodging, particularly with the onset of heading. The tetraploid Westerwold type has a stouter stem which helps to resist lodging. These two types were about equal in plant quality at comparble stages of growth.

According to test results, varieties not featured in the yield presentations of this report that merit consideration include the following:

Tetraploid Westerwold ryegrass: 'Billion'.

Tetraploid leafy types: 'Ninak', 'Terli', 'Tetrona'.

These varieties have not been tested as extensively as the varieties featured in this report, but their yields have equaled or exceeded those of their counterparts of the same type.

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