Forage Yield and Quality of Cereals at Pt. MacKenzie

by
William W. Mitchell
Professor of Agronomy

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

James V. Drew, Director

August 1983 Bulletin 61

Contents

Introduction

Cereals are an important option for forage production in the Pt. MacKenzie agricultural project area, located about 40 miles southwest of Palmer. A mixture of oats and peas has been used extensively for an annual forage in southcentral Alaska (Brundage and Klebesadel 1970; Brundage and Sweetman 1967; Hodgson 1956; Klebesadel 1966, 1969; Sweetman and Brundage 1960). The inclusion of peas bolsters the protein content of the mixture, while oats provide most of the dry- matter production as well as physical support for the pea vines. Barley generally has not been planted for the cereal component because the sharp awns, or beards, present a danger to animals when fed.

With the recent development of the beardless variety 'Weal' (Taylor 1972), however, barley use has increased in plantings of annual forages (Brundage, Taylor, and Burton 1979). The relatively high-producing characteristics of Weal barley on Matanuska Valley soils have promoted its use, often in combination with oats. Sometimes barley is planted in alternating strips with oats, a method developed at the Alaska Agricultural Experiment Station research farm (Brundage, Taylor, and Burton 1981). Earlier studies generally have resulted in recommendations for harvesting cereals in the soft-dough stage for the best balance of yield and quality.

This report presents the results of three field tests conducted during 1982: two at the University of Alaska research tract in the Pt. MacKenzie project area and one at the Palmer Research Center. One trial at Pt. MacKenzie compared seven oat and barley varieties, harvested simultaneously, for yield and quality. A second trial obtained yield and quality information

on an oat variety harvested at different stages. A stage-of-harvest experiment also was conducted with barley at Palmer for comparative purposes.

Cereal plots being harvested on August 10 in the fully headed stage at Pt. MacKenzie for forage yield and quality determinations. Weal barley, the beardless variety, is pictured in the center foreground; Lidal barley, a bearded variety, is to the left, with some oat plots in the background. Four oat varieties outyielded the barley varieties, providing over 5 tons per acre on a 12 per cent moisture, hay basis.

Experimental Methods

Trial I at Pt. MacKenzie

Seven cereal varieties were drill-seeded at about 125 lbs/acre on June 3, 1982, in plots measuring 4x15 ft., each plot consisting of eight rows 6 inches apart. The cereals were randomly assigned positions in each of four replications. Fertilizer (18-18-18) was applied at 500 lb/acre supplying 90 lbs each of N (nitrogen), P_2O_5 (phosphate), and K_2O (potash) per acre. A 2x13-ft swath was harvested from the center of each plot with a sickle-bar mower on August 10, 1982, leaving about 2.5 inches of stubble.

Trial II at Pt. MacKenzie

'Toral' oats was seeded and fertilized as above for a stage- of - harvest trial with harvests planned at the following five stages of development:

A) head-emergence stage (when the head is partially emerged and partially enclosed by the leaf sheaf)

B) fully headed stage

C) early- to -midmilk stage

D) soft-dough stage

E) hard-dough stage.

A sickled-bar mower was used to harvest a 2x13-ft section, as above, leaving about 2.5 inches of stubble.

Trial III at Palmer

A similar stage-of-harvest trial was established at Palmer, seeded and fertilized as above, using Weal barley instead of Toral oats. Serious lodging by the barley necessitated the use of hand clippers to harvest 2x11-ft sections from the plots. Much less of the lodged growth would have been obtained with field harvesting equipment than was obtained with the hand clippers. The oats did not lodge at Pt. MacKenzie, so could have been harvested easily with field equipment.

Samples from the harvested plots were collected for drying, weighing, and laboratory analyses. The samples were dried at about 140ºF (60ºC) to determine dry-matter yields. Plant-tissue samples were analyzed for percentage nitrogen (% N x 6.25 = crude protein content), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and digestibility according to a test employing rumen fluid in a test tube, termed *in vitro dry-matter disappearance* (IVDMD). Results were analyzed statistically to determine significance of differences between yields and between percentage contents. The statistical test provides a means of stating with a certain level of confidence (95% in this case) whether differences are significant and not due to chance alone.

The trials on the Pt. MacKenzie research tract were conducted on Flathorn silt loam. Soils on this tract grade from Homestead to Flathorn silt loam and have ranged in pH from about 5.3 to 5.7. The trial at Palmer was conducted on Bodenburg silt loam with a pH of about 6.2.

Results

Trial I

Two barley and five oat varieties were compared at Pt. MacKenzie for forage yield and quality characteristics. The cereals were planted on June 3 and harvested on August 10 in the fully headed stage prior to grain formation. The barleys included a bearded variety, Lidal, and a beardless (hooded) variety, Weal. Only the beardless variety is considered satisfactory for forage

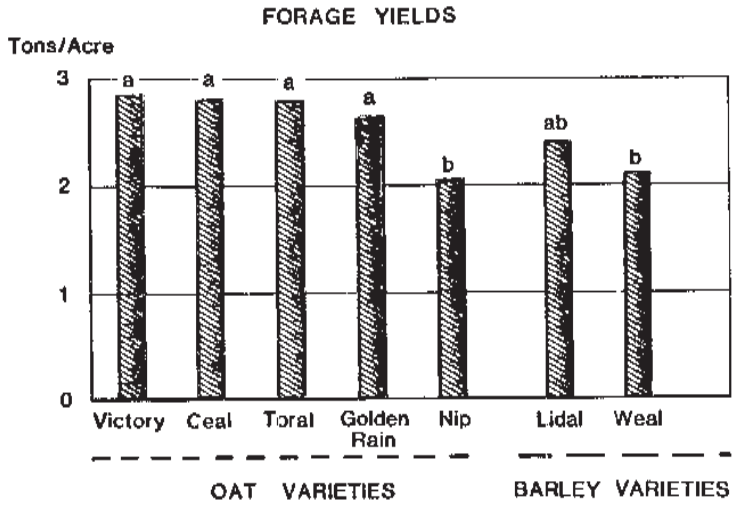

Figure 1. Oven-dry forage yields of seven cereals seeded June 3 and harvested August 10, 1982, at the Pt. MacKenzie research tract. The cereals were harvested in the fully headed stage prior to early grain formation. The small letters associated with the bars indicate whether differences between values are significant. Those with the same letter are judged not to be significantly different at the 95 per cent confidence level, according to the statistical test applied. Thus, the four oats, associated with the letter *a*, differ significantly in yield from Nip oats and Weal barley, identified only with *b*.

purposes. Lidal was included to provide additional information on barley performance. Two of the oat varieties, Ceal and Toral, and the barley varieties were developed by R.L. Taylor (National Research Council 1971), USDA plant breeder at the Alaska Agriculture Experiment Station at Palmer, while the other three oat varieties are of Swedish origin.

Four of the oat varieties—Victory, Ceal, Toral, and Golden Rain—differed little in herbage production (Figure 1), significantly outyielding Nip oats and Weal barley; they also surpassed Lidal barley but the difference was not statistically significant. The four highest-yielding oats averaged 2.77 tons per acre of oven-dry matter, which would equal 3.15 tons per acre of hay calculated on a 12 per cent moisture basis, or over 9 tons of silage at 70 per cent moisture. Dry-matter contents suggest that Ceal oats and Lidal barley were more advanced in maturity than the other cereals.

Crude protein (CP) contents (Table 1) were below the levels considered necessary to maintain beef animals. (National Research Council 1976), and much below that necessary for producing dairy cows (National Research Council 1971). Differences in CP content among the seven varieties were not significant.

Phosphorus content was marginal to low and differed little among varieties (Table 1). Calcium and magnesium concentrations were low, which is often true of forages grown on acid soils of this nature; potassium percentages also were relatively low but adequate to maintain beef animals.

Digestible dry-matter percentages (IVDMD) were marginal for maintenance of beef animals and inadequate for producing dairy cows. In general, the five oats tended to be higher in IVDMD than the two barleys. Energy supplementation would be necessary with all cereals tested.

Table 1. Forage-quality percentages for cereals seeded June 3 and harvested August 10, 1982, in fully headed stage at Pt. MacKenzie, fertilized at 90-90-90 lb/acre of N-P_2O_5-K_2O.

Forage	Dry Matter	Crude Protein	P	K	Ca	Mg	IVDMD
Oats:							
Toral	22.2b	7.50	.18ab	1.26	.16ab	.07bc	56.0ab
Ceal	24.9a	7.13	.19a	1.20	.12b	.07bc	56.0ab
Nip	21.4b	7.06	.19a	1.42	.17a	.09a	55.0b
Victory	22.3b	6.44	.16b	1.35	.16ab	.07bc	58.5a
Golden Rain	20.9 b	8.56	.19 b	1.37	.16ab	.08ab	57.2ab
Barley							
Weal	22.1b	7.13	.19a	1.37	.18a	.06c	51.4c
Lidal	25.2a	7.44	.17ab	1.56	.18a	.06c	54.1bc

*Values within a column followed by the same letter do not differ significantly at the 95 per cent level of confidence (Duncan's multiple- range test). Differences in crude protein and in K concentrations were not significant.

Trials II and III

Results of Trials II and III reflect generally increasing drymatter production and decreasing crude-protein and digestibility percentages through the growing season (Figures 2 and 3). The drop in yield for the final harvest of Weal barley was probably due to the severe lodging and wet conditions at the base of the plant, leading to deterioration. Weal achieved 5.2 tons per acre of oven-dry yield on September 3 at Palmer, and Toral oats yielded about 4.4 tons on September 23 at Pt. MacKenzie. This translates into 5.9 and 5.0 tons per acre of hay (12 per cent moisture), respectively.

Percent crude protein declined rapidly in both cereals from head emergence to the milk stage (Figures 2 and 3). This was also true for changes in phosphorus and potassium contents (Tables 2 and 3). Most of the decline in digestibility occurred in the initial stages as well.

Crude protein was much higher in Weal barley at Palmer (Bodenburg silt loam) than in the oats at Pt. MacKenzie (Flathorn silt loam). Toral oats maintained a higher level of digestibility, however, through the final harvest stages.

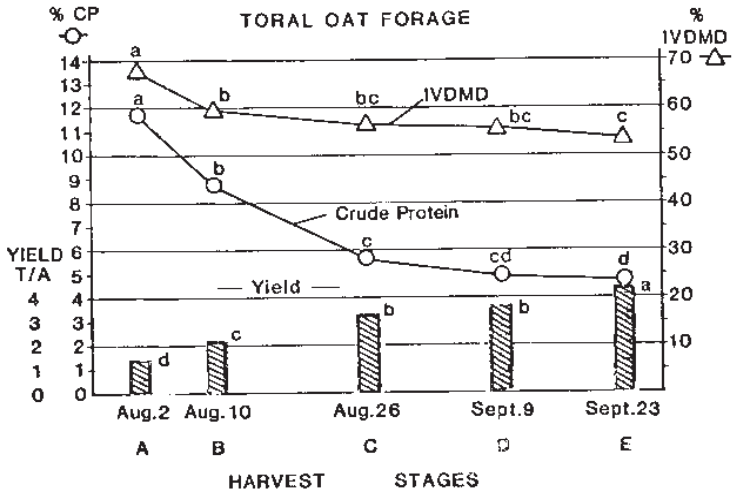

Figure 2. Oven-dry yield, crude-protein content, and per cent digestible dry matter (IVDMD) of Toral oats harvested at different growth stages were as follows: A – head emergence; B – fully headed; C – milk; D – soft dough; and E – hard dough. The small letters associated with the symbols indicate whether the differences between values are significant at the 95 per cent confidence level, as in Figure 1.

Because of the interaction of declining crude-protein percentages on increasing forage yields, crude-protein yields per acre remained relatively constant for each forage through the season (Table 4). However, Weal barley, grown on Bodenburg silt loam, yielded over twice as much crude protein as Toral oats, grown on Flathorn silt loam. Digestible dry-matter yields increased through all stages for the oats and was highest at the soft-dough stage for the barley. The two cereals about equalled each other in peak production of digestible dry matter. Toral oats attained its peak production of crude protein and digestible dry matter at final-harvest stage; Weal barley achieved its high yield of crude protein at fully headed stage, and of digestible dry matter at soft dough stage.

Table 2. Forage-quality percentages for Toral oats seeded June 4, 1982, and harvested at different stages at Pt. MacKenzie; fertilized at 90-90-90 lb/acre of N-P_2O_5-K_2O.

Harvest Stage * and Date	Dry Matter	P	K	Ca	Mg
		% content* *			
A: Aug 2	16.9d	0.26a	2.19a	0.18	0.08a
B: Aug 10	19.9c	0.22b	1.62b	0.19	0.08a
C: Aug 26	26.1b	0.17c	0.98c	0.16	0.07ab
D: Sep 9	31.1a	0.16c	0.88c	0.16	0.06b
E: Sep 23	32.2a	0.17c	0.85c	0.16	0.06b

*Harvest stages: A - head emergence; B - fully headed; C - milk; D - soft dough; E - hard dough.

**Values within a column followed by the same letter do not differ significantly at the 95 per cent level of confidence (Duncan's multiple-range test). Differences in Ca content were not significant.

Dry-matter content of Weal barley increased from 10.7 per cent when harvested in head- emergence stage to 29.3 per cent at hard-dough stage (Table 3). Lodging of the barley most likely affected these values, however, by maintaining moist conditions in the lower stratum of the stand. Oat dry-matter content increased from 16.9 per cent at emergence stage to 32.2 per cent at hard-dough stage (Table 2).

Summary

Indications from first-year results are that oats may yield 3 to over 4 tons of hay per acre at Pt. MacKenzie, if grown to the milk stage or beyond, and that oats significantly outyield Weal barley on soils of pH 5.7 or lower. It should be noted, however, that the Pt. MacKenzie trials reported here were conducted on Flathorn silt loam which is similar to but deeper than Homestead and that some soils in the project area may exceed pH 5.7. Much of the project area has been classified as Homestead silt loam. Oats were poor providers of protein, with percentage concentration declining rapidly from almost 12 per cent at head-emergence stage to less than 5 per cent in the late stages. Over half of the initial CP value was lost by the milk stage. Most of the decline in digestibility of Toral oats occurred between head-emergence and fully headed stages; it maintained about 55 per cent digestibility through the late stages. According to these results, relatively high forage quality can be preserved by cutting at the headed stage, prior to early grain formation, with expectations of obtaining about half the hay yield that would be obtained by a harvest in the late stages. A late-stage harvest would result in lower protein and digestibility percentages than the early-stage harvest, but produce about an equal amount of crude protein and a much greater amount of digestible dry matter per acre.

Barley and oat varieties, grown on Flathorn silt loam at Pt. MacKenzie and harvested at the same time, did not differ in crudeprotein content.

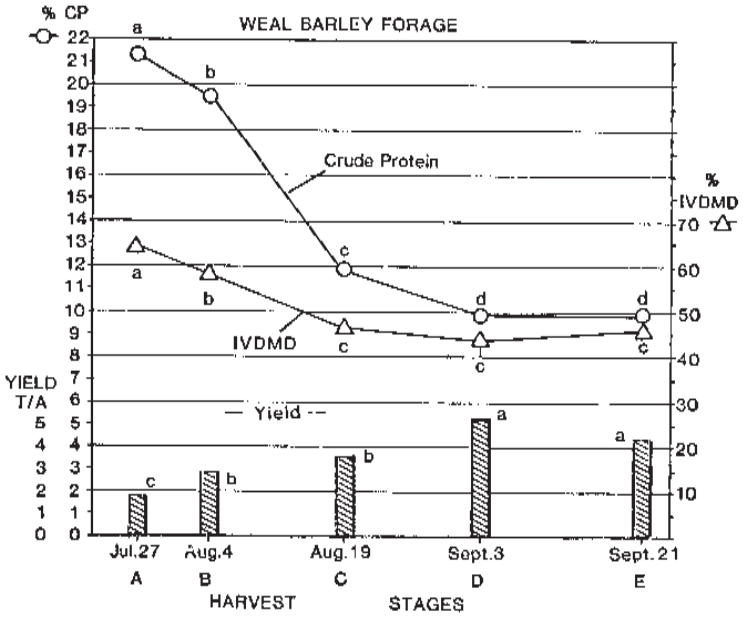

Figure 3. Oven-dry yield, crude-protein content, and per cent digestible dry matter (IVDMD) of Weal barley harvested at different growth stages were as follows: A — head emergence; B — fully headed; C — milk; D — soft dough; and E — hard dough. The small letters associated with the symbols indicate whether the differences between values are significant at the 95 per cent confidence level, as in the previous figures.

Table 3. Forage-quality percentages for Weal barley seeded June 7, 1982, and harvested at different stages at Palmer; fertilized at 90-90- 90 lb/acre on N-P_2O_5-K_2O.

Harvest Stage* and Date	Dry Matter	P	K	Ca	Mg	IVDMD
A: Jul 27	10.7e	0.21a	1.72a	0.88b	0.21ab	64.2a
B: Aug 4	14.1d	0.19a	1.62a	0.96ab	0.23a	58.7b
C: Aug 19	17.7c	0.13b	1.22b	0.94ab	0.22a	46.1c
D: Sep 3	20.9b	0.08c	1.05b	0.99a	0.19b	44.6c
E: Sep 21	29.3a	0.10be	1.10b	0.65c	0.13c	46.5c

*Harvest stages: A - head emergence; B - fully headed; C - milk; D - soft dough; E - hard dough.

**Values within a column followed by the same letter do not differ significantly at the 95 per cent level of confidence (Duncan's multiple-range test).

Table 4. Yield of crude protein and digestible dry matter obtained by Toral oats and Weal barley at different stages of growth at Pt. MacKenzie and Palmer, respectively.

	Toral Oats (Pt. MacKenzie)		Weal Barley (Palmer)	
Stage of Harvest	Crude Protein	Digestible Dry Matter	Crude Protein	Digestible Dry Matter
	tons/acre			
Head emergence	0.16	0.93	0.38	1.14
Fully headed	0.18	1.25	0.55	1.66
Milk stage	0.19	1.87	0.42	1.63
Soft dough	0.18	2.04	0.51	2.32
Hard dough	0.21	2.35	0.44	2.05

However, Weal barley grown on Bodenburg silt loam at Palmer provided higher yields and much higher protein content at the various harvest stages than Toral oats grown at Pt. MacKenzie. But harvest of the badly lodged barley, unless cut in the earliest stages before serious lodging had occurred, would have been difficult under field conditions. The N fertilization rate was inappropriately high for barley grown on Bodenburg silt loam.

References

Brundage, A.L., and L.J. Klebesadel. 1970. Nutritive value of oat and pea components of a forage mixture harvested sequentially. *J. Dairy* Sci. 5 3: 7 9 3 - 7 96.

Brundage, A.L., and W.J. Sweetman. 1967. Comparative feeding value of oat-pea forages ensiled at two stages of maturity. *J. Dairy Sci*. 50:696-699.

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. *J. Dairy Sci.* 62:740-745.

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

Hodgson, H.J. 1956. Effects of seeding rates and time of harvest on yield and quality of oat-pea forage. *Agron. J.* 48:87-90.

Klebesadel, L.J. 1966. Planting rate of oats and peas: Some yields, quality and cost considerations. Univ. of Alaska Agric. Exp. Sta. Forage Research Report 4. 5 pp.

Klebesadel, L.J. 1969. Chemical composition and yield of oats and peas separated from a forage mixture at successive stages of growth. *Agron. J.* 61: 7 13 - 7 16.

National Research Council. 1971. Nutrient requirements of beef cattle. Printing and Publishing Office, National Academy of Sciences, Washington, D. C.

National Research Council. 1976. Nutrient requirements of beef cattle. Printing and Publishing Office, National Academy of Sciences, Washington, D.C.

Sweetman, W.J., and A.L. Brundage. 1960. Better forage for Alaska's dairy industry. Univ. of Alaska Agric. Exp. Sta. Bull. 30. 19 pp.

Taylor, R.L. 1972. New cereal varieties for Alaska. *Agroborealis* 4:27-28.