Forage Extension Program

Forage Yield, Quality and Nitrate Concentration of Barley Grown Under Irrigation

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Annual cereal forages have been a major source of hay for Montana producers since the early 20th century. Acreage of these crops fell below 300,000 acres in 1952, and cereals are typically used as emergency forages. Cereal forage acreage has increased significantly since 2000, particularly during dry years. Since 2000, cereal hay was harvested on about 300,000 acres with average production of 453,000 tons (2007 Montana Agricultural Statistics).

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A number of cereals have been cut for hay in Montana, including winter wheat, spring wheat, barley, oat, triticale, rye, spelt and emmer. For hay production, plant breeders have selected for awnless or awnletted (reduced awns) head types to reduce instances of lumpjaw or sore eyes. Hooded head type barley varieties such as Horsford, Westford and Haybet were released for dry hay production. Barley is the most widely-used cereal forage in Montana, and Haybet currently is planted on 11% of all barley acreage. Despite the availability of hay-type varieties, it appears that much of the barley hay harvested comes from malt or feed varieties, like Harrington or Baronesse, respectively.

Barley is a flexible crop for Montana livestock producers. Malt and feed barley can be grown for cash income, or feed and hay type barley can be grown for feed on-site. A further advantage of barley hay for ranchers is its excellent fit as a rotation crop with alfalfa. When old stands of alfalfa or alfalfa-grass hay are renovated, a cereal or other grassy crop should be grown for two or three years to disrupt weed and disease cycles. On dryland conditions, hay barley can maintain good hay production during the crop rotation phase. In irrigated production systems, barley is a major rotation component. However, very little is published on irrigated hay barley production or the potential value of the hay for livestock. The objectives of this study were to compare several feed and forage type barley varieties for forage yield and quality at Bozeman, MT.

Materials and Methods

Eight barley varieties were grown in trials in 2000, 2001 and 2002 under wheel-line irrigation near Bozeman, MT. The varieties included two-row feed varieties (Baronesse, Lewis, and Valier), two-row hay types (Haybet and Hays), a six-row feed and malt type (Karl), and six-row hay types (Westford and Bestford). The fields were established in a randomized complete block design, with four replications. Seed of all varieties were planted at a uniform rate of 21 seeds per square foot with a cone plot seeder. The plots were 5 feet x 20 feet, and consisted of seven rows on 6-inch spacings. Planting occurred on 2 May in 2000 and 2001, and on 13 May 2002. Adequate fertilizer, irrigation water, and appropriate herbicides were applied to maintain optimum forage production.

After the boot stage, all plots were monitored closely to determine the appropriate harvest date. The targeted harvest date was the "watery" to "milky" stage of kernel development to optimize both forage production and quality. A harvest date was selected each year (14 July 2000, 12 July 2001, and 22 July 2002) when most of the entries were in the appropriate harvest stage.

On the day of harvest, several morphological traits were measured, including: visual stage of maturity, plant height, flag leaf width and height of the flag leaf attachment. Plots were cut with a self-propelled sickle-bar plot harvester, and fresh plot weights were recorded. Forage yields were calculated on an air-dry basis to estimate tons of dry forage per acre. Immediately prior to harvest, a one-foot sample of an inside row was clipped from each plot for dry matter determination and forage quality analyses. Fresh weights were obtained with a portable scale in the field, then samples were transported in paper bags to the laboratory and processed. All samples were sub-divided into two portions: "heads" and "forage" by detaching all heads from the stems, and fresh weights for each were weighed (the plant samples were refrigerated in plastic bags during this process, which required about two hours per replication). All head and forage samples were dried at 120° F for one week in a forced-air dryer, then weighed again for dry weights ("air-dry").

After the head and forage samples were weighed, they were ground in a Wiley mill, and analyzed for several traits as described by Surber et al. (2001). These included dry matter (DM), crude protein (CP) and nitrate-N (NO3-N) determinations (AOAC, 2000), and neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Van Soest et al., 1991). All samples were run in duplicate, and the results were reported on a 100% DM basis. Portions of the 2000 and 2002 data were previously analyzed and reported by Surber et al. (2001, 2003). The three-year summary presented here was generated by analyzing each of the agronomic and forage quality parameters by analysis of variance (ANOVA) as a split-plot design with years as main plot effects and the barley varieties as sub-plots.

Results and Discussion

Across the three years, Lewis and Haybet were the highest yielding varieties, significantly out-yielding Westford and Karl (Table 2). In previous yield trials prior to the release of Haybet, Lewis typically had superior forage production (Wichman, unpublished data). The contribution of heads to total dry matter production was higher in feed barley lines (32.1 to 42.7%) compared to the hay types (24.2 to 28.2%).

Concentrations of CP in the whole plant, forage and head were similar (12.4, 12.7 and 12.2%) but were not uniform across varieties (Table 3). Lewis, the highest-yielding variety, had consistently lower CP than most other lines. The six-row hay lines (Bestford and Westford) had higher whole plant and forage CP than most other varieties, and Bestford was significantly higher ($P<0.05$) than Lewis, Baronesse and Haybet.

In contrast to CP, the six-row lines had higher levels of whole plant, forage and head NDF and ADF (Tables 4 and 5). The two-row hay barley varieties (Haybet and Hays) had significantly lower whole plant NDF levels than Westford and Bestford ($P<0.05$). These data indicated that the dry matter intake of Haybet, Hays and several of the two-row feed barley varieties would be superior to the six-row hay varieties. Similarly, Westford had the highest

ADF levels, indicating that the digestibility of this variety was inferior to the others. These differences in fiber among Haybet and Westford agree with those previously reported by Surber et al. (2001).

Nitrate-N was analyzed on all of the barley samples, as this has been a major problem with cereal forages produced in Montana for several years. Across all three years, whole plant NO3-N concentrations ranged from 0.108 to 0.282 (Table 6). Each year, and across years, there were several entries with excessive levels of whole plant NO3-N. A NO3-N concentration up to 0.12% is generally safe for most livestock, but limited to 50% of the diet for pregnant animals (Cash et al. 2002). Levels up to 0.23% NO3-N can be fed at 25 to 50% of the ration for non-pregnant animals, but should not be fed to pregnant animals. Across the three years of the trial, Haybet had significantly lower whole plant and forage NO3-N than Karl, Bestford and Westford. Head NO3-N levels were low, and there were no differences among the varieties, indicating that as grain begins filling in the watery to milk stage, nitrogen in the head is primarily in the form of CP. In a recent study, Surber et al (2003) reported that whole plant NO3-N in barley declined from 0.23% at the boot stage to 0.14% at the grain milk stage.

Implications

The results from this three-year trial indicate that barley is a good annual forage option for irrigated production in western Montana. When producers renovate old alfalfa stands or pastures, barley would maintain an acceptable irrigated forage base of over 3 tons per acre. Forage concentrations of CP, ADF and NDF of forage barley appear to be adequate for maintenance diets of most livestock. Several awned feed barley lines had superior forage yields or quality. These varieties could be used for haylage or dry hay, however the hay should be processed before feeding. No selection has been imposed on barley for improved forage quality, but it appears that selection for improved fiber levels could be effective. Research is currently underway to include forage quality parameters in the barley breeding program at MSU.

Table 1. Forage yield and quality of eight barley varieties grown under irrigation near Bozeman, MT in 2000 – 2002.

	Two-row type					**Six-row type**		
	Baronesse	Lewis	Valier	Haybet	Hays	Karl	Bestford	Westford
Plant Height (cm)	82.0d	83.9d	81.6d	87.4c	84.2d	83.0d	103.9a	96.8b
Whole Plant Yield (air dry tons/acre)	3.26abc	3.42a	3.28ab	3.36a	3.33ab	3.01c	3.27abc	3.07bc
Forage Yield (air dry Tons/acre)	2.15c	2.16c	2.23bc	2.41a	2.40a	1.73d	2.40a	2.34ab
Head Yield (air dry tons/acre)	1.10b	1.25a	1.05bc	0.95cd	0.94cd	1.28a	0.87de	0.74e
Heads as % Whole Plant Yield	33.7c	36.8b	32.1c	28.2d	27.9d	42.7a	26.6de	24.2e
Whole Plant % Crude Protein	12.0bc	11.2c	12.5ab	12.0bc	12.6ab	12.6ab	13.4a	12.9ab
Forage % Crude Protein	11.5cd	10.6d	12.3bc	11.6cd	12.4bc	12.6bc	13.9a	13.0ab
Head % Crude Protein	13.1a	12.4ab	13.1a	13.1a	13.1a	12.5ab	12.1b	12.7ab
Whole Plant % Acid Detergent Fiber	31.4bc	32.2bc	31.7bc	30.5b	33.3cd	26.9a	34.1de	35.4e
Forage % Acid Detergent Fiber	38.3bc	40.2c	38.0bc	35.5a	39.3bc	35.3a	37.6ab	39.1bc
Head % Acid Detergent Fiber	18.6cd	16.2ab	18.0bcd	18.0bc	20.3d	14.0a	24.4e	25.5e

Whole Plant % Neutral Detergent Fiber	58.9c	56.3a	57.0b	57.0b	60.5c	54.5a	62.8d	64.4d
Forage % Neutral Detergent Fiber	63.2b	62.8b	61.0a	61.1a	64.4bc	60.4a	63.9bc	65.5c
Head % Neutral Detergent Fiber	51.1c	43.4a	48.6bc	46.8ab	51.5c	46.0ab	60.6d	61.5d
Whole Plant % NO3 N	0.162ab	0.120a	0.163ab	0.108a	0.173ab	0.216bc	0.281c	0.282c
Forage % NO3N	0.234ab	0.160a	0.226ab	0.141a	0.239bc	0.330cd	0.369d	0.366d
Head % NO3N	0.018a	0.033a	0.020a	0.015a	0.022a	0.012a	0.020a	0.018a

a-e: values within a row followed by different letters are significantly different ($P<0.05$).

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