

1 **Effect of Initial Harvest Timing on Cultivar Yield in Cool-Season Forage**
2 **Grass Trials**

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4 M.H. Hall*, R.C. Stout, and A. Deak
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21 Department of Crop and Soil Sciences, Pennsylvania State Univ., University Park, PA 16802.
22 Received 29 March, 2004. *Corresponding author: (mhh2@psu.edu)

Effect of Initial Harvest Timing on Cultivar Yield in Cool-Season Forage Grass Trials

ABSTRACT

Cool-season forage grasses have a range of inter- and intra-species heading dates in the spring. Selecting a manageable harvest schedule that does not confound yield estimates through a harvest X maturity interaction is troublesome in forage variety trials. Our objective was to determine the extent of interaction between cool-season forage grass maturity and initial spring harvest when estimating total season yield. Cultivars of orchardgrass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), smooth brome (*Bromus inermis* Leyss.), tall fescue (*Festuca arundinacea* Schreb.), and timothy (*Phleum pratense* L.) differing in relative maturity were established in silt loam soils in 1997 and 1999 at Rock Springs, PA. Orchardgrass and perennial ryegrass were established at the same site in 2001. After the seeding year, three harvest schedules resulting in four harvests yr⁻¹ were applied: A) each individual cultivar was harvested when it reached boot stage (R0 stage); B) all cultivars within a species were harvested when the average cultivar maturity within that species was at boot stage; C) all cultivars of all species were harvested when the average maturity of all species/cultivars was at boot stage. Subsequent harvests were taken at 35-day intervals. There was no cultivar X harvest schedule interaction for DM yields in this research. Tall fescue (12140 kg ha⁻¹ yr⁻¹) was the highest yielding and perennial ryegrass (5316 kg ha⁻¹ yr⁻¹) was the lowest yielding species. Cultivars within each species differed in DM yield. Delaying orchardgrass or smooth brome harvest beyond the boot stage (harvest schedule C) resulted in increased yields. The results of this research indicate that timing of initial harvest has no effect on relative cultivar total-season yield within the species tested.

Abbreviations: DM, dry matter.

1 Cool-season forage grass testing programs frequently have multiple species and multiple
2 cultivars within each species in a single trial. Differences in inter- and intra-species heading
3 dates for these grasses create a dilemma over when to harvest in the spring to compare total
4 yields fairly. It is difficult to select a harvest schedule that minimizes labor but does not
5 confound yield estimates through a harvest X cultivar maturity interaction.

6 Delaying initial spring harvest increased the season total DM yield of orchardgrass
7 (Krueger and Scholl, 1979; Kunelius et al., 1974; Mislevy et al., 1974), perennial ryegrass
8 (Binnie et al., 1980; Green and Eyles, 1960) smooth brome grass (Kunelius et al., 1974), tall
9 fescue (Mason and Lachance, 1983), timothy (Kunelius et al., 1974; Mason and Lachance, 1983;
10 Mislevy et al., 1974 and 1977), and reed canarygrass (*Phalaris arundinacea* L.) (Bonin and
11 Tomlin, 1968; Krueger and Scholl, 1979; Mislevy et al., 1977). These results imply that cultivars
12 of these species with different heading dates might yield differently based on timing of initial
13 spring harvest. Unfortunately, multiple cultivars of these species were not included in these
14 studies. Kunelius and McRae (1986) using timothy cultivars with differing heading dates found
15 that timing of initial harvest affected season total DM yield equally for all cultivars. Taube et al.
16 (1989), Tuabe (1990) and Scheijgrond and Vos (1960) reported that early initial harvests (early
17 to mid May) of perennial ryegrass resulted in higher season total DM yields for late heading
18 cultivars while late initial harvests (late May to early June) resulted in higher yields for early
19 heading cultivars.

20 Austenson (1964) reported that there was no harvest date X cultivar interaction for yield of
21 three orchardgrass and timothy cultivars. He concluded that a single, first-cut harvest date
22 provided accurate yield estimates for cultivars with varying maturities.

23 An informal survey of 14 research programs involved in cool-season forage grass
24 evaluation in the USA and Canada found a range in criterion for when initial harvest is taken
25 (Hall, unpublished). Three locations harvested individual entries based on maturity, five
26 locations harvested all entries within a species on the same date, and six locations harvested all
27 entries of all species in the trial on a same date. While there are numerous investigations into the
28 effect of initial harvest on yield of cool-season grasses, few used more than a single cultivar of
29 each species. This leaves cool-season forage grass breeders and agronomists involved with grass
30 evaluation uncertain if their initial harvest timing is confounding their results. To address this
31 concern we used multiple cultivars of five cool-season grass species to determine the extent of
32 interaction between cool-season grass maturity and initial harvest date when estimating season
33 total DM yield.

MATERIALS & METHODS

Study 1

Early, medium and late heading cultivars of orchardgrass, perennial ryegrass, smooth brome grass, tall fescue, and timothy were established in 1.8 x 5.1 m plots in a Murrill silt loam (fine-loamy, mixed, mesic Typic Hapludults) soil in 1997, and a Hagerstown silt loam (fine-loamy, mixed, mesic Typic Hapludalfs) soil at the Russell E. Larson Agric. Research Center near Rock Springs, PA in 1999 (Table 1). Cultivars were selected based on breeder/marketer information to achieve a range of cultivar maturities within a species. Prior to planting, soils were limed and fertilized with P₂O₅ and K₂O according to soil test recommendations. Herbage was removed from the plots twice during the establishment year and N applied at 39 kg ha⁻¹ after each removal. Yield was not determined during the establishment year.

After the seeding year, P₂O₅ and K₂O were applied at 80 and 220 kg ha⁻¹, respectively, each year. Nitrogen was applied at 56 kg ha⁻¹ at grass “greenup” and 39 kg ha⁻¹ after each harvest except for the final harvest each year when no N was applied. Four harvests were taken each year using one of three harvest schedules: A) each individual cultivar was harvested when it reached boot stage (R0 stage; Moore et al., 1991); B) all cultivars within a species were harvested when the average cultivar maturity within that species was at boot stage; C) all cultivars of all species were harvested when the average maturity of all species/cultivars was at boot stage. Subsequent harvests were taken at 35-day intervals. Yields were determined in 1998 and 1999 for the 1997 seeding and in 2000 and 2001 for the 1999 seeding by harvesting forage at a 5-cm height from a 0.9 x 4.6-m area within each plot.

The statistical arrangement was a strip, split-split plot arrangement of a randomized complete block design with four replicates. Species were the strip plots, harvest schedules were the subplots and cultivars were the sub-subplots.

Study 2

Based on the results of Study 1, a second study was established at the same research center in a Hagerstown silt loam soil in 2001 using six cultivars each of orchardgrass and perennial ryegrass that varied in heading dates (Table 1). Soil fertility, plot size, harvest schedules and statistical design were the same as in Study 1.

For both studies, only the yearly total DM yield data were analyzed. Homogeneity of variance was tested using Hartley’s *F*-max test (Milliken and Johnson, 1984) and data from different years within a study was combined when appropriate. Analysis of variance within the PROC GLM procedures of SAS (SAS Institute, Inc., 1999) were used to test treatment effect on total yearly yield. Tukey’s multiple-comparison procedure was used for mean separations. Unless otherwise stated, differences reported in this paper are all at the $P \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

As a result of the homogeneity of variance test, DM yield data within each grass species from 1998, 1999, 2000 and 2001, and orchardgrass data from 2002 and 2003 were combined. Perennial ryegrass data from 2002 and 2003 could not be combined because three cultivars did not survive the winter of 2002-2003.

Growing Conditions

Average monthly temperatures in each of the six growing seasons associated with this research were within 2.0° C of the 30-year monthly average except in July 2000 and Sept. 1998 when it was 2.9° C less and 2.5° C greater than normal, respectively (Table 2). Total rainfall during the same period was within 30 mm of the 30-year average in only two of the five seasons (Table 2). Total rainfall during the growing season in 1998, 2002 and 2003 was 60 mm greater, 60 mm less and 270 mm greater than normal, respectively. Although climatic conditions from year-to-year caused shifts in total season yield, they affected all cultivars within a species similarly.

Study 1

Within a species, cultivars differed in date of boot by an average of five to six days (Table 3). The earliest and latest maturing cultivars in each species corresponded with maturity information provided by the breeder/marketer, except for orchardgrass when the expected latest maturing cultivar was actually the earliest to mature (Table 1).

There was no cultivar X harvest schedule interactions for DM yield of any of the species (Fig. 1). However, DM yield rankings of orchardgrass and perennial ryegrass cultivars were numerically differ among harvest schedules. This nominal difference warranted additional evaluation of more cultivars of these species for potential cultivar X harvest schedule interactions.

Harvest schedule affected dry matter yield. In harvest schedule C (all cultivars of all species were harvested when half the species/cultivars had reached boot stage), orchardgrass and smooth bromegrass cultivars were harvested later than boot stage, whereas the perennial ryegrass and timothy cultivars were harvested before boot stage (Table 3). Delaying harvest of orchardgrass or smooth bromegrass beyond the boot stage resulted in increased yields in this study (Fig. 1). Krueger and Scholl (1979), Kunelius et al. (1974) and Mislevy et al. (1974) reported a similar response of orchardgrass and smooth bromegrass to delays in harvest. Our protocol did not allow the other grass species to mature past the boot stage so we cannot confirm the findings of others reported in this paper regarding delayed harvest of other species.

Species differed in DM yield [tall fescue ($12140 \text{ kg ha}^{-1} \text{ yr}^{-1}$) > orchardgrass > smooth bromegrass > timothy > perennial ryegrass ($5443 \text{ kg ha}^{-1} \text{ yr}^{-1}$)]. Similar rankings for species DM yield were reported by Krueger and Scholl (1979), Kunelius et al. (1974) and Mason and Lachance (1983). Within all species except perennial ryegrass, cultivars were different in DM yield (Fig. 1).

Study 2

The average range in cultivar date of boot was 7 and 8 d for orchardgrass and perennial ryegrass, respectively (Table 3). Observed cultivar maturity did not correspond with maturity information provided by the breeder/marketer (Table 1). The observed maturity of the expected earliest and latest maturing cultivars of orchardgrass was reversed in this study. As in Study 1, orchardgrass was harvested later than boot stage and perennial ryegrass was harvested earlier than boot stage in the C harvest schedule (Table 3).

There was no cultivar X harvest schedule interactions for DM yield of orchardgrass or

1 perennial ryegrass (Fig. 2).

2 Delaying harvest of orchardgrass resulted in increased yield (Fig. 2). Only the three highest
3 yielding cultivars of perennial ryegrass in 2002 survived into 2003. Cultivars within orchardgrass
4 and perennial ryegrass, in 2002, species differed in DM yield (Fig. 2). There were no differences
5 in perennial ryegrass DM yield among cultivars or harvest schedules in 2003 (Fig. 2). As in
6 Study 1, orchardgrass yielded more than perennial ryegrass.

7 **CONCLUSIONS**

8 We conclude that season total DM yield of orchardgrass, perennial ryegrass, smooth
9 bromegrass, tall fescue, and timothy cultivars is not influenced by a cultivar maturity X harvest
10 schedule (initial harvest date) interaction. Therefore, when evaluating for DM yield, cultivars of
11 these species can be harvested on the same day regardless of relative cultivar maturity. This
12 conclusion is unlikely to apply when evaluating cultivar quality because of the direct relationship
13 between maturity and quality. It also appears that maturity information provided by the
14 breeders/marketers of these grasses may not accurately reflect the relative maturity observed
15 when cultivars from a different breeders/marketers are evaluated together. Further research is
16 warranted to develop a standardized maturity scale for perennial cool-season grasses.

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38 dry matter production of contrasting varieties of perennial ryegrass. *Das Wirtschaftseigne*
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1 Fig. 1. Dry matter yield of early, medium and late maturing cultivars (CUL) of five cool-season
2 forage grass species subjected to three spring harvest schedules (HS): A) each individual
3 cultivar was harvested when it reached boot stage; B) all cultivars within a species were
4 harvested when the average cultivar maturity within that species was at boot stage; C) all
5 cultivars of all species were harvested when the average maturity of all species/cultivars was
6 at boot stage. Subsequent harvests were taken at 35 day intervals. Values for each species are
7 the means of 2 locations and two years.
8

9 Fig. 2. Dry matter yield of six different maturing cultivars (CUL) of two cool-season forage
10 grass species subjected to three spring harvest schedules (HS): A) each individual cultivar
11 was harvested when it reached boot stage; B) all cultivars within a species were harvested
12 when the average cultivar maturity within that species was at boot stage; C) all cultivars of
13 all species were harvested when the average maturity of all species/cultivars was at boot
14 stage. Subsequent harvests were taken at 35 day intervals. Values for orchardgrass are the
15 means of two years.

1 Table 1. Observed relative maturities of the cool-season forage grass cultivars used in this
 2 research. Subscript numbers are relative maturities within a species according to breeder
 3 and/or marketer information (1 is earliest, 6 is latest).

----- Observed relative maturities -----							
Species	Earliest	Early	Medium early	Medium late	Late	Latest	
Cultivars							
Study 1 (seeded in 1997 & 1999)							
Orchardgrass	Pennlate ₃	---	Exp. [†] ₁	---	---	Warrior ₂	
P. ryegrass	Exp. ₁	---	Rosalin ₂	---	---	Lafayette ₃	
S. bromegrass	Saratoga ₁	---	Baylor ₂	---	---	Exp. ₃	
Tall fescue	Stargrazer ₁	---	K-31 ₂	---	---	Barcel ₃	
Timothy	Tiller ₁	---	Clair ₂	---	---	Climax ₃	
Study 2 (seeded in 2001)							
Orchardgrass	Megabite ₆	Exp. ₂	Exp. ₅	Takena ₄	Quantum ₃	Prairial ₁	
P. ryegrass	Anton ₂	Aries ₁	Clermont ₆	Maverick Gold ₃	Quartet ₄	Polly ₅	

17 [†] Experimental cultivar.

18

1 Table 2. Air temperature and rainfall at Rock Springs, Pennsylvania during the growing seasons
 2 from 1998 through 2003.

3	Average monthly air temperature (°C)								Rainfall (mm)						
	4								30-yr						
5		1998	1999	2000	2001	2002	2003	avg	1998	1999	2000	2001	2002	2003	avg
6	Month	1998	1999	2000	2001	2002	2003	avg	1998	1999	2000	2001	2002	2003	avg
7															
8	April	10.0	9.0	8.6	9.4	9.4	8.7	8.8	172	96	101	72	28	62	84
9	May	17.0	15.1	15.9	14.4	12.7	13.6	15.0	116	36	82	36	151	120	101
10	June	18.5	19.2	19.7	19.3	19.5	18.1	19.6	131	104	117	146	125	118	102
11	July	20.7	22.9	18.9	19.5	21.8	20.7	21.8	89	49	71	84	34	143	95
12	Aug.	20.9	19.4	19.1	21.3	21.6	21.6	20.7	71	156	99	81	52	236	86
13	Sept.	18.5	16.9	15.1	15.1	17.6	16.1	17.0	44	122	69	106	92	134	75

1 Table 3. Average day of year when first harvest was taken for various species/cultivars of
 2 perennial cool-season forage grasses under three harvest schedules.

3	Harvest	Relative	Perennial	Smooth	Tall		
4	schedule [†]	maturity	Orchardgrass	ryegrass	bromegrass	fescue	Timothy
5	Day of year						
6	Study 1 (harvest years of 1998-2001)						
7	A	Early	134	143	136	141	153
8	A	Medium	136	146	139	143	155
9	A	Late	140	149	141	147	159
10	B		136	146	139	143	155
11	C		143	143	143	143	143
12	Study 2 (harvest years of 2002 & 2003)						
13	A	Earliest	135	145			
14	A	Early	136	148			
15	A	Medium early	136	150 [‡]			
16	A	Medium late	140	151			
17	A	Late	142	153 [‡]			
18	A	Latest	142	153 [‡]			
19	B		138	150			
20	C		145	145			

21 [†] First harvest taken: A) each individual cultivar was harvested when it reached boot stage; B) all
 22 cultivars within a species were harvested when the average cultivar maturity within that species
 23 was at boot stage; C) all cultivars of all species were harvested when the average maturity of
 24 all species/cultivars was at boot stage.

