JOURNAL OF APPLIED SEED PRODUCTION, VOL. 7, 1989

Effect of Forage Harvest Frequency on Bermudagrass Seed Yield Under Dryland Conditions

T.L. Springer[1] and C.M. Taliaferro[2]

ABSTRACT

Bermudagrass, *Cynodon dactylon* (L.) Pers., management for seed production has been studied previously in the southern Great Plains only under irrigation. However, areas of the southern Plains with an annual rainfall of 60 - 85 cm with 10 - 15 cm distributed in May, June, and July have potential for bermudagrass seed production under dryland conditions. In 1983 and 1984, replicated field studies were conducted in Oklahoma without irrigation to determine the effects of late spring and early summer forage-harvest frequencies on subsequent seed development and yield. Methods of estimating seed yield were also evaluated. Harvest frequencies had a significant inverse effect on dry-matter forage yield associated with the seed crop each year. Seed yield, inflorescences unit area^{-1}, number of florets inflorescence^{-1}, and number of florets to set seed were dependent on rainfall distribution. Seed yield from unharvested primary spring growth in 1984, the drier year, produced the higher yields. In 1983, the density of inflorescences was highest following a two-harvest treatment, whereas a linear decline with each harvest was observed in 1984. In 1983, florets inflorescence^{-1} ranged from 193 - 228 for the unharvested (control) through the two-harvest frequency treatment before a significant reduction occurred with the onset of dry weather. An average of 159 florets inflorescence^{-1} remained constant across harvest treatments in 1984. Seed yield potential was three to four times greater than actual yield. Calculated yield based on yield components measured from 0.09 m^2 samples showed essentially the same treatment yield responses, although magnified, compared to the standard 0.9 x 6.1 m plot. Thus, data collected from extremely small plots can be used reliably to estimate relative seed yield.

Additional key words: Cynodon dactylon, **yield components**

INTRODUCTION

The relationship between management and cultural practices for seed production of 'Guymon' bermudagrass (*Cynodon dactylon* (L.) Pers.) has been described in detail (Ahring et al., 1982a; Ahring et al., 1982b). High seed yields are dependent on optimum inflorescence (head) densities and seed set over time. To obtain high head densities, a combination of forage growth, available N, and water distribution is required. Seed harvests from two-year-old stands of Guymon bermudagrass have produced 400 - 800 kg seed ha^{-1}. These yields were the result of water management to regulate seedhead production and flowering and of fall and spring N fertilization practices (Ahring et al., 1982a).

In the southern Great Plains, prior to fertilization, a late spring (1 to 15 May) forage harvest is essential to minimize the vegetative growth associated with seed production and to insure uniform development (Ahring et al., 1982a). To measure bermudagrass seed yield requires harvesting the plant at a height of 5 cm, thoroughly drying and threshing the sample, and cleaning the seed. This process is extremely time consuming when large numbers of large plots are involved. Although larger samples more precisely estimate seed yield, errors created during the process of drying, storage, processing, and cleaning are more likely to occur than with smaller, less bulky samples. The effect of frequency of forage removal on seed yield and the value of small vs. large plot yield measurements has not been established. Our objectives were to determine the effects of frequency of forage removal on the seed crop including seedhead densities, seed set, and seed yield and to develop efficient methods for measuring and predicting bermudagrass seed yields.

MATERIALS AND METHODS

A bermudagrass seed production block containing two cross-compatible experimental lines, A-12156 and A-9959 [i.e., the cv. Guymon (Taliaferro et al., 1983)], in a mixed planting was established at the USDA-ARS Southwest Livestock and Forage Research Station, El Reno, OK. The test area consisted of a Brewer clay loam (fine, mixed, thermic Pachic Arguistoll) soil. Data were collected from this planting in 1983 and 1984.

Harvest treatments were initiated 10 May each year and consisted of an unharvested (control); one harvest, primary spring growth removed 10 May; two harvests, 10

---

[1] T.L. Springer, USDA-ARS, 1301 N. Western St., Stillwater, OK 74075. Corresponding Author.

[2] C.M. Taliaferro, Dept. of Agronomy, Oklahoma State University, Stillwater, OK 74078.

Contribution of the USDA-ARS and the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma. Journal Article No. 5635 of the Oklahoma Agricultural Experiment Station. Received for publication 1 September 1989.

May and 10 June; three harvests, 10 May and 10 and 24 June; and four harvests, 10 May, 10 and 24 June, and 10 July. All harvests were made at a stubble height of 5 cm. Four replications were used each year in a randomized complete block design. Plots were 2.4 x 6.1 m.

Seed crops were harvested both years between 8 and 17 August from the first two treatments, while the last three were harvested between 20 August and 8 September. Two methods of sampling seed yields were used, i.e., by harvesting an area 0.9 x 6.1 m with a Jari[3] sicklebar mower and by hand clipping random 0.09 m^2 areas. The entire harvest for each large plot was bagged and dried at 65 C for 1 week, then weighed for dry matter (DM); seeds were threshed and cleaned. Prior to recording seed yield weights, each harvested plot was screened to remove inert material and blown to remove light and empty florets with a South Dakota[3] seed blower at an air-valve setting of 16° and weighed. Processed in this manner, each weighed 0.9 x 6.1 m plot yield contained 98% pure seed. Seed yield obtained from the 0.09 m^2 samples were handled in a similar way, except that processing was done in the laboratory. Seedheads in the latter samples were first separated from the vegetative material and counted. Ten heads were selected at random in each sample for determinations of average number of racemes $head^{-1}$, florets $head^{-1}$, and florets containing a caryopsis $head^{-1}$ (seed set). These data were used to calculate seed yield as follows:

Calculated seed yield (kg ha^{-1}) = {[seedheads unit $area^{-1}$ x number florets $head^{-1}$ x percent florets to set seed x 107,637] / 2,425,500 pure seed kg^{-1}}.

Analyses of variance were used to evaluate data on both an individual and a combined year basis. Correlation coefficients were calculated using the SAS procedure CORR (SAS Institute, 1982) for the 0.9 x 6.1 m seed yield, 0.09 m^2 seed yield, calculated seed yield, forage DM yield, florets $head^{-1}$, and percent seed set. The regression model, $Y_j = \beta_o + \beta_1 X_1 + \beta_2 X_2 + E_j$, was fitted to the data using least squares to obtain the best linear unbiased estimators of the parameters. Regression equations were generated for predicting actual seed yield in kg ha^{-1} using either calculated yield values or 0.09 m^2 sample yields as the X_1 variables. The X_2 variable represents harvest frequency (number of forage harvests prior to harvesting mature seed). Data for the 2 years, five harvest frequencies (0, 1, 2, 3, and 4), and four replications were analyzed using SAS procedure REG (SAS Institute, 1982).

Expected seed yield values obtained from the equations were compared with actual yields from standard-sized plots (0.9 x 6.1 m) by chi-square analysis using a P-value of 0.05 and a tolerance of 50 kg ha^{-1} of seed (Freese, 1960). In addition, equations were tested using both published (Ahring et al., 1974; Taliaferro et al., 1983) and unpublished data.

RESULTS AND DISCUSSION

Frequency of forage harvests had a significant ($P < 0.01$) effect on DM associated with seed yields, heads unit $area^{-1}$, number of florets $head^{-1}$, and number florets to set seed. Vegetative growth associated with seed production decreased linearly as the number of harvests increased in both years (Fig. 1). Harvest effects under dryland conditions in 1984 resulted in slower growth rates due to moisture stress. Early season, April through May, moisture in 1983 was 30 cm compared to 17 cm for 1984. Unharvested full season DM production in 1984 was half that measured for the same treatment in 1983. Yet, mean seed yields of unharvested plots in 1984 were much higher than in 1983. Seasonal forage growth optimal for good dryland bermudagrass seed production evidently lies between 2500 and 5000 kg ha^{-1} of DM.

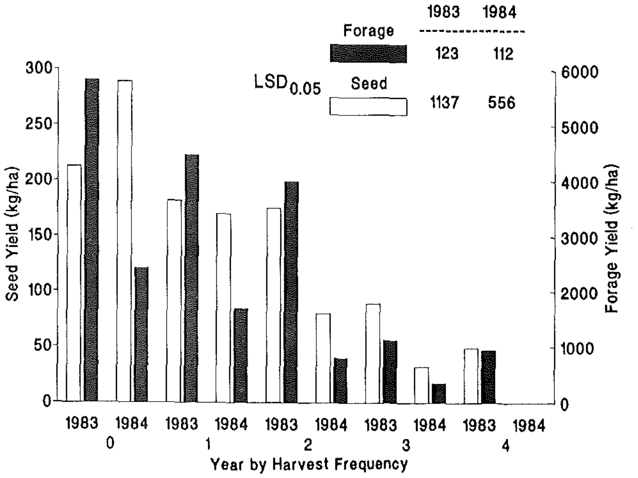

Fig. 1 **Mean effects of harvest frequencies (0 = unharvested; 1 = plots harvested 10 May; 2 = harvested 10 May and 10 June; 3 = harvested 10 May, 10 and 24 June; and 4 = harvested 10 May, 10 and 24 June, and 10 July both years) and years (1983 and 1984) on seed and forage production under dryland conditions.**

Highly significant differences were detected for harvest frequency on seed yield in both years. Rainfall patterns (Fig. 2) were more favorable for seed yields following forage harvest frequencies in 1983 than in 1984. Seed yields in 1984 declined linearly with each forage

---

[3] Mention of a trademark or proprietary product does not constitute a guarantee or warranty by the USDA or Oklahoma State Univ. and does not imply approval to the exclusion of other similar products.

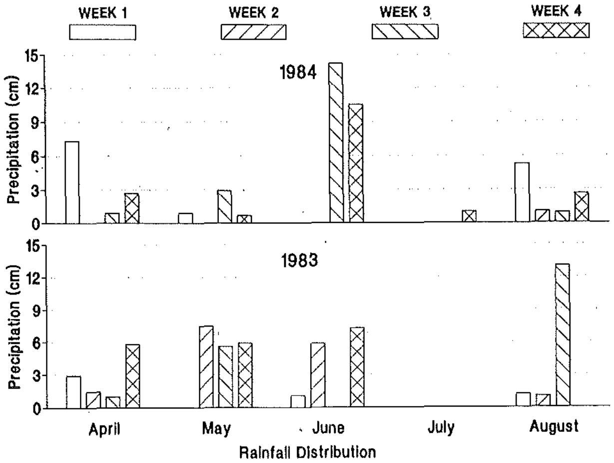

Fig. 2 **Seasonal rainfall (late spring and summer) received on experiment in 1983 and 1984.**

harvest. With the exception of the unharvested treatment, the harvest frequency effects in 1984 reduced seed yields below that of corresponding treatments in 1983. Yield measured by the smaller plot size showed significant yield differences for harvest effects. Although yield trends were the same, seed yields measured by the smaller plots averaged nearly twice as much (250 kg ha^{-1}) as the larger standard plots (128 kg ha^{-1}). The smaller plots were also used to measure components of yield, e.g., number inflorescences unit $area^{-1}$, number of racemes $head^{-1}$, number florets $head^{-1}$, and number florets $head^{-1}$ to set seed (caryopses) at harvest each year. Calculated yield based on yield components was on the average 4.7 times greater than the true plot yield. Although seed yield was magnified, treatment trends were the same.

The number inflorescences unit $area^{-1}$ and florets $head^{-1}$ as influenced by harvest frequency varied significantly between years. The highest number of inflorescences unit $area^{-1}$ were obtained following a two-harvest, 10 May and 10 June, treatment in 1983. However, head densities in 1984 declined (Fig. 3) with each harvest increment. The larger head numbers unit $area^{-1}$ in 1983 were accompanied by a greater number of florets $head^{-1}$. A significant year effect, in addition to harvest frequency and harvest frequency by year interaction, for number of florets $head^{-1}$ were measured. The average number of florets $head^{-1}$ (i.e., 159) during the dry season of 1984 remained constant across harvest treatments. In 1983, however, the average number of florets $head^{-1}$ ranged from 193 for the unharvested treatment to 228 for the two-harvest treatment before significant reductions occurred.

Florets $head^{-1}$ to set seed (caryopses) averaged 54 and 56, across all treatments for 1983 and 1984, respectively.

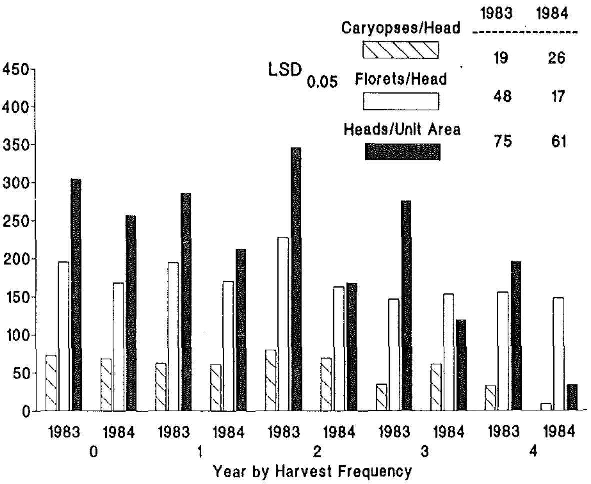

Fig. 3 **Mean effects of harvest frequencies and year (1983 and 1984) on three components of bermudagrass seed yield under dryland conditions.**

The highest seed set, 62 to 72 caryopses $head^{-1}$, occurred both years in the one- and two-harvest treatments. Seed set of plots from treatments harvested after 10 June was significantly reduced, with a range from 21 to 48 caryopses set $head^{-1}$. The susceptibility of flowering stigmas to late July and August hot dry winds may have influenced seed set in treatments having maturity dates after 20 August. However, considering the differences in the average number of florets $head^{-1}$ in 1983 compared to 1984, seed set was superior in 1984, the drier year.

Analyses of variance for both calculated and small plot yields showed the same trends as the seed yield data from the large plots. This suggested a positive relationship between the two plot sizes and that small samples could be used to predict relative yields. Regression analysis established a yield equation of Y = 185.8 + 0.059 (calculated yield) - 46.3 (harvest frequency) for calculated yields to predict actual yield. Similarly, a yield equation, Y = 116.9 + 0.286 (0.09 m^2 yield) - 29.9 (harvest frequency) was established for 0.09 m^2 plot yield to predict actual yield. The standard error of estimate (MSE) and R^2 values for each equation were 75.8 and 0.56 for calculated yield, and 64.8 and 0.68 for 0.09 m^2 plot yield.

Chi-square values, with and without the elimination of bias, tested against actual plot yields were less than the x^2 (0.05) tabular values. Thus, yield equations derived by the two methods provide essentially the same accuracy. X^2 values were also acceptable when testing these equations against two years of unpublished data from an unrelated irrigated study consisting of 12 cultivars and 6 replications and having rather high seed yields (300 - 600 kg ha^{-1}). A similar test using the 0.09 m^2 yield to predict actual yields of published data (Ahring et al., 1974) consisting of three replications and seven main plots with

Table 1. Correlations between methods of estimating seed yield and related yield component traits, based on 40 observations each year.

Yield and yield component traits	Seed yield Small-plot	Seed yield Calculated	Dry matter	Florets per head	Percent seed set
Large-plot yield	0.77**	0.59**	0.63**	0.33	0.41
Small-plot yield		0.86**	0.59**	0.53	0.59**
Calculated yield			0.68**	0.68**	0.64**
Dry matter				0.65**	0.25
Florets head^{-1}					0.17

**Significant at $P < 0.01$

each main plot containing a male and female parent and their respective hybrid showed acceptable χ^2 values.

Positive correlation coefficients existed for all elements of the correlation coefficient matrix (Table 1). High correlation coefficients were noted between the actual seed yield and the 0.09 m^2 seed yield, the calculated seed yield, and the DM forage yield, respectively.

Results of this study attribute variability in bermudagrass seed production under dryland conditions in the southern Great Plains to seasonal moisture and year effects on growth as well as to forage harvests prior to seed harvests. Management strategy for optimizing seed yields depends on established long-time rainfall patterns. Early spring weather combined with adequate N-fertilization favors rapid plant growth. This growth period, if followed by alternate wet and dry cycles, first to promote and then to slightly stress plant growth, will produce good seed crops. Alternate wet-dry cycles stimulate seedhead production and flowering and are needed to produce a high accumulated head density with good seed set. The negative effect of too much growth due to wet spring weather and head density can be offset by one or two forage harvests in May. Yield potential under dryland conditions both years was 3 to 4 times greater than the actual yield.

ACKNOWLEDGMENT

The authors are grateful to Dr. R.M. Ahring, USDA-ARS (Ret.), Stillwater, OK, for his assistance during this study and his critical review of this manuscript.

REFERENCES

1. Ahring, R.M., C.M. Taliaferro, and R.D. Morrison. 1974. Seed production of several strains and hybrids of bermudagrass, *Cynodon dactylon* (L.) Pers. Crop Sci. 14:93-95.
2. Ahring, R.M., C.M. Taliaferro, and W.L. Richardson. 1982a. Management of bermudagrass for seed production in Oklahoma. Okla. Agric. Exp. Stn. Tech. Bull. T-158.
3. Ahring, R.M., C.M. Taliaferro, and W.L. Richardson. 1982b. Single-cross bermudagrass seed production under different management. Agron. J. 74:445-446.
4. Freese, F. 1960. Testing accuracy. Forest Sci. 6:139-145.
5. SAS Institute Inc. 1982. SAS user's guide: Basics. SAS Institute Inc., Cary, NC.
6. Taliaferro, C.M., R.M. Ahring, and W.L. Richardson. 1983 Registration of Guymon bermudagrass. Crop Sci. 23:1219.