1997

Notes: Forage Yield, Quality, And Fertility Of Sorghum X Sudan Grass Hybrids In A1 And A3 Cytoplasm

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Published November, 1997

NOTES

FORAGE YIELD, QUALITY, AND FERTILITY OF SORGHUM × SUDAN GRASS HYBRIDS IN A1 AND A3 CYTOPLASM

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Abstract

Currently, no information is available comparing the agronomic performance of A1 and A3 cytoplasms in sorghum × sudangrass [*Sorghum bicolor* (L.) Moench] hybrids. The objectives of this study were to compare the effects of A1 and A3 cytoplasm on the maturity, fertility, height, forage yield, and forage quality of sorghum × sudangrass hybrids. In 1989, pollen from a bulk of eight sudangrass populations was used to pollinate four sorghum lines that had been male-sterilized in both A1 and A3 cytoplasm. Hybrids were grown at the Univ. of Nebraska Field Laboratory, Ithaca, NE, in 1990 and 1991, in a split-plot design with inbreds (females) treated as whole plots and cytoplasms treated as subplots. The soil was a Sharpsburg silty clay loam (fine montmorillonitic, mesic Typic Agriudoll). Cytoplasm had no effect on days to 50% anthesis, height, forage yield, in vitro dry matter disappearance (IVDMD), or crude protein. Seed set under selfing bags (fertility restoration) in A3 hybrids was observed, with interaction among A3 cytoplasm sources and lines.

SORGHUM × SUDANGRASS hybrids provide valuable forage for livestock consumption and ground cover over a broad geographic region. Important attributes of these hybrids include rapid growth, heat and drought tolerance, and high yield. With the discovery of A1 cytoplasmic male-sterility (Stephens and Holland, 1954), a method became available to produce large quantities of hybrid seed on grain sorghum females with a minimal amount of effort. Commercial production of sorghum × sudangrass hybrid seed is estimated at 45 400 000 kg annually (Kalton, 1989).

Several sorghum lines male-sterilized in an alternate cytoplasm, A3, have been available since the early 1990s (Atkins, 1990; Schertz et al., 1990). Grain sorghum hybrids produced by topcrossing 18 different lines onto one of these A3 lines were all male-sterile (Lee et al., 1992). Currently, no information is available comparing the agronomic performance and quality of A1 and A3 sorghum × sudangrass hybrids. A3 sorghum × sudangrass hybrids should be expected to be male-sterile. If grown in isolation, such male-sterile hybrids would not set seed, possibly resulting in high forage quality by eliminating seed production. Additionally, A3 male-sterilization of sorghum lines used as pollinators (fertility restorers) in A1 hybrid production systems would provide an entirely new heterotic gene pool for sorghum × sudangrass hybrid production. Recently, we released 18 combine height grain sorghum lines sterilized in A3 (Pedersen et al., 1997) and 29 forage sorghum cultivars male-sterilized in A3 cytoplasm (Pedersen and Toy, 1997). These new genetic resources could provide some practical benefits for grain sorghum seedsmen as well as forage producers.

The objective of this study was to compare the effects of A1 and A3 cytoplasms on the maturity, fertility, stature, forage yield, and forage quality of sorghum × sudangrass hybrids.

Materials and Methods

In 1989, pollen from a bulk of eight sudangrass populations (NP22, NP23, NP25, NP28, NP29, NP30, NP31, and NP35) was used to pollinate four combine-height sorghum lines that had been male-sterilized in both A1 and A3 cytoplasm: A1Martin and A3Tx398 (A3Martin), A1Redbine 58 and A3IA78 (A3Redbine 58), A1Wheatland and A3IA79 (A3Wheatland), and A1KS24 and A3IA80 (A3KS24) (Atkins, 1990; Schertz, 1984).

Hybrids were planted on 21 May 1990 and 21 May 1991, at the Univ. of Nebraska Field Laboratory, Ithaca, NE, in a split-plot design replicated three times with seed parents (females) treated as whole plots, and cytoplasms treated as subplots. Individual plots were two rows 6.5 m long and 0.76 m apart. The entire experiment was planted twice to allow collection of forage yield, quality, maturity, and seed set data. Ammonium nitrate fertilizer was applied prior to planting at 78 kg N ha^{-1}. Propachlor {2-chloro-*N* (1-methylethyl)-*N*-phenylaetamide/Atrazine [6-chloro-*N*ethyl-*N*-(1-methylethyl)-1,3,5,-triazine-2.4.-diamine]} was applied at 9.4 L ha^{-1} immediately after planting for weed control. Days to 50% anthesis was recorded every 2 d during the blooming period. Several panicles per row were bagged prior to anthesis and visually evaluated for percent seed set at maturity. Forage was harvested after all hybrids had reached the boot stage on 19 July 1990 and 26 Sept. 1990, and 16 July 1991 and 19 Aug. 1991, with an automated plot harvester (Pedersen and Moore, 1995) to a stubble height of 10 cm, and weighed. Subsamples were used to determine dry matter, and for subsequent quality analyses.

Subsamples were dried in a forced-air oven at 60°C and ground in a Wiley mill (Arthur H. Thomas, Philadelphia, PA), followed by grinding in a Udy cyclone mill (Udy Corp., Fort Collins, CO) to pass a 1-mm screen. Dry matter yield for each cutting was calculated as fresh yield × percent dry matter, and total dry matter yield for each year was calculated as the sum of the two individual cuttings each year. In vitro dry matter disappearance was determined as per Marten and Barnes (1980) and crude protein was determined as per AACC (1983). Data were analyzed with the appropriate test terms for the split-plot design using the general linear models procedure of SAS (SAS, 1989). Where significant differences were

J.F. Pedersen and J.J. Toy, USDA, ARS, NPA Wheat Sorghum and Forage Research, Dep. of Agronomy, Univ. of Nebraska-Lincoln, Lincoln, NE 68583-0937. Joint contribution of the USDA-ARS and the Nebraska Agric. Exp. Stn. Published as Paper no. 11756, Journal Ser., Nebraska Agric. Exp. Stn. Received 16 Dec. 1996. *Corresponding author (Email: agro137@unl.edu).

Published in Crop Sci. 37:1973–1975 (1997).

Abbreviations: IVDMD, in vitro dry matter disappearance.

Table 1. Treatment means for days to 50% anthesis, height, dry matter yield, in vitro dry matter disappearance (IVDMD), and crude protein at first and second harvest dates (cuts) of sorghum × sign sudangrass hybrids.

Variable	Level	Days to 50% anthesis	Height		Dry matter yield			IVDMD		Crude protein	
			Cut 1	Cut 2	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 1	Cut 2
		%	cm		kg ha^{-1}			g kg^{-1}			
Line	Martin	70	174	217	3742	6168	11 582	635	618	126	100
	Wheatland	76	167	212	3002	5579	9 892	641	603	125	90
	KS24	72	186	213	3577	5700	10 405	635	606	118	90
	Redbine 58	69	186	217	3734	6187	11 293	632	592	120	97
	LSD (P = 0.05)	3	18	ns†	ns	ns	1 671	ns	ns	ns	ns
Cytoplasm	A1	72	177	216	3516	5848	10 760	637	602	122	94
	A3	72	179	213	3512	5969	10 826	635	607	123	95
	Contrast (P = 0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

† ns = not significantly different at P = 0.05.

indicated by the F-test, least significant differences (LSD) were calculated. Single degree of freedom comparisons were made for the two cytoplasms. Single degree of freedom comparisons were made within lines for cytoplasm effects where significant line × cytoplasm interaction terms were present.

Results and Discussion

Although year effects were significant for several variables, no year interactions were significant. Therefore, all results were pooled across years.

Maturity

Differences among hybrids for days to 50% anthesis were expected due to known maturity differences in the lines used as seed parents, and were detected (Table 1). Cytoplasm had no effect on days to 50% anthesis, with hybrids in A1 or A3 cytoplasm both averaging 72 d to 50% anthesis. Line × cytoplasm interactions were not significant for days to 50% anthesis.

Fertility

Differences in percent seed set (under selfing bags) among seed parent lines indicate that variability for fertility restoration exists among these hybrids (Table 2). Percent seed set (or fertility restoration) by sudangrass was greater on average in A1 cytoplasm than in A3, but no fully male-sterile hybrids resulted from A3 sorghum × sudangrass crosses with this group of inbreds. The line × cytoplasm interaction was significant for percent seed set. Comparisons of line × cytoplasm combinations showed significant differences due to cytoplasm for A1Martin vs. A3Martin (73 vs. 14% seed set) and A1Wheatland vs. A3Wheatland (81 vs. 39% seed set). No differences due to cytoplasm were shown for A1KS24 vs. A3KS24 (87 vs. 75% seed set) and A1 Redbine 58 vs. A3Redbine 58 (94 vs. 82% seed set).

Table 2. Treatment means for percent seed set of sorghum × sign sudangrass hybrids in alternative cytoplasm.

Line	Cytoplasm	Seed set†
		%
Martin	A1	73
	A3	14
Wheatland	A1	81
	A3	39
KS24	A1	87
	A3	75
Redbine 58	A1	94
	A3	82
LSD (P = 0.05)		19

† Seed set under a selfing bag.

The significant fertility restoration observed in A3 hybrids was unexpected, since few sources of fertility restoration of A3 male-sterility have been known to exist (Bosques-Vega et al., 1989; Torres-Cardona, 1990). One possible explanation for the level of A3 fertility restoration in this experiment is that the sudangrass populations used as the bulk pollinator contain a relatively high level of A3 fertility restorers. A second possible explanation involves two immediate sources of A3 cytoplasm and their interaction with the female lines used in this study. A3KS24 (A3IA78), A3Wheatland (A3IA79), and A3Redbine 58 (A3IA80) were developed using A3Tx3197 (IS1112C) cytoplasm, and exhibit small, shrunken, pale yellow or white anthers, as compared with the plump, dark yellow anther characteristics of A3Tx398 (A3Martin) (R. E. Atkins, 1990). In this experiment, fertility restoration in A3Tx398 was 14%. Fertility restoration in A3IA78, A3IA79, and A3IA80 was 75, 39, and 82% respectively. In other experiments, hybrids made from the same pollen source on A3Tx7000 and A3Tx430 and grown under the same conditions in 1990 and 1991 exhibited fertility restoration of 9 and 1%, and 5 and 1%, respectively.

Plant Height and Yield

Differences among hybrids for height were expected because of known height differences in the lines used as seed parents, and were detected at the first harvest (Table 1). Height differences were not detectable on regrowth at the second harvest. Cytoplasm had no independent or interaction effects on the height of hybrids at either harvest.

Martin hybrids had higher total dry matter yield than Wheatland (Table 1). No differences in dry matter yield due to seed parent line were detected at either the first or second harvest, however. Cytoplasm had no independent or interaction effects on total yield, or yield at either first or second harvest.

Forage Quality

The range of mean values for these traits was small among hybrids with the four lines as seed parents. No significant differences due to lines used as seed parents

or cytoplasm, or their interactions, were detected for IVDMD or crude protein (Table 1). The potential impact of removal of seed as a photosynthetic sink (in A3 cytoplasm hybrids) was negated by harvesting the forage prior to seed set in this experiment, but could also be negated by the unexpected high amount of fertility restoration (seed set under selfing bags) observed in some of these hybrids.

Conclusion

Within the limits of the environments, techniques, and genetic resources used in this experiment, A3 cytoplasm appears to have no effect when compared with A1 cytoplasm for maturity, height, yield, or forage quality of sorghum × sudangrass hybrids. For some hybrids, fertility restoration using bulk pollen from several sudangrass populations was equivalent in A1 and A3 cytoplasm. For other hybrids, fertility restoration was much lower in A3 cytoplasm, but was still higher than would have been expected based on the literature. These A3 fertility restoration results suggest that the sudangrass populations used in this study may contribute much needed A3 restorers to the sorghum industry. These results, however, clearly indicate the need to further explore fertility restoration interactions among A3 cytoplasm sources and various lines crossed into these cytoplasm sources.

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