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Eastern Gamagrass Response to Nitrogen Fertilization in Northern Mississippi[1]

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ABSTRACT

The USDA- Natural Resources Conservation Service, Jamie L. Whitten Plant Materials Center near Coffeeville, MS selected an eastern gamagrass [*Tripsacum dactyloides* (L.) L.] accession 9062680 (680) for potential use as a livestock forage in the southeastern U.S. There is, however, no information on the response of 680 to different rates of N fertilizer. Objective of this study was to evaluate yield, crude protein concentration, and yield efficiency of 680 to different rates of N fertilizer. Nitrogen rates of 0, 134, 268, 403 and 536 kg ha^{-1} were applied to replicated plots at Coffeeville, Prairie and Starkville, MS in three equal split applications in 2001 and 2002. The first application of N was applied in the spring when the plants reached 15 cm regrowth and after each 45 day harvest. Season total yields increased linearly with increased rates of N at Prairie in both years. In contrast, season total yields of 680 at Coffeeville and Starkville responded curvilinearly to increased rates of N in 2001 and 2002. At Coffeeville, N rate at maximum yield in 2001 and 2002 was 419 and 530 kg ha^{-1}. These N rates produced maximum yields of 11.1 and 13.8 Mg ha^{-1}. At Starkville, N rate at maximum yield was 409 and 694 kg ha^{-1} in 2001 and 2002. These N rates produced peak yields of 6.9 and 12.9 Mg ha^{-1}. Nitrogen rate at maximum yield in 2002 was 23 percent higher than the highest level of N applied at Starkville (536 kg ha^{-1}), suggesting that 680 may respond to higher rates of N in a normal rainfall year. Crude protein concentrations generally increased as N rates increased. Yield efficiency varied between N rates, years and locations, and was directly related to the shape of the response curve. Additional analyses will be conducted to further evaluate nitrogen use efficiency.

INTRODUCTION

The USDA-Natural Resources Conservation Service (NRCS) Jamie L. Whitten Plant Materials Center (PMC) evaluated over 70 accessions of eastern gamagrass from collections made in the southeastern states (Snider, 1995). From this assembly, accession 9062680

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(collected from Montgomery County, TN) was selected for additional testing as a perennial forage crop. In comparative evaluations with 12 other eastern gamagrass accessions in Mississippi, Arkansas and Georgia, accession 9062680 produced dry matter yields in excess of 16 Mg ha^{-1} when fertilized with 225 kg N ha^{-1} and harvested on 45 day intervals (Douglas et al., 2002). Forage quality estimates of crude protein ranged from 6 to 14%, acid detergent fiber from 37 to 42% and neutral detergent fiber ranged from 67 to 73%.

Nitrogen fertilizer has shown to be beneficial for production of native warm season perennial grasses (Hall et al., 1982, Bredja et al., 1995). Brakie (1998) and Bredja et al. (1996) found that eastern gamagrass sources used in their research responded favorably to increased rates of N fertilizer for yield and percent protein concentration. There is no information on the response of accession 9062680 eastern gamagrass to different rates of N fertilizer. The objective of this study was to evaluate the response of accession 9062680 (referred hereafter as 680) to different rates of N fertilizer for dry matter yield, crude protein concentration and yield efficiency.

MATERIALS AND METHODS

The study was conducted at the PMC near Coffeeville, MS (Coffeeville), Mississippi Agricultural and Forestry Experiment Station, Prairie, MS (Prairie) and the South Farm at Mississippi State University, Mississippi State, MS (Starkville) in 2001 and 2002. Soil type at Coffeeville was an Oaklimeter silt loam, at Prairie, a Houston Black clay and at Starkville, a Marietta loam. Plots of 680 (3.7 m x 4.6 m) were planted at Coffeeville on 17 April 2000, at Prairie on 24 April 2000, and at Starkville on 25 April 2000. Plots at Starkville were irrigated because of drought conditions after planting and to increase survival of plants replaced in July. The experimental design was a randomized complete block with three replicates. Plots were not harvested in 2000.

Nitrogen rates were 0, 134, 268, 402, and 536 kg N ha^{-1} applied in three equal split applications using ammonium nitrate as the N source. First incremental rate of N was applied when the plants reached 15+ cm in the spring. Subsequent applications were made after each harvest, which occurred at approximately 45 day intervals (Table 1). Soil phosphorus and potassium levels were maintained at a high level according to soil test recommendations.

Grab samples were collected for dry matter yield determination and for N concentration. Crude protein (CP) was estimated by multiplying the N concentration by 6.25. Yield efficiency was determined by subtracting the yield obtained from the fertilized plot from the yield obtained from the control plot and dividing the difference by the N application rate (Brock, 1984). Linear and quadratic regression analyses were used to define response to N rates.

Table 1. Harvest dates by location and year.

	2001			2002		
Location	1st	2nd	3rd	1st	2nd	3rd
Prairie	17 May	10 July	23 Aug	21 May	9 July	22 Aug
Coffeeville	15 May	28 June	15 Aug	16 May	2 July	15 Aug
Starkville	22 May	5 July	5 Sept	22 May	15 July	4 Sept

RESULTS AND DISCUSSION

Forage Yield

Season total yields at Prairie in 2001 and 2002 increased linearly with increasing rates of N (Fig. 1.a). Apparently the highest N rate (536 kg ha^{-1}) was not enough to obtain a maximum N peak in the response curve in either year. Response to N was greater in 2002 despite low rainfall in mid and late season (Fig. 1.b). It is anticipated residual soil NO_3-N accumulation from previous forage and row crop experiments may have limited N response in 2001. As this residual N was removed in the above ground biomass in 2001, a greater response to applied N in 2002 was observed. Bredja et al. (1996) reported that eastern gamagrass did not respond to N the first year because of N accumulation from prior management for seed production. In subsequent years, the yields increased linearly with increasing rates of N.

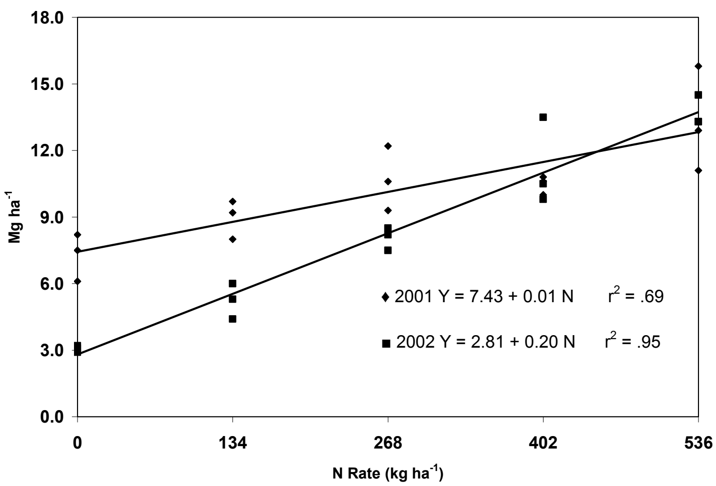

Fig. 1a. Season total dry matter yield for accession 9062680 in 2001 and 2002 as a function of N rates at Prairie, MS.

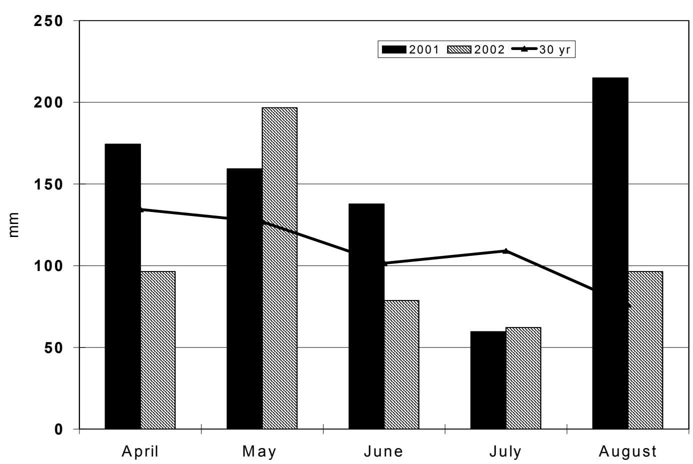

Fig. 1b. Monthly rainfall totals in 2001 and 2002 during the growing season and the 30 yr monthly average at Prairie, MS.

At Coffeeville, season total yields in 2001 and 2002 increased curvilinearly with increasing rates of N (Fig. 2.a). Maximum yield in 2001 and 2002 occurred at 11.1 and 13.8 Mg ha^{-1} with 419 and 530 kg N ha^{-1}, as calculated from the regression equation. Brakie (1998) reported that Texas genotypes of eastern gamagrass responded curvilinearly to increased rates of N (0, 140, 280, and 560 kg N ha^{-1}) on a fine sandy loam soil in East Texas. Maximum yields for Texas genotypes were at similar N rates to those reported for 680. Season total yields were higher in 2001 despite above average monthly rainfall totals during much of the growing season (Fig. 2.b). There may be another nutrient, other than N, that is limiting yields. Additional mineral analyses of the tissue samples will need to be conducted to verify whether or not some other nutrients may be restricting yield potential.

Season total yields increased curvilinearly with increasing rates of N at Starkville (Fig. 3.a). Peak yield in 2001 and 2002 occurred at 6.9 and 12.9 Mg ha^{-1} with 409 to 694 kg N ha^{-1}, as determined from the regression equation. Season total yields were substantially higher in 2002

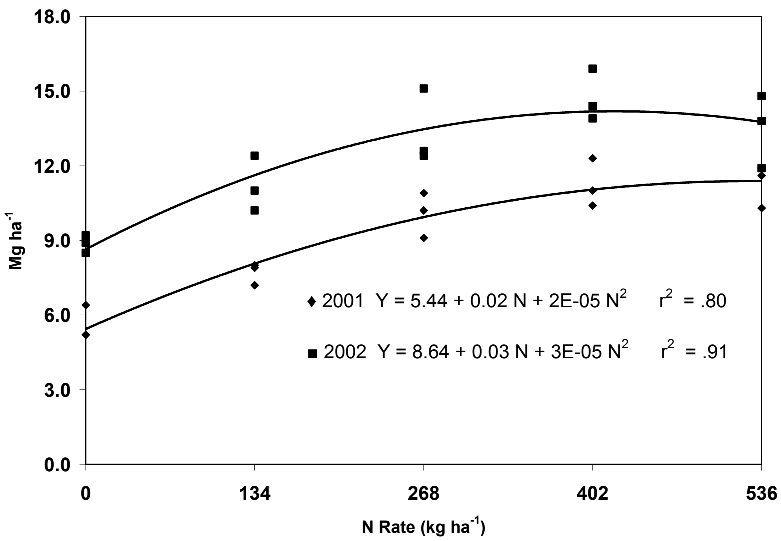

Fig. 2a. Season total dry matter yield for accession 9062680 in 2001 and 2002 as a function of N rates at Coffeeville, MS.

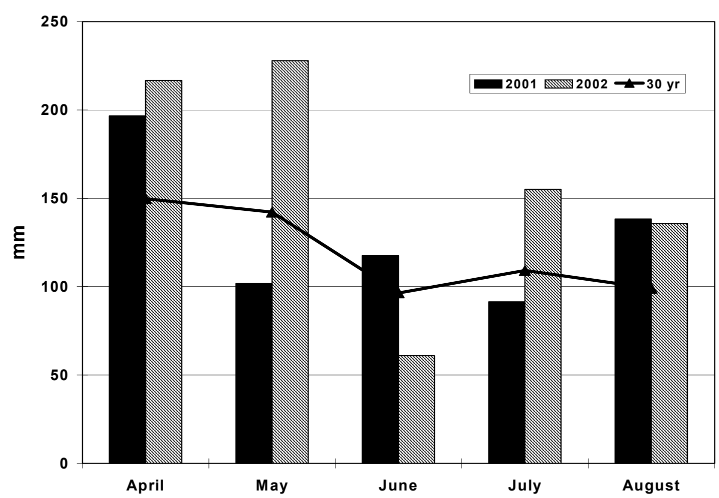

Fig. 2b. Monthly rainfall totals in 2001 and 2002 during the growing season and the 30 yr monthly average at Coffeeville, MS.

than in 2001 despite low rainfall (Fig. 3.b). This considerable increase in yield may be due to an increase in plant size from 2001 to 2002. Several plants did not survive the spring planting and were replaced in July. These replacement plants did not have the full growing season in 2000, which probably attributed to lower yields in 2001 compared to the other locations. However, the season total yields in 2002 were equal to or higher than yields at Coffeeville and Prairie. As these plants increased in size, response to N rates significantly improved from 2001 to 2002. Nitrogen rate at maximum yield in 2002 (694 kg ha^{-1}), which was 23 percent greater than the highest rate of N applied (536 kg ha^{-1}), suggests that 680 may respond to a higher rate of N on a Marietta loam soil in a normal rainfall year.

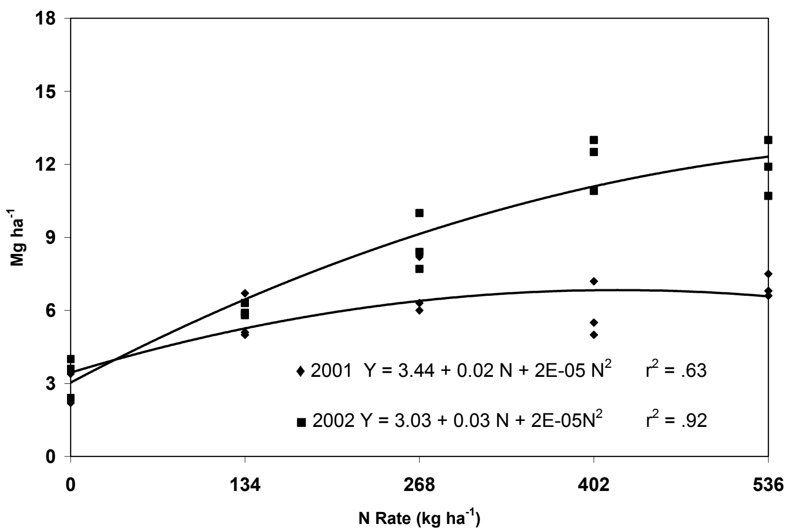

Fig. 3a. Season total dry matter yield for accession 9062680 in 2001 and 2002 as a function of N rates at Starkville MS.

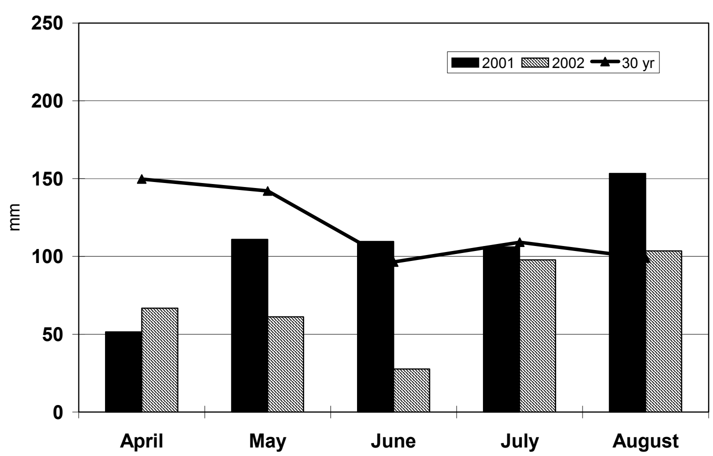

Fig. 3b. Monthly rainfall totals in 2001 and 2002 during the growing season and the 30 yr monthly average at Starkville, MS.

Crude Protein Concentration

Crude protein concentration varied between harvests due to differences in growth stages. The first harvest was characterized by reproductive stems at different stages of development (i.e. boot stage to emerged inflorescence) whereas the second harvest had fewer reproductive stems and more vegetative growth, and the third harvest was mainly vegetative growth. At Prairie, the first and third harvests produced the highest CP concentrations in 2001(6.3 to 10.6%), and in 2002 (6.0 to 10%). At Coffeeville, CP concentrations were highest in the second and third harvests in 2001 (6.9 to 10.6%), and in 2002, the first and third harvests produced the highest CP concentrations (7.5 to 14.4%). At Starkville, CP concentrations were highest in the first and second harvests in 2001 (10.4 to 15.6%). Douglas et al. (2002) reported a two year average CP concentration of 8 to 11% at Coffeeville, MS, and a three year average CP concentration of 8 to 9% at Americus, GA for accession 680.

Crude protein concentrations generally increased as N rates increased, and agree with results reported by Brakie (1998) and Brejda et al. (1996). The highest CP concentrations occurred at 179 (15.6%) and 134 (8.1%) kg N ha^{-1}. At Prairie, CP concentration increased linearly with increased N rates in the first and second harvests in 2001, and the first and second harvests in 2002 (Table 2). At Coffeeville, CP concentrations increased linearly with increased N rates in the third harvest in 2001 and the second and third harvests in 2002 (Table 3). At Starkville, CP concentrations increased linearly with increased N rates in the third harvest in 2001 (Table 4). Crude protein percentages of 680 fertilized with 45 or 90 kg ha^{-1} N after each harvest would meet the protein requirements for non-lactating beef cattle (Ball et al., 2002).

Table 2. Crude protein percentages of accession 9062680 by harvest date and N rates in 2001 and 2002 at Prairie, MS.

N Rate (kg ha^{-1})	2001 1st	2001 2nd	2001 3rd	2002 1st	2002 2nd	2002 3rd
	%					
0	6.9	5.6	7.5	7.0	5.7	6.0
45	8.1	4.8	6.3	8.9	7.0	8.1
90	10.6	5.3	8.1	8.9	5.8	6.9
134	10.0	6.9	7.5	10.0	8.1	8.8
179	10.6	6.9	8.8	10.0	8.8	7.0
N Linear (P<.05)	.05	.05	NS[1]	.05	.05	NS

1 = Not significant.

Table 3. Crude protein percentages of accession 9062680 by harvest date and N rates in 2001 and 2002 at Coffeeville, MS.

N Rate (kg ha^{-1})	2001 1st	2001 2nd	2001 3rd	2002 1st	2002 2nd	2002 3rd
	%					
0	7.5	6.9	6.9	11.9	4.9	7.5
45	7.5	8.8	7.5	12.5	6.9	8.1
90	8.1	8.8	9.4	11.9	6.2	10.0
134	8.1	8.1	10.0	13.1	8.8	13.1
179	8.1	9.4	10.6	13.1	9.4	14.4
N Linear (P<.05)	NS[1]	NS	.05	NS	.05	.05

1 = Not significant.

Table 4. Crude protein percentages of accession 9062680 by harvest date and N rates in 2001 at Starkville, MS[1]/.

N Rate (kg ha^{-1})	2001		
	1st	2nd	3rd
	---------------------% ---------------------		
0	11.4	12.1	8.3
45	11.9	11.7	10.1
90	10.4	13.0	10.5
134	11.5	14.3	14.0
179	12.4	15.6	13.3
N Linear (P<.05)	NS[2]	NS	.05

1 = 2002 protein analysis not available at the time this report was written.
2 = Not significant.

Yield Efficiency

Yield efficiency is defined as the average yield increase per unit of applied N (Brock, 1984). At Coffeeville, yield efficiency was similar between years. The highest yield efficiency occurred at 134 and 268 kg N ha^{-1} but decreased with increased rates of N (Table 5). In contrast, yield efficiency increased with increasing rates of N in 2002 at Prairie and Starkville, and occurred at 268 and 402 kg N ha^{-1}. Yield efficiency values are directly related to the shape of the response curve, and as response to N increased in 2002 at Prairie and Starkville, yield efficiency increased notably (Fig. 1a. and 2a.). Bredja (2000) reported yield efficiency range of 0 to 52 kg kg^{-1} N for PMK-24 eastern gamagrass in northern Missouri with increasing rates of N ranging from 56 to 224 kg ha^{-1}.

Table 5. Yield efficiency of accession 9062680 by N rate, year and location.

N Rate	Coffeeville		Prairie		Starkville	
(kg ha^{-1})	2001	2002	2001	2002	2001	2002
	------------------------------------kg DM kg^{-1} N------------------------------------					
134	17	17	13	16	13	20
268	17	17	13	19	14	20
402	11	15	8	20	7	22
536	9	9	11	20	7	16

Yield efficiency = [forage yield (fertilize) – forage yield (control)] / N fertilizer applied.

CONCLUSIONS

Accession 680 eastern gamagrass was responsive to increasing rates of N as measured by yield and CP concentration at Prairie, Coffeeville, and Starkville. Yields increased linearly at Prairie with increased N rates suggesting that more N may be needed before a peak N rate can be reached. Yield response at Coffeeville, and Starkville increased curvilinearly with increasing rates of N. At Coffeeville, N rate at maximum yield in 2001 and 2002 was 419 and 530 kg ha^{-1}. These N rates produced maximum yields of 11.1 and 13.8 Mg ha^{-1}. At Starkville, N rate at maximum yield was 409 to 694 kg ha^{-1} in 2001 and 2002. These N rates produced peak yields of 6.9 and 12.9 Mg ha^{-1}. Nitrogen rate at maximum yield in 2002 was 23 percent higher than the highest level of N applied at Starkville (536 kg ha^{-1}), suggesting that 680 may respond to higher rates of N in a normal rainfall year. Crude protein concentrations varied between harvests and locations and generally increased with increased rates of N. Crude protein percentages of 680 fertilized with 45 or 90 kg ha^{-1} N after each harvest would meet the protein requirements for non lactating beef cattle (Ball et al., 2002). Yield efficiency varied between N rates and years, and was greatly influenced by the shape of the response curve. Additional analyses will be conducted to evaluate nitrogen use efficiency.

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