The Effect of Additional Nitrogen Fertilization on the Nutritive Value of Grain Sorghum

C. A. Hibberd, D. E. Weibel, D. G. Wagner and R. L. Hintz

Story in Brief

Five varieties of grain sorghum were grown under dryland conditions to investigate the effect of additional nitrogen (N) fertilizer on chemical composition and relative digestibility of the sorghum. Addition of 50 extra pounds of nitrogen per acre increased berry size markedly and crude protein content slightly. Tannin content was decreased for the high tannin Darset variety. Although *in vitro* digestibility was not consistently increased by fertilizer addition, detrimental effects were not observed. Notably, these results were observed during a dry season when the benefits of additional fertilizer may not be as apparent as during a normal growing season.

Introduction

Several factors have been shown to affect the nutritive quality of grain sorghum. Specifically, variety (type), processing or location effects may alter the nutritive value of grain sorghum. Another major factor, which can be manipulated during the growing season, is the level of nitrogen fertilization. Extra nitrogen added during the growth stage of the sorghum plant could increase protein deposition, as well as yield. Because the protein matrix of the sorghum kernel appears to affect accessibility to the starch granules, increased protein deposition might hinder starch digestibility. Consequently, the purpose of this study was to investigate the effect of additional nitrogen fertilizer on the nutritive quality of several varieties of grain sorghum.

Experimental Procedure

Five varieties of grain sorghum (Table 1) were grown and harvested under identical dryland conditions at the Perkins Agronomy Research Station. Sorghum types represented were a waxy (Dwarf Redlan), a waxy bird resistant (1133), a normal (Redlan) and two normal bird resistants (ROKY 78 and Darset). Midway through the growing season, an additional 50 pounds of nitrogen per acre was added to half of the plots to provide the increased N treatment. After harvesting, each grain sample was finely ground in a Udy mill for chemical analysis or through a 20-mesh screen in a Wiley mill for evaluation of relative digestibility. Starch content was measured as α-linked glucose polymers via an enzymatic assay, and tannin content was determined by a modified vanillin-HCl assay. Relative digestibility was evaluated using a single stage *in vitro* dry matter disappearance (IVDMD) procedure. Grain samples were placed in 50 ml centrifuge tubes and inoculated with buffered rumen fluid. After a 24-hour incubation, the tubes were centrifuged and dried, and IVDMD was calculated by difference. An *in vitro* gas production (IVGP) procedure was used to measure relative starch availability. A small quantity of each grain sample was placed in a 50 ml Erlenmeyer flask and inoculated with an aqueous solution of amyloglucosidase (starch

Table 1. Descriptive characteristics of grain sorghum varieties

Variety	Seed coat color	Endosperm color	Endosperm starch	Classification
Dwarf Redlan	red	white	waxy	Waxy
1133	brown	yellow	waxy	Waxy-BR[a]
Redlan	red	white	normal	Normal
ROKY 78	brown	yellow	normal	Normal-BR
Darset	brown	white	normal	Normal-BR

[a]BR = bird resistant.

Table 2. Berry size, starch and tannin content of control and fertilized grain sorghum

Variety	Relative[1] berry size		Starch[2] content (%)		Tannin (cat. eq./g)	
	control	fertilized	control	fertilized	control	fertilized
Dwarf Redlan	3.09[b]	3.12[b]	67.4	66.0	.06[d]	.04[d]
1133	2.64[cd]	2.80[c]	63.1	64.1	.91[b]	.88[b]
Redlan	2.52[d]	3.46[a]	64.6	65.3	.05[d]	.04[d]
ROKY 78	3.48[a]	3.32[a]	64.3	64.1	1.00[b]	.92[b]
Darset	2.51[d]	3.01[b]	65.5	65.7	1.41[a]	.54
Mean	2.85	3.14	65.0	65.0	.68	.48

[1]Weight (g) of 100 kernels.
[2]No significant differences (P>.05).
[abcd]Means with different superscripts are significantly different (P<.05).

digesting enzyme) and commercial baker's yeast. Gas produced by the yeast was trapped in inverted burets and IVGP expressed as ml gas per gram of dry matter. Differences between varieties were estimated by method of least squares, and significant differences between varietal means were detected with Tukey's HSD test.

Results and Discussion

Minimal rainfall was recorded after the application of the additional nitrogen fertilizer. Consequently, the results of this study may not be as dramatic as might be expected. Some effects were noted, however, as additional nitrogen fertilizer did increase berry size in four of the five sorghums (Table 2). This increase was most dramatic (P<.05) for the Redlan (Normal) and Darset (Normal-BR). Starch content was not affected by fertilization for any of the varieties tested. In addition, fertilization appeared to beneficially decrease the tannin content of each sorghum (Table 2). Tannin content was decreased most drastically for the normally high tannin Darset variety (Normal-BR).

The effect of additional nitrogen fertilizer on crude protein content varied dependent on variety (Table 3). Percent crude protein was increased (P<.05) for the sorghums with waxy starch (Dwarf Redlan and 1133), resulting in increased protein deposition per kernel. Additional nitrogen fertilization increased protein deposition in the Redlan and Darset varieties by increasing berry size. Consequently, crude protein content per berry was increased in four of five sorghums via different mechanisms. Assuming that berry numbers were not changed by nitrogen addition, total protein yield per acre would be expected to increase dramatically.

Relative digestibility (IVDMD) of most varieties was not changed by the addition of nitrogen fertilizer (Figure 1). A small increase in IVDMD was observed for the high tannin Darset variety. This response may be a result of the decreased tannin content

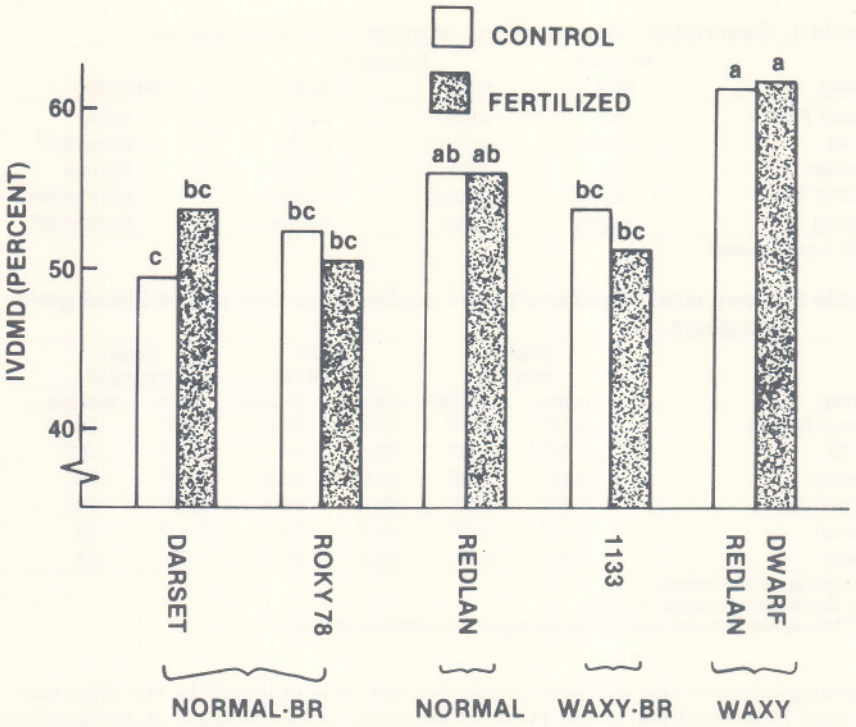

Figure 1. ***In vitro*** **dry matter disappearance of control and fertilized grain sorghums, (means with different superscripts are significantly different, P< .05).**

noted earlier. In addition, starch availability (measured by IVGP) was increased (P<.05) for the fertilized Darset variety although other sorghums were not markedly altered (Figure 2).

These studies suggest that the chemical composition of grain sorghum can be changed by supplying additional nitrogen fertilizer during the growth phase of the

Table 3. Protein content of control and fertilized grain sorghums

	Crude protein[1] control (%)		Crude protein[2] content (mg/berry)	
Variety	control	fertilized	control	fertilized
Dwarf Redlan	12.8^{e}	13.8^{cd}	3.96	4.30
1133	13.2^{de}	14.1^{bc}	3.48	3.95
Redlan	14.9^{a}	14.7^{ab}	3.75	5.09
ROKY 78	12.8^{e}	12.8^{e}	4.45	4.25
Darset	14.2^{bc}	14.3^{abc}	3.56	4.30
Mean	13.6	13.9	3.84	4.38

[1]Variety-by-fertilizer interaction significant (P<.05).
[2]Mg crude protein/berry = (relative berry size ÷ 100) × crude protein %.
^{abcde}Means with different superscripts are significantly different (P<.05).

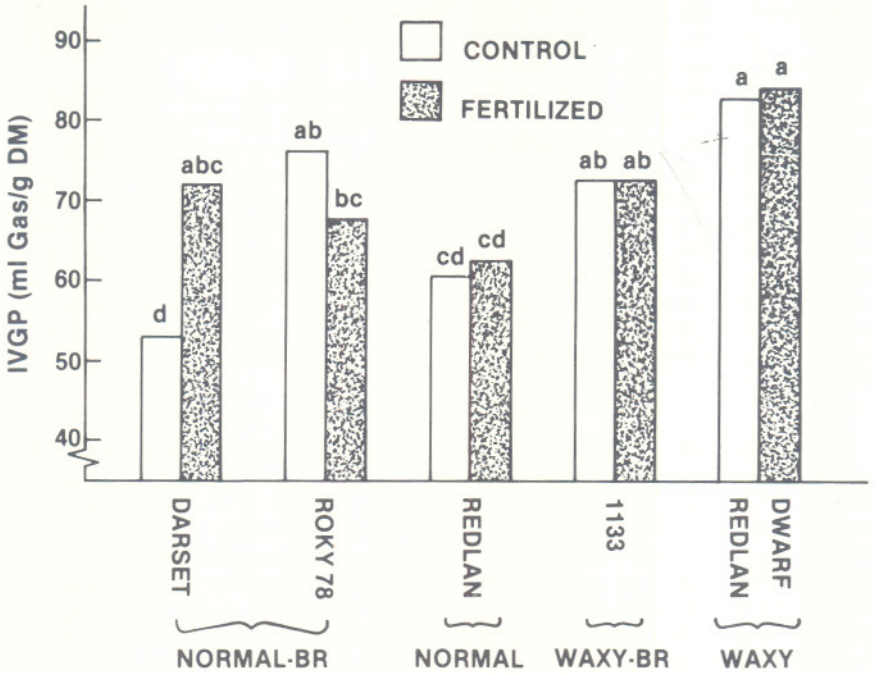

Figure 2. *In vitro* gas production of control and fertilized grain sorghums. (Means with different superscripts are significantly different, P<.05).

plant. Specifically, the decrease in tannin content noted for the Darset variety may be particularly beneficial. Additional fertilizer, however, did not have a consistent effect on digestibility (IVDMD). Because protein shielding of starch appears to be a major factor affecting the digestibility of grain sorghum, additional nitrogen fertilizer could theoretically increase protein content and subsequently decrease digestibility. Since no detrimental effects were observed, the addition of extra nitrogen to growing grain sorghum should not present a nutritional problem.

Roughage - Concentrate Associative Effects

R. G. Teeter, F. N. Owens
and D. R. Gill

Story in Brief

Twelve growing steers (657 lb) were fed whole shelled corn rations at two levels of feed intake. Cottonseed hulls or chopped alfalfa hay was added to the corn to form 10- and 40-percent roughage-supplemented rations for each roughage. Increasing ration