Yield Response of Grain Sorghum to Varying Nitrogen Rates Under Irrigated and Non-irrigated Conditions

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BACKGROUND INFORMATION

Grain sorghum (*Sorghum bicolor*) has been grown on an average of 170,000 acres over the past 10 years in Arkansas. Grain sorghum is grown as a low input crop, often under non-irrigated conditions and on "marginal" land, such that the state average yield oscillates between 75 and 85 bu/acre (<5000 lb/acre). However, yields from fields enrolled in the Arkansas Research Verification Program have been as high as 150 bu/acre (8000 lb/acre), which is evidence of the high yield potential for grain sorghum. The objective of these studies was to evaluate existing N-fertilization recommendations for grain sorghum grown under irrigated and non-irrigated conditions.

PROCEDURES

Research plots were established at the Lon Mann Cotton Branch Station (LMCBS, Memphis) near Marianna, the Northeast Research and Extension Center (NEREC, Sharkey-Steele complex) at Keiser, and the Southeast Research and Extension Center (SEREC, Hebert) at Rohwer during 2002 and 2004.

Soil samples were collected from the 0-to 6- and 6-to 12-inch depths prior to planting and were extracted using the Mehlich 3 procedure (extraction ratio of 1:7). Nitrate-N was analyzed with an ion selective electrode, and pH was measured in a 1:2 soil:water (wt:vol) mixture.

Treatments consisted of N rates equivalent to 0, 50, 100, 150, 200, and 250 lb N/acre under irrigated conditions and 0, 40, 80, 120, 160, and 200 lb N/acre under non-

irrigated conditions. Ammonium nitrate was used to minimize volatilization losses. The intended plant population was 80,000 plants under irrigated conditions and 60,000 plants under non-irrigated conditions. Tests were planted before April 15 of each year. Grain sorghum hybrids Pioneer 84G62, Terral 1050, and Triumph TR 82-G were used during the 2002 season, and only the Pioneer and Terral hybrids for the remainder of the study.

Each plot contained four, 38-inch wide and 25-ft long rows with treatments arranged in a randomized complete block design and replicated 5 times. Nitrogen rates were applied in a 2-way split as ammonium nitrate, with 50% of the total-N rate applied at emergence and the remaining N applied before the V6 stage. Phosphorus and potassium were applied according to soil-test recommendations, while irrigation and weed and insect control were performed according to Cooperative Extension Service recommendations.

At each location, the two middle rows were harvested with a plot combine equipped with a weigh-system and grain moisture meter. Yields were adjusted to 15.5% moisture content for statistical analysis. The least significance procedure of SAS was used to test for differences among mean treatment yields.

Relative yields from NEREC and LMCBS were plotted against N rate and an exponential model was fitted. An optimum N rate was estimated as the N rate where 95% relative yield intercepted the regression line. Yields from SEREC were not included in the calculations to determine the optimum N-fertilizer rate due to the lack of response to N, which is believed to be associated with high soil nitrate levels.

RESULTS

Residual soil nitrate-N levels varied across sites and were probably a contributing factor for the nature of the yield responses observed, particularly at SEREC. Table 1 shows soil-test results for samples collected during the spring of 2002 and 2004. Similar trends were observed during the other years, with nitrate-N levels at SEREC always being above 30 lb NO_3-N/acre in the top 12-inches of soil, and below 10 lb NO_3-N/acre at LMCBS. Soil pH ranged from a low of 5.8 for LMCBS and a high of 7.9 at SEREC. Potential deficiency problems were prevented by supplemental fertilizer applications of P, K and sulfur as needed.

Contrasting yield responses were observed as a result of erratic rainfall patterns and varying residual soil nitrate levels. Figure 1 shows the yield response of three sorghum hybrids at the LMCBS under irrigated conditions during 2002. Yields were maximized by application of 150-200 lb N/acre with no significant yield differences among hybrids. The yield response observed at LMCBS was typical of a site with low residual nitrate-N, under irrigated conditions.

The yield response under non-irrigated conditions (Fig. 2) at the LMCBS during 2002 did not follow the same pattern as the response observed under irrigated conditions (Fig. 1). This pattern was typical for relatively dry years. Rainfall at the LMCBS for the months of April to July in 2002 totaled 12 inches, which is 7 inches below the historical rainfall average. Yields from the Pioneer hybrid were consistently higher than the other two hybrids, but the response was not significantly different among N rates (data not shown).

Average yields under irrigated conditions during 2004 at SEREC are listed in Table 2. This yield trend, with no yield differences between the 0 and the 100 lb N/acre,

was consistent during the study and was probably influenced by significant amounts of residual nitrate-N and more timely rainfall as compared to the LMCBS. High residual nitrate levels are probably a result of atmospheric N fixation by the previous soybean crop. The tests at the LMCBS were always planted following a grain crop (corn or grain sorghum) and may have resulted in lower residual nitrate levels as compared to SEREC. A similar pattern was observed in yields from the non-irrigated test at SEREC (Table 3) and the irrigated test in 2002 (Fig. 3). It is not uncommon for non-irrigated plots to yield more than irrigated plots in the variety trial program at SEREC.

Relative yields from NEREC and CBS, for selected years, were used to develop yield response curves for non-irrigated and irrigated production. Relative yields were used to compensate for weather and management variations among site-years. A series of models were tested and an exponential model was selected and fitted to both irrigated and non-irrigated average relative yields.

Under irrigated conditions, 95% relative yield was achieved at a N rate of 160 lb N/acre, while under non-irrigated conditions 95% relative yield was achieved at 120 lb N/acre (Fig. 4 and 5). Close examination of the data shows that 95% relative yield occasionally occurred at N rates above or below the suggested 120 and 160 lb N/acre for non-irrigated and irrigated conditions, respectively. The goal of a soil-testing program is to provide fertilizer recommendations based on average responses from tests conducted at multiple locations during several years. The model proposed here is the one that best explained the variability among N rates. Each farmer should modify these general N-rate recommendations for the particular conditions that exist in their fields that may influence crop response to N fertilization.

PRACTICAL APPLICATIONS

Grain sorghum yields obtained at LMCBS and NEREC were maximized, on average, by application of 160 and 120 lb N/acre under irrigated and non-irrigated conditions, respectively. Results of studies showed that, on an average, 1.2 lb N are needed to produce a bushel of grain sorghum (56 lb/bu). Yield responses at SEREC were maximized at considerably lower N rates probably due to significant atmospheric N fixation by the preceding soybean crop. Soil testing can help farmers save significantly on fertilizer costs.

ACKNOWLEDGEMENTS

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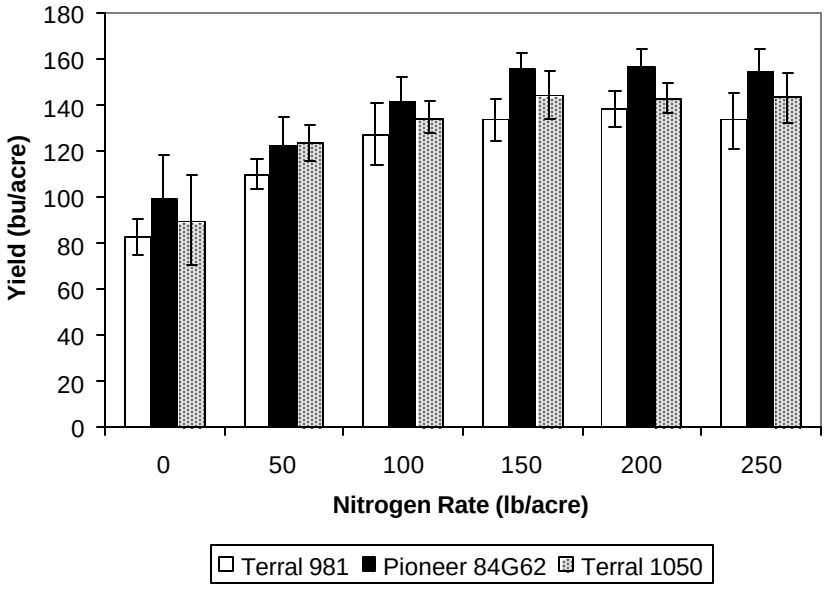

Figure 1. Yield response of three grain sorghum hybrids to varying N rates under irrigated conditions at the Lon Mann Cotton Branch Station during 2002.

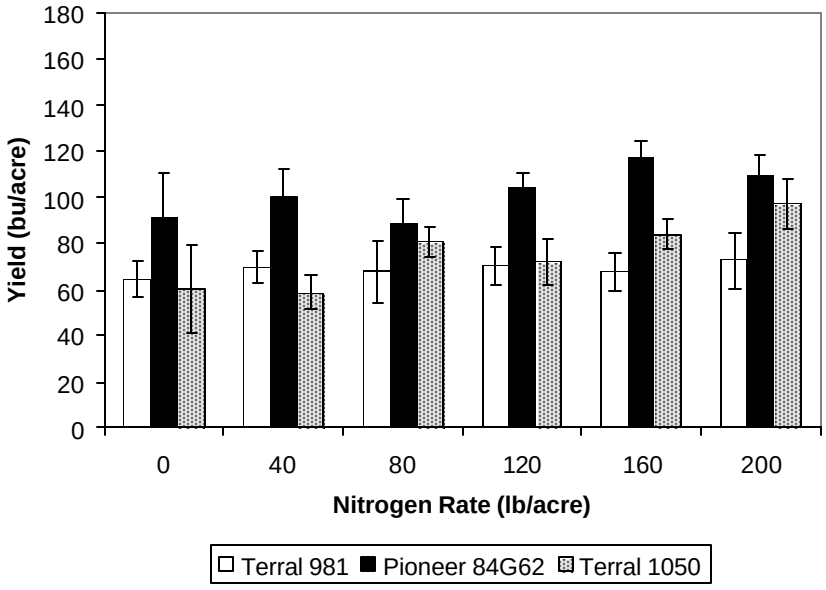

Figure 2. Yield response of three sorghum hybrids to varying N rates under non-irrigated conditions at the Lon Mann Cotton Branch Station during 2002.

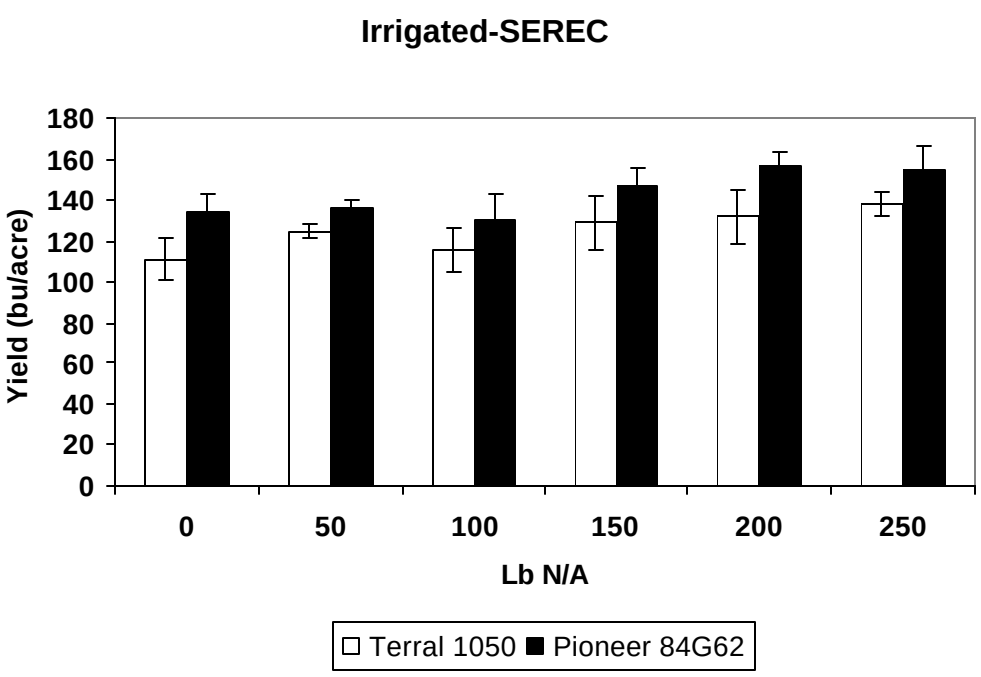

Figure 3. Yield response of two grain sorghum hybrids to varying N rates under irrigated conditions at SEREC during 2002.

Table 1. Residual soil nitrate -N levels at the experimental locations during 2002 and 2004.

	Location					
	NEREC		SEREC		LMCBS	
Soil depth	2002	2004	2002	2004	2002	2004
inches	---------- lb NO_3-N/acre ----------					
0-6	10	15	18	27	3	5
6-12	8	7	22	19	3	2

Table 2. Average yield response to varying N rates at SEREC under irrigated conditions during 2004.

	Hybrid	
N rate	**Terral 1050**	**Pioneer 84G62**
lbs N/acre	**Yield (bu/acre)**	
0	110.8 d	134.5 b
50	125.3 bc	136.1 b
100	116.8 dc	130.8 b
150	129.5 ab	147.7 a
200	132.8 ab	157.9 a
250	137.9 a	155.9 a
LSD (0.10)	12.9	11.4

Table 3. Average yield response to varying N rates at SEREC under non-irrigated conditions during 2004.

	Hybrid	
N rate	**Terral 1050**	**Pioneer 84G62**
lbs N/acre	**Yield (bu/acre)**	
0	96.3 d	117.4 c
40	106.9 bc	127.8 bc
80	123.3 dc	138.4 ab
120	123.4 ab	143.0 a
160	126.5 ab	144.8 a
200	137.9 a	148.1 a
LSD (0.10)	18.1	13.11

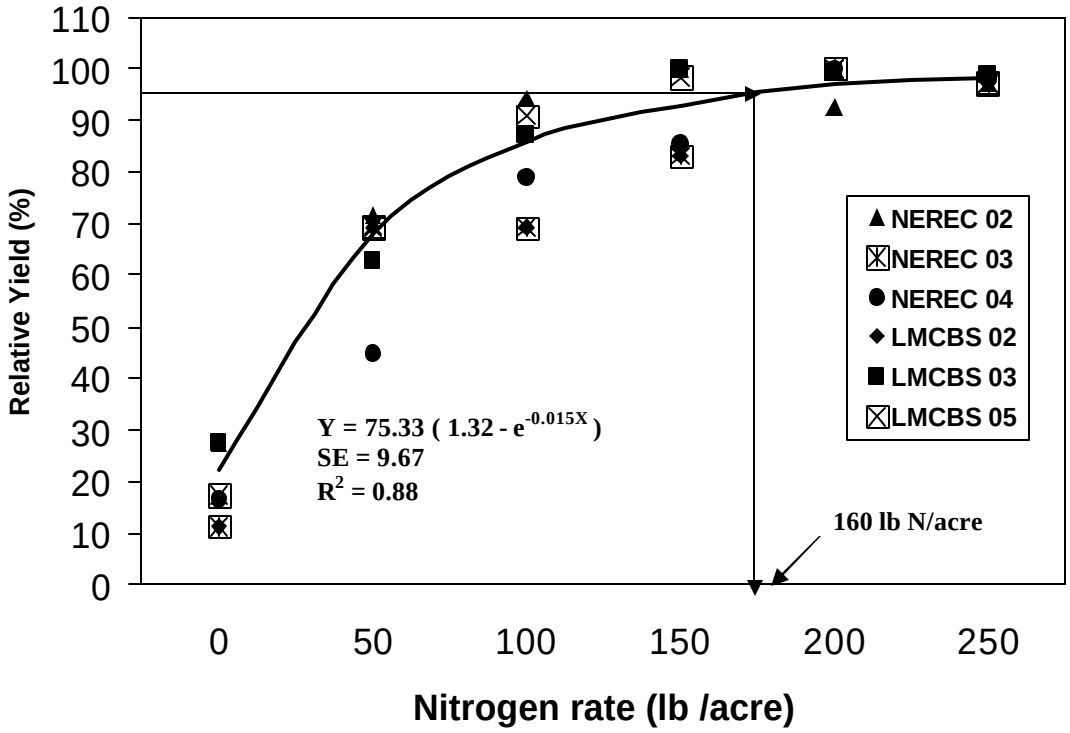

Figure 4. Regression model and associated model parameters for the relative yield response of grain sorghum to varying N rates under irrigated conditions.

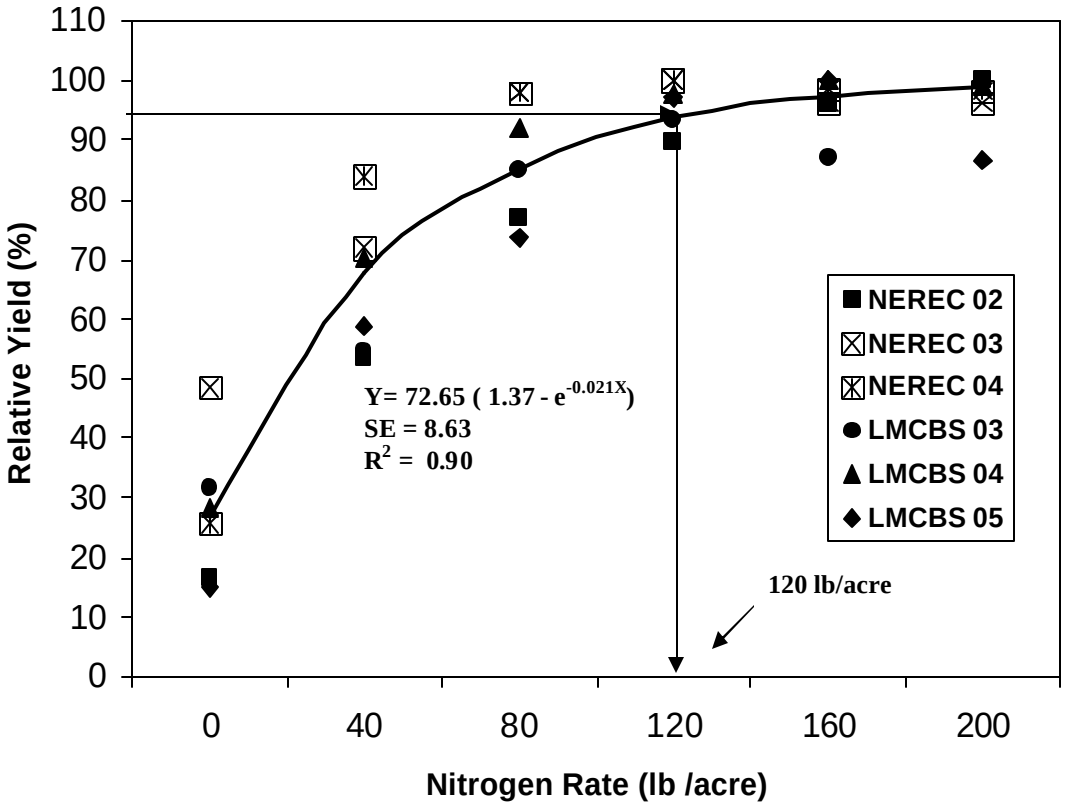

Figure 5. Regression model and associated model parameters for the relative yield response of grain sorghum to varying N rate under non-irrigated conditions