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Balanced Nutrition and Crop Production Practices for Closing Sorghum Yield Gaps

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Balanced Nutrition and Crop Production Practices for Closing Sorghum Yield Gaps

Abstract

In order to study how diverse cropping system approaches influence grain sorghum productivity, field experiments were conducted in Topeka, KS at the Kansas River Valley Experiment Field; and in Ottawa, KS at the East Central Kansas Experiment Field. The primary objective of this study was to understand how to close yield gaps between the current on-farm yields and the maximum attainable yields. The factors that were tested include narrow row spacing; high and low plant population; balanced nutrition practices, including various timings of nitrogen, phosphorus, and potassium (N-P-K); micronutrient applications of iron and zinc (Fe and Zn); crop protection with fungicide and insecticide applications; plant growth regulator effects; and the use of precision agricultural technology for maximizing yields, including a GreenSeeker meter (Trimble Navigation, Westminster, CO) for more precisely determining N needs for sorghum. Grain sorghum yields ranged from 149 to 166 bu/a in Topeka, KS under irrigation, and from 78 to 100 bu/a in Ottawa, KS, under dryland conditions. At Ottawa, yield potential was limited by precipitation, 10.8 inch. Still, sorghum yield gap between the highest (treatment #2, "kitchen sink" but with low seeding rate) and lowest (treatment #10, "standard practice") was 22 bushels per acre. The production practices that produced the highest yields varied between the two locations.

Keywords

Sorghum, nutrient uptake, production practices

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Summary

In order to study how diverse cropping system approaches influence grain sorghum productivity, field experiments were conducted in Topeka, KS at the Kansas River Valley Experiment Field; and in Ottawa, KS at the East Central Kansas Experiment Field. The primary objective of this study was to understand how to close yield gaps between the current on-farm yields and the maximum attainable yields. The factors that were tested include narrow row spacing; high and low plant population; balanced nutrition practices, including various timings of nitrogen, phosphorus, and potassium (N-P-K); micronutrient applications of iron and zinc (Fe and Zn); crop protection with fungicide and insecticide applications; plant growth regulator effects; and the use of precision agricultural technology for maximizing yields, including a GreenSeeker meter (Trimble Navigation, Westminster, CO) for more precisely determining N needs for sorghum. Grain sorghum yields ranged from 149 to 166 bu/a in Topeka, KS under irrigation, and from 78 to 100 bu/a in Ottawa, KS, under dryland conditions. At Ottawa, yield potential was limited by precipitation, 10.8 inch. Still, sorghum yield gap between the highest (treatment #2, "kitchen sink" but with low seeding rate) and lowest (treatment #10, "standard practice") was 22 bushels per acre. The production practices that produced the highest yields varied between the two locations.

Introduction

Low productivity is one of the biggest problems in grain sorghum production in Kansas. This productivity issue stems from a combination of management practices, genetics, and varied environmental conditions. Understanding best management practices and using better genotypes are essential to closing yield gaps between current on-farm yields and maximum attainable yield. This project seeks to take into account the multitude of factors that influence farmers' decisions in an effort to achieve higher yields through best management practices.

Procedures

At both locations, Topeka, KS (irrigated); and Ottawa, KS (dryland); the plots were set up in a randomized complete block design with 5 replications and 11 treatments in each replication (Table 1). In Topeka, KS, the plots were 10 × 70 ft. In Ottawa, KS the plots were 10 × 50 ft, or 0.01 acres. The hybrids used were DKS 53-67 for Topeka, and DKS 44-20 for Ottawa, these were chosen based on the Kansas Performance Tests for their suitability to each specific site. Measurements for plant characterization were taken at the V5 growth stage, at flowering, and at harvest. The measurements taken included: plant population stand counts, leaf area index (LAI) at V5 and flowering, chlorophyll (SPAD) readings at V5 and flowering, aboveground biomass and nutrient concentrations at these growth stages, and grain yield and its components (grain number and seed weight).

Soil Characterization and Phenological Information for Both Sites

Soil samples were collected prior to planting and fertilization. The Ottawa site had low values of P but a slightly higher organic matter content than Topeka. Both sites were planted the same date with hybrids of similar maturity groups.

Stand Counts

The plant population after emergence was measured for all the plots at both sites. The target population for the treatments at "Normal" seeding rate was 45,000 plants per acre (commonly used by producers). For the "Optimum" seeding rate, the target population was 90,000 plants per acre.

2015 Seasonal Precipitation and Irrigation for All Sites

At the Kansas River Valley Experiment Field in Topeka, KS the seasonal rainfall totaled 16.2 inches with an additional 4.2 inches of irrigation applied. At the East Central Kansas Experiment Field in Ottawa, KS, there was a total of 10.9 inches of rainfall during the growing season.

Results

Grain sorghum yields portrayed a contrasting picture at the evaluated sites. In Topeka under irrigation, sorghum yields ranged from 149 to 166 bu/a (Figure 2). At Ottawa under dryland, sorghum yields ranged from 78 to 100 bu/a (Figure 3). In Topeka, the higher yield potentials were related to the irrigation scheduling system, with the highest yields being achieved from treatments 4 and 10. The yield gaps between the highest yielding and the lowest was 17 bu/a, and the two highest yielding treatments were significantly different from the rest. This yield difference can be partially explained by the fertilizer N program employed during the 2015 growing season. With the GreenSeeker technology and in-season N application there was damage done to the green leaves on the plants, which was counter-productive by inhibiting photosynthesis and limiting yields (producing rapid senescence). The yield gaps across all the other treatments were minimized with the addition of adequate irrigation.

The yields in Ottawa were quite different with the greatest yield gap being 22 bu/a between the highest, treatment #2, and the lowest, treatment #10 (Figure 3). The yields were limited overall by the low precipitation of only 10.8 inches (Figure 1) during the growing season. Treatment #2 included a high input, narrow row spacing, except at a low seeding rate; and treatment #10 was a low input treatment with traditional 30 inch row spacing and low seeding rate. This site demonstrated how narrowing the row spacing and utilization of improved management practices can maximize the yields even in a low-yielding, water-limiting environment. Regardless of the treatment evaluated in both sites, the yield per plant was highly related to the grain number per head (Figure 4). By focusing on this yield component, such as how management factors affect the grain number per head, the variation in yields across environments can be better explained.

Table 1. Description of sorghum treatments for all sites

	Treatments										
	1	2	3	4	5	6	7	8	9	10	11
Seeding rate	Optimum	Normal	Optimum	Optimum	Optimum	Optimum	Optimum	Optimum	Optimum	Normal	Optimum
Row spacing	15 in.	15 in.	30 in.	15 in.	15 in.	15 in.	15 in.	15 in.	15 in.	30 in.	15 in.
N program	GS	GS	GS	Standard	GS	GS	GS	GS	GS	Standard	GS
Fungicide/insecticide	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Micronutrients	Fe, Zn	Fe, Zn	Fe, Zn	Fe, Zn	Fe, Zn	None	Fe, Zn	Fe, Zn	Fe, Zn	None	Fe, Zn
Plant growth regulator	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Starter fertilizer	NPKSZn	NPKSZn	NPKSZn	NPKSZn	NPKSZn	NPKSZn	NPKSZn	NP	NPKSZn	NP	NPKSZn
Chloride	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
GreenSeeker + N	No	No	No	No	No	No	No	No	No	No	Yes

Optimum seeding rate = 90,000 plants/a; Normal = 45,000 plants/a; 15 in. = narrow row spacing; 30 in. = wide row spacing; GS = GreenSeeker meter (Trimble Navigation, Westminster, CO); Standard = conventional N application (without precision agriculture technology); Fe = Iron; Zn = Zinc; N = Nitrogen; P = Phosphorous; K = Potassium; and S = Sulfur.

Table 2. Soil characterization before planting

	Topeka		Ottawa	
Soil parameters	0-6”	6-24”	0-6”	6-24”
pH (units)	6.9	6.9	6.3	6.5
Mehlich P (ppm)	67.1	40.2	12.1	4.6
K (ppm)	395	287.9	128.1	248.9
CEC (meq/100 g)	17.9	19.4	20.5	28.4
OM (%)	2.86	2.26	3.15	2.71

Table 3. Grain sorghum phenology during the 2015 growing season at Ottawa and Topeka sites

Plant phenology	Topeka	Ottawa
Planting date	June 9	June 9
V5 Growth stage	July 7	July 7
Flowering	August 10	August 12
Harvest	September 30	October 12

Table 4. Stand counts at each treatment and for each site

Treatments	Topeka	Ottawa
	----------------- plants in 17.5 ft row-length -----------------	
1	92	88
2	48	46
3	88	90
4	92	90
5	95	90
6	92	89
7	91	90
8	92	91
9	92	91
10	49	47
11	92	88
CV	3.1	3.7

CV = Coefficient of Variation (%).

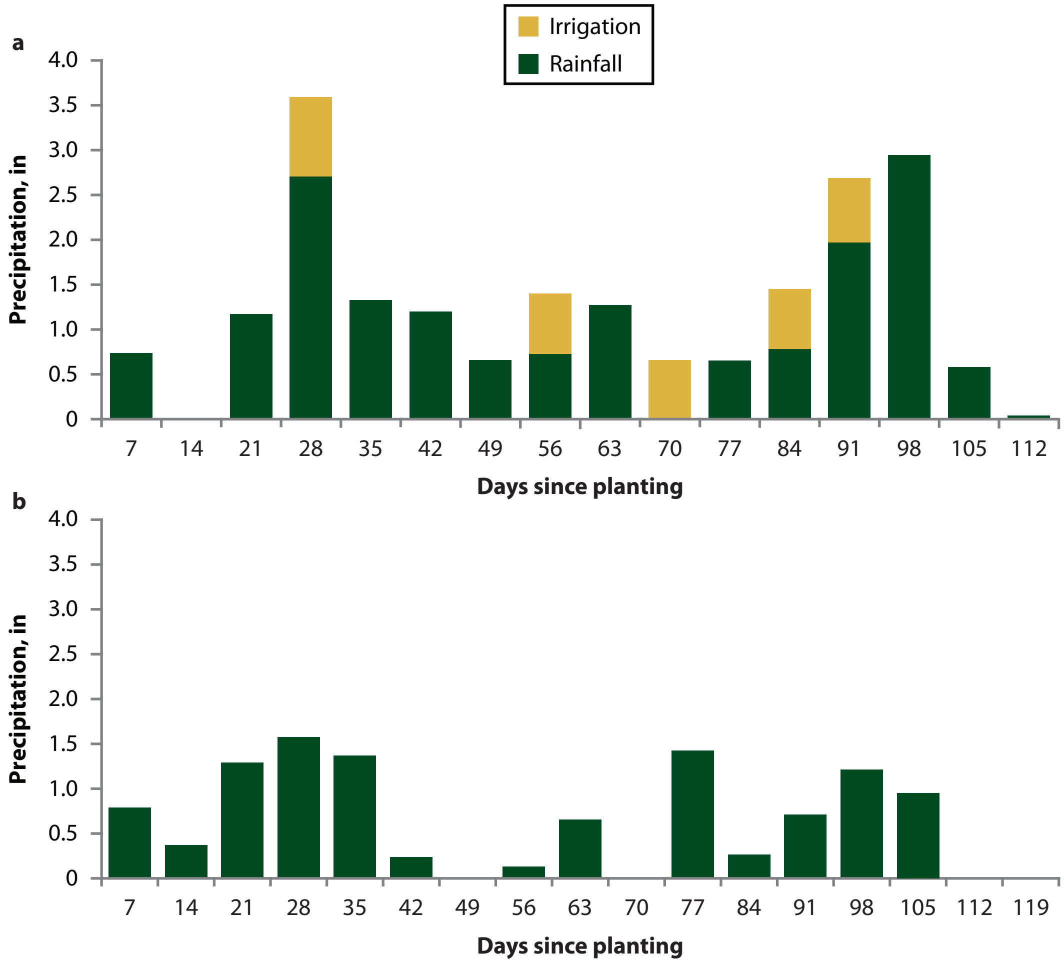

Figure 1. (a) 2015 seasonal precipitation in Topeka, KS, (b) 2015 seasonal precipitation in Ottawa, KS.

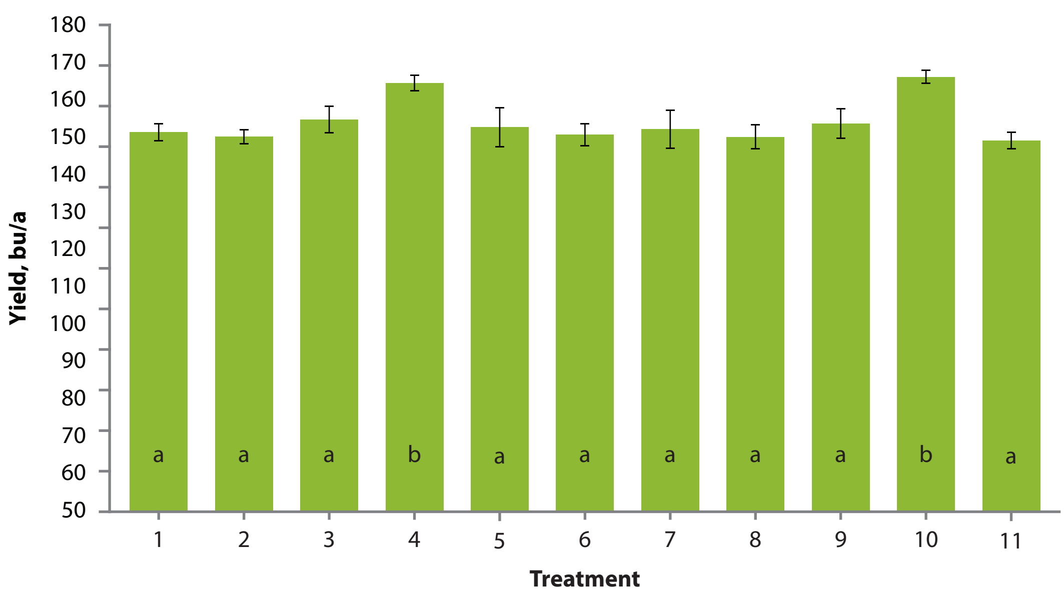

Figure 2. 2015 grain sorghum yield under diverse crop production practices at the Topeka unit of the Kansas River Valley Experiment Field. See Table 1 for treatment details. Different letter shows statistical significance ($P < 0.05$).

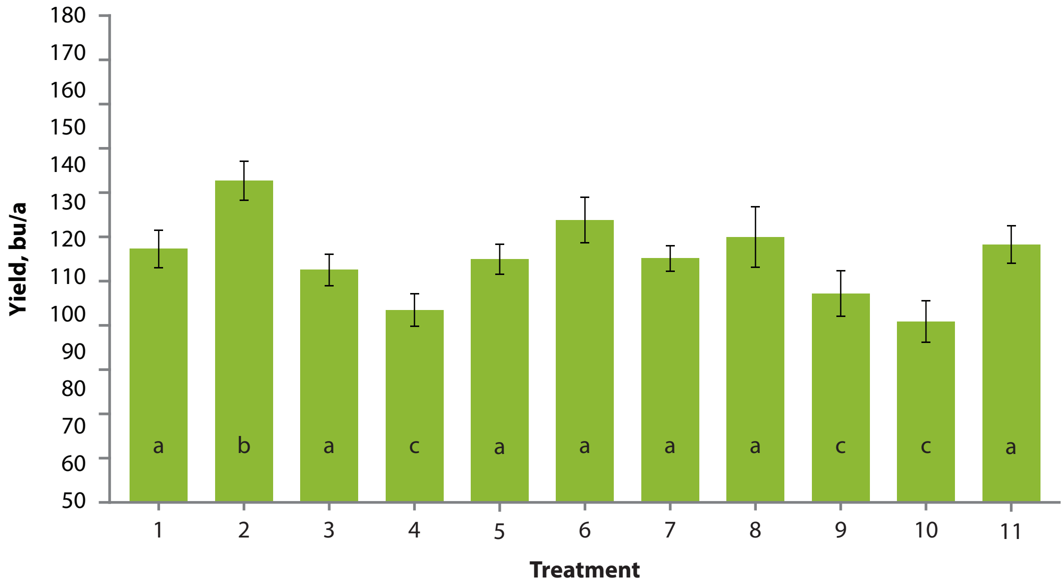

Figure 3. 2015 grain sorghum yield under diverse crop production practices at the Ottawa site of East Central Kansas. See Table 1 for treatment details. Different letter shows statistical significance (P < 0.05).

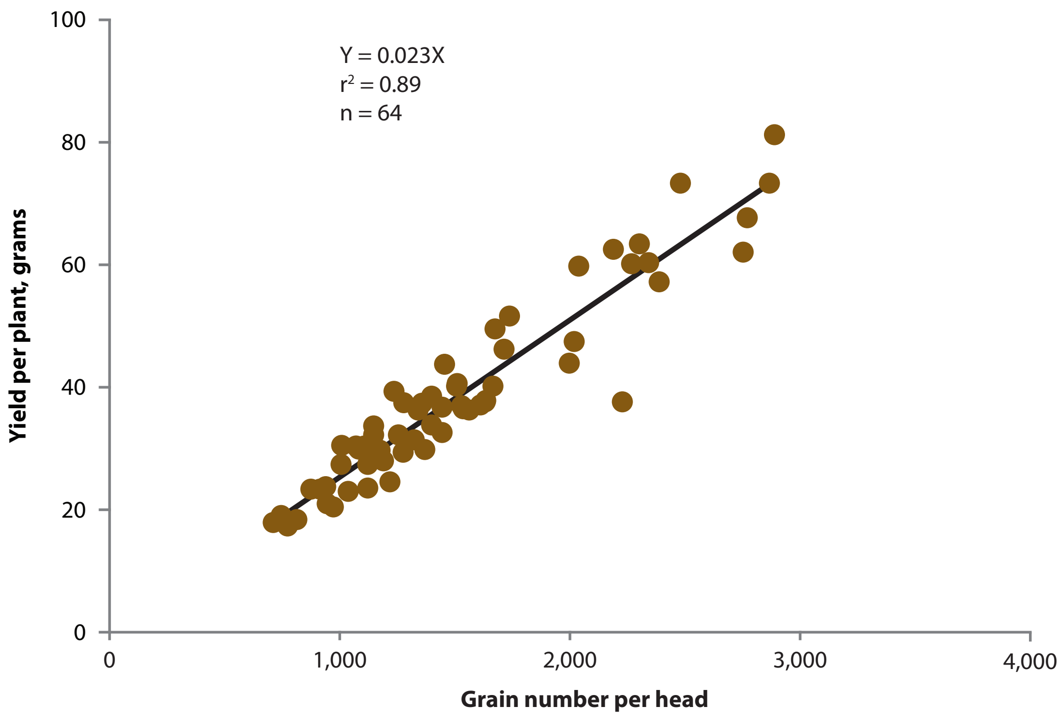

Figure 4. Grain number per head vs. yield per plant relationship for both sites for the 2015 growing season, regardless of treatment.