Skip-row Configuration and Plant Density Effects on Sorghum Grain Yield in Southern Nebraska

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Abstract

Equal spacing of sorghum rows typically results in the highest grain yield when soil water is adequate throughout the season. In deficit rainfall environments, skip-row planting may be a means to preserve stored soil water for use during reproductive growth stages. We evaluated the effect of skip-row planting configuration and plant population density on grain yield, yield components and water use efficiency at five locations in a transect across southern Nebraska where annual mean precipitation ranges from 300 to 900 mm yr^{-1}. Three row configurations including all rows planted (s0), alternate rows planted (s1), and two rows planted alternated with two skipped rows (s2) were evaluated in a complete factorial with two plant population densities. Soil water was measured to 120 cm depth biweekly with a neutron probe. Grain yield was reduced by 20 to 30% with s1 and s2 compared to s0 at the wettest site. At a site with moderate precipitation, grain yield was reduced by 18% with s2 and was not affected with s1. At sites with significant soil water deficits, grain yield increases with s1 and s2 ranged between 5 and 123% over s0. Skip row planting significantly increased the harvest index at all five sites while yield per panicle was significantly increased at the medium and low rainfall sites. Water use efficiency was highest with skip-row planting at sites where the mean monthly growing season precipitation ranged between 49 and 63 mm but lowest at sites where the mean monthly precipitation was between 75 and 79 mm.

Materials and Methods

In 2006, field studies were conducted in five counties across southern Nebraska (Fig. 1). Soil series, rainfall, production practices, and planting densities varied across locations (Table 1). We evaluated three planting row configurations and plant densities in a complete factorial. Row configurations included all rows planted with base 76-cm row spacing (s0) (Fig. 2a) and two skip row configurations: alternate rows planted (s1) (Fig. 2b), and two rows planted alternated with two skipped rows (s2) (Fig. 2c). At Clay County, a relatively high rainfall site, seeding rates were 75,000 and 150,000 seeds ha^{-1}, while at the four lower rainfall sites (Gosper, Frontier, Hayes and Cheyenne Counties) seeding rates were 50,000 and 100,000 seeds ha^{-1}. At each of the five sites, a randomized complete block design with four replications was used.

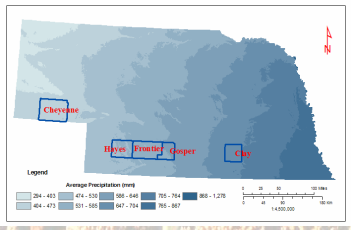

Figure 1. Map of average precipitation across Nebraska and study sites of 2006

Results and Discussion

From Jan. to Sep. 2006, Clay and Gosper Counties had higher total precipitation than the long-term average precipitation. On the other hand Cheyenne, Hayes and Frontier Counties had lower precipitation than the long-term average (Table 1). The effect of row configuration on soil water availability became evident as the growing season progressed and crop water uptake increased, except at Clay County where soil water content remained consistently high throughout the growing season due to timely rainfall.

Sorghum Grain Yield and Yield Components

At Cheyenne, Hayes and Frontier Counties, skip row configurations (s1 and s2) had higher grain yield than s0 (Fig. 3). Differences in grain yield between s1 and s2 were significant only at Hayes County. In these water deficit environments, grain yield increase of skip-row over conventional planting ranged between 5 and 123%. At the Gosper Co. site with moderate precipitation, grain yield was reduced by 18% with s2 and not affected with s1.

Table 1. Soil series, taxonomic classes, agronomic data and rainfall at each study site

County	Clay	Gosper	Frontier	Hayes	Cheyenne
Soil series	Crete silt loam	Holdrege silt loam	Hall silt loam	Kuma silt loam	Duroc loam
Taxonomic class	Fine, smectitic, mesic, Pachic Arguistolls	Fine-silty, mixed, superactive, mesic, Typic Argiustolls	Fine-silty, mixed, superactive, mesic,Pachic Arguisolls	Fine-silty, mixed, superactive, mesic Pachic Arguisolls	Fine-silty, mixed, superactive, mesic Pachic Haplustolls
Variety planted	DEKALB 42-20	DEKALB 29-28	DEKALB 29-28	DEKALB 29-28	DEKALB 29-28
Plant population	75,000 ha^{-1} 150,000 ha^{-1}	50,000 ha^{-1} 100,000 ha^{-1}	50,000 ha^{-1} 100,000 ha^{-1}	50,000 ha^{-1} 100,000 ha^{-1}	50,000 ha^{-1} 100,000 ha^{-1}
Plant date	June 7, 2006	May 16, 2006	May 23, 2006	May 24, 2006	June 1, 2006
Harvesting date	Oct. 25, 2007	Oct. 31, 2006	Oct. 31, 2006	Nov. 1, 2006	Oct. 17, 2006
Jan-Sept, 06 total rainfall (mm)	597	508	358	394	312
Jan-Sept long term mean rainfall (mm)	591	490	462	451	422

Figure 2a. Solid planting (S1)

Figure 2b. Plant 1 skip 1 (S2)

Figure 2c. Plant 2:skip 2 (S3)

At Clay County, grain yield was reduced by 20 to 30% with s1 and s2 compared to s0. The effect of different plant population density on sorghum grain yield was not consistent across sites (Fig. 4). At Clay, Cheyenne and Hayes Counties, grain yield was greater with the higher plant population, while the reverse was observed at Frontier and Gosper.

Harvest index (HI) across locations ranged between 0.12 and 0.53. Row configuration significantly influenced HI at all sites. In general skip-row planting had significantly higher HI than conventional planting, suggesting better conversion of accumulated biomass to grain yield. This may be due to improved water availability during the grain filling stage. With the exception of Clay County, skip row planted sorghum had higher grain yield per panicle than conventional planting (Table 2).

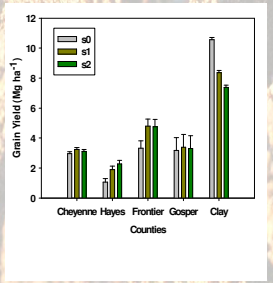

Figure 3. Effect of row configuration at five sites. LSD bars that do not overlap indicate treatment means that are significantly different at a probability of 0.05 or less

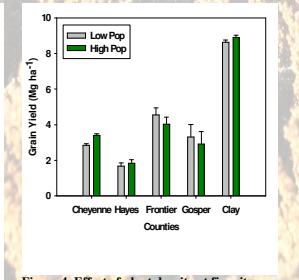

Figure 4. Effect of plant density at five sites on sorghum grain yield. LSD bars that do not overlap indicate treatment means that are significantly different at a probability of 0.05 or less

Considering the effects of planting configuration on yield across locations and rainfall regimes, there is an indication of a crossover at about 4 Mg ha^{-1}, with conventional planting outperforming skip-row planting when average yield was above 4 Mg ha^{-1} (Fig. 5).

Water use efficiency (WUE) was significantly influenced by row configuration at all sites except Gosper. At Cheyenne, Hayes and Frontier Counties, the-skip configuration had significantly higher WUE than the conventional planting. At Clay County, s0 had significantly higher CWU and WUE than s2 (Table 2). The difference in WUE between s1 and s2 were not significant at all sites and the pattern was not consistent (Table 2). The higher water use efficiency in the drier environment in skip planting could be attributed to the availability of the stored water in the skipped area during flowering and grain filling stage

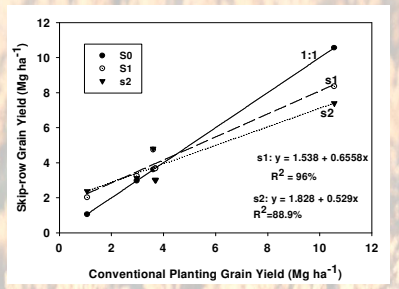

Figure 5. Planting pattern effects on grain yield at varying yield levels in five counties across southern Nebraska

Table 2. Effect of row configuration on panicle yield, crop water use (CWU) and water use efficiency (WUE) at maturity at five study sites, Nebraska, 2006. Values followed by different letters within a study site are significantly different at p<0.05.

County	Row Config.	Grain yield per Panicle (g)	Harvest Index	CWU (mm)	WUE (kg ha^{-1} mm^{-1})
Cheyenne	s0	49.84 a	0.48 a	152.6 a	19.5 a
	s1	60.76 b	0.53 b	151.7 b	21.4 b
	s2	55.82 ab	0.52 b	149.6 c	20.8 b
Hayes	s0	18.32 a	0.12 a	211.2 a	5.0 a
	s1	22.64 a	0.18 a	212.6 a	9.5 b
	s2	32.57 b	0.28 b	212.1 a	11.2 b
Frontier	s0	21.11 a	0.29 a	207.7 a	17.4 a
	s1	35.70 b	0.39 b	208.8 ab	22.7 b
	s2	32.70 b	0.39 b	209.9 b	22.9 b
Gosper	s0	28.42 a	0.19 a	271.2 a	13.6 a
	s1	29.16 a	0.27 b	277.5 a	13.3 a
	s2	29.93 a	0.29 b	274.7 a	11.0 a
Clay	s0	56.05 a	0.39 a	400.7 a	27.2 a
	s1	55.62 a	0.41 b	-	-
	s2	56.96 a	0.40 b	371.5 b	17.0 b

Summary

- At the wettest site, with high yield potential, skip-row produced lower grain yield compared to conventional planting.
- At the medium rainfall site, skip-row produced the same or higher yield than conventional planting.
- At the driest sites, with low yield potential, skip-row out-yield conventional planting.
- Skip-row significantly improved harvest index and WUE at medium and low rainfall sites.
- There was crossover at about 4 Mg ha^{-1}, with conventional planting outperforming skip-row planting when average yield was above 4 Mg ha^{-1}.

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