

SOYBEAN PLANTING CONFIGURATIONS ON FALLOWED SUGARCANE BEDS

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ABSTRACT

In Louisiana, sugarcane (*Saccharum* spp. hybrids) stubble is destroyed following the multi-year crop cycle and fields are fallowed during the summer months in preparation for replanting in August and September. Because conventional tillage and herbicide fallow weed control programs impose a cost with no direct return, planting an alternative crop during the fallow period may provide additional income to producers. Interest in growing soybean in fallowed sugarcane fields has further increased as early maturing varieties have become available that allow for earlier harvest and timely planting of sugarcane. Growth and yield of Maturity Group IV glyphosate resistant soybean planted on 1.8 m-wide sugarcane beds were evaluated using several planting configurations; two drills per bed spaced 46, 61, or 76 cm apart and three drills per bed spaced 38 cm apart, all at the same seeding rate per hectare. Excellent weed control was obtained with glyphosate for all planting configurations and weeds were not a contributing factor in the study. Differences in soybean height among the planting configurations were not observed from 8 weeks after planting (WAP) through the remainder of the growing season. Soybean height is important in regard to weed suppression from shading and can affect yield potential. Maximum soybean height was attained 11 WAP for 2 drills at 61 or 76 cm spacing and for 3 drills at 38 cm, but 13 WAP was needed to maximize height for 2 drills at 46 cm spacing. Soybean canopy closure on the top of the bed between drills was attained 7 WAP when drills were 46 or 38 cm apart, 9 WAP when drills were 61 cm apart, and 11 WAP when drills were 76 cm apart. Canopy closure in the row middles was determined by measuring the area not covered by soybean foliage between the two outermost drills for adjacent sugarcane beds. When 2 drills were planted 76 cm apart and where 3 drills were planted 38 cm apart, canopy closure in the row middles occurred by 11 WAP. Complete canopy closure in the row middles was not attained by 13 WAP for 2 drills at 46 or 61 cm spacing. Open row middles later in the growing season can contribute to weed reinfestation and reduction in soybean yield and harvest efficiency. In 2006 when soybean was planted in May, yield was reduced 12% when 2 drills were planted 76 cm apart compared with 3 drills planted 38 cm apart, both with 76 cm between the two outside drills. In 2007 when total rainfall was 1.6 times that of the previous year and when soybean was planted in April, yield differences among the various planting configurations were not observed. Expenses related to weed control and seedbed preparation would be incurred in fallowed sugarcane fields whether or not soybean is grown. Revenue generated from sale of soybean could help offset expenses and be economically advantageous.

INTRODUCTION

Sugarcane in Louisiana is grown as a perennial crop with three to five annual harvests made from a single, vegetative propagated planting. The decline in sugarcane stand over a multi-year crop cycle necessitates replanting. During the summer months fields are

fallowed and the sugarcane stubble and the beds are destroyed by tillage and beds are reformed in preparation for planting in August and September. Since conventional fallow weed control programs impose a cost with no direct return, planting an alternative crop during the fallow period may offer the potential to control weeds while providing additional income to producers (Griffin et al. 2006). Planting soybean on the raised sugarcane beds would also provide drainage which is critical to soybean production. In the mid 1990's when Roundup Ready (RR) soybean (Monsanto Company, St. Louis, MO) was first introduced in Louisiana, sugarcane producers used grain drills and as many as six 25-cm drills were centered on top of sugarcane beds around 1.8 m wide. Using a drill, seeding depth and seed coverage were not uniform, but in most cases adequate stands were obtained. Some growers shifted to using two standard planter units per sugarcane bed with units spaced around 50 cm apart; dependent on how close the units could be mounted on the tool bar. Using planter units decreased seeding rate, improved stands, and helped to assure that soybean drills were centered on the tops of beds. Interest in soybean further increased as high yielding early maturing varieties became available that allowed for earlier harvest without delaying sugarcane planting.

With two drills centered on a 1.8 m-wide sugarcane bed, canopy closure on the top of the bed would be fairly rapid but canopy closure in the middles between beds may never occur. The ability of soybean to compete with weeds is attributed to rate of soybean canopy closure (Weber et al. 1966). Planting soybean in rows 19 cm apart compared with rows 76 cm apart increased crop competitiveness by reducing number of weeds and weed dry matter accumulation (Hock et al. 2006). For narrow row spacing (50 cm or less) yield advantages (Board and Harville 1994; Etheredge et al. 1989; Hanna et al. 2008) and earlier canopy closure (Mickelson and Renner 1997) have been reported. In the southeastern U.S., narrow row culture is recommended for increasing soybean yield at late plantings. Crop growth rate during the latter half of the vegetative period accelerated more rapidly in narrow rows (25 and 50 cm spacing) resulting in greater leaf area index and light interception and total dry matter when compared with wide row (100 cm spacing) culture (Board and Harville 1996). Soybean yield increases observed for planting in 38 and 76-cm row spacings were also attributed to early season vegetative growth resulting in greater light interception and leaf area indices compared with 114-cm row spacing (Bullock et al. 1998). Soybean planted in 18-cm rows reached 80% ground cover five weeks after planting compared to 30% ground cover in 102-cm rows (Hartzler and Benson 1996). Excellent suppression of weeds was observed where glyphosate was applied early when soybean row spacing was reduced (Dalley et al. 2004). Additionally, Mays (1978) reported that natural populations of predators and parasitoids of arthropods were greater in narrow spaced closed canopies compared to the open canopies of conventionally planted soybean.

With the recent introduction of Asian soybean rust (*Phakopsora pachyrhizi*) to the southern U.S. (Benedict et al. 2006), farmers have increased the use of fungicides to prevent the spread of this pathogen (Anonymous 2008a). Additionally problems with red banded stinkbug (*Piezodorus guildinii*) have increased the number of late season insecticide applications (Anonymous, 2008b). Concerns exist over pesticide deposition within the crop canopy in narrow row systems. Differences in soybean canopy penetration of fungicide, however, were not observed for 19, 38, and 76 cm row spacings (Hanna et al. 2008).

Research was initiated to evaluate growth response and yield of Maturity Group IV soybean planted on raised sugarcane beds 1.8 m apart using several planting configurations including two drills per bed spaced 46, 61, or 76 cm apart and three drills per bed spaced 38 cm apart.

MATERIALS AND METHODS

Studies were conducted at the Central Research Station, Ben Hur Research Farm near Baton Rouge, LA, in 2006 and 2007 using a silty clay loam with 1.0% organic matter and pH 5.9. The experimental area was worked using conventional seedbed preparation and raised beds (1.8 m spacing) were drawn. 'Asgrow 4403 RR' soybean (Asgrow Seed Co., Marion, AR) was planted on 12 May 2006, and 16 April 2007, at a seeding rate of 45 kg/ha. Because the seeding rate per hectare was kept constant, the number of seed per drill varied depending on number of drills planted per bed. Maintaining the same seeding rate for all planting configurations would eliminate the effect of plant population that would occur with variable seeding rates. The planting configurations consisted of two drills per bed spaced 46, 61, or 76 cm apart and three drills per bed spaced 38 cm apart. Glyphosate at 1.12 kg ai/ha was applied as needed and season long weed control was obtained for all row configurations. Plots consisted of three sugarcane beds, 5.4 m wide x 15.2 m in length. Experimental design was a randomized complete block and treatments were replicated four times.

Soybean height, canopy width, and row middle width data were collected beginning 7 weeks after planting (WAP) and continued weekly until 13 WAP. Height was measured to top of the soybean canopy and canopy width at the widest point between drills on the top of the bed. Row middle width represented the area not covered with crop vegetation between the outermost drills on adjacent beds. Fungicide (pyraclostrobin at 0.109 kg ai/ha plus thiophanate-methyl at 0.784 kg ai/ha) was applied at R3 (Fehr and Caviness 1977) and insecticide (acephate at 1.0 kg ai/ha plus cyfluthrin at 0.018 kg ai/ha) was applied on an as needed basis. Soybean was combine-harvested in early September 2006 and in late August 2007 from the center bed of each three row plot. Yield was adjusted to 13% moisture.

Tests for normality and homogeneity of variance indicated no need for data transformation prior to analysis. Based on analysis of variance, a significant planting configuration by year interaction was not observed for soybean height and canopy and row middle width at any of the weekly data collection dates. Means for the various planting configurations were averaged across years and compared within each rating date. Data were also subjected to repeated measures analysis to compare changes in soybean growth from 7 to 13 WAP. For soybean yield, a significant planting configuration by year interaction was observed and because of differences in planting date and rainfall between the two years, data are presented separately. Means were separated using Fisher's Protected LSD Test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Rainfall across the growing season varied between years. During the first 8 WAP rainfall was 9.7 cm less in 2006 than in 2007 (Table 1). Total rainfall over the 19 week growing season was 38.6 cm in 2006, 38% less compared with 2007. The lack of early season rainfall affected

Table 1. Rainfall (cm) during the 19 weeks after planting soybean in 2006 and 2007.^a

Weeks after planting	2006	2007
0 – 4	1.1	14.2
5 – 8	10.3	6.9
9	1.7	4.0
10	0.4	10.9
11	2.8	0.2
12	1.1	7.8
13	5.8	5.1
14	0.7	1.3
15	5.4	2.7
16	0.2	4.1
17	0.0	0.0
18	4.9	4.6
19	4.2	0.4
Total	38.6	62.3

^aAsgrow 4403 RR soybean (Maturity Group IV) planted 12 May 2006 and 16 April 2007.

early season soybean growth the first year and soybean were shorter that year when flowering was initiated (data not shown). Glyphosate, regardless of planting configuration, provided excellent weed control and weeds were not a limiting factor to soybean growth or yield. Averaged across years, soybean height 7 WAP was greater when 2 drills were planted at 46 cm spacing compared with 2 drills at 76 cm spacing or 3 drills at 38 cm spacing (Table 2). Differences in soybean height among the planting configurations were not observed for the remainder of the growing season. Maximum soybean height was attained 11 WAP for 2 drills at 61 or 76 cm spacing and for 3 drills at 38 cm (103.3 to 108.5 cm), but maximum height was not attained until 13 WAP for the 2 drills at 46 cm spacing (108.7 cm).

By 7 WAP the soybean canopy had covered the area between drills on the row tops where drills were 46 or 38 cm apart (Table 3). Canopy closure between drills occurred 9 WAP when spaced 61 cm apart but where drills were 76 cm apart, canopy closure did not occur until 11 WAP. For each week of data collection, canopy width was lowest where 3 drills were planted at 38 cm spacing. The combination of an extra drill per bed along with the 38 cm spacing between drills contributed to more rapid canopy closure on top of the sugarcane beds. Although a significant planting configuration by year interaction was not observed, soybean canopy closure was delayed in 2006. A more open soybean canopy may be advantageous for insecticide application, but would encourage late season weed emergence (Yelverton and Coble 1991). In this study, weeds were not a factor contributing to decreased soybean growth and insects were controlled and eliminated as a yield limiting factor.

Even though canopy closure was attained on the top of the beds regardless of planting configuration, this was not the case for canopy closure in the row middles. For data collected at all weeks after planting, the area not covered with soybean foliage in the row middle was

Table 2. Soybean height 7 to 13 weeks after planting (WAP) as affected by number of soybean drills planted and drill spacing on sugarcane beds 1.8 m apart.^a

Number of drills / drill spacing per bed	Mean soybean height (cm)						
	7 WAP	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP	13 WAP
2 drills / 46 cm	49.0 a F ^b	69.1 a E	85.3 a D	95.0 a C	102.9 a B	103.1 a B	108.7 a A
2 drills / 61 cm	46.5 ab E	66.3 a D	82.6 a C	93.2 a B	103.6 a A	106.2 a A	102.1 a A
2 drills / 76 cm	45.2 b E	66.3 a D	82.8 a C	94.2 a B	103.4 a A	105.4 a A	105.4 a A
3 drills / 38 cm	45.2 b E	68.6 a D	86.1 a C	96.5 a B	108.5 a A	110.5 a A	110.2 a A

^aSoybean drills centered on the tops of sugarcane beds. Soybean height determined at the top of the crop canopy and data were averaged across two years.

^bMeans within a column followed by the same lowercase letter are not significantly different ($P \leq 0.05$). Means within a row followed by the same uppercase letter are not significantly different ($P \leq 0.05$).

Table 3. Soybean canopy width 7 to 13 weeks after planting (WAP) as affected by number of soybean drills planted and drill spacing on sugarcane beds 1.8 m apart.^a

Number of drills / drill spacing per bed	Mean soybean canopy width (cm)						
	7 WAP	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP	13 WAP
2 drills / 46 cm	48.7 a F ^b	54.8 b E	63.0 b D	71.6 a C	79.0 b B	81.0 b AB	84.8 a A
2 drills / 61 cm	51.3 a E	59.1 a D	67.0 ab C	73.9 a B	81.2 ab A	83.1 b A	83.8 a A
2 drills / 76 cm	50.0 a E	60.7 a D	68.6 a C	75.2 a B	83.8 a A	87.4 a A	85.3 a A
3 drills / 38 cm	42.7 b F	51.0 c E	57.2 c D	62.7 b C	69.6 c AB	66.3 c BC	70.9 b A

^aSoybean drills centered on the tops of sugarcane beds. Canopy width determined by measuring the widest point of the crop canopy and data were averaged across two years.

^bMeans within a column followed by the same lowercase letter are not significantly different ($P \leq 0.05$). Means within a row followed by the same uppercase letter are not significantly different ($P \leq 0.05$).

greatest for the 2 drill 46 cm drill spacing, intermediate for the 2 drill 61 cm spacing, and lowest for the 2 drill 76 and 3 drill 38 cm spacings (Table 4). For the 76 cm spacing, 2 drills were planted per bed and 3 drills were planted for the 38 cm spacing, both having the same width between the two outside rows (76 cm). Canopy closure in the row middles for both these planting configurations occurred by 11 WAP. Although canopy closure in the row middles was more rapid for the 2 drill 61 cm spacing compared with the 2 drill 46 cm spacing, complete row middle closure for both planting configurations was not attained by 13 WAP. Shading provided with canopy closure would be critical to suppression of weed emergence and growth. Weeds that emerge late in the growing season and present at harvest can affect harvest efficiency and crop quality (Ellis et al. 1998).

Because of differences in planting date and rainfall between years (Table 1), soybean yield is presented for each year. In Louisiana, optimum planting of Maturity Group IV soybean varieties is mid-April (Anonymous 2009). In 2006 because of limited soil moisture, planting was delayed until 12 May. Averaged across planting configurations, soybean yield in 2006 was 9.1% less compared with 2007 when soybean was planted 16 April (Table 5). Soybean yield in 2006 was equivalent for the 2 drill 46 cm spacing, 2 drill 61 cm spacing, and for the 3 drill 38 cm spacing. Yield, however, was reduced 12% when 2 drills were planted 76 cm apart compared with 3 drills planted 38 cm apart, even though width between the two outside drills was the same. The yield difference observed where three drills were planted per bed 38 cm apart (considered a narrow row spacing) compared with two drills planted per bed 76 cm apart (considered a wide row spacing) was not unexpected. Yield advantages to narrow row spacing (50 cm or less) have been documented and attributed to accelerated vegetative growth resulting in greater light interception (Board and Harville 1994; Bullock et al. 1998). In the present study the lack of rainfall in 2006 may have further contributed to decreased early season crop growth where two drills were planted per bed 76 cm apart compared with 3 drills 38 cm apart. In the second year when soybean was planted in April, yield differences among the various planting configurations were not observed. In other research, differences in crop growth rate during the vegetative period for soybean planted at the optimal date in narrow or wide rows did not affect yield (Board and Harville 1996).

This research shows that soybean grown during the sugarcane fallow period in Louisiana can produce excellent yield. When soybean is planted in May versus April and when early season rainfall is limited, three soybean drills per sugarcane bed produced greater yield than two drills per bed. With a two drill system, a wider spacing between drills would encourage more rapid soybean canopy closure of row middles which could affect emergence of weeds late in the growing season. In previous research, sugarcane yield was not negatively affected when soybean was grown during the fallow period compared with a non-crop program (Boudreaux et al. 2006; Griffin et al. 2006). Etheredge et al. (2009) reported that a typical non-crop conventional tillage and glyphosate program would cost \$110.94 to 160.90/ha (tillage plus herbicide cost). Since conventional fallow weed control programs impose a cost with no direct return, planting an alternative crop during the fallow period may offer the potential to provide additional income to producers. Griffin et al. (2006) reported a net return (gross return less variable production costs) where soybean was grown during the fallow period of as much as \$99.82/ha. This was based on a respectable yield of 2,590 kg/ha. Using these scenarios a soybean fallow program could help offset the cost of a typical non crop fallow program. For the

Table 4. Soybean row middle width 7 to 13 weeks after planting (WAP) as affected by number of soybean drills planted and drill spacing on sugarcane beds 1.8 m apart.^a

Number of drills / drill spacing per bed	Mean soybean row middle width (cm)						
	7 WAP	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP	13 WAP
2 drills / 46 cm	82.8 a A ^b	65.5 a B	52.1 a C	43.2 a D	32.0 a E	27.9 a EF	21.3 a F
2 drills / 61 cm	66.8 b A	50.3 b B	38.9 b C	31.5 b C	21.6 b D	12.4 b E	11.2 b E
2 drills / 76 cm	49.0 c A	36.6 c B	27.2 c C	13.7 c D	2.8 c E	0 c E	0 c E
3 drills / 38 cm	48.8 c A	35.1 c B	22.6 c C	9.1 c D	0 c E	0 c E	0 c E

^a Soybean drills centered on the tops of sugarcane beds. Row middle width determined by measuring the area between the outermost drills on adjacent beds not covered with crop vegetation and data were averaged across two years.

^b Means within a column followed by the same lowercase letter are not significantly different ($P \leq 0.05$). Means within a row followed by the same uppercase letter are not significantly different ($P \leq 0.05$).

Table 5. Soybean yield as affected by number of soybean drills planted and drill spacing on sugarcane beds 1.8 m apart.^a

Number of drills / drill spacing per bed	Mean soybean yield (kg/ha)		
	2006	2007	2-year average
2 drills / 46 cm	3970 ab ^b	4400 a	4190 a
2 drills / 61 cm	4180 ab	4360 a	4270 a
2 drills / 76 cm	3800 b	4680 a	4240 a
3 drills / 38 cm	4330 a	4460 a	4400 a

^a Soybean drills centered on the tops of sugarcane beds. Asgrow 4403 RR soybean (Maturity Group IV) planted 12 May 2006 and 16 April 2007. See Table 1 for rainfall data.

^b Means within a column followed by the same letter are not significantly different ($P \leq 0.05$).

soybean fallow study, gross return was based on a 2004 commodity price of \$0.198/kg of soybean yield with deduction of one-fifth land rent (Griffin et al. 2006). Cost of any sugarcane fallow program would be dependent on fuel and herbicide costs. If soybean is grown during the fallow period, then net return would also be dependent on soybean yield and price received.

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