Planting Date, Rate, and Twin-Row vs. Single-Row Soybean in the Mid-South

H. Arnold Bruns*

ABSTRACT

Comparisons were made of single-row vs. twin-row soybean [*Glycine max* (L.) Merr.] production on a Beulah fine sandy loam (coarse-loamy, mixed, active, thermic Typic Dystrudepts) (BFSL) and Sharkey clay (very-fine, smectitic, thermic Chromic Epiaquerts) (SC) in 2009 and 2010 at Stoneville, MS. Seeding rates of 20, 30, 40, and 50 seed m^{-2} were planted on beds in 102 cm single rows or 25 cm twin rows with 102 cm centers. Three planting dates, mid-April and mid-May representing the Early Soybean Production System (ESPS) and mid-June common to double-crop soybean were made. Data included plants at growth stage R4 (full pod), nodes and pods plant^{-1}, yield, seed weight, and seeds m^{-2}. Twin rows yielded more than single rows on both soils (3.8 Mg ha^{-1} vs. 3.6 Mg ha^{-1} on BFSL; 4.2 Mg ha^{-1} vs. 4.0 Mg ha^{-1} on SC). Yields in 2010 were less than 2009 due to drought and heat stress. Delayed planting across row types decreased yields as much as 40% while increasing seeding rates had no effect. Twin rows produced more plants m^{-2} than single rows. Differences in nodes plant^{-1} were noted but did not affect yield. Pods per plant did not differ between row configurations on either soil. Seeding rates above 30 seeds m^{-2} did not produce greater yields and above 50 seeds m^{-2} on the BFSL produced seed with less weight. Twin–rows generally produced more seeds per m^2 than single rows. Small yield increases and high equipment costs make considering a twin-row planter's usefulness with other crops important before purchasing it for soybean production.

Twin-row planting in conjunction with the ESPS as developed in the Mississippi Delta (Heatherly, 1999) has become popular in the Mid-South. Maturity Group (MG) IV cultivars planted during April to mid-May produce well in this system, along with a number of MG V cultivars (Koger, 2010). The ESPS has virtually transformed soybean production in the lower Mississippi River Valley away from growing MG VI and MG VII cultivars seeded from the latter half of May through June to growing MG IV and MG V cultivars seeded during April and the first half of May. The previous production system exposed the crop to the hottest and driest weather of the year during reproductive growth, stressing the plants, and reducing yields (Bowers, 1995). With ESPS the risk of crop failure due to drought and heat stress is reduced, which increases yield stability and enhances its acceptance by growers in the Mid-South (Boquet, 1998).

Soybean production in the Mid-South generally uses raised beds on wide rows to accommodate furrow irrigation and uses the same equipment for cotton (*Gossypium hirsutum* L.) and corn (*Zea mays* L.) planting and tending. Common row widths used for soybean in the lower Mississippi River Valley range from 88 to 102 cm. Twin-row planting of soybean in the Mid-South began around 2000 and in 2010 it was estimated that nearly 80% of the total hectareage of soybeans grown in the lower Mississippi River Valley was produced in twin rows (P. Giachelli, personal communication, 2010). Bell (2005) stated that twin-row seeded soybeans have greater yields than single-row plantings because they produce more pods plant^{-1}. Both Ebelhar (2010) and Smith (2010) report twin-row plantings of corn when compared to traditional single row plantings have greater yields which has aided the adoption of twin-row crop production.

Research on comparing single- vs. twin-row soybean production in the Mid-South is still limited. Grichar (2007) compared single- and twin-row soybean plantings at two locations along the Texas Gulf Coast and reported increased yields of both MG IV and MG V cultivars when grown in twin- vs. single-rows. In Louisiana Mascagni et al. (2008) observed yield increases in twin-row plantings over single-row plantings in two of three experiments. Graterol et al. (1996), reported seed yield increases in twin- over single-rows grown in Nebraska were only observed when environmental conditions were not yield limiting.

Timely planting of corn and cotton in the Mid-South can sometimes delay soybean seeding along with waiting for fields, especially those that are predominately clay, to dry sufficiently to hold up planting equipment but not be too dry to prevent emergence of the crop. Also, an appreciable hectarage of soybean produced in the lower Mississippi River valley involves double-cropping immediately behind winter wheat (*Triticum aestivum* L.) harvests. Such plantings are usually made in mid-June on a flat surface or the remnants of ridges used to grow previous row crops before the wheat. The idea is to increase income from the land, even though yields are comparatively low to earlier plantings. Seed yields from double-crop plantings behind wheat are often 10 to 40% less than earlier plantings (Kyei-Boahen and Zhang, 2006).

USDA-ARS, 141 Experiment Station Rd., Box 345, Stoneville, MS 38776.
Received 14 Mar. 2011. *Corresponding author (arnold.bruns@ars.usda.gov).

Published in Agron. J. 103:1308–1313 (2011)
Posted online 27 Jun 2011
doi:10.2134/agronj2011.0076

Abbreviations: BFSL, Beulah fine sandy loam; ESPS, early soybean production system; MG, maturity group; SC, Sharkey clay.

The objective of this research was to evaluate the effects of single- vs. twin-row planting of a MG IV soybean cultivar (commonly grown in ESPS) at four seeding rates grown under irrigation and different planting dates. The first two planting dates represent the range of the ESPS and the final one represents the time of a double-crop planting. A BFSL and SC soil were selected for the experiment as both are indigenous to much of the soybean production in the lower Mississippi River Valley and similar soils are found in many humid subtropical river deltas.

MATERIALS AND METHODS

The study was conducted at Stoneville, MS during 2009 and 2010 at two different sites. The soil at one site was a BFSL and the other site was an SC. Both sites were planted to soybean at least one season before the experiment and prepared for planting by fall disking followed by forming 40-cm wide ridges centered 102 cm apart in late winter. Ridges on the BFSL were prepared for planting by harrowing within 24 h of planting to form a seedbed approximately 40-cm wide. Harrowing of the ridges on the SC was done about 28 d before planting to allow rain to replenish soil moisture in the seeding zone. The cultivar used in this experiment was Pioneer[2] brand (Johnston, IA) 94B73 a late MGIV indeterminate plant type, representative of most of the cultivars grown in the ESPS in the Mid-South.

The experimental design used in this study was a split plot of a randomized complete block replicated four times. Individual experimental units were four ridges wide planted 11 m long and end-trimmed to 9 m at the V4 growth stage (four trifoliolate leaf nodes) as defined by Pedersen (2004). Whole plots were one of three planting dates assigned at random within each block. Planting dates on the BFSL site in 2009 were 8 April, 11 May, and 8 June. In 2010 planting dates for the same site were 14 April, 11 May, and 17 June. Planting dates for the SC site in 2009 were 22 April, 20 May, and 17 June. For 2010 at the SC site planting dates were 12 April, 11 May, and 2 June. Subplots were assigned at random within each whole plot and consisted of a combination of either a single-row or twin-row planting configuration and a seeding rate of 20, 30, 40, or 50 seeds m^{-2}. Single-row plots were planted using an Almaco cone plot planter (Allen Machine Company, Neveda, IA)[1] and twin-row plantings were made using a four unit Monosem NG-3 (Monosem Edwardsville, KS)[1] twin-row planter set on 102-cm centers between planting units and 25 cm between rows within a unit.

Before winter tillage soil tests taken at both sites and indicated no additional fertilizer applications were needed to achieve a 4.0 Mg ha^{-1} seed yield (Blaine et al., 2010). Weed control was accomplished at both sites with a pre-plant application of trifluralin [2,6-Dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)aniline] at 0.7 ai ha^{-1} followed by two postemergence applications of metolachloro [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy- 1-methylethyl) acetamide] and glyphosate {2-[(phosphonomethyl)amino] acetic acid} at factory label recommended rates. The postemergence herbicides were applied at growth stage V2 to V3 (2–3 trifolioate leaf nodes) and V5 to V6 (5–6 trifolioate leaf nodes). Fungal diseases were controlled with an application of pyraclostrobin {carbamic acid, [[[1-(4-cholrophenyl)-H-pyrazol-3-yl] oxy]methyl]phenyl]methoxy-,methyl ester} (BASF, Research Triangle, NC)[2] applied at factory label rates at V5 to V6.

Plots at both sites were furrow irrigated beginning at R1 (beginning flowering) and continuing to R6 (full seed). Approximately 25 mm of water was applied at about 10 d intervals or 10 d after a rain event of 25 mm or more. Data collected included plants m^{-2} at growth stage R4 acquired by counting the plants within 1 m^2 near the center of each plot, nodes and pods $plant^{-1}$ at R6 (full seed) of four randomly select plants in the interior of each plot.

The two center rows of each plot were harvested at maturity using a Kincaid 8 XP[1] plot combine (Haven, KS) equipped with a Juniper Systems[1] HM-400 Harvest Data System (Logan, UT) and seed sampling system. Plot seed yield and seed moisture content at harvest were recorded automatically. The collected seed samples were dried for at least 24 h and a 100 seed subsample counted and weighed to determine dry seed weight. Seed per m^2 were calculated from plot yields and seed weight data. Seed yields were adjusted to a standard seed moisture content of 130 g kg^{-1}. Data were analyzed using PROC MIXED of SAS (Research Triangle, NC). Sites were analyzed separately and reported as such. Year at both sites was analyzed as a fixed effect. Means separation was performed using Fisher's protected LSD (0.05).

RESULTS AND DISCUSSION

Rainfall and temperatures during the two growing seasons of the experiment contrasted markedly (Table 1). Rainfall and irrigations combined from April to August in 2010 were only 50% of the total received in 2009. May 2009 had 343 mm of rain, while June was exceptionally dry with only 7 mm of rain, necessitating three irrigations. Then in July 2009 a total of more than 200 mm rain fell along with only 16 d with temperatures ≥ 32.0°C and only 1 d ≥ 37.5°C. Rainfall in 2010 was very limited throughout most of the growing season. Most of June, July, and August of 2010 had daytime maximum temperatures ≥ 32.0°C with a total of 16 d ≥ 37.5°C which likely had an adverse effect on crops at both sites.

The number of established plants at R4 was greater for twin-row than single-row plantings of both the BFSL and SC at all seeding rates (Tables 2 and 3). This was also reflected in the relative amount of established plants to seeds planted. As expected, increased seeding rates resulted in increases of established plants on both soils except between 40 and 50 seeds m^{-2} in the twin-row plantings on the BFSL. Stand establishment under optimum conditions is generally assumed to be about 80% of the seeding rate (Heatherly et al., 1999). This occurred with the twin-row plantings on both the BFSL and SC at all seeding rates except 50 seed m^{-2}. Delayed planting though did not significantly affect the established stands within a seeding rate on the BFSL (Tables 2 and 4), while an increase in established stands on the SC was noted between April and May plantings at the two higher seeding rates.

Among all seeding rates at the BFSL site, both April and May plantings in 2009 had greater stand establishment and relative amounts of established plants than similar plantings in 2010 (Table 5). In 2009 within 48 h of seeding both the April

[1]Trade names are used in this publication solely for the purpose of providing specific information. Mention of trade name, propriety products, or specific equipment does not constitute a guarantee or warranty by the USDA-Agricultural Research Service and does not imply approval of the named product of exclusion of other similar products.

Table 1. Total days above 32 and 37.5°C, precipitation, and irrigation events on two planting date × row type × seeding rate experiments conducted at Stoneville, MS.

Year	Month	Days ≥32.0°C	Days ≥37.5°C	Precipitation	Irrigations	Total water
				mm	25 mm	mm
2009	April	0	0	58		58
	May	0	0	343		343
	June	24	2	7	3	83
	July	16	1	222	1	247
	August	20	0	36		36
						Total = 767
2010	April	0	0	32		32
	May	9	0	134		134
	June	27	2	32	3	108
	July	29	1	48	2	73
	August	30	13	7	1	32
						Total = 379

Table 2. Type three tests of fixed effects and covariance parameter estimates of two soybean planting date × row type × seeding rate experiments conducted at Stoneville, MS, on a Beulah fine sandy loam (BFSL) and a Sharkey clay (SC) soil in 2009 and 2010.

		BFSL (*P* > *F*)						
Source	DF	Plants m^{-2}	% established plants	Nodes $plant^{-1}$	Pods $plant^{-1}$	Yield	Seed wt.	Seeds m^{-2}
Planting date	2	0.865	0.659	0.014	≤0.01	≤0.01	≤0.01	≤0.01
Seeding rate	3	≤0.01	≤0.01	0.058	≤0.01	0.342	≤0.01	0.145
Planting date × seeding rate	6	0.648	0.715	0.374	0.358	0.054	0.436	0.059
Row type	1	≤0.01	≤0.01	0.524	0.113	0.035	0.186	≤0.01
Planting date × row type	2	0.726	0.595	0.759	0.218	0.070	0.367	0.022
Seeding rate × row type	3	0.082	0.106	0.157	0.426	0.491	0.241	0.788
Planting date × seeding rate × row type	6	0.501	0.639	0.202	0.131	0.823	0.949	0.868
Year	1	≤0.01	≤0.01	0.123	0.941	0.022	≤0.01	0.067
Planting date × year	2	≤0.01	≤0.01	0.425	0.766	0.296	0.045	0.483
Seeding rate × year	3	0.466	0.854	0.276	≤0.01	0.284	0.328	0.183
Planting date × seeding rate × row type	6	0.118	0.553	0.390	0.846	0.400	0.104	0.420
Row type × year	1	0.176	0.193	0.232	0.305	0.884	0.485	0.423
Planting date × row type × year	2	0.967	0.962	0.742	0.368	0.442	0.281	0.589
Seeding rate × row type × year	3	0.815	0.922	0.246	0.811	0.794	0.748	0.900
Planting date × seeding rate × row type × year	6	0.507	0.812	0.416	0.210	0.917	0.591	0.764
Components of variance for random effects		Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
σ Planting date × rep(year)		0.354	0	0.640	2.762	0	0	0
σ Rep(year)		0	0	0	3.415	0.014	1.984	6110
σ Residual		19.215	181.440	3.853	133.820	0.358	105.770	122 916

		SC (*P*>*F*)						
Source	DF	Plants m^{-2}	% established plants	Nodes $plant^{-1}$	Pods $plant^{-1}$	Yield	Seed wt.	Seeds m^{-2}
Planting date	2	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.252	≤0.01
Seeding rate	3	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.413	≤0.01
Planting date × seeding rate	6	0.495	0.663	0.311	0.182	0.183	0.419	0.116
Row type	1	≤0.01	≤0.01	0.531	0.138	≤0.01	0.491	≤0.01
Planting date × row type	2	0.693	0.705	0.270	0.168	0.489	0.309	0.033
Seeding rate × row type	3	0.025	0.489	0.647	0.779	0.809	0.428	0.514
Planting date × seeding rate x row type	6	0.289	0.789	0.976	0.571	0.616	0.430	0.446
Year	1	0.454	0.268	≤0.01	≤0.01	0.048	0.733	≤0.01
Planting date × year	2	0.532	0.679	≤0.01	0.627	0.304	0.427	≤0.01
Seeding rate × year	3	0.594	0.304	0.786	0.626	0.309	0.406	0.372
Planting date × seeding rate × row type	6	0.592	0.743	0.559	0.228	0.496	0.388	0.416
Row type × year	1	0.013	0.063	0.459	0.527	0.849	0.273	0.232
Planting date × row type × year	2	0.144	0.295	≤0.01	0.145	0.296	0.369	0.042
Seeding rate × row type × year	3	0.349	0.761	0.212	0.329	0.937	0.415	0.575
Planting date × seeding rate × row type × year	6	0.813	0.920	0.427	0.358	0.929	0.394	0.341
Components of variance for random effects		Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
σ Planting date × rep(year)		0.448	0	0	6.241	0	0	0
σ Rep(year)		0.549	3.392	0.046	0	0.046	0	67.722
σ Residual		17.103	221.050	1.858	174.560	1.858	7299	99.585

and May plantings received approximately 10.0 mm of rain which likely facilitate germination in these plots. By contrast no rainfall events occurred until 10 d after the April planting and 5 d after the May planting in 2010.

Mean established stands across all treatments was greater at the SC site in 2009 (27 plants m^{-2}) than 2010 (24 plants m^{-2}). The interaction between row type and year for mean number of plants per m^2 on the clay soil was statistically significant (Table 2). However, there was no significant difference for the single-row planting between 2009 and 2010 (22 vs. 23 plants m^{-2} respectively) and the twin rows only differed by two plants (29 vs. 27 plants m^{-2}) for 2009 and 2010, respectively. Relative established stand to seeding rate on the SC differed significantly among planting dates. However, no pattern was evident. The May planting averaged 79% establishment while the April and June plantings averaged 72%.

On the BFSL the April planting had significantly fewer nodes $plant^{-1}$ (18) than either the May (20) or June (19) which was less than the May planting. On the SC site the June planting date produced fewer nodes $plant^{-1}$ (17) than the April (19) or May (20) planting which were not significantly different from each other (Table 2). On the SC across both years April plantings ranged from 18 to 19 nodes $plant^{-1}$, May plantings from 19 to 21 nodes $plant^{-1}$, and June plantings from 16 to 18 nodes $plant^{-1}$ resulting in a significant Planting date × seeding rate × year interaction (Table 2). With respect row type, both single- and twin-row plantings produced an equal number of nodes $plant^{-1}$ on the BFSL (19) and the SC (18). Significantly more nodes per plant were produced at the SC site in 2010 than 2009 (19 vs. 18 nodes $plant^{-1}$) but a similar difference was not observed at the BFSL site (Table 2). On the SC increased seeding rate had no effect on nodes per plant (19) except at 50 seed m^{-2} which produced 18 nodes $plant^{-1}$ (Table 2). The planting date × row type × year interaction was statistically significant (Table 2) for the SC because the May plantings in 2009 averaged 19 nodes $plant^{-1}$ for both row types while in 2010 the single-row plantings averaged 21 nodes $plant^{-1}$ and the twin-row plantings 20 nodes $plant^{-1}$.

Twin-row plantings did not produce more pods per plant than single-row plantings on either soil nor were any interactions involving row type found to be statistically significant (Table 2). Delayed planting did reduce the mean number of pods per plant at both sites with a decrease occurring only between the May and June plantings on the BFSL and a steady decline occurring across all three planting dates on the SC (Tables 2 and 6). Plantings on the SC averaged more pods per plant in 2010 than 2009 (65 vs. 56) while no similar difference was noted on the sandy loam. Pods per plant tended to decline with increased seeding rates on the SC and on the BFSL in 2009 but not in 2010 (Tables 2 and 7).

Seed yields declined with delayed planting at all seeding rates and at both locations (Table 6). This could be contributed in part to the fewer number of pods per plant with delayed planting that was previously discussed. No differences in yields were observed across seeding rates at the SC site while at the BFSL site the 20 seed m^{-2} rate was less (3.8 Mg ha^{-1}) than all other seeding rates (4.2 Mg ha^{-1}) with no other differences being observed. No statistically significant interaction between row type and seeding rate were observed for seed yields from theses data (Table 2). Seed yields

Table 3. Established irrigated Maturity Group (MG) IV soybean plants at R4 (full pod), planted on three different planting dates, in single and twin rows in 2009 and 2010 on beds of a Beulah fine sandy loam (BFSL) and a Sharkey clay (SC) soil at Stoneville, MS†.

		Seeding rate, seeds m^{-2}							
		20		30		40		50	
Soil type	Row type	Plants m^{-2}‡	%§	Plants m^{-2}‡	%	Plants m^{-2}‡	%	Plants m^{-2}‡	%
BFSL	Single	15	77	19	64	23	57	28	58
	Twin	20	100	27	90	33	83	36	73
SC	Single	16	79	20	67	24	59	29	59
	Twin	19	98	24	81	32	80	36	72

† Means of three planting dates (April, May, and June) and four reps. Single rows were planted 102 cm apart. Twin rows were planted on 102 cm centers with 25 cm between planting units.

‡ For comparing means of Plants m^{-2} within a row or a column for BFSL LSD(0.05) = 4 and for SC LSD (0.05) = 3.

§ For comparing mean percentage of established plants to seeding rate within a row or a column for BFSL LSD (0.05) = 5 and for SC LSD (0.05) = 6.

Table 4. Established maturity group (MG) IV irrigated soybean plants at growth stage R4 (full pod) planted on beds of a Beulah fine sandy loam (BFSL) and Sharkey clay (SC) soil in twin or single rows in 2009 and 2010 at different seeding rates and planting dates at Stoneville, MS.†

Planting date	Established plants per m^2							
	Seeding rate, seeds per m^2							
	BFSL‡				SC§			
	20	30	40	50	20	30	40	50
April	18	23	29	32	18	20	26	31
May	18	22	27	33	19	23	30	35
June	19	24	28	32	16	22	27	32

† Means of 2 yr, four replications, and two row configurations. Single rows were planted 102 cm apart. Twin rows were planted on 102 cm centers with 25 cm between planting units.

‡ For means within a row or a column LSD (0.05) = 4.

§ For means within a row or a column LSD (0.05) = 2.

Table 5. Established Maturity Group (MG) IV irrigated soybean plants at growth stage R4 (full pod) planted on beds of a Beulah fine sandy loam (BFSL) in 2009 and 2010 at different planting dates at Stoneville, MS.†

Planting date	2009		2010	
	Plants m^{-2}‡	%§	Plants m^{-2}‡	%§
April	29	84	22	66
May	27	82	23	68
June	25	76	25	78

† Means of four replications, seeding rates of 20, 30, 40, and 50 seeds $m^{-2}$and two row configurations. Single rows were planted 102 cm apart. Twin rows were planted on 102 cm centers with 25 cm between planting units.

‡ For means within a row or a column LSD (0.05) = 2.

§ For means within a row or a column LSD (0.05) = 6.

Table 6. Mean number of pods per plant and seed yields of an irrigated Maturity Group (MG) VI soybean cultivar grown on either a Beulah fine sandy loam (BFSL) or a Sharkey clay (SC) soil planted in either 102 cm single rows or twin rows at different seeding rates and planting dates at Stoneville, MS.†

Planting date	BFSL		SC	
	Pods $plant^{-1}$	Mg ha^{-1}	Pods $plant^{-1}$	Mg ha^{-1}
April	60	4.7	68	5.1
May	60	3.6	60	4.2
June	53	2.8	53	2.9

† Means within a column are those of 2 yr (2009 and 2010), four replications, and seeding rates of 20, 30, 40, and 50 seeds m^{-2}. Single-rows were planted 102 cm apart. Twin-rows were planted on 102 cm centers with 25 cm between planting units. For means within a column LSD (0.05) = 3.

Table 7. Pods per plant of a Maturity Group (MG) IV irrigated soybean cultivar gown on beds of a Beulah fine sandy loam (BFSL) and Sharkey clay (SC) in 2009 and 2010 at different planting dates, row configurations, and seeding rates at Stoneville, MS.†

Seeding rate	Pods plant^{-1}		
	BFSL‡		SC§
	2009	2010	Mean
seeds m^{-2}			
20	74	61	68
30	58	59	61
40	52	54	59
50	46	56	53

† Means of three planting dates (April, May, and June), four reps, and two row configurations. Single rows were planted 102 cm apart. Twin rows were planted on 102 cm centers with 25 cm between planting units.

‡ LSD (0.05) = 6.0 for means within a column and a row.

§ Means of 2 yr (2009 and 2010). LSD (0.05) = 6.

across all planting dates and seeding rates were greater for twin-row than the single-row plantings on both the BFSL (Table 2) (3.8 vs. 3.6 Mg ha^{-1}) and SC (4.2 vs. 4.0 Mg ha^{-1}). Overall seed yields at both sites were greater in 2009 than 2010 (3.9 vs. 3.5 Mg ha^{-1} for the BFSL) and (4.1 vs. 4.0 Mg ha^{-1} for the SC). The lower yields observed in 2010 were likely due to less available soil moisture due to less rainfall, despite irrigation, along with a greater number of days with maximum temperatures ≥ 32.0 C.

Differences in seed weight were observed only from harvests at the BFSL site (Table 2). Seed weights were greater ($P \leq 0.01$) for April plantings both in 2009 and 2010 (165 and 141mg, respectively) than May (140 and 121mg, respectively) or June plantings (145 and 117 mg, respectively). Seed weights for the June 2009 plantings were greater than those of the May plantings while no difference was observed in seed weights between these two planting dates in 2010. The higher seed weights observed in 2009 compared to 2010 was likely due to the greater amounts of available soil moisture in 2009 vs. 2010 and fewer days of maximum temperatures ≥32.0°C (Table 1). This would have contributed to the higher yields observed in 2009 compared to 2010 at this site as previously mentioned. Seed weight was significantly (Table 2) less for the 50 seeds m^{-2} seeding rate (134 mg) than the lower seeding rates (140 mg) on the BFSL. No differences in seed weight though were observed from harvests at the SC site for any of the variables in the experiment (Table 2). Mean seed weight for this site was 145 mg.

Table 8. Seeds per m^2 of an irrigated Maturity Group (MG) VI soybean cultivar planted on a Buelah fine sandy loam (BFSL) and Sharkey clay (SC) soil on raised beds in single- or twin-rows, varying seeding rates, and dates of planting in 2009 and 2010 at Stoneville, MS.†

Planting date	Seed produced m^{-2}							
	BFSL				SC‡			
	Year§		Row type¶		2009		2010	
	2009	2010	Single	Twin	Single	Twin	Single	Twin
April	3071	3172	2959	3284	3280	3584	3219	3439
May	2657	2807	2741	2722	2764	2977	3289	3093
June	2041	2290	2061	2270	1934	2123	2244	2595

† Means of four replications, and four seeding rates (20, 30, 40, and 50 seeds m^{-2}).

‡ Means of either single row plantings 102 cm wide or twin-row plantings 25 cm wide centered 102 cm apart. For means within a column or a row LSD (0.05) = 156.

§ Means of two planting configurations (Single-row plantings 102 cm wide and twin-row plantings 25 cm wide centered 102 cm apart). For means within a column or a row LSD (0.05) = 148.

¶ Means of 2 yr (2009 and 2010) and either single row plantings 102 cm wide or twin-row plantings 25 cm wide centered 102 cm apart. For means within a column or a row LSD (0.05) = 164.

Except for May plantings at the BFSL both years and the SC site in 2010, twin rows produced more seed per m^2 than single-row plantings (Table 8). These data are likely the result of more plants per m^2 being established in twin row than single row as shown in Table 3. As previously discussed, pods per plant did not differ between the two planting schemes and thus would not account for the observed differences in yield or seeds per m^2. Delayed planting at both sites and both years reduced the seed per m^2 produced (Table 8) except between the April and May single-row plantings at the SC site in 2010 which resulted in the significant seeding rate × row type × year interaction (Table 2). The decline in seed per m^2 on most of the SC site plots as planting was delayed can be attributed in part to the steady decline in pods per plant with later planting as previously noted (Table 6). However, no differences in the number of pods per plant were noted between the April and May plantings on the BFSL (Table 4). Therefore the observed reduction in seed per m^2 (Table 8) at this site between these two planting dates would most likely have resulted from a decrease in the mean number of seed per pod. Both a reduction in pods per plant and seed per pod are possible explanations for the reduced seed per m^2 observed in June plantings at both sites compared to earlier plantings. Seeds per m^2 increased on the SC only as seeding rates increased from 20 seed m^{-2} (2710 seed m^2) to 30 seed m^{-2} (2905 seed m^{-2}). No further increases in seed produced per m^{-2} occurred with increased seeding rates (2952 and 2946 seeds m^{-2} for seeding rates of 40 and 50 seeds m^{-2}, respectively). A similar difference was not observed in plants grown on the BFSL.

Based on these data delaying planting past mid-May on either a sandy loam or clay soil in a humid subtropical environment such as the lower Mississippi River Valley is going to have a negative impact on yield regardless of the row configuration used. Double-cropping soybean after wheat harvest may increase income per unit land area but only if a good stand of soybean is established soon after planting. Irrigation may be necessary to force quick germination and emergence (Wesley, 1999). Regardless, a yield penalty will likely result by delaying planting of an MGIV cultivar until mid-June. This supports the findings of Kyei-Boahen and Zhang (2006) regarding double-cropping soybean after wheat. Based on these data twin-row plantings in mid-June produced no advantage in seed yield over comparable single row plantings.

Regardless of the row configuration, seeding rates above 30 seeds m^{-2} did not consistently increase yield and would therefore likely reduce profitability due to increased seed costs. On sandy loam soils, such as the BFSL, heavy spring rains can cause the surface to form a thick crust that impairs emergence and reduces stands well below the 80% ideal stand establishment to seeding rate. In the past seeding rates above 30 seeds m^{-2} were sometimes made on sandy loam soils as "insurance" against a potential crusting problem (Nafziger, 2005). However, today's high seed costs make such management practices expensive. Crusting is not a problem with soils such as the SC which instead cracks as it dries. Preparing a seedbed can hasten soil moisture loss to below the planting zone, causing poor germination and reducing stands (Elmore and Heatherly, 1988). Careful selection of a seeding depth in clay soils that places the seed in about 15 mm of moist soil is essential to completing emergence of the crop and is as critical to establishing a stand as is seeding rate (Ashlock et al., 2006).

The increased seed yields observed for twin-row over single-row plantings are most likely due to the greater number of established plants per m^2 in the twin rows. This conclusion is derived from a lack of differences in pods per plant, and seed weight between the two row types. The lack of differences in pods per plant between twin- and single-row plantings though is contrary to previously reported data (Bell, 2005). Mascagni et al. (2008) reported that the MGIV cultivars used in their experiments did not have greater seed yields in twin-row configurations compared to single-row plantings at one of their locations. Bruns (2011) also reported no consistent differences in seed yields of both a MGIV an MGV planted in twin rows vs. single rows. In this experiment the increased seed yields of twin rows over single rows was worth about $75.00 (US) ha^{-1} based on soybean prices at the time of harvest in 2010 (Index Mundi, 2011). The narrowness of the increase and the mixed results from other research (Graterol et al., 1996; Mascagni et al., 2008; Bruns, 2011) makes it advisable to consider the versatility of twin-row equipment for use with other crops in justifying the expense of transitioning to a twin-row soybean production system. Growers of large soybean hectarages though can more readily recover the costs of making a transition to twin-row soybean production and reap the potential benefits of increased yields (M. Walker, personal communication, 2010).

REFERENCES

Ashlock, L., R. Klerk, G. Huintink, T. Keisling, and E. Vories. 2006. Planting practices. Chapter 7. Arkansas Soybean Handb. MP 197. Available at http://www.uaex.edu/other_areas/publications/HTML/MP-197.asp (verified 21 June 2011). Coop. Ext. Serv., Univ. of Arkansas, Little Rock.

Bell, A. 2005. Higher yields with twin-row soybeans. Delta Farm Press. Available at http://deltafarmpress.com/higher-yields-twin-row-soybeans (verified 21 June 2011). Penton Media Inc., New York.

Blaine, A., L. Oldham, and K. Crouse. 2010. Soybeans liming and fertilization. Mississippi State Univ. Ext. Info. Sheet IS0873. Available at http://msucares.com/pubs/infosheets/is0873.pdf (verified 21 June 2011). Mississippi State, MS.

Boquet, D.J. 1998. Yield and risk utilizing short-season soybean production in the mid southern USA. Crop Sci. 38:1004–1010. doi:10.2135/cropsci1998.0011183X003800040020x

Bowers, G.R. 1995. An early soybean production system for drought avoidance. J. Prod. Agric. 8:112–119.

Bruns, H.A. 2011. Comparisons of single-row and twin-row soybean production in the Mid South. Agron. J. 103:702–708. doi:10.2134/agronj2010.0475

Ebelhar, M.W. 2010. Twin-row corn boosts yields. Corn & Soybean Digest. Available at http://cornandsoybeandigest.com/corn/twin-row-corn-boosts-yields (verified 21 June 2011). Penton Media Inc., New York.

Elmore, C.D., and L.G. Heatherly. 1988. Planting systems and weed control effects on soybean grown on clay soil. Agron. J. 80:818–821. doi:10.2134/agronj1988.00021962008000050026x

Graterol, Y.E., R.W. Elmore, and D.E. Eisenhaur. 1996. Narrow-row planting systems for furrow-irrigated soybean. J. Prod. Agric. 9:546–553.

Grichar, W.J. 2007. Row spacing, plant populations, and cultivar effects on soybean production along the Texas gulf coast. Available at www.plantmanagementnetwork.org/cm/. Crop Manage. doi:10.1094/CM-2007-0615-01-RS.

Heatherly, L.G. 1999. Early soybean production system (ESPS). p. 103–118. *In* L.G. Heatherly and H.F. Hodges (ed.) Soybean production in the midsouth. CRC Press, Boca Raton, FL.

Heatherly, L.G., A. Blaine, H.F. Hodges, R.A. Wesley, and N. Behring. 1999. p. 41–55. *In* L.G. Heatherly and H.F. Hodges (ed.) Soybean production in the midsouth. CRC Press, Boca Raton, FL.

Index Mundi. 2011. Soybeans monthly price. Available at http://www.indexmundi.com/commodities/?commodity=soybeans&months=60 (verified 21 June 2011). Index Mundi, Vancouver, WA.

Koger, C. 2010. 2010 Suggested soybean variety list. Available at http://msucares.com/crops/soybeans/variety_list10.pdf (verified 21 June 2011). Mississippi State Univ. Ext. Serv. Mississippi State.

Kyei-Boahen, S., and L. Zhang. 2006. Early maturing soybean in a wheat-soybean double crop system: Yield and net returns. Agron. J. 98:295–301. doi:10.2134/agronj2005.0198

Mascagni, H.J., E. Clawson, D. Lanclos, D. Boquet, and R. Ferguson. 2008. Comparing single-row, twin-row configurations for Louisiana crop production. Louisiana Agric. Magazine. Baton Rouge, LA. Available at http://www.lsuagcenter.com/en/communications/publications/agmag/Archive/2008/Summer/Comparing+SingleRow+TwinRow+Configurations+for+Louisiana+Crop+Production.htm (verified 21 June 2011). LSU AgCenter Res. and Ext., St. Joseph, LA.

Nafziger, E. 2005. Crop conditions and soybean seeding rates. The Bulletin. Available at http://bulletin.ipm.illinois.edu/article.php?id=249 (verified 21 June 2011). Univ. of Illinois Ext., Urbana-Champaign.

Pedersen, P. 2004. Soybean growth and development. PM 1945. Iowa State Univ. Univ. Ext. Ames.

Smith, C. 2010. Twin row corn. Corn South. Available at http://www.cottonfarming.com/home/Corn_South/issues/2010-01/2010_JanTwinRowCorn.html (verified 21 June 2011). One Grower Publ., Memphis, TN.

Wesley, R.A. 1999. Doublecropping wheat and soybeans. p. 143–156. *In* L.G. Heatherly and H.F. Hodges (ed.) Soybean production in the midsouth. CRC Press, Boca Raton, FL.