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EFFECTS OF BETWEEN AND WITHIN ROW SPACINGS ON GROWTH AND PRODUCTION OF SOYBEAN

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ABSTRACT

Proper soybean [*Glycine max* (L.) Merr.] seeding rates are important as production costs and lodging may be increased and yields reduced by seeding at excessive rates. A field study was conducted during 1982-84 to determine the effects of different between and within row spacings on growth and production of the soybean cultivar Union. Twin row soybeans were also evaluated. 'Union' soybeans (Maturity Group IV, indeterminate) were grown on a Stoy soil classified as a fine-silty, mixed, mesic Aquic Hapludalfs. Four between row spacings (17.5, 35.0, 52.5, and 70.0 cm) and three within row plant spacings (5, 10 and 15 cm) were employed. Space between paired rows in the twin row planting method was 17.5 cm and the paired rows were spaced 52.5 cm apart. As the between and within row spacings decreased, the number of days for soybean canopy cover decreased, whereas, soybean lodging and the soybean pod height from the soil surface increased. At the 5 cm within-row spacing, there was no significant difference in soybean seed yields between the 17.5 and 70.0 cm row widths. However, at the 10 and 15 cm within-row-spacings, soybean seed yields at the between-row-spacing of 17.5 cm averaged 25% and 22% higher than the 70 cm row width over a three year period. The twin row planting method showed a yield advantage over the 70 cm between row spacing at both the 10 and 15 cm within-row-spacing. In this study, there was a yield advantage of planting 'Union' soybeans in narrow rows when within-row-spacing was greater than 5 cm between plants.

INTRODUCTION

Soybeans [*Glycine max* (L.) Merr.] have the ability to make adjustments to different within and between row spacings. However, yields may vary with different row spacings, cultivars, management practices, and environmental conditions. In

narrow rows, soybean yields have generally been higher (Bouquet, 1982; Cooper 1977; Costa et al., 1980; Doss and Thurlow, 1974; Hicks et al., 1969; Mangold and Barnes, 1983; Parks et al. 1982; Shaw and Weber, 1967; and Taylor, 1980). Several advantages of narrow rows or solid seeding have been reported. If water and nutrients are in adequate supply, then solar radiation becomes a limiting factor in production. One of the objectives of changing plant arrangements is to improve light interception (Shaw and Weber, 1967). Plants in wider rows usually accumulate their leaf area index (LAI) at a slower rate than plants in narrow rows (Weber et al., 1966). In addition to improvement in light interception, (Timmons et al., 1967) showed that the best water use efficiency was obtained in 20 cm rows. Decreasing the inter and intra- row spacing generally results in increased plant height (Cooper, 1971; Dunphy et al., 1966; Hicks et al. 1969; Johnson and Harris, 1967; and Reiss and Sherwood, 1965).

Because lodging, especially early lodging, is detrimental to yield (Cooper, 1971; Hicks et al., 1969; Timmons et al., 1967; Weber et al., 1966; and Woods and Swearingin, 1977), some research studies in some years do not show a yield advantage for narrow rows over conventional rows (Cooper, 1971; Cooper, 1977; Hicks et al., 1969; Shibles et al., 1975; and Woods and Swearingen, 1977). The potential yield advantage of the narrow row system over the conventional width row system may be minimized or eliminated under nitrogen stress (Cooper and Jeffers, 1984). Late season moisture stress (Taylor, 1980), lodging (Cooper, 1971), or other nutrient stress may also reduce soybean yield response to the narrow row system.

Cooper, 1977 and Dominguez and Hume, 1978 observed that soybean lodging, plant height and lowest pod height increased with increasing plant population, whereas, plant maturity, branching and pod number per plant decreased.

The multiple effects of planting patterns on the soybean plant are cultivar dependent. According to Doss and Thurlow, (1974), average yields were influenced more by cultivar or irrigation than by row width or population.

Weed control, either chemical or mechanical, may be more effective in narrow rows because the control needs to effective for only a short period of time before the soybean canopy provides a dense shade (Dunphy, 1965).

The quest for higher yields has renewed interest in twin row planting (Mangold and Barnes, 1983). With the twin row method of planting, mechanical cultivation as well as herbicides and shading pressure from the crop can be used to help control weeds.

The objective of this study was to determine the effects of different between and within row spacings on the growth and production of the soybean cultivar Union. Twin row soybeans were also evaluated.

MATERIALS AND METHODS

This experiment was conducted at the Cooperative (Southern Illinois Univ. - Univ. of Illinois) Agronomy Research Center in Carbondale, Il. (38° latitude, 89° longitude) during 1982-84, using the soybean cultivar Union. This cultivar belongs to Maturity Group IV and is determinate. The soil was a Stoy, classified as a fine-silty, mixed mesic Aquic Hapludalfs. The experimental area was fertilized according to soil test recommendations. Herbicides used were pendimethalin (N-1-ethylpropyl-3-4 dimethyl-2,6 dinitrobenzeamine) applied at the rate of 2.3 L ha^{-1} and linuron

(3-(3-4-dichlorophenyl)-1-Methoxy-1-methylurea) at the rate of 1.7 L ha $^{-1}$. Weed control was supplemented by hand hoeing.

'Union' soybeans were planted on 8 June 1982, 15 June 1983 and 31 May 1984 using four between row spacings (17.5, 35.0, 52.5, and 70 cm) and three within row plant spacings (5, 10, and 15 cm). Space between paired rows in the twin row planting method used in 1983 and 1984 was 17.5 cm and the paired rows were spaced 52.5 cm apart. Spacings within each twin row were 5, 10, and 15 cm. Soybeans were planted at high seeding rates using a grain drill and then thinned back by hand to the proper plant densities when soybean plants were about 8 cm tall.

Each plot was 4 m × 5 m. The experiment was arranged factorially in a randomized complete block design with four replicates.

The following parameters were evaluated for each of the soybean treatments:

1. Canopy cover was evaluated visually and was considered as being complete when the tips of leaves of adjacent rows within each plot were touching. Days to canopy cover were calculated from the time of planting.
2. Pod height was measured in cm from the surface of the soil to the bottom of the lowest pod of ten plants selected at random from the center of each plot at full maturity (R8).
3. Plant height was measured as the average height of ten plants selected at random from the center of each plot at full maturity (R8). Measurements were taken from the ground level to the tip of the main stem and expressed in cm.
4. Plant lodging was recorded at maturity (R8). Lodging was rated visually 0-5: no lodging = 0; all plants lodged = 5.
5. Seed yield was expressed in kg ha^{-1} after the seed moisture content was adjusted to 13 percent.

Harvesting was done with a small plot soybean combine. The length of the plots harvested was 4 m.

Data were analyzed statistically using an analysis of variance and significant means were compared by the Least Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

The monthly rainfall during the 1982-84 growing season is presented in Table 1. The growth and production of soybeans were influenced by varying between and within row spacings. In 1982 and 1983, there was a highly significant interaction between within-row-spacing and between-row-spacings on the number of days to soybean canopy cover (Table 2). In all three years, days to canopy cover tended to be less with decreasing within and between row spacings. The earliest canopy cover occurred only 22 days after planting in 1984. Canopy cover was earlier in the twin rows than in the 70 cm between row spacing both years it was tested. Early canopy cover is highly desirable since herbicides or mechanical weed control measures need to be effective for a shorter period of time before the canopy cover provides sufficient shade to limit weed growth. Early canopy cover can also reduce the amount of soil moisture lost by evaporation and is an important factor in the reduction of possible soil erosion.

In 1982, as between row spacing and within row spacing decreased, height of the lowest soybean pod from the soil surface increased (Table 3). In 1983 and 1984,

as the between row spacing decreased, height of the lowest soybean pod from the soil surface increased. The height of the lowest pod from the soil surface also tended to increase. The height of the lowest pod from the soil surface also tended to increase with decreasing within row spacing in 1984. Taller plants observed in the narrower and closer within row spacing were attributed to competition for light and space (Table 4). This incresed plant height may have also resulted in increased pod height from the soil surface.

The soybean pod height from the soil surface was higher in the twin rows than in the 70 cm between row spacing. The amount of soybean seed lost during combine harvest may be reduced as a result of higher soybean pod height from the soil surface.

In 1982, soybean plant lodging increased as within and between row spacings decreased (Table 5). No plant lodging occurred in 1983 due to shorter soybean plants resulting from less precipitation (Table 1). In 1984, lodging occurred only at the narrowest between row spacing (17.5 cm) and in the twin rows. Lodging was attributable to taller weaker stemmed soybean plants due to competition for light. Plants with thinner stems were more vulnerable to lodging by wind. Potential seed yield increased from narrower row spacing could possibly be offset by greater early lodging which can reduce seed set.

As between row spacings decreased in 1982, soybean seed yields increased significantly except at the narrower row width (17.5 cm) and highest plant population (5 cm between plants) where severe lodging reduced potential yields (Tables 5 and 6). There were not significant differences in soybean seed yields among the various row spacings in 1983 probably as a result of the low precipitation during the growing season which also resulted in average yields less than half of the other two years (Cooper and Jeffers, 1984). In 1984, soybean seed yields increased as between row spacings decreased. Soybean seed yields tended to increase percentagewise as between row spacings decreased from 70 to 17.5 cm in the 10 and 15 cm within-row-spacings. During 1982-84, soybean seed yield with the 10 cm within-row-spacing at 17.5 cm between rows was 25% higher than in the 70 cm row width. A 22% average yield advantage occurred over the three period when the between row width was reduced from 70 to 17.5 cm using the within row spacing of 15 cm. However, there was no notable difference in soybean seed yield between the 17.5 and 70 cm between row widths at the 5 cm within-row-spacing. This study indicated that soybean seed yields of the cv. Union generally increased with narrower within row widths using 10 or 15 cm within-row-spacing but not at the 5 cm within-row-spacing.

The twin rows generally did not show any yield advantage over the between-row-spacing of 70 cm or the narrower between-row-spacings at the 5 cm within-row-spacing. The twin rows did show a yield advantage over the 70 cm between-row-spacing at the 10 and 15 cm within-row-spacing but no yield advantage over the narrower between-row-spacing. The twin rows had a yield advantage over the 70 cm between-row-spacing at the 10 and 15 cm within-row-spacing but not over the narrower between-row-spacings.

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Table 1. Monthly rainfall from April-Sept. 1982-1984 at Carbondale, Ill.

Month	Normal	Deviation		
		1982	1983	1984
	cm			
April	10.7	−5.3	+20.1	−2.8
May	11.7	+3.3	+5.3	−5.1
June	10.2	−1.8	−4.3	−1.8
July	8.9	−1.5	−6.6	−2.8
August	8.9	−2.3	−3.6	+0.2
September	8.9	−2.0	−5.8	+10.2

Table 2. Effects of between and within row spacings on the number of days for soybean canopy cover 1982-84.

Between Row Spacing	Within Row Spacing (cm)								
	5	10	15	Mean	5	10	15	Mean	5	10	15	Mean
	1982				1983				1984			
cm	Days											
17.5	24	27	31	27	26	29	32	29	22	22	23	22
35.0	36	36	38	37	33	37	41	37	33	34	34	34
52.5	40	45	47	44	58	58	62	59	44	45	45	45
70.0	50	56	61	56	78	78	81	79	63	64	64	64
Twin Row	-	-	-	-	43	43	46	44	45	44	46	45
Mean	38	41	44		48	49	52		41	42	42	
Statistical significance:												
Between Row Spacing	**				**				**			
Within Row Spacing	**				**				**			
Between Row Spacing × Within Row Spacing	**				**				NS			
Between Row Spacing LSD									0.5			
Within Row Spacing LSD									0.4			
Between Row Spacing × Within Row Spacing LSD	3				2							
CV (%)	4.3				2.7				1.5			

**Significant at the 0.01 level. NS = not significant at the 0.05 level.

Table 3. Effects of between and within row spacings on the lowest soybean pod height from the soil surface 1982-84.

Between Row Spacing	Within Row Spacing (cm)											
	5	10	15	Mean	5	10	15	Mean	5	10	15	Mean
	1982				1983				1984			
cm	Days											
17.5	24	25	25	24	23	22	23	23	23	25	18	22
35.0	25	19	10	18	17	15	16	16	13	15	15	14
52.5	10	11	8	10	16	16	15	16	15	18	10	14
70.0	14	9	7	10	13	13	12	13	18	15	13	15
Twin Row	-	-	-	-	26	25	26	26	20	18	15	18
Mean	18	16	13		19	18	18		18	18	14	
Statistical significance:												
Between Row Spacing	**				**				**			
Within Row Spacing	**				**				**			
Between Row Spacing × Within Row Spacing	**				NS				NS			
Between Row Spacing LSD					1.5				1.1			
Within Row Spacing LSD									0.8			
Between Row Spacing × Within Row Spacing LSD	2.5											
CV (%)	18.7				9.8				19.1			

**Significant at the 0.01 level. NS = not significant at the 0.05 level.

Table 4. Effects of between and within row spacings on soybean plant heights at maturity 1982-84.

Between Row Spacing	Within Row Spacing (cm)											
	5	10	15	Mean	5	10	15	Mean	5	10	15	Mean
	1982				1983				1984			
cm	cm											
17.5	101	102	104	103	68	69	66	68	79	84	72	78
35.0	107	100	88	98	60	61	59	60	70	77	84	77
52.5	99	89	86	91	50	50	48	49	75	78	74	75
70.0	93	87	79	86	67	62	64	64	87	83	84	84
Twin Row	-	-	-	-	66	62	61	63	86	89	94	89
Mean	100	95	89		62	61	60		79	81	82	
Statistical significance:												
Between Row Spacing	**				**				**			
Within Row Spacing	**				**				NS			
Between Row Spacing × Within Row Spacing	NS				**				NS			
Between Row Spacing LSD+	5								6			
Within Row Spacing LSD	5											
Between Row Spacing × Within Row Spacing LSD					2.5							
CV (%)	6.9				2.9				9.1			

*,**Significant at the 0.05 and 0.01 levels, respectively.
NS = not significant at the 0.05 level.
+ Fisher's LSD, P = 0.05.

Table 5. Effects of between and within row spacings on soybean plant lodging 1982-84.

Between Row Spacing	Within Row Spacing (cm)											
	5	10	15	Mean	5	10	15	Mean	5	10	15	Mean
	1982				1983				1984			
cm	Lodging Rating +											
17.5	4.1	2.3	1.9	2.8	1.0	1.0	1.0	1.0	1.9	3.1	1.8	2.3
35.0	3.2	1.4	1.0	1.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
52.5	2.1	1.1	1.0	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
70.0	2.1	1.1	1.0	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Twin Row	-	-	-	-	1.0	1.0	1.0	1.0	2.9	1.9	1.0	1.9
Mean	2.8	1.5	1.2		1.0	1.0	1.0	1.0	1.6	1.6	1.2	-
Statistical significance:												
Between Row Spacing	**				**				**			
Within Row Spacing	**				**				**			
Between Row Spacing × Within Row Spacing	**				NS				NS			
Between Row Spacing LSD									0.6			
Between Row Spacing × Within Row Spacing LSD	0.7											
CV (%)	24.5								46.1			

+ Lodging rated visually 0-5: no lodging = 0; all plants lodged = 5.
**Significant at the 0.01 level. NS = not significant at the 0.05 level.

Table 6. Effects of between and within row spacings on soybean yields 1982-84.

Between Row Spacing	Within Row Spacing (cm)											
	5	10	15	Mean	5	10	15	Mean	5	10	15	Mean
	1982				1983				1984			
cm	kg ha^{-1}											
17.5	2537	2602	2660	2600	1255	1423	1230	1303	3161	3251	3053	3155
35.0	2873	2595	2356	2608	1407	1122	1136	1222	2725	3007	2895	2876
52.5	2499	2383	2219	2367	1266	1307	1136	1236	3045	3245	2739	3010
70.0	2553	2254	1911	2239	1263	1107	1089	1153	3106	2465	2637	2736
Twin Row	-	-	-	-	2398	1188	1230	1239	3083	2764	3039	2962
Mean	2616	2459	2287		1298	1229	1164		3024	2946	2873	
Statistical significance:												
Between Row Spacing	**				NS				**			
Within Row Spacing	NS				NS				NS			
Between Row Spacing × Within Row Spacing	NS				NS				*			
Between Row Spacing LSD	321											
Between Row Spacing × Within Row Spacing LSD									406			
CV (%)	16.0				16.5				9.7			

*,**Significant at the 0.05 and 0.01 level, respectively. NS = not significant at the 0.05 level.