SOLID SEEDED SOYBEAN YIELD AND PLANT STAND AS INFLUENCED BY TIRE TRACKS

ABSTRACT

Increases from planting soybeans (Glycine max (L.) Merr.) in rows narrower than conventionally spaced (0.8 to 1.0 m) have been reported with the greatest increases occurring in the northern areas of the United States. Where rotary hoeing or chemicals have to be applied in solid seeded (rows less than 0.3 m apart) soybeans, pressing down of plants by tractor or implement tires, may reduce both plant stand and yield.

This study was conducted in 1979, 1980, and 1981 at Arlington, Wisconsin, on a Plano silt loam (Typic Argiudoll) soil to determine the effect of tire tracks on yield and stand of solid seeded soybeans. 'Wells II' soybeans were planted in plots consisting of eight rows 25 cm apart. Two of the eight rows were driven on (TRACK rows) at different stages of growth (VC to R1) and in morning and afternoon.

The effect of morning and afternoon treatments were not different on yield. Stand and yield decreased when plants were driven on at later stages of growth. Yield in rows not depressed increased as yield in TRACK rows decreased with stages. This compensation resulting from an increase in pods per plant minimized the rate of decline in yield and resulted in no over-all yield differences among stages VC through V4. After the V4 stage, plants in TRACK rows were lodged badly and could result in combine harvesting losses. However, since in the northern soybean production areas, most post emergence field operations are done soon after plants are established and before they flower, yield will be reduced only slightly or not at all by tire tracks.

LITERATURE REVIEW

Research has shown that planting soybeans (Glycine max (L.) Merr.) in rows narrower than conventional 0.8 to 1.0 m increases yields (Costa et al., 1980). This yield increase has been higher in northern than in southern regions of the United States (Costa et al, 1980; Parker et al., 1981).

Where chemicals such as herbicides, fungicides, and insecticides have to be applied or where rotary hoeing needs to be done in narrow row (0.3 m to 0.6 m) or solid seeded (less than 0.3 m) soybeans, driving on plants is unavoidable. This may reduce both plant stand and the yield advantage from narrow row or solid seeded soybeans.

Soybeans are known to have the ability to compensate for yield across a wide range of plant populations (Costa et al., 1980; Stivers and Swearingin, 1980). Costa et al. (1980) reported that varying intra-row plant spacing from 5 to 10 cm in both wide and narrow rows had no effect on seed yield. Caviness (1961) found that skips 0.6 m long did not decrease yield. In a similar experiment, Stivers and Swearingin (1980) found that in the full rows adjacent to a skip, compensation ranged from 0.4% next to a 0.8 m skip, to 18.3% next to a skip of 3 m. They concluded that the constant yield at the three populations and a relatively small decline in yield for the longer skips (0.6, 0.9, and 1.2 m) was due to compensation. This compensation resulted from increases in number of branches per plant, number of pods on the main stem and branches, and in number of seeds per pod, as each plant was given more space.

The ability of the soybean plant to recover from physical damage, depends on the age of the plant when damage is inflicted (Boerma, 1977; Burmood and Fehr, 1973; Teigen and Vorst, 1974). Most yield losses due to physical damage occur during the late vegetative and early reproductive periods of growth (Burmood and Fehr, 1973; Teigen and Vorst, 1974). Burmood and Fehr (1973) reported that with 50% stand reduction, the ability of undamaged plants to compensate decreased with advanced stages of development. Teigen and Vorst (1974) found that seed yield was reduced by 17% when stands were reduced by 50% at the R3 stage (Fehr and Caviness, 1977). There were no significant changes in seed yield due to stand reduction at stage V7, indicating that the soybean community compensated fully for plant removal at this stage of growth.

The objective of this study was to determine the effect of depressing the plants in the row by implement tires on yield and stand in solid seeded soybeans.

MATERIALS AND METHODS

Field experiments were conducted at Arlington, Wisconsin (43^{o} 20' Lat., 89^{o} 23' Long.) on a Plano silt loam (Typic Argiudoll) of high fertility and an average pH of 6.0. Fall plowed fields used were in a small grain-corn-soybean rotation. Fertilizer applied prior to planting consisted of 18, 32, and 32 kg ha^{-1} of N, P, and K, respectively.

'Wells II', a group II relative maturity cultivar, was planted at 450,000 seeds ha^{-1} on 29 May, 23 May, and 28 May, in 1979, 1980, and 1981, respectively. Plots consisted of eight rows 25 cm apart and 4.6 m long. A Tye soybean drill was used in 1979, and a toolbar planter was used in the other two years. Each plot was bordered by four rows on either side.

Two of the eight rows (the second and seventh row) were depressed by both front tires (0.2 m wide) and the rear tires (0.3 m wide) of a Ford 3600 tractor weighing approximately 1 800 kg. Rows were depressed at different growth stages (Fehr and Caviness, 1977), starting after emergence (VC) and continuing until flowering (R1). At each stage, one set of plots was driven on in the morning (0800 to 0900 hours) and the other in the afternoon (1500 to 1600 hours). Plots were kept weed free by using herbicides and hand weeding.

Treatments were arranged in a split split plot design with three replications. Stages of growth were main plots, morning and afternoon treatments were subplots consisting of row types: rows depressed (TRACK), rows adjacent to the depressed rows (ADJ), and rows not depressed and not adjacent (OTHER).

Yield adjusted to 13% moisture was determined by hand harvesting each row separately using a sickle-bar cutter and threshing with a stationary plot thresher. Stands were recorded by counting plants within each row before depressing and at maturity (R8). The difference between the two counts is reported as a percent of the count before rows were depressed. In 1981, pods per plant at maturity were recorded on three plants selected at random within each row. Other data collected at the time plants were depressed were plant height, maximum and minimum air temperature, and total rainfall during the week treatments were applied.

Yield, percent stand reduction, and pods per plant were analyzed by the analysis of variance procedures (Steel and Torrie, 1980). Percent stand reductions were analyzed after converting then to arcsine transformations. Single degree of freedom (d.f.) contracts were used to partition sums of squares and d.f. for row treatments. Stages sums of squares and d.f. were partitioned into linear and quadratic components according to procedures described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Table 25 shows plant height, maximum and minimum air temperatures, and rainfall at the time plants were depressed. The year 1980 was drier and had the lowest daily temperatures than the other two years.

Tracks imposed at different stages resulted in significant changes in yield, stand, and pods per plant (Table 26). At early stages, damage was from plants being pressed down whereas at later stages (V4 to R1), damage was primarily due to stem breakage. The S x Y interaction for stand reduction indicated that plant damage was not consistent among years.

The effect of morning and afternoon treatments was not different in yield. Soybean plants were not damaged any greater in the morning when they were more turgid than in the afternoon. Therefore, the data presented are averaged across morning and afternoon treatments.

Significant differences were detected for row types and the R x S interaction. For all traits, the R x S interaction was caused primarily by differences between TRACK rows and the rest of the rows at each stage (Table 27). TRACK rows yielded less, had higher stand reductions and less pods per plant (Figures 10 and 11). The R x Y interaction is attributable to inconsistent responses in TRACK rows (Table 27 and Figure 10). Yield showed a linear response to the R x S interaction in all the three years (Table 27). Stand reduction was linear in 1979, but showed a quadratic response in 1980 and 1981. Similarities in stand reduction at V1 to V5 in 1980 and 1981 (Figure 10) can be explained by examining plant height in the two years (Table 25). Low rainfall in 1980 and

Table 25. Plant characteristics and climatic conditions at the time of track application. 1979-1981.

Days after planting	Stage of growth	Plant height	Temperature min.	max.	Rainfall
		cm	--- ^{o}C	---	cm
1979					
0	-	-	20	37	3
16	VC	5	31	46	0
23	V1	12	32	46	1
29	V2	15	32	46	4
35	V4	23	31	45	1
42	V5	38	35	47	1
50	R1	47	34	44	-
1980					
0	-	-	31	46	0
18	VC	5	21	37	0
27	V1	10	26	38	0
33	V2	12	36	48	0
39	V4	15	32	48	0
46	V5	30	38	53	0
52	R1	38	37	48	3
1981					
0	-	-	25	43	0
15	VC	4	33	47	1
21	V1	8	34	43	1
29	V2	12	29	41	2
35	V4	18	35	44	1
40	V5	22	36	49	1
49	R1	30	34	44	4

Table 26. Analysis of variance table for 1979-1981.

Source	df 1979-1981	df 1981	Yield 1979-1981	Stand reduction 1979-1981	Pods per plant 1981
Year (Y)	2	-			
Blocks (B)/Y	6	2			
Stages (S)	5	5	**[1/]	**	*
S_L	1	1	**	**	NS
S_Q	1	1	*	NS	NS
S_R	3	3	NS[2/]	NS	NS
S x Y	10	-	NS	*	-
Error a	30	10	537×10^3	0.05	24
Time (T)	1	1	NS	NS	NS
T x S_L	1	1	NS	NS	NS
T x S_Q	1	1	NS	NS	NS
T x S_R	3	3	NS	NS	NS
T x Y	2	-	NS	NS	-
T x S x Y	10	-	NS	*	-
Error b	36	12	186×10^3	0.02	6
Row (R)	2	2	**	**	**
R x S_L	2	2	NS	**	NS
R x S_Q	2	2	NS	**	NS
R x S_R	6	6	NS	NS	NS
R x T	2	2	NS	NS	NS
R x S x T	10	10	NS	NS	NS
R x Y	4	-	**	**	-
R x S x Y	20	-	*	**	-
R x T x Y	4	-	NS	NS	-
R x S x T x Y	20	-	NS	NS	-
Error c	144	48	663×10^3	0.04	21

1/ *,** = significant at the 0.05 and the 0.01 level of significance, respectively.

2/ NS = not significant at the 0.05 level of significance.

Table 27. The ROW x STAGE interaction for yield, stand reduction, and pods per plant. 1979-1981.

Source	1979 Yield	1979 Stand reduction	1980 Yield	1980 Stand reduction	1981 Yield	1981 Stand reduction	Pods per plant
ADJ x S_L	NS[2/]	**[1/]	NS	NS	**	NS	NS
ADJ x S_Q	NS	NS	NS	NS	NS	NS	NS
ADJ x S_{Res}	NS	NS	NS	NS	NS	NS	NS
TRACK x S_L	*	**	**	**	**	*	*
TRACK x S_Q	NS	NS	NS	**	NS	**	NS
TRACK x S_{Res}	NS	NS	NS	NS	NS	NS	NS
OTHER x S_L	NS	NS	NS	NS	*	NS	NS
OTHER x S_Q	NS	NS	NS	NS	NS	NS	NS
OTHER x S_{Res}	NS	NS	NS	NS	NS	NS	NS

1/ *,** = significant at the 0.05 and the 0.01 level of significance, respectively.

2/ NS = not significant at the 0.05 level of significance.

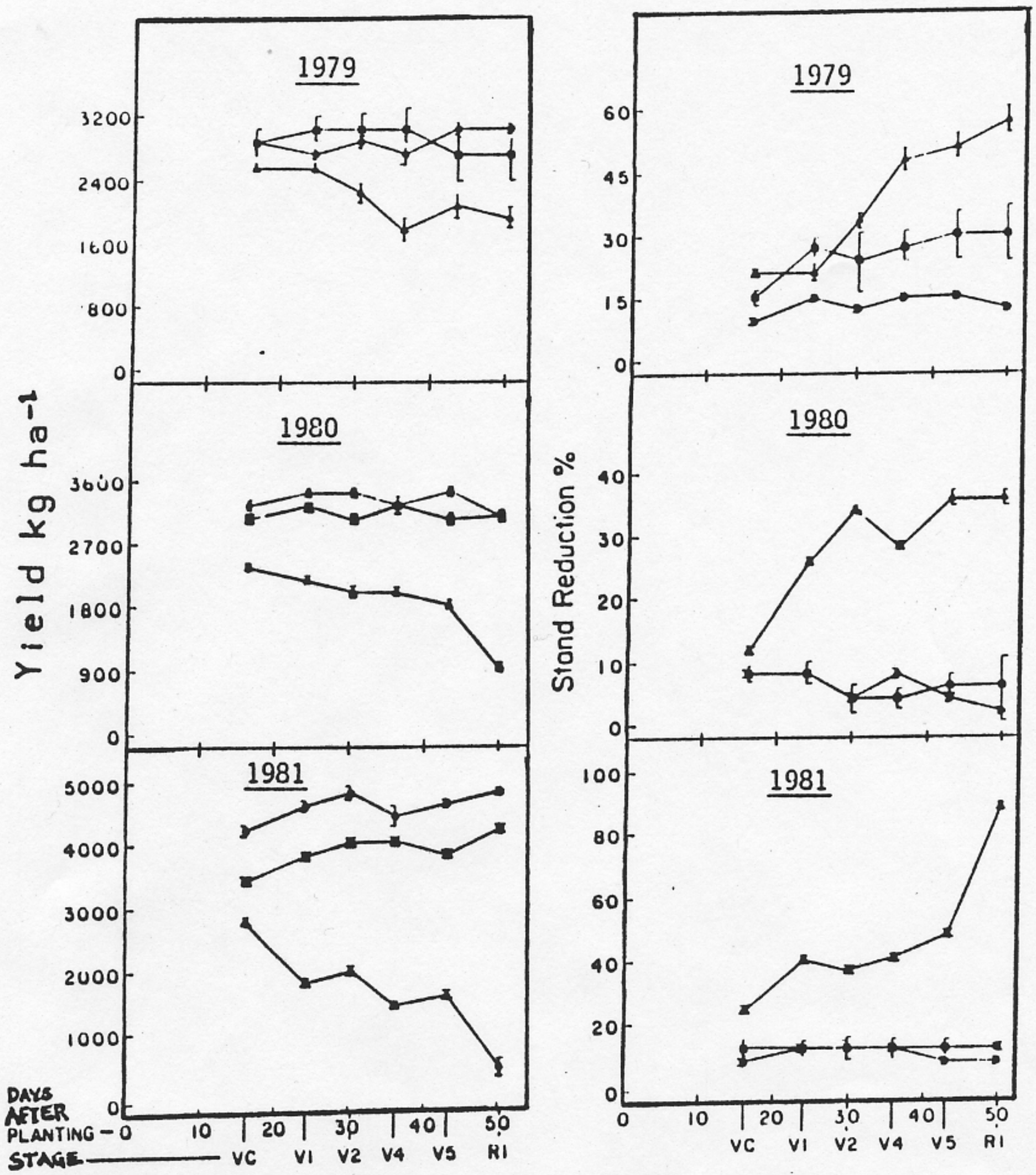

Figure 10. Effect of tire tracks on soybean yield and stand reduction in TRACK (▲-▲), ADJ (■-■), and OTHER (●-●) rows, at different stages of growth. Bars indicate $s_{\bar{x}}$.

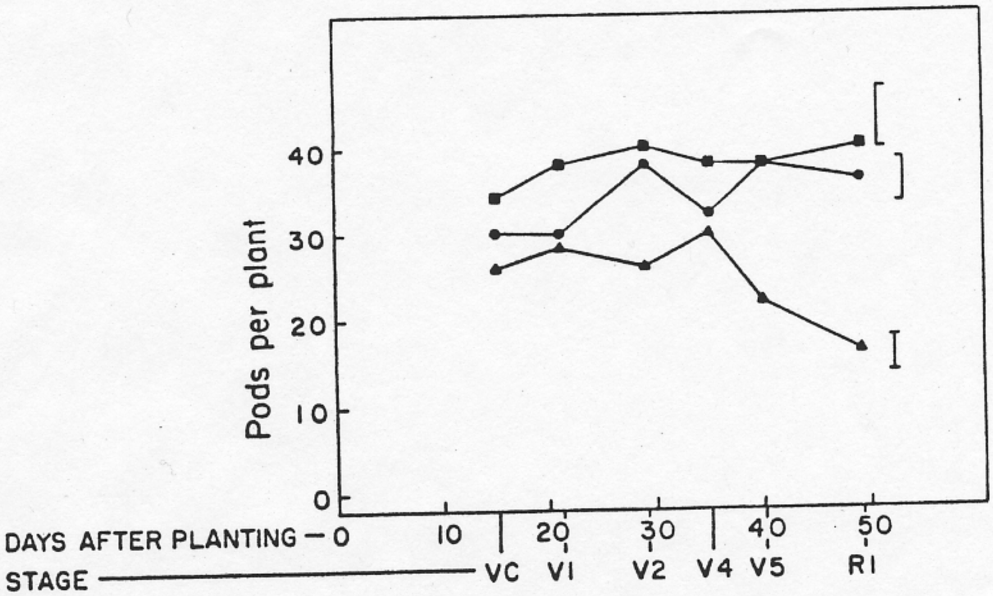

Figure 11. Effect of tire tracks on pods per plant in TRACK (▲-▲), ADJ (■-■), and OTHER (●-●) rows, at different stages of growth. Bars indicate $s_{\overline{x}}$.

cooler temperatures in 1981 reduced plant height. Shorter plants are more likely to recover from damage caused by tire tracks than taller plants. Stand reductions were highest in 1979, suggesting that more damage by tire tracks occurred under warm conditions with adequate soil moisture than when either of the conditions was below optimal.

ADJ and OTHER rows were not different except in 1981 when the latter outyielded the former (Table 28). Trends showing yield increases in ADJ and OTHER rows were observed in 1979 and 1980, but the only significant yield increase was found in 1981. Compensation for yield was detected not only in ADJ rows but also in OTHER rows. This implies that the response to the empty space caused by tire tracks may not be limited to rows immediately adjacent to the track, but may be spread over to other rows as well.

Changes in pods per plant are shown in Figure 11. Reductions in pods in TRACK rows at VC to V4 were not different. The response of pods per plant to TRACK rows was similar to that observed for yield and stand reduction (Figure 10). However, no correlation was found among these variables ($r = 0.43$). In ADJ rows, pods at VC were less than those at V2 and R1, but were not different from those at V1, V4, and V5. In OTHER rows, pods per plant at VC were less than those at V1, V2, and V5, but were not different from those at V4 and R1. Higher pods per plant contributed to increased yield at later stages (R1 in ADJ and V5 in OTHER rows). However, the increase in yield was not high enough to compensate fully for the yield reduction in TRACK rows.

No differences in lodging were observed among treatments except

Table 28. Indication of significance of comparisons of mean values of row types. 1979-1981.

Comparison	1979 Yield	1979 Stand reduction	1980 Yield	1980 Stand reduction	1981 Yield	1981 Stand reduction	Pods per plant
TRACK vs ADJ + OTHER	*[1/]	**	**	**	**	**	**
ADJ vs OTHER	NS[2/]	NS	NS	NS	**	NS	NS

1/ *,** = significant at the 0.05 and the 0.01 level of significance, respectively.

2/ NS = not significant at the 0.05 level of significance.

in TRACK rows at V4 and later stages. Plants at these stages were lodged badly and could result in combine harvesting losses. Seed yield losses from lodging and combine harvesting have been reported by Weber and Fehr (1966).

These results may be interpreted as representing an extreme situation. If extrapolated to field conditions, the decreases would be minimal since these results were based on small plots which were only 2 m wide and of which 25% of the area was subjected to wheel tracks. In actual field operations, the same yield reduction in wheel track rows reported here would be spread over a wider area determined by the width of the equipment used (i.e. sprayer's boom swath, or the width of a rotary hoe). Any yield reductions due to wheel tracks would be diluted and would therefore, be of little economic significance (Figures 12 and 13). Not considered in these experiments, but certainly of great importance, would be the detrimental effects of poorer weed control or plant stands that would occur as a result of not going ahead with the necessary field operations that impose wheel tracks. Furthermore, most field operations are done soon after plants are established and before flowering, therefore, the effect of wheel tracks should not pose a barrier to high yields in solid seeded soybeans.

These data indicate that if tire tracks are applied early in the season (VC to V4) thereby permitting ADJ rows to compensate for the yield loss, yield will be reduced only slightly or not at all. This applies particularly to the northern soybean production areas where most post-emergence operations are done soon after plants are established and be-

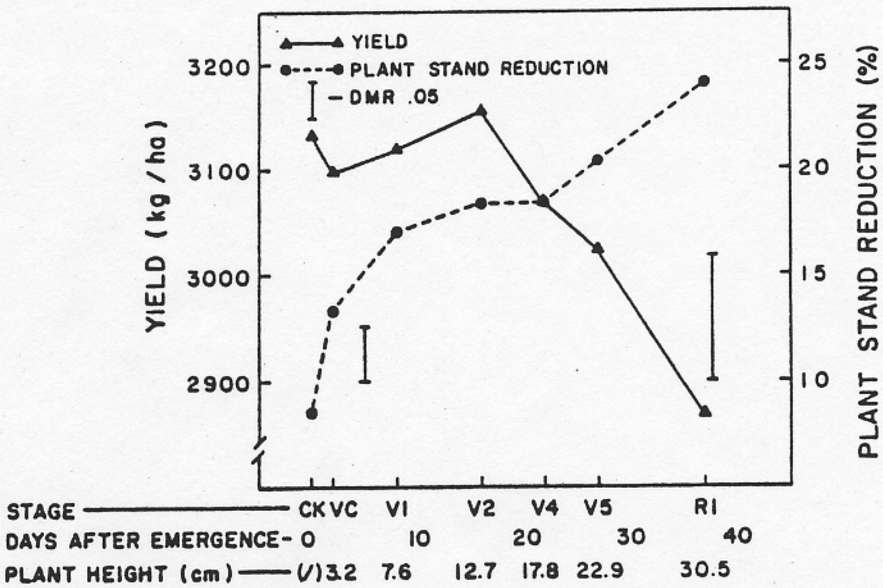

Figure 12. Actual effect of wheel tracks (plot width = 2.0 m, and 25% of area in wheel tracks) on soybean yield and plant stand reduction at different stages of growth. 1979-1981.

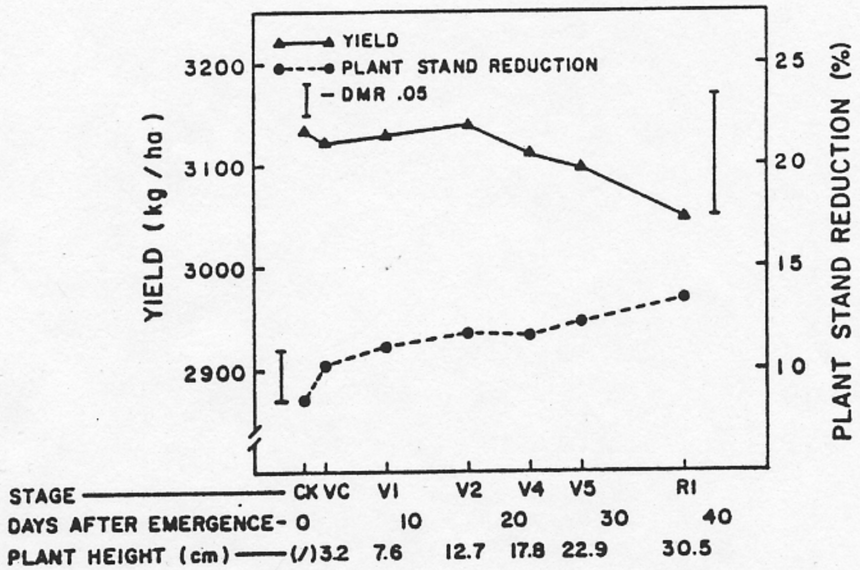

Figure 13. Projected effect of wheel tracks (plot width = 6.4 m, and 8% of area in wheel tracks) on soybean yield and plant stand reduction at different stages of growth. 1979-1981.

fore they flower. These findings should apply to late season (after R1) applications also, provided that the first tire tracks are applied earlier in the season.

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