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Response of Three Soybean Cultivars to Different Seed Rates

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ABSTRACT

Proper soybean [*Glycine max* (L.) Merr.] seeding rates are important as production costs may be increased and yields reduced by seeding at excessive rates. A field trial was conducted to determine the effect of different seeding rates of three soybean cultivars on stand density, plant growth parameters, and seed yield. The cultivars 'Amsoy 71', 'Williams', and 'Essex' (maturity groups II, III, and V, respectively) were seeded at four rates (150, 300, 450, and 600 thousand seed/ha) in 75-cm rows. The soil was a Wier silt loam classified as a fine, montmorillonitic, messic Typic Ochraqualfs. Parameters measured were stand density, plant height, lowest pod height, branch and pod numbers per plant, and yield. Soybean plant densities at maturity, expressed as a percentage of the seeding rates, were reduced each year as a result of low emergence due to severe soil crusting. Emergence was greatest for the small-seeded cv. Essex. Soybean plant height was dependent on the cultivar. The cultivar Williams grew taller then cvs. Amsoy 71 or Essex. Plant height and lowest pod height tended to increase with higher seeding rates. 'Essex' set its lowest pods higher from the soil surface compared with other cultivars. There was a consistent decrease in branch number as seeding rates increased. Pod number per plant generally increased with increasing branch number. Soybean yields were influenced by differences in stand density and pods per plant. The 'Essex', the highest-yielding cultivar in 1980, had the greatest stand density and largest pod number per plant. Planting soybeans at 150,000 seed/ha generally gave the lowest yields, but there was little advantage in sowing beyond 300,000 seed/ha.

INTRODUCTION

Soybeans [*Glycine max* (L.) Merr.] have the ability to make adjustments to different plant spacing within and between rows. For a given row spacing, however, it is important to determine the most suitable seeding rate for optimum yield. The quantity of seeds to be sown per hectare (ha) may vary depending upon cultivar, seed viability, planting method, soil type, and tillage practices used (Morse et al. 1949 and Scott and Aldrich 1970). Because so many factors are involved, no standard rule has been given for the exact quantity of seeds under all conditions. Cartter and Hartwig (1962) concluded, however, that planting rates of 20 to 60 viable seed/m of row were generally satisfactory for all production areas. Buttery (1969) found that a high soybean planting density (32 plants. m^{-2}) produced larger plants with low dry weight per unit area. Soybean seed yield was reported to be less for thick than thin sowing because in the former, the lower leaves that feed the pods were shaded (Black and Watson 1960). An experiment conducted in tropical Tanzania (Enyi 1973) showed that bean yield decreased by 38, 51, and 72% when the population was increased from 74 to 111, 222, and 444 thousand plants/ha, respectively.

High plant population may occasionally result in higher yields. Lueschen and Hicks (1977) observed significant yield response from higher plant populations one year out of three in a study with three soybean cultivars. Wiggins (1939) noted that within wide ranges, the number of plants m^{-2} had little effect on net yield. Therefore, there was nothing to be gained by seeding beyond a given optimum.

Cooper (1977) and Dominguez and Hume (1978) found that soybean lodging, plant height, and lowest pod height increased with increasing plant population, whereas plant maturity, branching and pod number per plant varied in the opposite direction. 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. Hicks and Bernard (1969) found that tall determinate types of soybeans yielded 4.6% more than short determinate types although the latter did not lodge. Osaf (1977) noted that a tall soybean cultivar produced three times as many filled pods on the main stem as a short one. This difference increased with higher populations.

Soil crusting is also an important factor which may influence soybean emergence and production. Raindrop impact on bare soils can result in severe soil crusting which may inhibit seedling emergence. Taylor (1971) observed that high soil crust strength reduced the proportion of seedlings that emerged. Yield reductions occurred when adequate plant populations were not established or where the soil crust caused plants to undergo substantial water or nutrient stress.

The influence of seeding rates on stand densities has not been fully investigated. The objective of this study was to evaluate the effects of different seeding rates of three soybean cultivars on stand density, growth, and productivity.

MATERIALS AND METHODS

This experiment was conducted at the Cooperative (Southern Illinois Univ.-Univ. of Illinois) Agronomy Research Center at Carbondale, IL. in 1979 and 1980. Three soybean cultivars 'Amsoy 71', 'Williams' and 'Essex' were evaluated. For the latitude of this study, these cultivars are early, medium, and full season maturity (group II, III, V), respectively. Essex is a determinate cultivar and the other two are indeterminate. Four seeding rates (150, 300, 450, and 600 thousand seed/ha) were used for each cultivar with 75-cm row spacing. Planting was done with an Allis Chalmers No-Till planter on 25 May 1979 and 15 May in 1980, respectively. Seed germination tests (warm and cold) were made before planting (Table 1). A new supply of soybean seed was obtained each year for each of the soybean cultivars. The soil was a Weir silt loam classified as a fine, montmorillonitic, mesic Typic Ochraqualfs. The soil had an organic matter content of 1.5%. Initial soil pH was 6.7 and soil test available P was high and exchangeable K very high. No lime was applied during the study. A topdressing of 15 kg P/ha (0-46-0) and 84 kg K/ha (0-0-60) was applied in 1979. Weed control was accomplished in 1979 with 1.1 kg/ha of Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) and 1.8 liters/ha of Trifluralin (α,α,α, Trifluro-2,6-dinitro-N,N-diprophyl-p-toluidine). In 1980, 4.6 liters/ha of Alachlor (2-chloro-2, 6′-diethyl-N-(methoxymethyl) acetanilide) and 1.6 kg/ha of Linuron were applied.

A randomized complete block experimental design with three replications was employed. Individual plots were 3 m by 12 m. Two inner rows within each four-row plot were used for data collection. Data was analyzed using the analysis of variance, and significant means were separated with Duncan's Multiple Range Test.

The following parameters were evaluated: 1) stand density, 2) plant height from ground level to the tip of main stem at maturity, 3) height from soil surface to the lower tip of the lowest pod, 4) average number of branches and pods per plant, and 5) seed yields adjusted to 13% moisture.

RESULTS AND DISCUSSION

Stand counts. Soybean stand densities were influenced by cultivars and seeding rates. Greater seeding rates generally resulted in higher stand densities at harvest. Final stand densities at maturity (expressed as a percentage of the seeding rate) indicated that seedling emergence and survival were low (Fig. 1 and 2). This can be attributed to soil crusting caused by rains following planting in a conventional seedbed in both years of the study. The beating rains on the low organic matter soils commonly found in souther Illinois, southern Indiana, and western Kentucky break down the soil structure resulting in severe crusting. Penetrometer readings were taken to evaluate soil crust strength after rains. The pressure required to break the soil crust for three successive days following a rain was 2.04, 3.42, and 4.15 kg/cm^2, respectively. This progressive increase in soil crust strength made seedling emergence difficult.

There were no notable differences in stand density among soybean cultivars in 1979 (Fig. 1). However, in 1980, the cv. Essex had a higher stand density than the cvs. Amsoy 71 or Williams (Fig. 2). Other factors besides genetic differences among soybean cultivars affect seedling emergence. Two such factors are seed viability and seed size (Morse et al. 1949). The cold germination test indicated that the cv. Essex seed should germinate and emerge better under stress conditions than the cvs. Amsoy 71 or Williams (Table 1). This may account for some of the differences in seedling emergence observed among cultivars. Additionally, the greater seedling emergence of the cv. Essex may be related to smaller seed size. Small seed size may be advantageous in cases of soil moisture stress and soil crusting. These two factors were especially severe in 1980.

Variation in seeding rates of each cultivar did not affect the percentage of mature plants during 1979 (Fig. 1). However, in 1980, the seeding rates of the cvs. Williams and Essex did influence the final plant population. The percentage of mature plants tended to increase with higher seeding rates. The percentage plant population of the cv. Essex increased with seeding rates up to 450,000 seed/ha. When the seeding rate of this cultivar was low, the seedlings were further apart within the row, and thus, were unable to provide mutual assistance in breaking the soil crust. At 600,000 seeds/ha, more seedlings emerged but subsequent competition for space within the row may have reduced seedling numbers.

Plant height. Plant height variations differed significantly among soybean cultivars (Table 2). The cv. Williams tended to have the tallest plants, whereas the cvs. Essex and Amsoy 71 had lower but similar plant height. Soybean plant vegetative growth varies with different latitudes because of its dependence on temperature and photoperiod. A given soybean cultivar usually grows taller as latitude increases. The cv. Amsoy 71 is a maturity group II cultivar which is better adapted to latitudes north of the region where this study was conducted. Shorter plants probably resulted because Amsoy 71 was grown in a more southern latitude in this study. The experimental location was well suited to the cv. Williams, a maturity group III cultivar. The cv. Essex was expected to grow taller than it would in its best zone of adaptation. Soybean plant heights decreased by 27% from 1979 to 1980 when averaged over cultivars and seeding rates. Lower rainfall and higher temperatures during the summer of 1980 (Table 4) may have contributed to the shorter soybean plants. Plants tended to be taller as seeding rates increased (Table 3). This may have occurred because soybean plants compete for light more at higher densities.

Height of the lowest pod. In 1979, the cv. Essex set its lowest pod much higher from the soil surface than the other two cultivars (Table 2). Again in 1980, the cv. Essex set its lowest pod much higher than the other cultivars. Lowest pod height generally increased with increasing seeding rates (Table 3). Although the trend was consistent in both years, the lowest pods tended to be nearer to the soil surface in 1980 than in 1979 when compared at the same seeding rate. It is possible that the cv. Essex is genetically predisposed to set its lowest pod at a higher level from the soil surface than the cvs. Amsoy 71 or Williams. Other determinate soybeans like the cv. Essex need to be evaluated before this difference can be attributed to the determinate character.

Plant branching. The early-maturing cv. Amsoy 71 generally had more branches per plant than the late-maturing cv. Essex (Table 2). Plant branching of the cv. Williams was similar to the cv. Essex in 1979. All three cultivars had more branches and were shorter in 1980 than in 1979. Branch numbers increased as stand densities decreased (Table 3). At lower stand densities, less competition among plants may have resulted in the production of more branches. Lower stand densities resulted in a great number of branches per plant for all cultivars in 1980 compared with 1979.

Pods per plant. The cv. Essex produced the greatest number of pods per plant in both years (Table 2). No statistical differences were observed in pod numbers per plant between the cvs. Amsoy 71 and Williams. The number of pods per plant tended to decrease with higher seeding rates, with the greatest decrease occurring from 150,000 to 300,000 seed/ha (Table 3). There was no notable difference in pod numbers per plant when sowing 450,000 or 600,000 seed/ha.

Soybean yields. The cv. Essex outyielded the cv. Williams in 1980 but not in 1979 (Table 2). 'Amsoy 71' was the lowest yielding cultivar both years. Soybean yields tended to increase with increasing days to maturity, especially with unfavorable climatic conditions. The period from planting to maturity of the cvs. Amsoy 71, Williams, and Essex was 108, 128, and 149 days, respectively, in 1980. Yields were less in 1980 than in 1979 by 59, 51, and 38% for cvs. Amsoy 71, Williams, and Essex, respectively. The relatively low yields obtained in 1980 were attributed primarily to high temperature and dry conditions during the major period of vegetative growth and seed filling (Table 4). Additionally, rainfall distribution was concentrated in the early period of plant growth (Table 4). During both years, planting 150,000 seeds/ha gave the lowest yields (Table 3). There was no significant yield advantage in seeding beyond 300,000 seeds/ha in either year. The lowest yield each year was from the cv. Amsoy 71 planted at 150,000 seed/ha.

Correlations among parameters measured. In general, soybean yields were positively correlated with plant heights, lowest pod heights, stand densities and seeding rates (Table 5). The positive correlation of yields with lowest pod heights may be accounted for by reduced seed loss during harvest because pods were set higher. Soybean yields were negatively correlated with branch number per plant probably because branch and pod numbers per plant were negatively correlated with stand density. Greater branch or pod numbers per plant were accompanied by lower stand densities and lower yields. Soybean plant height was found to be negatively correlated with branch number and pod number per plant. Soybean plant heights were positively correlated with stand densities, and seeding rates. Higher stand densities from increased seeding rates resulted in severe competition among plants and greater plant heights. Branches and pods per plant were highly positively correlated. The numbers of branches per soybean plant were negatively correlated with stand densities and seeding rates. The number of pods per plant tended to be negatively correlated with stand densities and seeding rates and the lowest pod heights were positively correlated with stand densities and seeding rates.

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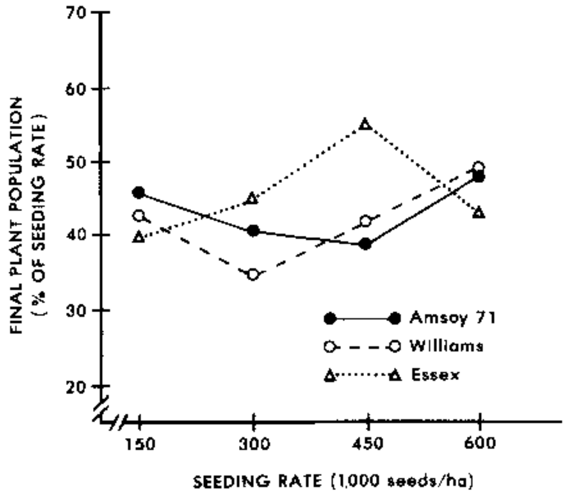

Fig. 1. Relationships between seeding rate and the percentage of final plant population of three soybean cultivars during 1979.

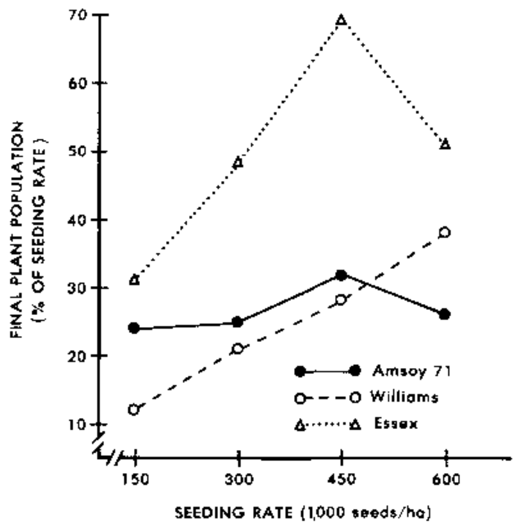

Fig. 2. Relationship between seeding rate and the percentage of final plant population of three soybean cultivars during 1980.

Table 1. Germination tests and seed size prior to planting three soybean cultivars in 1979 and 1980.

	Warm tests		Cold tests		Seed sizes	
Cultivars	1979	1980	1979	1980	1979	1980
	---------------% germination			---------------	---g/100 seeds---	
Amsoy 71	100	97	46	48	19.6	19.6
Williams	100	98	38	68	17.6	18.1
Essex	99	99	63	79	15.7	14.0

Table 2. Effects of soybean cultivars on plant heights, lowest pod heights, branches per plant, pods per plant and yields during 1979 and 1980.

Cultivars	1979 Plant Heights	1979 Lowest Pod Heights	1979 Branches	1979 Pods	1979 Yields	1980 Plant Heights	1980 Lowest Pod Heights	1980 Branches	1980 Pods	1980 Yields
	----------cm	----------	----number/plant	----	---kg/ha---	----------cm	----------	----number/plant	----	---kg/ha---
Amsoy 71	74b*	3.5b	3.9a	71b	1,982b	52b	2.4b	4.5ab	68b	790c
Williams	86a	3.7b	3.0b	63b	2,466a	63a	3.2b	4.8a	59b	1,054b
Essex	77b	13.2a	3.3b	99a	2,486a	55b	8.5a	3.7b	92a	1,522a

*Means in the same column with the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 3. Effects of soybean seeding rates on plant heights, lowest pod heights, branches per plant, pods per plant and yields during 1979 and 1980.

Seeding Rates	1979 Plant Heights	1979 Lowest Pod Heights	1979 Branches	1979 Pods	1979 Yields	1980 Plant Heights	1980 Lowest Pod Heights	1980 Branches	1980 Pods	1980 Yields
seeds/ha $\times 10^3$	----------cm	----------	----number/plant	----	---kg/ha---	----------cm	----------	----number/plant	----	---kg/ha---
150	71b*	4.1b	5.6a	119a	1,966b	54a	2.1c	8.0a	138a	858b
300	79ab	5.5ab	3.7b	78b	2,297a	55a	4.4b	4.4b	57b	1,133a
450	81ab	6.9a	2.4c	62c	2,369a	59a	5.3ab	3.9b	51bc	1,218a
600	83a	6.5a	2.2c	53c	2,456a	59a	5.7a	2.9c	42c	1,162a

*Means in the same column with the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 4. Monthly mean maximum and minimum temperatures and rainfall from May-Sept. 1979 and 1980 at Carbondale, Il.

	1979			1980		
	Temperature			*Temperature*		
Month	Max	Min	Rainfall	Max	Min	Rainfall
	-------C°-------		cm	-------C°-------		cm
May	24.9	10.1	8.0	25.7	11.6	7.3
June	30.1	15.1	9.3	31.4	15.7	15.0
July	30.8	19.2	14.3	35.1	21.1	11.0
Aug.	30.6	26.1	10.9	34.9	20.9	3.0
Sept.	27.5	11.6	3.7	30.5	16.6	8.7

Table 5. Correlation coefficients among soybean parameters during 1979 and 1980.†

	Yields	Plant Heights	Branches	Pods	Lowest Pod Heights	Stand Densities
Plant Heights	0.63** 0.28					
Branches	-0.55** -0.63**	-0.54** -0.20**				
Pods	-0.23 -0.30	-0.56** -0.49**	0.73** 0.76**			
Lowest Pod Heights	0.38* 0.84**	-0.02 0.15	-0.30 -0.62**	0.16 -0.27		
Stand Densities	0.34 0.59**	0.38* 0.35*	-0.84** -0.75**	-0.68** -0.68**	0.31 0.81**	
Seeding Rates	0.93* 0.80	0.93* 0.96**	-0.95* -0.92*	0.95* -0.85	0.89* 0.94*	-0.27 0.77

*Significant at the 5% level.
**Significant at the 1% level.
†Top numbers are for 1979 and bottom numbers for 1980.