Influence of Brown Stem Rot and Cropping History on Soybean Performance

B. W. KENNEDY, Professor, Department of Plant Pathology, and J. W. LAMBERT, Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108

ABSTRACT

Kennedy, B. W., and Lambert, J. W. 1981. Influence of brown stem rot and cropping history on soybean performance. Plant Disease 65:896-897.

The effects of continuous soybean culture on yield and other characters of 10 soybean cultivars were measured by planting each of four consecutive years in an area that had been cropped to soybeans continuously for 22 yr and in adjacent areas that had been in crop rotation. Maturity (Group 00–II) and lodging were not greatly affected by type of culture. Infection by *Phialophora gregata* was lower, plant height and seed size were greater, and yield was 13% higher in the rotation culture. Cultivars differed for all plant characters except seed quality. Season × cultivar interactions were significant, but interactions involving culture regimes were not.

Additional key words: *Glycine max*

As soybean (*Glycine max* (L). Merr.) becomes an "older" crop and occupies a larger proportion of tillable land, questions often arise regarding the advisability of planting it successively 2 yr or more on the same land. Jeffers et al (6) reported that soybean crops grown in Ohio on the same land every year yielded 97% as much as those grown on the same land every other year and 92.6% as much as those grown on the same land every third year. One of the primary explanations given for lower yields under continuous culture is the increase in incidence of soilborne pathogens, particularly the brown stem rot fungus, *Phialophora gregata* (Allington and Chamberl.) W. Gams (1). Gray and Sinclair (4) reported up to 31% yield reduction in Illinois. In field surveys in Iowa, 6% of soybeans were infected with the brown stem rot pathogen in 1956 compared with 53% in 1964 (2). Dunleavy (2) related this to a shift away from crop rotations including corn, soybean, oats, and meadow to those including only corn and soybeans. He reported soybean yield reductions of 9% in the first year and 20% in the second year in infested soils, compared with uninfested soils. Weber et al (8), working with infested and uninfested soils, found that soybeans in the uninfested soils yielded 11% more than those in the infested soil. Dunleavy and Weber (3) showed that after 10 yr of continuous culture, yield of soybeans was only 44% of the yield of soybeans grown after 5 yr of corn. Brown stem rot incidence had increased markedly, up to 94.5%, in Iowa by 1979 (7).

Hueg et al (5) state that brown stem rot develops late and damage is minor in Minnesota compared with that in states farther south. Weber et al (8) indicated that early maturity allows plants to escape brown stem rot.

Our study was planned to determine the effects of planting soybeans in continuous culture and in rotation cropping on yield and other characters of plants grown in Minnesota, the northern edge of soybean production.

MATERIALS AND METHODS

Two plot areas were used for a four growing-season experiment at St. Paul, MN, from 1964 to 1968. One plot area had a high incidence of the brown stem rot pathogen and had been cropped to soybeans for 22 consecutive years. The other plot area was planted on one of three nearby fields (not more than 10 m from a border of the continuously cropped plot) that had been rotated with various crops including wheat, peas, corn, oats, and barley, and soybeans that occurred not more than once every 3 yr. Other than cropping sequence, the fields had similar characteristics: Waukegan silt loam, well drained, and high levels of P and K.

Ten soybean cultivars ranging from Group 00 to Group II maturity were used. In order of early to late maturity, the cultivars were Acme, Flambeau, Merit, Mandarin (Ottawa), Grant, Traverse, Chippewa 64, A-100, Lindarin 63, and Harosoy 63.

The experimental design was a split-plot rotation for main plots and cultivars for subplots. Cultivars were replicated three times in each culture regime for each season.

Individual plots were three rows wide and 5.5 m long, with 75 cm of space between rows. Planting was done with a multiple-row cone planter and an attempt was made to attain 12 plants per 30 cm of row. Stand counts were made 1–2 wk after emergence.

A 4.9-m section of the center row of a plot was harvested for determining yield. The border rows were used for brown stem rot observations that were made near maturity by splitting stems and observing for brown pith three to six nodes above the soil line. Plants were considered mature when the leaves had dropped and 90% of the pods were brown. Data were obtained for maturity, lodging, plant height at maturity, seed quality, and seed size. Lodging was scored on a 1–5 scale, where 1 was an erect plant and 5 was a prostrate plant. Plant height was measured in centimeters; seed quality was scored 1 (excellent) to 5 (poor), based on the general appearance of color and shape; seed size was expressed as grams per 100 seeds.

Table 1. Means and ranges of eight soybean plant and seed characteristics for rotation (R) versus continuous (C) culture over four seasons (1964–1968) in Minnesota

			Range of values for cultivars			
	Mean, all cultivars		Maximum		Minimum	
Character	R	C	R	C	R	C
Stand, plants/30 cm	11.5	10.1	12.7	11.3	9.1	8.2
Date mature	9/14	9/13	10/8	10/8	9/4	9/4
Lodging score[a]	3.1	3.2	4.2	4.2	2.2	2.2
Plant height (cm)	85	80	100	95	70	65
Brown stem rot (% of plants)	1.4	73.9	4	88	0	58
Yield (q/ha)	19.2	17.0	23.2	22.4	14.9	12.3
Seed quality score[b]	3.1	3.2	3.7	3.7	2.8	2.9
Seed size (g/100)	15.1	14.6	18.4	17.2	12.6	12.3

[a] 1 = erect, 5 = prostrate.
[b] 1 = excellent, 5 = poor.

Contribution of the Minnesota Agricultural Experiment Station (Scientific Journal Series paper 11,312).

Accepted for publication 5 May 1981.

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0191-2917/81/11089602/$03.00/0

Table 2. Results from analyses of variance of five plant and seed characteristics studied under rotation and continuous cultures for four seasons (1964–1968) in Minnesota

	Plant characteristics				
Source of variation	Stand	Lodging	Height	Yield	Seed quality
Culture methods (C)	**	NS	**	**	NS
Years (Y)	**	**	**	**	**
C × Y	NS	NS	NS	NS	NS
Varieties (V)	**	**	**	**	NS
C × V	NS	NS	NS	NS	NS
Y × V	*	**	**	**	**
C × Y × V	NS	NS	NS	NS	NS

* F values significant, $P = 0.05$.
**F values significant, $P = 0.01$.
NS = F values not significant, $P = 0.05$.

RESULTS

The rotation plot averaged 1.4 more plants per 30 cm of row than the continuous plots (Table 1) and this difference was statistically significant ($P = 0.05$), but the number of plants in the continuous culture did not fall below that considered adequate for maximum yield (Table 2). Date of maturity was affected little by the type of culture; plants in the rotation plot averaged only 1 day later than plants in the continuous production plots. Similarly, lodging was not noticeably affected. Plant height, on the other hand, was highest in the rotation plots. The percentage of plants with brown stem rot was lower in the rotation plots (1.4%) than in the continuous plots (73.9%). Seed yield was 13% higher in the rotation plots. Greater seed size could account for 27% and greater seed number could account for 73% of this difference. The quality of seed from the two culture regimes differed little.

Growing seasons significantly affected all cultivars and all five plant characteristics analyzed except seed quality. Season × cultivar interactions were significant for all five, but none of the interactions involving culture regime were significant.

DISCUSSION

The most obvious difference between the continuously grown soybeans and those grown in rotation over the 4 yr was the percentage of plants showing infection with brown stem rot fungus. The magnitude of the yield difference is consistent with that from other studies (2–4,6,8). Noteworthy, however, are the absence of cultivar × culture method interaction and the fact that the differences in cultivars was not related to their relative maturities.

The 13% lower yield of soybeans in continuous culture than in conventional rotation is of concern. The precise cause for this cannot be positively ascertained, although several factors may have contributed. Stand, however, does not appear to be a particularly important one. An r value of 0.1133 between stand and yield was not significant and would not have accounted for more than 1 or 2% of the variation ($r^2 = 0.0128$). Fertility and soil structure probably contributed also to yield variability.

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