Effects of Row Spacing and Within-Row Plant Population on Rhizoctonia Aerial Blight of Soybean and Soybean Yield

G. F. JOYE, Former Graduate Assistant, G. T. BERGGREN, Professor, and D. K. BERNER, Instructor, Department of Plant Pathology and Crop Physiology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge 70803

ABSTRACT

Joye, G. F., Berggren, G. T., and Berner, D. K. 1990. Effects of row spacing and within-row plant population on Rhizoctonia aerial blight of soybean and soybean yield. Plant Dis. 74:158-160.

Greenhouse and field experiments were conducted from 1983 to 1985 to study the influence of row spacing and within-row plant density on Rhizoctonia aerial blight (caused by *Rhizoctonia solani*) and yield of soybean (*Glycine max*). A disease rating system was developed that accounted for both disease incidence and severity. A significant negative relationship between disease and soybean seed weight and number was observed in the greenhouse. Within-row plant population had no significant effect on disease or yield. In all years, row spacings of 50 cm or more resulted in decreased disease. In 1983 and 1985, row spacing of 25 cm resulted in higher yields than row spacings of 50, 75, or 100 cm. Rhizoctonia aerial blight reduced leaf area, but higher plant populations associated with decreased row spacing more than compensated for the reduction. In 1984 the effect of row spacing on yield was reversed; wider spacing resulted in higher yield. Drought stress in 1984 may have influenced this trend. Simulations from a soybean growth model (SOYGRO) indicated that higher yields could be expected with wider row spacings during drought years.

Rhizoctonia aerial blight (RAB) caused by *Rhizoctonia solani* Kühn (anastomosis group 1A) is a widespread disease of soybeans (*Glycine max* (L.) Merr.) in Louisiana. RAB was first reported on soybeans in Louisiana in 1954 (7) and was considered to be epidemic there in 1973 (4). More than half of the approximately 750,000 ha of soybeans planted annually in Louisiana are grown in areas where RAB has been observed. Annual yield losses due to RAB in Louisiana have been estimated at 1–2% (3). At present, recommended registered fungicides do not adequately control RAB, and although cultivars differ somewhat in susceptibility, no highly resistant commercial cultivars have been developed.

The lack of effective chemical control and cultivar resistance has shifted the focus of research toward the development of cultural practices for managing the disease. In the past, producers have been advised to plant on wide rows and to reduce plant density to enhance air movement through the canopy to aid drying and thus lower the amount of free moisture available for the development and spread of RAB (5).

The disease rating system previously used to assess RAB severity is not effective. It rates disease on a linear scale from 0 to 9, with 0 indicating no disease symptoms and 9 indicating 90% or more of the plants with RAB (8). This system indicates only the incidence of RAB in the field and does not take into account the severity of the disease on individual plants. RAB may be mild but widespread throughout a crop canopy. The rating system proposed herein considers disease severity as well as incidence and allows more accurate estimation of the disease across an entire field.

We attempted first to develop a disease rating system to rapidly and accurately estimate RAB in the field and to correlate disease with yield loss and second to reexamine the current row spacing recommendation and determine the effects of different row spacings and plant densities on RAB of soybean and resultant yield.

Approved by the Director, Louisiana Agricultural Experiment Station, as manuscript no. 88-38-2779.

Accepted for publication 12 September 1989 (submitted for electronic processing).

MATERIALS AND METHODS

Disease rating system. The disease index used throughout this study was calculated as the product of estimates of the incidence and severity of the disease within a field. Incidence and severity values ranged from 0 to 5. Incidence categories were 1 = 1–20, 2 = 21–40, 3 = 41–60, 4 = 61–80, and 5 = 81–100 infected plants per 100 plants. Severity categories were as follows: 1 = small, water-soaked lesions near leaf bases, less than half of leaf area symptomatic; 2 = lesions present on half or more of leaf area; 3 = as in 2, with mycelial webbing between plants; 4 = extensive leaf necrosis, widespread webbing, and pod abortion, with sclerotia present; and 5 = plants dying or dead. The incidence-by-severity rating scale thus ranged between 0 and 25.

To determine the correlation between

the disease rating for RAB and yield, a greenhouse study was conducted. Eight chambers (60 × 122 × 244 cm) covered with clear polyethylene were placed on greenhouse benches filled to a depth of 30 cm with steam-pasteurized growth medium (equal volumes of soil, sand, and peat moss). Seeds of the cultivar Davis were planted in eight rows 60 cm long and spaced 25 cm apart. Rows were thinned to 20 plants each. Free moisture was maintained on plants in the chambers with cool vaporizers (Hankscraft model 240, Gerber Products Co., Reedsburg, WI).

Inoculum of *R. solani* (isolate 465, anastomosis group 1) was grown on sterilized rice hulls for 6–8 wk. At growth stage V4 (1), 1 kg of inoculum (rice hulls with mycelia and sclerotia) per row was placed at the soil line around the stems. Water was applied over the top of the foliage once a week with a garden hose with a nozzle attached to simulate rainfall and provide a mechanism for splashing inoculum.

After foliar symptoms appeared, the selective fungicide pencycuron was applied at the rate of 0, 0.3, 0.62, and 1.23 g a.i./1,500 cm^2 of ground area with a 350-ml Spray Pal all-purpose sprayer (model S-67, Delta Industries, Philadelphia, PA). Application of the fungicide enabled maintenance of different levels of RAB, which was necessary to obtain a correlation between the amount of disease present and yield. Treatments were arranged in a randomized complete block design with the eight chambers as blocks. Four rows within each chamber received a treatment, and four were used as guard rows. Each row that received fungicide was temporarily isolated by a polyethylene barrier during application.

Disease was rated 45, 55, and 74 days after planting. Seeds were harvested by hand, weighed, and counted. Seed weight was adjusted to 13% moisture.

Field studies. The effects of row spacing and plant density on RAB and yield were determined in a field with a history of RAB at the Louisiana State University Burden research farm in Baton Rouge in 1983 and 1984. Davis soybeans were planted on 1 June in plots measuring 9 × 4 m with 2-m alleys. Row spacing and broadcast treatments included both high and low plant populations. High populations were 33–39, 26–33, and 18–26 plants per meter for row spacings of 100, 50, and 25 cm, respectively. Low populations were 26–29, 18–23, and 10–13 plants per meter for the same row spacings. Broadcast populations were 105–126 (high) and 63–84 (low) plants per square meter. The experimental design was a randomized complete block with four replications per treatment.

Weeds were controlled with preemergence applications of alachlor (2.24 kg a.i./ha) and metribuzin (1.23 kg a.i./ha) and a postemergence application of fluazifop (0.62 kg a.i./ha). Insects were monitored, and plots were treated as needed with permethrin (0.07 kg a.i./ha). Plots were sprayed once in 1984 on 3 August; no insecticide was applied in 1983.

Disease was rated seven times at regular intervals between 20 July and 9 September in 1983 and three times in 1984 between 27 July and 1 August. The test area was harvested on 10 and 7 November in 1983 and 1984, respectively. The middle two rows of each plot were harvested with a Hege 125B research combine (Hans-Ulrich Hege, Wurtt, West Germany). For broadcast plantings, one combine header width (132 cm) was harvested. Seed moisture was determined using a Burrows digital moisture computer (model 700, Burrows Equipment Co., Evanston, IL). Seed weights were adjusted to 13% moisture.

Field studies in 1985 were conducted at a commercial farm in Vermilion Parish, LA, where RAB had been severe in previous years. Davis soybeans were planted on 1 June at row spacings of 75, 50, and 25 cm, with two plant density levels (high and low) at each row spacing. Low populations were 26–29, 18–23, and 10–13 plants per meter of row for row spacings of 75, 50, and 25 cm, respectively, and the corresponding high populations were 33–39, 26–33, and 18–26 plants per meter. The experimental design was a randomized complete block with four replications. Disease was rated monthly after symptoms appeared.

Leaf area indices were determined at growth stage R1 by subsampling 1 m of the middle row 4 m from the north end of each plot. The leaves were stripped from the stem, and total leaf area of the sample was determined with a Decagon Delta-T leaf area meter (Delta-T Devices, Ltd., Burwell, Cambridge, England).

At maturity, the middle two rows of each plot were harvested by hand, because of excessive moisture in the field, and were threshed mechanically with a Hege 125B research combine. Seed weights were adjusted to 13% moisture.

Simulations. To examine the effects of row spacing on yield in the absence of disease and under different weather scenarios, we ran 5 yr of weather data through the soybean growth simulation model SOYGRO (2). One simulation was run for each row spacing in each year. The cultivar used in the simulations was Davis, and the planting date was 1 June. The weather data used in the simulations were collected at Gainesville, FL, because weather data from the study sites were not available. The similarities between the study sites and Gainesville in latitude, summer temperature, and rainfall allow a general comparison of trends at different row spacings under various weather conditions.

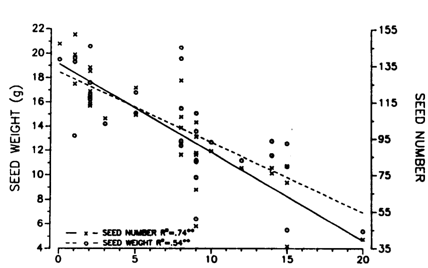

Fig. 1. Linear regressions of soybean seed weight and seed number on the incidence-by-severity direct-product disease rating scale (0–25) for Rhizoctonia aerial blight.

RESULTS

Disease rating system. There was a significant negative relationship between disease rating (*DR*) and seed number ($R^2 = 0.74$) and seed weight ($R^2 = 0.54$) (Fig. 1). When regression analyses were run using a disease rating scale of 0–9, R^2 values for seed number and seed weight dropped to 0.72 and 0.49, respectively.

Field studies. Symptoms of RAB appeared on soybean foliage at growth stage V5 in 1983 and 1984 and at growth stage V8 in 1985. Because lodging in the broadcast plantings caused low yields in both 1983 and 1984, this treatment was eliminated from analysis.

Within-row plant populations had no significant effect on yield or disease in any of the three study years. The data from the within-row populations were pooled for analysis.

In all years, disease decreased with

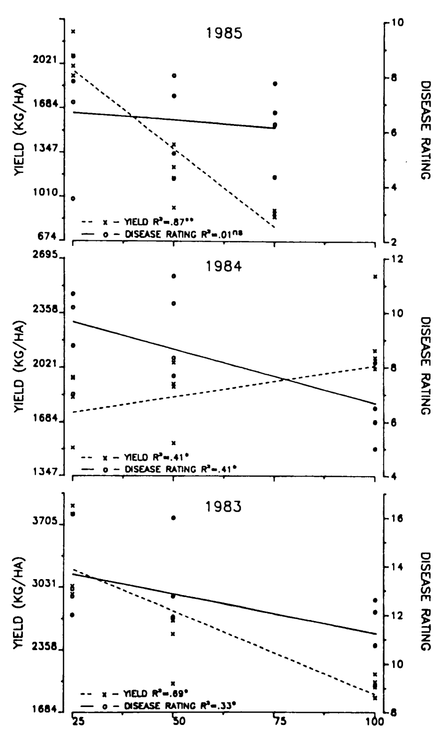

Fig. 2. Linear regressions of soybean yield and incidence-by-severity disease rating on row spacing in each of three study years.

increased row spacing, but this effect was significant only in 1983 and 1984 (Fig. 2). In 1983 and 1985, increased row spacing had a significant negative effect on yield; in 1984, this effect was positive and significant (Fig. 2).

Multiple regression analysis of the 1985 leaf area index (*LAI*) data showed that the index was significantly influenced by both row spacing (*RS*) and disease (*DR*). The resulting regression equation ($LAI = 0.56 + 0.02RS - 0.03DR$) fit the data with a highly significant R^2 of 0.48. Standardized partial regression coefficients (variables measured in standard deviations from their respective means [6]) for *RS* and *DR* indicated that the variables were nearly equal but opposite in their effect ($\beta = 0.52$ for *RS* and -0.44 for *DR*). When included as independent variables in multiple regression analysis of yield (*Y*), both *LAI* and *RS* were highly significant variables. The resulting equation ($Y = 37.1 + 3.1LAI - 0.95RS$) had a highly significant R^2 of 0.79. Standardized partial regression coefficients indicated that the influence of *RS* on *Y* was considerably greater than that of *LAI* ($\beta = -0.95$ and 0.11, respectively).

Although lower row spacings resulted in greater yields in 1983 and 1985, the opposite was observed in 1984. We postulated that this reverse trend may have been the result of drought stress in 1984, a dry growing season. Simulated growth data from SOYGRO indicated increased yields at narrower row spacings for 3 yr of weather data but the opposite effect for the other 2 yr. A comparison of extractable soil water content throughout the respective growing seasons indicated that the 2 yr in which a reverse trend was observed were also the years in which extractable soil water was greatly reduced.

We ran linear regressions of yield and relative drought stress against row spacing for the 2 yr that had given the most dramatic opposite results. Relative drought stress was calculated as the sum of the drought-induced reductions in photosynthetic rate (from SOYGRO output) that occurred during the respective growing seasons. In 1978, when drought stress was virtually uniform for all row spacings, yield declined significantly as row spacing increased (Fig. 3), as in our study in 1983 and 1985. The simulation was markedly different in 1981; drought stress declined rapidly and yield increased rapidly with increased row spacing, as was observed in our study in 1984. The simple correlation (*r*) between drought stress and yield in the simulations was -0.95.

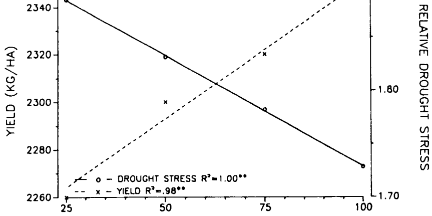

Fig. 3. Linear regressions of simulated yield of Davis soybeans and drought stress (from SOYGRO simulation model) on row spacing in drought (1981) and nondrought (1978) years.

DISCUSSION

Disease rating system. The incidence-by-severity direct-product rating system employed in this study produced slightly better regressions with seed number and seed weight data than did a 0–9 rating scale under controlled greenhouse conditions. The highly significant regressions of these yield components on disease ratings show that the rating system is a good indicator of disease. Under field conditions, where RAB severity fluctuates with rainfall and relative humidity, this system accounts for more variability than the 0–9 incidence scale because incidence is less prone to fluctuation than is severity after the initial disease outbreak.

Field studies. In two of the three study years, disease ratings declined with increasing row spacing (Fig. 2). This result supports the current view that more space between rows promotes aeration and decreases RAB development (5). In 1985, disease also decreased with increased row spacing, but the effect was not significant, probably because disease ratings were substantially lower than in the two previous years (Fig. 2) and because a 75-cm row spacing, which is more acceptable to growers, was substituted for the wider row spacing of 100 cm. Use of the wider spacing might have further decreased disease and resulted in a steeper regression line.

Soybean yields decreased significantly as row spacing increased in two of the 3 yr. This result is contrary to the expected outcome since wider row spacings generally result in lower disease incidence. The leaf area regression equations showed that increased row spacing resulted in increased leaf area, while increased disease had a strong negative effect on leaf area. Because increased row spacing also reduces disease, leaf area and subsequent yield would be expected to increase at wider row spacings. However, standardized partial regression coefficients indicated that the negative effect on yield attributable to increased row spacing was considerably greater than any positive effect of increased leaf area. Although the primary effect of RAB is in reducing leaf area, this reduction is more than compensated for by reducing row spacing and increasing plant population. The effect of increases in plant population seems to function only across row spacings; increased within-row populations had no effect on yield. The compensatory effect of reduced row spacing does have a lower limit, as shown by the broadcast seeding treatments, in which plants lodged severely and produced considerably lower yields than in any of the other row spacing treatments.

The opposing effects of row spacing on yield in drought and nondrought years are not irreconcilable. Higher plant populations (narrow row spacings) aggravate drought stress and reduce yields. When soil moisture is adequate, yield is a positive function of plant population up to the point at which lodging is induced. When RAB is present, narrower row spacing compensates for the loss of leaf area caused by the disease, and higher yields can be expected. However, drought imposes much more serious plant stress than RAB. If drought could be foreseen, a row spacing recommendation could easily be made. Unfortunately, this is not the case. Based on the data collected in this study and from SOYGRO simulations, a row spacing of 50 cm appears to be the best generic recommendation to account for both RAB and drought stress.

ACKNOWLEDGMENTS

We thank E. E. Butler for furnishing *R. solani* isolate 465 and M. E. Pace, E. P. White, J. A. Freedman, J. S. Gershey, and J. P. Snow for their assistance in field experiments. This research was funded in part by the Louisiana Soybean and Grain Research and Promotion Board.

LITERATURE CITED

1. Fehr, W. R., Caviness, C. E., Burmood, D. T., and Pennington, J. S. 1971. Stage of development descriptions for soybeans, *Glycine max* (L.) Merrill. Crop Sci. 11:929-931.
2. Jones, J. W., Boote, K. J., Jagtap, S. S., Hoogenboom, G., and Wilkerson, G. G. 1988. SOYGRO V5.41 User's Guide. Agricultural Engineering and Agronomy Department, University of Florida, Gainesville.
3. Mulroony, R. P. 1986. Soybean disease loss estimate for southern United States in 1984. Plant Dis. 70:893.
4. O'Neill, N. R., Rush, M. C., Horn, N. L., and Carver, R. B. 1977. Aerial blight of soybeans caused by *Rhizoctonia solani*. Plant Dis. Rep. 61:713-717.
5. Sinclair, J. B., ed. 1982. Compendium of Soybean Diseases. 2nd ed. The American Phytopathological Society, St. Paul, MN. 104 pp.
6. Steel, R. G. D., and Torrie, J. H. 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd ed. McGraw-Hill Book Company, New York. 633 pp.
7. Stroube, W. H. 1954. Host range of the Rhizoctonia aerial blight fungus in Louisiana. Plant Dis. Rep. 38:789-790.
8. Sturgeon, R. V. 1978. Standardization and uniformity of recording and reporting agricultural research data. Proc. South. Soybean Dis. Work. 5:81.