Yield Reductions in Soybeans Infected With Cowpea Mosaic Virus

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ABSTRACT

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Soybeans (*Glycine max* 'Improved Pelican') were mechanically inoculated at the primary leaf or midbloom stage with a soybean isolate of cowpea mosaic virus (CPMV) in field trials at Isabela, Puerto Rico. Yields from treatments with 25, 50, 75, or 100% of the plants inoculated were measured and compared with yields from a noninoculated treatment. In three experiments (planted on 29 December 1976, 13 May 1977, and 1 July 1977), statistically significant ($P = 0.01$) yield reductions were observed when 50% or more of the plants were inoculated at the midbloom stage. In one experiment (planted 29 December 1976), yield reductions were statistically significant ($P = 0.05$) when 25% or more of the plants were inoculated at the primary leaf stage and ($P = 0.01$) when 50% or more were inoculated at the primary leaf or midbloom stage. Correlation coefficients between disease incidence and yield were significant ($P = 0.05$) for inoculation at the primary leaf stage in two of three experiments and for inoculation at the midbloom stage in all experiments.

An early report on cowpea mosaic virus (CPMV) from tropical America indicated that soybeans were susceptible (2), but only recently has the potential threat of this virus to soybean production been investigated (5). In 1975, we isolated CPMV from field-grown soybeans at Isabela, Puerto Rico (5). The severity of the disease caused by this virus as well as the biochemical and biophysical properties of the virus have been reported (5–7). Our isolate (designated CPMV-PR) is similar to a CPMV isolate from Puerto Rico described previously (4), and belongs to the severe subgroup of CPMV. The symptoms in soybeans inoculated with CPMV-PR and disease severity, together with the abundance of the bean leaf beetle (*Ceratoma ruficornis* Oliv.) vector in the field and the incidence of infection in cowpeas raised the possibility that the disease in soybeans could become a serious problem. This led us to conduct field experiments to measure the yield loss caused by infection of soybeans with CPMV-PR.

MATERIALS AND METHODS

Isolate CPMV-PR used in this experiment was described previously (5). Experiments were conducted at the University of Puerto Rico Agricultural Experiment Station, Isabela Substation near Isabela, Puerto Rico (lat. 18° N).

Soybeans (*Glycine max* 'Improved Pelican') were planted on 29 December 1976, 13 May 1977, and 1 July 1977. The experimental design was a split plot, with four replications in the experiment planted 29 December 1976 and five replications in the other two experiments. Main plots were time of inoculation (primary leaf or midbloom stage). The five treatments each subplot received were 0, 25, 50, 75, or 100% of plants inoculated. Plants were left noninoculated for 0% inoculation and every fourth plant, every other plant, three out of four plants, and all plants were inoculated for 25, 50, 75, and 100% inoculations, respectively. Each subplot consisted of five treatment rows. Each treatment row in the experiment planted 29 December 1976 was 5 m long; in later experiments rows were 6 m long. Treatment rows in each subplot were separated by one row of nontreated soybeans. Spacing between rows was 60 cm.

Inoculum was prepared by homogenizing the leaves of CPMV-PR infected cowpeas inoculated 14 days earlier in 0.05 M potassium phosphate pH 7.0. A small amount of Carborundum was added to the homogenate before it was applied with a gauze pad. Primary leaf-stage inoculations were at 8 to 10 days after planting when the first trifoliolate leaves were beginning to expand. Midbloom-stage inoculations were at the time when approximately half of the flowers had color.

Plots were hand-harvested. Seeds from the 0.5-m ends

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of each treatment row were not included in yield measurements to minimize edge effects. Seeds were dried to a uniform moisture content of 10% (29 December 1976 planting) or 11% before being weighed.

RESULTS

Inoculated soybean plants in the field showed symptoms of CPMV-PR within 5 to 7 days after inoculation. Infected plants were counted several weeks after inoculation to verify that all of the inoculated plants became infected. In the experiment planted 13 May 1977, not all the plants inoculated at the primary leaf-stage became infected; the symptomless plants were reinoculated 10 days after the first inoculation.

Yield data from all treatments were recorded as seed weight in grams per plot (or subplot). The mean yields from all treatments were calculated and compared with that of the noninoculated control (Fig. 1). Within one standard deviation range, a straight line showing the relationship of percentage of plants inoculated and yield could be drawn except for the primary leaf-stage inoculation in the experiment planted 1 July 1977. Correlation coefficients (r) of percentage of plants inoculated and yield for the primary leaf-stage and the midbloom-stage inoculations were −0.9839 and −0.9899, −0.9944 and −0.9748, and −0.9202 and −0.9503, respectively, for the experiments planted in December, May, and July. All r values except that for the primary leaf-stage inoculation from the July experiment were significant ($P = 0.05$).

The mean of the yield data from each treatment also was converted to kilograms per hectare basis and used in the calculation of analysis of variance. The mean yields (kilograms per hectare) of the noninoculated controls for the primary leaf-stage and midbloom-stage inoculation treatments, respectively, were 1,430.51 and 1,406.92 for the December experiment, 1,611.22 and 1,354.70 for the May experiment, and 1,641.13 and 1,384.76 for the July experiment. The effect of inoculation level but not inoculation time was significant at both 0.05 and 0.01 probabilities. In the experiment planted 29 December 1976, significant yield reduction was obtained ($P = 0.05$) when as few as 25% or more of the plants were inoculated and ($P = 0.01$) when 50% or more of the plants were inoculated. For midbloom-stage inoculation, significant yield reduction ($P = 0.05$) was obtained when 75% or more of the plants were inoculated in all three experiments.

DISCUSSION

Significant yield reduction resulted when 25% of the plants were inoculated with CPMV-PR at the primary leaf stage. There was no significant difference, however, in any of the experiments between the two inoculation times employed. Midbloom-stage inoculation always gave higher yields than did primary leaf-stage inoculation, although the difference was not statistically significant. The yield differences between inoculation times were greatest when all the plants were inoculated.

The low yield from the 100% inoculation treatment at the primary leaf stage is in agreement with our observations in both the field and in the greenhouse that CPMV-PR-infected soybean plants produce little if any seed. This is, in most cases, the result of flower bud blight (5). The yield reductions at other inoculation levels, however, were not proportional to the number of plants inoculated. In the first experiment, the slope of the line showing the relationship of percentage yield and percentage of plants inoculated was larger (−0.9077) than the slopes measured in the May and July experiments (−0.8539 and −0.8532). During the winter months the

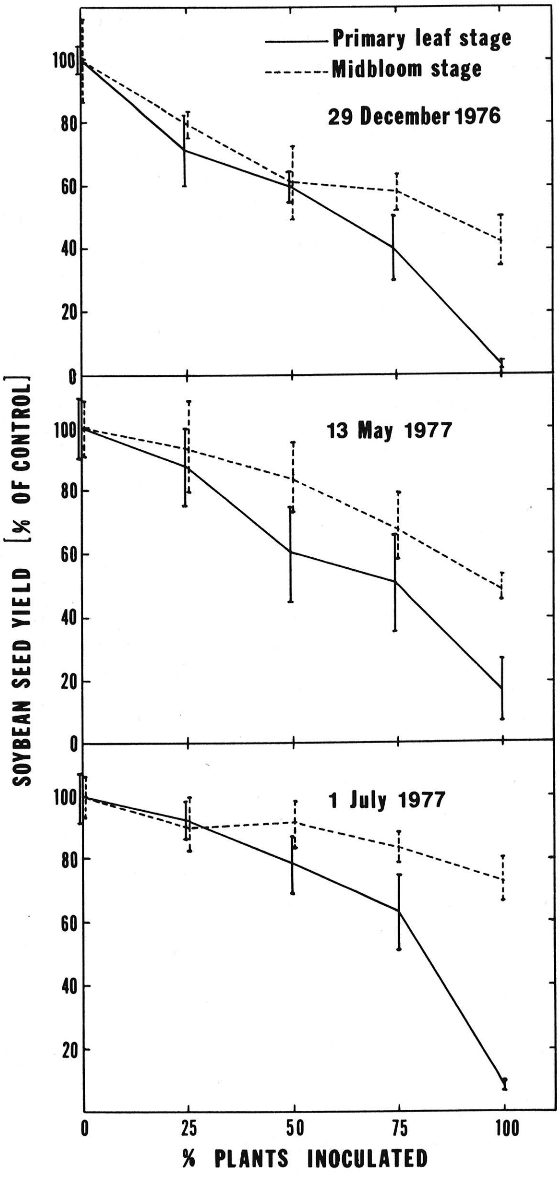

Fig. 1. Relation between yield (expressed as percentage of noninoculated control) and percentage of plants inoculated from three experiments planted on 29 December 1976 (four replications) or 13 May or 1 July 1977 (five replications). Soybean plants were inoculated with Puerto Rico isolate of cowpea mosaic virus at primary leaf stage, or midbloom stage. Vertical bars represent one standard deviation range.

plants were subjected to shorter days. The amount of vegetative growth in the December experiment was less than that achieved in the May or July experiment when plants were more apt to perform up to their genetic potential and healthy plants could thus produce more to compensate for the infected plants. Caviness and Miner (1) found stand reduction of up to 45% 2 wk before bloom had no effect on soybean seed yield. A similar effect was reported with increased spacing within rows of navy beans (*Phaseolus vulgaris*) (3). As observed in our experiments, CPMV-PR—infected soybean plants were stunted and sometimes killed. Thus, infected plants probably did not compete well with noninfected plants for nutrients and space in the canopy. This situation would allow the noninfected plants to compensate by producing more yield than they would have without infected plants. This reasoning may explain the disproportionate yields at 25, 50, and 75% inoculation levels in summer experiments.

Information on yield reduction due to virus infections is valuable for making decisions about whether control measures, which may be expensive, are warranted. This line of study is needed to gain more insight into the potential threat of virus diseases, but is often overlooked. The seriousness of CPMV in cowpeas has been recognized, and up to 100% yield reductions have been observed in western Nigeria (8). Little, however, was known about the effect of this virus on soybeans. Our results (Thongmeearkom et al, *unpublished*) on natural spread of CPMV-PR indicated that the transmission rate from infected cowpeas to soybeans growing nearby was quite low, even though the beetle vector was present. This does not preclude the possibility of CPMV becoming a serious threat in soybean production, however, since under some circumstances the natural incidence of CPMV infection in fields next to naturally infected cowpeas at Isabela can occur (R. M. Goodman, *unpublished*). Our results suggest that significant yield loss occurs in soybeans when the incidence of infection is above 25%. Such disease incidences might occur in situations in which CPMV-infected cowpeas and soybeans are grown close by and when the timing of the two crops encourages migration of the beetle vector from senescing, infected cowpeas to young soybean seedlings.

LITERATURE CITED

1. CAVINESS, C. E., and F. D. MINER. 1962. Effects of stand reduction in soybeans simulating three-cornered alfalfa hopper injury. Agronomy J. 54:300-302.
2. DALE, W. T. 1949. Observations on a virus disease of cowpea in Trinidad. Ann. Appl. Biol. 36:327-333.
3. GOULDEN, D. S. 1976. Effects of plant population and row spacing on yield and components of yield of navy beans (Phaseolus vulgaris L.). N. Z. J. Exp. Agric. 4:177-180.
4. PÉREZ, J. E., and A. CORTÉS-MONLLOR. 1970. A mosaic virus of cowpea from Puerto Rico. Plant Dis. Rep. 54:212-216.
5. THONGMEEARKOM, P., and R. M. GOODMAN. 1976. A severe disease of soybeans caused by an isolate of cowpea mosaic virus. Proc. Am. Phytopathol. Soc. 3:209-210 (Abstr.).
6. THONGMEEARKOM, P., and R. M. GOODMAN. 1978. Complementation and pseudorecombination between ribonucleic acids from two natural isolates of cowpea mosaic virus (severe subgroup). Virology 85:75-83.
7. THONGMEEARKOM, P., and R. M. GOODMAN. 1978. Electrophoretic properties of cowpea mosaic virus (severe subgroup). J. Gen. Virol. (In press).
8. WELLS, D. G., and R. DEBA. 1961. Sources of resistance to the cowpea yellow mosaic virus. Plant Dis. Rep. 45:878-881.