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Control of the Soybean Cyst Nematode by Crop Rotation in Combination with a Nematicide[1]

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Abstract: An experiment to evaluate the control of soybean cyst nematodes compared 1-year, 2-year, and 3-year nonhost rotations with continuous soybeans (*Glycine max*) in 0.2-ha plots. In a second 1-year rotation, the plots were planted to soybean or corn (*Zea mays*) after fumigation in the spring with a split application of 1,3-dichloropropene (748.2 liters/ha). The effects of the nematicide were apparent the first year. Soybean yield was 1,482 kg/ha compared to 233 kg/ha in the untreated plots. In the second year, the highest yielding plants (2,035 kg/ha) were those following 1 year of corn that had been treated the previous year; plants in untreated plots yielded 288 kg/ha. Average yield of soybean following 1 year of corn was 957 kg/ha compared to 288 kg/ha for continuous soybean. In the third year, the effects of the nematicide were still evident. Soybean plants in plots treated the first year, followed by corn, then soybean, yielded 1,044 kg/ha compared to 761 kg/ha for soybean following 1 year of corn and 991 kg/ha for soybean following 2 years of corn. Plots planted to soybean for 3 consecutive years yielded 337 kg/ha. Nematicidal effects were no longer evident during the fourth year. Yields were most improved by the greatest number of years in the nonhost crop; highest yields in descending order were from plants following 3 years of corn, 2 years of corn, and 1 year of corn. Plots planted to soybean for 4 consecutive years yielded 130 kg/ha. Highly significant negative correlations occurred each year between initial nematode population densities and seed yield.

Key words: 1,3-dichloropropene (1,3-D), corn, *Glycine max, Heterodera glycines,* nematicide, population dynamics, soybean, soybean cyst nematode, *Zea mays.*

The soybean cyst nematode (*Heterodera glycines* Ichinohe) is the most important cyst nematode in North America and the most serious nematode pest of soybean (*Glycine max* (L.) Merr.) in the United States. The first commercially suitable soybean cultivar (Pickett) resistant to the cyst nematode became available in 1965. Resistant cultivars currently available often fail to control some populations of this pest. Chemical soil treatments continue to be uneconomical and of little utility for this crop in North Carolina.

Rotation studies conducted in field bins or small plots have been reported (1,2,4,5,7,9) in which populations of *H. glycines* were greatly reduced following the growth of nonhost crops. This paper reports results of a rotation experiment initiated in 1960 in Pender County, North Carolina, designed to determine the effects of rotation combined with soil fumigation on *H. glycines* and related soybean yield. A preliminary report has been published (6).

MATERIALS AND METHODS

In 1960, a farm in Pender County, North Carolina, was divided into 24 plots (0.2 ha) with a 6.1-m alley seeded to fescue (*Festuca arundinacea* Schreb cv. Kentucky 31) between plots. Soybean had been grown on the entire farm for several years before these studies, and in 1959 the crop failed completely because of the soybean cyst nematode. Five series of cropping systems involving 12 treatments, replicated twice, were evaluated over 4 years (Table 1). The experimental design was a randomized complete block. Three of the series involved rotations of nonhost corn (*Zea mays* L. cv. Golden Dent) and soybean cv. Lee in which corn was grown for 1, 2, or 3 years. The fourth series was a 1-year rotation of corn–soybean where plots to be planted to corn and soybean were treated in the first year with a split application of 748.2 liters/ha of 1,3-dichloropropene (1,3-D). Two weeks after the first broadcast application of 374.1 liters/ha, the soil was

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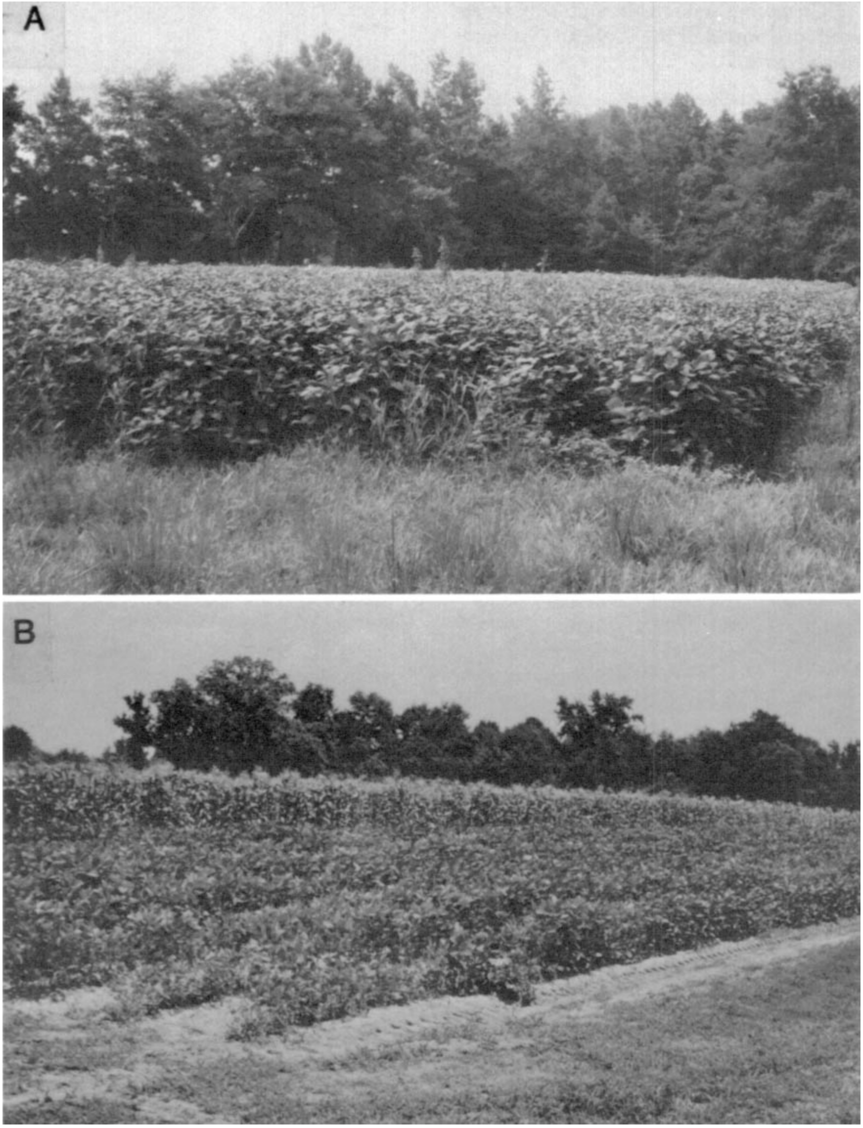

FIG. 1. Soybean growing in plots. A) Following 3 years of corn, a nonhost crop. B) Planted to soybean for 4 years.

turned 23 cm deep with a moldboard plow and a second application of 374.1 liters/ha was applied. The corn and soybeans in all plots were planted 2 weeks after the last application.

The rotations were set up in all possible combinations so that each crop was grown every year to allow measurement of environmental influences. Plots in the fifth series (treatment) served as the control and were planted to soybean all 4 years.

The soybean cultivar, highly susceptible to the soybean cyst nematode, was planted 2 weeks after the second application of 1,3-D, fertilized, and cultivated in a manner consistent with good farming practices. Soil samples to determine nematode population densities were taken in the spring before planting and in the fall after harvest. Soil assays were made by personnel of the Plant Pest and Quarantine Division, USDA, Wilmington, NC. Yields in kilograms per hectare were regressed against $\log_{10}$ Pi for the years 1960–63 as well as yields combined across years. Yields were taken on soybean only.

TABLE 1. Cropping sequences and soil treatments evaluated for control of the soybean cyst nematode, *Heterodera glycines.*

1960	1961	1962	1963
Corn	Soybean	Corn	Soybean
Soybean	Corn	Soybean	Corn
Corn	Corn	Soybean	Corn
Corn	Soybean	Corn	Corn
Soybean	Corn	Corn	Soybean
Corn	Corn	Corn	Soybean
Corn	Corn	Soybean	Corn
Corn	Soybean	Corn	Corn
Soybean	Corn	Corn	Corn
Soybean†	Corn	Soybean	Corn
Corn†	Soybean	Corn	Soybean
Soybean	Soybean	Soybean	Soybean

† These plots were treated in the first year with 1,3-D (748.2 liters/ha) in a split application of 374.1 liters/ha.

RESULTS AND DISCUSSION

Plant growth was better in soybean following 3 years of corn (Fig. 1A) than in soybean following soybean for 3 years (Fig. 1B). Yields are shown in Figure 2. In 1960, average yield from untreated plots planted to soybean was 233 kg/ha compared to 1,482 kg/ha from the fumigated plot. In 1961, average yield of soybean following 1 year of corn was 957 kg/ha compared to 288 kg/ha for continuous soybean. Soybean yield following corn grown in plots treated the previous year with 1,3-D averaged 2,035 kg/ha. In 1962, average yield of soybean following 1 year of corn was 761 kg/ha compared to 991 kg/ha for soybean following 2 years of corn. Yield from plants in plots fumigated in 1960 and planted to soybean in 1960 followed by corn in 1961 and soybean in 1962 was 1,044 kg/ha. Yield in 1962 from continuous soybean was 337 kg/ha. In 1963, yields of soybean following corn were 234 kg/ha after 1 year, 950 kg/ha after 2 years, and 1,259 kg/ha after 3 years. Yield of continuous soybean was 130 kg/ha. Soybean following 1 year of corn, in plots fumigated the first year, produced 156 kg/ha.

The relationship of nematode population density (juveniles) before planting to

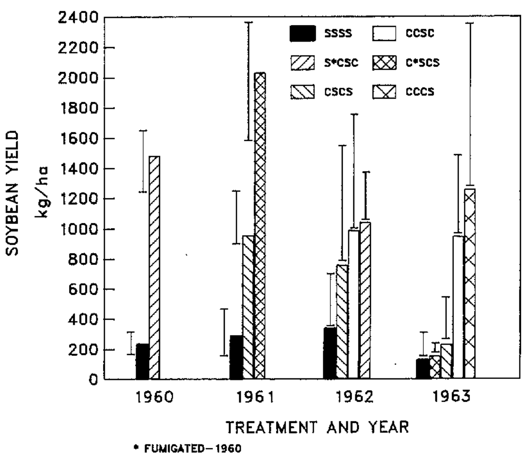

FIG. 2. Yield of soybean over a 4-year period as influenced by previous crop, number of years a nonhost crop preceded the planting of soybean, and effect of initial fumigation of certain plots. Single lines represent the standard deviation per treatment per year.

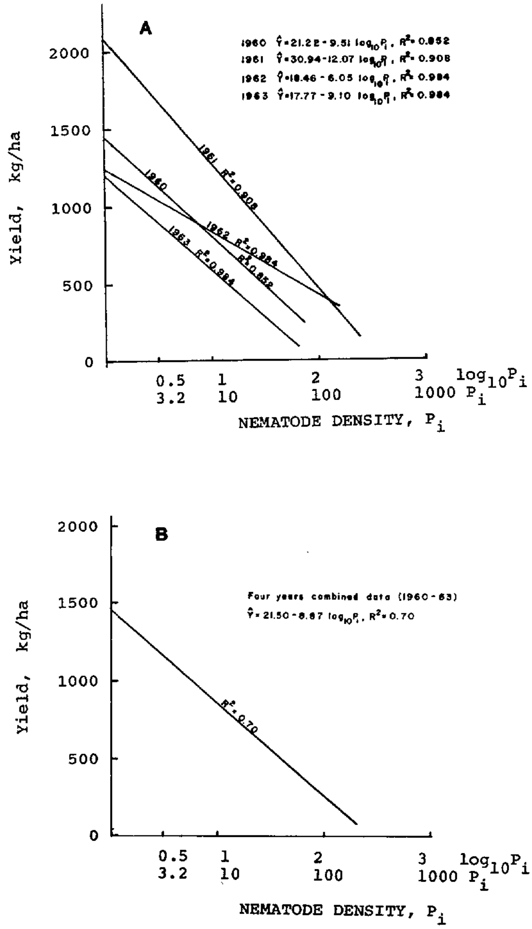

FIG. 3. Relationship of nematode population density before planting to soybean yield. A) For each of 4 years. B) With 4 years combined.

soybean yield for each of the 4 years was negative (Fig. 3A). The regression coefficient (R^2 values) for each year represents the combined data from all treatments in which soybean was grown in that year. Significant (*P = 0.05 and **P = 0.01) negative regressions occurred between initial nematode densities (Pi) in the spring and yield, with R^2 values of 0.85* (1960); 0.91* (1961); 0.98** (1962) and 0.98** (1963). When data from the 4 years were combined, the R^2 was 0.70 (Fig. 3B).

These and other studies (3,8) indicate that using nonhost crops in rotations has great potential for controlling the soybean cyst nematode. The host specificity of *H. glycines* makes it possible to use a large number of economically important nonhost crops between crops of soybean. Such crops include corn, cotton, tobacco, peanut, cowpea, sweetpotato, and many others. These data demonstrate that continuous planting of susceptible soybean cultivars in fields infested with *H. glycines* results in crop failure. The more years of planting nonhost crops between crops of susceptible soybean, the greater the soybean yield increases over planting soybean in the same field every year. A chemical soil treatment to reduce the initial infestation before planting soybean or before planting nonhost crops to be followed by soybean may be economical in some instances; populations of cyst nematodes are reduced and yields are increased, but the cost of the nematicide could be greater than the value of the additional soybeans produced.

Chemical soil treatments before planting resistant soybean cultivars followed by 2 or 3 years of nonhost crops should reduce the nematode population to a level low enough that a susceptible crop could be grown without affecting yield. This cropping pattern, with 2 years of nonhost following soybean, would enable the grower to plant soybean twice in 4 years without experiencing appreciable loss due to the cyst nematode. If 3 years of nonhost followed soybean, the grower could plant soybean twice in 5 years. This practice should also limit the chances of new nematode race development, which would probably occur with more frequent planting of resistant soybean cultivars (8).

Much remains to be learned about the long-range effects of cropping sequences on population dynamics of target nematodes. Potential increase of populations of *Meloidogyne*, *Pratylenchus*, and other nematode species must be considered when selecting nonhost crops for the target species. The economic impact of population increases of nontarget nematode species on salable nonhost crops (corn, cotton, tobacco, and others) could nullify increases in soybean yield resulting from cropping sequences designed to reduce populations of *H. glycines*.

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