Effects of Nitrogen Fertilization on Cylindrocladium Black Rot of Peanuts and Peanut Yield

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ABSTRACT

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The effect of nitrogen fertilization on Cylindrocladium black rot (CBR) of peanuts and peanut yield was examined in *Cylindrocladium crotalariae*-infested fields and in an uninfested field. When CBR was severe, soil applications of 168 kg N/ha (applied as ammonium nitrate granules) reduced incidence of CBR and pod rot caused by *C. crotalariae* compared with treatments of 84 kg N/ha. Soil applications of high rates of ammonium nitrate also decreased yields. Consequently, yield increases that could have resulted from less CBR that occurred in plots treated with high rates of nitrogen were nullified by the effects of these treatments on peanut yield.

Additional key words: *Arachis hypogaea*

Cylindrocladium black rot (CBR) of peanuts (*Arachis hypogaea* L.), caused by *Cylindrocladium crotalariae* (Loos) Bell & Sobers, is a serious peg, pod, and root rot problem in North Carolina and Virginia. A management program that reduces the population of *C. crotalariae* microsclerotia (ms) is needed so that resistant peanuts can be grown economically in infested fields. Production practices that have been recommended to growers with CBR problems include crop rotations, weathering of peanut debris after harvest, tillage of infested soil to minimize "hot spots" of inoculum, nematode control, sanitation of equipment, and use of a recently released moderately CBR-resistant cultivar, NC 8C (13). These practices can reduce CBR incidence but do not eliminate *C. crotalariae* from infested fields.

In a recent report, Hallock (2) indicated that less CBR developed in peanuts to which 225 kg N/ha was sidedressed soon after emergence. Incidence of CBR was also reduced when peanuts were grown in soils with high nitrogen (1) and in an area of a *C. crotalariae*-infested field where anhydrous ammonia was accidentally spilled (E. Byrd, *personal communication*).

Nitrogen fertilization is not a recommended peanut production practice in North Carolina (11). Applications of nitrogen fertilizer to peanuts have produced varied yields (5,6,10–12). This study was initiated to investigate the effects of nitrogen fertilization on CBR incidence and peanut yield.

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MATERIALS AND METHODS

Trials were conducted in fields that were naturally infested with *C. crotalariae* in Bladen County, NC, in 1981 and 1982, in Martin County, NC, in 1981, and in an uninfested field in Bertie County, NC, in 1981. A moderately CBR-resistant Virginia-type peanut cultivar, NC 8C, was planted in all trials to obtain stands of about seven plants per meter of row. Rows were about 0.91 m apart and 6.1 m long. In infested fields, plots were two rows wide. In the uninfested field, plots were four rows wide, but only the middle two rows were measured for yield. In all trials except nitrogen treatments, standard peanut production practices (11) were followed.

All trials included seven treatments arranged in a randomized complete-block design with five to 10 replicates. Treatments were one, two, or three applications of low (84 kg/ha) or high (168 kg/ha) rates of nitrogen and a control to which no nitrogen was applied. Nitrogen, as ammonium nitrate granules, was sidedressed by hand. In 1981, nitrogen applications were made at planting (11, 13, and 14 May for Bertie, Martin, and Bladen counties, respectively) and 5 and 9 wk after planting. In 1982, nitrogen applications were made 3, 6, and 9 wk after planting (18 May). Nitrogen was applied on the first date if one application was made or on the first and second dates if two applications were made.

In the infested fields, 16 soil samples (2 cm in diameter and 16 cm deep) were taken from each plot 1–2 wk after planting. Samples were assayed for ms by an elutriation semiselective medium procedure (8) to estimate inoculum density. Aboveground CBR symptoms were measured as the number of dead and wilted plants per plot from mid-July until late September or early October when peanuts were dug. Incidence of CBR was expressed as a percentage by dividing the number of symptomatic (dead and wilted) plants by the total number of plants per plot and multiplying by 100. In 1981, each plot was visually rated at digging by two individual evaluators for percentage of pod rot and for nodulation on a scale of 0 (no nodules) to 3 (numerous nodules). Pod rot was assumed to be caused by *C. crotalariae*, although only a few isolations of the fungus were made.

In the uninfested field, 10 plants were randomly selected and carefully dug from the outer two rows of each four-row plot 9, 13, and 18 wk after planting. Soil was shaken from roots and nodules per root were counted. Roots and nodules were weighed (fresh and dry).

Data were analyzed for all trials individually because of differences in inoculum density among trials. The six nitrogen treatments were compared by analysis of variance ($P = 0.05$) as a two-by-three factorial treatment design with two levels of nitrogen and three applications. The control treatment was compared with the six nitrogen treatments by Dunnett's procedure for two-sided comparisons between treatment means and a control ($P = 0.05$). For trials conducted in infested fields, incidence of CBR 1 wk before digging was tested as a covariate in analyses of yield. If CBR incidence was a significant covariate, least-square mean yields were determined. Least-square mean yields (adjusted for CBR incidence) were the mean yields of particular treatments as predicted by the covariance regression equation at the overall mean CBR incidence.

RESULTS

Infested field in Martin County, 1981. Estimates of initial ms populations were from 0 to 6.3/g of soil. Applications of the high rate of nitrogen reduced CBR. Incidence of CBR and percentage of pod rot were significantly less for high- than for low-nitrogen treatments (Fig. 1A,B). Mean CBR incidence and pod rot were 14.3 and 20.9% for high-nitrogen treatments and 34.7 and 36.2% for low-nitrogen treatments, respectively. There was no significant main effect of number of applications or an interaction between rate and number of applications. When all treatments were compared with the control treatment, incidence of CBR and percentage of pod rot were significantly less for treatments in which two or three applications of 168 kg N/ha were made (Fig. 1A,B).

Yield was also reduced by high-nitrogen treatments when treatments were adjusted for CBR incidence. When percentage of CBR incidence 1 wk before digging (25 September) was the covariate, mean yield was 2,992 kg/ha for high-nitrogen treatments and 3,786 kg/ha for low-nitrogen treatments (Fig. 1D). Similarly, yields were significantly less from plots that received two or three applications of 168 kg N/ha than from control plots. Unadjusted mean yields were 3,281, 3,496, and 3,220 kg/ha for high-nitrogen, low-nitrogen, and control treatments, respectively (Fig. 1C). The regression equation for the covariance analysis of yield was $Y = B_0 - 39.3X$, where Y = yield (kg/ha), B_0 = the intercept of each treatment (ie, maximum yield in the absence of CBR, ranging from 3,626 kg/ha for two applications of the high rate of nitrogen to 5,053 kg/ha for two applications of the low rate), and X= percentage of CBR incidence on 25 September.

Nodulation ratings were higher (more nodules) for controls than for all nitrogen treatments, and ratings were higher for low- than for high-nitrogen treatments. The number of nitrogen applications also affected nodulation because nodulation ratings were lower with multiple nitrogen applications.

Infested field in Bladen County, 1981. Estimates of initial ms populations were from 0 to 3.1/g of soil. Even though inoculum density was relatively high in some plots, CBR incidence was relatively low. Mean CBR incidence ranged from 1.4 to 8.3 about 1 wk before digging (28 September).

No significant differences occurred in CBR incidence or percentage of pod rot among rate or number of nitrogen applications, although means of CBR incidence and percentage pod rot were higher for low- than for high-nitrogen treatments (Fig. 2 A,B). When the control was compared with all nitrogen treatments, percentage of pod rot was significantly less in plots to which one or three applications of 168 kg N/ha were made (Fig. 2B), and nodulation ratings were higher for controls than for all nitrogen treatments. Mean yields of low- and high-nitrogen treatments were 4,914 and 4,518 kg/ha, respectively (Fig. 2 C) and were different ($P = 0.10$).

Infested field in Bladen County, 1982. Estimates of initial ms populations were lower than 1/g of soil for all plots. High-nitrogen treatments and multiple nitrogen applications reduced CBR. Mean percentage of CBR incidence on 23 September was 8 and 5% for low- and high-nitrogen treatments and 9, 7.3, and 3.4% for one, two, and three applications, respectively (Fig. 3A). On 5 October, mean percentage of CBR incidence was 14.5 and 8.3% for low- and high-nitrogen treatments and 13, 14.1, and 7.3% for one, two, and three applications, respectively (Fig. 3B).

Yields were not significantly different even when percentage of CBR incidence on 5 October was included as a covariate in the analysis. Mean yields were 4,787, 4,583, and 4,675 kg/ha and least-square mean yields (adjusted for percentage of CBR incidence on 5 October) were 4,905, 4,696, and 4,522 kg/ha for control, low-nitrogen, and high-nitrogen treatments, respectively (Fig. 3C,D). The regression

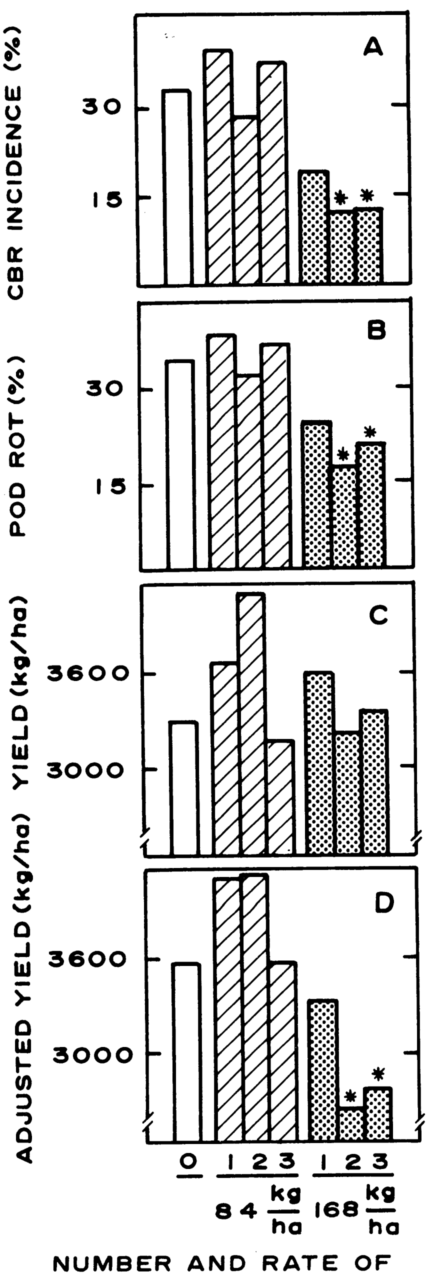

Fig. 1. Results of a field trial in Martin County, NC, in 1981 that included a control treatment and nitrogen fertilization treatments in which one, two, or three applications of 84 kg/ha (as ammonium nitrate) or 168 kg/ha were made. **(A)** Mean percentage of CBR incidence on 25 September, **(B)** mean percentage of pod rot, **(C)** mean peanut yield, and **(D)** least-square mean yield (adjusted for percentage of CBR incidence on 25 September). * = Nitrogen treatments that were different from the control on the basis of Dunnett's two-sided comparison procedure ($P = 0.05$).

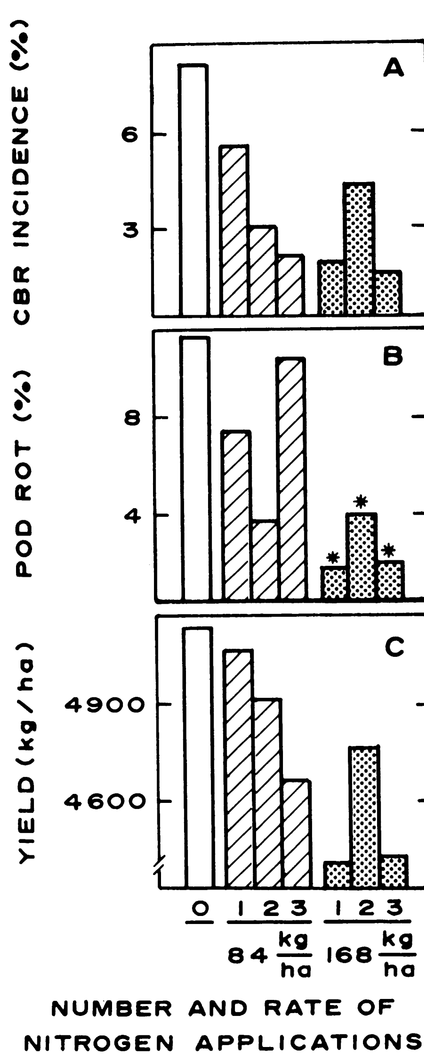

Fig. 2. Results of a field trial in Bladen County, NC, in 1981 that included a control treatment and nitrogen fertilization treatments in which one, two, or three applications of 84 kg/ha (as ammonium nitrate) or 168 kg/ha were made. **(A)** Mean percentage of CBR incidence on 28 September, **(B)** mean percentage of pod rot, and **(C)** mean peanut yield. * = Nitrogen treatments that were different from the control on the basis of Dunnett's two-sided comparison procedure ($P = 0.05$).

equation for the covariance analysis was: $Y = B_0 - 43.1X$, where Y = yield (kg/ha), B_0 = the intercept of each treatment (ranging from 4,209 kg/ha for one application of high nitrogen to 5,416 kg/ha for the control), and X = percentage of CBR incidence on 5 October.

Uninfested field in Bertie County, 1981. Nitrogen treatments affected peanut nodulation. At all three sampling dates, the number of nodules per plant was significantly greater for control plots than for low- or high-nitrogen plots and for low-nitrogen plots than for high-nitrogen plots (Fig. 4A). Yield was significantly different between low- and high-nitrogen treatments. Mean yields of control, low-nitrogen, and high-nitrogen plots were 4,157, 4,201, and 3,808 kg/ha, respectively (Fig. 4B).

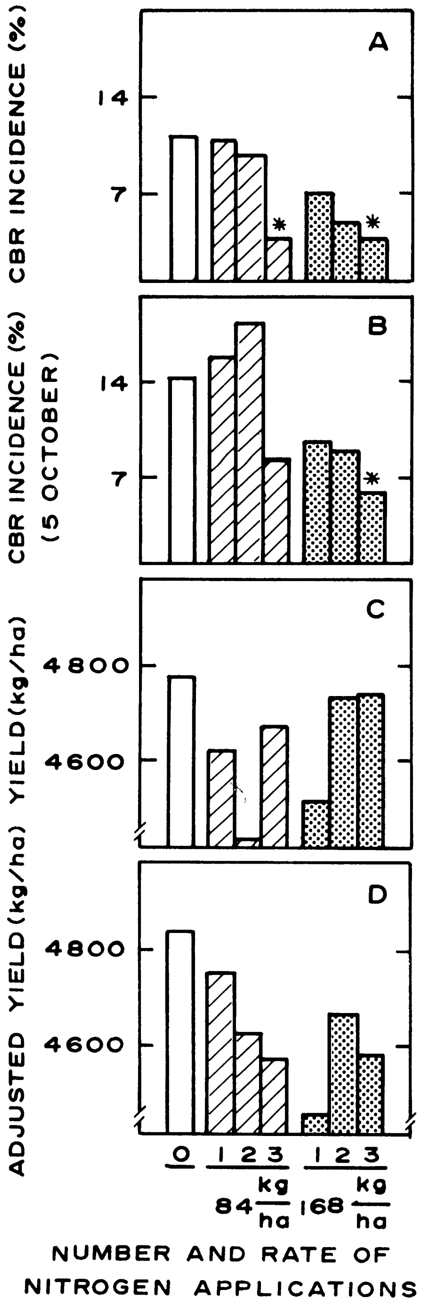

Fig. 3. Results of a field trial in Bladen County, NC, in 1982 that included a control treatment and nitrogen fertilization treatments in which one, two, or three applications of 84 kg/ha (as ammonium nitrate) or 168 kg/ha were made. **(A)** Mean percentage of CBR incidence on 23 September, **(B)** mean percentage of CBR incidence on 5 October, **(C)** mean peanut yield, and **(D)** least-square mean yield (adjusted for percentage of CBR incidence on 5 October). * = Nitrogen treatments that were different from the control on the basis of Dunnett's two-sided comparison procedure ($P = 0.05$).

DISCUSSION

Nitrogen fertilization decreased CBR when the disease was severe. In the two infested trials for which mean CBR incidence was greater than 8%, incidence of CBR was lower in plots that received the high rate of nitrogen than in plots to which the low rate was applied. Percentage of pod rot was also reduced in 1981 trials in plots to which the high rate was applied. These results were similar to those of Hallock (2). Nonetheless, soil applications of high rates of ammonium nitrate did not appear to be an agronomically acceptable CBR management tactic because yield was also reduced by high-nitrogen applications. Consequently, yield increases that could have resulted from less CBR that occurred in plots treated with high rates of nitrogen were nullified by the effects these treatments had on peanut yield.

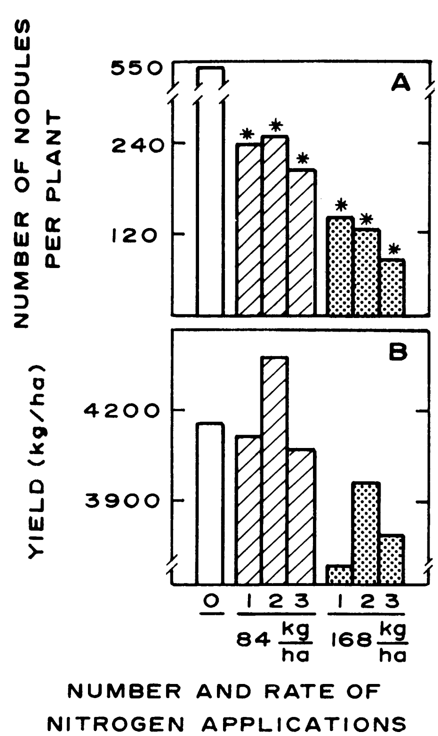

Fig. 4. Results of an uninfested field trial in Bertie County, NC, in 1981 that included a control treatment and nitrogen fertilization treatments in which one, two, or three applications of 84 kg/ha (as ammonium nitrate) or 168 kg/ha were made. **(A)** Number of nodules per peanut plant at 18 wk and **(B)** peanut yield. * = Nitrogen treatments that were different from the control on the basis of Dunnett's two-sided comparison procedures ($P = 0.05$).

Yield reductions resulting from nitrogen fertilization have been reported previously (5,6,10). Reddy et al (10) suggested that reduced nitrogen fixation may be the cause of lower yields. In our study, profuse flowering, many new pegs, and many immature pods were observed at harvest in plots fertilized with high rates of nitrogen. Apparently, flowering was delayed in those plots. Timing of nitrogen applications to avoid delayed flowering, applications of nitrogen in forms other than ammonium nitrate, and other methods of nitrogen application are alternatives that could be tested to determine if nitrogen can decrease CBR without an accompanying decrease in yield. Management of nitrogen residues from previous crops should also be evaluated.

A better understanding of the mechanisms by which nitrogen reduces CBR incidence and pod rot caused by *C. crotalariae* may aid in developing acceptable CBR management practices. Reduced nodulation was apparently one mechanism by which nitrogen fertilization decreased CBR. Harris and Beute (3) noted that peanut nodules were more susceptible to *C. crotalariae* infection than were nonnodulated tissues. In our study and that of Reddy and Tanner (9), nodulation was decreased by all nitrogen applications. Consequently, nitrogen fertilization apparently decreased CBR by lowering the number of highly susceptible infection sites for *C. crotalariae*, and therefore, plants with reduced numbers of nodules were less susceptible than plants with a normal number of nodules. Percentage of pod rot was also decreased by nitrogen fertilization in our study. Because pods are nonnodulated tissue, nodulation was not the only way in which nitrogen affected CBR. Control of several diseases through nitrogen management has been associated with soil microfloral interactions (4). Further investigations have been conducted concerning the role of soil microorganisms in relation to nitrogen and CBR (1).

Analyses in which percentage of CBR incidence was a covariate provide further information concerning CBR-yield relationships. Regressions from the covariance analyses in this study were similar to a critical-point yield loss model developed for CBR from other data (7). In the critical-point model, yield of NC 8C was reduced by about 7.5% for each 10% CBR incidence 1 wk before digging. In this study, yield was reduced by about 7.9% for each 10% CBR incidence 1 wk before digging when the best estimates of maximum yield were considered to be the intercepts of treatments for which yields were highest.

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