Effects of Light Intensity and Quality on Reproduction of Plant Parasitic Nematodes[1]

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Abstract: Growing cotton in a greenhouse with 12-h of supplemental light [8,608 lux (800 ft-c) from combination of mercury and Lucalux® lamps] resulted in 2 × to > 3 × greater reproduction of *Meloidogyne incognita* and *Belonolaimus longicaudatus* as compared to natural light alone. Rate of increase of *Hoplolaimus galeatus* was affected little in this experiment. In a second experiment under controlled conditions in a phytotron, light source and intensity had greater influence on the reproduction of *Heterodera glycines* and *Pratylenchus penetrans* on soybean than on *B. longicaudatus*. Fluorescent plus incandescent and metal halide light sources resulted in the greatest nematode reproduction. Lucalux lamps resulted in much lower rates of nematode increase than other light sources. Rates of nematode increase on soybean under the different light sources in the phytotron generally were positively related to plant growth. *Key words: Gossypium hirsutum, Glycine max.*

Exposure to light may be detrimental to nematodes (13). Indirect effects of various light sources on nematode activity on plants however, have received only limited attention (5, 6, 7, 11, 12). Wallace (13) suggested that light probably has little influence on nematodes in soil except through indirect effects on the host plant. Several investigators have found that photoperiod influences nematode reproduction (5, 7, 11, 12). Ellenby (5) obtained much greater larval emergence and development of *Heterodera rostochiensis* Wollenweber on certain potato cultivars grown under long days than under short days. This response was not consistent on all cultivars tested, however. Patterson and Bergeson (11) showed that *Pratylenchus penetrans* (Cobb) Filipj. & Schuurm.-Stekh. reproduces at greater rates under 8- and 12-h photoperiods on peppermint than with 20-h days. Gillard and van den Brande (6) found that the source of light had a major effect on the development of *Meloidogyne arenaria* (Neal) Chitwood on tomato. Greatest numbers of nematode galls occurred under lights with the highest intensity in the red range of the spectrum.

The purpose of our investigations was to determine the influence of supplemental, as well as different types of, lighting systems on the reproduction of selected species of nematodes. Knowing the effects of supplemental light on nematode activity is important, since light intensity varies greatly in greenhouses with geographic area and time of the year. Light sources and intensities also vary in growth chambers.

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MATERIALS AND METHODS

Treatments in the greenhouse experiment included two inoculum levels (5,000 and 10,000 specimens per 15-cm pot) of three nematode species, *Hoplolaimus galeatus* Cobb, *Meloidogyne incognita* (Kofoid & White) Chitwood and *Belonolaimus longicaudatus* Rau on cotton, *Gossypium hirsutum* L., 'Rowden', under two light sources, Two populations of *B. longicaudatus* were used, one from North Carolina and one from Georgia. Eggs of *M. incognita* were used as inoculum in lieu of larvae (8). The two light regimes were: (i) natural light in greenhouse; and (ii) natural light plus 12-h supplemental light of 8608 lux (800 ft-c) from GE mercury and Lucalux® lamps. Single cotton plants were grown in 15-cm pots filled with a 1:1 mixture of a sandy loam soil and 0.67-mm (35-mesh) sand, previously fumigated with methyl bromide. Each treatment was replicated three times. All plants received half-strength Hoagland's nutrient solution. The experiment was terminated 63 days after inoculation of established seedlings.

A second experiment conducted in a phytotron (Southeastern Plant Environmental Laboratories) involved three species of nematodes (*B. longicaudatus*, *Heterodera glycines* Ichinohe, and *P. penetrans*) on soybean *Glycine max* (L.) Merr. and five light sources including two intensities of Lucalux lamps, "color-improved" metal halide lamps alone, metal halide plus incandescent lamps, and fluorescent lamps plus incandescent lamps. Spectra of these light sources have been described (3), but the major characteristics of each light are given in Fig. 1. Night temperatures were approximately 20 C, with day temperature being 24-26 C except for the low intensity Lucalux which was 22 C. Three-day-old 'Lee seedlings were transplanted to 15-cm diam clay pots filled with a 1:1 mixture of 0.17- and 0.67-mm (65- and 35-mesh) sand. Inoculum levels were: *B. longicaudatus - 3,000; P. penetrans* - 5,000; and *H. glycines* - 18,000 (eggs) per 15-cm pot. A commercial preparation of *Rhizobium japonicum* Kirch. was added at the rate of 200 mg per pot. Each treatment was replicated eight times in this experiment. Half-strength Hoagland's nutrient solution was provided as needed. No nitrogen was provided after 3 wk. The experiment was terminated 50 days after inoculation.

Upon termination of each experiment, fresh shoot and root weights of plants were determined. Final nematode numbers were assayed by sugar-flotation-sieving (2) unless otherwise indicated. Soil from a given 15-cm pot was mixed by running it through a sample-splitter three times, and a 100 or 200-g aliquant was weighed for nematode extraction. Cysts of *H. glycines* were extracted by centrifugal-flotation with a solution containing 908 g sucrose per liter. Roots of plants inoculated with *H. galeatus* or *P. penetrans* were incubated in a Seinhorst mist chamber for 14 days, and nematodes were collected and counted every 4-7 days.

Separate statistical analyses was performed for each parameter. Data of the first experiment were analyzed by Duncan's new multiple range test.

RESULTS

Effects of supplemental light on nematode reproduction on cotton varied with nematode species under greenhouse conditions (Table 1). Providing supplemental light with Lucalux and mercury lamps resulted in much greater reproduction of *B. longicaudatus* compared to only natural light (Table 1). Final larval populations of *M. incognita* were also greater on cotton plants which received supplemental light. However, the rate of increase of *H. galeatus* was affected little by supplemental light.

Plant growth, as measured by top and root weights, was also much greater where supplemental light was provided. Inoculation with *H. galeatus* tended to stimulate top growth in both light treatments. This response may have been due to the presence of unidentified mycorrhizal fungi in the nematode inoculum.

In the phytotron, fluorescent plus incandescent and the metal halide light sources resulted in greatest nematode reproduction (Fig. 1). Although all light sources resulted in similar rates of increase for *B. longicaudatus*, the low-intensity Lucalux lamps and the "color-improved" metal halide plus incandescent lamps supported lower populations than the other

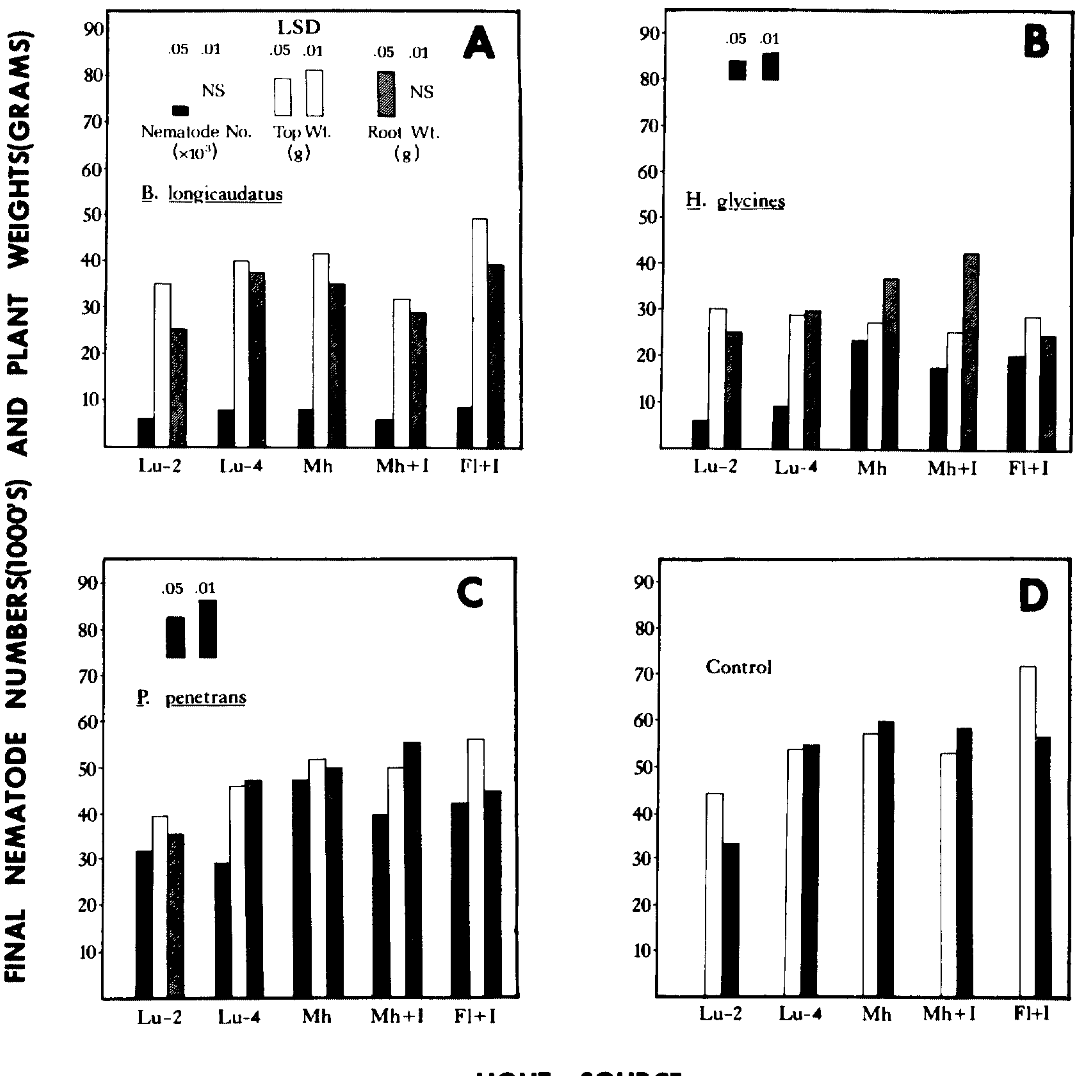

FIG. 1-(A to D). Influence of light source and intensity of reproduction of nematodes and growth of soybean in growth chambers (phytotron): **A**) *Belonolaimus longicaudatus*; **B**) *Heterodera glycines*; **C**) *Pratylenchus penetrans*; and **D**) Noninoculated controls. (Nematode numbers in 1,000's). Total output for lights were: Lu-2 (two Lucalux lamps) = 175 w/m^2 (3,350 ft-c); Lu-4 (four Lucalux lamps) = 340 w/m^2 (6,350 ft-c); Mh (five metal halide lamps) = 185 w/m^2 (4,400 ft-c); Mh + I (five metal halide lamps + four incandescent flood lamps) = 250 w/m^2 (4,650 ft-c); and Fl + I (84 fluorescent lamps + 48 100-w incandescent bulbs) = 260 w/m^2 (4,800 ft-c). LSD values may be used for comparing treatment means for given nematode species; interaction LSD values (top or root weights × nematode species and control) may be used for comparisons in either direction.

light sources. In a preliminary greenhouse test with soybean, a supplemental metal halide light (clear GE multivapor®) regime depressed the reproduction of the three nematode species used in this experiment even though it enhanced root growth. *Heterodera glycines* also developed poorly on soybean growing under the low intensity as well as the high intensity light regimes with Lucalux lamps. Results similar to those for *H. glycines* were obtained with *P. penetrans.*

Plant growth under the different light regimes in the phytotron generally correspond to nematode increase. The

TABLE 1. Effects of supplemental light on reproduction of *Heterodera galeatus*, *Meloidogyne incognita*, and *Belonolaimus longicaudatus* on cotton.

Treatment	P_f per pot (in 1000's)[w]	Plant weights[x] (g) Top	Roots
No supplemental light:[y]			
Noninoculated control	. . .	13.1 c	14.6 b
H. galeatus	11.1	18.4 b	14.9 b
M. incognita	7.3	8.7 cd	11.8 bc
B. longicaudatus:			
N. C. population	3.7	8.5 cd	8.9 c
Georgia population	6.6	7.6 d	7.5 c
Supplemental light:[z]			
Noninoculated control	. . .	22.6 b	26.4 a
H. galeatus	12.3 NS	32.8 a	24.9 a
M. incognita	12.2 **	21.3 b	27.8 a
B. longicaudatus:			
N. C. population	13.2 **	17.9 b	16.3 b
Georgia population	12.3 **	12.7 cd	13.8 b

[v]Data are means of three replicates for each of three or four subtreatments involving initial inocula of 5,000 and 10,000 nematodes per species (eggs used as inoculum for *M. incognita*).

[w]Final nematode numbers (P_f) in treatment with ** are significantly different at 1% level for supplemental, vs. no supplemental, light.

[x]Duncan's new multiple range test used for comparing plant weights. Treatment means with the same letter(s) are not significantly different from each other, $P = 0.05$.

[y]Normal greenhouse conditions.

[z]Supplemental light − 12 h under GE Lucalux and mercury lamps, giving 8,608 lux (800 ft-c) at plant height.

fluorescent-plus-incandescent light source gave the greatest growth in the control plants as well as in plants inoculated with *P. penetrans* and *B. longicaudatus*. However, with *H. glycines*, plant growth was very similar in all treatments as measured by top weights. The metal halide, and the metal halide plus incandescent light sources resulted in somewhat greater root development in plants inoculated with this nematode. The high intensity Lucalux light resulted in poor reproduction of *H. glycines* and *P. penetrans*, even though it supported root growth that was generally comparable to that with other light regimes. Plants grown under the low- and high-intensity Lucalux lights also had elongated stems.

DISCUSSION

Although other investigators (4, 11), have found that treatments resulting in poor plant growth tended to stimulate reproduction of certain nematodes, light sources that provide greater growth usually resulted in greater nematode populations in our experiments. Discrepancies probably are caused by differential effects of the light sources on kinds and amounts of nutrients available. In the preliminary greenhouse experiment with soybean, the depressive effect of the metal halide lamps on nematode reproduction apparently was indirect due to altered host growth. The metal halide "color improved" lamps used in the phytotron, however, were very satisfactory. Far-red light (Lucalux lamps) often results in excessive stem elongation and suppresses nodulation in leguminous plants (9). Such responses may be due to altered distribution of carbohydrates to the shoot and the roots which also may be responsible for the lower rates of nematode increase. Attraction of nematodes to roots also could be altered by light since Henderson and Katznelson (7) observed that the population distribution patterns of nematodes such as *Pratylenchus* in the rhizosphere of wheat or soybean under high light intensities were not maintained under low light intensities. Since certain wavelengths stimulate secretion of root diffusates (1), the type of light provided may alter the attractiveness of host roots of nematodes. Moussa et al. (10), however, failed to obtain a consistent relationship between the type of lights and attraction of *H. rostochiensis* to tomato seedlings.

Although light may have little direct effect on nematodes in soil as Wallace (13) suggested, light quantity and quality have immense effects on plant growth which in turn alter rates of nematode reproduction. Light intensity as well as light quality should be considered when experiments with nematodes are conducted in greenhouses or in growth chambers. In limited comparisons, we have found that supplemental lights such as the Lucalux and the mercury lamps in the greenhouse in summer may have little effect on nematodes such as *B. longicaudatus*, whereas in winter and spring with the low-light intensities and short days, supplemental light may have a striking effect on nematode reproduction.

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