Note brève

SYNERGISTIC REDUCTION IN ROOT GALLING BY *MELOIDOGYNE JAVANICA* WITH *PASTEURIA PENETRANS* AND NEMATICIDES[1]

Stephen M. Brown* and Dieter Nordmeyer**

Pasteuria penetrans (Thorne, 1940) Sayre & Starr, 1985 has been shown to be a widespread parasite (Sayre, 1980), and under natural conditions tends to be in equilibrium with its nematode hosts (Swellengrebel, 1940). However, in agroecosystems the addition of the bacterium to the field can reduce galling of plant roots caused by root-knot nematodes (Stirling, 1984) and increase crop yield (Brown, Kepner & Smart, 1985). Brown, Kepner and Smart (1985) suggested a combination of organisms as a possibility for sustainable, long-term control of root-knot nematodes. Another alternative may be to combine organisms with nematicides. Roy (1982) demonstrated synergistic suppression of the galling of tomato roots by *Meloidogyne incognita* (Kofoid & White) Chitwood with the nematophagus endoparasitic fungus, *Catenaria anguillulae*, and the nematicide, ethoprop. Because the spores of *P. penetrans* are not affected by nematicides (Prasad, 1971; Stirling, 1984), a combination of this organism and a nematicide may provide effective multiple stresses on a nematode population. Our objective was to test for a synergistic reduction in galling of roots by *M. javanica* (Treub) Chiwood with *P. penetrans* and the carbamate nematicides carbofuran or aldicarb.

The effect on the penetration by second-stage juveniles of *M. javanica* into tomato roots (*Lycopersicon esculentum* Miller " Rutgers ") in the presence of *P. penetrans* and nematicides was investigated using a modified penetration inhibition test (Bunt, 1975). The six treatments were arranged in a completely randomized design with each treatment replicated ten times : (1) nematodes alone, (2) nematodes + bacteria, (3) nematodes + carbofuran, (4) nematodes + aldicarb, (5) nematodes + bacteria + carbofuran, and (6) nematodes + bacteria + aldicarb.

Thirty cubic centimeters of quartz sand and 50 mg of inoculum (Stirling & Wachtel, 1980) of *P. penetrans* were added to 30-ml plastic cups in treatments 2, 5 and 6. We had determined in previous tests that this amount of inoculum reduced galling by approximately 50 percent. The same amount of dried, ground tomato roots without *P. penetrans* was added to the cups of the remaining treatments. Five milliliters of water were added to each cup, and they were incubated for two days at 28°(Brown & Smart, 1984). Carbofuran (Treatments 3 and 5) and aldicarb (Treatments 4 and 6) were added as technical material to the cups to give final concentrations of 1.5 and 0.25 ppm, respectively. We had determined in previous tests that these concentrations reduced galling by approximately 50 percent. Six hours later 125 juveniles in 0.5 ml water were injected into the cups. After 24 hours at 28°, one tomato seedling was planted in each cup. The cups were placed randomly on an incubator shelf at 28° with a cycle of 13 hours of light (260 lux) and 11 hours of dark. After ten days galls on roots were counted, and the *a priori* contrasts of treatment effects :

$$[H_1 : C = E_{total} - (E_{nematicide} + E_{bacterium}) > 0]$$

were tested by normal approximation (Mendenhall, Schaeffer & Wacherly, 1981). The effects (E) are defined as the difference in proportions of galled plants in the treatment with nematodes alone (Treatment 1) and that of the treatment of interest. For example, $E_{total} = P_1 - P_5$, or $P_1 - P_6$, $E_{nematicide} = P_1 - P_3$ or $P_1 - P_4$, and $E_{bacterium} = P_1 - P_2$, where P_i is the true (unknown) proportion of galled plants that could result from the ith treatment (i = 1, 2, ..., 6). For aldicarb the contrast, $C = E_{total} - (E_{nematicide} + E_{bacterium})$ is estimated by $\hat{C} = \hat{E}_{total} - (\hat{E}_{nematicide} + \hat{E}_{bacterium}) = (\hat{P}_1 - \hat{P}_6) - [(\hat{P}_1 - \hat{P}_4) + (\hat{P}_1 - \hat{P}_2)] = (0.9) - [(0.3) + (0.2)] = 0.4$.

The combined effect of *P. penetrans* and carbofuran or aldicarb exceeded the sum of the effect of the bacterium and the effect of each nematicide alone ($p = 0.03$ for each nematicide, Table 1).

Our results confirm the absence of detrimental effects on *P. penetrans* by carbofuran and aldicarb at the concentrations used (Prasad, 1971; Stirling, 1984) and demonstrate a synergistic reduction of root galling by *M. javanica* with these nematicides and the bacterium. An explanation for this synergism has not been studied, but

* *Division of Nematology, University of California, Davis, CA 95616, U.S.A.*
** *Departement of Entomology and Nematology, University of Florida, Gainesville, FL 32611. Present address : CIBA-GEIGY AG, Division Agro, AG 2.82 Forschung und Entwicklung, 4002 Basel, Schweiz.*
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Table 1

Proportions of tomato plants galled by *Meloidogyne javanica*

Treatment	*Proportions of galled plants**
1. Nematodes alone	(1.0)
2. Nematodes + Bacteria	(0.8)
3. Nematodes + Carbofuran	(0.7)
4. Nematodes + Aldicarb	(0.7)
5. Nematodes + Bacteria + Carbofuran	(0.1)
6. Nematodes + Bacteria + Aldicarb	(0.1)

*Ten replicate plants.

one possibility is increased spore attachment by *P. penetrans* in the presence of nematicides. At low concentrations, carbamate nematicides affect the movement and orientation of nematodes toward host roots rather than kill the nematodes (Wright, 1981). In our experiments the nematicides might have increased movement of nematodes in soil and the probability of nematode contact with bacterial spores. Further experiments should be conducted under field conditions to confirm these results.

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