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Insecticide-Induced Resurgence of the Brown Planthopper, *Nilaparvata lugens*,[1] on Rice Varieties with Different Levels of Resistance[2]

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Abstract

Three rice varieties, IR29, IR40, and IR42, which are, respectively, susceptible, moderately resistant, and resistant to *Nilaparvata lugens* Stål in the Philippines, were treated in the field with decamethrin, an insecticide known to cause resurgence. *N. lugens* populations increased to a significantly higher level in the treated plots than in untreated checks, but the degree of resurgence varied among varieties. The maximum population increases in the treated plots compared with the checks were ca. 74-, 50-, and 5-fold, respectively, for IR29, IR40, and IR42. Decamethrin was toxic to predators, and this reduction of natural enemies of *N. lugens* may have contributed to the pest resurgence. However, the differences between populations of *N. lugens* in treated and nontreated plots within varieties were larger than differences in predator numbers, suggesting that other factors were also involved.

Nilaparavata lugens (Stål), formerly considered to be a minor pest in the tropics, has caused extensive damage to rice in many countries in South and Southeast Asia during the last decade (Dyck and Thomas 1979). Changing agricultural practices designed to increase rice production, such as the introduction of improved, high-yielding varieties, increased use of nitrogenous fertilizer, expansion of irrigation, and the growth of multiple, consecutive rice crops may have caused this pest to become more serious (Dyck et al. 1979, Mochida and Dyck 1977). Severe outbreaks of *N. lugens* have also been observed in fields treated with certain insecticides (Anonymous 1977–1979). Although the causal mechanisms involved have not been definitely established, resurgence has been attributed to the destruction of natural enemies (Chiu 1979, Kenmore 1980), and a direct stimulation of reproduction in *N. lugens* females receiving sublethal dosages of insecticide (Chelliah et al. 1980).

Most of these severe outbreaks of *N. lugens* have occurred on susceptible varieties of rice. Currently, this pest is controlled in many countries in tropical Asia by planting resistant varieties. *N. lugens* usually feeds less on these varieties, nymphal mortality is high, and surviving nymphs grow and develop more slowly than those reared on susceptible varieties (Paguia et al. 1980, Sogawa and Pathak 1970). Even though *N. lugens* populations do not usually build up to damaging levels on resistant varieties in the field, small numbers of the pest occur throughout crop growth (Cheng 1977). Because farmers often apply insecticides to *N. lugens*-resistant varieties for the control of other pests, it is possible that numbers of *N. lugens* occurring on these varieties could be increased by applications of some insecticides. This study compared the response of *N. lugens* populations in the field on varieties with different levels of resistance treated with a resurgence-promoting insecticide.

Materials and Methods

The test was conducted on the International Rice Research Institute (IRRI) experiment farm in Los Baños, Laguna, Philippines. Three rice varieties with different levels of resistance to *N. lugens* (Anonymous 1977–1979) were planted in the field: IR29, which is susceptible to the *N. lugens* biotype 2 occurring in the IRRI fields; and IR40 and IR42, which are moderately resistant and resistant, respectively. These improved, dwarf rice varieties all mature in 115 to 130 days and have a similar yield potential. All varieties were transplanted 21 days after seeding at a spacing of 25 by 25 cm during the dry season on 25 April 1980. Fertilizer was incorporated into the soil just before transplanting (19 kg of N + 14 kg of P + 14 kg of K/ha). Additional nitrogen was broadcast 25 to 30 days after transplanting (DT) and at panicle initiation (26 kg/ha). Treatments were arranged in a split-plot design. Each main plot contained two subplots (5 by 9 m): one subplot was treated with the synthetic pyrethroid decamethrin, which is known to cause resurgence of *N. lugens* (Anonymous 1978, Chelliah and Heinrichs 1980), and the other subplot received no insecticide. Decamethrin (30 g of AI/ha) was applied to the treated plots with a knapsack sprayer calibrated to deliver 500 liters of water per ha at 20, 35, and 50 DT. Treatments were replicated four times. Plots were separated by levees and irrigated separately.

Ten randomly selected hills were sampled in the center of each plot with a FARMCOP suction device (Cariño et al. 1979) 1 day before and 3 days after each insecticide treatment. A final sample was taken at 60 DT. The following species were counted in each sample: *N. lugens* adults and nymphs; the predators, *Microvelia atrolineata* (Bergoth), and *Cyrtorhinus lividipennis* Reuter; and the predaceous spiders *Lycosa pseudoannulata* Boes et Str., *Tetragnatha* sp., *Araneus* sp., and *Callitrichia formosana* Oi. These selected predaceous spiders were sampled because they are the most common in Asian rice fields and are considered to be the most important in regulating *N. lugens* populations. The percentage of "hopperburned" hills in each plot was recorded when maximum damage occurred at 62 DT. Numbers of each species and average number of prey per predator (number of *N. lugens* adults and nymphs per number of predators) and percent hopperburn were subjected to an analysis of variance, and means were separated with a Duncan's multiple range test ($P < 0.05$).

Results

N. lugens numbers in the untreated check plots were significantly highest in IR29 , followed by IR40 and IR42, respectively (Fig. 1). These population differences reflected the amount of resistance of the different varieties to the pest. *N. lugens* populations were significantly greater in the insecticide-treated subplots than the check plots within each variety later in the season from 49 to 60 DT. The maximum populations in the treated plots compared with the checks within varieties were ca 74-, 50-, and 5-fold, respectively, for IR29, IR40, and IR4Z (Fig. 1). Neither the treated nor the untreated plots of IR40 and IR42 were hopperburned. Only 3% of the untreated IR29 plants were hopperburned, but 51% of the insecticide-treated IR29 plants were killed.

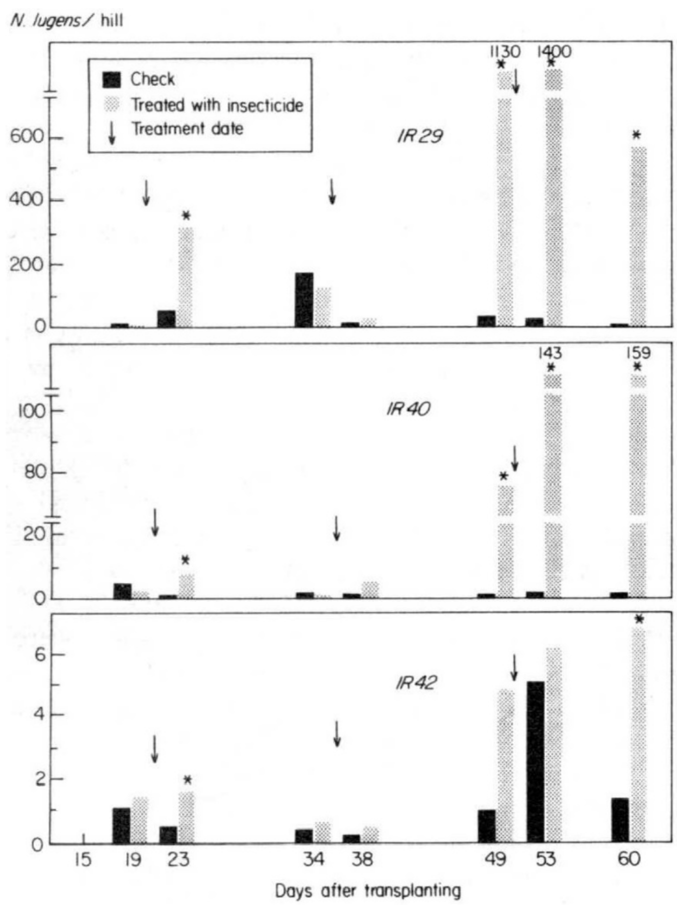

Figure 1. *N. lugens* populations in decamethrin-treated and untreated field plots of a susceptible (IR29), a moderately resistant (IR40), and a resistant (IR42)rice variety. Asterisks indicate populations significantly greater than the untreated check at the 5% level.

Decamethrin was toxic to all predator species, particularly spiders. Predator populations within all varieties were lower in insecticide-treated plots than in the checks, although the differences were not always statistically significant (Figs. 2, 3, and 4). Spider populations in treated plots failed to recover from the insecticide treatments within the 15-day interval between sprays and remained low during the last sample taken 10 days after the last insecticide application at 60 DT. In contrast, the populations of *C. lividipennis* in IR29 and IR40 were significantly larger in treated plots than the checks at this time, indicating that this species was able to recover more rapidly than spiders after insecticide applications and responded to the increasing populations of *N. lugens*.

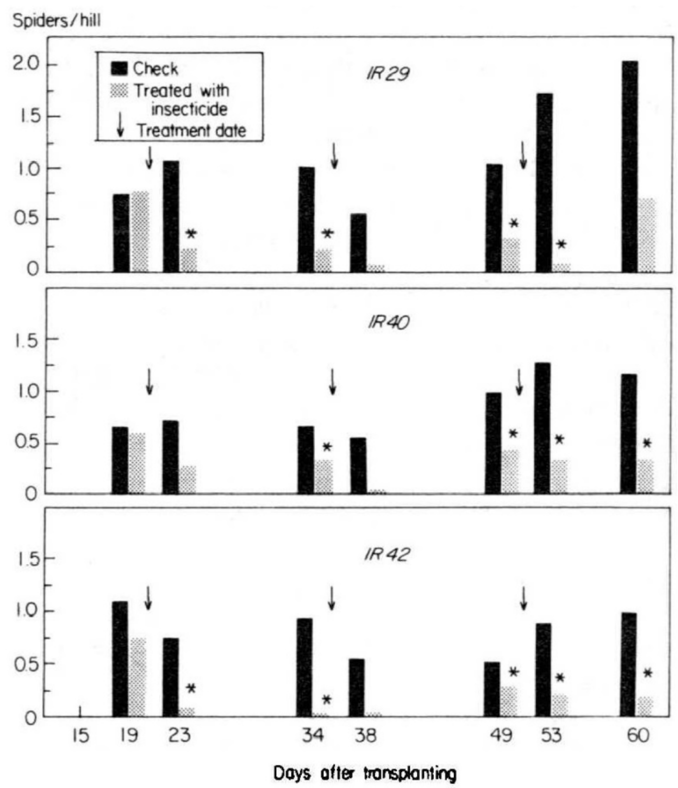

Figure 2. Spider populations in decamethrin-treated and untreated field plots of a susceptible(IR29), a moderately resistant (IR40), and a resistant (IR42) rice variety. Asterisks indicate populations significantly lower than the untreated check at the 5% level.

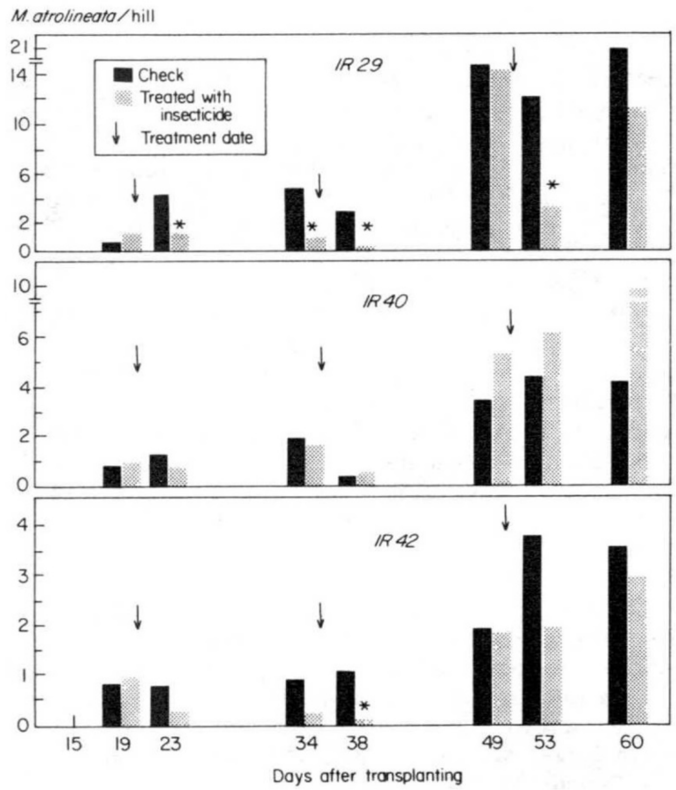

Figure 3. *M. atrolineata* populations in decamethrin-treated and untreated field plots of a susceptible (IR29), a moderately resistant (IR40), and a resistant (IR42) rice variety. Asterisks indicate populations significantlylower than the untreated check at the 5% level.

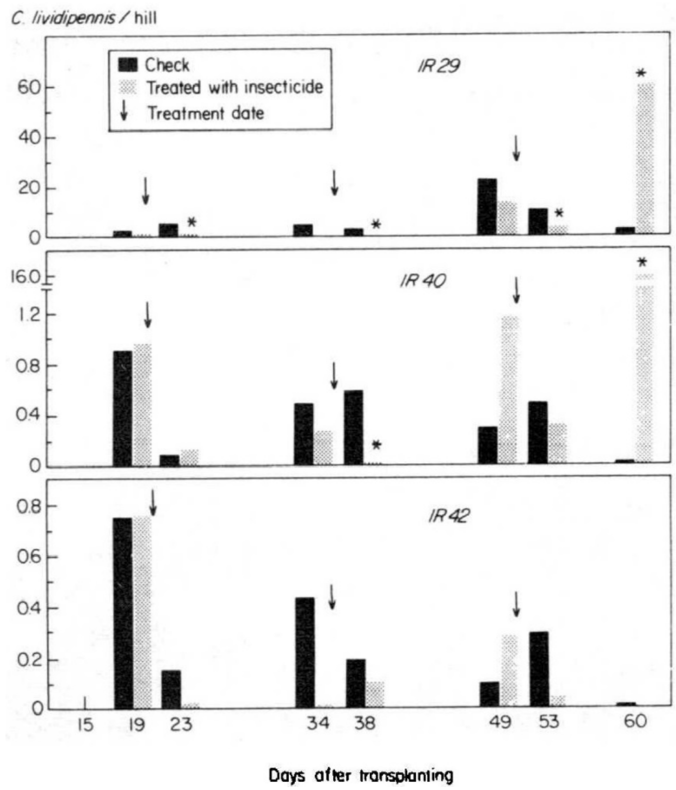

Figure 4. *C. lividipennis* populations in decamethrin-treated and untreated field plots of a susceptible (IR29), a moderately resistant (IR40), and a resistant (IR42) rice variety. Asterisks indicate populations significantlydifferent from the untreated check at the 5% level.

Predator numbers differed among the three rice varieties, being generally highest in the susceptible IR29, but these differences were not as striking as those occurring among *N. lugens* populations. At all sampling dates except the first, *C. lividipennis* were statistically more abundant in IR29 than in the resistant varieties. *M. atrolineata* were also generally most numerous in plots of IR29, although the differences among populations in the varieties were usually not statistically significant. In contrast to the other predaceous species, spider numbers were relatively similar in different varieties throughout the season.

The prey/predator ratios in the untreated check plots were also different among the three varieties. The average numbers of *N. lugens* per predator were usually largest in IR29, followed, respectively, by IR40 and IR42, indicating a more favorable ratio for biocontrol of *N. lugens* as level of resistance increased. Differences between the average number of prey per predator in treated and untreated plots within each variety increased immediately after decamethrin treatment, indicating that the insecticide was more toxic to predators than to *N. lugens*. These differences between treated and check plots in the relative abundance of *N. lugens* compared with *M. atrolineata* and spiders were largest in the samples taken 49 to 60 DT. At 53 DT, the *N. lugens*/spider ratio reached ca. 18,000, 5,000, and 1,000 in treated plots and only 22, 3, and 4 in the check plots of IR29, IR40, and IR42, respectively. The same trend occurred for *N. lugens*/*C. lividipennis*, except that the differences between subplots within varieties were not as large in the last sample, primarily because of the rapid population increase of this predator in the treated plots of IR29 and IR40 at about 60 DT. The extremely high predator/prey ratios that occurred at 49 to 60 DT were primarily the result of *N. lugens* populations, which significantly increased throughout the sampling period, rather than because of a large decrease in the predator population. For example, at 53 DT, when the *N. lugens* population in the treated IR29 was 49-fold greater than that of the check plots, spiders, *M. atrolineata*, and *C. lividipennis* populations were only 23-, 4-, and 4-fold lower in the treated than in the check plots.

Discussion

This study demonstrated that decamethrin can induce resurgence of *N. lugens* in the field on both resistant and susceptible varieties of rice, but that the amount of population increase is greatly influenced by the degree of host resistance. The amount of pest resurgence decreased as varietal resistance increased. Although the yields from plots were not recorded because the crop was severely damaged before harvest by rats and birds, the insecticide-treated plots of IR29 were obviously more seriously damaged than the untreated plots, as indicated by the relatively large differences in hopperburn between the two treatments. In the untreated plots of the moderately resistant IR40, the population of *N. lugens* remained well below the suggested economic threshold level of 10 to 20 per hill (Heinrichs et al. 1979). However, the populations in the treated IR40 plots averaged 38, 71, and 79 *N. lugens* per hill at 49, 53, and 60 DT, respectively. Although there is little information on the effects of higher numbers of *N. lugens* on a resistant variety, these populations could cause substantial yield losses on susceptible varieties during the mid to late portions of crop development (Cheng 1977, Sogawa and Cheng 1979). Therefore, resurgence-causing insecticides should not be used indiscriminately on moderately resistant varieties in the field because they may increase *N. lugens* populations to potentially damaging levels. Even if *N. lugens* numbers on highly resistant varieties such as IR42 that are treated with resurgencepromoting insecticides do not exceed the economic threshold, the chances of biotype selection or virus transmission may increase at these substantially higher pest populations.

This study supports previous work (Kenmore 1980) demonstrating that decamethrin is toxic to important predators of *N. lugens*. This toxicity to natural enemies probably contributed to the resurgence of *N. lugens* in the treated plots, particularly in the resistant varieties which had relatively low prey/predator ratios throughout the season in the untreated checks. However, late in the season, as populations of *N. lugens* increased in the treated plots, the differences in predator populations between treated and check plots were much smaller than the respective differences in numbers of particularly in IR29 and IR40. This suggests that the insecticide may also have had an additional direct effect on the pest, as suggested in previous studies demonstrating that sublethal doses of decamethrin stimulated the reproductive activity of *N. lugens* females (Chelliah et al. 1980).

Notes

1. Homoptera: Delphacidae.
2. Received for publication 19 February 1981.
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