Effect of Supplemental Nitrogen Fertilization on the Movement and Injury of Azalea Lace Bug (*Stephanitis pyrioides* (Scott)) to Container-grown Azaleas[1]

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Abstract

Certain arthropods feed selectively and perform better on plants and plant tissues with elevated levels of nitrogen. Yet it is a common practice to use supplemental nitrogen in the production and maintenance of woody landscape plants. The link between elevated nitrogen levels and improved performance of herbivorous arthropods is particularly strong for sap suckers in the order Heteroptera, the majority of which are phloem feeders. There have been no studies to date on the effects of fertilization of woody plants on important mesophyll-feeding Heteroptera, such as azalea lace bug.

We examined the relationship between the movement and injury of azalea lace bug and levels of fertilization of azaleas. The objective of this study was to determine if this insect responded to supplemental nitrogen fertilization in a way similar to many phloem-feeding Heteroptera and mesophyll-feeding Acarina. In these taxa, numerous studies documented improved performance and increased host plant injury as a result of supplemental nitrogen fertilization. We measured injury and colonization by azalea lace bug of azaleas receiving four levels of nitrogen fertilization. Plants with elevated nitrogen levels were preferentially chosen by azalea lace bug but did not exhibit greater levels of leaf injury.

Index words: azalea, azalea lace bug, insect choice, insect injury, nitrogen fertilizer.

Species used in this study: azalea (*Rhododendron muculonatum* 'Delaware Valley White'); azalea lace bug (*Stephanitis pyrioides*).

Significance to the Nursery Industry

The results of this study indicate that supplemental nitrogen fertilization of container-grown azaleas does not affect the injury caused by azalea lace bugs. The results do indicate that lace bugs may preferentially choose plants that have received supplemental nitrogen fertilization over those that have not. Therefore, it may be necessary for landscapers and growers to monitor more frequently for lace bugs on fertilized plants.

Introduction

Azaleas (*Rhododendron* spp.) are woody landscape shrubs in the family Ericaceae. The production of woody landscape plants, particularly those in the genus *Rhododendron*, is an important component of the nursery industry in Maryland and the mid-Atlantic region. In a survey of more than 30,000 plants found in landscapes in Maryland, Raupp et al. (22) found woody shrubs in the genus *Rhododendron* to be the most common. The azalea *Rhododendron muculonatum* 'Delaware Valley White' was chosen for this study because it was reported by Schultz (26) to be a cultivar susceptible to azalea lace bug.

The azalea lace bug, *Stephanitis pyrioides* (Scott) (Heteroptera: Tingidae) was introduced into New Jersey from its native Japan in 1916 (31). It overwinters in the egg stage and passes through five nymphal stadia before becoming an adult (2). There are two to four generations per year from the northern edge of its range in central New England to the southern edge of its range in Florida. It is found as far west as Missouri (9). Both the nymphs and the adults feed by inserting their mouthparts into the leaf palisade cells and extracting the cell contents, which results in stippling damage to the upper leaf surface (30).

Azalea lace bug is more often observed on evergreen rather than deciduous azaleas (2), and the injury persists for several years. It is the most important insect pest of azaleas in Maryland and is consistently reported as a key pest in Maryland landscapes (24) and nurseries by the Maryland Department of Agriculture (14).

The effect of nitrogen fertilization of plants on the biology of piercing and sucking arthropods has been well documented (7, 8, 15, 19, 27, 28, 32). Altered arthropod feeding and host plant selection occurs in response to supplemental nitrogen and results in increased levels of injury to various plant parts. Arthropod injury can reduce crop yield, salability, or aesthetic value (23). In the case of piercing and sucking arthropods that feed in the phloem, the interaction between nitrogen fertilization and injury is often seen as reduced accumulation of new biomass and altered leaf color or appearance (17). In the case of fruit it is seen as reduced yield (20). Mesophyll-feeding piercing and sucking arthropods injure plants by extracting chlorophyll from the palisade parenchyma and other mesophyll cells. Their injury is seen as chlorotic stipples on the upper leaf surface (30).

The first objective of this study was to examine colonization by adult azalea lace bugs of 'Delaware Valley White' azaleas fertilized at four nitrogen levels. The hypothesis was that lace bugs would prefer to move to plants fertilized at higher rates of nitrogen. The second objective was to examine the effect of nitrogen fertilization rate on injury caused by the azalea lace bug to 'Delaware Valley White' azalea. The hypothesis was that lace bug injury would increase as nitrogen fertilizer rate increased.

[1]Received for publication December 15, 1997; in revised form May 21, 1999. We would like to acknowledge the support of the Sylvan Nursery/Sylvia and Neil Van Sloun Grant of **The Horticultural Research Institute, 1250 I St. N. W., Washington, DC 20005**, and the Maryland Agricultural Experiment Station.

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Materials and Methods

All experiments were conducted at the University of Maryland greenhouses (College Park, MD) using one-year-old *Rhododendron muculonatum* 'Delaware Valley White' in Sunshine S-3 mix (Sun Gro Horticulture, Bellevue, WA), a peat-based soilless media. Nitrogen levels were selected to span the range of fertilization regimes that might be encountered in nursery and landscape situations (3). They were 0 ppm (water-only control), 25 ppm (sub-optimal nitrogen), 100 ppm (optimal nitrogen), and 400 ppm (supra-optimal nitrogen). All plants received the same amount of phosphorus and potassium fertilizer. The experimental design was a completely randomized block consisting of ten blocks. Each block contained four plants and each of the four plants received one level of nitrogen fertilization. The plants received bi-weekly applications of the four nitrogen treatments for at least six weeks prior to initiation of the colonization and injury experiments to establish differences in leaf tissue nitrogen levels. Fertilization then continued weekly throughout each experiment.

Effect of nitrogen fertilization on leaf tissue nitrogen. This experiment was started in May 1993 using plants in #2 containers grown under natural light. To confirm that bi-weekly fertilizer applications would result in different leaf tissue nitrogen levels, the plants received bi-weekly applications of fertilizer as 250 ml of solution for six weeks. Two leaf tissue samples were then taken from each of the 40 plants for nutrient analysis. Each sample consisted of all fully expanded leaves on a branch about halfway up from the base of the plant. Plants were approximately 1 m (3 ft) in height. All azalea leaf tissue samples were dried in an oven for 48 h at 36C (96F), ground in a Wiley mill using a 60-mesh screen and analyzed for total nitrogen at the University of Maryland Soil Testing Laboratory using a Leco CHN 600 gas analyzer (Leco Corp., St. Joseph, MI). The samples were placed in aluminum capsules, weighed, combusted, and passed through the analyzer. The machine calculated total nitrogen as a percentage of total dry weight of the leaf tissue. The average of 2 sub-samples from each plant was used to estimate leaf nitrogen content. The results were analyzed by analysis of variance (PROC GLM, SAS Institute 1990) (26). Means separation was performed using an LSD test.

Effect of nitrogen fertilization on azalea lace bug host plant colonization. This experiment was conducted in November 1993. Plants were grown in 12.5 cm (5 in) pots in the greenhouse under supplemental lighting (16h light:8h dark). The nitrogen treatments were applied weekly as 150 ml of solution. Each block of four plants was placed inside a wood frame cage that was 61 cm (24 in) wide, 61 cm (24 in) deep, and 107 cm (42 in) tall. The cage had a front opening door and the sides of each cage were covered with organdy. The plants were placed randomly in the four corners of the cage, and 50 adult lace bugs were released from vials in the center of the cage. The number of lace bugs on each plant was counted 24, 48 and 72 hours after the initial time of dispersal, and the results were analyzed by analysis of variance (PROC GLM, SAS Institute 1990) (25).

Effect of nitrogen fertilization on azalea lace bug injury to azalea. This experiment was started in July 1993 using plants in #2 containers in an outdoor bed under 55% shade cloth.

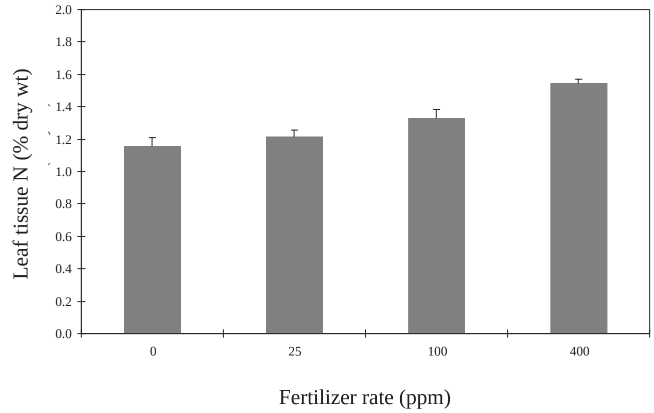

Fig. 1. Effect of nitrogen fertilizer rate on nitrogen content of azalea leaves.

The four nitrogen fertilizer treatments were applied weekly as 250 ml of solution. The experiment was conducted inside mylar tube cages that enclosed a portion of a branch. Each tube was constructed from mylar rolled into a tube 15.6 cm (6.1 in) in length and 8.1 cm (3.2 in) in diameter sealed with a 2.5 cm (1 in) wide piece of duct tape. Each cage had two 14.5 cm^2 (5.7 in^2) wide center openings on opposite sides to allow air movement. These were covered with organdy and sealed with caulk. Each cage was attached to an azalea branch by means of a 2.5 cm (1 in) foam plug slit from the edge to the center to allow it to be slipped over the branch. Two branches at approximately the same height with about the same number of recently, fully expanded leaves were selected at random on each plant for this experiment. Five adult lace bugs were introduced into the sleeve cages and allowed to feed for five days. Lace bug mortality was assessed daily so that final injury measurements could be standardized for the total number of lace bugs present over the course of the experiment (lace bug days). At the end of the five day feeding period, the branches with the cages were cut from the plants and all leaves inside the cage were removed. Injury was measured on each leaf by a visual estimate of the percentage of the total leaf area discolored by lace bug stippling. Visual discoloration was estimated using the guidelines for estimating leaf area injury outlined in Dively (10). The effect of fertilizer treatment on injury was analyzed using a Kruskal-Wallis statistic (PROC NPAR1WAY, SAS Institute 1990) (25).

Results and Discussion

Host plant tissue analysis. There was a significant effect of nitrogen fertilizer rate on final leaf tissue nitrogen as a percentage of dry weight (Fig. 1). Plants fertilized at the highest nitrogen rate of 400 ppm had the highest leaf tissue nitrogen, which was significantly greater than all other fertilizer treatments. Leaf tissue nitrogen at 100 ppm was significantly greater than 25 or 0 ppm, which did not differ significantly. The lack of a significant difference between the control and the low nitrogen rate is not surprising, because 25 ppm nitrogen is a very low fertilizer rate. Artificial soils such as the one used in this experiment do not retain nutrients well, so most of the fertilizer applied at this rate was probably leached from the soil. Yeager and Barrett (33) found that several types of peat-based artificial soils lost 66 to 76% of added phos-

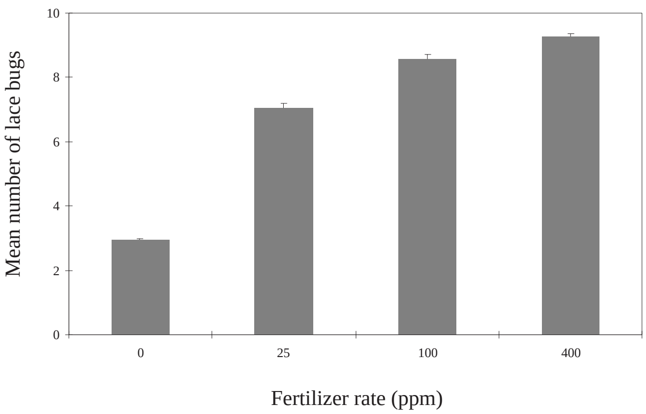

Fig. 2. Effect of nitrogen fertilizer rate on lace bug colonization of azalea.

phorous through leaching following the 21-day period following fertilizer application. Stewart et al. (29) determined that daily irrigation of privet (*Ligustrum japonicum* Thunb.) in one-gallon plastic containers resulted in 36.2% of the total nitrogen applied being lost through leaching each day.

Effect of nitrogen fertilization on azalea lace bug host plant colonization. Colonization of 'Delaware Valley White' azalea plants fertilized at the four different nitrogen rates was measured after 24, 48 and 72 hr. An analysis of variance showed no significant effect due to time, so colonization was analyzed as the total number of lace bugs that had moved to each treatment by the end of the 72-hr time period. There was a significant effect of nitrogen fertilization on host plant colonization (Fig. 2). The differences in mean number of lace bugs choosing each treatment, however, is probably not large enough to have a great deal of biological significance.

This contrasts with many other studies, in which the preference of arthropods to colonize high nitrogen plants or plant parts is well-documented (4, 6, 8). In the laboratory, planthoppers were found to choose high nitrogen plants for feeding and ovipositing (5). Prestidge and McNeil (21) observed that certain leafhopper species moved to specific regions of plants with elevated nitrogen levels. Similar observations were made by McNeil (18) with a mirid, *Leptopterna dolabrata*. The early instar nymphs fed on leaves of *Holcus mollis*, but they moved to flower heads of *H. lanatus* as leaf tissue nitrogen levels of the first host dropped. As mirids entered the period of gonadal maturation, their nitrogen requirements increased and they colonized high nitrogen flower heads.

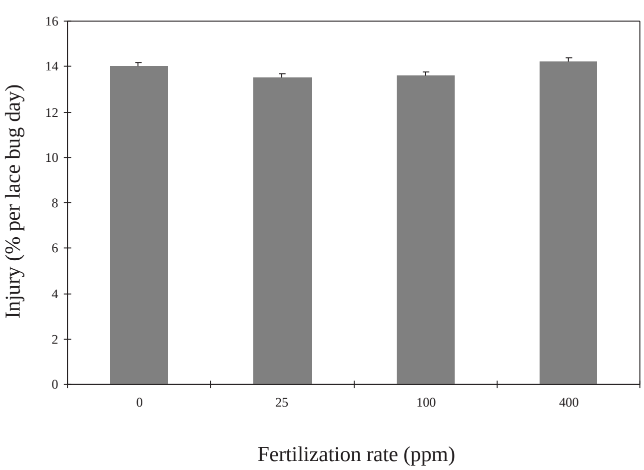

Fig. 3. Effect of nitrogen fertilizer rate on lace bug injury to azalea.

Effect of nitrogen fertilization on azalea lace bug injury to azalea. There was no significant difference in injury per lace bug day to caged azalea branches at the four fertilizer rates (Fig. 3). This was not predicted by the initial hypothesis and is not what would be expected based on previous studies. Few studies have considered the relationship between fertilization and host plant injury caused by sucking insects. Of those that have, generally the results indicate that plants sustain greater levels of injury when they receive supplemental nitrogen fertilization (11, 16, 17, 20). Apparently, the improved insect performance that results from added nitrogen leads to increased insect feeding or reduced plant ability to compensate for insect injury, or both.

The outcome of these studies and those discussed previously conflict with the results reported here in that nitrogen fertilization of 'Delaware Valley White' azaleas did not influence azalea lace bug injury. However, since we observed that lace bugs chose to move to plants that had received supplemental nitrogen fertilization, perhaps nitrogen fertilization affects another plant attribute unrelated to lace bug injury. For example, total chlorophyll has been shown to be related to leaf greenness (13) and net photosynthesis and leaf greenness have been positively correlated with fertilizer rate (12). Perhaps there is a relationship between fertilizer rate and total chlorophyll in this system, so that the highest nitrogen plants are more attractive and preferentially colonized.

Adult lace bugs were observed to both probe and to feed, and it is not known if probing and feeding result in the same type of injury. It is possible that plants grown under different nitrogen regimes were probed and fed upon at different ratios but that the overall number of leaf punctures was constant across all treatments. This could be determined if rates of feeding and probing could be independently measured at each level of fertilization.

There are other reasons why fertilization may not have affected lace bug injury. This experiment was conducted under artificial conditions. Since the lace bugs were confined in cages they could not move from a poor quality food source and may have faced the choice of feeding or starving. Other studies have documented that the relationship between nitrogen fertilization and host plant injury varies with insect density (1). Densities were low in this experiment (20 adult lace bugs per branch that had an average of 20 leaves). Perhaps at a higher lace bug density nutrients would have been more limiting and differences in injury at the four fertilizer rates would have been seen. Finally, other phytochemicals such as hormones, vitamins, and allelochemicals may function as feeding stimulants or antifeedants and could have been influenced by fertilization. These effects were not investigated in the present study, but could be examined in further work.

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