THE BIONOMICS OF THE COTTONWOOD LEAF BEETLE, CHRYSOMELA SCRIPTA FAB., ON TISSUE CULTURE HYBRID POPLARS[1]

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ABSTRACT.--Tissue culture methods are applied to poplars of the Aigeiros group in attempts to overcome premature decline thought to be associated with viral infections. Hybrid selections from such cultures outplanted in 1975 at the F. G. Wilson Nursery in Boscobel, Wisconsin subsequently were severely infested by the Cottonwood Leaf Beetle, Chrysomela scripta Fab. Beetle populations built up rapidly in spring 1977 and severe defoliation occurred; an average of 45% of the terminal buds were destroyed and 73 percent of the tips of a preferred clone were fed upon. Younger foliage appeared preferred and certain clones sustained more feeding in field and laboratory studies. Plants receiving greater amounts of overhead irrigation were least defoliated. Rapid increases in the numbers of the insect in Wisconsin are reflected in the following facts. The Cottonwood Leaf Beetle has a rapid life cycle (19 days at 27°C). Consequently, the insect undergoes 4-5 generations per year in Wisconsin where it exhibits a high fecundity of approximately 510 eggs. Finally, because of the larval defensive secretion, salicylaldehyde, the insect has few natural enemies; mainly predatory pentatomids on larvae and adults, and Shizonotus latus Walker, a pupal parasite.

Black poplars of the Aigeiros group maintained by the University of Wisconsin were undergoing premature decline, thought to be associated with viral infections. In an attempt to culture poplars for high yields, heat treatment followed by tissue culture methods were applied to the apical meristems to eliminate viruses. Heat treatments allow the trees to outgrow viruses and shoot-tip culture capitalizes on the absence or

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lowered concentration of viral particles in the apical meristems (Hollings 1965). Such clonal propagation might allow genetically superior traits to be transferred by eliminating the chance of gene recombination occurring via a sexual cycle. However, a wide range of variation for height, number of branches, and leaf traits were discovered among subclones. The basis of this variation is as yet unknown, but the more obvious possible causes include incomplete elimination of viral infection, gene mutation, and chromosomal instability (Lester and Berbee 1977).

Hybrid selections of these subclones were outplanted in 1975 at the F. G. Wilson Nursery at Boscobel, Wisconsin, and subsequently were severely infested by the Cottonwood Leaf Beetle, Chrysomela scripta Fab. The defoliator, although it rarely reaches epidemic numbers in natural stands of Populus, Alnus, and Salix, has become an established annual problem in the monoculture cottonwood plantations of the South, as well as in the nurseries of Wisconsin.

In Mississippi, the insect increased rapidly in numbers because of its high natural fecundity of 823 eggs, a short life cycle, and as many as seven generations per year (Head and Neel 1973). In addition, the Cottonwood Leaf Beetle has few natural enemies because of its defensive secretation, salicylaldehyde, which is exuded by eversible glands on the thorax and abdomen (Wallace and Blum 1969).

We are studying the bionomics of the Cottonwood Leaf Beetle in Wisconsin to develop means of preventing the insects from reaching numbers that result in severe defoliation and destruction of apical tips. In addition, since the tissue cultured hybrid poplar subclones showed variability in vigor and other characteristics, we expect that there would be variability in resistance to insect attack. We will try to develop a method of screening clones for relative resistance.

METHODS

In May, 1977, three Latin squares were established at the F. G. Wilson Nursery at Boscobel, Wisconsin: each square consisted of 25 trees, five trees from each of four of tissue culture Aigeiros subclones and five trees from a tissue culture Lombardy clone. The three Latin squares made up one replicate. A second replicate of these three Latin squares was planted at the University Experimental Farms in Arlington, Wisconsin, in May, 1977. Twice weekly, a count was made of all eggs, larvae, pupae, and adults of the Cottonwood Leaf Beetle on each of the trees in the three Latin squares at the Arlington and Boscobel sites. In addition, a field plot of 1512 tissue culture poplars consisting of six subclones planted in 1975 at the F. G. Wilson Nursery at Boscobel, Wisconsin, served as a third site for biological observations of the Cottonwood Leaf Beetle. Eggs, larvae and pupae were also collected from this field plot and reared in the laboratory for

parasites. A record was made of predators seen on the trees. These data later will be incorporated into life tables.

At the end of each generation of the Cottonwood Leaf Beetle, a count was made of all the host apical tips destroyed in the plots to evaluate the economic damage and relative change in insect numbers.

Leaves on which eggs were laid were transferred to environmental chambers at different temperatures (10°C, 17°C, 21°C, 23°C, 27°C, 28°C) to determine the effects of temperature on developmental times and mortality; all rearing occurred at an 18-hour photoperiod.

Virgin males and females were paired and caged in 21.5 cm x 6.7 cm x 5.8 cm plastic boxes with foliage and placed in an environmental chamber at 27°C and 18 hrs of light. Daily counts were made of eggs laid to determine the average fecundity.

The number of larval instars was determined by measuring the head capsule widths of ten larvae daily throughout their development.

Adult preferential feeding tests were carried out by offering a caged male and female a choice of one leaf from each of two different subclones. Leaves of the approximate same size and relative position on their respective trees were used in each replicate. The turgor of the leaves was maintained by keeping the petioles of the leaves submerged in a vial of water plugged at the top with cotton. The tests were run for a week at 27°C, 18 hrs light. The area of the leaves was determined before and after feeding by using a plane polarimeter. The relative feeding preference by adult beetles on mature versus immature foliage from the same clone were likewise tested.

RESULTS

In Wisconsin, the Cottonwood Leaf Beetle has 4-5 generations per year. In the laboratory the females exhibit an average fecundity of 510 ± 153 eggs. The insect has three larvel instars and a short life cycle of 19 days at 27°C; optimal development occurred at 23°C.

Field studies showed both the larvae and adults to be defoliators and to prefer to feed on the more tender young leaves near the apical tip. The first and second instars feed by etching the lower surface of the leaves while the third instars and adults may skeletonize the leaves and leave only the main ribs. In addition, the third instars and adults feed on the apical tips and destroy them. Laboratory studies revealed that of the clones tested for adult preferential feeding, only Aigeiros clone 13 showed a significant difference (at α=5% for 2-t-test) from the others; it was preferred by at least four times that of the standard. Immature foliage was likewise preferred by a

ratio of 33:1 over mature foliage. In the field plot of 1512 trees, an average of 45 percent of the apical tips were destroyed and 73 percent of Aigeiros clone 13 tips were fed upon.

Natural control agents were unable to maintain the population of the Cottonwood Leaf Beetle on the Boscobel plot in the second generation at a low economic level: Shizonotus latus Walker parasitizes 3.2 percent of the pupae while Coleomagilla maculata DeGreer consumes 12.4 percent of the eggs. The larval predators such as the lacewings, syrphids, and the pentatomids, Podisus maculiventris Say and Perillus bioculatus Fab. were unable to maintain the population of the Cottonwood Leaf Beetle at an acceptable sub-economic damage level. The amount of feeding damage sustained in the Boscobel nursery was inversely related to the amount of water received via an overhead sprinkler system.

On the Arlington replicates; the Cottonwood Leaf Beetle population was too low to evaluate meaningfully except for making biological observations.

DISCUSSION

Several facets of the Cottonwood Leaf Beetle's biology enhance its prospects for being a continuing problem in Populus nurseries in the Lake States. First, is its high fecundity of 510 eggs. Secondly, is its short life cycle which requires 19 days from adult at 27°C. Thirdly, the insect is multivoltine, having 4-5 generations per year in Wisconsin.

A larval defensive secretion repels insect predators and thus appears to restrict the kinds of the biotic control agents that can successfully attack the insect to pentatomids, syrphids and lacewings. Neither the egg predator, Coleomagilla maculata, nor the pupal parasite, Shizonotus latus, can reduce the Cottonwood Leaf Beetle to an economically acceptable level. This enables the beetle to increase rapidly in population. Abiotic factors, notably temperature, seem to mainly control the rapidity of increase. Watering from overhead sprinkler systems also limits the destructiveness of the beetle by knocking the adults off the trees. The more water falling on a plant, the less likely it is that an adult will feed there and oviposit. However, even temperature and overhead watering are unable to prevent the insect from reaching such numbers that an average of 45 percent of the apical tips are destroyed and 73 percent of the tips of the preferred clone are fed upon as at Boscobel.

LITERATURE CITED

Head, R. B., and W. W. Neel. 1973. The Cottonwood Leaf Beetle (Chrysomela scripta: Coleoptera, Chrysomelidae): Observations of

the Biology and Reproductive Potential in Mississippi. J. Econ. Entomol. 66(6):1327-8.

Hollings, M. 1965. Disease control through virus-free stock. Ann. Rev. Phytopath. 3:367-396.

Lester, D. T., and J. G. Berbee. 1977. Within clone variation among black poplar trees derived from callus culture. For. Sci. 23(1):122-131.

Wallace, J. B., and M. S. Blum. 1969. Refinded defensive mechanisms in Chrysomela scripta. Ann. Entomol. Soc. Am. 12(3):503-506.