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A SPLIT-STEM LESION ON YOUNG HYBRID *POPULUS* TREES CAUSED BY THE TARNISHED PLANT BUG, *LYGUS LINEOLARIS* (HEMIPTERA [HETEROPTERA]: MIRIDAE)

Frank J. Sapio, Louis F. Wilson, and Michael E. Ostry[1]

ABSTRACT

The tarnished plant bug, known principally as an agricultural pest, injures young hybrid *Populus* by feeding on the stems and meristems. Tarnished plant bug eggs, fungi associated with some lesions, and simple mechanical stimuli alone from feeding appeared not to cause lesion formation. Of 20 *Populus* hybrids tested in a clonal trial, four appeared to be consistently susceptible to lesion injury, with *Populus nigra* var. *betulifolia* × *trichocarpa* the most susceptible. Several clones showed high resistance in the trial but a few were susceptible in other plantings and in host preference tests when caged with tarnished plant bugs. Lesions diminished tenfold on *Populus* where horseweed, the insect's principal wild host, grew along with susceptible poplars. The tarnished plant bug can be suppressed by ultra-low volume pesticides and cultural manipulation of understory vegetation.

Since 1978 an agent has been injuring young hybrid *Populus* trees planted on the Harshaw Forestry Research Farm near Rhinelander, Wisconsin. Each summer lesions developed on the stems and occasionally on short branches, growing tips, and leaf petioles of certain clones of newly planted and 1- and 2-year-old *Populus* grown from cuttings. The stem lesions occurred in the middle of upper portion of young trees; the injured areas sometimes calloused over but frequently stems were girdled or broken above the injury. The injured area is technically a split-stem lesion and when fully formed consists of an irregular elongate split with a swollen flared area of necrotic bark and xylem tissues around the stem (Figs. 1A, B). Mature lesions ranged from less than 0.5 cm to 5 cm long.

Initial dissections of lesions for insects and isolations for pathogens provided no clue to the cause of the injury. A possible insect and disease association, however, was indicated following the application of malathion, which eliminated the majority of insects at the spray-test site. New lesions continued to form in an unsprayed area following the test but only a few formed in the treated area. In this study we set out to: (1) determine the causal agent(s) of the lesion; (2) determine if the incidence of injury differed among hybrid *Populus* clones; and (3) suggest preventive or control measures for the lesion-causing agent.

STUDY AREAS AND MATERIALS

This study was conducted during the summer and fall of 1981 at the USDA Forest Service, Forestry Sciences Laboratory at Rhinelander, Wisconsin. Observations and tests were made at the facility's Harshaw Forestry Research Farm, nursery, and greenhouses. Eight-inch (20-cm) stem cuttings of *Populus* were outplanted in spring 1981 for testing. Some cuttings were potted and set in the greenhouse for additional tests. Previously determined susceptible clones NC-9921, NE-1, and NE-299 were used in the tests; clone NE-375 was used when apparent resistance was needed in a test. Established trial plantings of 20 clones were also used in the study (see Table 1 for acquisition numbers and clonal parentages).

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DETERMINING THE CAUSAL AGENT

The insect fauna were observed daily at the Harshaw Farm and records were kept of all insects sighted between 15 June and 1 September to determine if any insects were involved in lesion formation. Representative specimens were collected and identified to family. Mirids were the most common insects found on or near stem lesions. Captured adults of the more numerous species were sleeve-caged on susceptible *Populus* clones at the farm, nursery, and in the greenhouse. About 10 insects of the same species were placed in each cage (approximately 35 cm dia. by 80 cm long). Caged trees that developed lesions all contained a mirid identified[2] as the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), suggesting that it was directly or indirectly the causal agent.

Microscopic examinations of growing lesions early in the season revealed insect eggs embedded in the bark of about half of the lesions (Fig. 2). Emerging nymphs fed on *Populus*

Table 1. Susceptibility of 20 *Populus* clones to a split stem lesion caused by the tarnished plant bug, Harshaw Research Farm, Rhinelander, WI.

Clonal Numbers: Original	Clonal Numbers: North Central Forest Experiment Station	Parentage	Percent trees with lesions[a]
NE-298	NC-5332	*Populus nigra* var. *betulifolia* × *P. trichocarpa*	43
NE-386	NC-5263	*P.* 'Candicans' × (*P.* × *berolinensis*)	30
NE-387	NC-5262	*P.* 'Candicans' × (*P.* × *berolinensis*)	26
—	NC-9921	*Populus* sp.	20
—	NC-5351	*Populus* sp.	6
DN-34	NC-5326	*P.* × *euramericana* 'Eugenei'	3
—	NC-5277	*P.* × *euramericana* 'Wisconsin #5'	3
NE-1	NC-5272	P. nigra × *P. laurifolia* 'Strathglass'	3
—	NC-5258	*Populus* sp.	0
NE-372	NC-5266	*P. deltoides* var. *angulata* × *P. trichocarpa*	0
—	NC-5260	*P. tristis* × *P. balsamifera* 'Tristis #1'	0
DN-30	NC-5323	*P.* × *euramericana* 'Canada Blanc'	0
NE-252	NC-5334	*P. deltoides* var. *angulata* × *P. trichocarpa*	0
NE-299	NC-5331	*P. nigra* var. *betulifolia* × *P. trichocarpa*	0[b]
—	NC-9922	*Populus* sp.	0[b]
NE-375	NC-5264	*P. deltoides* var. *angulata* × *P. nigra* var. *plantierensis*	0[b]
NE-388	NC-11505	*P. maximowiczii* × *P. trichocarpa*	0
I-476	NC-4879	*P.* × *euramericana* 'I-476'	0
DN-28	NC-5325	*P.* × *euramericana* 'Ostia'	0
—	NC-5339	*P. alba* × *P. grandidentata*	0

[a]64 trees per clone, lesions from 1980 season.
[b]Moderate number of lesions in other field and greenhouse test plantings.

[2]Determined by T. J. Henry, Research Scientist, Systematic Entomology Laboratory, USDA, Beltsville, MD, and B. J. Harrington, Director Insect Research Collection, University of Wisconsin, Madison, WI.

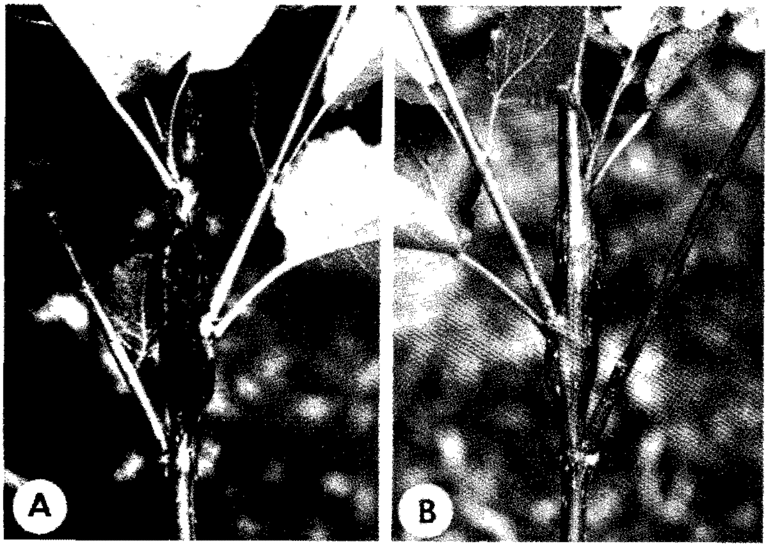

Fig. 1. Split-stem lesion on hybrid *Populus*. A, front; B, back.

stems (Fig. 3) and within 20 days grew into tarnished plant bug (TPB) adults. In a greenhouse test to determine if oviposition affected lesion formation, 16 young trees of clone NE-299 were sleeve-caged: eight with three female TPBs each and eight with three male TPBs each. Cages remained in place for nearly two weeks. Examinations showed that females laid eggs in stem tissues prior to lesion formation, but oviposition was not the cause of the lesion because both sexes produced about an equal number and size of lesions. Eggs were later found in succulent healthy tissue of growing tips of trees and leaf petioles that had no lesions. All lesions, however, appeared to be directly associated with feeding injury caused by both sexes of TPB.

Isolation and inoculation trials were made to determine if a fungus or bacterium was associated with lesion formation and to determine if the TPB was a vector. Isolation from TPBs and tissue samples of lesions collected from affected *Populus* clones and native quaking aspen (*Populus tremuloides* Michx.) were made onto potato dextrose agar (PDA) and incubated at 20°C. *Fusarium* sp. (Fungi Imperfecti: Tuberculariaceae) was most consistently isolated from lesion tissue. Young trees were inoculated with the cultured fungus by inserting 5-mm^2 sections of cultures growing on PDA in wounds that reached the cambium and securing them with moist cotton and tape. Inoculated wounds showed some tissue necrosis and callousing, but split-stem lesions did not form. No organisms pathogenic to poplars were isolated from TPBs.

Patch grafting was also used to determine if organisms in the lesion were responsible for lesion formation. Three trees were used in each of four tests over a three-week period. Test sites were on the basal, mid, and apical portions of the stem. Treatments were (1) a small piece of actively growing lesion from an affected poplar was inserted into a 6-mm bark flap cut with a sterile scalpel, the wound was wrapped with either dampened sterile cotton or gauze and tied loosely with string; (2) identical to treatment (1) but with healthy poplar stem tissue; and (3) 6-mm bark flap cut without added tissue. The latter treatment was to determine the response of the tissue to wounding only. The tests were repeated twice with cotton left on for 24 h and with gauze left on for a week.

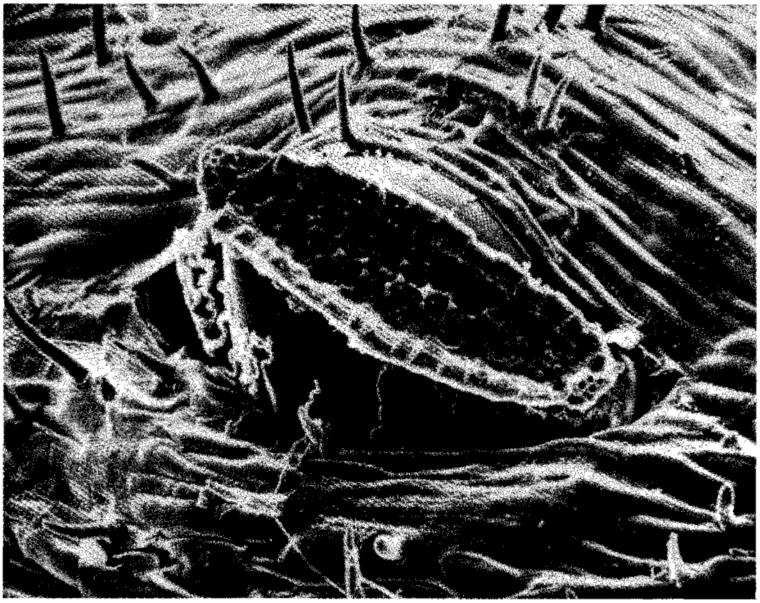

Fig. 2. Electron photomicrograph of a tarnished plant bug egg imbedded in hybrid *Populus* bark. (Mag. apx. 350×)

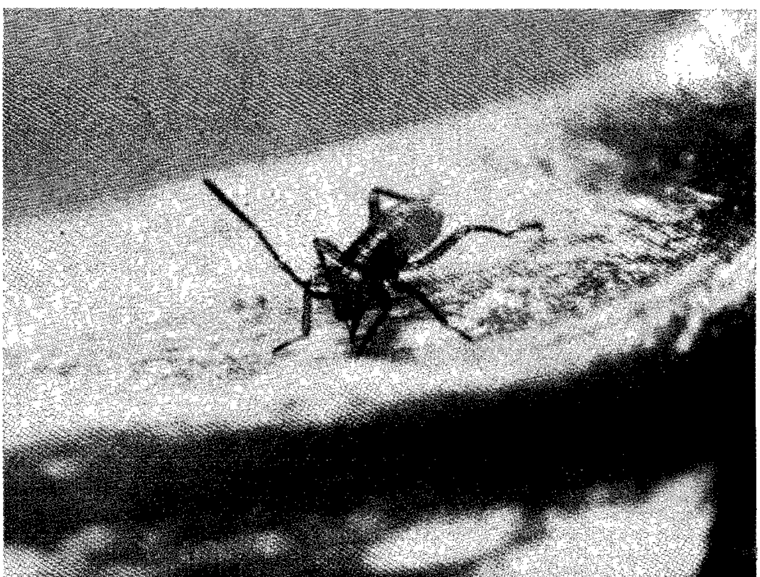

Fig. 3. First-instar tarnished plant bug nymph feeding on hybrid *Populus*.

Small calluses and swellings developed at healthy and lesion tissue patch-grafted sites suggesting the reaction was to foreign tissue rather than to a pathogen. Tissues that were wounded only formed callus but no swelling was evident. Further trials in which stem tissues were probed with a fine needle to simulate stylet penetration by a plant bug or in which bark was wounded with a scalpel to simulate agricultural implement wounding also yielded no obvious lesion or swelling. This suggests that the lesions are not mechanically induced.

HOST SUSCEPTIBILITY AND ATTRACTION

To assess susceptibility of various *Populus* clones to the lesion, 20 *Populus* clones were examined in a two-year-old genetic test plot. Each of 64 trees of each clone was examined thoroughly for lesions. Four clones showed moderate numbers of trees with lesions (20–43%), four clones had a few trees with lesions (3–6%), and 12 clones had no lesion (Table 1), indicating an apparent wide range of susceptibility. Further tests of host susceptibility were made after noting that the majority of TPBs frequented flowers of two asteraceous weed species associated with the poplar plots: horseweed, *Erigeron canadensis* (= *Conyza canadensis*), and daisy fleabane, *E. annuus*. Observations also indicated lesions were less numerous when horseweed was present.

In the greenhouse, we tested 10 trees of susceptible clone NC-9921 and 10 of "resistant" clone NE-375. Five trees from each clone were caged with a live horseweed plant and five trees from each clone were caged alone. Five TPBs were then placed in each cage. Plants were irrigated and fertilized with an automatic trickle system, and lesions were counted after seven days. Three contrasts were analyzed using the Bonferonni t-statistic (t_B; Gill 1978) with the following results: (1) NC-9921 vs. NC-9921 with horseweed ($t_B = 2.03$, n.s.); (2) NE-375 vs. NE-375 with horseweed ($t_B = 2.54$, $P > 0.05$); and (3) NE-375 and NC-9921 vs. NE-375 and NC-9921, both with horseweed ($t_B = 3.23$, $P > 0.01$). The first contrast was not significant because of wide variability between numbers of lesions within treatments. The mean numbers of lesions per tree per test were as follows:

TEST	LESIONS ($\bar{x}$)
Populus clone NC-9921	4.4
Populus clone NE-375	5.4
Populus clone NC-9921 and horseweed	0.4
Populus clone NE-375 and horseweed	0.4

Apparently horseweed was associated with a marked decrease in the number of lesions developing on *Populus*.

In another test, 720 young trees were censused for lesions in the early fall of 1981 to determine effects of weed control and associated treatments on prevalence of the lesion. The study was begun in 1980 to learn the growth response of *Populus* clones to weed treatments[3] and contained three clones observed to be susceptible to lesions, NE-378, NE-1, and NC-9921.

Unsoaked hardwood cuttings were planted on 9 May 1980. Thirty trees of each clone were chosen sequentially and examined for lesions in September 1981, in each of the following six treatment plots:

1. **Furrow-cultivation:** Cultivated 10 times in 1980.

2. **Furrow-cultivation—clover cover crop:** Similar to above except 12 lbs/ac white dutch clover (WDC) seed was applied by cyclone spreader after the eighth and final cultivation in late July.

3. **Linuron-glyphosate:** Linuron at 2 lbs active ingredient (ai)/ac was applied prior to planting. Glyphosate at 2 lbs ai/ac was applied in late July.

[3]Morris, P. R. 1980. Study plan for evaluation of weed control practices for short rotation intensively cultured *Populus* plantations. North Central Forest Experiment Station, FS-NC-1112-80-06.

4. **Glyphosate:** Herbicide was applied at 2 lb ai/ac twice in June and July with a shielded sprayer.

5. **Rolling-cultivation:** Cultivated over the tops of cuttings for first three cultivations and thereafter between the rows for a total of 11 cultivations.

6. **Clover cover crop:** Benefin was incorporated into the soil at 1.5 lb ai/ac prior to seeding 6 lb/ac WDC in mid-May.

Analysis of variance showed highly significant clonal, treatment, and interaction sources of variance (significant at 0.01 level):

SOURCE OF VARIATION	df	MS	F
Clonal	2	5.22	15.75
Treatment	5	6.86	20.73
Clonal × Treatment	10	2.84	8.59

Lesions per tree varied by clone as follows: NE-386 averaged 0.50, 9921 averaged 0.22, and NE-1 averaged 0.08. The susceptibility ranking was the same as in the previous clonal trials. Number of lesions also varied by weed treatment (Fig. 4). Plots furrow cultivated yielded the most lesions, while those with only WDC the least, especially for clone NE-386. Four non-orthogonal comparisons were made within the six treatment groups using t_B the Bonferonni t-statistic with the following results (1, 2 significant at 0.01 level; 4 significant at 0.05 level):

TREATMENT COMPARISONS	t_B
1. WDC cover crop vs. furrow cultivaton.	8.09
2. WDC cover crop vs. furrow cultivation and WDC cover crop.	5.38
3. WDC vs. all other weed control, excluding furrow cultivation.	0.77
4. Furrow cultivation vs. furrow cultivation and WDC cover crop.	2.69

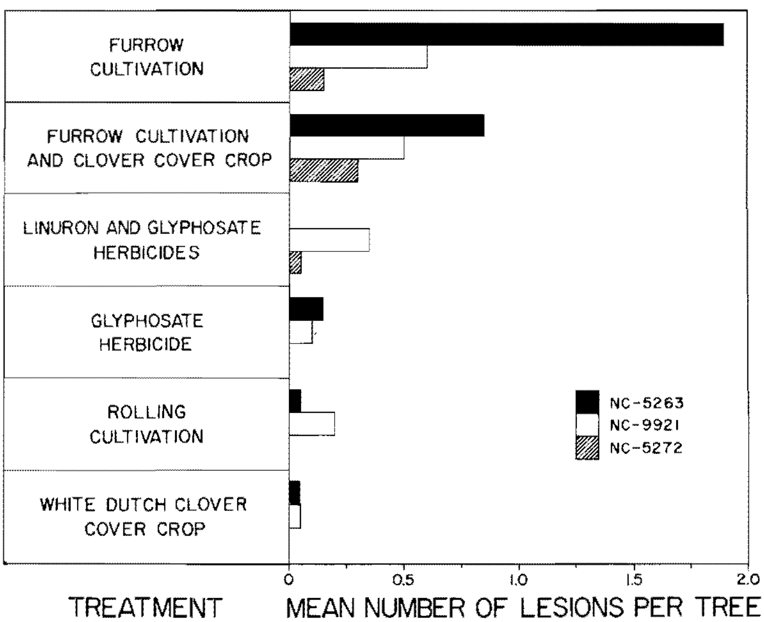

Fig. 4. Incidence of tarnished plant bug lesions on three *Populus* clones after various weed management treatments.

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The first comparison shows difference of lesion occurrence between treatments with the most and least amount of ground cover. Trees in WDC-treated plots had significantly fewer lesions than those in furrow cultivated plots. The second comparison shows that WDC added to cultivation treatments lessens the prevalence of lesions but number of lesions are still significantly higher than WDC alone. The third comparison suggests that the WDC cover crop is no better than herbicide treatments or rolling cultivation. All of these treatments reduce the prevalence of the lesion. The fourth comparison indicates that the addition of WDC following cultivation significantly lessens the prevalence of the lesion but not as much as other treatments.

CAUSAL AGENT

The split-stem lesion on *Populus* at the Harshaw Research Farm at Rhinelander, Wisconsin, was shown to be caused by the tarnished plant bug, known principally as a pest of agricultural crops such as alfalfa, cotton, beans, apple, and peach. Other insects and fungi associated with *Populus* did not produce lesions in cage and inoculation tests.

Many insects of the family Miridae produce lesions and other deformations on their host plants. Tingey and Pillemer (1977) reviewed *Lygus* feeding injury and generalized the damage into five categories: (1) localized tissue necrosis, (2) abscission of fruiting forms, (3) morphological deformation of fruit and seeds, (4) altered vegetative and fruiting growth patterns, and (5) tissue malformations. Split-stem lesion caused by TPB on *Populus* appear to fit several of these categories and appeared similar to *Lygus*-caused lesions on cotton plant stems (King and Cook 1932). Besides split-stem lesions on the stem, which is the most common injury to *Populus*, the TPB sometimes causes tissue necrosis of tip meristems and altered growth of leaf petioles.

The lesion on *Populus* was induced by TPB feeding of either sex and not from oviposition, transmission of a pathogenic fungus, nor simple mechanical stimulus. TPB eggs were associated with about half of the lesions, the expected ratio if the insect has an equal number of males and females. Painter (1929) gives a 50:50 sex ratio for the TPB and Khattat and Stewart (1980) found a 54:46 female to male ratio on alfalfa in spring. Male and female TPBs feed on stems, meristems, and leaf petioles of *Populus*; females usually oviposit at the feeding site, but they also oviposit at nonfeeding sites.

Lygus spp. are capable of transmitting pathogenic organisms. The TPB has been responsible for transmitting fire blight caused by the bacterium *Erwinia amylovora* (Burrell) Winslow to pears (Stahl and Luepschen 1977). The TPB did not appear to induce *Populus* lesions by vectoring pathogens.

Lygus bugs feed by inter- and intra-cellular stylet penetration, and during feeding they secrete saliva that carries a variety of substances that affect tissue development (Tingey and Pillemer 1977). Hori (1974) listed specific growth regulators (i.e. IAA), amino acids, and enzymes in lygus bug saliva. Tingey and Pillemer (1977) suggested that split-stem lesions in cotton caused by various mirids can be attributed to the auxin content of the salivary injection. Auxins, of course, play a role in cell enlargement and division. Miles (1968) suggested that IAA could be the universal cause of cecidogenesis (gall-formation) by plant bugs. Strong (1970), however, indicated that injury caused by *Lygus hesperus* Knight is not due to hormonal injection but rather to the mechanical and enzymatic destruction of hormone-producing sites in the plant tissue.

In our study mechanical probing and slicing with a scalpel did not yield lesions, suggesting a nonmechanical cause. Enzymatic activity, however, was not ruled out. Varis (1972), who studied the feeding injury of *L. rugulipennis* Poppius to sugar beet, artificially probed sugar beet tissues and no feeding symptom injuries developed. But probing combined with removing plant tissue juices and injecting pectinase produced all the symptoms associated with feeding damage. The TPB lesion on *Populus* also may be due to enzymatic activity, but further studies of the feeding process will be needed to substantiate this conclusion.

HOST SUSCEPTIBILITY AND ATTRACTION

TPBs feed and cause lesions on various clones of hybrid *Populus* grown for intensive culture. Lesions were also found on branches of quaking and bigtooth aspen near the Harshaw Farm. Out of 20 clones tested in the clonal trial, clones NE-298, NE-386, NE-387, and NC-9921 appeared to be consistently the most susceptible. Clones NE-299 and NC-9922 appeared totally resistant in the trial but were moderately lesioned in other locations on the farm. The reason for the variable incidence of attack of these two clones was not determined, but it may have been due to the TPB preferring these clones over even less desirable ones or from lack of other suitable food sources nearby. Most or all *Populus* clones on the farm are probably somewhat susceptible to TPB injury when food choice is limited. For instance, clone NE-375, which had no TPB lesions in the clonal trial, developed lesions when caged with TPBs. In fact, it developed more lesions than susceptible clone NC-9921.

The TPB is a highly polyphagous insect that has a range of hosts, including 120 plant species representing 30 families (Taksdal 1963). Besides being a pest on numerous agricultural crops, TPB also feeds on various weeds. A survey of the Harshaw Farm revealed 21 principal weeds, of which 13 are known hosts of the TPB. Several of these weeds are high or moderate competitors of *Populus* (Table 2). Latson et al. (1977) and Tugwell et al. (1976) noted that horseweed and fleabane are the principal wild hosts of the TPB; these weeds are prevalent in and around the Harshaw Farm plantings. General observations throughout the farm indicated that *Populus* had fewer lesions where horseweed was abundant. TPBs were common on the horseweed, however, suggesting that preference for horseweed over *Populus* lowered the incidence of attack on *Populus*. Results were similar in tests where the TPB was caged with *Populus* and horseweed; the latter was fed on 10 times more often.

Latson et al. (1977) studied the behavior of TPB and found that the insect spent three times longer feeding on horseweed than on cotton, though it spent nearly four times as much time walking and resting on the cotton. Cotton is moderately attractive to the TBP. Stern (1969) suggested interplanting cotton and other crops with alfalfa to minimize lygus bug damage, because alfalfa is one of the preferred hosts of the TPB.

Although resistance of hybrid *Populus* to TPB feeding and subsequent lesion formation appears to be partly clonal, it is tempered by proximity to other food sources and TPB behavior (Fig. 4). The three clones in the test, though showing a wide range of injury over the range of treatments, retained the same ranking in susceptibility as in the clonal trial. In both trials clone NE-386 was most susceptible, NC-9921 intermediate, and NE-1 the least. When WDC was used as a cover crop with these susceptible clones, few lesions developed suggesting that WDC may have satisfied the TPB feeding. WDC is a normal host of the TPB

Table 2. Potential competitive level of the principal weed species at the Harshaw Research Farm that are hosts of the tarnished plant bug (TPB).

Common Name	Scientific Name	Potential Competiive level[a]
Lamb's quarters	*Chenopodium album* L.	High
Mustard	*Brassica* sp.	High
White cockle	*Lychnis alba* Mill.	High
Quack grass	*Agropyron repens* (L.) Beauv.	High
Horseweed	*Erigeron (Conyza)* canadensis (L.) Cronq.	Moderate
Daisy fleabane	*Erigeron annuus* (L.) Pers.	Moderate
Pigweed	*Amaranthus* sp.	Moderate
Canada thistle	*Cirsium arvense* (L.) Scop.	Low
Dandelion	*Taraxicum officinale* Weber	Low
Field-bindweed	*Convolvulus arensis* L.	Low
Goldenrod	*Salidago* spp.	Low
Ragweed	*Ambrosia* spp.	Low
Shepherd's purse	*Capsella bursa-pastoris* (L.) Medic.	Low

[a]Research data on file at USDA Forest Service, Forestry Sciences Laboratory at Rhinelander, WI.

and probably preferred over most *Populus* clones. Venables and Waddell (1943) suggested planting WDC as a cover crop in orchards to lure TPB away from fruit trees. They reported that red clover and alfalfa are superior hosts over WDC when in bloom but resisted recommending these on insect trap-crops because they would attract higher numbers of TPB and increase instead of decrease the risk to fruit trees. Alfalfa and clover are common near the Harshaw Farm and may affect the TPB population on the *Populus* plantings.

Populus is probably most attractive to TPB in the spring when the TPB adults emerge from their overwintering quarters in the dead weeds. At this time most weeds have not reached a stage that is attractive to the TPB. Prokopy et al. (1979) reported that TPB adults fed on flower buds in apple orchards in early spring but completed feeding by the time the developing fruit was about 1 cm in diameter. Most of the adults then died. Subsequent generations had little effect on apples, presumably because other plants were then more attractive to the TPB. Flowering plants attract the TPB so *Populus* should be least susceptible in summer and fall, unless the plants are removed and the TPB seeks other food. Poston and Pedigo (1975) found the TPB nymphs and adults migrate to other crops after cutting alfalfa. Stern (1969) observed lygus migrations to cotton and alfalfa from potatoes, other host crops, and weedy areas following harvest or cutting. Similar dispersal probably occurs over portions of the Harshaw Farm when potatoes, alfalfa, sunflowers, and clover are harvested nearby. Also, mowing or disking the weeds at the farm probably aid TPB migration to *Populus*.

Populus trees within herbicide, rolling cultivation, and WDC cover crop treatments had similarly low numbers of lesions probably due to the similarity of the amount of vegetation in each treatment at crucial times for the TPB. Sufficient clover as well as weeds in the herbicide and rolling cultivation plots probably lured the TPB away from the *Populus*. In contrast, the furrow cultivation plots were free from vegetation for much of the summer leaving the *Populus* more vulnerable to attack.

During the first two growing seasons after planting, *Populus* hybrids are a higher risk for the TPB lesion. Mueller and Stern (1973) found that lygus bugs, including the TPB, rarely fly more than 2 m above the ground. The succulent tissue of the main stem of *Populus* is usually well out of reach after the second growing season. Feeding may still occur on lateral branches but such lesions unless extremely numerous, are inconsequential to *Populus* growth and biomass production.

PREVENTION AND CONTROL

Herbicides, rolling cultivation, and cover cropping may minimize TPB injury if properly used or integrated with pesticides. Studies on the management of horseweed, white dutch clover, alfalfa, and other associated treatments are still needed before conclusions can be drawn. Horseweed is somewhat resistant to glyphosate herbicide and its presence seems to be beneficial. Perhaps some flowering weeds should be maintained near *Populus* plantings to entice TPBs away from the trees and encourage parasitism. Shahjahan (1974) and Shahjahan and Streams (1973) found that the major braconid parasite *Peristenus pseudopallipes* (Loon) of the TPB was attracted to horseweed and other *Erigeron* spp. flowers for feeding and prey searching. Species of *Erigeron* were necessary foods for maximum longevity of the parasite.

The TPB can be suppressed readily by one or more applications of suitable insecticides. Pruess (1974) reduced the TPB in alfalfa fields in Nebraska with ultra-low volume (ULV) malathion. He obtained from 89–98% control by applying 9.7 oz. ai/acre over a 16-mile^2 area in mid-August. Though generally successful as short-term suppression, he found nymphs from resident eggs and migrating adults from areas nearby quickly repopulated the field. Sevacherian and Stern (1975) showed that *Lygus* spp. move in mass numbers when attracted to a host. Pruess (1974) concluded that the TPB could not be successfully controlled by chemicals alone in Nebraska because of overlapping stages of the 3–4 yearly generations and strong migratory habits. Khattat and Stewart (1980) reported that Canada has three generations and Wisconsin probably has three generations also, indicating control difficulties similar to Nebraska. The single pilot test using malathion at the Harshaw Farm significantly reduced lesions. This test was made early in the season and probably killed most of the adults shortly after they emerged from overwintering before they laid many eggs. And, because few weeds were available at that time, most TPBs in untreated areas probably remained in place. Perhaps an early-season spray integrated with an appropriate weed management program might successfully control the TPB.

LITERATURE CITED

Gill, J. L. 1978. Design and analysis of experiments. Iowa State Univ. Press, p. 176–177.

Hori, K. 1974. Plant growth-promoting factor in the salivary gland of the bug, *Lygus disponsi*. J. Insect Physiol. 20:1623–1627.

Khattat, A. R. and R. K. Stewart. 1977. Development and survival of *Lygus lineolaris* exposed to different laboratory rearing conditions. Ann. Entomol. Soc. Amer. 70:274–278.

———. 1980. Population fluctuations and inter-plant movements of *Lygus lineolaris*. Ann. Entomol. Soc. Amer. 73:282–287.

King, W. V. and W. S. Cook. 1932. Feeding punctures of mirids and other plant-sucking insects and their effect on cotton. USDA Tech. Bull. 296, p. 1–11.

Latson, L. N., J. N. Jenkins, W. L. Parrott, and F. G. Maxwell. 1977. Behavior of the tarnished plant bug *Lygus lineolaris* on cotton, *Gossypium hirsutum* L. and horseweed, *Erigeron canadensis*. USDA, Agric. Res. Serv., Tech. Bull. 85, 5 p.

Miles, P. W. 1968. Studies on the salivary physiology of plant-bugs: experimental induction of galls. J. Insect Physiol. 14:97–106.

Mueller, A. J. and V. M. Stern. 1973. *Lygus* flight and dispersal behavior. Environ. Entomol. 2:361–364.

Painter, R. H. 1929. The tarnished plant bug, *Lygus pratensis* L., a progress report. Rep. Entomol. Soc. Ontario 60:102–107.

Poston, F. L. and L. P. Pedigo. 1975. Migration of plant bugs and the potato leaf hopper in a soybean-alfalfa compex. Environ. Entomol. 4:8–10.

Prokopy, R. J., R. G. Adams and K. I. Hauschild. 1979. Visual responses of tarnished plant bug adults on apple. Environ. Entomol. 8:202–205.

Pruess, K. P. 1974. Tarnished and alfalfa plant bugs in alfalfa; population suppression with ULV malathion. J. Econ. Entomol. 67:525–528.

Sevacherian, V. and V. M. Stern. 1975. Movements of *Lygus* bugs between alfalfa and cotton. Environ. Entomol. 4:163–165.

Shahjahan, M. 1974. Erigeron flowers as a food and attractive odor source for *Peristenus pseudopallipes*, a braconid parasitoid of the tarnished plant bug. Environ. Entomol. 3:69–72.

Shahjahan, M. and F. A. Streams. 1973. Plant effects on host-finding by *Leiophron pseudopallipes* (Hymenoptera: Braconidae), a parasite of the tarnished plant bug. Environ. Entomol. 2:921–925.

Stahl, F. J. and N. S. Leupschen. 1977. Transmission of *Erwinia amylovora* to pear fruit by *Lygus* spp. Plant Dis. Rptr. 61:936–939.

Stern, V. M. 1969. Interplanting alfalfa in cotton to control Lygus bugs and other insect pests. Tall Timbers Conference on Ecol. Animal Control by Habitat Mgt. Proc. 1:55–69.

Strong, F. E. 1970. Physiology of injury caused by *Lygus hesperus*. J. Econ. Entomol. 63:808–814.

Taksdal, G. 1963. Ecology of plant resistance to the tarnished plant bug, *Lygus lineolaris*. Ann. Entomol. Soc. Amer. 56:69–74.

Tingey, W. M. and E. A. Pillemer. 1977. Lygus bugs: crop resistance and physiological nature of feeding injury. Entomol. Soc. Amer. Bull. 23:277–287.

Tugwell, P., S. C. Young, Jr., B. A. Dumas, and J. R. Phillips. 1976. Plant bugs in cotton: importance of infestation time, types of cotton injury, and significance of wild hosts near cotton. Arkansas Agric. Exp. Sta. Rpt. Series 227, 24 p.

Varis, A. L. 1972. The biology of *Lygus rugulipennis* Popp. (Het., Miridae) and the damage caused by this species to sugar beet. Ann. Agric. Fenn. 11:1–56.

Venables, E. P. and D. B. Waddell. 1943. The influence of leguminous plants on the abundance of tarnished plant bug. Canadian Entomol. 75:78.

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