EFFECTS OF ASH FLOWER INDUCED BY *ERIOPHYES FRAXINIFLORA* ON TREE VITALITY

by Robert P. Wawrzynski[1] and Mark E. Ascerno

Abstract. The effect of ash flower gall (AFG) on green ash *(Fraxinus pennsylvanica)* vitality was assessed using root starch, diameter at breast height (dbh) and shigometry techniques. A chi-square analysis for root starch content versus gall density, indicated that root starch storage is independent of tree gall numbers. Percent change in dbh for the growing season was not affected by gall density (P=.261). In addition, percent change in electrical resistance and average electrical resistance over the growing season, were found to be independent of tree gall density (P=.054, P=.807, respectively) in multiple regression analyses. Assuming the methods used are reliable vitality indicators, AFG has no significant affect on these parameters of tree health. These results can be used in public education programs to better inform persons about AFG which may reduce the demand for control measures for this problem.

Résumé. L'effet du phytopte à fleur du frêne (AFG) sur la vigueur du frêne rouge (*Franinus pennsylvanica*) a été établi par l'emploi des techniques de l'amidon racinaire, du diamètre à hauteur de poitraine (D.H.P.) et du shigomètere. Une analyse de khi-carré pour le contenu en amidon racinaire par rapport à la densité de galles indiquait que l'emmagasinage d'amidon racinaire est indétendant du nombre de galles par arbre. Le pourcentage de variation dans le D.H.P. pour la saison de croissance n'était pas affecté par la densité de galles (*p*=0.261). De plus, le pourcentage de variation dans la résistance électrique et la moyenne de la résistance électrique après la saison de croissance s'étaient avérés être indépendant de la densité de galles (respectivement *p*=0.054 et *p*=0.087) lors d'analyses de régression multiple. Assumant que les méthodes employées sont des indicateurs sûrs de la vigueur, le photopte à fleur du frêne (AFG) n'a aucun effet significatif sur ces paramètres de la santé de l'arbre. Ces résultats peuvent être utilisés dans les programmes d'éducation du public afin de mieux informer les gens sur le photopte à AFG ce qui peut réduire la demande pour des mesures de contrôle envers ce problème.

Ash flower gall (AFG) is a common abnormality occurring on various ash *(Fraxinus)* species throughout the northern hemisphere (8). Extensive planting in the urban landscape has made green ash *(F. pennsylvanica)* the predominant species with this problem. The gall is caused by the eriophyid mite *Eriophyes fraxiniflora*, which feeds on the staminate (male) flowers each spring (6, 15), causing distorted, lobulate galls to form (15). Galls can remain on trees for two or more years.

Whether AFG affects tree vitality or is only an aesthetic problem remains unclear. Various authors (4, 5, 24) have suggested that AFG has no effect on tree vitality, although no scientific evidence is presented. Roivaine (13) did, however, report large numbers of *F. excelsior* to be dying from mite-destroyed inflorescences in Europe. In addition, galls on various other plant species have been shown to adversely affect plant health (1, 7). Debate among arborists, city foresters and researchers on the AFG-tree vitality relationship has contributed to the confusion.

The purpose of this study was to determine if AFG affects tree vitality as measured in three different ways. Various indicators are available to assess growth and vitality (10, 19, 21). Three indicators used in this study were root starch (18); diameter at breast height (2) and shigometry (14, 21). Information on AFG's effect on tree vitality can be used to determine the need for control measures to manage AFG.

Materials and Methods

Experimental Design. Sixty-three green ash *(F. pennsylvanica)* trees of similar size (6.1-7.6 m) and age (10-15 yr) were divided into nine replicates of seven trees each. Replicates had varying locations throughout St. Paul, Minnesota. However, one tree died during the course of the experiment, leaving 62 trees for analysis. Chemicals were applied in the spring of 1988 to six of the seven trees in each replicate for insecticide efficacy tests (25). Although the materials applied (Kelthane, Mavrik, Sevin, Soap, Sevin/Soap mix) were not found to be statistically significantly different in efficacy, a wide range of gall densities was created. The various levels of galls contained on each tree, then allowed for an accurate assessment of tree vitality.

Ash Flower Gall Sampling. Gall density

1. Present address: Swingle Tree Company, 8585 E. Warren, Denver, Colorado 80231.

estimates for each tree were obtained on 1 and 8 July 1988. The crown of each tree was visually divided into thirds (top, middle, bottom). Three branches were randomly chosen from each crown level. The terminal two-feet (61 cm) of each branch comprised the sample unit from which all current season's galls were counted and recorded. Nine terminals were selected per tree. Gall density estimates varied from 0-853 galls per tree. Previous season's (1987) galls were brown-black in color and easily distinguished from the current year's (1988) green galls.

Vigor Estimation Techniques. Root samples were collected and rated for starch content using a method that qualitatively determines root starch levels (19). Single, 2.54 cm square (approximately) root samples were collected from each of the 62 trees on 27 and 29 October 1987 (pre-growing season), one week after leaf abscission. Samples were taken from the same trees one year later on 21 October 1988 (post-growing season), using the same procedure.

Root samples were rated for high, medium or low starch content (19). Root starch was categorized as either increasing, decreasing or remaining the same during the 1988 growing season by comparing the fall 1987 and fall 1988 root sample ratings for each tree. In order to test for independence of root starch content and gall density using a Chi-square analysis, trees needed to be placed into gall density categories. Therefore, each tree was assigned to either of two arbitrarily created gall density categories, 0-25 and > 25 galls per tree. The root starch rating determined for each tree and the two gall density categories were then analyzed using a 2 × 3 chi-square test for independence.

Pre and post-growing season measurements of tree diameter at breast height (dbh) were taken on 10 March 1988 and 15 October 1988, respectively. These measures were used to calculate percent change in dbh for the 1988 growing season. All measures were taken at 1.4 m above the trunk base. Percent change in dbh was used in a multiple regression analysis to assess the affects of various gall densities on tree growth.

Electrical resistance (ER) measurements were taken using a Shigometer model 7950, on 10 dates between 16 May and 13 September 1988. A cambial probe, consisting of two non-insulated steel electrodes (1.5 cm apart; 5.4 cm long), was inserted into the tree cambial zone at 1.4 m above the trunk base. Electrical resistance was measured from the four cardinal points, then averaged to obtain a single electrical resistance estimate for each tree.

A multiple regression analysis was used for the percent change in electrical resistance over the growing season as it related to tree gall density. The percent change was calculated using the first (16 May 1988) and last (13 September 1988) electrical resistance readings for each tree. A simple linear regression model was fit for mean electrical resistance and gall density. Mean electrical resistance was computed by averaging the 10 electrical resistance readings taken throughout the growing season for each tree.

Results

Chi-square analysis indicated that root starch content and tree gall density were independent (Table 1). Amount of starch stored during the growing season was independent of tree gall density.

The multiple regression analysis for percent change in dbh used total tree gall numbers, initial dbh and their interaction as predictor variables. Analysis indicated that gall density was not significant ($P=.261$), and that only initial dbh ($P < .000$) was useful in predicting percent change in dbh. A graph of the pecent change in dbh versus gall density is given (Figure 1) to indicate the independence between the two variable (R^2). These data indicate that tree growth during the season (as measured by % change in dbh) was independent of tree gall density.

The regression model for percent change in electrical resistance used total gall numbers, initial electrical resistance and their interaction as indicator variables. Although the regression sug-

Table 1. Chi-square table for root starch ratings versus ash flower gall density categories.

Gall Density	*Seasonal Change in Root Starch*			
Per Tree	*Increase*	*No Change*	*Decrease*	*Total*
0-25	*9*	*19*	*6*	*34*
>25	*14*	*9*	*5*	*28*
Total	*23*	*28*	*11*	*62*

X^2 = 4.20; X^2 critical value (F = .05, 2 d.f.) = 5.99.

gested that percent change in electrical resistance and all density were related (P=.024), a graph of this relation (Figure 2) indicated that little correlation existed between percent change in electrical resistance and gall density (R^2=.082).

A simple regression analysis using mean electrical resistance for the growing season versus total gall density indicated that gall numbers had no predictive power (P=.807; R^2=.001) in estimating mean electrical resistance (Figure 3). Thus, shigometer analyses indicated that tree vitality as measured by cambial electrical resistance was independent of tree gall density.

Discussion

While it is likely that AFG does in some way affect the tree, this effect was not severe enough to reduce vitality, as assessed by the methods used. Mani (11) indicated that plants "suffer loss of substance and have increases in non-essential parts at the cost of essential parts" due to galls. In addition, Anderson and Mizell (1) noted that galls produced by *Phylloxera notabilius* Pergande on pecan *(Carya illinoensis)* foliage interfered with nutrient status and photosynthetic capacity. Thus, galls are capable of affecting plant vitality.

Root starch (17, 19, 20, 22) dbh (9) and shigometry (3, 23) have all been used to reveal the adverse effects of defoliation on tree vitality resulting from carbohydrate loss. Galls may have a similar effect in that they can "steal" vital nutrients as Mani (11) suggested causing a carbohydrate loss. Substantial reduction in carbohydrate should be detectable by the methods used in this study.

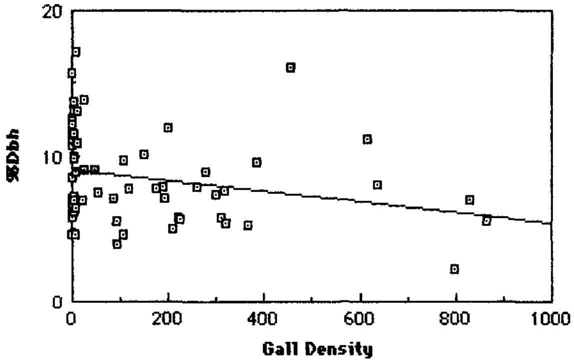

Fig. 1. Relationship between % change in dbh over the growing season and ash flower gall density.

Because we believe these methods are reliable, we conclude that AFG did not have an adverse affect on tree vitality in 1988. However, there are some factors that must be considered in making this conclusion.

A severe drought was experienced in Minnesota in 1988. Stress brought on by drought, may either increase the severity of a certain problem or mask a potential problem because of the trees reduced vitality. Also, this study was conducted during only one growing season. An accumulated effect on trees over several years wouldn't be reflected in a single-season measurement. Thus, a small effect on vitality in one season may not be important, but that effect magnified over several growing seasons could adversely affect tree condition. Periodic growth rate (PGR), a method to compare current and past growth (10),

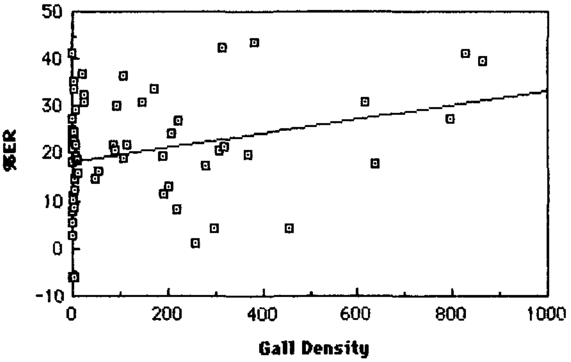

Fig. 2. Relationship between the percent change in ER as it relates to ash flower gall density.

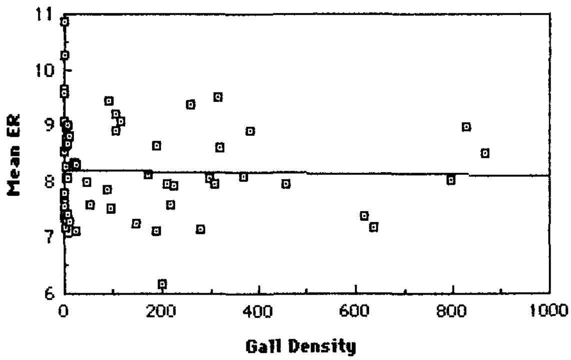

Fig. 3. Relationship between average ER for the growing season and ash flower gall density.

may be of value to study the long term effects of AFG.

Finally, the methods used to assess vitality are not without problems. Root starch was a qualitative measure and thus not as sensitive as a quantitative analysis would be. The use of the shigometer as a tool to assess vitality is relatively new (16), and there is skeptism as to its predictive power (12). Newbanks indicated that little correlation existed between electrical resistance and vitality in sugar maple *(Acer saacharum).* In addition, Wargo and Skutt (23) indicated that the shigometer is affected by tree species, diameter, crown classification and condition.

This study used trees with wide ranges of gall density and the authors selected trees to counter problems associated with the methodology (i.e. Shigometry). Thus, we feel this permitted an accurate assessment of AFG's effect on vitality. It is concluded that tree vitality was not adversely affected by gall density in 1988. If this conclusion can be verified over several seasons, the information may be useful to persons involved in the management of AFG. Educating the public that AFG doesn't affect tree health, may reduce requests for its control.

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Literature Cited

1. Anderson, P.C. and R.F. Mizell. 1987. Physiological effects of galls induced by *Phylloxera notabilius* (Homoptera: Phylloxeridae) on pecan foliage. Environ. Entomol. 16:264-268.
2. Avery, T.E. and H.E. Burkhart. 1983. Forest measurements. Mcgraw-Hill, Inc., 331 pp.
3. Davis, W., W. Shortle and A. Shigo. 1980. Potential hazard rating system for fir stands infested with budworm using cambial electrical resistance. Can. J. For. Res. 10:541-544.
4. Dix, M.E., J.E. Pasek, M.O. Harrell and F.P. Baxendale. 1987. Common insects pests of the Great Plains. Great Plains Agric. Council Publ. No. 119, 44 pp.
5. Felt, E.P. 1906. Insects affecting park and woodland trees, VII. New York State Education Dept., Albany, N.Y. 857 pp.
6. Felt, E.P. 1918. Key to the American insect galls. The Univ. of the State of New York. 310 pp.
7. Furniss, R.L. and V.M. Carolin. 1977. Western forest insects. USFS Misc. Publ. No. 1339, 654 pp.
8. Keifer, H.H. 1952. The eriophyid mites of California. Bull. Calif. Ins. Serv., 2:1-23.
9. Kramer, P.J. and T.T. Kozlowski. 1979. Physiology of woody plants. Academic Press, Inc. New York, N.Y., 811 pp.
10. Mahoney, R.L. 1977. Classifying lodgepole pines as resistant or susceptible to mountain pine beetle. M.S. Thesis, Univ. of Idaho, Moscow. 28 pp.
11. Mani, M.S. 1964. Ecology of plant galls. Dr. W. Junk, Publishers-The Hague, 434 pp.
12. Newbanks, D. 1976. The relationships between electrical resistance of cambial tissues of *Acer saocharum* and physiologic stress. M.S. Thesis Univ. of Mass. 59 pp.
13. Roivaine, G. 1951. Contribution to the knowledge of eriophyids of Finland. Acta. Entomol. Fenn. 8:1-76.
14. Shigo, A.L. and W.C. Shortle. 1985. Shigometry: A reference guide. USDA For. Serv. Agric. Handb. No. 646, 48 pp.
15. Stein, J.D. and P.C. Kennedy. 1972. Key to the shelter belt insects in the northern Great Plains. USDA For. Serv. Res. Pap. RM-85, 152 pp.
16. Tattar, T.A. and R.O. Blanchard. 1977. Electrical techniques for disease diagnosis. J. Arboric. 3(2): 21-24.
17. Wargo, P.M. 1971. Seasonal changes in carbohydrate levels in roots of sugar maple. USDA For. Serv. Res. Pap. NE-213.
18. Wargo, P.M. 1975. Estimation of starch content in roots of deciduous trees-a visual technique. USDA For. Serv. Res. Pap. NE-313.
19. Wargo, P.M. 1978. Judging the vigor of deciduous hardwoods. USDA Comb. For. Pest Res. Dev. Prog. Agric. Inf. Bull. No. 418.
20. Wargo, P.M. 1981. Defoliation and secondary action organism attack: with emphasis on *Armillaria mellea.* J. Arboric. 7(3):64-69.
21. Wargo, P.M. 1981a. Measuring the response of trees to defoliation. *In* The Gypsy moth: research toward integrated pest management. USDA For. Serv. Tech. Bull. No. 1584.
22. Wargo, P.M., J. Parker and D.P. Houston. 1972. Starch content in the roots of defoliated sugar maple. For. Sci. 18:203-204.
23. Wargo, P.M. and H.R. Skutt. 1975. Resistance to pulsed electric current: an indicator of stress in forest trees. Can. J. For. Res. 5:557-561.
24. Wawrzynski, R.P. and M.E. Ascerno. 1988. Plant galls. Univ. of Minnesota Extension Public. AG-FS-1009, 2 pp.
25. Wawrzynski, R.P. and M.E. Ascerno. 1989. Ash flower gall: within tree distribution and chemical management. J. Arboric. 15(9):215-218.

Department of Entomology
University of Minnesota
St. Paul, MN 55108