Bur oak blight on *Quercus macrocarpa*, an exploration of two macro-infusion treatments

Danielle Penke[1]
Mike Bahe[2]
Doug McNew[3]
Thomas C. Harrington[3]

Department of Plant Pathology, 351 Bessey Hall,
Iowa State University, Ames, Iowa 50011

ABSTRACT

Bur Oak Blight, discovered by previous research at Iowa State University, is a leaf disease caused by a recently discovered fungus[2]. This disease appears to be more serious than other diseases on bur oaks, causing major defoliation and leading to mortality of trees. Bur Oak Blight has been documented largely in Iowa, southwestern Wisconsin, Eastern Nebraska, and Southern Minnesota[1,3]. Only recently has the disease been becoming more prevalent in regions of central Minnesota due to the availability of a bur oak variety in the oak savannah that is particularly susceptible to the blight. Although disease seems to progress slowly, infected trees become weaker each year. Previous macro-injections have shown a way to control the symptoms of Bur Oak Blight by injecting a fungicide into the vascular system, allowing the tree to draw up the fluid and distribute it to the branches[3,6]. Managing the disease is important to control the effects of secondary pests, prevent loss of habitat to species living on and around bur oaks, and allow the maximum food source production by bur oaks for other organisms[1]. In addition, large, bur oak trees in communities are of high-value to citizens and park systems that are willing to apply treatment to prolong the life of these trees. This study aims to compare two groups: a single macro-injection at full amount and two injections at half amount of propiconazole fungicide to treat the symptoms of Bur Oak Blight. Our hypothesis was that double injections may be more effective at preventing phytotoxicity due to the fungicide and allow a more distributed uptake of the fungicide, causing an better recovery of the experimental trees. We found that there is no statistical significance between single injections and double injections. However, both injections were successful in improving the symptoms and health of the trees compared to trees with no injection.

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[1] Author; Biology student; Iowa State University
[2] Arborist and Natural Resource Specialist; Hutchinson, MN
[3] Principal Investigators; Iowa State University

INTRODUCTION

Bur Oak Blight, a disease that affects the leaves of *Quercus macrocarpa var. oliviformis,* is becoming more evident in regions of central and southern Minnesota[4,6]. The disease is caused by a recently discovered fungus, *Tubakia iowensis,* which resides on the petioles of infected bur oak trees[3]. The fungal spores are spread via rainfall, particularly in the early spring months. Bur Oak Blight or BOB tends to develop slowly and become more severe each year. After many years the disease can result in limb dieback and increased vulnerability to secondary pests such as the two-lined chestnut borer[1,2,3]. The fungus causes serious leaf and veinal necrosis on a large percentage of leaves, making the trees appear entirely brown or yellow[2,3]. *Quercus macrocarpa var. oliviformis* is a variation of bur oaks that are susceptible to BOB[2]. The most susceptible bur oaks are those naturally occurring on upland sites in former oak savannahs. Interestingly, many of the infected bur oaks are near trees of the same variety that are resistant to the fungal disease[3]. Trees infected with BOB have a tendency to retain infected and dead leaves over the winter[1,2,4,6]. The petioles of these leaves have a strong hold on the branches of the tree allowing them to remain attached during heavy snowfall and strong winds. On these attached petioles, black pustules containing spores are broken open by spring rainfall and the spores are dispersed to other leaves and trees within the water droplets, and a new infection occurs[2]. At the beginning of summer, leaves appear healthy and green. However, in late August and September, infections are in full force and quite apparent. During winter these dead leaves remain on the tree and form black pustules at the base of the petiole. The cycle begins again. As of present, few treatments are available to manage BOB and none are known to completely eradicate the disease. However, improvement of the appearance and health of large, native trees is extremely important in urban areas and communities. If homeowners and citizens are passionate about prolonging the lives of bur oaks in their community, fungicide injection of Propiconazole may be a useful tool to manage Bur Oak Blight and prevent infestation of secondary invaders[1,2,5]. This paper describes and compares two experimental macro-infusion procedures, single injections and double injections of propiconazole fungicide, as a way to combat the symptoms of Bur Oak Blight. Fifteen trees were used in the study: 5 single injections, 5 double injections, and 5 controls.

STUDY SITE

All 15 trees included in the study were located across the 34 acres of Oakland Cemetery in Hutchinson, MN. Hutchinson is part of the oak savannah habitat where Bur Oaks were formally the dominant species, due to fire tolerance. Even after much cultivation and urbanization of the area, the rich soil of Oakland Cemetery is still home to a number of Bur Oaks, many of which present the symptoms of Bur Oak Blight. Bur Oak Blight is also prevalent across the city, both on private and public land, causing concern from citizens and the Hutchinson Forestry Department.

MATERIALS AND METHODS

Solution and Dilution
A systemic propiconazole fungicide produced by Alamo® was purchased from Rainbow Treecare Scientific Advancements. Single injection trees received the full amount in the one injection. Double injection trees received half the amount of propiconazole in the first injection and the other half in the second injection. The amount and dilution injected was 10mL Propiconazole: 1 L Water: 1 in DBH.

Conditions
A total of 15 trees were chosen from the site based on the presence of Bur Oak Blight. The petioles of the overwintered leaves were examined for pustules, and upon identification were given a tree ID number. The trees included in the experiment had varying degrees of severity; however, the averages of the severity of the trees for each treatment were similar. Each tree was randomly assigned to the single injection, double injection, or control group using a random number table. A random number table was also used to determine the order in which the experimental trees would be injected starting on June 18th, 2013. Trees in the double injection group received the second injection exactly one week after the first injection. The date to begin injecting depended largely on the long winter as the last snow occurred in early May. Once the trees had fully leafed out and weather was suitable, we began injections.

All injections were done on warm, sunny days with temperatures between 70 and 80°F. These conditions facilitated rapid uptake of the propiconazole solution, which may have led to a more even distribution of the fungicide to effectively knockback the disease. Injection procedure started on June 18th, 2013 and ended on June 27th, 2013. All single injections trees were done in the first week while all doubles injections received the initial injection during week one and the final injection in week two.

Preparation of Trees
Using a shovel, the soil around the tree was removed, creating approximately a one-foot radius around the base of the tree. The root flares were exposed and brushed off with a hard bristled brush to remove all soil and debris. Clean surfaces of the roots ensured consistent drilling and prevented soil from clogging the holes and affecting uptake of the fungicide. The trees were inspected for rot, girdling roots, and decay, which also affect uptake time.

A new 15/64 diameter, high helix drill bit was used for each treatment of trees (n=5). In the single injection trees, one inch holes were drilled into the healthy xylem tissue (this depended on the thickness of the bark) every four inches around the base of the tree. The holes were made perpendicular to the surface of the root flare. In the double injection trees, one inch holes were made every seven inches for the first injection. For the second injection, new holes were drilled in between the previous holes. The previous holes were not used as soil blocked most of them. Areas of decay and valleys between the root flares were avoided in order to allow the most efficient uptake and prevent the fungicide from pooling up in cavities within the tree. This created slight variation in the distance between infusion tees.

Equipment

The macro-infusion equipment was purchased from Rainbow Treecare Scientific Advancements, 11571 K-Tel Drive Minnetonka, MN 55343. The equipment included a macro-infusion pump, infusion tees, connector tees, tubing, and drill bits. Addition equipment included a shovel, hard bristled brush, reservoir for the fungicide solution, battery, mallet, drill, and wire.

Assembly

One foot sections of tubing were connected to the infusion tees to make a continuous hose. The infusion tees were inserted vertically into the previously drilled holes and gently pounded into the vascular tissue with a rubber mallet. On opposite sides of the tree, two secondary supply hoses were connected to single infusion tees. The two secondary supply hoses were joined with a connector tee to the primary supply hose which was connected directly to the pump. The primary and return hose were placed in the reservoir.

Injection

One liter of water was run through the system, while bubbles were removed from the hoses connected to the infusion tees. Care was taken to ensure no air entered the primary hose. The pump was turned off while the propiconazole was diluted. The infusion was continued and maintained at a pressure of 15 psi until the solution was completely taken up by the tree. The infusion sites were monitored for leaks throughout the procedure. Another liter of water was added after the solution was gone to clear out the hoses. The apparatus was disassembled and the soil and sod was replaced.

FIG. 1. Macro-infusion setup for injection of bur oaks. A. Excavation and preparation of root flares for drilling. B. Vertical placement of infusion tees to maximize steady flow of solution. C. Propiconazole solution flowing from reservoir through primary hose to the infusion tees. D. Broad view of the macro-infusion apparatus.

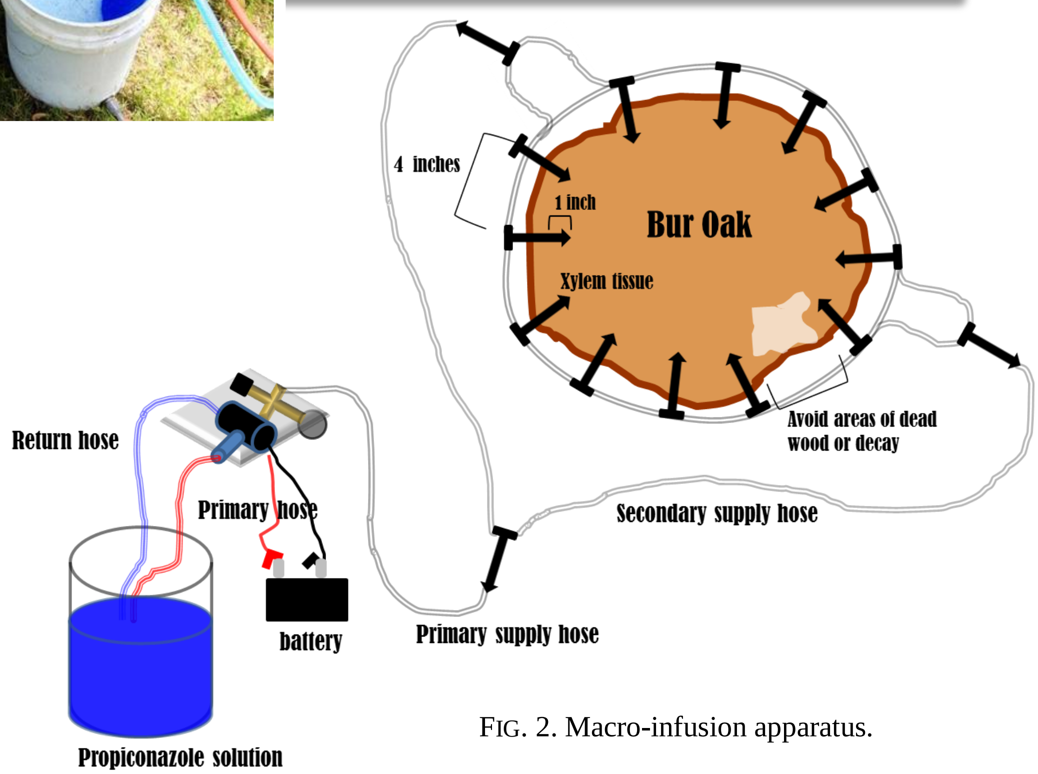

FIG. 2. Macro-infusion apparatus.

TABLE I. Ratings of Bur Oak trees with confirmed Bur Oak Blight before and after injections

Tree ID	Treatment	DBH	Overwintered leaves rating[a]	Combined[b]	Distribution of symptomatic leaves rating[c]	Combined[d]
10	single	46	3/2.	5	2/0.	2
11	single	32	2/2.	4	3/2.	5
3	single	26	3/2.	5	0/0.	0
15	single	40	3/3.	6	3/3.	6
13	single	32	3/2.	5	3/2.	5
9	double	40	3/3.	6	3/2.	5
1	double	42	3/3.	6	3/3.	6
7	double	36	3/2.	5	3/1.	4
14	double	32	2/1.	3	1/1.	2
4	double	52	2/1.	3	2/1.	3
12	control	27	3/2.	5	3/3.	6
6	control	30	3/3.	6	3/3.	6
8	control	34	2/1.	3	3/1.	4
2	control	24	3/2.	5	3/3.	6
5	control	22	2/2.	4	3/3.	6

[a] Rating of disease severity based on retention of leaves over the winter. Data collected 05-17-13. The first number is the severity of the lower half of the tree and the second number is the severity of the top half of the crown. Ratings go from 0-3: 0 is the presence of no symptoms, 3 is representative of severe symptoms.
[b] Combined rating based on the addition of the two ratings of the overwintered leaves rating.
[c] Rating of disease severity based on the distribution of brown/yellow colored leaves. Data collected 09-21-13.
[d] Combined rating based on the addition of the two ratings of distribution of symptomatic leaves.

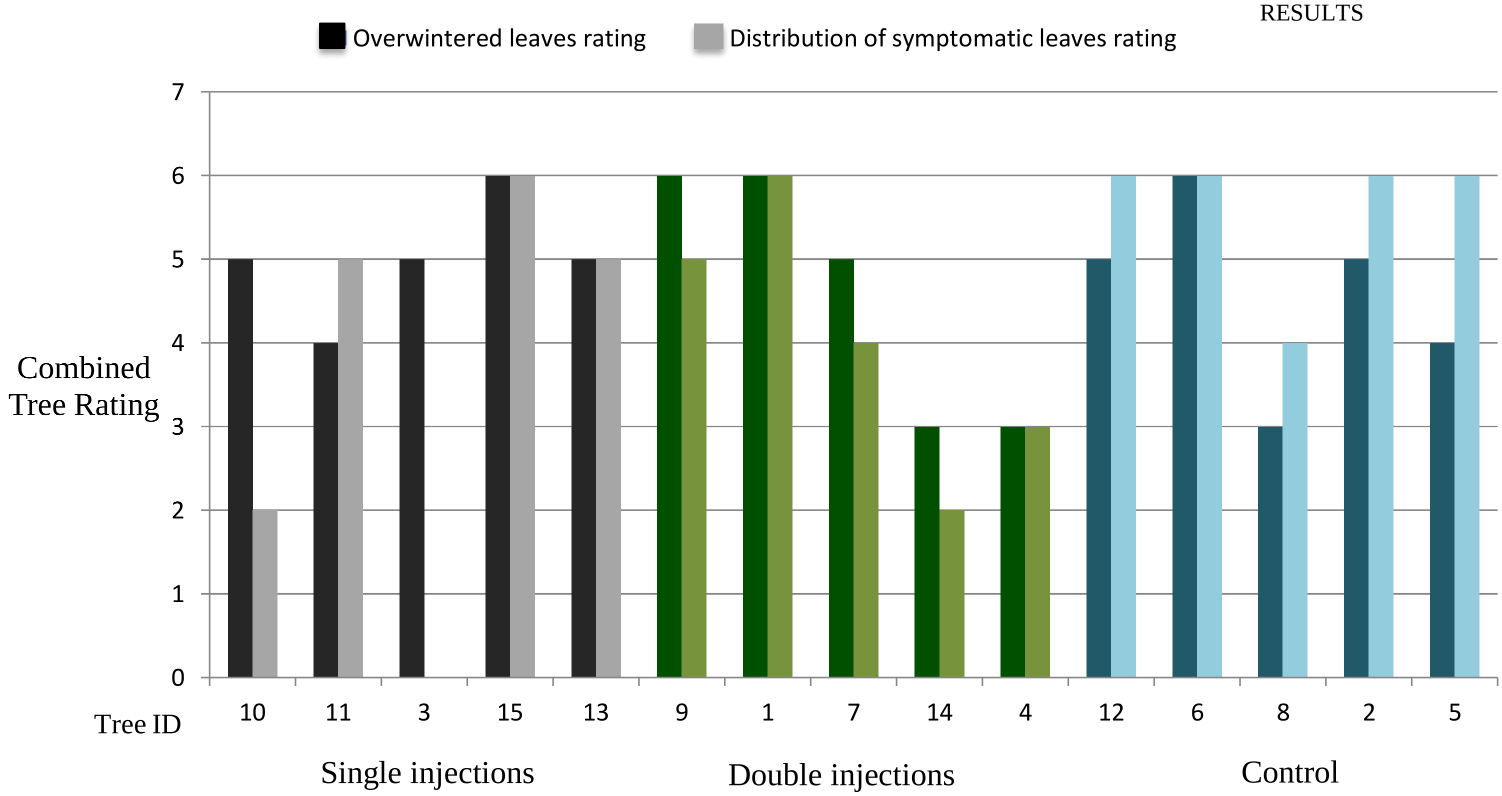

FIG. 3. A comparison of combined ratings before injections on 05-17-13 based on the retention of leaves over the winter and after injection on 09-21-13 based on distribution of necrotic leaves on both single injection trees and double injection trees. The ratings were done the same in the control group which received no injection.

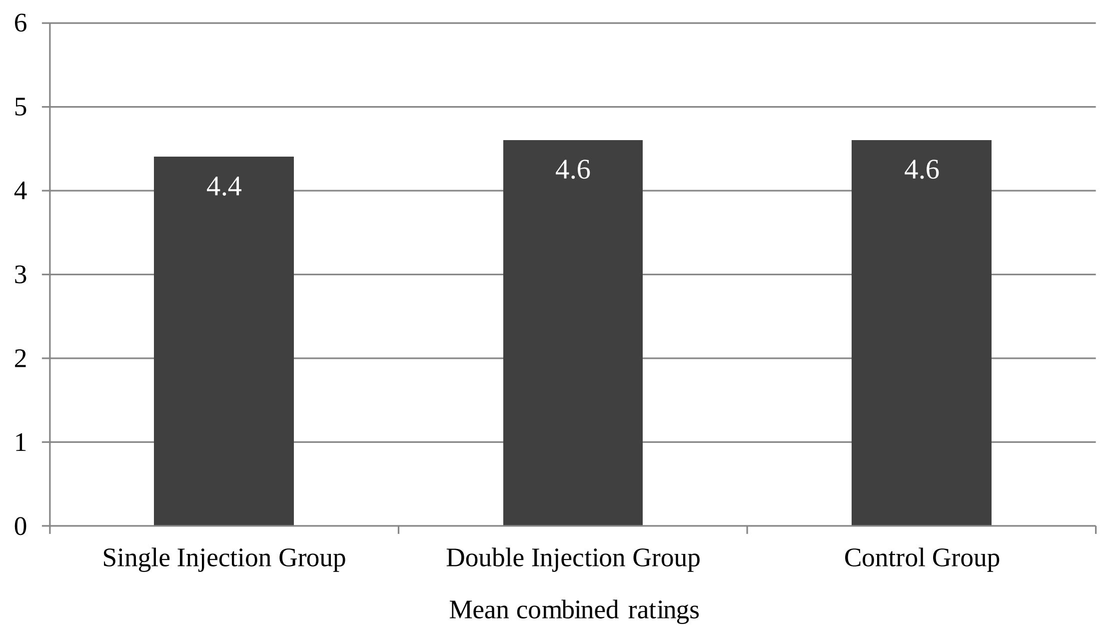

FIG. 4. A comparison of the mean combined ratings *before injections* based on retention of overwintered leaves of the single injection, double injection, and control group.

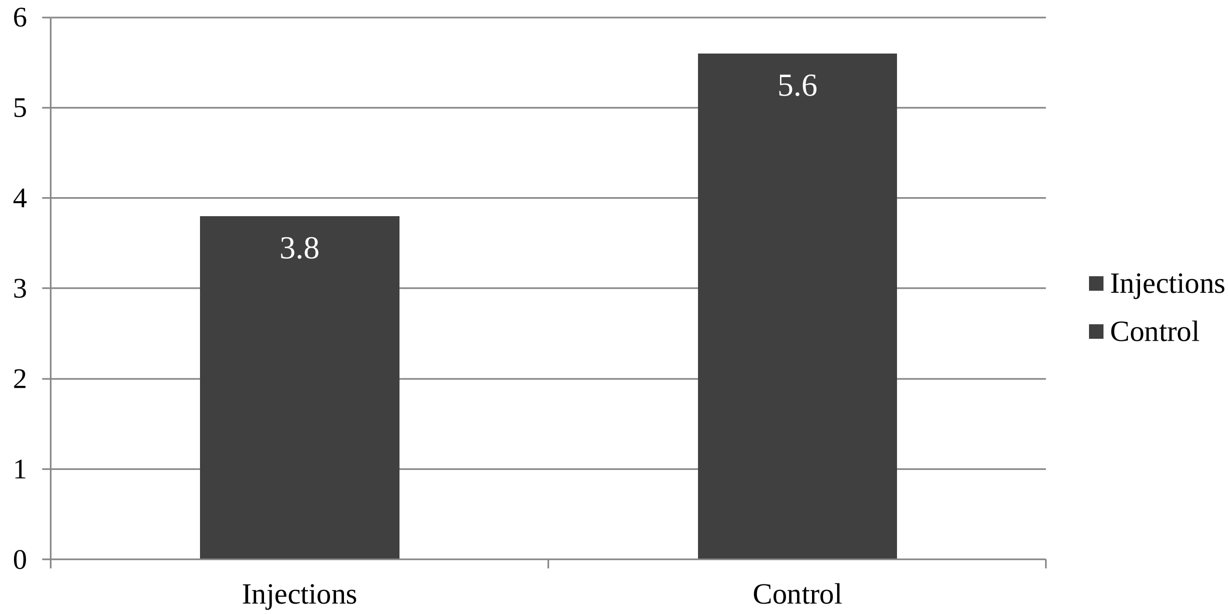

FIG. 5. A comparison of the mean combined ratings *after injections* based on distribution of disease of a combination of the two injection groups (single and double) versus control.

Based on the comparison of individual tree ratings before and after injections, the ratings of trees in both experimental injection groups either decreased or remained constant with one exception: tree 11 (FIG. 3). Trees 10 and 3 of the single injection group showed very visible improvement. In contrast, all ratings of control trees either increased or remained the same (FIG. 3). Before injections, the mean of combined ratings taken on 05-17-13 for each experimental group showed no significant difference (FIG. 4). After injections, the differences in mean combined ratings taken on 09-21-13 between the single injection group and the double injection group were not significant. However, together the two injection conditions show a statistically significant decrease in mean combined rating compared to the control trees (FIG.5). An unpaired, two-tailed t-test was conducted to compare the injections and the control conditions. We are 95% confident that there was a significant difference in the mean combined ratings of the injection group (M= 3.8, SD= 1.89) and the control group (M= 5.6, SD=.894) conditions; t (13) = 1.77, p=.031, a=.05. These results suggest the effectiveness of either methods of injection.

Phytotoxicity was observed randomly between single injection and double injection groups. No trees experienced severe leaf burn. Two trees in the single injection condition (trees 1 and 15) and one tree in the double injection condition (tree 7) showed phytotoxicity to the propiconazole approximately three days post injection. Even the single injection of full amount at the previously stated dilution seems to be safe and effective. In terms of disease, 14/15 trees started showing symptoms within in the first two weeks in August.

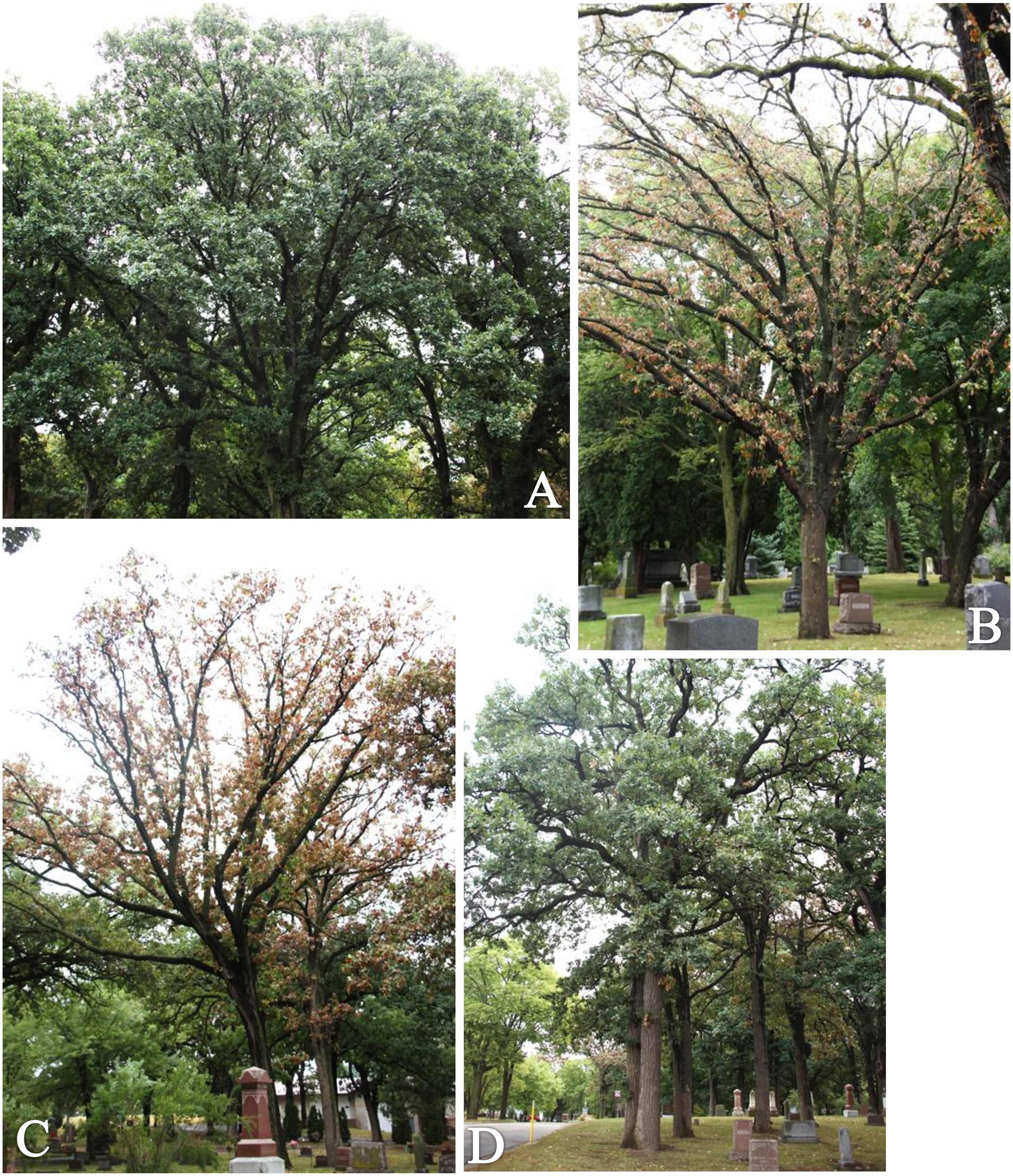

FIG. 8. A comparison of ratings and treatments. A. Single injection tree with a decreased rating of 0/0 (Tree 3). B. Severe control tree with a rating of 3/3 (Tree 12). C. Control tree with an increased rating of 3/3 (Tree 5). D. Double injection tree with a consistent rating of 2/1 (Tree 4).

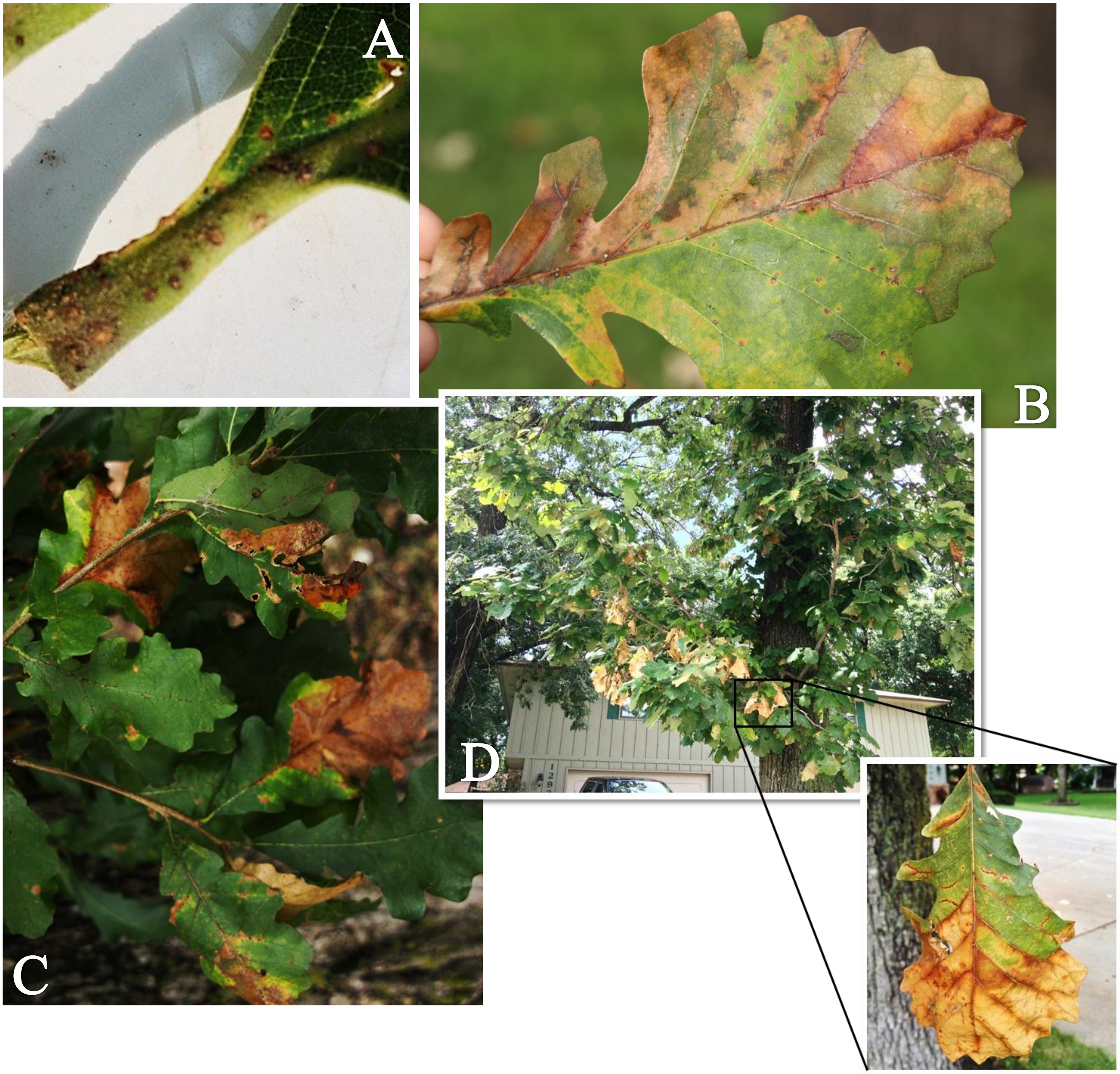

FIG. 7. Symptoms of disease and results of injections. A. Petiole pustules containing fungal spores of *Tubakia iowensis.* B. Leaf and veinal necrosis in late August. C. Affected branch of an injected tree. D. An example of phytotoxicity or leaf burn as a result of injection of fungicide.

Discussion

Macro-infusions of propiconazole fungicide provide an effective way to decrease the symptoms of Bur Oak Blight in bur oak trees. From the data, we see that there is no significant difference in single and double injection treatments of fungicide. When pooling the data from the injected trees, there is a significant decrease in symptoms and increase in heath of the trees compared to the trees without injections (Fig. 5).

Because macro-infusions are time consuming, arborists and citizens should proceed with single injections of the full amount. These single injections will effectively knockback the disease, presumably for a few years, causing very minimal phytotoxicity, if any. However, some trees may be too developed in the disease that treatment will have negligible effects such as tree 15 and tree 1 (Fig. 3). This should be taken into consideration before committing time and money to these trees.

Previous data shows that symptoms of injected trees may continue to decrease in the next season of the disease. The severity of this disease may also be related to the amount and timing of rainfall, as the fungal spores require water to disperse. Additional data will be collected during next spring and summer to observe the later effects of the fungicide injections.

Future exploration should be done to determine the optimum time of injections, the length of effectiveness of the fungicide, and which trees may be too severe to treat.

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