Effect of Nickel Applications for the Control of Mouse Ear Disorder on River Birch[1]

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Abstract

Mouse ear (leaf curl, little leaf, squirrel ear) disorder has been a problem in container-grown river birch (*Betula nigra* L.) for several decades. The disorder is easy to detect in nurseries as the plants appear stunted due to shortened internodes which give the appearance of a witches-broom. The leaves are small, wrinkled, are often darker green in color, are commonly cupped and have necrotic margins. Plants grown in soil rarely express the disorder. A trial was initiated in June 2003 to determine if a deficiency of nickel was the cause of mouse-ear on river birch. Symptomatic river birch trees (*Betula nigra* 'BNMTF' Dura-Heat™) in their second growing season in #15 containers were selected for uniformity of size and mouse ear. Treatments included a 1) control, 2) 789 ppm Ni sprays, 3) 394 ppm Ni sprays, 4) 0.005 lbs Ni/yd^3 as a drench, 5) 26 g/pot triple superphosphate (0–46–0), and 6) 130 g/pot Milorganite. Nickel was applied as nickel sulfate, whereas triple superphosphate and Milorganite contain trace amounts of nickel. At 16 days after treatment, up to 5 cm of new growth was evident on plants sprayed with nickel. Thirty days after treatment shoot length increased up to 60%, leaf area increased 80 to 83%, and leaf dry mass increased 76 to 81% for plants sprayed or drenched with nickel sulfate. Plants treated with triple superphosphate or Milorganite did not resume normal growth. All plants treated with nickel sulfate in 2003 did not show symptoms of mouse ear after initiation of growth in 2004. Based on this research mouse ear disorder of river birch is caused by a deficiency of nickel which can be corrected by foliar or drench applications of nickel sulfate.

Index words: foliar application, mouse ear disorder, nickel sulfate, river birch.

Species used in this study: *Betula nigra* L. 'BNMTF' Dura-Heat.

Significance to the Nursery Industry

This is the first research to document that mouse ear disorder on river birch is caused by a deficiency of nickel. Mouse ear disorder on river birch has become a national problem during the past decade. There are approximately 300,000 to 400,000 river birch trees grown in the southeastern United States annually. Many growers have dropped river birch from production because of the mouse-ear problem. Research is currently under way to refine methods of application, rates of application, cultural practices to assure bioavailability of nickel, and sources of nickel suitable for use. Being a heavy metal, research is needed to determine the safest methods of application and the lowest use rates possible. Solving the mouse ear problem has substantial economic impact for growers across the United States. While nickel has been considered an essential element for some crops, it has never been recognized as a fertilizer. The American Association of Plant Food Control Officials (AAPFCO) approved nickel as a micronutrient fertilizer in August 2004 (Bruce Wood, Research Scientist, USDA-ARS, Byron, GA, personal communication) and a commercial nickel product will be available pending state registrations in 2005 (Mark Crawford, Owner, NIPAN LLC, Valdosta, GA, personal communication).

Introduction

Mouse ear (leaf curl, little leaf, squirrel ear) has been a problem in container-grown river birch (*Betula nigra*) since the 1970s (Larry Edwards, Turtle Creek Nursery, Davidson, NC, personal communication). To date mouse ear has been noticed in several southeastern states as well as Minnesota, Ohio, Oregon, and Wisconsin (6, 14). The problem has caused considerable economic impact in the southeast with some growers indicating that they plan to drop river birch from production.

The disorder is easy to detect in nurseries as the plants appear stunted and may appear to have been 'sheared' into their stunted form (6, 14). The leaves are small, wrinkled, often darker green in color, commonly cupped, and have necrotic margins. Interveinal chlorosis is generally lacking in symptomatic leaves. New growth also has severely shortened internodes, giving a witches-broom appearance (Fig 1).

Plant pathogens and eriophyid mites have been suggested as possible causes of mouse ear, but these have never been detected. Non detectable concentrations of sulfonyl-urea her-

Fig. 1. Leaves of river birch tree expressing mouse ear disorder. Note shortened internodes, small leaves with crinkled foliage and marginal necrosis.

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bicides have been suggested as the cause (C. Whitcomb, Lacebark, Inc., Stillwater, OK, personal communication). Jeffers et al. (6) determined that mouse ear does not appear to be caused by herbicide damage, macronutrient deficiency or plant pathogens, while McNamara et al. (11) ruled out insects, insect-vectored pathogens and the need for viable soil microorganisms. Symptomatic plants have been noted from tissue-cultured liners to #45 containers. Health of the root system appears to be important. The problem appears to be correlated with plants that have been in containers for too long and are rootbound. The problem occurs in plants grown using the pot-in-pot system. Water stress also appears to be related to the problem. Mouse ear disorder commonly occurs on border rows near the road where the sprinklers do not provide enough overlap to adequately water the plants (J. Ruter, personal observation). This generally occurs later in the summer when roots have filled the containers. Containers on border rows are also exposed to increased solar radiation, which results in reduced root growth and mortality due to high root-zone temperatures (13).

Mouse ear disorder has occurred on named cultivars and seedlings from several sources (14). The problem occurs on plants fertilized with controlled release fertilizers and plants receiving fertigation. Symptoms have been seen on plants with high and low soluble salt readings, high and low substrate pH, with or without healthy root systems, and early, mid, and late season. Plants may appear free from the disorder in the fall, but develop the problem when growth resumes in the spring. Strangely, some plants may only show the problem on one branch, or only certain plants in a block may show the problem. Symptoms may be uniform thru an entire block or quite often appear randomly.

Mouse ear on river birch plants growing in the field is rare. Symptomatic plants in the southeast have been associated with high pH soils (14). Several growers have noted symptoms on field grown plants in Oregon (B. Marable, Tree Introductions, Inc., Athens, GA., personal communication). River birch is intolerant of high pH soils, and in native areas of Ohio is only found on soils with a pH of 5.5 or less (10). Plants with the problem that are transplanted into the field generally grow out of the problem within one season (14). Plants growing in containers that root into the native soil either do not express the problem or grow out of the disorder. This leads me to believe there is an element in native soil that we are not supplying via the pine bark-based substrates and highly refined fertilizers commonly in use today. Research in 2003 (11) indicated that adding native soil to river birch grown in a peat-based substrate prevented mouse ear disorder from developing, but the authors did not give a reason for the response.

Boron, manganese, molybdenum, and zinc were evaluated to determine if foliar, drench, and topdress applications would correct mouse ear symptoms on river birch, but they did not (J. Ruter, unpublished data). Combinations of manganese, zinc, and gibberellic acid provided no improvements. Zinc deficiency has been shown to cause classic little leaf disorder on *Betula pendula* (5). However, rosetting from zinc deficiency, though similar, looks different from mouse ear.

Recent research in Georgia has indicated that the cause of mouse ear on pecans (*Carya illinoinensis*) appears to be a nickel (Ni) deficiency induced by high levels of zinc and/or other metal micronutrients in the soil (17). Applications of Ni to pecan trees in the fall or spring eliminated mouse ear and trees resumed normal growth. Application of phosphorus (triple superphosphate) to pecan trees also reduced severity of mouse ear (18). Phosphorus fertilizers are known to be contaminated with nickel (2, 16). Milorganite is a fertilizer product derived from the digestion of sewage sludge which contains nickel and is used in the preparation of container substrates. The purpose of this research was to determine 1) if foliar and drench applications of nickel sulfate or 2) topdress applications of triple superphosphate or Milorganite would correct mouse ear disorder on container-grown river birch.

Materials and Methods

A study was initiated on June 9, 2003, at Wight Nurseries, A Monrovia Grower in Cairo, GA. River birch (*Betula nigra* L. 'BNMTF' Dura-Heat™) in their second growing season in #15 (50.6 liter) containers were selected for uniformity of size. All plants showed severe stunting and symptoms typical of mouse ear disorder on river birch. Plants were treated between 11 a.m. and 12 p.m. EST under partly cloudy skies with an air temperature of 32.2C (90F). Treatments included a 1) control, 2) 789 ppm Ni spray, 3) 394 ppm Ni spray, 4) 0.005 lbs Ni/yd^3 (150 mg Ni/pot) as a drench, 5) 26 g/pot triple superphosphate (0–46–0; Royster-Cark, Inc., Tifton, GA), and 6) 130 g/pot Milorganite (Milwaukee Metropolitan Sewerage District, Milwaukee, WI). Nickel for treatments 2–4 was from nickel (II) sulfate hexahydrate (certified ACS; Fisher Scientific, Pittsburg, PA). Spray treatments were applied at ~100 gal/A and included 4.0 lb/100 gal urea and 4.0 ml/gal SilEnergy surfactant (Brewer International, Vero Beach, FL). The drench treatment was applied at a volume of 500 ml/pot. Both triple superphosphate and Milorganite were applied to the surface of the substrate. Plants were arranged utilizing a completely randomized design with six single plant replicates.

Observations were made weekly and plants were rated for mouse ear (percentage of canopy showing mouse ear symptoms). Samples were collected 30 days after treatment. Five stems from each plant were cut back to the point where new growth had initiated in 2003. Shoot elongation was recorded, then leaves from the five stems were removed, counted, and run thru an LI-COR 3000 (LI-Cor, Inc., Lincoln, NE) leaf area meter to determine leaf area for the composite sample. Leaves were dried for three days at 66C (150F) in a forced-air dryer and dry mass was determined. Specific leaf area was calculated as leaf area/leaf dry mass. Number of leaves per unit shoot elongation was calculated as number of leaves/mean shoot elongation. Data was subject to analysis of variance using SAS (15) and mean separations were conducted using Dunnett's t-test to compare treatments to a non-treated control. Plants were maintained under standard cultural practices at the nursery through May 2004 so observations could be made on development of mouse ear during the following growing season after application of nickel sulfate.

Results and Discussion

Within seven days after treatment (DAT), plants sprayed with nickel sulfate showed normal leaf growth. At 16 DAT, the same plants had up to 5 cm (2 in) of normal growth, while the plants drenched with nickel were beginning to show normal shoot elongation. After 30 days, all plants treated with nickel sulfate had 100% normal growth, where as plants

Table 1. Growth analysis of river birch trees (*Betula nigra* 'BNMTF' Dura-Heat™) in # 15 containers 30 days after treatment in 2003.

Treatment	% canopy with normal growth	Leaf area (cm^2)	Leaf dry mass(g)	Specific leaf area (cm^2/g)	Shoot elongation (cm)	# leaves per unit shoot elongation
Control	6	44	0.31	138	8.1	5.7
Ni Spray (394 ppm)	100*[z]	263*	1.57*	168*	20.3*	2.3*
Ni Spray (789 ppm)	100*	265*	1.63*	164*	20.2*	2.2*
Ni Drench (0.005 lbs/yd^3)	100*	223*	1.27*	176*	17.4*	2.7*
Triple Superphosphate (26 g/pot)	2	41	0.33	122	8.6	4.1
Milorganite (130 g/pot)	9	71	0.48	140	10.5	4.2

[z]Mean separation using Dunnett's t-test. Means within columns followed by a * are different from the non-treated control at P = 0.05.

treated with superphosphate, Milorganite and the non-treated control still suffered from severe mouse ear (Table 1). Plants treated with nickel had an 80 to 83% increase in leaf area, a 76 to 81% increase in leaf dry mass, a 53 to 60% increase in shoot elongation, and a 16 to 21% increase in specific leaf area compared to non-treated control plants (Fig. 2). Number of leaves per shoot was not different among treatments (data not shown) whereas number of leaves per unit shoot elongation decreased up to 60% for plants treated with nickel, indicating that internode elongation increased. Triple superphosphate and Milorganite, which both contain a small amount of nickel, did not correct the problem on plants with severe mouse ear symptoms at the rates used in this study.

Foliar application of nickel corrects mouse-ear on field-grown pecans (17) and has now been shown to correct mouse-ear disorder on container-grown river birch. Nickel is considered an essential element for some higher plants (12) and is required for activity of the enzyme urease. Marginal necrosis associated with mouse ear is believed to be due to the accumulation of toxic concentrations of urea along the margins of the foliage (4, 9). In soybeans, the addition of nickel prevented the accumulation of urea and marginal necrosis (4). Nickel is an essential constituent of the urease enzyme and is required for the conversion of urea to ammonia in the leaf.

Fig. 2. *Betula nigra* 'BNMTF' Dura-Heat™ tree (left) six weeks after treatment with a nickel sulfate spray application of 394 ppm. Non-treated control tree with mouse ear disorder is on the right.

Both foliar and drench applications of nickel sulfate were effective in this study. Nickel is readily taken up by plants from soils and uptake is positively correlated with concentration of nickel in the soil (7). Nickel has been shown to be absorbed by the roots of *Betula pubescens* subsp. *czerepanovi* and translocated to the shoots and leaves (8). A significant linear relationship was found between exchangeable nickel in the soil and twigs of two birches (*Betula pumila* var. *glandulifera* and *Betula papyrifera*) growing on sites contaminated with high concentrations of nickel (3). These studies support the concept that nickel applied to soilless substrates can be absorbed by the roots and transported to the foliage of river birch. No previous studies could be found relating to nickel nutrition and *Betula nigra*.

Superphosphate fertilizers are no longer recommended as substrate amendments due to the fact that phosphorus readily leaches from pine bark-based container substrates (19, 20) and concerns regarding contamination of surface and groundwater. While the concentration of nickel in the triple superphosphate and Milorganite used in this study was not determined, the mean concentration among 24 samples of triple superphosphate in a previous study was 17 mg/kg (2), while the mean concentration of nickel in Milorganite for 2003 was 23 mg/kg (1). Based on these numbers, the amount of nickel applied per #15 container was estimated to be 0.44 mg Ni/pot for the triple superphosphate treatment and 3.0 mg Ni/pot for the Milorganite treatment. Drench treatments in this study received 150 mg Ni/pot. Thus, at the rates used in this study it appears fertilizer amendments in the form of triple superphosphate and Milorganite do not provide sufficient nickel to reverse mouse ear disorder on symptomatic river birch. Further research may be warranted to determine if trace levels of contaminant nickel in triple superphosphate and Milorganite would prevent mouse ear disorder from developing on healthy plants.

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