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# RESPONSE OF *RUMOHRA ADIANTIFORMIS* TO A COMBINATION OF CALCIUM, UREA, MAGNESIUM AND BORON

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*Abstract.* **An experiment was conducted using leatherleaf fern (*Rumohra adiantiformis*) to evaluate production benefits of a commercially available product containing urea, calcium nitrate, magnesium sulfate and boric acid. Two adjacent plots, owned by the same growers, were selected that use the same water source and have been maintained by the same University of Florida, Institute of Food and Agricultural Sciences (IFAS) recommended practices for the past five years. The test plot received, in addition to standard inputs, ten oz per acre per week of the test material for nine weeks. The control site received only standard inputs. Fronds with stems and frond tissue samples were collected before, during and after the study. Average stem size, measured just below the first "leaf", increased by 148.2% in the test plot vs. a 36.7% increase in control site stem size. Average frond weight increased by 115.8% in the test site while frond weight in the control site increased by 41.9%. Tissue analysis demonstrated a 74.4% increase in calcium (Ca) in test site tissue vs. a 15.6% increase in Ca in tissue from the control site. Magnesium (Mg) in tissue from the test plot increased 11.3% vs. a 52.6% increase in control site tissue. Boron (B) increased 38.7% in tissue from the test plot vs. a 27.9% increase in the control site tissue. Visually, the foliage in the test plot was a darker green color than foliage from the control site. Visually, the test plot ferns had fewer symptoms of disease than ferns in the control site. The use of nutritional supplements, such as the one used in the study, may open an opportunity for leatherleaf fern growers to increase production and improve sales with fern that has a more appealing appearance.**

Due to a predominance of soils with sandy texture and low organic matter within the state, Florida growers of in-ground plants are challenged to keep a constant, balanced supply of available nutrients within the root zone of plants. Leatherleaf fern [*Rumohra adiantiformis* (Forst.) Ching] is an herbaceous perennial crop that is grown predominately on well-drained, mostly sandy soils having low water- and nutrient-holding capacities (Stamps, 1995). Even though leatherleaf fern can grow epiphytically and on rocks, production of commercially acceptable fronds in economically viable numbers requires the application of nutrients to the low nutrient containing soils in which it is grown (Stamps, 1995). Because many nutrients are easily leached in sandy soils, frequent, small applications of liquid fertilizer are a standard practice for many growers. Furthermore, growers are using many different combinations and levels of nutritional supplements in an effort to grow higher quality fern, reduce the use of costly pesticides and decrease ground water contamination. The purpose of the paper is to document and evaluate the results of weekly applications of a combination nutritional supplement containing calcium (Ca), nitrogen (N), magnesium (Mg) and boron (B) as a supplement to a standard nutritional program.

## Materials and Methods

This study was conducted in a fernery owned by Wayne and John Bennett in Seville, Fla. The study area consists of two adjacent areas with leatherleaf fern growing in Astatula

Table 1. Effects of a supplemental Ca, Mg, N and B combination product on average frond weight.

| | 29 Aug. 2003 | | 30 Sep. 2003 | | 3 Nov. 2003 | |
|---|---|---|---|---|---|---|
| | Bunch wt | Avg wt | Bunch wt | Avg wt | Bunch wt | Avg wt |
| Control | 8.0 oz | 0.31 oz | 8.25 oz | 0.33 oz | 11.0 oz | 0.44 oz |
| | (26 fronds) | | (25 fronds) | | (25 fronds) | |
| Test | 6.0 oz | 0.19 oz | 9.0 oz | 0.28 oz | 13.0 oz | 0.41 oz |
| | (32 fronds) | | (32 fronds) | | (32 fronds) | |

fine sand soil. The two plots were designated "control" and "test". The control and test plots both use the same water source and have been treated as one farm for over five years. Both plots were managed to receive one inch of water per acre per week from overhead irrigation, if rainfall did not provide at least one inch for the week. A combination Ca supplement was applied using a low profile stream crop sprayer (a citrus sprayer retro-fitted to spray in one direction only). The formulation was 10 oz of a commercially available combination calcium product called Gro-Cal MGB® diluted in 50-75 gal of water per acre. The product is derived from urea, calcium nitrate, magnesium sulfate and boric acid. The analysis is 11.25% Ca, 6.6% N, 2.6% Mg and 0.9% B. It also contains 0.013% manganese (Mn), 0.0014% copper (Cu), 0.01% iron (Fe) and 0.001% cobalt (Co). This formulation was applied to each acre of the test plot once per week for a total of nine treatments beginning 4 Sep. 2003 and ending on 29 Oct. 2003. Standard IFAS recommended application practices were followed.

On 29 Aug. 2003, 30 Sep. 2003, and 3 Nov. 2003 soil samples and frond tissue samples were collected from the control area and test site. Soil samples were taken in accordance with IFAS recommended procedures. Mature fronds were collected with clippers and were typical of those harvested commercially. Soil and plant tissue analysis tests were performed by Brookside Laboratories, Inc. (New Knoxville, Ohio). Prior to submission, the fronds were washed with distilled water. Soil samples were tested by the Mehlich III extractable nutrient method. Frond tissue analysis was performed by the Induced Coupled Plasma (ICP) method. Additional bunches of fronds were collected from the test plot and control areas for determining frond weight and stem sizes. On the first collection date, 32 fronds were collected from the test area and 26 were collected from the control area. On the second and third collection dates, 32 fronds were collected from the test plot and 25 fronds were collected from the control area.

Control and test bunches from each area were weighed and divided by the total number of fronds collected in each area to determine average frond weight. Sizes of all the stems from bunches from each area were measured just below the first "leaf" using a digital caliper. The dimensions of all stems in the test and control plots were added. Then the sums were divided by the total number of stems to determine the average stem size of fronds from each area.

## Results and Discussion

*Frond weight.* Average frond weight, over the course of this study, increased by 115.8% in the test plot vs. a 41.9% increase in the control site (Table 1). Average test area frond weight was initially 0.12 oz less than control area frond weight, but by the end of this study, the difference was only 0.03 oz.

*Stem size.* Over the course of the study, average stem size increased in both plots. Average stem size increased by 148.2% in the test plot vs. 36.7% in the control (Table 2). Initially the average stem size of the test plot fronds was less than control area stem size, but by the end of the study, the average stem size of test plot fronds was greater than the average control area stem size.

*Elemental frond tissue content.* Tissue analysis indicated a 74.4% increase in Ca in test plot fronds vs. a 15.6% increase in control site fronds (Table 3). The desirable Ca leaf tissue content of mature leatherleaf fern fronds is between 0.3-0.7% according to the IFAS (Stamps, 1995). At the conclusion of the treatments, the test frond tissue content was 0.75%, putting the test Ca tissue level slightly above this range. On the other hand, Ca in control frond tissue was at the mid-range level of 0.52%. The frond tissue level of Mg increased more in plants from the control plot than the test site, 52.6% and 11.3% respectively. Both the control level of 0.174% and the test level of 0.157% were still short of the desirable 0.2-0.4% range (Stamps, 1995). Boron increased 38.7% in tissue from the test plot and 27.9% in tissue from the control site. Both were within the lower part of the desirable range of 25-75 ppm (Stamps, 1995). In spite of additional N supplementation to the test plot, there was a reduction of N in frond tissue of 2.22% from 2.27% to 2.22%. This contrasts with a 77.6% N increase from 1.96% to 3.48% in the control site.

Interestingly, the Ca combination supplemented test plants stayed within the desirable range of 2.0-3.0% for N (Stamps, 1995), while the control plants without supplementation went from below the desirable range at the beginning of the experiment to above the desirable range at the conclusion of this study. P in the test frond tissue decreased by 36.4% from 0.280% to 0.178% vs. a 5.2% decrease from 0.252% to 0.20% in the control site tissue. P tissue level in test ferns changed from 0.028% more to 0.022% less than control area tissue by the end of the study. P in tissue in both the test plot and control site dropped from within the desirable range to below the desirable range of 0.22-0.40% (Stamps, 1995). This reflects that P was not being supplied in the fertilizer program during the study. K in the test frond tissue decreased by 27.7% from 2.35% to 1.70% vs. a 7.3% decrease from 1.93% to 1.79% in the control site tissue. Test plot tissue initially was in the desirable range of 2.3-3.4% (Stamps, 1995), but by the

Table 2. Effects of a supplemental Ca, Mg, N and B product on average stem size.

| | 29 Aug. 2003 | 30 Sep. 2003 | 3 Nov. 2003 |
|---|---|---|---|
| | Avg stem size | Avg stem size | Avg stem size |
| Control | 3.40 mm × 2.71 mm | 3.55 × 2.51 mm | 4.0 mm × 3.15 mm |
| Test | 3.15 mm × 2.23 mm | 3.65 × 2.75 mm | 4.65 mm × 3.75 mm |

Table 3. Effects of a supplemental Ca, Mg, N and B combination product on frond mineral content.

| | 29 Aug. 2003 | | 30 Sep. 2003 | | 3 Nov. 2003 | |
|---|---|---|---|---|---|---|
| Element | Control | Test | Control | Test | Control | Test |
| | | | Percentages (%) | | | |
| N | 1.96 | 2.27 | 2.00 | 1.96 | 3.48 | 2.22 |
| P | 0.252 | 0.280 | 0.219 | 0.195 | 0.20 | 0.178 |
| K | 1.93 | 2.35 | 1.76 | 1.72 | 1.79 | 1.70 |
| Ca | 0.45 | 0.43 | 0.61 | 0.65 | 0.52 | 0.75 |
| Mg | 0.114 | 0.141 | 0.129 | 0.128 | 0.174 | 0.157 |
| S | 0.294 | 0.252 | 0.287 | 0.264 | 0.386 | 0.396 |
| | | | Parts per million | | | |
| B | 21.9 | 23.5 | 33.9 | 42.0 | 28.0 | 32.6 |
| Fe | 74.3 | 81.5 | 80.7 | 115.2 | 221.0 | 123.3 |
| Mn | 777.3 | 223.1 | 379.8 | 293.3 | 914.9 | 762.8 |
| Cu | 6.1 | 6.8 | 6.7 | 7.5 | 10.8 | 7.8 |
| Zn | 166.6 | 61.3 | 98.4 | 72.9 | 177.1 | 153.6 |
| Al | 81.8 | 112.9 | 97.0 | 189.5 | 269.3 | 132.2 |

end of the study had dropped below the desirable range to less than that of the control area. S in test tissue increased by 57.1% from 0.252% to 0.396% vs. a 31.3% increase in control tissue from 0.294% to 0.386%. However, both stayed within the desirable range of 0.20-0.50% (Mills and Jones, 1996). Interestingly, aluminum (Al) in tissue from the test plot increased by 17.1% while increasing by 177.0% in control tissue. This resulted in an Al level in the untreated tissue more than twice that of the treated tissue.

*Elemental soil mineral levels.* Soil testing for anions determined that sulfur (S) increased by 4.5% in the test plot, vs. a 75% increase in the control soil. Easily extractable phosphorus (P) showed a reduction of 1.3% in the test plot vs. a reduction of 18.1% in the control. Bray II extracted P showed a 40% increase in the test plot vs. a 11.3% increase in the control. Soil testing for exchangeable cations determined that Ca increased by 22.7% in the test plot vs. 28.7% in the control. The base saturation percentage of Ca in the test area in-

Table 4. Effects of a supplemental Ca, Mg, N and B combination product on elemental soil mineral content and pH.

| | 29 Aug. 2003 | | 30 Sep. 2003 | | 3 Nov. 2003 | |
|---|---|---|---|---|---|---|
| | Control | Test | Control | Test | Control | Test |
| pH ($H_2O$ 1:1) | 6.5 | 5.9 | 6.4 | 6.3 | 6.8 | 6.7 |
| | | | Anions (ppm) | | | |
| Soluble S. | 16 | 22 | 27 | 21 | 28 | 23 |
| Easily extractable P | 83 | 75 | 71 | 77 | 68 | 74 |
| Bray II P | 53 | 50 | 52 | 52 | 59 | 70 |
| | | | Exchangeable cations (ppm) | | | |
| Ca | 527 | 626 | 698 | 690 | 678 | 768 |
| Mg | 34 | 46 | 50 | 38 | 81 | 63 |
| K | 14 | 19 | 23 | 18 | 49 | 49 |
| Na | 13 | 15 | 28 | 22 | 27 | 28 |
| | | | Base saturation percent | | | |
| Ca | 75.60 | 65.89 | 73.47 | 74.51 | 72.75 | 75.59 |
| Mg | 8.24 | 8.07 | 8.77 | 6.84 | 14.48 | 10.33 |
| K | 1.04 | 1.03 | 1.24 | 1.00 | 2.70 | 2.47 |
| Na | 1.64 | 1.37 | 2.56 | 2.07 | 2.52 | 2.40 |
| Other bases | 4.90 | 5.60 | 5.00 | 5.10 | 4.60 | 4.70 |
| Hydrogen | 7.50 | 18.00 | 9.00 | 10.50 | 3.00 | 4.50 |
| | | | Extractable minors (ppm) | | | |
| B | 0.38 | 0.54 | 0.50 | 0.50 | 0.75 | 0.61 |
| Fe | 96 | 117 | 100 | 118 | 100 | 111 |
| Mn | 99 | 107 | 160 | 119 | 110 | 129 |
| Cu | 1.85 | 1.66 | 2.25 | 2.68 | 3.32 | 4.69 |
| Zn | 13.00 | 9.63 | 18.13 | 9.77 | 16.06 | 11.17 |
| Al | 371 | 273 | 429 | 369 | 504 | 345 |

Fig. 1. Mature leatherleaf fern (*Rumohra adiantiformis*) fronds in the control plot photographed on 28 Oct. 2003.

Fig. 3. Mature leatherleaf fern (*Rumohra adiantiformis*) fronds in the test area photographed on 28 Oct. 2003.

creased by 14.7% as contrasted to a 5.0% reduction in the control. The base saturation percentage of Ca in the test area was lower than that of the control area when first tested, but was higher by the end of the study. Mg increased by 37.0% in the test plot vs. an even greater 138.2% in the control. Likewise, the base saturation percentage of Mg in the control area increased by a larger percentage than that of the test plot (75.7% vs. 28.0%). K increased by 158% in the test plot vs. 250% in the control. The base saturation percentage of K increased by 139.8% in the test plot vs. a 159.6% increase in the control. Other bases showed reductions in the test plot and control, 16.1% and 6.1% respectively. Total exchangeable anions showed a 28.6% increase in the test plot and a 42.0% increase in the control. Hydrogen (H) cations showed a reduction of 75% in the test plot and a 60% reduction in the control. This is a reflection of the greater increase in the pH of the test area versus the control, although the final pH for the test area was 6.7 versus 6.8 for the control (Table 4).

This particular experiment indicated a positive correlation between supplemental Ca, Mg, N and B and increased frond weight and stem size. Of note is the elevated level of Ca and B within the leaf tissue with the use of this supplement. Soil and tissue testing indicates the need for long term monitoring of mineral inputs and timely pH adjustments, when using supplemental combinations such as the one used in this experiment. Of special concern when Ca is increased is the suppression of K and Mg uptake. Of interest was the stabilization of test fern tissue N within the desirable range vs. the change from below the desirable range to above the desirable range in the control. Visual observations indicated that the leatherleaf fronds in the test plot were a darker green and had fewer symptoms of disease than the foliage observed in the control site (Figs. 1-4). More extensive experiments may find that targeted nutritional supplementation can be a cost effective tool to lower pesticide use. These results suggest that supplemental Ca, Mg, N and B combination products at rates as

Fig. 2. Leatherleaf fern (*Rumohra adiantiformis*) control plot photographed on 28 Oct. 2003.

Fig. 4. Leatherleaf fern (*Rumohra adiantiformis*) test plot photographed on 28 Oct. 2003.

low as 10 oz per acre may result in economic benefits to cut foliage growers. Using such products may increase quality and production. Additional long-term studies, with nutritional supplements of various combinations, are needed to give definitive answers to which materials work best under certain conditions. Considering the intense competition faced by growers of leatherleaf fern and other cut foliage, having a good selection of low-cost supplements suitable for growing various crops in a variety of situations is potentially very important for growing better crops and lowering production costs.

## Literature Cited

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