Cantaurus, Vol. 4, 8-10, May 1996

The Effect of Soil Nutrient Status on the Resorption Efficiency of Nitrogen from the Leaves of Green Ash (*Fraxinus pennsylvanica*)

Michael D. Epps

ABSTRACT

The purpose of this experiment is to test the hypothesis of whether or not nutrient status has an impact on resorption efficiencies of trees. Green Ash (*Fraxinus pennsylvanica*) bare-root seedlings were obtained from the Kansas Department of Conservation, they were picked for their fast growing capacity. They were divided into two groups which were manipulated through controlling nitrogen availability in the soil, through fertilization. The plants were grown uniformly in the McPherson College Biology Department's green-house to limit outside factors affecting growth. The fertilized group was treated starting in early September through abscision. In the control and fertilized groups, leaf samples were taken in late October (pre-abscision) and then again immediately following leaf abscision. This was done to achieve readings of the plants resorption efficiency of nitrogen due to the lack or presence of nitrogen. Samples were dried and ground in preparation for the Kjeldahl method. Samples were done in duplicate to ensure precision, and blanks were run with them to test lab technique. Results were somewhat conflicting to what was thought: the control group did in fact on the average reabsorb more nitrogen than did the treatment group (.389%, .341% respectively). Yet there was no statistical significant difference in the percent nitrogen reabsorbed between the control and treatment groups (mean value 18.35%, 12.99% respectively; standard deviation 8.04%, 9.66% respectively).

INTRODUCTION

Little is known about the factors which control the resorption of N (nitrogen) and P (phosphorus) from tree leaves. This information could be useful to tree farms and reforestation projects, whether the question is how often to fertilize, whether to fertilize at all, or what trees will grow better in the different soils due to nutrient availability.

Interest has been shown in this area by researchers', Chapin (1989) measured N and P resorption from trees that differed strongly in their tissue nutrient status. Experimentally manipulating factors thought to control nutrient resorption, he found that trees of higher nutrient status had larger N and P pools, translocated more N and P out of leaves, and left more N and P pools in abscised leaves than those trees of infertile soils. Yet, plant nutrient status was found not to have an effect on the efficiency of N or P resorption, except the low efficiency of N or P resorption in highly fertile lawns. Based on his work and previous literature (Zimmerman and Brown, 1971), he concluded that nutrient resorption efficiency is influenced more strongly by carbohydrate flux from leaves than by factors controlling hydrolysis of nutrient-containing fractions in leaves (Chapin, 1989).

Later, Pugnaire and Chapin (1992) tested whether individuals growing in nutrient-deficient habitats are more efficient at nutrient resorption that are individuals of the same species growing on fertile soils. Secondly, they tested whether species adapted to infertile sites have a higher nutrient resorption efficiencies than do species adapted to more fertile soils. They found that plants growing in serpentine soils had smaller, thicker leaves than those growing in richer sites, and had lower N and P concentrations and pools on a unit-area basis. Pools of nutrients resorbed and nutrients left in higher litter rich-site leaves were larger than pools in poor-site leaves, but N resorption efficiency was higher in less fertile sites. Differences in efficiency may be due to the soluble/non-soluble proteins, which is higher in low-N sites. Trends for phosphorus resorption efficiency were not significant. There were no significant differences among species adapted to poor vs. rich soils, nor between evergreen vs. broad-leafed species. They concluded that a high nutrient resorption efficiency is a phenotypic response to low-nutrient environments (Pugnaire and Chapin, 1992).

The findings of Chapin (1989) and Pugnaire and Chapin (1992) are conflicting with one another; in the first study it was said that resorption efficiency was not related to plant nutrient status, and the second cited that nutrient resorption efficiency was due to a phenotypic response.

This difference is of interest to me and will be approached by subjecting *Fraxinus pennsylvanica* (variety *subintegerrima*) to different soil nutrient conditions (controlling nitrogen), to assess what effect nutrient status has on nutrient resorption efficiency. Two groups of fifty green ash (bare-root) seedlings will be studied by subjecting them to differentiated N status. The groups will be N rich and N poor; these two groups are then separated into pre. and post-abscission. Samples will be taken during early fall and later of abscised leaves. Nitrogen determination will be carried out by the Kjeldahl method.

MATERIALS AND METHODS

The study was carried out in the biology department's greenhouse, where conditions were stable and external elements could be limited. The bare root seedlings were potted and placed into two groups of fifty to ensure that the plant leaf material sampled was adequate and

that excess would be available in case of mistakes during lab manipulations. The control group received tap water, and the fertilized group received nitrogen in the form of potassium nitrate.

The trees were watched over the summer by a fellow student and I resumed responsibility in late August. At this time the fertilized group received the first treatment, each plant received 2g of potassium nitrate (13.75-0-44.5) VICKNITE brand fertilizer through abscision in late October.

Samples were tested, before abscision in late September and then again when leaves started to abscess in late October. Leaf samples were tested for the percent of N resorption efficiency, due to soil nutrient status.

Nitrogen Determination was carried out by the Kjeldahl method in the Association of Official Analytical Chemists book of methodology (1975) . The weighed samples (0.4-2.0g) and filter paper were placed in a Kjeldahl flask, three glass beads, one Kjel-pak, and 25 ml concentrated H_2SO_4 was added. Next the flasks were placed on the digester, the water was turned on, and burners set at five (5). Samples were digested until clear, plus an additional 30 minutes. After digestion was completed flasks were cooled by placing them in racks and positioned in the exhaust hood, then 250 ml of distilled water was added; at this time parafilm was placed over them so distillation could be done at a later time.

When distillation was ready, the receiving flasks were filled with 25 ml Kjel-Sorb (saturated boric acid solution, about 4% solution), next the Flasks were placed on the upper shelf making sure that the end of the tube was submerged in the liquid.

Next several pieces of mossy zinc were added to the Kjeldahl flasks, they were then tilted and immediately 75 ml 46% NaOH (added slowly so that it layered on the bottom of flask) was added. Then I immediately connected the Kjeldahl flask to the condenser with the tip of the condenser immersed in standard acid (with indicator) in the receiver. The flasks were rotated to mix contents thoroughly, then heated until all NH_3 had distilled (> 150 ml distillate; 15 min.), the flasks were then placed on the lower shelf for three more minutes. When this was completed, burners were turned off and beakers containing 50 ml distilled water were placed on upper shelf. When the Kjeldahl flasks cooled this caused a vacuum and water was sucked into the flask, cleaning the distillation apparatus.

Receiving flasks were then titrated to neutral with 0.1 N H_2SO_4. The amount of titer was recorded for calculations.

$$\% N = \frac{(\text{ml titer})\,(N)\,(14)\,(100)}{\text{mg sample}}$$

RESULTS

When comparing the total percent nitrogen (%N) present to the %N reabsorbed, in the two groups, both groups did in fact reabsorb some of the total nitrogen from their leaves before abscising. On the average, plants in the treatment group did reabsorb less of the total %N in their leaves than did the control group. This value on the average was: Treatment 0.341g (Figure 1) and Control 0.389g (Figure 2) of nitrogen reabsorbed. But when comparing the %N reabsorbed between the two groups this percent overlaps, with standard deviations of 8.04 and 9.6 respectively. Therefore there is no statistical significance between the two groups to prove that those plants with lower nitrogen availability would in fact reabsorb more of the total nitrogen present in their leaves than would those which grew in nitrogen rich environments.

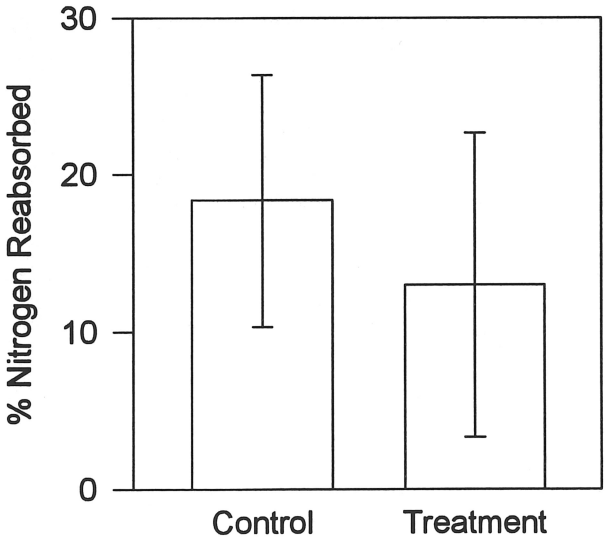

Figure 1. %Nitrogen Reabsorption Control vs. Treatment

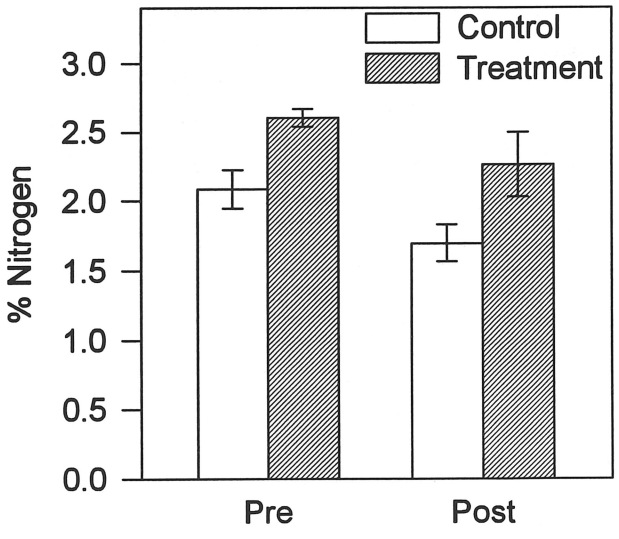

Figure 2. Total % Nitrogen available in pre- and post-abscission Control vs. Treatment.

DISCUSSION

The purpose of this experiment was to look at the hypothesis of whether or not nutrient status has an impact on the reabsorption efficiencies of trees. When I completed charting the data, three facts were present: first, Figure 2 shows that there was reabsorption differences between the pre- and post-abscision groups, also in Figure 2 it shows that the control group did on the average reabsorb more than the treatment did, and lastly that comparing the two groups' %N reabsorbed (Figure 1) the control group seems as if it reabsorbed more than did the treatment but the standard deviation clearly overlaps giving no statistical significance.

I think there were more factors involved that needed to be considered in this research project. For instance the interaction between nitrogen and phosphorus reabsorption, the length or the number of growing seasons the trees need to be exposed to the conditions before significant results can be obtained. If I could do this process over again, I think the trees should be grown for at least two seasons before accurate results could be obtained. This would be a good point to consider since Chapin (1998) and Pugnaire and Chapin (1992), both studied in mature forested areas, the trees had been exposed to those same conditions for many years. This definitely could have a effect on the trees response. Especially looking at the trees in my experiment, the treatment group only had 2-2.5 months of fertilization, starting when I resumed care of them in the fall. The length of fertilization would have been lengthened if I could have stayed in McPherson through the summer to monitor growth more accurately.

LITERATURE CITED

Bryant, J. P., P. B. Reichardt, and T. P Clausen. 1993. Effects of mineral nutrition on delayed inducible resistance in Alaska paper birch. Ecology 74:2072-2084.

Chapin, F S., and L. Moilanen. 1991. Nutritional controls over nitrogen and phosphorus resorption from Alaskan birch leaves. Ecology 72:709-715.

Chapin, F S., P.M. Vitousek, and K. Van Cleve. 1986. The nature of nutrient limitation in plant communities. The American Naturalist 127:48-58.

del Arco, J.M., A. Escudero, and M.V. Garrido. 1991. Effects of site characteristics on nitrogen retranslocation from senesing leaves. Ecology 72:701-708.

McNaughton, S J., and F.S. Chapin. 1985. Effects of phosphorus nutrition and defoliation on C4 graminoids from the Serengeti plains. Ecology 66:1617-1629.

Pugnaire, F. I., and F.S Chapin. 1993. Controls over nutrient resorption from leaves of evergreen Mediterranean species. Ecology 74:129-139.

Rideout, J. W., and C.D. Raper. Diurnal changes in net uptake rate of nitrate are associated with changes in estimated export of carbohydrates to roots.

Improved Kjeldahl Method for Nitrate-Free Samples (19) Official Final Action. Official Methods of Analysis of the Association of Official Analytical Chemists. Twelfth Edition 2.049 1975.