ROOT NITROGEN CYCLING AND ALFALFA STRESS TOLERANCE

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ABSTRACT

Our hypothesis is that certain root N pools are utilized preferentially during the early shoot regrowth. Our objective was to determine the relative contribution of crown N, root N, and specific root N pools to shoot regrowth after defoliation. We used ^{15}N to follow N into and out of crowns, roots, and specific root N pools, to regrowing shoots after defoliation. The low molecular weight N pool (amino acids, inorganic N,...) acquired ^{15}N rapidly within 2 d of N application. Movement of ^{15}N into the protein-N and insoluble-N pools was delayed initially, but continued until 8 d after N application. Defoliation 30 d after ^{15}N application resulted in N transfer from roots and crowns to regrowing shoots. All root N pools lost ^{15}N label initially after defoliation, with a more extensive decline occurring for the protein-N and low molecular weight-N pools.

KEYWORDS

Defoliation, amino acids, protein, nitrogen fertilizer, lucerne, stress tolerance, vegetative storage proteins

INTRODUCTION

Our work, and recent work of others, has failed to show a positive association between root total nonstructural carbohydrate (TNC) concentrations and variation in alfalfa regrowth and winter hardiness (Brink and Marten, 1989; Brown et al., 1990; Jung and Smith, 1961; Volenec, 1985; Boyce and Volenec, 1992). We are exploring alternatives to the conventional thinking that root TNC reserves control alfalfa regrowth and persistence. Our research shows that root N pools decline 1) in spring when shoot growth resumes and 2) during herbage regrowth after defoliation (Hendershot and Volenec, 1993a,b; Li *et al*., 1996). We believe that certain root N pools are utilized preferentially as N reserves during the early stages of shoot regrowth. Our objective was to determine the relative contribution of crown N, and root N, and root N pools to shoot regrowth after defoliation.

MATERIALS AND METHODS.

Plants were provided 50 kg N/ha as $^{15}NH_4{}^{15}NO_3$ to label root and crown N pools. Uptake of ^{15}N into root N pools was determined by sampling a portion of the plants immediately and 2, 4, 8, 12, and 16 d after transplanting. After 30 d remaining plants were defoliated, and transplanted into coarse river sand, and these plants were sampled immediately and at 2, 4, 8, 12, and 16 d after transplanting. At sampling, shoots, roots, and crowns were dried, weighed, milled, and analyzed for ^{15}N using mass spectrometry. Root N pools were separated into low molecular wt. N (soluble in acetone: primarily amino acid-N and inorganic N), protein N, and buffer-insoluble N. Details of the root N fractionation scheme are published elsewhere (Barber et al., 1996).

RESULTS AND DISCUSSION

Accumulation of N into Root N Pools. ^{15}N was found in root tissues 2 d after ^{15}N application (data not shown). The low molecular wt. N fraction initially accumulated ^{15}N more rapidly than other root N pools. Between Days 0 and 8, ^{15}N accumulated into both the protein-N pool and the insoluble -N pool in a linear fashion. When ^{15}N incorporation into the protein and insoluble-N pools slowed after Day 8, ^{15}N accumulated in the low molecular wt. N pool. Even though ^{15}N content of these three root N pools appeared to attain equilibrium by Day 12, label incorporation was allowed to proceed until Day 30 during which time incorporation of label into the protein-N and insoluble -N pools increased, while that found in the low molecular wt. N pool remained unchanged. The extensive incorporation of label into the protein-N pool is consistent with our observations of extensive accumulation of vegetative storage proteins during late vegetative development of this species (Hendershot and Volenec, 1993b).

^{15}N Redistribution After Defoliation. Shoot ^{15}N content increased in a linear fashion between Days 2 and 16 (Fig. 1). Crowns contained more ^{15}N than roots on Day 2, but both organs exhibited a linear decline in ^{15}N content as shoots regrew and acquired ^{15}N. The movement of N from crowns and roots to shoots agrees with previous results. Barber et al. (1996) reported that 30 to 40% of crown and root N was mobilized to shoots during the first 10 days of shoot regrowth after defoliation. Kim et al. (1991) showed that 80% of the N in leaves of hydroponically grown alfalfa plants was derived from roots after 6-d of regrowth. They observed large reductions in root N concentrations that coincided with shoot regrowth, but did not examine N loss from specific root N pools.

Nitrogen Mobilization From Root N Pools.. Large reductions in ^{15}N content occurred for all three root N pools between Days 0 and 2 (Fig. 2). Thereafter, the root protein and the low molecular weight N pools remained relatively constant, whereas label content of the insoluble N pool began to increase on Day 8. Culvenor and Simpson (1991) reported that most of the N found in new leaves of regrowing subterranean clover (*Trifolium subterraneum* L.) was mobilized from vegetative tissues. They found that nodulated roots supplied 75% of the mobilized N, and that soluble proteins were the major N source mobilized from roots. Barber et al. (1996) also showed that in roots the low molecular weight-N and the protein-N pools lost ^{15}N after defoliation, and that the ^{15}N content of the insoluble N pool remained relatively unchanged. Furthermore, they showed that specific proteins within the root protein pool were preferentially lost during root protein utilization. The nature of these vegetative storage proteins has been recently described (Cunningham and Volenec, 1996; Volenec *et al.*, 1996).

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Figure 1
Loss of ^{15}N from roots and crowns and acquisition of ^{15}N by shoots during shoot regrowth after defoliation on Day 0.

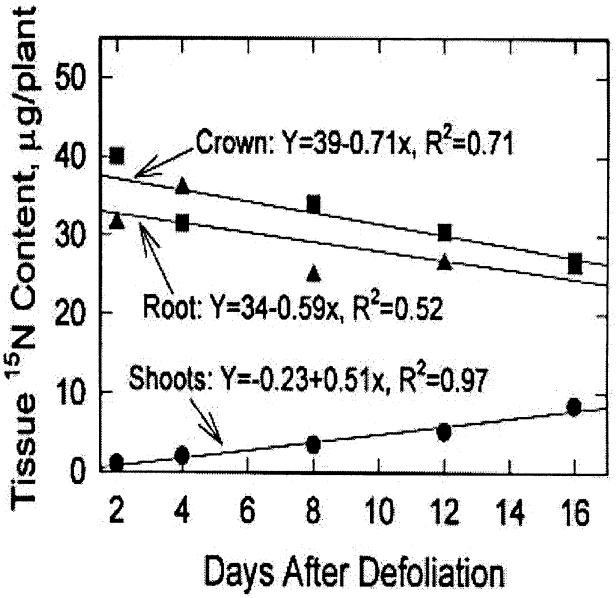

Figure 2
The loss of ^{15}N from root N pools after defoliation on Day 0. The low molecular wt. N pool is composed mainly of amino acids and inorganic N. Insoluble N is that N which is insoluble in aqueous buffer. The least significant difference (LSD) is provided at the 5% level of probability.