Nitrogen Use Efficiency of Timothy Populations

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ABSTRACT

The objective of this study was to determine the variability in N use efficiency among field-grown timothy (*Phelum pratense* L.) populations. Shoot biomass and N uptake were measured at the end of the spring growth cycle on six timothy populations fertilized with three N rates at two sites in Eastern Canada. The variability in shoot biomass among populations was similar under limiting and non-limiting N conditions. The ranking of the populations, however, differed under limiting and non-limiting N conditions, and also between the two sites under limiting N conditions. The differences in shoot biomass among populations under highly N deficient conditions were more related to N conversion efficiency than N uptake efficiency. These preliminary results indicate significant interactions between the N nutrition status and timothy populations, and the importance of N conversion efficiency under highly N deficient conditions.

KEYWORDS

Timothy, nitrogen, efficiency, uptake

INTRODUCTION

Nitrogen use efficiency (NUE), the amount of shoot biomass produced per unit of N available in the soil, has two components: N uptake efficiency and N conversion efficiency (Moll *et al*., 1982). Genotypic differences in N uptake and/or conversion efficiency were found in wheat (Cox *et al*., 1985), corn (Moll *et al*., 1982) and sorghum (Zweifel *et al*., 1987). In perennial grasses, inter-specific differences in NUE were reported by Lemaire et al. (1989) but there are few reports on intra-specific differences. Lemaire and Salette (1984), under non-limiting N conditions, reported no differences in NUE among tall fescue populations. Schapendonk *et al*. (1990) reported that the ranking of ryegrass populations in terms of shoot biomass were similar under limiting and non-limiting N conditions.The objective of this study was to determine if there were differences in NUE among six field-grown timothy populations. We hypothesized that differences among populations would be greater under limiting than under non-limiting N conditions.

METHODS

In early May of 1995, six timothy populations established the previous year were fertilized with three N rates (0, 40 and 180 kg N ha^{-1}) at two sites in Eastern Canada (Sainte-Foy, Qubec and Fredericton, New Brunswick). Two recommended cultivars (Clair and Champ) were compared to four populations selected for low (P-) and high (P+) N concentration, and low (R-) and high (R+) digestible DM yield. A split-plot arrangement of the experimental treatments (main plots, N rates; subplots; timothy populations) was used in a randomized complete block design with four replications. Individual plots were 1.5 x 9 m. Shoot biomass was sampled on 23 June in Sainte-Foy and 16 June in Fredericton on an area of 1.3 m^2. The N concentration in shoot biomass was determined by dry combustion using a LECO CNS-1000 elemental analyzer (LECO Corporation, Michigan, USA). Nitrogen uptake was calculated by multiplying shoot biomass and N concentration. The level of N deficiency was assessed by calculating the relative N concentration (RNC) as the ratio of the shoot biomass N concentration to the optimal N concentration predicted by the model of Lemaire and Salette (1984). A value greater than 1.0 indicates that N is not limiting shoot growth.

RESULTS AND DISCUSSION

The average RNC of the six populations were 0.52, 0.67, and 1.02 with 0, 40, and 180 kg N ha^{-1} in Sainte-Foy, respectively. In Fredericton, the RNC was 0.64 with no N applied and 1.05 with 40 kg N ha^{-1}. Nitrogen was therefore not limiting shoot growth with 180 kg N ha^{-1} in Sainte-Foy and 40 kg N ha^{-1} in Fredericton. Because of lodging in Fredericton, the data with 180 kg N ha^{-1} are not presented.

Shoot biomass - Contrary to our initial hypothesis, the range of shoot biomass among populations in relation to the average shoot biomass of the six populations was similar under limiting (18.1% in Sainte-Foy and 9.3% in Fredericton) and non-limiting N conditions (16.7% in Sainte-Foy and 8.6% in Fredericton). Furthermore, in contrast to the results of Schapendonk *et al*. (1990), the ranking of the populations was different under limiting and non-limiting N conditions at both sites (Fig. 1). As an example, in Sainte-Foy, the population R+ had the lowest shoot biomass under non-limiting N conditions but one of the highest shoot biomass when no N was applied.

Under non-limiting N conditions, the ranking of the populations in terms of shoot biomass were similar at both sites. Under limiting N conditions, however, the ranking of the populations differed in Sainte-Foy and Fredericton (Fig. 1). The population R+ had a greater shoot biomass than R- in Sainte-Foy but the opposite was true in Fredericton.The population P- had a greater shoot biomass than P+ in Sainte-Foy, but in Fredericton, P+ and P- had a similar shoot biomass. The level of N deficiency with no N applied, however, was greater in Sainte-Foy than in Fredericton which might explain the different response at the two sites.

N uptake - With no N applied in Sainte-Foy, the range among populations was much greater for shoot biomass than for N uptake (Fig. 1). The range in N uptake was 6% of the average N uptake of the six populations whereas the range in shoot biomass was 18% of the average shoot biomass (Fig. 1). Under non-limiting N conditions, the range in N uptake and shoot biomass were 23% and 17% of the average values of the six populations, respectively. Hence, the differences in shoot biomass among populations under N deficient conditions were more related to N conversion efficiency than N uptake efficiency. The range in N uptake and shoot biomass in Fredericton were approximately 9% of their respective average values, indicating that both N uptake and conversion efficiencies were involved. Our preliminary results indicate that, for shoot biomass accumulation, there appears to be an interaction between the N nutrition status of the sward and timothy populations. Hence, in selecting timothy populations for yield, the N nutrition status of the sward should be taken into account. Furthermore, under highly N deficient conditions, N conversion efficiency seems to play a significant role in NUE.

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Figure 1
The relationship between N uptake and shoot biomass for different timothy populations grown under contrasted N rates in Sainte-Foy and Fredericton. The solid line represents the optimal N uptake; the dashed lines represent the average shoot biomass (vertical line) and average N uptake (horizontal line); vertical and horizontal bars indicate standard error of the mean for N uptake and shoot biomass, respectively.