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VARIABILITY FOR NITROGEN AND PHOSPHORUS UPTAKE AMONG TIMOTHY GENOTYPES

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Abstract

Cultivars of timothy (*Phleum pratense* L.) with high N and P use efficiencies are required to reduce costs of production and risks of N and P pollution, and to meet the nutrition requirements of high producing animals. This field study aimed at comparing, (under three N rates) the relationship between DM yield, N uptake, and P uptake of 27 timothy half-sib families, plus the cultivar Champ as a control (Dry matter yield), N and P uptake increased with increasing N rates. Genotypes also differed for DM yield, N and P uptake. For a given DM yield, the genotypes had contrasting N uptake. Similarly, for a given N uptake, there was variability in P uptake. Overall, P uptake was highly correlated to N uptake. We conclude that there is genotypic variability in timothy for N use efficiency, and N and P uptake efficiencies. Our results also confirm that P uptake follows, to a large extent, variations in N uptake as an effect of N rates and genotypes.

Keywords: Timothy, nitrogen, phosphorus, uptake, variability

Introduction

Timothy (*Phleum pratense* L.) is the most important perennial forage grass species grown in Eastern Canada. Cultivars with high N use efficiency, defined as high DM yield produced per unit of N available in the soil, are required to reduce costs of production and risks of N pollution. In addition to high DM yield or N use efficiency, cultivars with high forage N concentration are required to meet the needs of high producing ruminant animals. Improving the forage N concentration, for a given DM yield, would improve the N uptake efficiency of timothy.

Selection for greater N uptake efficiency in timothy may affect its P status because of the close relationship between N and P concentrations (Bélanger and Richards, 1999). Increasing P uptake of timothy might help to decrease the levels of P in soils with excess P.

This field study aimed at comparing the relationship between DM yield, N uptake, and P uptake of timothy genotypes grown under three N rates.

Material and Methods

In June 1998, 27 half-sib families were transplanted on a clay soil in a field near Québec city (Canada) (Lat. 46º46'N; long. 71º19'). These half-sib families (thereafter called genotypes) resulted from intercrossing 27 genotypes obtained from 2 yr. of selection for DM yield and N concentration on several cultivars of medium maturity. The experimental design was a split-plot including three replications, with three rates of fertilizer N as main plots (0, 40 and 180 kg N ha^{-1} yr^{-1}, referred to as N0, N40, and N180, respectively) and genotypes as subplots. For each genotype, ten individual plants were transplanted on one row 3.66 m in length. Rows were 91 cm apart. The recommended cultivar Champ was used as a reference. The three N rates and P (20 kg

P ha^{-1} yr^{-1}) were surface broadcast before growth started in spring 1999. Timothy was harvested twice with a Carter plot harvester at a cutting height of 5 cm. The first harvest was taken at heading stage, and the second harvest was taken 55 days later. The harvested material was dried at 55ºC for 48 h, weighed, ground to pass a 1-mm screen and stored prior to laboratory analyses. All samples were scanned using near infrared reflectance (NIR). Sixty samples were designated for the calibration and validation set, and their N and P concentrations were determined after the H_2SO_4-H_2O_2 digestion method of Kjeldahl. The N and P uptake were calculated as the product of DM yield and concentration. The DM yield, N uptake and P uptake values of the two harvests were accumulated and the cumulative values were subjected to an analysis of variance.

Results and Discussion

Relationship between DM yield and N uptake. Dry matter yield (P=0.08) and N uptake (P=0.027) increased significantly with increasing N rates (Fig. 1.). Under the most limiting N fertilization (N0), DM yield and N uptake averaged, respectively, 73% and 60% of that under N180. The N nutrition index, that is the measured N concentration divided by the critical N concentration (Bélanger and Richards, 1997), was 0.70 at N0, 0.79 at N40, and 0.95 at N180.

Genotypes differed significantly (P<0.001) for DM yield and N uptake, and there was no interaction with N rates. The genotypes with the greatest DM yield for the three N rates yielded, on average, 22% more than the cultivar Champ. This confirms the previously reported contrasting N use efficiency among timothy genotypes (Michaud et al., 1998; Brégard et al., 2000). As for DM yield, the genotypes with the greatest N uptake accumulated 27% more N than Champ, indicating variability for N uptake among genotypes. Furthermore, for a given DM yield, the genotypes had contrasting N uptake, and this was also previously reported by Michaud et al.

(1998) and Brégard et al. (2000) in timothy. This variability for N uptake efficiency was greater under the non-limiting N rate.

P uptake as a function of N uptake. Nitrogen fertilization is known to affect P uptake (Bélanger and Richards, 1999). In our study, soil P availability was similar at all N rates. Nitrogen fertilization tended to increase P uptake (P=0.11) (Fig. 2). At N0, P uptake averaged 75% of that under N180. Bélanger and Richards (1999) also reported an increase of P uptake with increasing N rates in timothy.

Phosphorus uptake significantly (P<0.001) differed among genotypes. The genotypes with the greatest P uptake took up, on average, 24% more P than Champ. Consequently, these genotypes would accumulate more P in the forage, and, therefore, would drive more P out of the field at harvest. As well, for a given N uptake, there was genotypic variability in P uptake. Hence, variability for P uptake efficiency and P concentration exists in timothy.

Phosphorus uptake was highly correlated to N uptake (r = 0.95). Hence, increasing N uptake with higher N rates or with high yielding genotypes resulted in increased P uptake. This relationship of P uptake to N uptake, however, has its limitation. For example, the P uptake was greater with N0 than with N40 at a given level of N uptake. This was previously reported by Bélanger and Richards (1999).

We conclude that there is genotypic variability for N use efficiency, N uptake efficiency and P uptake efficiency in timothy. Our results also confirm that P uptake follows, to a large extent, variations in N uptake as an effect of N rates and genotypes.

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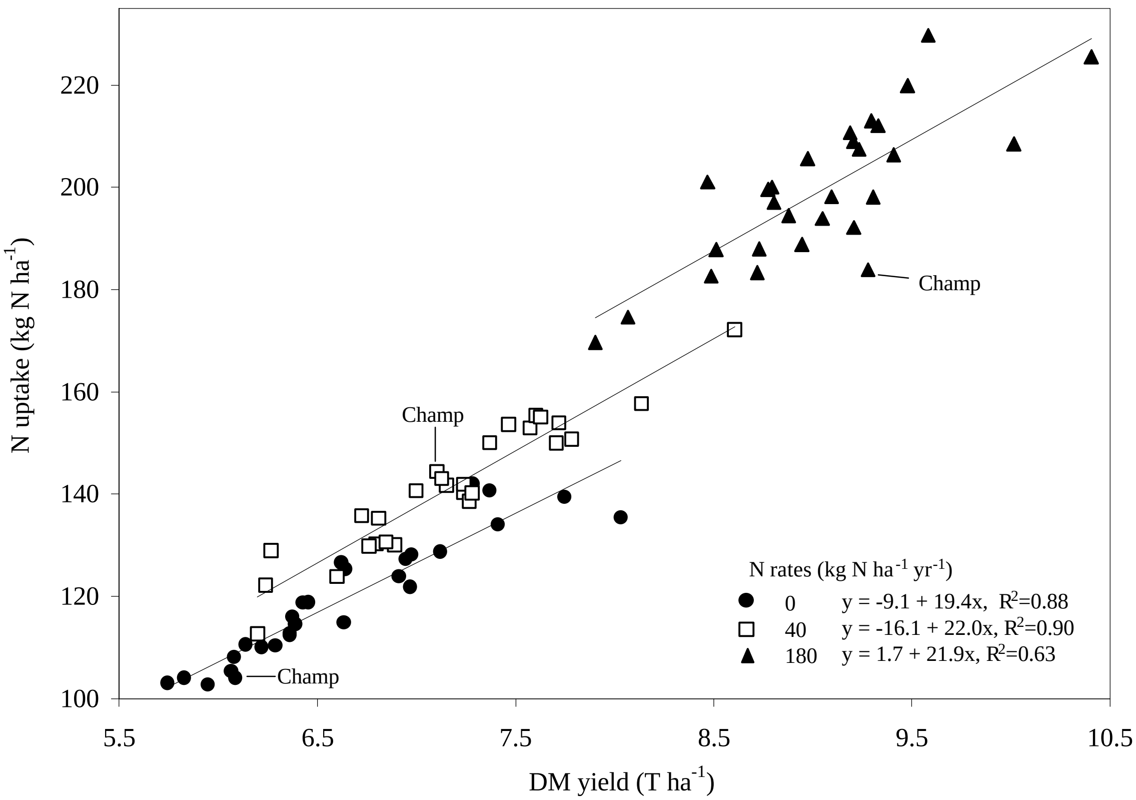

Figure legends

Figure 1 – N uptake as a fuction of DM yield of 27 timothy genotypes and the cultivar Champ grown under 0,40, and 180 Kg N ha^{-1} yr^{-1}.

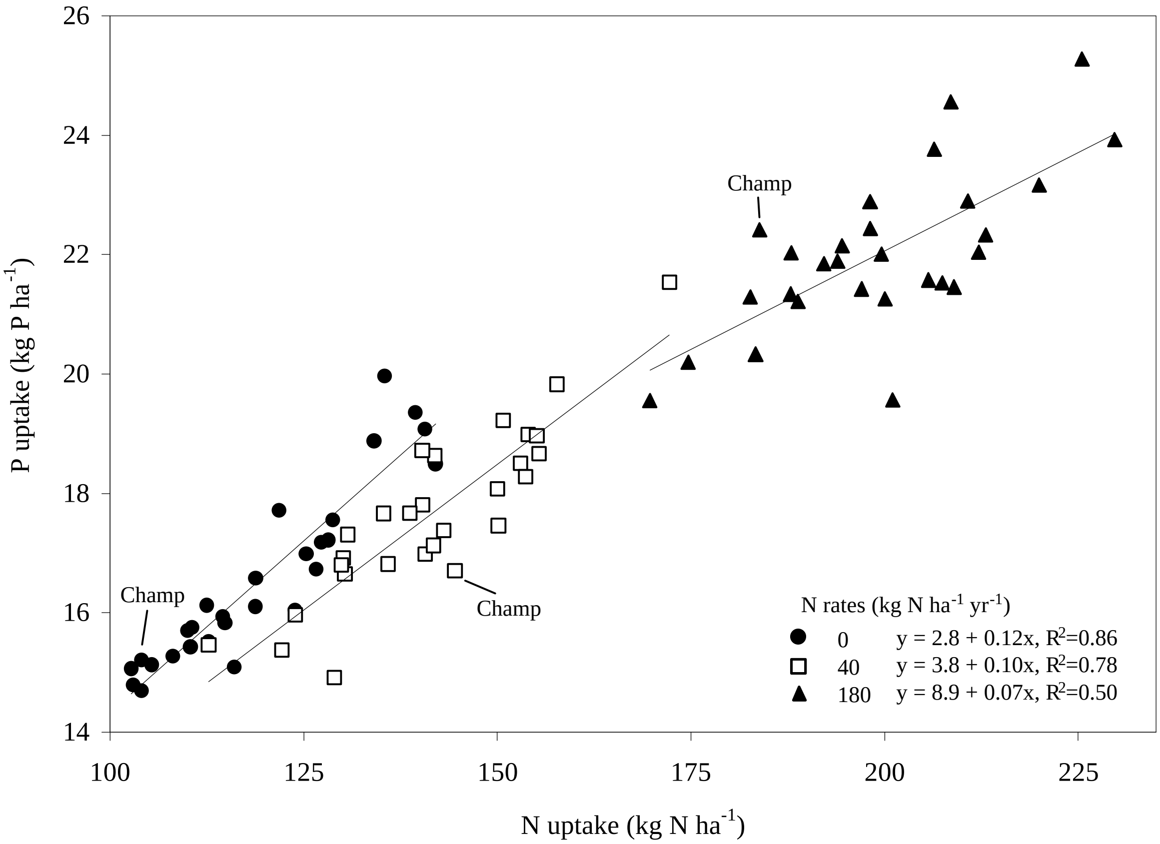

Figure 2 – P uptake as a function of N of 27 timothy genotypes and the cultivar Champ grown under 0, 40, and 180 kg N ha^{-1} yr^{-1}.