Is Phosphorus Uptake Related to Crop Lodging in Oat?

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Canada

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Introduction

- Oat (*Avena sativa* L.) is a low input cereal with excellent nutritional quality. Recent increase in the use of oat and a broadening of oat-based products in the market signify the oat's importance in healthy food industry.
- Nitrogen (N) fertilizer could strongly affect both yield and grain quality (May et al., 2004; Mohr et al., 2007). However, a particular problem with oat crop is its propensity to lodge with increasing N supply (Brinkman and Rho, 1984; Marshall et al., 1987), thereby limiting the effectiveness of fertilizer N in maximizing grain yield.
- Sensitivity of some oat genotypes to lodging limits the effectiveness of fertilizer N in maximizing grain yield (Ohm, 1976). A recent study showed that higher [P] in stems at flowering under high N supply conditions may be related to more severe lodging in oat than in wheat cultivars (Ma et al., 2012).
- It is hypothesized that with increasing N supply, P accumulation and distribution among plant parts may be associated with crop lodging.
- **Objective:** To determine N fertilizer effects on plant N uptake, P accumulation and their association with crop lodging and yield in diverse oat genotypes.

Methodology

- Field experiments were conducted in Ottawa, ON; Melfort, SK and Normandin, QC for two years.
- 10 (Melfort and Normandin) or 12 (Ottawa) genotypes treated with 4 fertilizer rates (0, 50, 100, and 150 kg N ha^{-1}) were arranged in a split-plot design in each site-year.
- Measurements of plant biomass at flowering and at maturity, yield and yield components at harvest.
- N and P concentrations in the plant, stem and leaves at flowering, and grain and straw at harvest.
- Belgian lodging scores when it occurred and at physiological maturity.

Belgian Lodging Rating System:

Lodging Index = S × I × 0.2

S= Area of surface lodged (1 = no lodging, to 9 = entire plot lodged)

I = Intensity of lodging (1 = completely upright, to 5= totally flat).

Results and Discussion

- Grain yields varied considerably among sites, with the lowest yield at Ottawa and the highest yield at Melfort for all four N levels (Fig. 1A).
- N fertilizer increased ($P < 0.01$) grain yield (Fig. 1). The pattern of yield response to N was similar, but yield plateaued at different N levels among genotypes (Fig. 1B).

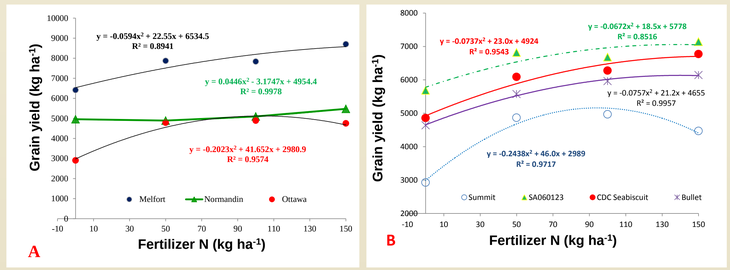

Fig. 1 Effect of N fertilizer rate on grain yields at 3 sites (A) and interactive effects of N-by-genotype on grain yield (B).

- Nitrogen application significantly affected lodging scores ($p<0.01$), with little lodging at 0 and 50 kg N ha^{-1}, and the highest lodging scores with 150 kg N ha^{-1} (Fig. 2). The reduced yields caused by high N application at the Ottawa site were highly associated with lodging scores.
- Lodging differed largely among genotypes ($p<0.01$) with the lowest lodging score for CDC Morrison, and the highest lodging scores for Summit (Fig. 2B).

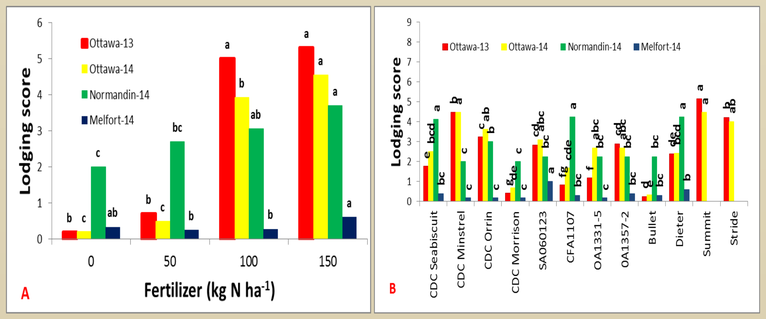

Fig. 2 Crop lodging scores as affected by N fertilizer rates (A) and genotypes (B) across sites.

- Regardless of the N levels, straw [N] were higher and [P] were lower at Normandin than at Ottawa and Melfort sites (Fig. 3A and 3B).
- Plants accumulated more P (Fig. 3B) and had smaller N:P ratio (Fig. 3C) at Ottawa than at the other sites.

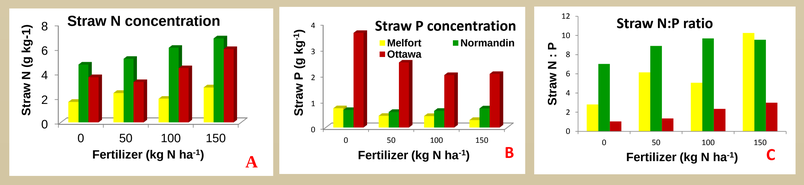

Fig. 3 Effects of fertilizer N rate on straw N (A), straw P (B) and straw N:P concentration ratio (C) at final harvest.

- Straw N and P concentrations for all genotypes varied widely at each site, with the highest straw [N] found at Normandin (Fig. 4A), the highest [P] (Fig. 4B) and lowest N:P ratio at Ottawa, and the lowest straw [N] and [P] at the Melfort site (Fig. 4A and 4B).

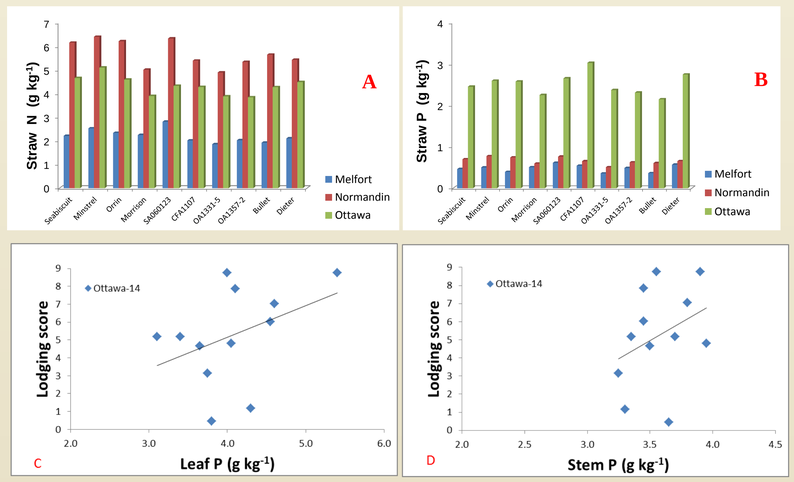

Fig. 4 Straw N and P concentrations of different genotypes at harvest across three sites, and leaf [P] and stem [P] in relation to lodging at Ottawa.

- No lodging was found at the Normandin site in 2013, but occurred with some genotypes in 2014. Ottawa had the most severe lodging among all sites.
- Leaves had higher [P] than stem P at heading; both appeared to be related with lodging (Fig. 4C, 4D).
- Straw [P] at harvest was negatively correlated with lodging (Fig. 5A) and straw N:P ratio was positively correlated with lodging (Fig. 5B).

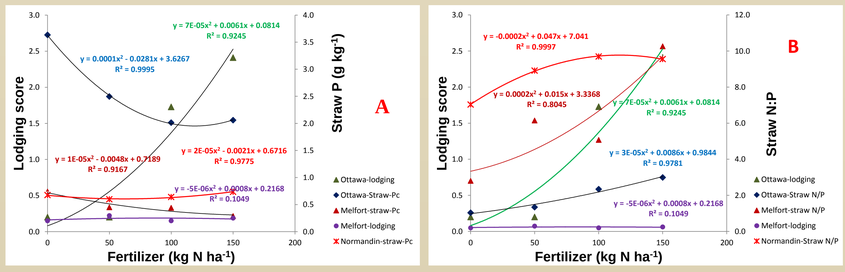

Fig. 5 The effect of straw P concentration (A) and straw N:P ratio (B) at harvest on oat lodging at different sites.

Summary and Conclusions

- Lodging differed largely among sites, N levels and cultivars; and severely affected grain yield.
- Stem P at harvest was negatively and N:P ratio positively correlated with lodging index.
- Accumulation of P in oat leaves and stems at flowering was often associated with crop lodging.
- Genotypes also differed largely in N and P uptake and N:P ratio among sites.
- Crop lodging is likely associated with an imbalanced accumulation of N and P in oat plants.

References

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