A ‘wait and see’ approach to N fertilizer management in maize: is it physiologically feasible?

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Introduction

Maize yield potential is regulated by crop growth rates during the critical period bracketing silking (± 2 weeks around silking), when kernel set is established. Interestingly, kernel set at silking reaches a plateau at relatively low fertilizer nitrogen (N) rates; these low N rates become suboptimal later, during grain-filling, due to rapid kernel abortion induced by post-silking N stress [1,2]. **Our overall hypothesis is that a second N application delivered before the start of grain-fill can maintain the yield potential achieved at low initial N rates.** If this is true, then a ‘wait and see’ approach to fertilizer N management is possible: applying a low initial N rate around planting that ensures yield potential at the onset of grain fill is not limited by N, along with a second, variable N rate applied around the critical period that, for the yield potential achieved, minimizes reductions in kernel number and weight during grain-fill.

Fertilizer N rate recommendation systems generally rely on farmer-derived yield goals made at the beginning of the season (i.e. an educated guess). The potential advantage of a ‘wait and see’ approach is that the second N application is made during the critical period, when farmers can better assess crop yield potential, the impact of extreme weather, and also perhaps use precision agriculture technologies with increased efficacy. We test whether such a management strategy is physiologically feasible.

Objective and Hypotheses

Objective: To determine the physiological feasibility of a management strategy that splits N fertilizer into two applications: 1) an initial pre-plant application and, 2) an application at the onset of the critical period in maize (V13).

1. The N rate which maximizes crop growth rates (CGR) during the critical period (V13-R2; ~4 weeks), and potential kernel number (pKN) at R2, is lower than the N rates which maximizes yield (i.e. where yield plateaus).
2. For crops receiving the same initial N rate, a non-limiting N rate delivered at V13 will prevent reductions in kernel number (KN) and weight (KW) if N stress would otherwise have reduced KN and KW during grain-fill.
3. There is no yield drag associated with splitting N, as opposed to delivering an equivalent amount of N all in a pre-plant application.

Materials and Methods

Location

Elora Research Station, Ontario, Canada
Summer 2017
Silt loam soil
Plant Density: 7.9 pl m^{-2}

Split plot experimental design

Main Plot: Initial pre-plant N rate (5 treatments)
0, 80, 140, 200, 260 – all kg N ha^{-1}
Split plot: In season N @ V13 (2 treatments):
1) No additional N, 2) Non-limiting N*
*N applied such that total N application = 260 kg N ha^{-1} (See table)

Pre-plant N rate (kg N ha^{-1})	N rate at V13 (kg N ha^{-1})
0	260
80	180
140	120
200	60
260	0

All N supplied as granular ammonium nitrate (NH_4^+-NO_3^-) incorporated to 2 cm depth

Parameters Measured (4 replicates)

1) Crop growth rate and N uptake during critical period (V13-R2)
2) Kernel set at R2, and kernel number/weight determination every 10 days thereafter
3) Grain yield at R5*
4) Grain yield plateau determined by regression with quadratic plateau model

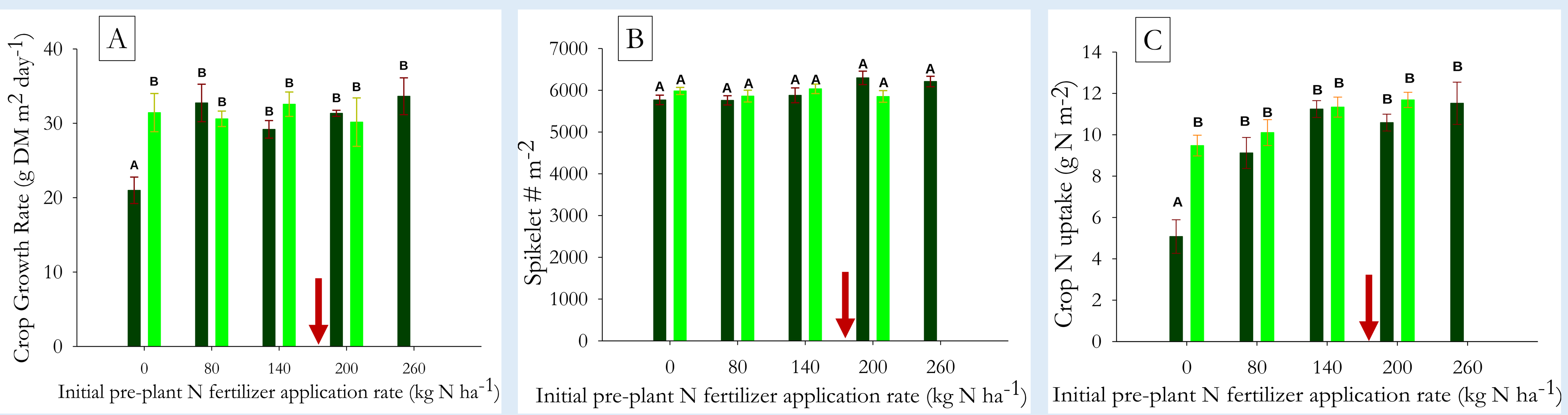
*final yield data not available in time for poster

Hypothesis #1: Final grain yield plateaued at 180 kg N ha^{-1}, but CGR during the critical period and spikelet count were maximized at much lower pre-plant N rates

i) A pre-plant N rate of 80 kg N ha^{-1} maximized CGR (g DM d^{-1}) during the critical period (Fig. A).
ii) Potential kernel number (kernel # m^{-2}) was not affected by pre-plant N rate (Fig. B).
iii) A non-limiting N application at V13 did not affect crop N uptake at R2 (g N m^{-2}) (Fig. C), CGR (Fig. A) or potential kernel number (Fig B), compared to crops which did not receive any in-season N.

No additional N
N applied at V13

N rate at yield plateau (180 kg N ha^{-1})



References: [1]: Lemcoff, J.H., and Loomis, R.S. 1986. Crop Sci., 26 [2]: Jacobs, B.C., and Pearson, C.J. 1991. Field Crops Res., 27

Conclusion

1. A farmer can apply relatively low N rates initially and, as late as the onset of grain-filling, suffer no reduction in yield potential
2. A second N rate applied at the start of the critical period (V13) will maintain KN and KW against N-stress that would otherwise have reduced KN or KW. This implies that the ‘wait and see’ N fertilizer management strategy we propose is feasible physiologically. This strategy may be advantageous, since it allows farmers, and the technologies they are using, to tailor N rates based on in-season measurements of important parameters (e.g. yield potential, canopy reflectance).

Hypothesis #3: A non-limiting N rate applied at V13 yielded equivalently to crops which received a non-limiting pre-plant N rate

i) For pre-plant N rates of 80 kg N ha^{-1} or above, there was no significant differences in yield between the treatments which received 260 kg N ha^{-1} pre-plant or a split N application totalling 260 kg N ha^{-1} at V13 (Table 1).
ii) In the lowest 3 pre-plant N rates (0, 80, 140), the N application at V13 significantly increased yields (Figure D).

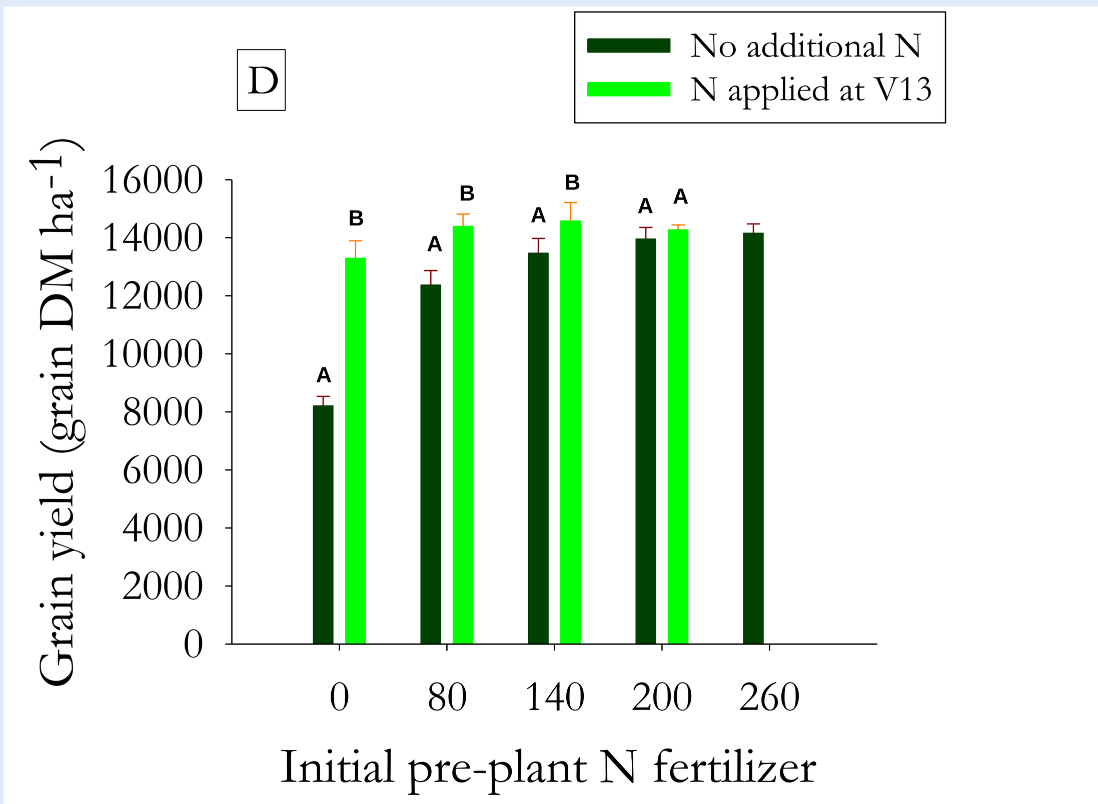


Table 1. Mean (±S.E.) grain yield for all treatments receiving 260 kg N ha^{-1} total*.

Pre-plant N rate (kg N ha^{-1})	N applied at V13 (kg N ha^{-1})	Dry grain yield (kg DM ha^{-1})
0	260	**13,228 (± 603) a**
80	180	**14,383 (± 433) b**
140	160	**14,577 (± 633) b**
200	60	**14,267 (± 170) b**
260	None	**14,152 (± 324) b**

***means followed by the same letter are not significantly different according to a Tukey’s multiple comparison test ($p < 0.05$). N=4.

Hypothesis #2: A second N application at V13 reduced kernel abortion and maintained kernel weight during grain-fill in the 3 lowest pre-plant N rates

i) When 0 kg N ha^{-1} was applied pre-plant, KN and KW were significantly reduced by 10 days after silking (DAS) when no additional N was applied at V13 (Fig. E and F).
ii) When 80 kg N ha^{-1} was applied pre-plant, KN was significantly reduced by 20 DAS, and KW significantly reduced by 40 DAS, when no additional N was applied at V13 (Fig. G and H).
iii) When 140 kg N ha^{-1} was applied pre-plant, KW was significantly reduced by 40 DAS when no additional N was applied at V13 (Fig. I and J).
iv) When 200 kg N ha^{-1} was applied pre-plant, additional N did not result in significant differences in KN or KW. This suggests that when sufficient N is applied pre-plant, additional in-season N will not improve yield components.

No additional N
N applied at V13

0 kg N ha^{-1} | **80 kg N ha^{-1}** | **140 kg N ha^{-1}**