Injected and Banded Nitrogen Fertilization for No-Tillage Winter Wheat in the Mid-Atlantic

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ABSTRACT

Wheat acreage produced using no-tillage has increased across Virginia over the last 10 years resulting in a need for refinement of fertilization practices. Recently, an increase in nitrogen (N) fertilizer price has prompted producers to look for additional ways to increase efficiencies in fertilizer management. The use of N injection equipment is currently being evaluated in no-tillage corn production in Virginia and may be useful in no-tillage wheat production systems. We initiated a study on a loam soil to test the utility of various N treatment application methods and to find the corresponding N rate for each practice. Nitrogen application methods included surface-broadcast, surface-banded (38 and 76-cm bands), and subsurface-banded applications (38 and 76-cm bands) of urea-ammonium nitrate (300 g N kg^{-1}) at four different N rates (45, 90, 135, and 180 kg N ha^{-1}). Three no-fertilizer controls were included. Two of the no-fertilizer controls had the subsurface applicator ran across the plots at 38 and 76-cm spacing to test for plant damage from the no-tillage coulters. Nitrogen treatments were made in the spring with 50% of the N applied at Zadoks' growth stage 25 and the remaining N applied at Zadoks' growth stage 30. Wheat grain yield and aboveground biomass were used to compare N treatments. Wheat yield was highest when 135 kg N ha^{-1} was used; which is the current Spring N recommendation for winter wheat in Virginia (4334 kg grain ha^{-1}); averaged over application method. Wheat aerial biomass peaked at 9333 kg biomass ha^{-1} when 90 kg N ha^{-1} was applied; averaged over application method. For application method, 38-cm surface band applications had superior yields compared to other treatments and averaged 4704 kg grain ha^{-1}; averaged over N rate. Broadcast, surface band and 76-cm subsurface band had similar aerial biomass production and averaged 13% higher than subsurface 38-cm bands. Overall, alternative N application practices may increase yield, biomass production, or decrease necessary N application rates to maintain current production and should be further investigated in the Mid-Atlantic.

INTRODUCTION

Wheat is an important crop to Virginia producers as we annually produce over 93,100 hectares valued in excess of US$71.5 million (USDA-NASS, 2008). Nitrogen losses commonly occur by leaching, volatilization when using urea containing fertilizers, and assimilation by competing microbes in the soil system. Nitrogen losses from volatilization are aggravated in conservation tillage systems where large amounts of crop residue remain on the soil surface. Exorbitant losses waste natural resources, pollute sensitive waterways, add to greenhouse gas emissions, and cause a decrease in fertilizer use efficiency that reduces farmers' profit margins. Research in Kansas indicated that subsurface fertilizer applications may increase efficiency by 30% and warrants research in the Mid-Atlantic (Kelley and Sweeney, 2007).

OBJECTIVE

- To increase N efficiency in Virginia winter wheat production through innovative fertilizer application procedures.

MATERIALS AND METHODS

- Site description:
  - Pamunkey loam (Pamunkey fine-loamy, mixed, semiactive, thermic Ultic Hapludalfs)
    - Brandon Plantation, Prince George County, Virginia.
      - One of the longest running agricultural enterprises in the United States. In continuous operation since 1614.
- No-tillage wheat planted in rotation with corn.
- Fall N application = 34 kg N ha^{-1} over entire field area.
- Spring N applied in 50-50 split applications at Zadoks' growth stage 25 and 30.
- Source = Urea-ammonium nitrate solution (300 g N kg^{-1}).
- Nitrogen application methods:
  - Surface broadcast (Standard Extension recommendation).
  - Surface band.
    - 38-cm apart.
    - 76-cm apart.
  - Subsurface band.
    - 38-cm apart.
    - 76-cm apart.
- Nitrogen rates:
  - 45 kg N ha^{-1}.
  - 90 kg N ha^{-1}.
  - 135 kg N ha^{-1} (Standard Extension recommendation).
  - 180 kg N ha^{-1}.
- Control plots:
  - No-fertilizer.
  - No-fertilizer + knifing rig at both growth stages.
    - 38-cm apart = Two trips over plot.
    - 76-cm apart = One trip over plot.
- All other nutrient applications and production practices were made according to Virginia Cooperative Extension recommendations for no-tillage wheat.
- Plant aboveground biomass sampled at harvest by harvesting 90 cm of3 rows within the plot.
- Harvested with a plot combine and grain weights corrected to 135 g water kg^{-1}.
- Economic return for N rate is calculated based on incremental increases after subtracting out yield from the 0-N control plots.
- Data analyzed using the PROC GLM procedure with SAS software and means separated using Fisher's least significant difference (LSD) at an alpha level of 0.10.

RESULTS AND DISCUSSION

Fig. 1. Yield on a loam soil impacted by subsurface nitrogen applicator with no fertilizer.

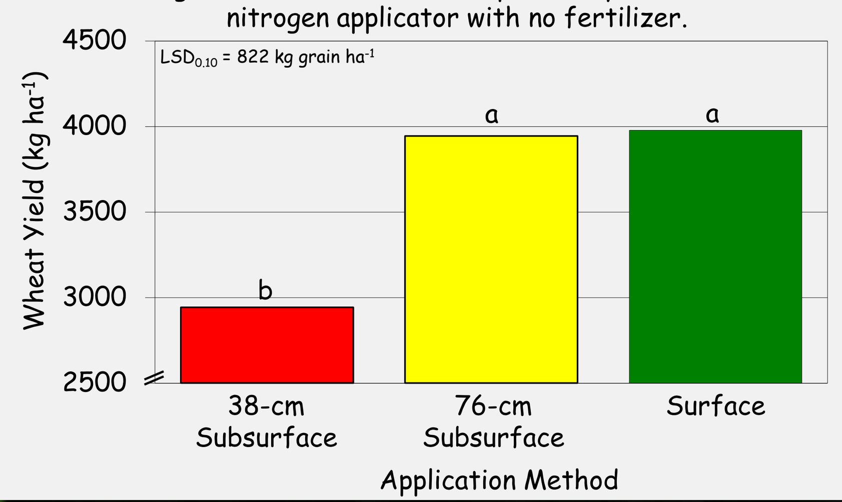


Fig. 2. Biomass production on a loam soil impacted by subsurface nitrogen applicator with no fertilizer.

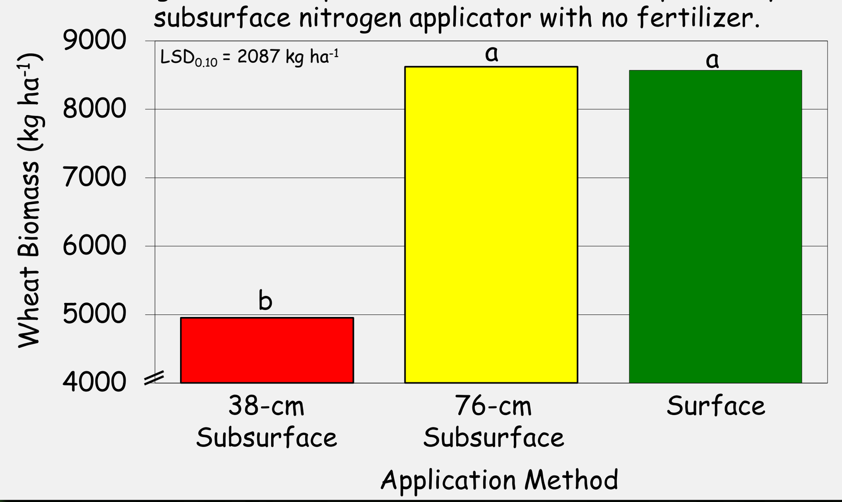


Fig. 3. Yield on a loam soil as impacted by nitrogen application method†.

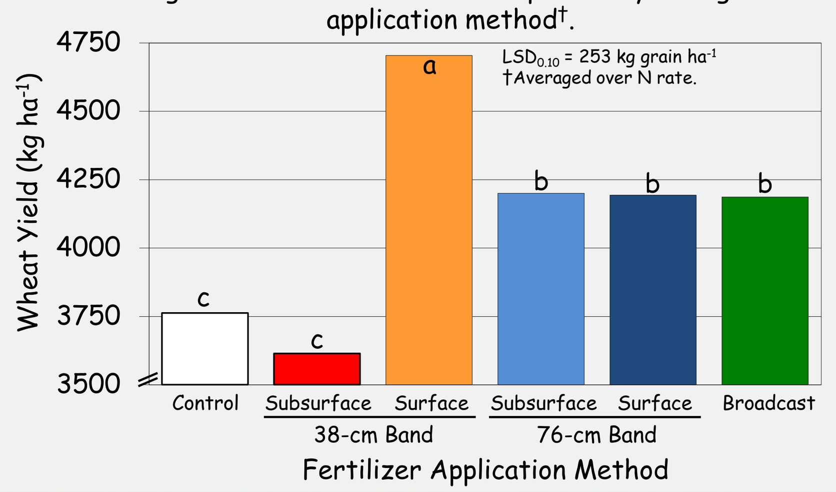
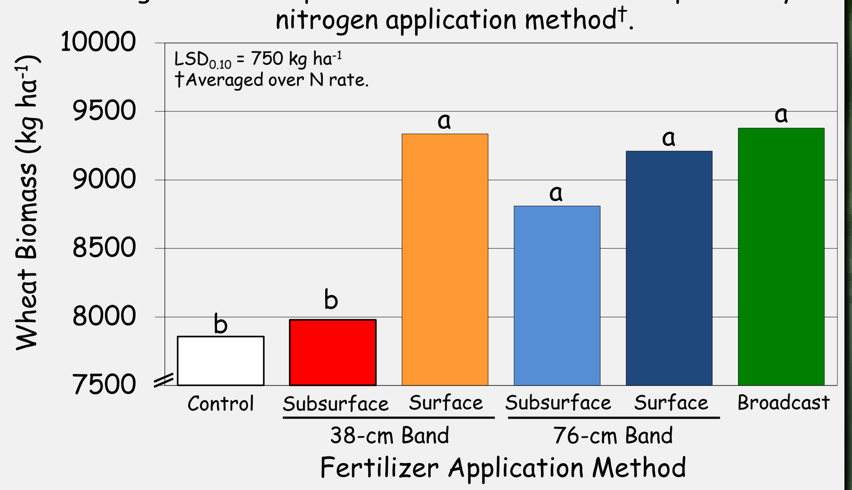


Fig. 4. Biomass production on a loam soil as impacted by nitrogen application method†.



No-Fertilizer Plots

- Yield (Figure 1):
  - The 76-cm subsurface application method (one pass over the plots) were statistically similar to surface application treatments (3945 vs. 3978 kg grain ha^{-1}, respectively).
  - Crop injury was observed when the subsurface applicator was ran over the plots twice to generate the 38-cm row spacing (2943 and 3945 kg grain ha^{-1} for the 38 and 76-cm spacing, respectively).
  - We suspect that most injury occurred at Zadoks' growth stage 30 during the second split application.
- Aboveground biomass production mirrored yield results (Figure 2).

Nitrogen Application Method

- Yield (Figure 3):
  - Surface 38-cm band treatments produced highest grain yields (4704 kg grain ha^{-1}), averaged over N rates.
  - Subsurface 38-cm treatments yields were statistically similar to no-fertilizer control plots (3615 vs. 3763 kg grain ha^{-1}), averaged across N rates.
  - The 76-cm subsurface or surface application methods were not more efficient than the current Extension recommendation of surface broadcast applications (4200, 4193, and 4187 kg grain ha^{-1}, respectively), averaged across N rates.
- Aboveground biomass production (Figure 4) generally mirrored yield results; with the exception of the 38-cm surface band that was similar to other surface band and broadcast treatments.

Fig. 5. Yield on a loam soil as impacted by nitrogen rate†.

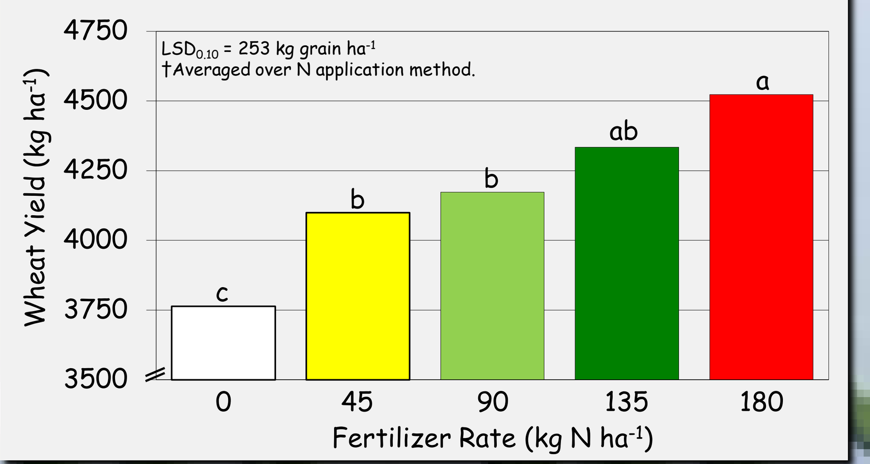
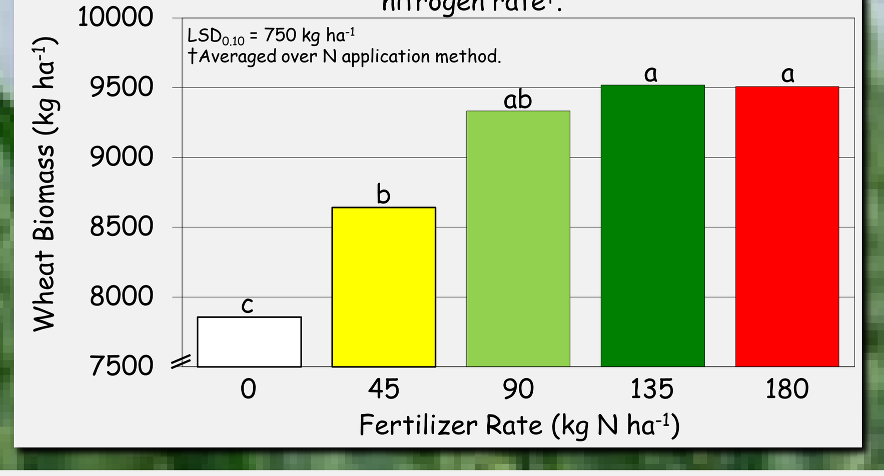


Fig. 6. Biomass production on a loam soil as impacted by nitrogen rate†.



Nitrogen Rate

- Yield (Figure 5):
  - Statistically, no yield advantage was obtained by applying 180 kg N ha^{-1} instead of the current Virginia Extension recommendation of 135 kg N ha^{-1} (4523 vs. 4334 kg grain ha^{-1}, respectively), averaged across N application method.
    - Wheat must reach US$0.24 per kg grain (US$6.43/bushel) to be economical feasible at 135 kg N ha^{-1} if N costs US$1 per kg.
  - On this particular loam soil, the 45 kg N ha^{-1} rate (US$0.13 per kg grain) is the highest economically viable N rate.
    - Assuming US$0.15 per kg grain (US$4.00/bushel) and US$1 per kg N.
  - The 180 kg N ha^{-1} rate had highest lodging (43%) (data not shown).
- Aboveground biomass production (Figure 6) generally mirrored yield results.

CONCLUSIONS

- Surface and subsurface banding of urea-ammonium nitrate to wheat warrants further research in the Mid-Atlantic.
- Current nitrogen rate Extension recommendations provide maximum yield and biomass production, but economical N rates may differ due to rising fertilizer prices.