Impact of banding enhanced efficiency nitrogen fertilizers on nitrogen use efficiency in agriculture

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Abstract

A suite of enhanced efficiency fertilizers (EEFs) have been developed in response to poor nitrogen (N) use efficiency in agriculture; but mechanistic understanding to support their effective utilization is not well developed. In particular, banding N-fertilizer creates a vastly different biochemical environment to broadcast and/or incorporated applications, influencing the efficacy of EEFs. This paper presents findings from laboratory and field experiments, thereby informing the effective utilization of EEFs under banded application with respect to soil physico-chemical properties.

Keywords: nitrogen use efficiency, enhanced efficiency fertilizer, inhibitor, polymer-coated-urea, N transformations

1. Introduction

Enhanced efficiency fertilizers (EEFs) utilize controlled release or nitrogen (N) stabilising mechanisms that improve the opportunity for crop recovery of N-fertilizer, reducing potential environmental losses. Similarly, banding of fertilizers in/near the root zone can enhance the opportunity for nutrient uptake by plants and minimize loss risks. However, the efficacy of EEFs in banded application is unknown and preliminary studies (Janke et al., 2019) indicate considerable modification of soil chemical conditions within the band may limit nitrogen use efficiency (NUE).

2. Methods

This study utilized laboratory and field experiments to investigate the distribution and transformation of N and inhibitors within and outside the fertosphere (fertilizer band and soil within 0.01 m) of a nitrification inhibitor (NI)-coated urea, a urease inhibitor (UI)-coated urea, and a controlled-release polymer-coated urea (PCU). All EEF treatments were benchmarked against similar rates of granular urea.

3. Results and discussion

3.1 Standard urea

Rapid hydrolysis of a urea band resulted in significant localized increases in pH (>9.0), electrical conductivity (1.5 – 2.5 dS m^{-1}) and aqueous NH_3 (10 -30 mg L^{-1}), with the severity and extent of chemical changes dependent on soil type. In all soils, a zone of nitrification inhibition was observed within and around the fertosphere, with the impacted zone greater in soils that support diffusive movement (i.e., coarse-texture, low CEC).

3.2 Urease inhibitor – NBPT

Banded NBPT slowed urea hydrolysis for *ca*. 7 – 21 days. This is consistent with studies of broadcast/incorporated application and indicates UI efficacy is not influenced by banding. However, preservation of N as urea permitted leaching of N deeper into the soil profile where changes in soil chemistry were minimal, enabling more rapid nitrification.

The NUE benefits of sub-surface banded UIs are therefore limited.

3.3 Nitrification inhibitor – DMPP

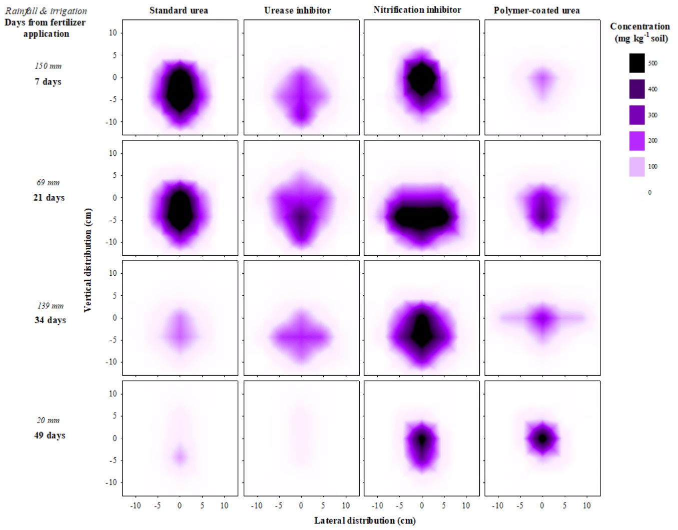

Fig 1: Distribution of NH_4-N (mg kg^{-1} soil) over time in soil treated with 150 kg N ha^{-1} of banded N-fertilizer.

Soil physico-chemical properties which dictate solute movement were the dominant factors influencing NI efficacy. In soils where diffusion may be limited (i.e., high clay, high OM, high CEC), the movement of N from the fertosphere was limited. As ureolytic-induced chemical changes disipated, the zone of nitrification was more closely aligned to inhibitor distribution (*ca*. 1 cm from fertosphere) *cf.* soils that support diffusive movement. Inhibitory effects on nitrification in NI-treated soils were observed for *ca*. 30 days longer than with standard urea. This is considerably longer than inhibitory effects reported from broadcast/incorporated application, and is hypothesized to be due to hostile band conditions limiting microbial degradation of the inhibitor.

3.4 Controlled-release - PCU

Banding PCU limited the availability of N to soil solution as a result of diminished concentration gradients slowing diffusive release. This extended the predicted release period and resulted in an unpredictable N supply. The relatively 'benign' chemical conditions of PCU bands produced nitrification rates similar to that of standard urea. Soil moisture was therefore a key factor influencing PCU efficacy, with relatively moist conditions necessary for effective release of N but an elevated risk of leaching or denitrificatioon loss if conditions are too wet.

4. Conclusions

Banding has a significant impact on EEF efficacy, but NUE benefits may be realized if the EEF technology is matched to key soil physico-chemical properties.

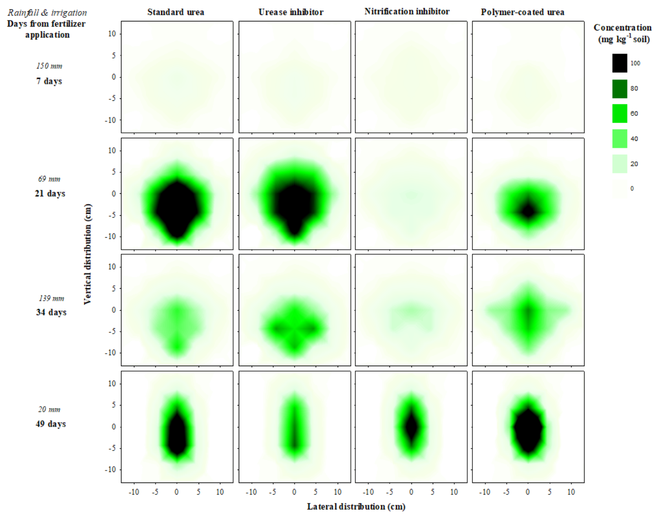

Fig 2: Distribution of NO_3-N (mg kg^{-1} soil) over time in soil treated with 150 kg N ha^{-1} of banded N-fertilizer.

Acknowledgements

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References

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