Release dynamics and crop recovery of Controlled Release Fertilizers (CRF)

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Abstract

This study compared the release dynamics, three-dimensional soil distribution, and crop recovery of nitrogen from polymer coated (PCU) and plant oil coated (POCU) urea to that from granular urea applied in a Vertisol soil in a subtropical climate. While the controlled release fertilizers (CRFs) slowed the release of N into the soil solution, no clear yield or crop N uptake advantages were observed. A large wet event between 61-72 days after fertilizer application (DAF) disadvantaged both urea and CRF products (N80 and N90), given most N had been released and nitrified in the first 60 days of the experiment, thus reducing N availability and crop N uptake.

Keywords: nitrogen use efficiency, controlled release fertilizers, PCU, POCU

1. Introduction

Enhanced Efficiency Nitrogen Fertilizers (EENFs) aim to improve nitrogen use efficiency (NUE) through better synchronization of fertilizer N supply with crop N demands. CRFs are one example of EENF technologies. Most CRFs are PCU, and thus non-biodegradable, remaining in the soil as a form of environmental pollutant (Azeem *et al*., 2014). New biodegradable coatings offer an opportunity to avoid environmental pollution concerns that exist from polymers, but their effectiveness relative to PCU and standard urea products is largely unknown.

2. Materials and methods

This study examined the release dynamics (Experiment 1, uncropped) and crop recovery (Experiment 2, with maize) of N from fertilizer bands for a number of CRF products. This paper reports data from PCU's with 90 and 180d release profiles (N90 and N180) and POCU with an 80d release profile (N80), against a granular urea reference at the same N rate. In Experiment 1, plots were sampled 8, 27, 48, 82 and 173 DAF. In Experiment 2, maize hybrid PAC 606IT was sown on 17 January 2019 at 70,000 plants/ha in rows 75cm apart. Fertilizers were applied in bands 10 cm away from the seeding row and 10cm deep at 125 kg N/ha at the time of sowing.

3. Results and discussion

3.1 Nitrogen release from CRFs

The release of N from CRF granules over time shows N80 and N90 products performed similarly, with more than 75-85% of N released by 48 DAF, but release of N from N180 was slower (Fig. 1). At 48 DAF, N180 had only released 57% of N, but by 82 DAF >75% of N had been released. Manufacturer specifications suggested the products were functionally 'exhausted' when >80% of applied N had been released. Interestingly, both PCU products continued to slowly release

N until 173 DAF, despite wet conditions (162.2mm rainfall and irrigation) that occurred 61-72 DAF. Soil mineral N persisted for longer in the sampling zone for all CRF products compared to standard urea in the order: urea < N80 < N90 < N180 (data not shown).

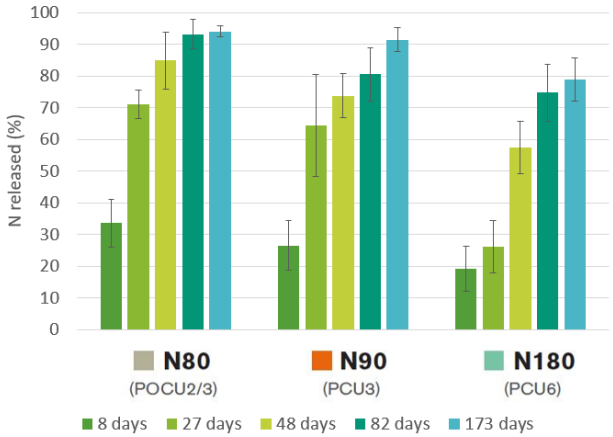

Fig. 1: Nitrogen released (%) from CRF granules.

3.2 Agronomic performance

Across all treatments, dry biomass averaged 14.4-16.1 t/ha, biomass N concentrations of 1.22-1.29%, and grain yield ranged from 9-10.8 t/ha, with no significant differences between treatments (Table 1). Crop N recovery mirrored grain yield data, ranging from 115-130 kg N/ha. There was a trend for both grain yields and N uptake to be maximized with N180. No CRF product showed any yield or crop N recovery advantage over standard granular urea.

Table 1. Dry biomass, grain yield and crop N recovery data.

	Dry biomass (t ha^{-1})	Biomass N (%)	Grain yield (t ha^{-1})	N recovery (kg N ha^{-1})
Urea	16.0	1.25	10.0	120.8
N80	16.1	1.28	9.9	123.4
N90	14.4	1.22	9.0	114.8
N180	15.9	1.29	10.8	130.3

Concentrated urea bands can temporarily restrict root access and subsequent nitrification (due to high pH, EC and aqueous NH_3 in and around the band). There was some evidence of these effects 8 DAF for urea and N80, but not in either PCU. These conditions moderated quickly, with substantial acidification in the fertilizer band of all products, presumably due to rapid nitrification up to 48 DAF. The further decline in pH from 48-82 DAF in the N180 was consistent with continuing N release (Fig. 1) and subsequent nitrification.

4. Conclusions

Slower release of N into the fertosphere soil was observed for both PCU and POCU products, with the performance of the N80 comparable to that of the PCU with an equivalent release period (N90). Nevertheless, there was no clear advantage in yield or N uptake which may be related to a large event from 61-72 DAF that would have disadvantaged urea, N80 and N90 similarly, given most N was already released and nitrified. The apparent increased N uptake and grain yield with N180 may have been related to continued release of N after the probable loss event. This research is currently under active investigation.

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References

Azeem B, Kushaari K, Man, Z B, Basit A and Thanh T H 2014 Review on materials and methods to produce controlled release coated urea fertiliser *Journal of Controlled Release* **181**: 11-21.