Ian Levett et al., Agrotechnology 2018, Volume 7
DOI: 10.4172/2168-9881-C2-033

The fabrication and evaluation of novel slow release agrichemicals for improving nitrogen uptake

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Nitrogen (N) loss from agricultural land represents inefficiencies for the farmer and significant environmental impacts through N pollution of fresh and coastal waters, potent greenhouse gas emissions, and volatilization of other reactive N compounds. In Queensland, protecting our Great Barrier Reef (GBR) from nutrient dumping has environmental, social and economic benefits. More than 80,000 tonnes of N enters the GBR lagoon annually. Only 30-50% of N applied to sugarcane land in QLD is accounted for in crop biomass, with the balance lost to the environment. N stabilizing agents are commonly used in conjunction with N fertilizers to slow the biological oxidation of ammonium to nitrate in the soil. However, efficacy has only been proven for temperate climates. The persistence of nitrification inhibitors in agricultural soils diminishes rapidly with increasing temperature. Consequently, their use in tropical agriculture is limited. Dicyandiamide (DCD) has been studied as a fertiliser stabilizer for over 50 years for temperate and sub-tropical regions, however, efficacy is limited at elevated temperatures. The encapsulation and controlled release of DCD may prevent exposure of the molecule to degradation mechanisms until it is in the soil profile. Here, poly(3 hydroxybutyrate co 3 hydroxyvalerate) (PHBV) has been investigated as a biodegradable matrix for the encapsulation of DCD. Industrially relevant extrusion processing was used to fabricate DCD-PHBV pellets at a loading of 25 wt% DCD. Release profiles were monitored in water, sand and soil at 30°C. Release curves show significant surface wash (30-45%) within the first week, with a sustained release rate of 2.10 µg DCD pellet-1 day-1 from 3 weeks out to 20 weeks. After 20 weeks ~40-57% of the DCD was mobilized. We have demonstrated the ability to initially load the soil with a significant proportion of the encapsulated DCD, followed by a very gradual mobilization of the DCD into the soil.

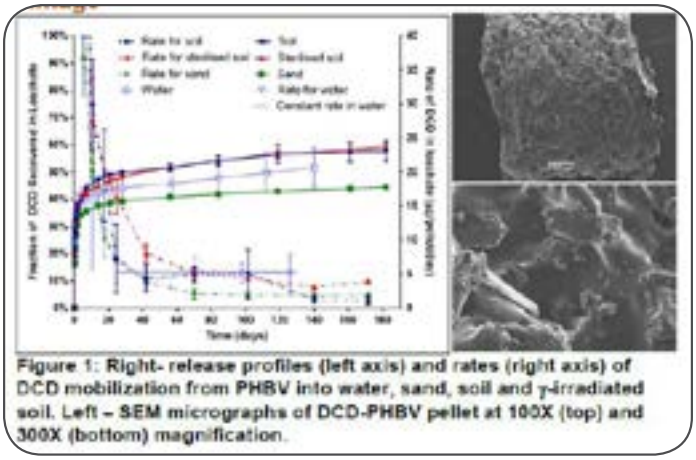

Figure 1: Right- release profiles (left axis) and rates (right axis) of DCD mobilization from PHBV into water, sand, soil and γ-irradiated soil. Left – SEM micrographs of DCD-PHBV pellet at 100X (top) and 300X (bottom) magnification.

Recent Publications:

1. Minet E P et al. (2013) Slow delivery of a nitrification inhibitor (dicyandiamide) to soil using a biodegradable hydrogel of chitosan. Chemosphere. 93(11):2854-2858.
2. Costa M M E et al. (2013) Use of polyhydroxybutyrate and ethyl cellulose for coating of urea granules. Journal of Agricultural and Food Chemistry. 61(42):9984-9991.
3. Kelliher F M et al. (2008) The temperature dependence of dicyandiamide (DCD) degradation in soils: a data synthesis. Soil Biology and Biochemistry. 40 (7):1878-1882.

4. Boyandin A N et al. (2013) Microbial degradation of polyhydroxyalkanoates in tropical soils. International Biodeterioration & Biodegradation. 83:77-84.
5. Abalos D et al. (2014) Meta-analysis of the effect of urease and nitrification inhibitors on crop productivity and nitrogen use efficiency. Agriculture, Ecosystems & Environment. 189:136-144.

Biography

Ian Levett is currently a PhD student looking into the development of novel controlled release agrichemical formulations using biodegradable polymers, predominantly using polyhydroxyalkanoates (PHAs). He obtained his integrated Bachelor's and Master's Degree in Chemical and Biological Engineering at The University of Queensland, Australia (2014).

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