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Review

Methods for Determining Nitrogen Release from Controlled-release Fertilizers Used for Vegetable Production

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ADDITIONAL INDEX WORDS. **incubation, column, pouch method, leaching, enhanced efficiency**

SUMMARY. **The purpose of this article is to review nitrogen (N) controlled-release fertilizer (CRF) research methods used to measure nutrient release from CRFs. If CRF-N release patterns match vegetable crop needs, crop N uptake may become more efficient, thus resulting in similar or greater yields, reduced fertilizer N needs, and reduced environmental N losses. Three methods categories to estimate N release are: laboratory; growth chamber, greenhouse, or both; and field methods. Laboratory methods include a standard and accelerated temperature-controlled incubation methods (TCIMs); methods incubate CRF using selected time periods, temperatures, and/or sampling methods. Accelerated TCIMs, in contrast to the standard method, allow for shorter incubation periods. Growth chamber and greenhouse methods, including column and plastic bag studies, may be used to test new CRF products in conditions similar to particular vegetable production systems. However, the column method predicts N release from CRFs more effectively than the plastic bag method because of ammonia volatilization and lower N recovery rates associated with the bag method. Both field methods, pot-in-pot and pouch methods, are viable vegetable research options. The pouch method measures N remaining in the CRF prill and the pot-in-pot method measures N released from the CRF, thus each method can be applied to different research objectives. Nitrogen released during incubation may be measured using methods such as total Kjeldahl N (TKN), prill weight loss, combustion, colorimetric, or ion-specific electrodes. The prill weight loss method is the least expensive but can only be used with urea CRF. Thus, the CRF-N source(s) and research objectives will determine the appropriate N analysis method. More research needs to be completed on correlations of field and laboratory CRF extractions. Field release methods should be considered the most reliable indicator of CRF-N performance until a laboratory method reliably predicts CRF-N expected field response.**

Enhanced efficiency fertilizers (EEF) are a group of fertilizers that reduce the risk of nutrient loss to the environment and subsequently increase fertilizer use efficiency (Slater, 2010). This increase may be accomplished through maintaining nutrients in the root zone by physical barriers (coating), reduced solubility, or retaining nutrients in a less leachable form (Trenkel, 2010). There are three subgroups of EEFs with different characteristics for horticultural production systems. Slow-release fertilizers (SRFs) contain N in a less-soluble, plant-unavailable form that usually need to be microbially degraded into plant available N. Stabilized fertilizers are a group of fertilizers that have a chemical inhibitor to either stop the oxidation of ammonium (NH_4^+) to nitrate (NO_3^-) by bacteria or to slow the enzymatic transformation of urea to NH_4^+ (Trenkel, 1997). Controlled-release fertilizers, the last subgroup of EEFs, are urea, ammonium nitrate, potassium nitrate, or other soluble fertilizer materials coated with a polymer (polyethylene and ethylene-vinyl-acetate or thermoplastics), resin (a subgroup of polymers and refers as alkyd-type resins and polyurethane-like coatings), sulfur, or a hybrid of sulfur-coated urea (SCU) coated with a polymer or resin. These coated materials release nutrients in water at a predictable rate when used at the manufacturer specified temperature (e.g., 25 °C) (Trenkel, 2010). The European Committee for Standardization's (2002) method determines nutrient release time based on 75% nutrient release from CRFs.

The European Union has developed both standard and accelerated laboratory procedures for measuring N release from CRFs; however, researchers in the United States are still developing a universal test for CRFs and SRFs for commerce purposes (European Committee for Standardization, 2002; Sartain et al., 2004). Growth chamber and greenhouse methods are used to evaluate or compare how CRFs will act in a particular controlled environment (Broschat and Moore, 2007; Huett and Gogel, 2000). Lastly, field methods are used to measure N release in commercial

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
2.54	inch(es)	cm	0.3937
645.1600	inch^2	mm^2	0.0016
28.3495	oz	g	0.0353
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32