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Comparing the Adequacy of Controlled-release and Water-soluble Fertilizers for Bedding Plant Production

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Abstract*. Four complete water-soluble fertilizer (WSF) formulations including micronutrients applied at 200 mg·L^{-1} nitrogen (N) at each irrigation [Peters Excel (21N–2.2P–16.5K), Daniels (10N–1.8P–2.5K), Peters Professional (15N–1.3P–20.8K), and Jack's Professional (20N–1.3P–15.7K)] were compared with two controlled-release fertilizer (CRF) products (also containing micronutrients) substrate incorporated at transplant at a rate of 3000 g·m^{-3} of substrate [Osmocote Plus (15N–4P–9.9K, 90 to 120 days longevity at 21 °C) and Osmocote Bloom (12N–3.1P–15K, 60 to 90 days longevity at 21 °C)] in the greenhouse production of four commonly produced bedding plant species with high alkalinity irrigation water (pH 7.1, 280 mg·L^{-1} $CaCO_3$ equivalent). Species included *Argyranthemum frutescens* (L.) Sch. Bip. 'Madeira Cherry Red' and iron-inefficient *Calibrachoa* Cerv. hybrid 'Cabaret Pink Hot', *Diascia barberae* Hook. f. 'Wink Coral', and *Sutera cordata* Roth 'Abunda Giant White'. Additional treatments included a combination of 100 mg·L^{-1} Excel and 2100 g·m^{-3} Osmocote Plus and an Osmocote Plus treatment irrigated with reduced alkalinity water (acidified to pH 6.3, 92 mg·L^{-1} $CaCO_3$ equivalent). Bedding plants were evaluated at the end of a finish or market stage (3 or 5 weeks depending on species) for shoot dry mass (SDM) and root dry mass (RDM), tissue nutrient concentrations, and visual quality rating (0 to 4). At 3 weeks, there were no significant differences in SDM and RDM between fertilizer treatments for any of the four species. Shoot dry mass significantly increased at 5 weeks in the WSF and combination treatments over the three CRF only treatments for *Argyranthemum* and over the non-acidified Osmocote Plus treatment only for *Calibrachoa*. At finish, 3 weeks for *Sutera* and *Diascia* and 5 weeks for *Argyranthemum* and *Calibrachoa*, visual quality rating for all species was lowest when using Osmocote Plus with or without acidified irrigation water compared with the WSF treatments, except the Daniels treatment in *Argyranthemum*, which also resulted in a low visual quality rating. Leaf tissue N for all species and phosphorus (P) for all except *Diascia* were below the recommended range for bedding plant crops in the CRF treatments, which was reflected by the lower substrate electrical conductivity (EC) for the CRF alone and combination treatments. Leaf tissue N and P were related to visual quality rating for all species, leaf tissue potassium (K) for *Argyranthemum* and *Calibrachoa* only, and leaf tissue iron (Fe) for *Diascia* only.

Potted annual bedding and garden plants represented a \$1.33 billion wholesale value in the 15 top-producing states [U.S. Department of Agriculture (USDA), 2012]. New varieties have been released at a rapid rate motivated by the 48% market share bedding and garden plants have of the total floriculture crop sales in the United States (USDA, 2012). Breeders have released many new varieties to feed the market-driven demand for designer colors in flower and foliage, modified growth habit, and improved garden performance for the increasingly inexperienced gardener (Abate and Peterson, 2005). This presents challenges to bedding and garden plant producers, because production problems can be coupled with these desirable marketing qualities. Inefficient Fe uptake is one such characteristic documented in the genus of *Calibrachoa*, *Diascia*, *Petunia*, *Sutera*, and others, occurring at substrate pH above 6.2 (Fisher and Argo, 2002). High alkalinity irrigation water (at 150 mg·L^{-1} $CaCO_3$ equivalent or greater) (Nelson, 2003) is conducive to an increase in substrate pH. The median alkalinity value for irrigation water in the United States is estimated at 130 mg·L^{-1} $CaCO_3$ equivalent with four of the five top floriculture-producing states having a median value exceeding this (Argo et al., 1997; USDA, 2012). Regionally, the Great Lakes states of Illinois, Michigan, and Ohio had the highest median alkalinity (187 mg·L^{-1} $CaCO_3$ equivalent) (Argo et al., 1997), yet accounted for a wholesale annual bedding plant value of ≈\$331 million in 2011 (USDA, 2012). Growers have the options of using a substrate with a lower lime charge, acidifying irrigation water, or using a fertilizer that is acidifying in reaction or contains Fe in a highly soluble form (Fe-EDDHA) to avoid Fe deficiency-induced chlorosis (Fisher and Argo, 2002). Irrigation water acidification and using multiple substrates and fertilizer formulations are particularly difficult for smaller growers. Economics, including the cost of acidifying water, and number and types of crops grown dictate which approach is used. Environmental conditions influence outcome and Fe deficiency-induced chlorosis may not be a significant issue every production cycle. Avoidance is preferable to corrective procedures because value is typically lost by the time deficiency symptoms are observed (Argo and Fisher, 2009).

Coinciding with the genetic changes in bedding plant material are environmental concerns in regard to fertilizer runoff from inefficient fertilizer delivery systems and excess application (Evans et al., 2007). Volatility in fertilizer costs (Silva, 2011), together with the environmental impacts of WSF application rates that err on the side of overapplication, have driven advances in coating technologies for CRF products. Complex polymer coatings that release nutrients to the substrate as a slow, continuous dose at a rate more compatible with uptake have the potential to decrease the environmental impact of excess N, P, and K (Hulme, 2012). Nutrient release rates in polymer-coated CRF products are temperature-dependent and the CRFs are formulated for different longevities (nutrient release period at a standard temperature). In addition, micronutrients can be incorporated to provide the full array of elements necessary for production in soilless substrates. The objective of this study was to compare two formulations of polymer-coated CRFs containing micronutrients (differing slightly in N–P–K ratio and in longevity) applied at the recommended N rate to four WSF options suitable for production with high alkalinity water and one combination CRF and WSF treatment for the production of *Argyranthemum* and iron-inefficient *Calibrachoa*, *Diascia*, and *Sutera*. In addition, species were chosen to represent a range of nutrient requirements, including *Argyranthemum*

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