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Nutrient Uptake of Taro [*Colocasia esculenta* (L.) Schott var. *esculenta*] Applied with Controlled and Fast Release Nitrogen Fertilizers

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Abstract

Field experiments were conducted to determine the nutrient uptake of taro to which controlled release (CR) and fast release (FR) fertilizers were applied. A factorial experiment in randomized complete block design with three replications was conducted in each site. Four nitrogen treatments, three harvest dates and two sites were the experimental factors examined. The results showed that interactions between sites, harvest dates and nitrogen sources were significant ($P < 0.05$) for the variables analysed. Hence, FR fertilizers resulted in the maximum N, P, Ca, Cu, Fe and Zn uptake at 6 months after planting (MAP). Also, the application of FR fertilizers resulted in the maximum P and Cu uptake at 2 MAP. Meanwhile, CR fertilizers resulted in the maximum K, Ca, Mg and Cu uptake at 4 MAP. Also, CR fertilizers resulted in the maximum Mn uptake at 6 MAP. Therefore, the application of FR and CR fertilizers enhanced the nutrient uptake of taro plants with temporal variation.

Key words: Taro, nutrient uptake, N fertilizers

Introduction

Taro cultivation dates back to 400 BC making it one of man's oldest food crops (Kagbo et al., 1977). Global taro production is estimated at 11.8 million tons per annum and is ranked fifth behind other root crops such as potato, cassava, sweet potato and yam (Akwee et al., 2015; Quero-García et al., 2006). The composition of taro corms includes carbohydrate (between 13 and 29%), protein (between 1.4 and 3%) and fat (between 0.16 and 0.36%) while taro leaves are sources of Vitamin A, C, B_1 (thiamine) and B_2 (riboflavin) (FAO, 1999). Studies have shown that taro requires large quantities of soil nutrients for its growth and development (Fa'amatuainu, 2016; Fa'amatuainu and Amosa, 2017; Prasad, 1999). Even though there are a number of studies that discuss the influence of applying varying nitrogen rates on taro (Fa'amatuainu and Amosa, 2017; Fa'amatuainu and Amosa, 2016; Hartemink et al., 2000; Mare et al., 2009) there is a scarcity of information on the influence of different nitrogen sources (nitrate versus ammonium fertilizers as well as controlled release (CR) versus fast release (FR) nitrogen fertilizers) on the nutrient uptake of taro plants. The use of FR fertilizers such as urea and calcium nitrate has long been used in farming. However, new next generation fertilizers such as the CR polymer coated urea are now available in the market. The gradual nitrogen supply by the polymer coated urea is due to the polymer coating which enclosed the urea. The coating contains a small opening which allows water to move in, causing the urea to slowly diffuse out (Ruark, 2012). Therefore, the main objective of this study is to determine the nutrient uptake of taro plants applied with CR and FR nitrogen fertilizers.

Materials and Methods

Two experiments were conducted at the UWI Field Stations in Mt Hope (North 10°38'17.16, 61°25'40.8 West) which contain the River Estate soil series, fluventiceutropepts and Orange Grove (10°38'6.36 North, 61°21'59.76 West) containing the Orange Grove soil series, aerictropaquepts, for one season. The experiment was setup in a factorial design layout, consisting of four nitrogen treatments; urea, calcium nitrate, polymer coated urea and the control, three harvests at two, four and six MAP in two sites *viz*., Mt Hope and Orange Grove. Taro suckers of uniform size of the local "Blue" taro cultivar from farmers were used as planting materials. Each plot had 85 plants planted at 55 cm spacing, while the inner 15 plants were harvested for analysis.

Nitrogen fertilizers (@ 100 kg ha^{-1}) were applied during the first month of planting, with the FR urea and calcium nitrate applied in split applications while the CR polymer coated urea was applied in a single application. FR fertilizers were applied at planting and at 1 MAP while the CR fertilizer was applied only at planting. Nitrogen from CR fertilizers is gradually released while nitrogen from FR fertilizers is instantly available to plants. Phosphorus (50 kg ha^{-1}) was applied using triple superphosphate while potassium (100 $kgha^{-1}$) was applied as muriate of potash to the plots at planting. Fifteen taro plants were harvested per treatment for nutrient analysis at two, four and six MAP. At each harvest, the plants were washed with water to remove any soil on the plants. Taro corms were then air-dried before placing them in the oven for drying. Dried samples were ground to pass through a 1.0 mm-mesh screen before acid digestion to prepare for nutrient (N, P, K, Ca, Cu, Mg, Mn, Fe and Zn) analysis. All chemical analysis followed standard laboratory methods (AOAC, 1995). Nutrient uptake was calculated from the corms nutrient content and dry matter. Analysis of variance (ANOVA) was performed on the data collected using the IBM SPSS 20 statistical software.

Results and Discussion

Fig. 1 to 9 shows the N, P, K, Ca, Mg, Cu, Mn, Fe and Zn uptake of taro plants as influenced by CR and FR nitrogen fertilizers at two, four and six MAP. The ANOVA revealed that interactions between sites, harvest dates and nitrogen sources were statistically significant ($p < 0.05$) for the nutrients uptake in taro corms.

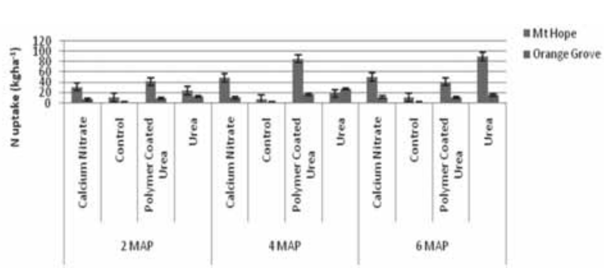

Fig. 1. Nitrogen uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.77

At 2 and 4 MAP, polymer coated urea resulted in the maximum N uptake while urea resulted in the maximum N uptake at 6 MAP in Mt Hope (Fig.1). Hence, gradual nitrogen supply by CR fertilizers favours maximum N uptake during the early growth stages while instant nitrogen supply by FR fertilizers favours maximum N uptake during the later growth periods of taro plants in Mt Hope. At Orange Grove, urea resulted in the maximum N uptake at 2, 4 and 6 MAP. Hence, FR fertilizers resulted in maximum N uptake at 2, 4 and 6 MAP. Fig. 2 shows that at 2 and 6 MAP, urea resulted in the maximum P uptake while calcium nitrate produced the highest P uptake at 4 MAP in Mt Hope. Hence, instant nitrogen supply by FR fertilizers produced maximum P uptake throughout the growing season in Mt Hope. At Orange Grove, urea resulted in the maximum P uptake at 2 and 6 MAP while polymer coated urea resulted in the maximum P uptake at 4 MAP. Therefore, FR fertilizers resulted in maximum P uptake in the corms at 2 and 6 MAP while CR fertilizers resulted in maximum P uptake in the corms at 4 MAP.

Fig. 3 shows that polymer coated urea resulted in the maximum K uptake 2, 4 and 6 MAP. Hence, gradual nitrogen supply by CR fertilizers favours maximum K

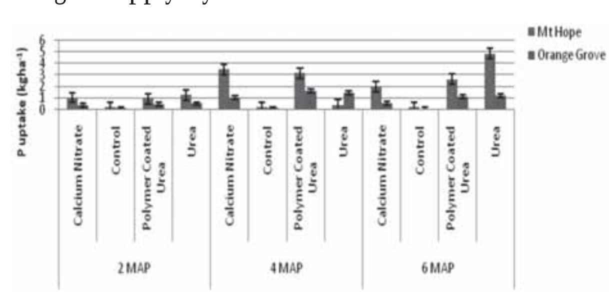

Fig. 2. Phosphorus uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.08

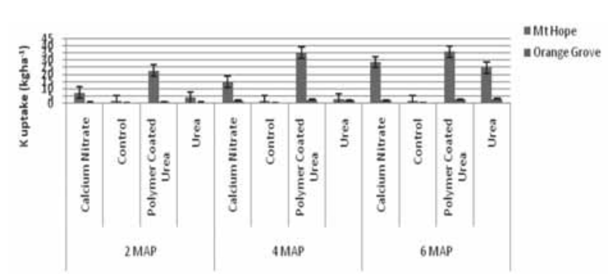

Fig. 3. Potassium uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.06

uptake throughout the growing season in Mt Hope. At Orange Grove, polymer coated urea resulted in the maximum K uptake at 2 and 4 MAP while urea resulted in the maximum K uptake at 6 MAP. Fig. 4 shows that at 2 and 6 MAP, urea resulted in the maximum Ca uptake while polymer coated urea resulted in the maximum Ca at 4 MAP in Mt Hope. At Orange Grove, polymer coated urea resulted in the maximum Ca uptake at 2 and 4 MAP while urea resulted in the maximum Ca uptake at 6 MAP. It seems that CR fertilizers resulted in the maximum Ca uptake at 2 and 4 MAP. Hence, gradual nitrogen supply by CR fertilizers favours maximum Ca during the early growth stages while instant nitrogen supply by FR fertilizers leads to maximum Ca in the later growth periods. Fig. 5 shows that at 2 MAP, calcium nitrate resulted in the maximum Mg uptake while polymer coated urea resulted in the maximum Mg uptake at 4 and 6 MAP in Mt Hope. At Orange Grove, polymer coated urea resulted in the maximum Mg at 2 and 4 MAP while urea resulted in the maximum Mg uptake at 6 MAP.

Fig. 6 shows that urea resulted in the maximum Cu uptake at 2 and 6 MAP while polymer coated urea resulted in the maximum Cu uptake at 4 MAP in Mt Hope. At Orange Grove, calcium nitrate, polymer coated urea and urea resulted in the maximum Cu uptake at 2, 4 and 6 MAP respectively. Fig. 7 shows that calcium nitrate resulted in the maximum Mn uptake at 2 MAP

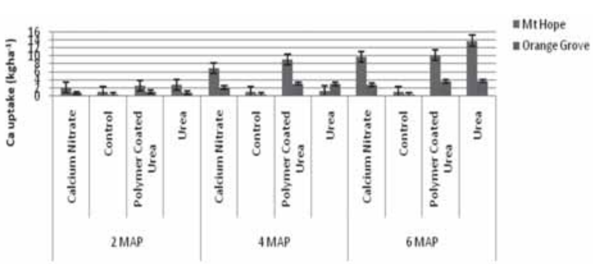

Fig. 4. Calcium uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.07

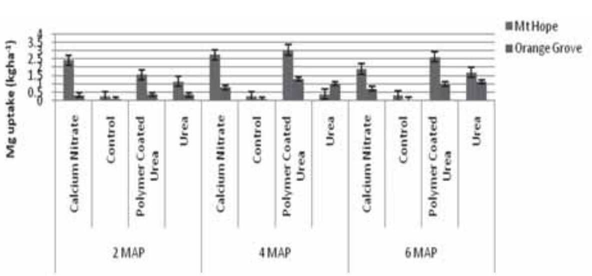

Fig. 5. Magnesium uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.06

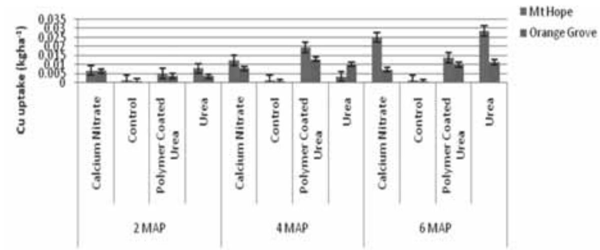

Fig. 6. Copper uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.0004

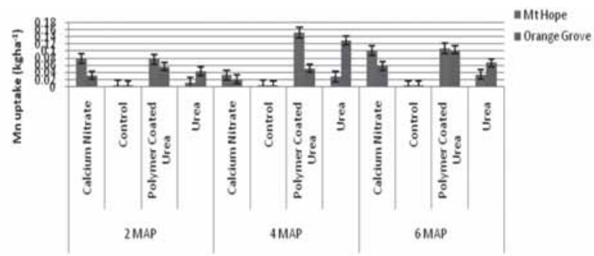

Fig. 7. Manganese uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.003

while polymer coated urea resulted in the maximum Mn uptake 4 and 6 MAP. Hence, instant nitrogen supply by FR fertilizers leads to maximum Mn uptake during the early growth stages while gradual nitrogen supply by CR fertilizers favours maximum Mn uptake during the later growth periods in Mt Hope. At Orange Grove, polymer coated urea resulted in the maximum Mn uptake at 2 and 6 MAP while urea resulted in the maximum Mn uptake at 4 MAP. Hence, gradual nitrogen supply by CR fertilizers leads to the maximum Mn uptake during the early and later growth stages while instant nitrogen supply by FR fertilizers favours maximum Mn uptake midway through the growth period.

Fig. 8 shows that calcium nitrate resulted in the maximum iron uptake at 2 and 6 MAP while polymer coated urea resulted in the maximum iron uptake at 4 MAP. Hence, instant nitrogen supply by FR fertilizers leads to maximum Fe uptake during the early and later growth stages. Gradual nitrogen supply by CR fertilizers favours maximum Fe uptake midway through the growing season in Mt Hope. At Orange Grove, polymer coated urea, urea and calcium nitrate resulted in the maximum Fe uptake 2, 4 and 6 MAP respectively. Hence, gradual nitrogen supply by CR fertilizers leads to maximum Fe uptake during the early growth stages while instant nitrogen supply by FR fertilizers favours maximum Fe uptake during the later growth periods (Fig. 9). Calcium nitrate resulted in the maximum Zn uptake at 2 and 4

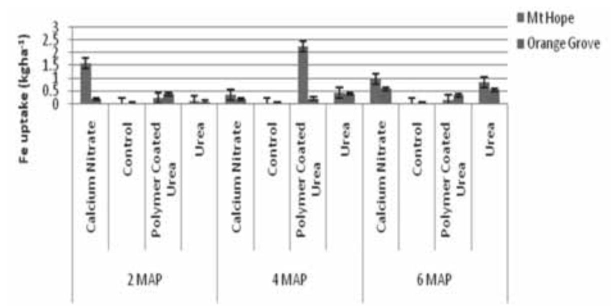

Fig. 8. Iron uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.02

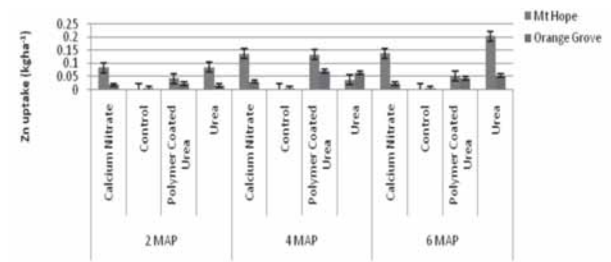

Fig. 9. Zinc uptake by taro corms as influenced by nitrogen sources and crop age, LSD = 0.002

MAP while urea resulted in the maximum Zn uptake at 6 MAP. Hence, rapid nitrogen supply by FR fertilizers leads to maximum Zn uptake in Mt Hope. At Orange Grove, polymer coated urea resulted in the maximum Zn uptake at 2 and 4 MAP while urea resulted in the maximum Zn uptake at 6 MAP. Hence, gradual nitrogen supply by CR fertilizers favours maximum Zn uptake during the early growth stages while instant nitrogen supply by FR fertilizers leads to maximum Zn uptake during the later growth periods.

Conclusion

Overall, the results showed that FR fertilizers resulted in the maximum N, P and Cu uptake while CR fertilizers resulted in the maximum K, Mg and Mn uptake for taro plants with temporal variation during the growing season. Calcium nitrate which is both FR and nitrate based fertilizer seems to enhance the nutrient uptake of taro plants in comparison to ammonium fertilizers (urea and polymer coated urea). Generally, ammonium fertilizers acidified the growth medium which leads to stunted growth and eventually lower yield in plants (Mattson et al., 2009). As a result, ammonium uptake lowers the pH of the growing medium because plants released hydrogen ions (H^+) in order to maintain a balanced pH inside the plants. Meanwhile, the uptake of nitrate instigates the release of OH^- ions which combines with H^+ ions in the medium to form water molecules (Mattson et al., 2009).

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