TURF RESPONSE TO REDUCED RATES OF POLYMER-COATED UREA

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ABSTRACT

Polymer-coated urea (PCU) is a controlled-release fertilizer which can enhance nitrogen (N) use efficiency (NUE), reduce N pollution, reduce the need for repeated fertilizer applications, and reduce turfgrass shoot growth and associated costs. A PCU fertilizer rated for 120 d was applied at 50, 75, and 100% of the recommended full rate and compared to an unfertilized control and urea, applied either all at once or split monthly at the full recommended rate. Spring applied PCU showed no initial response until 42 d after application. After which, the 75 and 100% rates were equivalent to urea split monthly for biomass growth, verdure, and shoot tissue N. At the 50% rate, there was reduced growth and shoot tissue N and a 4% reduction in verdure. This PCU is effectively applied as a fertilizer at a reduced rate between 50 and 75%. More research is required to reach the goal of uniform seasonal growth with adequate verdure and to better quantify reduction of N pollution.

INTRODUCTION

All plants require nitrogen (N) to complete their life cycle, as it plays vital roles in various biochemical processes. N is often the primary limiting factor for plants growing in soil-based ecosystems, due to its high demand and mobile characteristics (Chatterjee, 2012). Nitrate is easily lost through leaching, and it can be denitrified and lost to the atmosphere. Turfgrass requires a constant supply of N. However, excessive N is often applied in an effort to maximize benefits, which can result in immense increases in biomass. It then can contribute to N pollution in the atmosphere, which can lead to global warming and acid rain, and in water, which causes eutrophication and nutrient pollution (Ransom, 2014).

Controlled-release fertilizers (CRF) and/or slow-release fertilizers (SRF) are used to increase nitrogen-use efficiency (NUE) and allow for the provision of N over extended periods of time. This attempts to better match plant N needs throughout the growing season and to reduce time of exposure for N losses to the environment. In our use of Polymer-coated urea, the polymer coating has micropores to allow soil moisture to diffuse through the coating to dissolve urea. The main objectives of this study will be to evaluate PCU products to provide adequate N, similar to traditional grower's standard practice (GSP). Another objective is to determine the optimal N that can be used with PCU to maintain sufficient turfgrass quality in comparison to GSP. We hypothesize that 1) PCU provides a slow release of N that will maintain turfgrass quality throughout the spring/summer growing months, and 2) Rates can be reduced to 50%, which will limit excessive growth of turfgrass but still maintain adequate quality color in turf.

MATERIALS AND METHODS

One field study was conducted in 2011 and three studies in 2012 at separate Utah, USA locations with established Kentucky bluegrass over 120 days. The 2011 site was conducted at the

BYU experimental farm near Spanish Fork, on a Timpanogos clay loam. The 2012 sites were located in the vicinity of the BYU sports turfgrass sod farm. The 2012 site 1 turfgrass plots were established in manufactured sand soil from crushed quartz minerals with 1% peat moss. The 23 cm (9.05 in) layer of sand lay over a gravel layer for a designed perched water table. The 2012 site 2 was also a manufactured urban loam soil. The 2012 site 3 was classified as a sandy soil (>95% sand). All soils were alkaline pH (7.5-8.2), had low organic matter (1-2%), low to moderate levels of all nutrients, and minimal salts. Air temperature and precipitation for all sites were monitored, and best management practices were followed in growing the turfgrass. Applications of phosphorus (0-30-0) and macro and micronutrients were applied as needed.

Plots, 1 m x 3 m (3.28 ft x 9.84 ft), were set up in a randomized block design with four replications of six treatments. Treatments included: 1) an unfertilized control, 2) urea (46-0-0), 3) urea with four equal split applications every 30 d, 4) polymer-coated urea (PCU 100%; 43- 0-0), 5) PCU at a 75% rate (PCU 75%), and 6) PCU at a 50% rate (PCU 50%). Treatments 2- 6 were applied at a "full" rate (100%) at 140 kg N ha-1 (308 lbs). The plots were then sprinkle irrigated.

The overall quality of the KBG (verdure) was weekly measured visually using a scale from 0 to 5 (0= dead, brown shoots; 5 = dark green, healthy) and Normalized Difference Vegetation Index (NDVI). Soil samples were taken 7, 14, and 119 d after application for all sites during 2012. Samples were taken from three random cores and then air dried. Differences between treatments were determined using an analysis of variance (ANOVA) utilizing R software with significance determined at $P \leq 0.05$. Resulting source X site interactions were analyzed by pooling all sampling dates together and analyzing each site separately. Source X date interactions were further analyzed by pooling all sites together and analyzing each date separately. Significant means were separated using a Duncan mean separation test.

RESULTS AND DISCUSSION

Verdure and NDVI

An overall N response for green up was seen over the unfertilized control, with specific differences between N treatments varied by date (Ransom, 2014). Assuming the GSP is the ideal, the results of the other fertilized treatments are shown in relation to this treatment representing the baseline at 0. When sites were pooled and treatments were compared for each sampling date, urea applied all at once had a significant increase in verdure at 35 and 42 d after application over the GSP (Fig. 1). After which, there was a decrease at 63 and 117 d after application—being significantly lower than the GSP. In contrast, PCU at the 75% and 100% rates weren't significantly different from the GSP. At a reduced 50% rate, PCU showed a decrease of verdure at 42, 47, and 63 d after application, but was the same at all other measured dates. The 2011 site 1 produced no treatment response over the control. Sites 1 and 2 in 2012 resulted in all N treatments with a significant response higher than the control, while site 3 resulted in only urea, urea split, and PCU 75% significantly greater than the control. All three PCU rates provided the same verdure except for the reduced rates at site 2.

Data for taken for NDVI showed no significant difference across time, although source response differed by site. NDVI showed no significant difference between N sources on either 2012 site 1 and 2. This data matches verdure ratings for the same site and confirms a significant difference between GSP and PCU 50% on 3 of the 17 sampling dates.

Plant Growth

No differences were measured for root biomass or length for any treatments (Ransom, 2014). There were significant differences as a function of fertilizer source, for shoot height, with significant source X date and source X site interactions. When pooled across dates, there was an N response for height for all treatments over the control for all sites except for the 2011 site. In 2012, all treatments produced taller plants than the control for sites 1 and 2, but only PCU 100% consistently produced taller plants than the control. The reduced rates of PCU in 2012 site 3 did not have significantly greater height than the control, despite having better verdure and NDVI readings. It is noteworthy that the height of turfgrass with PCU 100% rate was greater than with urea applied all at once at site 1 in 2012.

When combined across sites, urea applied all at once produced an increased height at 28 d after fertilization (Fig. 2). However, after 49 d after application to the end of the study, urea applied all at once produced a trend for a decrease in height measurements. The PCU treatments did not result in significantly greater heights than the GSP and, in fact, the trend was for lower height during 5 to 50 d for all PCU treatments. The PCU 50% rate was significantly less than GSP at 49 d after application.

Shoot Nitrogen and Carbon

Shoot N concentrations showed a significant N response over the control for all treatments in two of the four sites; 2012 sites 1 and 2 (Ransom, 2014). The least responsive treatment, PCU 50%, averaged a factor of 1.25 and 1.32 higher than the control, for sites 1 and 2, respectively. There were no significant differences between GSP and other fertilizer treatments. When sites were pooled, turfgrass shoots contained higher concentrations of N for urea, relative to GSP, followed by a steady decline for the remainder of the study with shoot N being lower than GSP. Both PCU 100% and PCU 75% were not different from GSP, while PCU 50% showed a significant decrease at 98 d after application. The overall average root C concentration when pooled across all treatments, sites, and dates was 45.7%.

Soil Nitrate

Because of significant two-way (source X site, source X date, and site X date) and three-way interactions (source*site*date), soil NO3-N data are calculated for each site, source, and sampling date (Ransom, 2014). The three 2012 sites showed significant increases in NO3-N for urea applied at once 7 d after application, and site 2 and 3 showed increases 14 d after application. 2012 site 2 and 3 had a significant increase of urea over all of the treatments. By the end of the study, averaging NO3-N values shows site 3 having the highest average NO3-N, and site 1 with the lowest.

Nitrogen Response

An N response in terms of verdure, NDVI, height, and shoot N was observed for all fertilizer sources (Ransom, 2014). The response varied by site, with sites that had high initial shoot N concentrations showing the least response. Fertilizers did not impact crown density, shoot C, root length, root or shoot biomass, or the shoot:root ratio. However, the shoot biomass results were likely impacted in the current study by variation associated with too small of a sampling area. Future studies would likely have greater sensitivity by harvesting a larger area. While results were not conclusive for biomass, there were significant height differences among treatments and we would expect an increase of biomass for higher rates of N applied, as previous research has shown (Walker et al., 2007). Source of N fertilizer generated differing results, with urea applied at the full rate in early spring resulting in a temporary increase in plant growth and verdure. In comparison to split application, this type of application is ineffective. An application of urea on sandy soils has been shown to result in high levels of leaching (Unruh et al., 2013). Such rainfall events would likely reduce available N supplied by unprotected urea applied all at once. Splitting the urea applications reduces these losses due to spreading the supply of N over a longer period and increasing the plant's ability to utilize it.

Polymer-coated Urea Rates

Compared to urea-N, PCU produced a more controlled response that resulted in a better-maintained turfgrass quality through the end of summer. An increased N response was seen with increasing N applied. The controlled release effect from PCU showed that a reduced rate of PCU 50% applied early in the spring results in similar quality turfgrass as GSP. Overall applying a reduced rate would help reduce labor costs associated with clipping removal as well as reduce N inputs into the environment (Ransom, 2014; Walker 2007).

Results seen also depend on previous N levels in the soil and turfgrass. Current research shows that some field sites that were initially high in N showed minimal difference in rates and source applied, while those that had minimal N concentrations showed the greatest differences. A onetime application at the beginning of spring will not sustain turfgrass over time. With cool-season turfgrass, this is often remedied with a second application in the fall. Our current research indicates that PCU treatments were starting to decline in terms of shoot N, verdure, NDVI, and heights by the end of summer, in comparison to GSP. A second application of PCU in the fall would help maintain N concentrations in the fall and subsequent spring. In conditions where fall applied N was not applied or not enough N is available, it is recommended to mix a quick release N, like urea, with PCU to help compensate for the lag time seen with PCU products in the spring.

SUMMARY

Urea that was applied all at once resulted in an initial spike of N concentrations and subsequent growth, which declined towards the end of summer, compared to GSP. This method is more prone to N lost to the environment as well as increased labor due to increased growth. Split application of urea overcame these issues. However, a reduced rate of PCU applied at 50 and 75% of recommended rates results in similar verdure and growth as GSP for spring application to Kentucky bluegrass. The PCU at 50% of GSP showed sampling dates that had a small but acceptable decrease in verdure, as well as slightly slower growth. In comparison to GSP and urea, PCU products had a slight time lag before N was uptaken by plants. Based on verdure, N concentration, and height data, PCU could be recommended at 50% GSP with a low supplemental application in the early season (before temperature rises to release N). Future studies will include monitoring using PCU 50% in combination with small amounts of quick release N during lag periods, in an effort to better match the GSP verdure and growth patterns.

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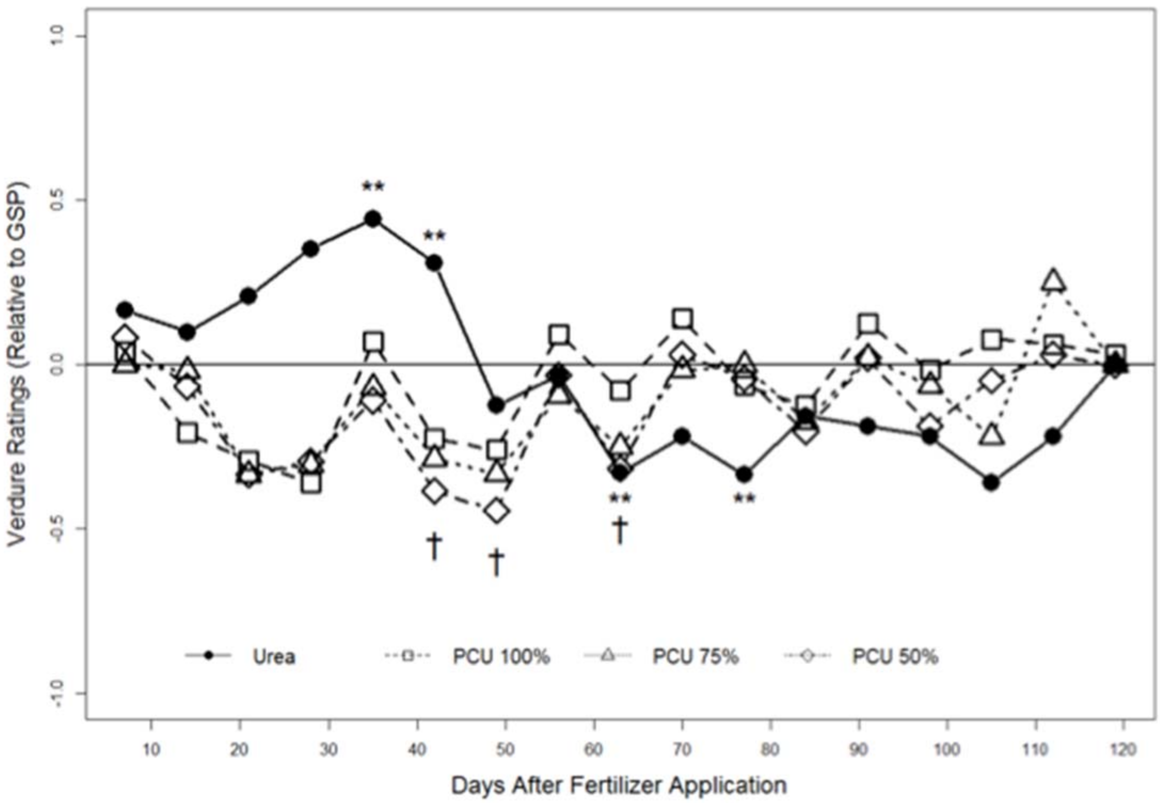

Fig. 1. Relative verdure measurements with all 2011 and 2012 sites pooled together. Verdure was measured on a scale from 1-5 (1=dead brown shoots, 5 = healthy green shoots). All treatments were expressed relative to grower's standard practice (GSP), which is urea split applied monthly. "**" indicates when urea is significantly different from GSP (P<0.05), "†" indicates when PCU 50% is significantly different from GSP. Unfertilized control treatments are not included to simplify presentation of the data.

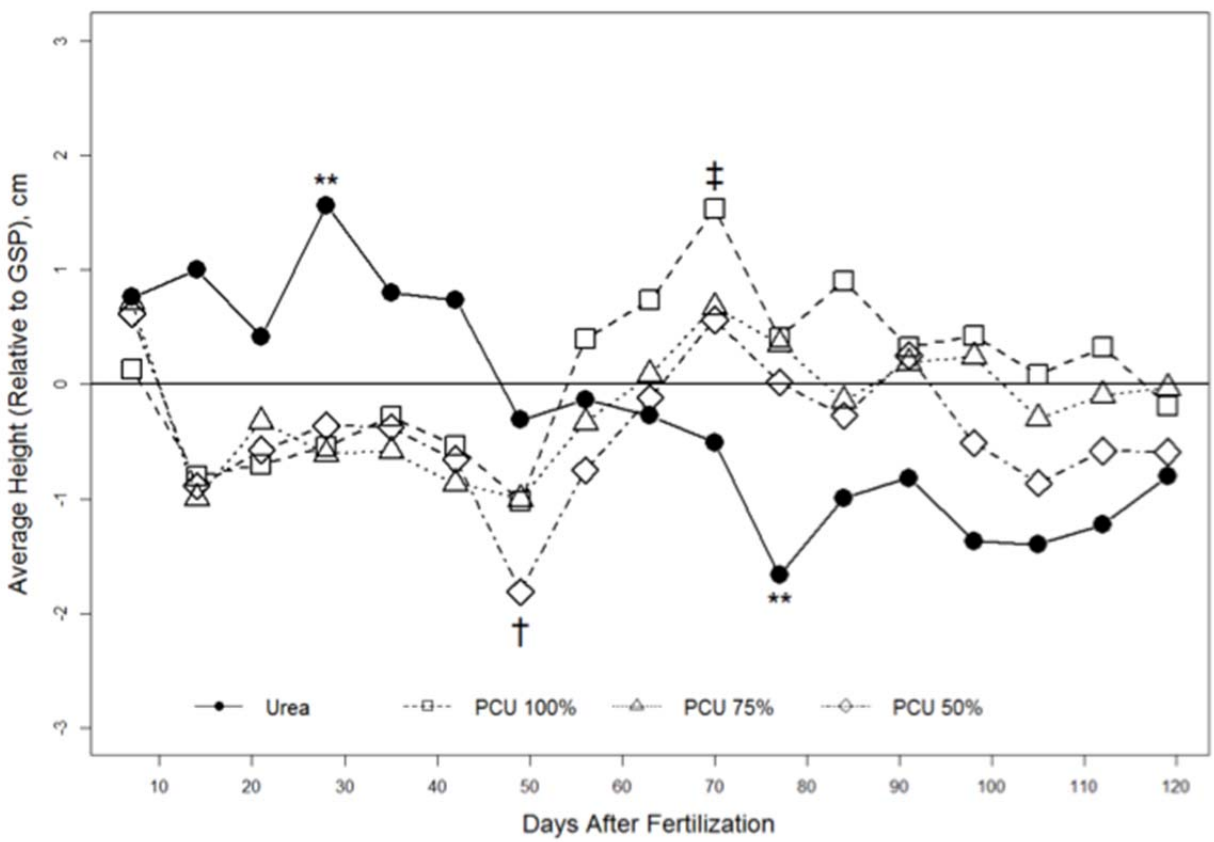

Fig. 2. Average heights, pooled across all sites, taken weekly and measured from the soil surface to tip of blades. All treatments were expressed relative to the grower's standard practice (GSP), which is urea split applied monthly. "**" indicates when urea is significantly different from GSP (*P*<0.05), "‡" indicates when PCU 100% is significantly different from GSP, "†" indicates when PCU 50% is significantly different from GSP. Unfertilized control treatments are not included to simplify presentation of the data.

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