Critical phosphorus levels for butterfly pea and buffel grass and the impact of inter-specific competition

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Abstract: *The establishment of legumes in tropical pasture swards is often difficult due to competition from tropical grasses. It has been observed that this situation is not improved even under low nitrogen (N) conditions, where legumes should have an advantage due to N fixation. This may be due to competition limiting the availability of phosphorus (P) to the legumes. As part of a larger study to establish if critical P requirements of butterfly pea (Clitorea ternatea) were higher when establishing in the presence of buffel grass (Cenchrus ciliaris) compared with a monoculture, this paper reports the P response of buffel grass after 40 days growth for six rates of P (0–120 kg/ha) applied to a sandy soil. Soil Colwell P values were compared with biomass production to determine critical P levels. Initial results for buffel grass showed a critical P level of ~20 mg/kg Colwell P. Final results will indicate butterfly pea critical P, and critical P levels under competition*

Key words: limiting factor, labile P, efficiency

Introduction

Legumes are a key component of productive tropical pasture systems, providing nitrogen (N) for other pasture species through root and litter decomposition. A healthy legume component (15–25%) in a pasture sward may be more cost effective than regular N additions to tropical grass species to increase animal protein intake (Graham and Vance 2003). Typical tropical pasture swards, however are low in protein and dominated by N deficient C_4 grasses. Under conditions of extreme N deficiency, legumes should have a competitive advantage as they are not reliant on soil N reserves for growth. However, establishment and persistence of legumes in tropical pastures is low; often legumes make up less than 5% of a sward (Cech *et al.* 2010). The problem can be partly traced to preferential grazing of palatable tropical legume species, preventing seed set, and hence persistence. However, plant nutrition may play a more significant role than previously thought.

Internal nutrient use efficiency, particularly of N and phosphorus (P), is higher in tropical grasses than legumes, resulting in a higher amount of biomass produced per unit of nutrient taken up (Cech *et al.* 2010). Coupled with grass growth habits that result in a larger, more fibrous root system that competes more effectively for water, and an erect shoot architecture that competes with legumes for light (Cruz and Sinoquet 1994), the relative advantage of fixing N does not result in dominance, or even persistence in tropical swards. Cech *et al.* (2010) investigated the relationships between N and P nutrition, competition and drought stress for a C_4 grass and a savannah legume species. Although N was more important for biomass production of the grass under competition, P had the greater impact on biomass production of the legume. In contrast, when not competing, P had no effect on legume growth (Cech *et al.* 2010). In essence, their results suggest that the ability of the grass to out-compete the legume for scarce soil P reserves results in N deficient, grass dominant swards. However, where soil P resources are sufficient to allow the grass to exhaust N supplies before complete exploitation of soil P reserves, the ability of the legume to fix N, and use the remaining P resources, may allow legumes to become a larger component of the sward (Cech *et al.* 2010). Hence, the critical P requirements for legumes establishing in competition with tropical grasses may be higher than when legumes are grown alone.

This paper reports the P response of buffel grass after 40 days growth from a larger experiment seeking to establish if critical P requirements are higher for a legume [butterfly pea (*Clitorea ternatea*)] establishing in the presence of a tropical grass [buffel grass (*Cenchrus ciliaris*)] compared with being grown as a monoculture.

Methods

Pots (20 cm diameter) were filled with 6.8 kg of sandy soil treated with six rates of P (0, 5, 10, 20, 40 and 120 kg/ha) thoroughly incorporated, providing labile (Colwell-extractable) P levels ranging up to 80 mg/kg. Ten to 20 buffel grass plants were established in half (24) of the pots and grown in a glasshouse at 35/28 °C (day/night) for 40 days. Buffel grass was cut 2 cm above the soil surface to simulate grazing before six germinated butterfly pea seeds were planted. A further 24 pots were sown with six butterfly pea plants without an established sward of buffel grass. All pots were twice supplied with urea at 0.217 g in 40 ml of water per pot; and basal nutrients (minus P) were applied at 2.5 ml of each of stock 3 mM NH_4SO_4, 2 mM KNO_3, 1 mM $MgSO_4$, and 10 mM $Ca(NO_3)_2$ in 400 ml of water per pot, split over four applications, and 0.25 ml of stock 80 uM FeEDTA and 80 uM micronutrients (boron, copper, manganese, zinc, molybdenum and cobalt) in 400 ml water per pot, split over four applications. Pots were watered to 7.3 kg daily to ensure water and nutrients, other than P, were not limiting. After five weeks growth, shoots from all treatments were harvested, dried and weighed prior to digestion in acid and determination of P uptake (data not reported in this paper). Treatment responses will be analysed using ANOVA to determine final critical P response values for both buffel grass and butterfly pea.

Results

Preliminary results for the buffel grass biomass harvested prior to planting the legume (40 days growth) showed a distinct P response curve (Figure 1), reaching maximum production at ~20 mg/kg (Colwell P).

Discussion

The preliminary results from this study showed a strong response of buffel grass growth to soil P concentration, with a critical P level at 20 mg/kg (40 kg/ha P treatment).It is expected that the final results will also identify the critical value for butterfly pea and how these values are altered by competition. Pang *et al.* (2010) found critical P values for 11 legume species of between 12 and 24 mg/kg without competition. It is expected that the critical P value for the legume will be increased due to the grass reducing P availability.

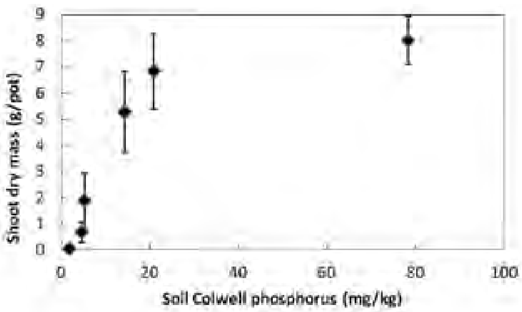

Figure 1. Initial shoot dry mass of buffel grass for P treatment rates after 40 days growth. Bars show ±1 standard deviation (n = 4).

Final results from this study should confirm competition for P resources as a limiting factor for legume establishment in tropical pasture swards. This information is important for ensuring that resources are used to their greatest efficiency and effectiveness in tropical pasture systems.

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