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Establishment and growth of *Vigna parkeri* on an acid Florida spodosol in response to lime and phosphorus*

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Abstract

Vigna parkeri, a tropical forage legume, is difficult to establish on acid soils. The effects of lime (0, 3.4, 6.8, and 10.2 Mg $CaCO_3$ ha^{-1}) and P (0, 25, 50, and 75 kg P ha^{-1}) on establishment of *V. parkeri* on an acid (pH 4.4), infertile spodosol were evaluated. In a greenhouse study, the increasing $CaCO_3$ rates resulted in soil pH levels 4.4, 5.8, 6.4, and 6.6, respectively. Both shoot and root weights responded quadratically to $CaCO_3$ ($P < 0.001$) with highest shoot and root mass at 3.4 Mg $CaCO_3$ ha^{-1}. This level of $CaCO_3$ resulted in shoot-dry-mass gains of 245% over the unlimed control and 62% and 49%, respectively, over the 6.8 and 10.2 Mg $CaCO_3$ ha^{-1} rates. Root mass at 3.4 Mg ha^{-1} was 176, 48 and 73% greater than root mass at the 0, 6.8, and 10.2 Mg $CaCO_3$ ha^{-1} rates, respectively. Shoot-tissue concentrations of Mn, Fe, Ca, and Mg responded quadratically ($P < 0.001$) to increasing rates of $CaCO_3$, while Zn decreased linearly ($P < 0.001$). Total shoot N was increased by 3.4 Mg $CaCO_3$ ha^{-1} and not changed by additional $CaCO_3$ increments. Phosphorus did not affect yield. A field study confirmed plant response to 3.4 Mg $CaCO_3$ ha^{-1}, although higher rates of lime did not reduce plant growth. Phosphorus had no effect on plant establishment. The lack of response to P treatments in this study may be due to a low external-P requirement for the plant and the presence of large organic and inorganic-P fractions in the soil. Liming acid soils to a pH of 5.4 to 5.8 is important for the establishment of *V. parkeri*.

Introduction

Vigna parkeri is a promising forage legumes for grass pastures on acid, infertile spodosols in south Florida due to its persistence under grazing (Pitman and Kretschmer, 1984; Pitman *et al.*, 1988). Forage potential of *V. parkeri* has been evaluated in Australia (Cameron *et al.*, 1989; Jones and Clements, 1987) and the southern U.S. (Thro and Shock, 1987). This cultivar was recommended for use under intensive grazing in the wetter, subtropical areas of Australia (Cook and Jones, 1987). It is thought to have promise as a forage legume in many areas of the humid subtropics and in higher elevations of the tropics (Oram, 1986). Although this legume has shown potential for subtropical pastures, problems have been encountered with stand establishment and low tolerance to water stress. To date, persistence of *V. parkeri* has been the focus of most studies with little research conducted on its response to nutrients. As a consequence, little is known of the fertility requirements of *V. parkeri*.

Responses of several tropical legumes to lime and P on spodosols have been evaluated. Kretschmer (1970) reported a 300% yield increase for *Stylosanthes humilis* when 2.5 Mg ha^{-1} of lime was applied. He also found that dry matter production increased 10-fold for *Macroptilium atropurpureum* when 2.5 Mg lime ha^{-1} rather than 0.6 Mg ha^{-1} of lime was applied. Urrutia (1972), in a pot study with *Centrosema*

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pubescens on a spodosol, obtained top growth five times that of the unlimed control with an application of 1200 mg kg^{-1} lime. In pot and field studies, Snyder and Kretschmer (1975) found that four tropical legumes (*C. pubescens*, *Desmodium heterocarpon*, *Stylosanthes guyanensis* and *M. atropurpureum*) exhibited fair growth with no added lime, but that optimum top growth required lime. In the same study, both *D. heterocarpon* and *C. pubescens* responded to P levels up to 90 mg kg^{-1}. Yields of these four legumes were highest at 2.2 Mg $CaCO_3$ ha^{-1} and 45 kg P ha^{-1}. Snyder *et al.* (1978) found that lime rates of 2.2 Mg ha^{-1} were required for maximum dry matter production of *C. pubescens*, *D. heterocarpon*, *S. guyanensis*, and *M. atropurpureum*. Regression analysis of the data indicated that *C. pubescens* and *M. atropurpureum* would respond to even higher rates of lime, in the presence of adequate P, while additional lime above the 2.2 Mg ha^{-1} rate depressed production of *D. heterocarpon* and *S. guyanensis*. In subsequent research (Snyder *et al.*, 1985), maximum dry matter yields of *S. guyanensis* and *D. heterocarpon* were suggested to be attained at lime and P rates of 5333 and 111 and 2744 and 75 kg ha^{-1}, respectively. Medina *et al.* (1990), in a study using a Florida spodosol, found that colonization by vesicular-arbuscular mycorrhizal (VAM) fungi could reduce the fertilizer-P requirement of *M. atropurpureum* and *Aeschynomene americana* by 30%.

To introduce *V. parkeri* into pastures, its nutrients requirements must be determined. Success in establishment and the ability to survive periods of water stress may depend on early response to specific nutrients. The objectives of these studies were to determine optimum pH and P levels for establishment and growth of *V. parkeri* on a virgin, acid spodosol.

Materials and methods

Pot study

A factorial study was conducted in a glasshouse using a randomized complete-block design with four levels of $CaCO_3$ (0, 3.4, 6.8, 10.2 Mg ha^{-1}) and four levels of P (0, 25, 50 and 75 kg ha^{-1}) in four replicates. The top 15 cm (Ap horizon) of a virgin Pomona fine sand (sandy, siliceous, hyperthermic, Ultic Haplaquod) from the Agricultural Research Center, Ona, FL (27°26′N. latitude; 82°55′W. longitude) was used. Initial soil pH was 4.4 and soil elemental content was: Ca, 170; Mg, 32; K, 26.4; P, 5.2; Mn, 44; Fe, 12; Zn, 8.1; and Cu, 0.08 mg kg^{-1}. Organic matter content of the soil was 26 g kg^{-1}. Treatment levels of $CaCO_3$ were mixed with 2500 g (dry weight) of soil and placed into 15-cm-diameter plastic pots, brought to field capacity and allowed to equilibrate for 8 wk prior to planting. Immediately before planting, P, K and micronutrients were added to the soil and thoroughly mixed. Phosphorus was applied in the form of triple superphosphate and K, in the form of KCl, was applied at the rate of 166 kg K ha^{-1}. Micronutrients (TEM 300, Traylor Chemical and Supply Co., Orlando, Florida; elemental content: B, 24; Cu, 2.4; Fe, 144; Mn, 60; Zn, 56; and Mo, 0.6 g kg^{-1}) were applied at the rate of 22 kg ha^{-1}. Twenty scarified seeds of *V. parkeri* were planted per pot, in May 1989. Seeds were inoculated with 'cowpea' type Rhizobium (Nitragin Co., Milwaukee, Wisconsin) before planting. Nine days after emergence, plants were thinned to 5 per pot. Soil-moisture level was maintained near field capacity throughout the study.

Shoots were cut at the soil surface 35 d after planting, dried at 70°C for 48 h, and weighed. Shoots were ground in a Wiley mill to pass a 0.84-mm mesh screen, ashed at 500°C for 6 h, and nutrients extracted using 0.302 *M* HCl. Solutions were analyzed for Ca, Mg, K, Mn, Cu, Fe, and Zn using an atomic absorption spectrophotometer and for P using a spectrophotometer by the colorimetric method (Murphy and Riley, 1962). Tissue N was determined using the Kjeldahl method described by McKenzie and Wallace (1954).

Nutrients were extracted from 5 g of air dry soil with 20 mL of Mehlich I-extracting solution (0.05 *N* HCl and 0.025 *N* H_2SO_4) and analyzed for Ca, Mg, K, Mn, Fe, Cu, and Zn using an atomic absorption spectrophotometer. Phosphorus was analyzed using the colorimetric method on a spectrophotometer. The pH of the soil sample was measured in a 2:1 (v:w) H_2O to soil solution. Soil and H_2O were thoroughly mixed and then allowed to stand for 1 h prior to