INFLUENCE OF SOIL NUTRIENTS ON REPRODUCTION AND PATHOGENICITY OF *ROTYLENCHULUS RENIFORMIS* ON COTTON

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Abstract

Greenhouse studies were conducted to determine the effects of different soil nutrients on reniform nematode pathogenicity and reproduction. The nutrients evaluated were phosphorus (P), potassium (K) and sulfur (S). For the first greenhouse study, P and K were used in high and low levels. Treatments for the second, third and fourth greenhouse studies were five different levels of P, K, and S, respectively. Application of P showed a significant increase in plant shoot and root dry weights in both greenhouse studies one and two. Similarly, it was observed that reproduction of reniform nematodes in greenhouse studies one and two was significantly affected by the levels of P included in the treatments. Greenhouse studies three and four that were treated with P and S, did not show any effect on reniform reproduction or pathogenicity, but significantly affected shoot dry weights.

Introduction

Reniform nematode (*Rotylenchulus reniformis*) damage is a major problem in Louisiana and many cotton producing states in the southern United States (Overstreet, 2006). Among the different management options, usage of nematicides is the primary and most widely used approach (Koenning et al., 2004; Starr et al., 2007). Even though nematicides provide protection against some nematodes, they also increase production cost and have many negative environmental impacts (Starr et al., 2007). Therefore, finding a low cost, environmentally friendly alternative would be a step forward for nematode management in cotton. Previous observations in cotton fields in Louisiana indicate that in many cases severe nematode damage were observed in fields having issues with their soil nutrient levels. Therefore to evaluate the effects of nutrients on reniform nematode reproduction and pathogenicity, four greenhouse studies were conducted using three types of primary and secondary macro nutrients.

Materials and Methods

The studies were conducted in the LSU greenhouse complex in Baton Rouge, Louisiana. Sterile terra-cotta pots with an inside top diameter of 10.2 cm or 15.2 cm were used in the studies. Soil mixtures used in the greenhouse studies were three parts steam-sterilized commerce silt loam soil and one part steam-sterilized sand (68% sand, 30% silt, and 2% clay). Initial soil nutrient analysis was conducted before initiating the studies. The initial soil mixture was low in phosphorus, potassium and sulfur (7.5 mg/kg for P, 40.6 mg/kg for K, and 6 mg/kg for S). The experimental duration was 60 days per trial. For all greenhouse studies, Stoneville LA887 cotton was used. This cultivar has been reported as susceptible to the reniform nematode (McGawley et al., 2010). Desired levels of each nutrient were acquired by the addition of commercially available triple phosphate (0-45-0), ammonium sulfate (21-0-0) and muriate of potash (0-0-60) fertilizers. Water soluble ammonium nitrate (33% N, 45 mg/kg of soil) was used as the nitrogen (N) source for the studies and applied in 12 day intervals throughout the duration of all four greenhouse studies. The preliminary experiment in greenhouse one was initiated to evaluate the influence of combinations of P and K on reniform nematode pathogenicity and reproduction on Stoneville LA 887 cotton. Treatments in this experiment were arranged in 2 × 2 × 2 factorial with main effects being P, K and nematodes. The experiment consisted of high or low concentrations of P (112 kg/ha or 0 kg/ha respectively) combined with high or low concentrations of K (112 kg/ha and 0 kg/ha respectively), and nematode infestation concentrations of 0 or 3000 vermiform life stages. Each treatment was replicated five times. Experiments two, three, and four each involved nematode infestation concentrations of 0 or 10,000 vermiform reniform nematodes per pot and increasing concentrations of either P, K, or S fertilizer. In the second greenhouse study increasing P concentrations of very low,

low, medium, high, and very high (10, 20, 35, 60, and 73 mg/kg, respectively) were used based on nutrient recommendations for cotton from the LSU soil testing and plant analysis laboratory. K, S and N were kept at the medium concentration (106 mg/kg for K, 20 mg/kg for S and 45 mg/kg for N respectively) for all treatments in greenhouse study two. Increasing K concentrations (44, 70, 106, 123, and 153 mg/kg) were used for the third greenhouse study as described for greenhouse experiment two. P, S and N were kept at the medium concentration (35 mg/kg for P, 20 mg/kg for S and 45 mg/kg for N, respectively) for all treatments in greenhouse study three. S was used as the main nutrient in the fourth greenhouse study with increasing concentrations (3, 12, 20, 40, and 50 mg/kg) as described in experiment two and three. P, K and N were kept at the medium concentration (35 mg/kg for P, 106 mg/kg for K and N 45 mg/kg, respectively) for all treatments in greenhouse study four. Treatments in experiment two, three and four were arranged in a 5 × 2 factorial with main effects being treatments and nematodes. At the end of each study, plant height and dry shoot and root weights were determined. Plant materials were placed in paper bags and dried at 45° C for two days in a laboratory oven to obtain shoot and root dry weights. Nematodes were extracted from soil by wet-sieving through nested 850-µm-pore and 38-µm-pore sieves followed by sugar flotation and centrifugation (Jenkins, 1964). Data were analyzed using factorial analysis and Tukey's HSD P≤0.05 mean separation technique.

Results and Discussion

In greenhouse study one there was a significant main effect of P on all three plant measurements (Table 1). However, no significance was seen in main effects of K and nematodes or in the interactions.

Table 1. Main and interaction effects (*P*-values) for Stoneville LA 887 cotton grown in 10.2 cm diameter clay pots infested with *Rotylenchulus reniformis.*

Treatments	Shoot height (cm)	Shoot dry weight (g)	Root dry weight (g)
P	<0.0001	<0.0001	<0.0001
K	0.6519	0.2760	0.2720
Nematodes	0.7411	0.5910	0.3445
P*K	0.6525	0.7573	0.9128
P*Nematodes	0.6265	0.9329	0.1750
K*Nematodes	0.3453	0.1759	0.4700
P*K*Nematodes	0.1106	0.7760	0.8039

Egg and vermiform counts were significantly affected by the main effects of P and nematodes (Table 2). In egg counts there was a significant interaction between P and K (Figure 1). In this interaction the P and K high treatment combination (PhKh) had a significantly lower egg count compared to P low and K high treatment combination (PlKh). Another interaction was observed between P and nematodes (Figure 2). A similar reduction in egg counts also resulted from the P high (Ph) treatments compared to P low (Pl) treatments. A significant interaction between P and nematodes was also observed for vermiform counts (Figure 3). There was a significant reduction in vermiform counts in P high treatments.

Table 2. Main and interaction effects (*P*-values) for *Rotylenchulus reniformis* egg counts per root system and nematodes per 500 cc of soil in Stoneville LA 887 cotton.

Treatments	Egg counts	Vermiform counts
P	0.0290	0.0102
K	0.6385	0.4691
Nematodes	<0.0001	<0.0001
P*K	0.0183	0.0747
P*Nematodes	0.0290	0.0102
K*Nematodes	0.6385	0.4691
P*K*Nematodes	0.0183	0.0747

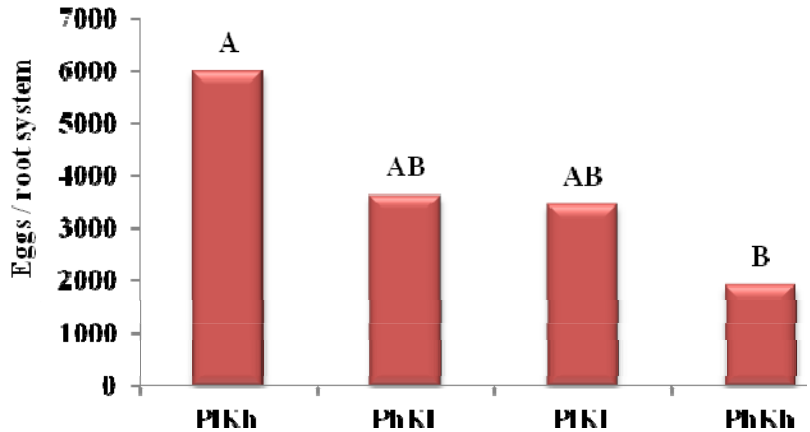

Figure 1. Interaction between different phosphorus (P) and potassium (K) concentrations in egg counts. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

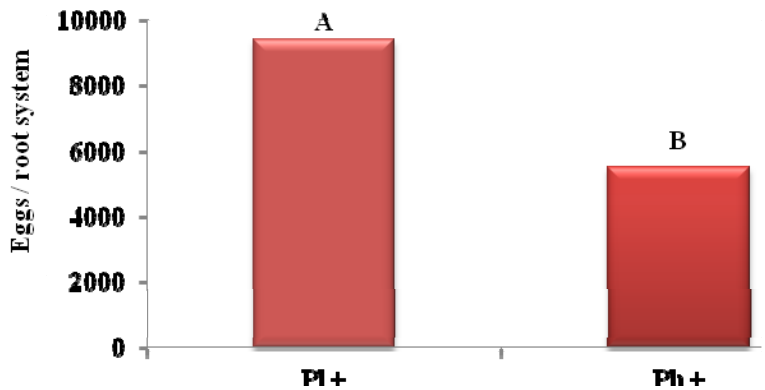

Figure 2. Interaction between phosphorus (P) and nematodes in egg counts. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

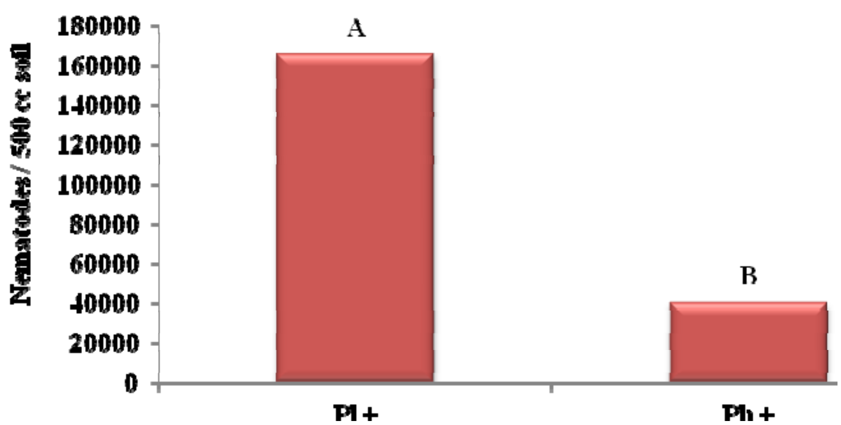

Figure 3. Interaction between phosphorus (P) and nematodes in vermiform counts. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

In the second greenhouse study five concentrations of P significantly affected both shoot and root dry weights (Table 3). Shoot dry weights were also significantly affected by the main effect nematodes. With increasing P concentrations [from medium (Pm) to high (Ph)] there was a significant reduction in egg counts compared to P low (Pl) concentration (Figure 4). A similar pattern was seen in vermiform counts, with significant reduction in vermiform counts in P high treatment (Ph) compared to P low treatment (Pl) (Figure 5).

Table 3. Main and interaction effects (*P*-values) for Stoneville LA 887 cotton grown in 15.2 cm diameter clay pots infested with *Rotylenchulus reniformis.*

Interactions	Shoot height (cm)	Shoot dry weight (g)	Root dry weight (g)
Treatments	0.1310	<0.0001	<0.0001
Nematodes	0.1544	0.0046	0.3070
Treatments*Nematodes	0.6470	0.5656	0.1311

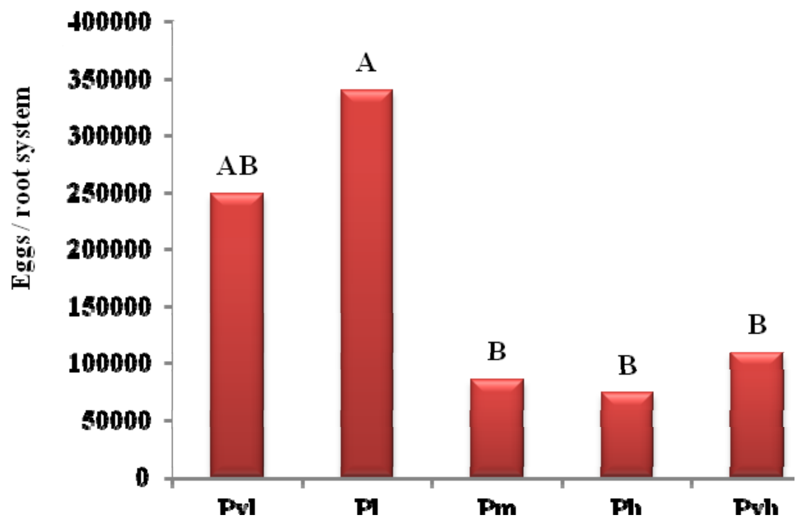

Figure 4. Effects of different phosphorus (P) levels on egg counts in greenhouse study two. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

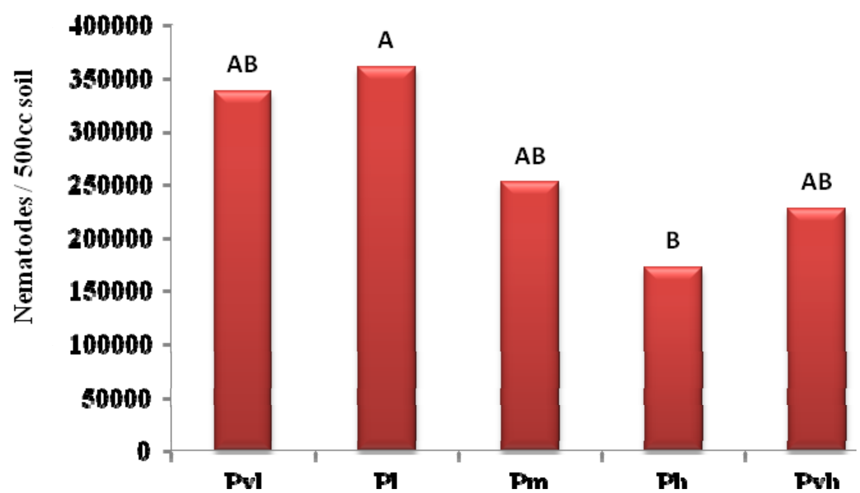

Figure 5. Effects of different phosphorus (P) levels on vermiform counts in greenhouse study two. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

The five concentrations of K in the third greenhouse study significantly affected both shoot and root dry weights (Table 4). There was no significance between egg counts with respect to K treatments (Figure 6). However, there was a decreasing trend of egg counts with increasing K concentrations from very low (Kvl) to very high (Kvh). Similar results were obtained for the vermiform counts. There was no significance between vermiform counts, but decreasing trend was observed with increasing K concentrations (Figure 7).

Table 4. Main and interaction effects (*P*-values) for Stoneville LA 887 cotton grown in 15.2 cm diameter clay pots infested with *Rotylenchulus reniformis.*

Interactions	Shoot height (cm)	Shoot dry weight (g)	Root dry weight (g)
Treatments	0.1224	<0.0001	0.0007
Nematodes	0.7056	0.4608	0.8421
Treatments*Nematodes	0.9640	0.1389	0.0016

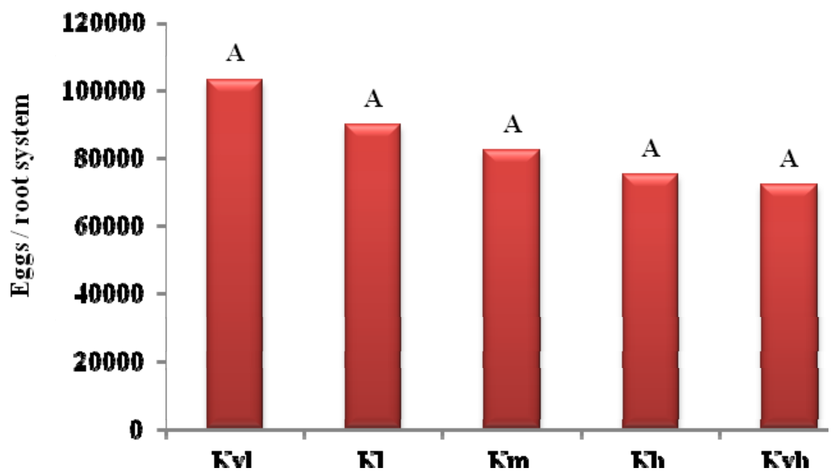

Figure 6. Effects of different potassium (K) concentrations on egg counts in greenhouse study three. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

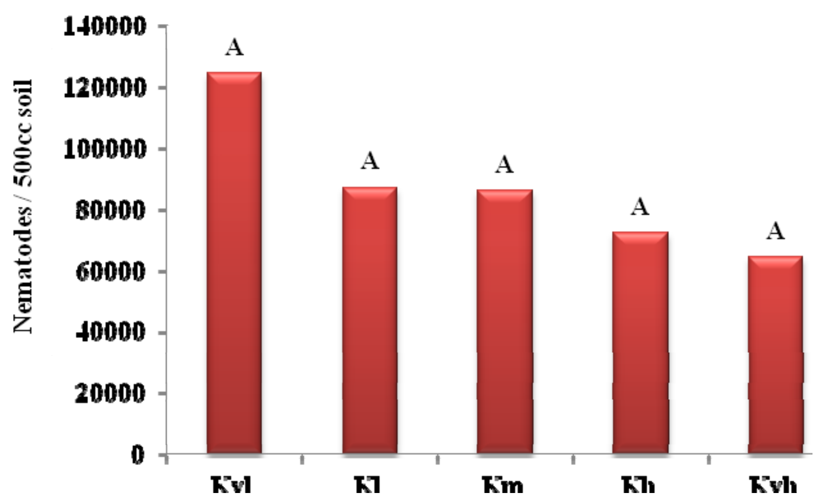

Figure 7. Effects of different potassium (K) concentrations on vermiform counts in greenhouse study three. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

S was the main nutrient for the fourth greenhouse study. Only dry shoot weight was significantly affected by S treatments. However, the main effect of nematodes had a significant impact on all three plant measurements (plant height, shoot and root dry weight) (Table 5). There was no significance observed in either egg counts or vermiform counts with different S treatments (Figures 8 and 9).

Table 5. Main and interaction effects (*P*-values) for Stoneville LA 887 cotton grown in 15.2 cm diameter clay pots infested with *Rotylenchulus reniformis.*

Interactions	Shoot height (cm)	Shoot dry weight (g)	Root dry weight (g)
Treatments	0.4832	0.0119	0.3784
Nematodes	0.0198	0.2520	0.0440
Treatments*Nematodes	0.6945	0.1092	0.0934

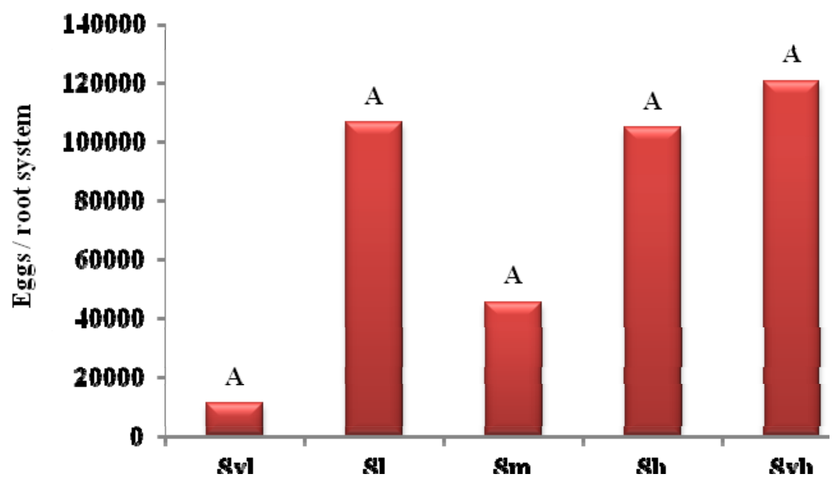

Figure 8. Effects of different sulfur (S) concentrations on egg counts in greenhouse study four. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

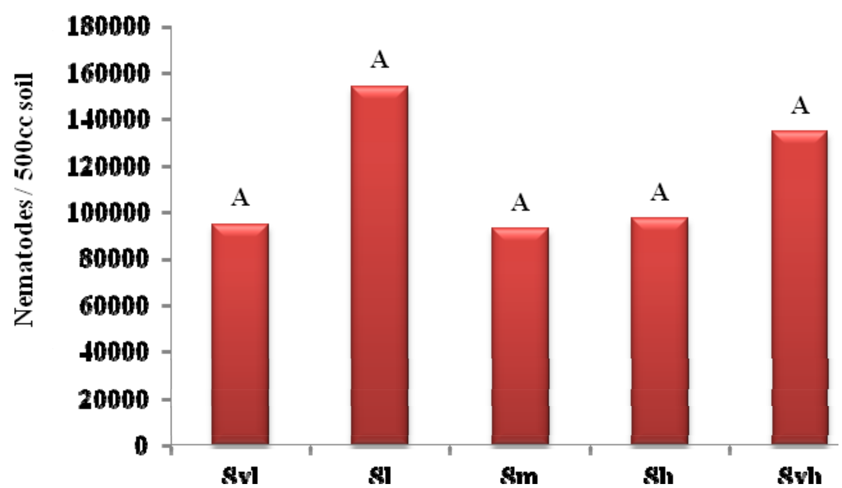

Figure 9. Effects of different sulfur (S) concentrations on vermiform counts in greenhouse study four. Within each column, means followed by the same letter are not significantly different based on Tukey's HSD, ($P \leq 0.05$).

Summary

Both greenhouse studies one and two indicate that P nutrition has the capacity to significantly increase plant biomass. Results also show that P is capable of reducing reniform nematode reproduction significantly. K and S in greenhouse studies three and four did not show any significance in reniform reproduction or pathogenicity. However, they significantly altered plant dry shoot weight. These results indicate the importance of nutrients on controlling nematode reproduction and increasing plant growth. Therefore, enhancing soil fertility could be another approach towards reniform nematode management.

References

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