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Seedling competition of *Lasiurus scindicus* and *Rhazya stricta* in response to water stress

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Rhazya stricta is a widespread invading shrub in deteriorated rangelands in Saudi Arabia. Limited studies indicate that overgrazing by livestock puts this species at a competitive advantage. The objective of this study was to investigate the competitive relationships of *R. stricta* and *Lasiurus scindicus,* a valuable range grass, under three levels of soil water at seedling stage. Seeds of both species were sown in 500-mm high and 160-mm diameter tubes filled with soil either in monoculture or in mixtures at equal rates. When seedling emergence ceased, seedlings were thinned to 10 seedlings of monocultures or mixtures of the two species at equal rates. Soil water was brought back to capacity when depleted to 75%, 50% or 25% of field-water capacity. Results indicated that soil-water had very limited effect on plant growth and survival when averaged over species and species mixture treatments. Performance of the two species differed significantly. As inferred from the ratio of mixture to monoculture for both species, growth and survival of *L. scindicus* was favored by mixing while that of *R. stricta* was reduced. This indicates that under similar conditions, *L. scindicus* out-competes *R. stricta*. These results have practical implications on grazing management and revegetation of rangelands in Saudi Arabia.

Keywords: *Lasiurus scindicus*; *Rhazya stricta*; competition; seedlings; soil water; Saudi Arabia

Introduction

Rhazya stricta is an evergreen noxious shrub that spreads over extensive areas of rangelands in Saudi Arabia. It is often found forming pure stands in some degraded areas. Chaudhary & Al-Jowaid (1999) reported that it is rapidly replacing *Rhanterium epapposum* in central Saudi Arabia due to overgrazing. Assaeed (1996) studied the possibility for competitive relations between *Haloxylon salicornicum* and *R. stricta* in a deteriorated range site and concluded that heavy grazing could have put this poisonous species in a competitive advantage over *H. salicornicum* and other range plants. Also, Assaeed and Al-Doss (1996, 1997) suggested that *R. stricta* might have spread through its allelopathic effects on other range plant species. The studies of Assaeed & Al-Doss (1996; 1997) suggested that native rangeland plants be used to improve rangelands infected with *R. stricta*. *Lasiurus scindicus* was one of the least affected by *R. stricta* allelopathic effects in that study. Though a prominent feature of desert

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vegetation of the central Saudi Arabia, this tall grass is widely distributed in other areas of the Kingdom. It is palatable and contributes well to forage production in rangelands (Chaudhary & Al-Jowaid 1999). The objective of this study was to investigate competitive relationships between seedlings of *R. stricta* and *L. scindicus* at three different levels of soil water.

Materials and methods

One hundred and eighty PVC tubes (500 mm high and 160 mm diameter) were filled with 13-kg sandy loam soil having a field-water capacity of 17·5%. Prior to sowing, five extra tubes were used to establish a relationship between soil water loss by weight and the amount of water evaporating from an open pan (Pruitt, 1966). This relation was later used to extrapolate soil water level by monitoring water loss from the open pan. Before sowing, seeds of *R. stricta* were exposed to running tap water for about 12 h before sowing as they are reported to contain a water soluble chemical inhibiting germination (El-Naggar,1965). Seeds of *L. scindicus, R. stricta* or a mixture of the two species were sown on 4 April 1996. The soil-water in tubes was maintained at field-water capacity to ensure maximum seedling emergence. Two weeks after sowing, all tubes were thinned to 10 seedlings having similar appearance of either species or an equal mixture of the two species. Soil water was brought back to field water capacity when it was depleted to 75%, 50% or 25% of field-water capacity. The experiment was laid out in a split plot design with five replicates and four observations. Soil water treatments were allocated to the main plots and species were assigned to the split plots. Six months later, the first harvest was taken. The next three harvests were taken every 3 months. At each harvest, the number of surviving seedlings was counted and seedling height was measured. Shoot and root dry weights were determined by oven-drying at 60°C for 24 h. Data were statistically analysed using SAS program (SAS, 1988).

Results and discussion

By the end of the experiment, soil water level did not have significant effects on seedling survival or growth with the exception of plant height; shoot and root dry weights in monocultures (Table 1). Generally, the three mentioned characteristics increased with a decrease in soil water level. Similar results were observed when other desert plants were exposed to water stress (Al-Qarawi *et al.*, 1997, 1998). With the exception of percentage plant survival in monoculture, the two species differed significantly ($p \leqslant 0{\cdot}01$) in all measured attributes. In general, when the two species were grown in monoculture, growth of *L. scindicus* exceeded *R. stricta* in all growth attributes reflecting the inherited differences between the two species. The behavior of the two species in response to mixing is of great importance. Survival of *L. scindicus* was 60% higher than that of *R. stricta* and was improved by 9% over monoculturing while *R. stricta* decreased in survival by 60% when mixed with *L. scindicus*. This indicates that *L. scindicus* is a good suppressor of *R. stricta* when given equal opportunity. Further, intraspecific competition was more limiting to survival of *L. scindicus* than inerspecific competition with *R. stricta*. Plant height followed a similar trend to plant survival. *Lasiurus scindicus* was 58 cm taller than *R. stricta* when grown in a mixture as opposed to 45 cm difference between the two species when grown in monoculture. *Rhazya stricta* shoot dry weight was greatly reduced to 0·041 g when grown in mixture with *L. scindicus* as opposed to 5·19 g when grown alone.

Although the structure of root system of the two species is different, roots of *L. scindicus* appeared to be more effective in exploiting soil water than those of *R. stricta* when grown in mixture. Root dry weight of *L. scindicus* decreased from about

Table 1. *Effect of soil water on seedling survival, height, shoot dry weight and root dry weight of* Lasiurus scindicus *and* Rhazya stricta *when grown alone or in a mixture at the final harvest*

Percentage of field water capacity	Survival (%)		Plant height (cm)		Shoot dry weight (g)		Root dry weight (g)	
	Alone	Mixed	Alone	Mixed	Alone	Mixed	Alone	Mixed
				Soil water				
75%	66·00 ± 4·52	34·00 ± 11·5 7	25·81 ± 5·79	26·83 ± 9·52	24·28 ± 8·24	29·07 ± 10·81	26·95 ± 10·46	26·39 ± 9·01
50%	71·00 ± 7·95	38·00 ± 13·81	34·48 ± 8·62	28·27 ± 9·50	56·03 ± 17·30	48·27 ± 16·92	43·25 ± 14·37	42·42 ± 14·68
25%	74·00 ± 4·76	62·00 ± 14·13	44·82 ± 8·93	33·70 ± 10·60	90·68 ± 30·03	42·04 ± 15·64	58·05 ± 19·09	30·00 ± 11·37
$LSD_{0·05}$	NS	NS	11·037	NS	23·808	NS	22·967	NS
				Plant species				
Lasiurus scindicus	65·33 ± 5·24	74·67 ± 6·01	57·50 ± 3·70	58·37 ± 2·89	108·80 ± 16·28	79·55 ± 7·80	82·81 ± 9·23	65·86 ± 5·87
Rhazya stricta	75·33 ± 4·01	14·67 ± 9·04	12·57 ± 1·80	00·83 ± 0·55	05·19 ± 0·54	00·041 ± 0·03	02·69 ± 0·30	00·02 ± 0·009
$LSD_{0·05}$	NS	23·779	3·9501	6·049	18·669	15·340	15·022	10·767

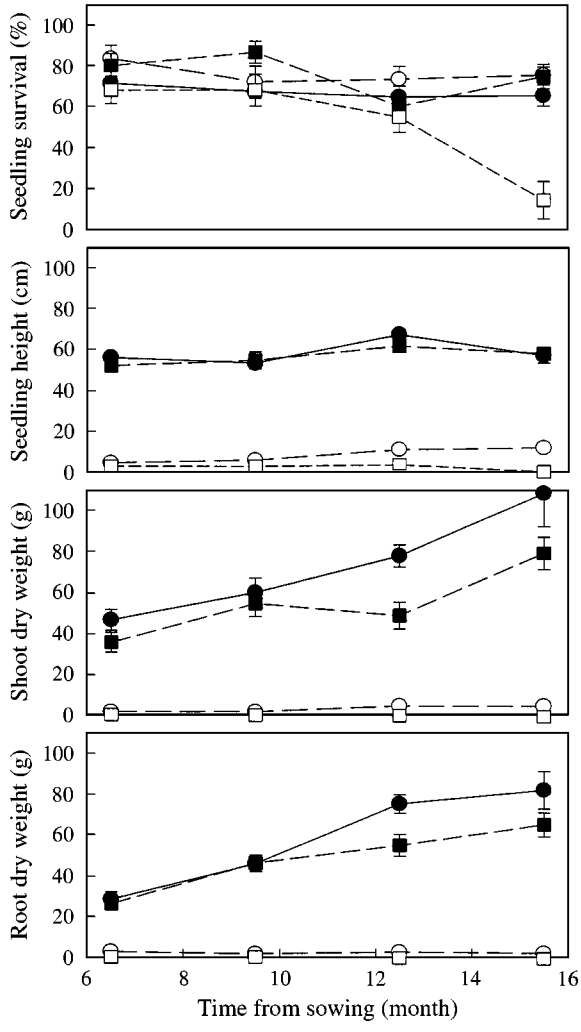

Figure 1. Changes in seedling survival and growth characteristics of *Lasiurus scindicus* (—●— monoculture, —■— mixed) and *Rhazya stricta* (–○– monoculture, –□– mixed) averaged over all soil water treatments.

83 g to about 66 g when mixed with *R. stricta* as compared to *R. stricta* in which root dry weight decreased from about 3 g to 0·02 g when grown in mixture. When root to shoot ratios (RS ratio) were calculated for the two species (data not shown), it appears that *L. scindicus* plants were investing more assimilates in root growth when mixed with *R. stricta* in comparison with *R. stricta* in which RS ratio was greatly reduced when grown in a mixture. After reviewing many studies on competition, Trenbath (1974) concluded that total biomass yields from most mixtures did not significantly exceed the expected yields from monoculture of the higher yielding member of the mixture; suggesting that resource partitioning between components of the mixture was equal. Our data indicate that resource partitioning is far from reaching equilibrium, suggesting great competition is taking place in mixture components in favor of *L. scindicus*.

Figure 1 shows the changes in seedling survival and growth with time; averaged over the three levels of soil water. Seedling survival of *R. stricta* decreased sharply (about 14%) towards the end of the experiment when grown in a mixture, but maintained a high

Table 2. *Seedling survival and growth characteristics of* Lasiurus scindicus *and* Rhazya stricta *expressed as a ratio of mixed to monoculturing in response to soil water at the final harvest*

Percentage of field water capacity	Plant survival	Plant height	Shoot dry weight	Root dry weight
75%	0·6786	0·6419	0·9079	0·6331
50%	0·7390	0·4857	0·4545	0·5612
25%	0·8544	0·5700	0·2652	0·2771
$LSD_{0·05}$	NS	NS	NS	NS
Plant species				
Lasiurus scindicus	1·2883	1·0631	1·0739	0·9715
Rhazya stricta	0·2265	0·0686	0·0112	0·0094
$LSD_{0·05}$	0·5516	0·0743	0·6036	0·2734

level of survival when grown alone. Seedling survival of *L. scindicus* remained relatively constant whether grown alone or in a mixture. The overall performance of *R. stricta* during the course of the experiment was poor in general and particularly when grown in mixture compared to *L. scindicus* (Fig. 1).

The ratio of mixed to monoculturing for plant survival and growth of the two species was calculated. Again, soil water treatments had no significant ($p \leqslant 0·05$) effect on any of the measured attributes. However, significant ($p \leqslant 0·01$) differences were detected between the two species in all measured attributes (Table 2). The results indicate that independently of soil water level, *L. scindicus* has benefited from mixing with *R. stricta* in terms of survival suggesting that intraspecific competition is more critical to *L. scindicus* survival than interspecific competition with *R. stricta*. Similarly, *L. scindicus* performed well in the mixture in terms of growth characteristics in comparison to *R. stricta* suggesting that the later species is an inferior competitor to *L. scindicus*.

Only when species were grown in monoculture, significant interaction between soil water treatments and species occurred. These interactions included seedling survival in the second cut ($p \leqslant 0·01$), seedling height in the last cut ($p \leqslant 0·01$) and shoot and root dry weight in the first and last cuts ($p \leqslant 0·05$). These results indicate that species may respond differently to changes in soil water when grown in monoculture. However, when grown in a mixture, the effect of competition was more pronounced than that of soil water.

Conclusion

Soil water treatments did not have significant effect on survival and growth of either species whether grown alone or in a mixture. When the two species were grown in a mixture, *L. scindicus* was the superior competitor to *R. stricta* within the range of investigated levels of soil water. These results have practical implications in range management and improvement. If enough seed sources are present in the soil, proper grazing management might be effective in vegetation restoration. However, if deterioration is so severe, that the soil seed reserve is depleted, then revegetation is necessary. In both cases, further work is needed to determine minimum density of cohort plant species required to control *R. stricta*.

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