destruction of the existing sward by cultivation would also aid survival of seedlings by reducing competition.

The studies on spelling were a logical outcome of the detailed studies on Siratro persistence (Jones and Bunch 1988 a, b) and the possibility of using demographic measurements to develop improved management strategies for pastures has been discussed in a wider context by Jones (1986). The use of small exclosures within grazed pastures proved to be an easy and effective way of investigating the immediate benefits of pasture spelling. However, it would be impossible to use such exclosures to measure the residual benefit of spelling once the exclosures are removed, as grazing on such areas is initially quite atypical of that of the remainder of the pasture.

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RESISTANCE OF SOME *LEUCAENA* SPECIES TO THE LEUCAENA PSYLLID

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ABSTRACT

Twenty lines representing 4 Leucaena *species* (L. leucocephala, L. diversifolia, L. collinsii, L. pallida) *were screened for resistance to the leucaena psyllid by placing potted seedlings in an infested field planting of* L. leucocephala. *Estimates of numbers of adult psyllids, egg numbers, nymph numbers, and plant damage were recorded. All 4* L. leucocephala *lines were susceptible.* L. collinsii *had least damage. All species were damaged to some extent, but there were differences between accessions within* L. diversifolia, L. collinsii, *and* L. pallida. *All estimates of psyllid susceptibility were well correlated.*

INTRODUCTION

Leucaena leucocephala is a leguminous tree or shrub, native to areas of Mexico and Central America. From these areas it has spread over much of the tropical regions of the world where it has been used largely as a source of cut-and-carry feed and also as fuel. In northern Australia it has been used to provide high quality green feed for grazing beef cattle (Bray 1986) and some 8000 hectares had been planted by mid-1985 (Wildin 1986). This area had been confidently expected to increase in future years.

In 1983 the presence of leucaena psyllid (*Heteropsylla cubana* Crawford) was reported in Florida (Othman and Prine 1984). Since then this insect, which is native to Central America and the Carribean, has spread to most areas where leucaena is grown, and has posed a serious economic threat to the continued successful use of this plant (NFTA 1987). The psyllid was recorded in Australia in April 1986 and rapidly spread throughout Queensland (Bray and Sands 1987).

Selection and/or breeding of genotypes resistant to the psyllid is one possible method of overcoming the problem. To date, observations of resistance have been made on field plantings, with or without replication (e.g. Othman and Prine 1984; Sorensson and Brewbaker 1987; Bray and Sands 1987). Such studies suffer from a lack of precision in that psyllid populations may not be uniform, plants may be in different growth stages, and only crude estimates of psyllid damage have been reported. Nevertheless this research has suggested that some species (especially *L. diversifolia*, *L. collinsii*, *L. pallida*, and *L. esculenta*) showed some resistance to the psyllid.

This paper presents the results of an experiment designed to provide information on the psyllid resistance of 20 lines from 4 species.

MATERIALS AND METHODS

Genetic material

Twenty lines were tested. These included 4 from *L. leucocephala* (including the susceptible cv. Cunningham and 3 others selected as showing some resistance in unreplicated plots), 5 from *L. diversifolia* and *L. collinsii*, and 6 from *L. pallida*. Details of these lines are given in Table 1.

TABLE 1

Origins of the 20 Leucaena *lines tested for psyllid resistance*

Species	CPI[1]	Origin	Comment
L. leucocephala	cv. Cunningham	Bred in Queensland	Known susceptible
	58396	Spain (not native)	Possible field resistance
	91551	Yucatan, Mexico	"
	91675	Yucatan, Mexico	"
L. diversifolia	33820	Vera Cruz, Mexico	Tetraploid
	34112	Ivory Coast (not native)	Diploid
	46568	Guatemala	Diploid
	85132	Vera Cruz (K157)[2]	Tetraploid
	85879	Oaxaca, Mexico	Diploid
L. collinsii	46567	Guatemala	
	46570	Guatemala	
	87842	Chiapas, Mexico	
	95582	Chiapas, (K456)	
	95583	Chiapas, (K461)	
L. pallida	84351	Puebla, Mexico	
	85874	Oaxaca, Mexico	
	85876	Oaxaca, Mexico	
	85890	Oaxaca, Mexico	
	85896	Oaxaca, Mexico	
	91308	Oaxaca, Mexico	

1. Commonwealth Plant Introduction number
2. K numbers refer to University of Hawaii accessions

Techniques

Seedlings (1 per pot) were grown in 20cm diameter plastic pots holding *c.* 3 kg of potting mix (60:40 v/v sand:peat, with appropriate nutrients added) for 6 weeks in an enclosed insect-free glasshouse. On March 25, 1987, pots were transferred to a field plot of cv. Cunningham at Samford, south-east Queensland (27° 22′S, 152° 53′E). This plot was part of a larger (*c.* 2 ha) area of cv. Peru and cv. Cunningham leucaena used for farm grazing. It had been planted in rows 1.5m apart, and was over 10 years old. An area of thick, even stand was chosen, and a number of rows cut back on February 5, 1987. The resulting young growth was constantly infested with large populations of all stages of psyllids throughout the experimental period.

When transferred to the field, all seedlings had a single growing point, and were approximately 25 to 30 cm tall. Pots were placed beside the infested rows of leucaena, about 1m apart, in a randomised complete block design with 12 replications. The experimental pots were watered in the field when rainfall was judged to be insufficient for their needs. They were returned to the glasshouse on April 14. Total period of exposure to psyllids was 20 days.

Sampling methods

Data were obtained from the seedlings on 4 occasions, 3 while in the field and once after they had been returned to the glasshouse: on March 30, April 6 and April 13 adult numbers, egg ratings, nymph numbers and damage ratings were estimated. On April 24, damage ratings were made. These observations were all made on the young leaves that had been produced while the plants were in the field.

Numbers of adult psyllids could be counted after a careful approach to the plant, and without touching it. However the mobility of the adults made counting difficult.

Egg numbers were estimated using the following rating system (eggs are laid between the pinnules of the unexpanded leaf):

0: no eggs visible
1: few scattered eggs only
2: less than 20% of pinnules with eggs
3: between 20% and 75% of pinnules with eggs
4: most or all pinnules with eggs
5: young leaves and stems covered eggs.

Nymph numbers were also estimated by using a rating system because of the large numbers of nymphs that may be present:

0: none present
1: less than 5
2: between 5 and 30
3: between 30 and approximately 100
4: large numbers restricted to leaf only
5: large aggregations extending onto stem.

Damage to the plant was estimated on a scale of 0 to 7:

0: nil
1: slight puckering of pinnules
2: pinnules curled at tip
3: yellowing of pinnules and loss of up to 25% of pinnules from first fully expanded leaf (1 FEL)
4: more than 25% pinnules lost from 1 FEL
5: total defoliation of 1 FEL, plus distortion of unexpanded leaves.
6: total defoliation of 1 FEL, plus blackening of younger leaves and growing points.
7: total defoliation of 1 FEL, plus collapse of growing points.

Data analysis

Adult numbers were analysed by analysis of variance, after transformation to log (x + 1). Analysis of the rating data was by comparison of various accessions to the susceptible control cv. Cunningham using the sign test (Steel and Torrie 1960, p. 401). Although this nonparametric test does not make use of all of the information available, it is suitable for the aims of this experiment. Since the ratings used nonlinear scales, some caution must be exercised in considering means based on them.

RESULTS

During the 20-day experimental period no other pests likely to damage leucaena were present. It is therefore reasonable to ascribe all damage to the presence of the psyllids.

Adult numbers

Adult psyllids were recorded on all lines, although not every plant within some lines had adults on it. In general the conclusions from the counts on the 3 different dates were similar, and only the data from March 30 are presented in Table 2. Highest numbers were recorded on the *L. leucocephala* lines, while *L. collinsii* accessions generally had fewest psyllids. CPI's 34112, 87842, and 95583 were consistently lowest in psyllid counts.

TABLE 2

Reaction of 20 Leucaena lines to leucaena psyllid

Species	CPI	Adult number[1] Mar 30	Egg rating Apr 6	Nymph rating Apr 13	Damage rating Apr 13	Damage rating Apr 24
L. leucocephala	cv. Cunningham	0.927	3.75	4.00	3.83	5.82
	58396	0.837	2.67	3.08	3.50	4.58
	91551	0.930	2.83	3.00*	3.17	5.42
	91675	0.835	2.91	2.92*	3.91	5.27
L. diversifolia	33820	0.652*	1.75*	2.58*	2.42	4.00**
	34112	0.364**	1.58**	1.50**	1.00**	1.83**
	46568	0.455**	1.33**	1.25**	1.00**	1.10**
	85132	0.804	2.33	4.00	3.33	5.44
	85879	0.559**	1.75*	3.90	2.55	4.36
L. collinsii	46567	0.601*	0.92**	1.92*	2.60	3.90
	46570	0.671	1.42**	2.00**	2.58	3.50
	87842	0.335**	0.50**	1.33**	0.92**	1.17**
	95582	0.511**	0.83**	1.17**	1.00**	2.00**
	95583	0.367**	0.58**	1.50**	0.92**	1.08**
L. pallida	84351	0.759	2.92	3.00*	2.42*	3.83**
	85874	0.772	1.92**	2.67	2.00	3.83**
	85876	0.808	2.33**	3.42	2.83*	5.08
	85890	0.613*	1.83**	2.58*	2.36*	4.00**
	85896	0.550**	2.08*	2.01*	1.73**	3.33*
	91308	0.499**	1.17**	1.83**	2.09**	3.27**

[1] Data transformed to log (x + 1)

*, **: significantly different from Cunningham at $P < 0.05$ and $P < 0.01$ respectively

Egg ratings

Only the data for the rating of April 6 are presented (Table 2). The March 30 and April 13 ratings gave comparable results, but the first rating had generally lower egg ratings (probably due to the lack of development of suitable young leaves as egg-laying sites) and by the last rating, many eggs had hatched and considerable death of young tissue had also occurred. Highest scores for egg laying were obtained from the *L. leucocephala* accessions, followed by *L. pallida*, *L. diversifolia*, and *L. collinsii*. There appeared to be considerable variation within the latter 3 species. However, no accession was free of eggs.

Nymphs

There were few nymphs on March 30, and conclusions from April 6 and April 13 were similar. Nymph ratings for April 13 are shown in Table 2. The pattern is the same as for egg ratings. *L. leucocephala* had highest numbers, and *L. collinsii* lowest. However *L. diversifolia* 85132 and 85879 had scores equal to cv. Cunningham, as did *L. pallida* 85876.

Damage rating

Ratings for April 13 and April 24 are shown in Table 2. There was very slight damage at the other 2 ratings. All *L. leucocephala* accessions suffered severe damage, and all *L. pallida* at least moderate amounts. Within the other 2 species, *L. diversifolia* 34112 and 46568 and *L. collinsii* 87842, 85582 and 95583 showed least damage.

DISCUSSION

In this trial, all accessions in all species were damaged to some extent by psyllids. Any line with a damage rating greater than 3 would suffer total loss of new leaves, and ratings of 5 and above mean a considerable delay in any further development of new shoots. All *L. leucocephala* accessions were badly damaged, with scores close to that of cv. Cunningham, and cannot therefore be considered resistant. Further screening of accessions from northwest Mexico (Sorensson and Brewbaker 1987) may provide sources of resistance.

TABLE 3

Correlations between 5 aspects of psyllid infestation on 20 lines of Leucaena. (All correlations are significantly different from zero, P < 0.01)

	Egg rating Apr 6	Nymph rating Apr 13	Damage rating Apr 13	Damage rating Apr 24
Adult number, Mar 30	0.86	0.79	0.89	0.91
Egg rating, Apr 6		0.79	0.80	0.81
Nymph rating, Apr 13			0.83	0.89
Damage rating, Apr 13				0.95

The different aspects of resistance recorded in Table 2 are well correlated with each other (Table 3), suggesting some common genetic control. However, there may be a number of different resistance mechanisms operating. Thus some accessions were not preferred by adult psyllids (e.g. CPI 87842). Within *L. diversifolia* both CPI 33820 and CPI 85879 had lower adult numbers and egg ratings than cv. Cunningham, but only CPI 33820 had lower nymph and damage ratings. Some form of antibiosis may be operating. In another case, CPI 84351, although having an egg rating not different to cv. Cunningham, had significantly less damage, perhaps suggesting some form of tolerance. Further study is needed to clarify these possibilities.

It is unknown whether results on young seedlings challenged with heavy psyllid loads are relevant to field situations of pure stands of mature trees. It is possible that more accurate work could establish what minimum egg loads are needed to give significant damage levels. To achieve these aims, improved measurement techniques will be required as the system used for rating eggs in this work is imprecise because of the different pinnule numbers and pinnule sizes in the different species. However this work has served to demonstrate that a range of resistance exists within the seedling populations of 3 species, and that all species tested are damaged to some extent. There appears to be possibilities for selection within accessions of species other than *L. leucocephala*.

The results in this trial are, in general, consistent with those reported in earlier studies, although in this experiment both *L. collinsii* and *L. pallida* suffered more damage than would have been expected. For precise comparisons, experiments which overcome confounding effects such as variability in moisture supply and variation in stage of growth need to be initiated.

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SEED RESERVES OF BARREL MEDIC (*MEDICAGO TRUNCATULA*) AND SNAIL MEDIC (*M. SCUTELLATA*) IN THE TOPSOIL OF PASTURES ON A BRIGALOW SOIL IN SOUTHERN QUEENSLAND

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SUMMARY

Seed reserves of barrel medic (Medicago truncatula) *and snail medic* (Medicago scutellata) *in the topsoil of a fertile brigalow clay soil were measured in 1985 at Narayen in subcoastal south-east Queensland. Measurements were made on 2 grazed crop-pasture rotations where medic was sown every fourth year, on an ungrazed crop-pasture rotation sown to medic every year and on a 10-year-old permanent pasture. Seed reserves to a depth of 10 cm were highest under permanent pasture (14,200 seeds/m^2) followed by the ungrazed ley (8600/m^2), a 3-year pasture: 1 year-wheat rotation (6400/m^2) and a 2-year pasture: 2 year-wheat rotation (2300/m^2).*

In the surface 10 cm of soil under permanent pasture, 96% of medic seed was in the top 5 cm of soil compared with 77% in ley pastures. The percentage of seed recovered in pods was highest in the top 5 cm of soil (70–80%) and lowest at 15-20 cm (<5%). Seedling emergence after adequate germinating rain in early winter accounted for less than 10% of the reserves of medic seed. The possibility of low densities of medic seedlings limiting medic productivity is discussed.

INTRODUCTION

Annual medics are widely used in pastures in southern Australia (Carter 1983b) but have also shown promise in some areas of subcoastal south-east Queensland (Jones and Rees 1972; Clarkson 1977; Lloyd and Hilder 1985; Russell 1985). Medics have been used on a fertile clay brigalow soil at Narayen Research Station (25°41′S, 150°52′E) as 1 component of a ley pasture in a crop rotation experiment. After being sown in autumn (May) as a component of a ley pasture, the average percentage of medic in the presentation yield in the following spring had been 25%. However, this had declined to an average of 6-10% in the second and third spring periods of the ley (author's unpublished data). Carter (1982, 1983a, 1983b) has shown that poor yields of medic in pastures in southern Australia can be largely attributed to low soil reserves of soil seed. Hence we initiated this study of soil seed reserves of medic in ley pastures