ABOVE AND BELOW GROUND: A COMPARATIVE STUDY OF THE ROOT AND SHOOT GROWTH OF PASTURE LEGUMES

M. C. Campbell, S. J. Bennett and P. S. Cocks

University of Western Australia, Perth, WA 6907, Centre for Legumes in Mediterranean Agriculture, Perth, WA 6907.

Abstract

Successful establishment of a crop or pasture species depends on a number of environmental factors. It is also dependent on inherent growth characteristics to allow adaptation to the specific stresses that might arise. The relative root and shoot growth of the seedling may be a critical parameter in determining the species potential to establish reliably in the face of competition from other plants or moisture stress. An experiment was carried out to compare the root and shoot growth of 4 annual and 8 perennial pasture legumes with that of *Medicago sativa* cv Sceptre (lucerne) twelve weeks after germination. The results indicated that lucerne was generally more productive than the other perennial *Medicago* species and equal to the annual species. However, *Trifolium pratense* (red clover) and *T. vesiculosum* (arrowleaf clover) had significantly more laterals branching off the main taproot and a greater total root length than lucerne.

Key words: Pasture legumes, competition, Medicago, Trifolium, Ornithopus, lucerne, root growth.

Lucerne has often proven difficult to establish, as the seedlings do not compete well with weed species in contrast to some other pasture species. (2). Knowledge of the characteristics that enable the seedlings of some pasture species to compete successfully with weeds would be valuable. Once established, lucerne can withstand considerable moisture stress due to its deep taproot. The aim of this study was to compare the early growth characteristics, energy partitioning and the survival of seedlings of 12 pasture legumes and lucerne in order to define the strengths and weaknesses of lucerne relative to other successful species. Selection guidelines could then be defined which might be useful in improving the establishment of lucerne.

Materials and methods

The experiment was carried out at the University of Western Australia Field Station located at Shenton Park, Perth. PVC storm water pipes, 16 cm in diameter and 1 m in length, were sunk into the ground and filled with a sandy loam soil. Three germinated seeds of the thirteen different species were planted in each of these pipes at the beginning of June 1997, with 6 replicates of each species. All seedlings planted were allowed to grow. The species evaluated were; annuals; *Medicago lupulina* (black medic), *Ornithopus sativus* cv Cadiz (pink serradella), *Trifolium subterranean* cv Dinninup (subclover), *T. vesiculosum*, cv Cefalu, wild type perennials; *M. arborea*,(tree medic), *M. cancellata*, *M. falcata* (yellow lucerne), *M. marina*, *M. polychroa*, 2 lines of *M. sativa*, and the commercially-bred perennials; *M. sativa* cv Sceptre and *T. pratense* cv Caprera. As the appropriate rhizobia for some of the perennial *Medicago* species has not been defined, a fertilizer application rather than seed inoculation was employed as the nitrogen source. The seedlings were not irrigated. Whole plants were removed and the roots carefully washed out for all surviving plants 12 weeks after germination.

Measurements taken included maximum root depth, total root length, number of laterals off the taproot, dry weight of the roots, number of trifoliate leaves at sampling, total leaf area and shoot dry weights. The data was analysed using Dunnet's test. (1).

Results and discussion

The mean values for the measurements taken are given in Table 1. As a group, the annuals had a longer total root length, a greater number of laterals branching from the taproot and a heavier dry root weight

than the perennial medics. The annuals also, had a larger total leaf area and a heavier shoot dry weight. However, in a comparison of individual species, the roots of *T. pratense*, a perennial, grew the deepest, had the longest total length and the heaviest dry weight. *T. pratense* also had the largest total leaf area. *T. vesiculosum*, an annual, had the greatest number of lateral roots and the heaviest shoot dry weight.

Table 1. Means of the character measurements taken for each pasture legume.

?

Line	Max Root Depth (cm)	Total Root Length (m)	No. of Laterals	Root dry Weight (g)	Number leaves	Shoot dry Weight (g)	Total Leaf Area (cm ²)	Shoot/Root Ratio
M. lupulina	23.6	7.1	30.6	0.07	22.8	0.15	12.0	2.13
O. sativus	22.4	6.7	30.4	0.07	20.7	0.22	24.6	3.23
T. subterranean	25.7	9.1	44.1	0.09	21.5	0.27	24.1	2.87
T. vesiculosum	24.0	14.5*	58.8*	0.12	23.6	0.35	30.8	3.00
M. arborea	26.3	1.3*	23.0	0.04*	14.0	0.08*	7.2*	1.76
M. cancellata	16.7	3.5*	23.6	0.04*	14.9	0.07*	5.1*	1.68
M. falcata	17.3	1.9*	17.5	0.03*	12.4	0.04*	2.7*	1.14
M. marina	11.3	0.4*	7.3*	0.01*	18.0	0.05*	2.1*	4.45
M. sativa 124	17.4	4.8	27.9	0.07	17.4	0.10	10.4*	1.44
M. polychroa	25.7	5.8	34.4	0.08	24.0	0.13	12.0	1.57
M. sativa I1937	16.7	2.7*	22.6	0.05*	18.1	0.10*	4.3*	2.06
M. sativa, Sceptre	26.3	7.3	31.2	0.11	22.1	0.23	22.9	2.12

Τ.	pratense	26.8	16.1*	51.3*	0.17	12.3*	0.30	40.5	1.73
			-		-	-			-

Average number of plants surviving = 11-15, except for M. marina = 3 *Using Dunnets test: species significantly different from lucerne (P<0.05).

The lucerne was either equal to or more productive than the other perennial medics for many of the characteristics assessed (P<0.05). However, *T. pratense* and *T. vesiculosum* had significantly more laterals branching off the main taproot and a greater total root length. *Ornithopus sativus*, **T. vesiculosum** and *T. subterranean* had higher shoot to root weight ratios than the lucerne, suggesting a stronger competitive ability of the seedlings stages providing that water was freely available. *Medicago marina* had the least number of surviving plants and for many characteristics, it had the lowest measurements. However, as it grows naturally in an environment inhospitable to most other plants, competition from other plants is of less concern than its adaptation to its niche.

Conclusions

Under the conditions of this study, for the measurements taken, the lucerne was more productive than the other perennial medics were; this is perhaps a reflection of the 3,000 years of lucerne cultivation. *T. pratense* and *T. vesiculosum* were the only species evaluated that were significantly (P<0.05) more productive than lucerne for any of the characteristics measured. As this was for the number of laterals produced from the taproot and also the total root length, selective breeding in lucerne to increase these characteristics could be an aid to improving the establishment and early survival of lucerne in the field.

Acknowledgments

This project was funded by a grant from GRDC

References

1. Dunnett, C. W., 1955. J. Amer. Stat. Assoc. 50, 1096-1121

2. Evans, P., and Richardson, J., 1994. Farmnote No. 67/94 'Establishing lucerne' (Agdex 121/22)