The change in the proportions of annual legume species in response to the presence of lucerne and the addition of gypsum.

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Abstract

The relative competitiveness of a mixture of 4 annual pasture legume species, 3 of which were sown and one naturalised, was assessed on the basis of seed reserves in a 3 year-old pasture when grown with and without lucerne on two sodic Vertisols treated with gypsum to improve surface drainage. The 2 experiments were located at Grogan and Morangarell in southern NSW on soils prone to winter waterlogging.

Clover seed reserves were 4 to 6 fold greater (445-642 kg/ha) in annual pastures compared to those sown with lucerne (73-172 kg/ha). In the absence of lucerne, of the two subterranean clover (Trifolium subterraneum L.) cultivars sown, the brachycalycinum cultivar Clare formed 55-66% of the seed pool by weight after 3 years compared to 12-34% for the yanninicum cultivar Riverina. Naturalised burr medic (Medicago polymorpha) constituted 18-24% of the seed pool at Morangarell but less than 3% at the Grogan site; balansa clover (Trifolium michelianum Savi.) formed less than 6% of the seed pool at the two sites in annual swards.

When lucerne was sown as part of the sward, the proportion of Clare fell to 8-14% at Morangarell and 40-49% at Grogan. Burr medic at 54-68% of the seed pool became the dominant component at the Morangarell site. The proportion of Riverina changed little with the addition of lucerne at Grogan but fell at the Morangarell site. Including lucerne in the sward significantly increased the proportion of balansa clover from 3 to 15 % at Grogan and the small-seeded kidney weed (*Dichondra repens* J. R. & G. Forst.) from 3% to 18 % at Morangarell. The addition of gypsum increased the proportion of Clare and decreased the proportion of Riverina at Grogan, the most sodic site, but had no effect on proportions at Morangarell.

Introduction

The Bland region of the eastern NSW wheat-belt is characterised by cracking clays (Vertisols) (1) which are often sodic, neutral in pH, and prone to extended periods of waterlogging over winter. The *yanninicum* sub species of subterranean clover and balansa clover have both proven to be suited to these soils because of their tolerance to waterlogging. Clare subterranean clover is not widely sown despite its adaptation to clay soils, as it is not considered to be highly tolerant to waterlogging. Lucerne (*Medicago sativa* L.) is increasingly being sown on these soils to increase the perenniality of the pastures and to dry the subsoil with a view to reducing the severity and frequency of waterlogging. Gypsum is also increasingly being applied by many farmers to improve soil structure and drainage.

Recent studies (2,3,4,5) have shown that lucerne can effect the persistence of subterranean clover but there have been no studies to examine which annual legume species combine best with lucerne on waterlogged soils or if gypsum changes their performance. Given the variable nature of these soils with a mosaic of waterlogging in winter due to gilgai formations, sowing mixtures of annual legumes might be expected to give a more adaptable pasture capable of responding to variable soil and seasonal conditions. Treating these soils with gypsum to improve surface drainage and sowing a deep-rooted perennial legume such as lucerne, could both be expected to change the water relations and therefore the relative competitiveness of the different annual legumes.

The following study examined the relative persistence of different annual legumes based on their seed reserves, when sown in a mixture with and without lucerne in the presence and absence of applied gypsum at two sites on the Bland.

Methods

Two experiments were established at Grogan and Morangarell in 1999. The Grogan site (pH($CaCl_2$) 0-7.5 cm of 5.3), had been in pasture for the previous 3 years, the Morangarell site (pH 5.6) had been in crop for 3 years. The first pasture treatment consisted of a mixture of Clare and Riverina subterranean clover each sown at 4 kg/ha and balansa clover sown at 0.5 kg/ha. A second pasture treatment included lucerne at 2 kg/ha with the annual legumes sown at half the rate as in the annual only treatment. The plots were split for plus and minus gypsum, the Grogan site received 5.0 t/ha and the Morangarell site 2.5 t/ha, the gypsum rate being adjusted to allow for the different levels of sodicity. The gypsum was incorporated lightly as part of the preparation of the seed-bed. The plots were grazed by sheep every 3 months. At the end of the third growing season the seed reserves were sampled by taking 3 strips 10 cm wide by 2 m long from each plot. The seed was recovered by washing the sample in a sieve, drying the residue and then thrashing and separating the seed based on seed size using a series of sieves. Seed of the subterranean clover cultivars were separated by hand on the basis of seed colour and the medic on seed shape.

Statistical analysis

The experiments at both Grogan and Morangarell were split-plot designs with 4 replicates and pasture type as main plot. For the variables: total mass of sown species, mass of medic and mass of other clover species, a logarithmic transformation was taken so that normality assumptions were met. For each of these variables an analysis of variance was performed using Genstat 6 fitting the factorial structure of pasture types by gypsum (3 rates).

Originally, Clare, Riverina and balansa clover were sown at 4, 4, 0.5 kg/ha respectively in the annual pasture but were sown at 2, 2, 0.25 in the lucerne+annual pasture so that in each case they represent 47.1%, 47.1% and 5.9% by composition of the sown pasture species. The proportions present after 3 seasons have been calculated for each plot and the change in proportion from the original percentage for the principal species (Clare and Riverina) analysed using analysis of variance in Genstat 6 fitting pasture by gypsum by species. The proportional change in balansa results from the change in proportions of Clare and Riverina.

Results

The total seed reserve of clover after 3 years was significantly lower ($P<0.001$) in swards where lucerne was sown than in swards where only annual pastures were sown. The total seed reserve of all sown annual legume species at the end of the third year at the two sites ranged from 382-436 kg/ha in the absence of lucerne but declined to between 29-77 kg/ha when lucerne was part of the mixture. The total seed reserve of sown and naturalised annual legumes showed a similar trend and is given in italics in Figure 1. Clare subterranean clover was the dominant cultivar at both sites in the annual only swards, consisting of between 55 and 66% of the seed pool (Figure 1).

Riverina formed 12-15 % of the seed pool at the Morangarell site and 29-34 % at the Grogan site where waterlogging was most severe. Burr medic formed the second largest component of the seed pool by weight at Morangarell with 18-24% but formed only a very small proportion (<3%) at the Grogan site.

With the addition of lucerne, burr medic became the dominant legume at Morangarell, consisting of 54-68 % seed pool, and Clare decreased to 8-14 % (Figure 1). At the Grogan site, the addition of lucerne to the mixture resulted in a smaller fall in the proportion of Clare to between 40-49 %, with large increases in the proportion of balansa clover and kidney weed in the seed pool. The proportion of Riverina declined to around 5% at Morangarell site with the addition of lucerne, but changed little at the Grogan site.

The application of gypsum had a comparatively small but significant (P<0.05) effect on the proportions of the legumes at Grogan resulting in an increase in the proportion of Clare and a decrease in the proportion of Riverina. Gypsum had no significant effect at Morangarell.

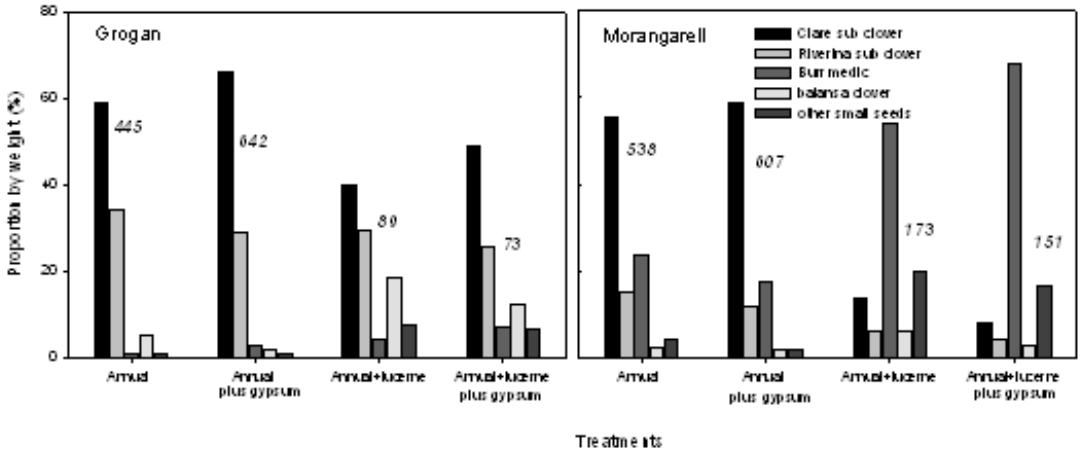

Figure 1. The relative proportions of Clare and Riverina subterranean clover, balansa clover, burr medic and other small seeded species in the seed bank at two sites after 3 years of pasture, in the presence and absence of lucerne, and applied gypsum. Total seed reserves are given in italics.

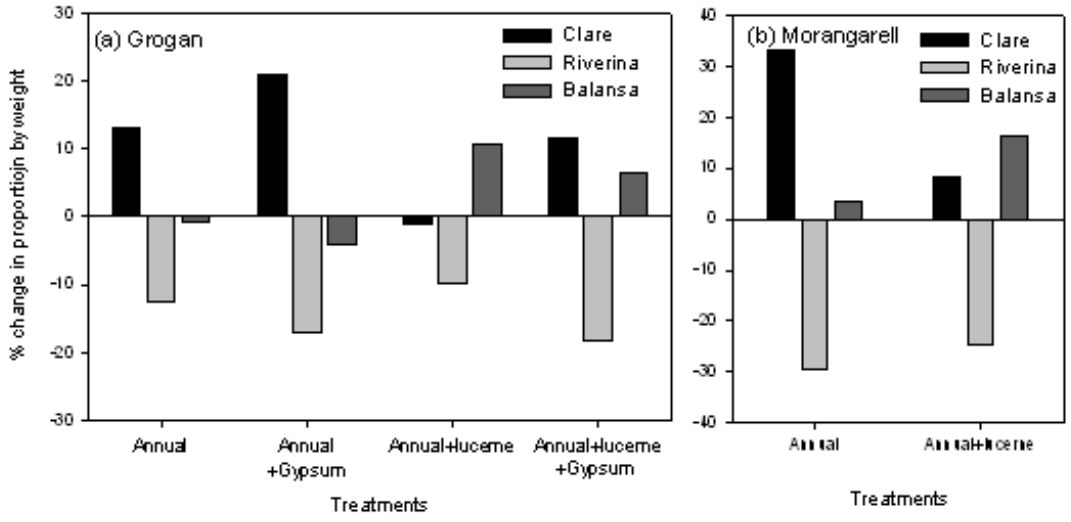

Figure 2. The change in the proportion of the 3 sown clover cultivars in the seed reserve relative to their initial sowing rates at the two sites. Gypsum had no effect at the Morangarell site.

When the changes in the proportion of the legumes were examined relative to the proportions in which they were originally sown, Clare increased at both sites and Riverina decreased (Figure 2). The proportion of balansa clover decreased in the absence of lucerne at Grogan but increased where lucerne was added. At the Morangarell site, gypsum had no effect on the changes in legume proportions, but adding lucerne increased the proportion of balansa seed (Figure 2).

Discussion

There are two major findings apparent from this study. Firstly, clover seed reserves are likely to decline significantly where lucerne is added to the pasture mix. Secondly, the relative proportions of different clover species and cultivars in the pasture will change significantly in response to the inclusion of lucerne.

The significant reduction in clover seed reserves when perennials are present is consistent with previous findings (4,5) and field observations that lucerne stands frequently lack a good annual clover component and have significant bare areas existing between plants where lucerne density is moderate to high.

The higher proportion of Riverina at the Grogan site (Figure 1) compared to Morangarell is likely to be a reflection of the more pronounced waterlogging and higher levels of sodicity experienced at Grogan. Riverina is a member of the yanninicum subspecies of subterranean clover which is better adapted to growing in anaerobic conditions present in poorly drained soils.

Little is known about which annual legume species or cultivars are more compatible as companion plants in mixtures with lucerne. In this study, Clare appeared to be the most sensitive of the legumes to competition from the lucerne, showing the greatest decline in the seed pool at the Grogan site, whereas the small-seeded balansa clover, kidney weed and woolly clover (*T. tomentosum*), all increased their presence in the seed pool. Lucerne has been shown to compete strongly with annuals at germination and emergence in autumn by drying the soil (2,4,5), and may also compete in spring during seed-set through competition for light and moisture. Young clover seedlings can be placed under increased moisture stress in autumn in mixtures with lucerne and phalaris (2,3), resulting in increased seedling mortality. However, it is difficult to see how lucerne affected the survival of the large and vigorous seedlings of Clare, more than the very small seedlings of the other species.

Lucerne could potentially increase competition for moisture during seed-set of the annuals and it could be argued that the later maturing Clare, which flowers up to 14 days later than Riverina, would be more susceptible to competition at this time. Balansa clover is relatively early flowering, and being small-seeded, should be able to successfully fill more seeds than the large-seeded, later flowering Clare, under conditions of increased moisture stress and thus would increase its seed reserves in the presence of lucerne.

Given the change in the proportions of the seed reserves of the various clover cultivars and species in response to the presence of lucerne, it is unlikely that any beneficial effect of lucerne in reducing the severity of waterlogging over winter influenced the relative competitiveness of the legumes, as drier soil conditions would be expected to favour Clare over the waterlogging tolerant Riverina and balansa clover. On balance, it would seem that the changes in the proportions of annual legumes with the addition of lucerne were a result of increased moisture stress at seed-set, rather than lucerne reducing waterlogging in winter or reducing water availability during seedling emergence.

The study has demonstrated that brachycalycinum cultivars of subterranean clover should be more widely used on these heavy soils and annual medics and small-seeded species such as balansa clover may form more compatible companion species in mixtures with lucerne.

Acknowledgments

We thank Mr A. Matiske and Mr C. McCrae for providing land for the experiments, the Grogan and Morangarell Landcare groups, and the Grains Research and Development Corporation for financial support.

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