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Plant Breeding Influences the Performance of Temperate Pasture Species in the Subtropics

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ABSTRACT: Data from a series of experiments over a 15-year period in the subtropics were interrogated to determine whether plant breeding had influenced the performance of ryegrass and lucerne in the subtropics of Australia. It was found that, within sets of plant breeders' lines available for sowing in any one experiment, yield of the best experimental lines of perennial and annual ryegrasses and lucerne were almost always above that of standard cultivars. The range in rust resistance was not as great in annual ryegrass, with breeders' lines rarely being superior to the standard cultivars. However in perennial ryegrass and lucerne, the range of disease: resistance was greater and did show improvement relative to the standard cultivars. There was also a trend towards improved performance of breeders' lines over time. Those available between 1996 and 1999 showed an overall increase in yield over the general experimental mean, and the performance of the best and worst experimental lines in ryegrass and lucerne at the commencement of the study period (1978 for lucerne and 1992 for ryegrasses). Persistence of lucerne showed the reverse trend with an overall fall in the general experimental mean. Resistance to Phythophthora root rot (PRR) and leaf diseases improved over time but that for Colletotrichum crown rot (CCR) declined. The reasons for these trends are discussed.

Key words: Plant breeding, perennial, annual, ryegrass, lucerne

INTRODUCTION

Attempts to grow temperate species in the subtropics have ken relatively unsuccessful because of the poor adaptation of commercially available cultivars (Lowe and Hamilton 1985; Read *et al.* 1991). Breeding in subtropical areas for lucerne has been conducted since the mid 1970s but active selection *to* improve temperate grass performance has only *taken* place in the last 10 years. Cooperation between private and public breeding programs have resulted in the evaluation of a large range of experimental annual *(Lolium multiflorum)* and perennial *(L perenne)* ryegrass and lucerne *(Medicago sativa)* lines and a smaller range of tall fescue *(Festuca arundinacea)* and white clover *(Trifolium repens)* lines in south-east Queensland.

This paper attempts to document the achievements of these programs in improving dry matter production, resistance to the major diseases and persistence of these important pasture species.

MATERIALS AND METHODS

All experiments were sown at Gatton Research Station (latitude 27°34'S, longitude 152°20'E, altitude 70 m) in south-east Queensland. The soil was a black alluvial clay (Ug5.16, Northcote 1971), high in nitrogen (N), phosphorus (P) and potassium (K) and with a neutral pH. Experiments were sown as randomised blocks with 3 or 4 replicates. Cutting experiments used a plot size of 5 m by 2 or 3 m. Row experiments were sown in single, 1 m rows separated within rows by 0.5 m gaps; rows were 0.35 or 0.7 m apart. Row experiments usually contained between 50 and 200 lines, and plot experiments, between 10 and 25 lines plus standards. All were fully irrigated-using a 2 weekly schedule with watering to field capacity.

Grass evaluations received 60 kg N/ha/month. Lucerne experiments received 25 kg P/ha at the end of the first and second years. Perennial experiments were conducted over a 3-year period of monthly samplings. Annual ryegrass experiments were sown annually and sampled for yield every 3 weeks. All were defoliated at 5 cm. Persistence was recorded at the end of summer for perennial ryegrass but in early spring and early autumn for lucerne. Persistence was estimated by the presence or absence of live crowns in a fixed 2 m by 0.25 m quadrant divided into 100 equal squares for plots or as a percentage of the row length in row evaluations. Rust damage was ranked by a visual linear scale where 1 = the worst level of infection at the time and 9 = no infection (Lowe *et al* 1995). Lucerne diseases were scored on a 1 - 5 scale according to standardised tests (Fox *et al.* 1996).

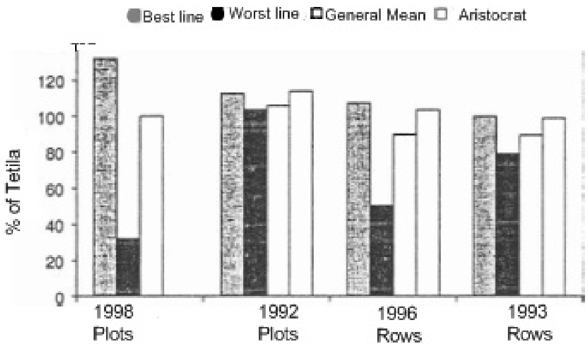
This paper compares the results from the earliest, to those of the most recent, experiments conducted on annual ryegrass, perennial ryegrass and lucerne. Not always could the same years data be presented as only experiments with full data sets have been used. For each experiment, the General Mean, regional standard cultivar and the best and poorest performing experimental lines are presented as a percentage of cv. Tetila (annual ryegrass), cv. Ellett (perennial ryegrass) and cv. Hunter River (lucerne). These cultivars were the standard cultivars at the beginning of the study period. The yield, persistence and disease resistance of these are compared to determine if advances have occurred as a result of continued breeding programs.

RESULTS

Annual ryegrass

There has been an increase in the dry matter yield of the best experimental line and the general mean from the earliest to the most recent experiments (Figure 1). The performance of Aristocrat, the most adapted cultivar in the subtropics suggests that there has been little change in the relative performance of the standard cultivars over the same period.

Figure 1. Yield of annual ryegrasses, relative to that of cv. Tetila at Gatton in row and plot evaluations from 1992-1998.

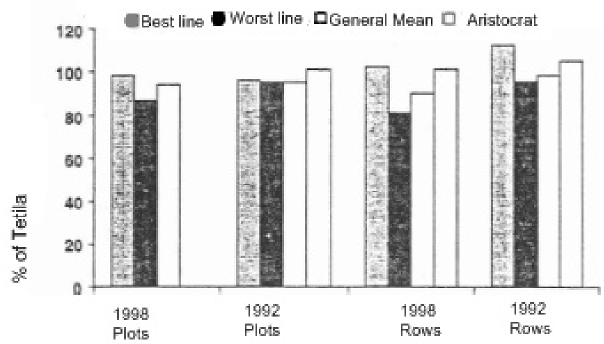


There has been a fall in the level of rust resistance in the lines emanating from annual ryegrass breeding programs from 1992 to 1998 (Figure 2). Row experiments show a decline in the performance as measured by the experimental general mean and the performance of the best and worst lines. Cutting experiments suggest that no improvement has occurred over the six years.

Perennial ryegrass

There has been a substantial improvement in the performance of perennial ryegrass in the subtropics over the study period. Yield of the best experimental line and the general mean has increased in both row and cutting experiments from the 1992 or 1993 sowings to the most recently completed experiment sown in 1996 (Figure 3). The same trend is being shown in the 1997- and 1998- sown experiments but these have not been presented because they do not have 3-year yield totals available. Figure 3 shows a small increase in the yield of Dobson relative to Ellett. In the case of the plot experiments, this increase is considerably smaller than the increase in the general mean.

Figure 2. Resistance to rust in annual ryegrasses at Gatton in sow and plot evaluation from 1990 to 1946



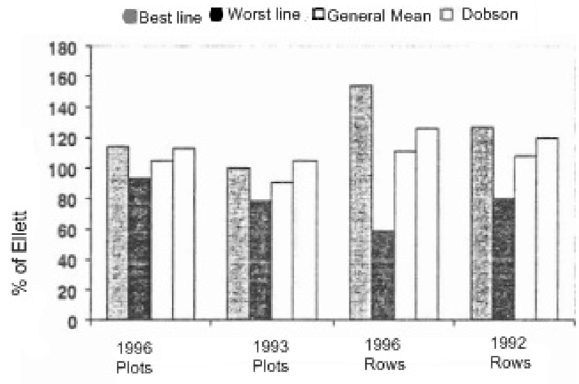
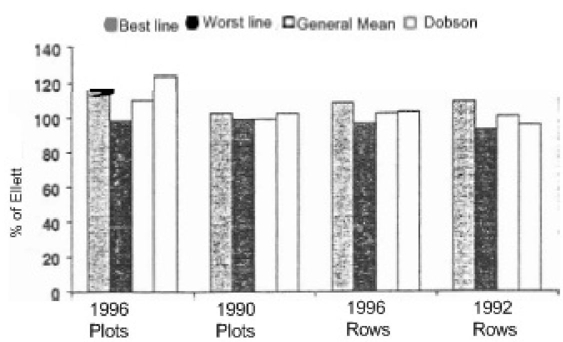


Figure 3. Yield of perennial ryegrass in row and plot evaluations at Gatton from 1992 to 1996.

Rust resistance has shown little improvement between 1992 and 1996 in she row evaluations but there has been a small improvement in the rust resistance recorded in the plot experiment (Figure 4). The fact that there has been such a large increase in the performance of Dobson relative to Ellett would suggest that some factor other than breeding may have been the cause of this apparent improvement.

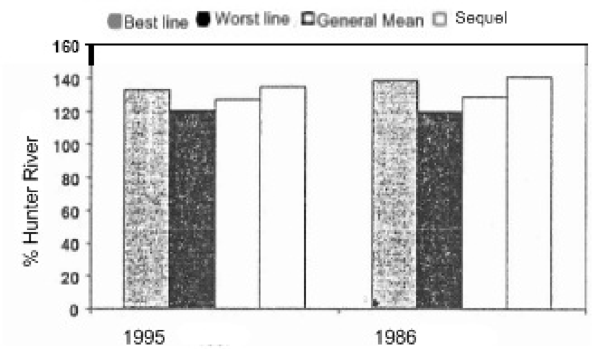
Figure 4. The response of rust resistance in perennial ryegrass in a subtropical area to plant breeding from 1992 to 1998



Lucerne

Seven experiments have been conducted in south-east Queensland to evaluate lucerne breeding lines. The general mean, expressed as a percentage of the yield of Hunter River, of these experiments from 1978 to 1997 was 138, 142, 167, 129, 136, 127 and 130% respectively. This suggests that there was a significant increase in performance of lucerne as a result of breeding from 1978 to 1983 but from then there has been no further improvement. This is confirmed by Figure 5, which shows that there has been no improvement in the yield of the best experimental line in the 1986 and 1995 experiments.

Figure 5. Yield of lucerne experimental lines and the experiment general mean, relative to Hunter River between sowings in 1986 and 1995.



The data in Figure 6 suggests that there has been a loss of persistence over the study period. However, more than any other data presented in this paper, there seems to have been substantial changes in other pressures on cultivar performance because the performance of Sequel, relative to Hunter River has also fallen substantially.

In all three diseases, the performance of Sequel has deteriorated, relative to Hunter River from 1986 to 1995 (ie. disease ratings have increased). However the performance of the best of the experimental lines and the general mean have shown considerable improvement in all but the response to Colletotrichum crown rot (CCR). In Phytophthora root rot (PRR) there has also been an improvement in the worst performing line.

Figure 6. Persistence of lucerne experimental lines and the experiment general mean, relative to Hunter River between sowings in 1986 and 1995

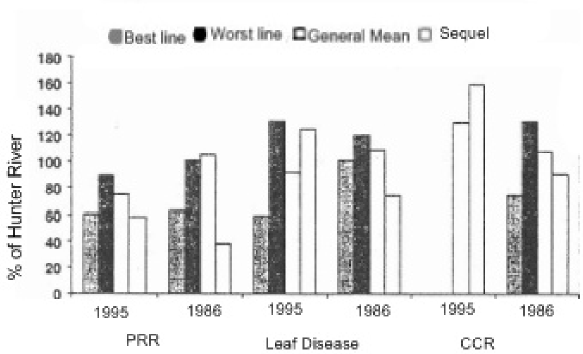
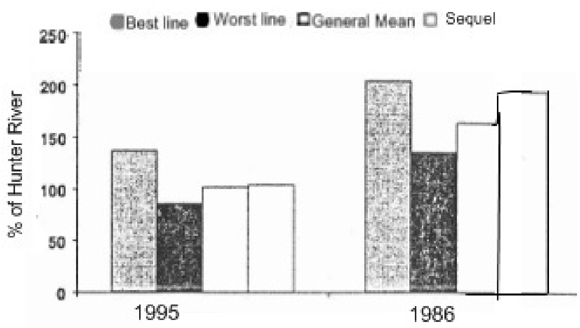


Figure 7. Influences of plant breeding on the disease resistance of breeding populations of lucerne from 1986 to 1995



DISCUSSION

We present evidence that breeding programs in southern Australia and New Zealand have had a significant impact on the performance of a number temperate species in the coastal subtropical region of Australia. The impact appears strongest in the yielding ability of annual and perennial ryegrasses. Resistance to the damaging effects of rust was less influenced by breeding but this is not unexpected because of the very much higher pressures from rust infection in the humid subtropical environment.

Breeding in lucerne has also been shown to be effective in improving its performance. The major effect of breeding came between 1977 and 1983 as a result of the introduction of aphid-resistance into Australian lucerne cultivars and the introduction of resistant cultivars from USA. Subsequently, there has been little improvement in yield. However at the same time as aphid resistance was introduced, resistance to significant diseases of lucerne in subtropical areas (Irwin 1977) was also introduced into breeding programs (Gramshaw *et al.* 1985). These resistances also had an impact on the yield over that early period. Breeding continues to influence disease resistance of experimental lines as indicated by the improvement in PRR and leaf disease ratings in experimental lines. The lack of improvement in CCR ratings is partly because Hunter River is one of the most resistant cultivars to CCR as a mature plant in the field (Gramshaw *et al.* 1985). The other reason is because most of the experimental lines evaluated in these experiments are winter active or highly winter active and these are inherently less resistant to CCR. Persistence was shown to fall over the study period. Again this can be related to the lower inherent persistence of the more winter active material. However we do have evidence (J. Mackie and K.F. Lowe, unpublished data) that other pressures such as root burrowing insects and other crown diseases have become more damaging over the period.

The lack of improvement in the rust resistance of annual ryegrasses is surprising, considering the effort which has been put into this species. The main reason is the outstanding performance of cv. Aristocrat in south-east Queensland. This is a selection from cv. Midmar which had been bred in South Africa (Lowe 1990) with adaptation to a subtropical environment and high level of resistance to rust.

The difference between the row and cutting experiment results can be attributed to lag time, because lines may take a number of years to enter the cutting trial after being in the row evaluations. In perennial ryegrass the performance in rows was better than in plots, suggesting that the best material had not yet reached *the* plot experimentation stage. However in annual ryegrass the plots were showing the improvement, suggesting that the effect of breeding may have
already achieved its optimum effect.

Other important species for the subtropics include fescue *(Festuca arundinacea)* and white clover *(Trifolium repens).* There have been some experiments conducted in the subtropics on these species; our limited data suggests that breeding may also be improving a number of attributes of these species (Lowe, Bowdler and Lowe, unpublished data).

Plant breeding has had a positive influence on the performance of temperate grasses and legumes in a subtropical environment. Its effect was most notable on the yielding ability of lucerne and perennial ryegrass and least on persistence of these species. Breeding has had varied success in improving disease resistance. Overall, we conclude that continued cooperation between plant breeders and agronomists will continue to improve temperate species performance.

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