Tropical Grasslands (2003) Volume 37, 151–164

Experiences with farm pastures at the former CSIRO Samford Research Station, south-east Queensland, and how these relate to results from 40 years of research

R.M. JONES AND G.A. BUNCH
CSIRO Livestock Industries, Brisbane, Australia

Abstract

Samford Research Station in coastal south-east Queensland was operated by CSIRO from the late 1950s–2002. Many experiments on tropical legumes and grasses were carried out on the station and many farm pastures were sown. Furthermore, once most experiments had ended, they were grazed as farm pastures. Hence, considerable experience was gained about how different species did or did not persist under farm grazing. This paper outlines these experiences with individual species of legumes and grasses and discusses how they relate to experimental results. In general, performance of species in farm pastures was similar to the results from experiments, provided the experiments were run for long enough and with appropriate grazing pressures. The main reason for the failure of short-term experiments to predict long-term results was that they did not allow sufficient time to establish whether recruitment could compensate for death of the original plants.

The most persistent legumes were perennial peanut (*Arachis glabrata*), Pinto peanut (*Arachis pinto*) cv. Amarillo and leucaena (*Leucaena leucocephala*), followed by siratro (*Macroptilium atropurpureum*) cv. Siratro, white clover (*Trifolium repens*) and Shaw creeping vigna (*Vigna parkeri*), all of which persisted in some situations. The most persistent and aggressive grass was Bahia grass (*Paspalum notatum*), with reasonable persistence from Queensland blue couch (*Digitaria didactyla*) and setaria (*Setaria sphacelata*).

Correspondence: Mr R.M. Jones, 20 Fairholme Street, Kenmore, Qld 4069, Australia.
e-mail: rmdjjones@bigpond.com

Introduction

Samford Research Station in coastal south-east Queensland (27°22′S, 152°53′E) was established as a field station for the former CSIRO Division of Tropical Pastures. Essentially it comprised 2 dairy farms, purchased in the late 1950s. The station was extensively used for research during the 1960s and 1970s, but the requirement for research then gradually declined and it was closed in 2002. The station always supported several hundred cattle, primarily run on farm pastures.

Consequently, considerable experience was gained with pasture species under farm grazing over the past 40 years. In some cases, these species had been sown as farm pastures and in other instances they were "left-over" after experiments had ceased. In this paper, we relate our experiences with pasture species under farm grazing and consider how this relates to research results, with particular emphasis on results from Samford. We then discuss some possible reasons for any differences between "farm experience" and "research results". One of us (R.M. Jones) was involved in experiments at Samford for many years between 1969–2000 while G.A. Bunch worked as a field technician at Samford from 1969–1993 and was Samford farm manager from 1993–2002.

Samford Research Station

Soils and vegetation

The farm comprised 290 ha, with approximately 10% being well drained alluvial flats and 30% gleyed soils bordering the well drained soils or along small drainage lines. All these areas had been cleared prior to development of the station and the dominant species would have included carpet grass (*Axonopus fissifolius* syn. *A. affinis*), green couch (*Cynodon dactylon*), paspalum (*Paspalum dilatatum*) and blue couch (*Digitaria didactyla*).

A further 40% of the farm was comprised of red-yellow podsolic soils with small areas of prairie soils on gently sloping hillsides. Most of these areas had been previously cleared and supported similar grasses to the alluvial flats, along with blady grass (*Imperata cylindrica*). Other areas were cleared and sown after 1960. The dominant tree genera prior to clearing were *Eucalpytus* and *Tristania* spp. The remaining 20% of the farm was comprised of lithosols on hilltops. The small areas of lithosols that had been cleared prior to 1960 supported kangaroo grass (*Themeda triandra*) along with some of the grasses previously listed. Further clearing of these lithosols was carried out in the 1960s while some areas were left uncleared.

Average annual rainfall was 1100 mm, two-thirds of which fell in the 6 warmer months from October–March. Frosting of varying intensity was recorded on the alluvial flats, at about 40 m above sea level, in every year and there was usually lighter frosting on the low–intermediate hillslopes. The frosting records given by Cook and Russell (1983) are from an intermediate hillslope position. The tops of the hills, at about 70–80 m elevation, were rarely frosted.

More details of the climate have been given by Stirk (1963) and Cook and Russell (1983) and of the soils by Beckmann (1957) and Thompson and Murtha (1960). Detailed analyses of some soil profiles were given by Stace *et al*. (1968).

The cattle herd and grazing management

Until 1990 a breeding herd of about 150 cows was run on the station. The breed was initially Hereford but was changed in the early 1970s to Belmont Red by introducing Afrikander and then Belmont Red bulls. After 1990, equivalent numbers of cattle were maintained by trucking in Belmont Red weaners from the former CSIRO Narayen Research Station, Mundubbera. Steers were usually retained until turn-off at 450–500 kg. A small dairy herd of about 40 Jerseys was maintained for about 14 years.

Farm sowings

Farm pastures were usually sown into cultivated soil although some legumes were oversown into existing grass pastures on steeper slopes. Most farm sowings were made during the 1960s, although several areas were re-sown, mainly in the early 1990s. The early sowings were usually heavily fertilised with superphosphate plus trace elements at 600 kg/ha and potassium chloride at 250 kg/ha as a basal fertiliser. During most of the 1960s, 250 kg/ha of superphosphate and 125 kg/ha of potassium chloride were usually applied annually as maintenance fertiliser. After that, levels of fertiliser were reduced and typically 250 kg/ha of superphosphate, sometimes including Mo, was applied every 2–3 years.

Many species were included in farm sowings, but the main legumes were siratro (*Macroptilium atropurpureum*) cv. Siratro, greenleaf desmodium (*Desmodium intortum*) cv. Greenleaf, silverleaf desmodium (*D. uncinatum*) cv. Silverleaf, leucaena (*Leucaena leucocephala*) and white clover (*Trifolium repens*). Smaller areas were sown to Kenya clover (*Trifolium semipilosum*) cv. Safari, Pinto peanut (*Arachis pintoi*) cv. Amarillo, lotononis (*Lotononis bainesii*) cv. Miles, greater lotus (*Lotus uliginosus*) cv. Maku, round-leafed cassia (*Chamaecrista rotundifolia*) cv. Wynn and *Aeschynomene americana* cv. Glen. The main sown grass was setaria (*Setaria sphacelata*) cvv. Nandi, Kazungula and Narok, with smaller areas of rhodes grass (*Chloris gayana*) cvv. Pioneer and Samford, green panic (*Panicum maximum* var. *trichoglume*) cv. Petrie, *Brachiaria brizantha* and *Panicum coloratum* var. *kabulabula*. Some areas, usually on the alluvial soils, were planted to pangola grass (*Digitaria eriantha*) or sown to kikuyu (*Pennisetum clandestinum*) cv. Whittet.

Grazing management of the farm pastures was at the discretion of the farm manager, and there were 5 managers between 1960–2000. Grazing during the warmer months tended to be concentrated on the lower areas and this management strategy was followed far more deliberately over the last 10 years (1993–2002).

Experiments

Experiments varied in size from tens of square metres to over 20 ha with individual plots ranging from about 1 m^2–3 ha. Experiments were usually heavily fertilised, although, if they were laid out on existing farm pastures, they were rarely fertilised again with the original heavy basal applications (*e.g.* Jones and Bunch 1995a).

Some experiments involved planting out of lines from breeding programs and many hectares of Samford were used in the breeding of Siratro and later attempts to develop an improved siratro (Hutton and Beall 1977). Other experiments involved breeding populations of genera such as *Stylosanthes, Centrosema*, *Desmodium, Leucaena*, *Setaria* and *Digitaria*.

Some small-plot experiments involved the characterisation of a large range of accessions from individual species or genera, such as *Teramnus* (Eagles and Pengelly 1996). Other experiments involved assessing different accessions in small plots that were grazed or cut in common (*e.g*. Strickland 1978; Strickland and Haydock 1978). Small-plot experiments were also used to discover how species reacted to different cutting frequencies and intensities (*e.g*. Jones 1973a; 1974). In other cases, accessions or lines were in individually grazed plots of about 0.2 ha (*e.g*. Jones 1979) or in paddocks large enough to record animal production (*e.g*. Jones and Jones 1984; 2003), usually of 0.5–3.0 ha. Over 40 years, several thousand accessions would have been sown.

In most cases, these experimental sites were subsequently opened to farm grazing, usually as part of a larger farm paddock. Some experimental sites were re-used for other experiments and this usually, but not always, involved removing accessions surviving from the previous trial.

Experiences with legumes

Our experiences with the different species are listed in alphabetical order for legumes and then for grasses, with results from research studies where relevant. We have also drawn on research results from other sites in coastal south-east Queensland, mainly from the former Beerwah Research Station (26°50′S, 152°02′E).

Aeschynomene falcata *cv. Bargoo*

Bargoo was never sown in farm pastures, but persisted and spread from several small-plot sowings (Jones 1986, 2001; Cameron *et al.* 1989). The earliest 2 of these experimental sowings were grazed as part of farm pastures for over 15 years. Bargoo also spread as isolated plants into farm paddocks where it was not planted, primarily on the well drained red-yellow podsolic soils, and was obviously spread in cattle dung. Although it persisted and spread, especially under heavier grazing and in lower fertility sites, it did not appear to be productive, invariably contributing less than 10% of dry matter. These experiences are in accord with research findings at Samford (Jones 1986; 2001) and elsewhere (Wilson *et al.* 1982; Roe and Jones 2000). If seed production problems could be overcome, it or another accession could warrant inclusion as part of a mixture of species in coastal and subcoastal areas, except for high fertility or poorly drained sites. Evidence from northern New South Wales suggests that it can improve animal production in such situations (Mears *et al.* 1993).

Arachis glabrata

This species has to be planted vegetatively. Although planted in only small areas, usually on alluvial or gleyed podsolic soils, it persisted very well. One planting of CPI 12121, reported to be made in the late 1950s, was still persisting in a farm pasture in 2002. Plantings of a wider range of lines in 1970 (Cook *et al.* 1994), open to farm grazing since 1974, were still productive in 2002, despite some years when they were grossly undergrazed and other years when they were very closely grazed.

Research associated with these plantings continued for only 3–6 years, as reported in Cameron *et al.* (1989), Cook *et al.* (1994) and Jones (2001), but reports of these experiments noted the good persistence of this species over that limited experimental period. Spread was slow as it was based on gradual extension of rhizomes. Cook *et al.* (1994) reported that well established *A. glabrata* at the former Beerwah Research Station could invade adjacent grassland at the rate of up to 30 cm per year, but spread at Samford was slower than this. While *A. glabrata* has unquestioned potential to persist and produce in pastures (Cook *et al.*1994), the slow rate and high cost of establishment will limit its use.

Arachis pintoi *cv. Amarillo*

Results from farm sowings in the 1980s and 1990s were variable. Most persisted well while others established poorly and did not improve; the reasons were not clear but could be partly related to ineffective nodulation.

The first experimental sowing of this species at Samford was made in 1974, which may have been the earliest sowing in Australia. This site was used for seed production for some years and since then Amarillo persisted there in a farm pasture although growing with *Paspalum notatum.* It was still persisting in 2002 in 2 of the 3 sites reported in the 1984–1990 study of Jones (1993) where these sites were grazed as part of a farm pasture. Amarillo failed soon after sowing at the third site on a poorly drained gleyed podsolic soil that could be waterlogged during wet periods yet very dry at other times. In 2002, Amarillo was still persisting on a trial site sown in 1981 (Cameron *et al.*1989) then grazed as farm pasture for 15 years, and in recent sowings made in 1995–1997 (Jones 2001). Most sowings were on alluvial-gleyed podsolic soils, but some were on red-yellow podsolics.

Amarillo spread slowly, less than 20 cm per year, as spread depends on rooting of stolons or seedling recruitment from below-ground seed production, which can occur only beneath existing stolons (Jones 1993). However, a near-sterile hybrid between *A. pintoi* and *A. repens* spread more rapidly (Jones 2001) and shows promise as a ground cover in macadamia orchards in northern New South Wales (Firth *et al.* 2002).

Centrosema virginianum

Approximately 3 ha of a bred line of *C. virginianum* was sown in a hillslope site in 1984 as part of the experiment on legume growing points described by Clements (1989). It was grazed as part of a farm pasture since 1987. Although usually grazed only at a moderate pressure, it did not persist well and very few plants were present in 2002. Results reported by Clements (1989) and from a trial at Beerwah (Jones and Clements 1987) strongly suggest that persistence would be even poorer at heavier grazing pressures.

Chamaecrista rotundifolia *cv. Wynn*

Wynn was sown mainly on red-yellow podsolic soils and on the drier end of the gleyed podsolic soils at Samford as it was known that it did not persist well on poorly drained sites (Cook 1988). In 1984, it was sown into 1 ha as part of the experiment described by Clements (1989) and this site was also used in a 1986–1993 study of how the population dynamics of Wynn was affected by stocking rate (Jones and Bunch 1995a). The dominant companion grass between 1988–2002 was *Paspalum notatum*. Wynn persisted under farm grazing on this site until 2002 although density was lower than during the 1986–1993 experiment. Persistence was much poorer on an adjacent site used by Clements *et al.* (1996) where Wynn was a very high yielding legume when the experiment ended in 1988. The decline at this latter site is at least partially attributed to undergrazing. Our experience has been that, in the long term, Wynn will persist better with reasonably close grazing. However, in an experiment with controlled grazing (Jones and Bunch 1995a), Wynn was affected to only a minor degree by the moderate to heavy stocking rates imposed (2–4 yearlings/ha).

Wynn persisted in some small-plot experiments where it was sown, and invaded nearby areas. However, it did very poorly in other experiments (Jones 1986; Cameron *et al*. 1989) and did not improve after these were opened to farm grazing. Based on our experience at Samford, Wynn can be a useful legume in well drained sites in coastal areas, although it is better suited to more open pastures that are moderately-heavily grazed. Persistence will be much poorer if the pasture is undergrazed, largely due to poor seedling recruitment in dense grass. Wynn is a short-lived perennial and adequate seedling recruitment and establishment are essential for long-term persistence (Jones and Bunch 1995a).

Desmodium incanum

Desmodium incanum was sown only in small plots and not in paddock sowings. It persisted well in these areas (*e.g*. the trial described by Cameron *et al.* 1989) and slowly spread, even under heavy grazing. There were isolated small patches around the station in 2002 and we assume that these established from seed disseminated in faeces or through seed pods adhering to animals. *D. incanum* was usually lightly, but not avidly, grazed. It did not appear to be highly productive, but occasionally contributed 20% or more of the pasture. Further evaluation could be warranted, although it should be recognised that in Hawaii it did not fulfill the promise it showed in early results (Hacker 1992).

Desmodium intortum *cv. Greenleaf*

Greenleaf desmodium was widely sown in both farm pastures and experiments in the 1960s. While it grew well in both for about 4 years, resulting in good animal production (Jones and Jones 2003), subsequent persistence was very poor. It was very unusual to find plants of Greenleaf desmodium after 1980 except in one unusual location where it was still productive in 2002. The water supply at Samford was based on reticulation from a central water tank sited at the top of a hill. Water was pumped to the tank and the pump was usually turned off only when the tank overflowed. This always occurred on one side of the tank and the water flowed and then seeped in a broad band down the hillslope. Greenleaf desmodium was apparently sown in the pasture below the tank in the 1960s, but since 1970 was effectively limited to the area that received this extra water. The paddock had always been moderately or, on rare occasions, heavily grazed.

Jones (1989) suggested that the failure of Greenleaf and Silverleaf desmodium to persist could be due partly to the presence of low levels of weevil larvae that prevented development of new tap roots to compensate for the death of the original taproots. Persistence would then rely on smaller surface adventitious roots, making desmodium vulnerable to dry periods. Studies at Beerwah suggested that few of the original taproots lasted for longer than 4 years, which coincides with the time span during which Greenleaf was productive at Samford (Jones and Jones 2003).

Greenleaf persistence at other sites on Samford was poorer than in the 1600 mm rainfall environment of Beerwah Research Station (Bryan and Evans 1973; Jones and Evans 1984) where some desmodium pastures maintained over 20% legume for more than 10 years. As Samford has a lower rainfall than Beerwah, this would be expected. However, in the area "irrigated" by overflow from the water tank at Samford, conditions never became very dry and so it is possible that the better persistence of Greenleaf desmodium on this site was due to smaller adventitious roots being able to meet the plants' demands for water.

Desmodium triflorum

This pan-tropical species (Pengelly 1992) occurred in patches over Samford, usually in heavily-grazed and open swards. It was most conspicuous, along with native legumes such as *Glycine tabacina, G. tomentella* and *Zornia dictyiocarpa*, on a heavily-grazed and well drained paddock in the grazing trial reported by Jones and Jones (2003). However, animal production was consistently poor from that paddock, despite heavy applications of superphosphate, not offering any encouragement for commercialisation of these legumes.

Desmodium uncinatum *cv. Silverleaf*

This legume was widely sown in farm pasture in the early 1960s but its contribution was usually insignificant from 1970–2000 although isolated plants of this species were more common than plants of *D. intortum.* Following the favourable growing conditions in 1998–2000, *D. uncinatum* was more conspicuous than it had been for many years. It even appeared in farm paddocks that were lightly grazed in summer, where it had not been noted for many years, with small areas containing over 10% desmodium. Its persistence was favoured in the site near the water tank previously described for *D. intortum*, where it was more prominent than *D. intortum.* We consider that the reasons previously advanced for the better persistence of *D. intortum* would also apply to *D. uncinatum*.

Leucaena leucocephala
cvv. Peru and Cunningham

Over 12 ha of leucaena were successfully planted or sown around 1960 and a further 6 ha in the 1970s. There were also several unsuccessful attempts to establish leucaena, with failures due more to competition from weeds and grazing by marsupials than to poor seedling emergence. Most stands persisted very well. The survival of plants in 3 stands, one of which was solely used as a farm pasture and the other 2 mostly used as farm pastures, has been outlined by Jones and Bunch (2000). Forty years after planting, about 75% of plants still survived. Survival of another stand, sown in 1959 and used in the experiment described by Jones and Bunch (1995b), was poorer, but it was still a useful stand in 2002. Areas where survival was poor in this stand, and also in the trial described by Jones and Jones (1984), were associated with areas that were poorly drained during extended wet periods, even though they were on hillslopes.

Psyllids invaded in 1984 and depressed yields. During some years we consider they reduced the production of edible material in some pastures by more than the 50% reduction measured at Samford by Bray and Woodroffe (1991). We consider that we sometimes reduced psyllid damage by strategic rotational grazing where the frequency of grazing was manipulated depending on the severity of psyllid attack. While psyllids were still a major limitation in 2002, their influence appeared to be less serious in the late 1990s than in the previous 5 years.

Samford was the first site where the goitrogenic effect of DHP, a ruminal metabolite from mimosine, was demonstrated (Jones *et al.* 1976; R.J. Jones, personal communication). Other studies at Samford showed the potential for leucaena, even prior to the advent of rumen bacteria to degrade DHP, to produce high liveweight gains (Jones and Jones 1984; Jones and Bunch 1995b) and our observations suggest that this has also applied to farm pastures. Although the stands of leucaena at Samford were small, they included the first stands in Australia to be regularly grazed and one provided over 20-years data on liveweight gain (Jones and Bunch 1995b). They were seen by thousands of visitors, including primary producers, university students and visiting research workers, and played a useful role in promoting the use of leucaena as a pasture legume in northern Australia and probably overseas.

The variable soils within small areas at Samford resulted in considerable differences in the growth of leucaena within individual paddocks. This was noted by Jones and Bunch (1995b) who pointed out that this variability makes it difficult to adequately graze leucaena over the whole area of the paddock without consistently overgrazing the poorer plants or allowing the more vigorous plants to produce seed and possibly spread outside the leucaena stand. We have observed no spread of leucaena from any stands at Samford and only a small amount of recruitment in very small sections in 2 of the 7 leucaena paddocks. We attribute this to the good grazing control which, depending on the paddock, avoided or minimised seed production and also maintained dense grass swards that prevented recruitment from the small amount of seed which had been produced. In larger commercial leucaena pastures, if sited on variable soil types likely to result in variable leucaena growth, subdivision may be important to get adequate control of grazing and prevent seed production.

Lotononis bainesii *cv. Miles*

Miles lotononis was included in both farm sowings and experiments. At Samford it did not persist in grazed pastures but was present every year in certain very isolated and specific situations, either along the edges of certain farm roads, possibly where coarse sand had been brought in as a road base, or in areas of grass with low N status on well drained sites which were regularly mowed. Miles is known to favour heavily grazed sites, open grass swards, light-textured soils and well drained sites (Cook 1992).

Lotus uliginosus (pedunculatus) *cv. Grasslands Maku*

Maku lotus persisted well in a 1976 farm sowing on 4 ha of gleyed soil. The density of Maku stolons and rhizomes fluctuated throughout the year, generally being highest in late spring-early summer and lowest, sometimes extremely low, in early autumn. It grew best on moist soils provided they were free of standing water during summer. Single 30 x 30 cm plugs of Maku were planted into such sites in 2 farm pastures in 1982. By 2002, these plugs had spread into patches of 30 and 80 m^2. However, the density of stolons and rhizomes in these patches also fluctuated wildly between seasons and between years (Vos and Jones 1986), being highest in late spring provided there had been good cool season rainfall. In contrast, Vos and Jones found there was little change in the density of rhizomes of *A. glabrata* sampled at the same times.

The persistence of Maku was much poorer in 3 experiments than in the farm pastures, even though they were established on alluvial or gleyed podsolic soils (Cameron *et al.* 1989; Blumenthal *et al.* 1999; Jones 2001). However, not surprisingly since they were experiments, they were not laid out on the wetter end of the range of gleyed soils where Maku did well in farm sowings. Thus, our experience at Samford in an area of 1100 mm rainfall suggests that Maku will be an effective legume only on very restricted areas where there is little severe soil moisture stress yet no lengthy periods of standing water during summer. It can be a persistent and productive legume in these limited areas.

Macroptilium atropurpureum *cv. Siratro*

Siratro was the most widely sown legume in both farm pastures and experiments at Samford. The farm pastures were established mainly during the 1960s though some were sown in the 1990s. Siratro did not persist in heavily grazed farm pastures or under sustained close defoliation in cutting trials (Jones 1974), small grazed plots (Jones 1979) or continuously grazed paddocks (Jones and Jones 2003). Persistence may also have been reduced by the advent of siratro rust (*Uromyces appendiculatus*) which reduced yield of both forage and seed.

Even in lightly grazed farm or experimental pastures, the proportion of Siratro generally declined with time. However, there was a recovery of Siratro in some old farm pastures in the late 1990s. This is attributed in part to better rainfall than in the early 1990s and also to the management strategy of resting the Siratro pastures during late summer and autumn. The recovery was particularly marked where the Siratro, sown in the 1960s, was growing with an unknown *Digitaria* sp. and much of this pasture contained about 20% Siratro in 1998–2002. There was also a recovery, although less marked, where Siratro was grown with setaria.

These results are similar to those observed in an experiment at Samford where Siratro percentages of well above 10% were maintained for more than 12 years, but then declined under set stocking and continuous grazing (Jones and Jones 2003). Even so, Siratro persisted for much longer than Greenleaf desmodium in both the experiment (Jones and Jones 2003) and farm pastures. Studies within this experiment also suggested that autumn spelling could be an effective way of restoring Siratro (Jones 1988, 1992; Jones and Jones 2003). Spelling in late summer–early autumn was an acceptable management practice at Samford as grazing during this period should be concentrated on the alluvial areas and lower slopes — partly to avoid a build up of material that would be frosted in winter and partly to aid persistence of white clover (see later).

Neonotonia wightii

Glycine was sown to a much lesser extent than Siratro, Greenleaf desmodium and Silverleaf desmodium and it persisted only in small areas. It was most prominent where it was growing on a more fertile prairie soil in a small part of a larger farm pasture. The preference of glycine for fertile soils is well known (Pengelly and Benjamin 1992).

Stylosanthes *spp.*

Samford, having a mesic subtropical environment, is not typical stylo country. Nevertheless, it was extensively used as a field site in breeding programs on *S. guianensis* and *S. scabra.* Consequently isolated plants could be found over the station in 2002. *S. scabra* accessions had persisted for some years on a drier upper slope and some patches of *S. guianensis,* still present in 2002, had persisted for more than 30 years, usually on drier sites with more open grass swards.

Trifolium repens *(white clover)*

White clover was the most important legume on the alluvial soils and some of the lower slopes at Samford. The clover at Samford was very variable in morphology and leaf markings as many different types had been sown, apart from the mixture of types present in naturalised clover in south-east Queensland (Ostrowski 1972). Most research on clover management was done at the Beerwah Research Station (Jones 1982; 1984), although some studies were made on seedling survival at both Samford and Beerwah (Jones 1980). These studies showed that some clover stolons in south-east Queensland could usually survive over summer and early autumn, even though most stolons died during these months. However, seedling recruitment in late autumn and early–mid-winter was also very important. Spring rainfall is essential for a good "clover year", but spring rain will be of no benefit if there are insufficient stolons or plants to respond.

The studies also showed that both stolon survival and seedling recruitment were enhanced if stocking rates on clover-based pastures were increased from mid-summer to mid-autumn. This practice was followed on farm pastures at Samford, particularly in the last 10 years, and was reasonably successful. The period when more stock are needed on the clover pastures largely coincides with the period when resting on the higher slopes can aid survival and growth of Siratro and conserve stand-over feed for winter in frost-free areas. Many properties in south-east Queensland include these different land classes. White clover is still a very important legume for coastal south-east Queensland, given appropriate rainfall, fertiliser and grazing management.

Trifolium semipilosum *cv. Safari*

Safari was sown in small-plot experiments (Jones 1973b; Jones 1986; Cameron *et al.* 1989) where it showed promise during the experiments and thereafter under farm grazing. However, in another small-plot sowing, it was not promising (Jones 2001). It persisted in one paddock where it was experimentally grazed for more than 20 years, although its contribution to yield was less in the last 10 years than in the first 10 years when it produced very good liveweight gains (Jones and Bunch 1995b). Safari swards also gave high milk yields in a trial planted in 1972 (Stobbs 1976) and Safari was still present on this trial site in 2000, though only as scattered plants. Our observations suggest that Safari can be adversely affected more by undergrazing than by overgrazing. This can be explained on the basis that sustained undergrazing does not allow for the necessary development of adventitious rooting from stolons (Sproule *et al.* 1983).

Yellowing or reddening of Safari sometimes occurs in older stands, usually in spring. There has been considerable discussion about the cause of this yellowing (*e.g.* Cook and Shaw 1985; Jones and Bunch 1995b). The fact that it tended to be seasonal, and has occurred in old stands and in plants well nodulated from the applied *Rhizobium* strain (Jones and Date 1975), suggests to us that, although the yellowing may be associated with impaired nitrogen metabolism (Cook and Shaw 1985), it could still reflect an attack by a disease organism, but not necessarily Rugose Leaf Curl virus. The variable results from Safari sowings at Samford are similar to the variable success in farm sowings in southern coastal Queensland (B.G. Cook, personal communication).

Other African Trifolium *spp.*

A mixture of 4 *Trifolium* spp. from elevated areas of Africa (*T. ruepellianum, T. usambarense, T. tembense* and *T. mattirolianum*) was established in areas of 0.5 ha in each of 3 different farm pastures, all on gleyed podzolic soil. The 6 accessions sown were selected following evaluation of a wide range of accessions in row sowings in northern NSW (Wilson and Bowman 1993). All accessions established, nodulated, grew well and seeded in the first year. However, they have been absent or seen only as very isolated plants in subsequent years.

Vigna parkeri *cv. Shaw*

Only one farm pasture was sown to Shaw, but small areas were also oversown within other farm pastures. The best results from these sowings were in sites towards the wetter end of the range of gleyed podsolic soils, provided the sites were very rarely under standing water. Stands here were very productive and, given favourable rainfall years, Shaw spread from these sites, both from stolons and from seed in cattle dung. The better persistence of Shaw in these sites was somewhat similar to that noted above for Maku lotus, although we have consistently observed that Maku can persist in saturated soils better than Shaw and the reverse was the case on slightly drier sites. Shaw did not persist well in the trial described by Cameron *et al.* (1989) on a yellow podsolic soil. In the experiments described by Jones (2001), on a site at the drier end of the gleyed podsolic soils, it was present only as isolated unproductive patches in the first 2–3 years but then recovered during 2 years with more favourable rainfall, spread outside the sown area and was selectively grazed by cattle.

With the favourable rainfall experienced in 1998–1999 and 1999–2000, small patches of Shaw appeared in many areas of the farm, confirming other observations about its spread in cattle faeces (Cook and Benjamin 1992). Given consecutive years with good rainfall, we anticipate that Shaw will be very successful in localities similar to Samford. However, in dry years, it will be found only in moister areas and even there its productivity will be greatly reduced (Jones and Clements 1987). Shaw will have a very restricted role in sites with less than 1100 mm rainfall, but has many desirable attributes that make it a useful legume in well grazed pastures in the wetter subtropics or elevated tropics (Cook and Benjamin 1992).

Other legume species

Other legumes were sown but failed to show real promise. *Aeschynomene americana* cv. Glen grew well and seeded in one farm sowing on a gleyed podsolic soil, but did not re-establish. Occasional plants of earlier flowering lines of *A. americana* were noted, in one case being very prominent after cultivation, but otherwise they have been sparse even in years when they did best. *Macrotyloma axillare* cv. Archer survived only as isolated plants at the top of hillslopes and did best where it was allowed to grow up the framework of leucaena bushes. *Aeschynomene villosa* was under farm grazing for only 4 years after 3 years of experimental grazing, so no firm conclusions can be drawn about its long-term persistence. However, its density had appreciably declined and we noted that its flowering and seeding can be markedly reduced by dry periods in early autumn, to a much greater extent than Wynn cassia. More detailed lists of some of the legume accessions evaluated at Samford can be found in Cameron *et al*. (1989) and Jones (2001).

Experiences with grasses

Axonopus fissifolius *(synonym.* A.affinis*)* *(narrow-leaf carpet grass)*

This was a common species over much of the station in the late 1950s and was still present on some of the more closely grazed areas in 2002 (Jones and Jones 2003) although to a large extent it had been replaced by Bahia grass. It was absent in heavily grazed areas that had received appreciable N fertiliser (Jones and Jones 2003).

Chloris gayana *(rhodes grass)*

Paddocks of cultivars Pioneer and Samford, and smaller areas of cv. Callide, were sown over the station. In general, rhodes grass in these areas declined with time, but persisted better with N fertiliser and when more leniently grazed. However, Callide sown in 1973–1974 had virtually disappeared from N-fertilised paddocks in 1987 whereas the paddocks sown to setaria at the same time were still dominated by setaria (Jones and Evans 1989). In another N-fertilised experiment, that ran for more than 20 years, a rhodes grass contaminant, probably cv. Pioneer, persisted at a low level in fertilised setaria when lightly grazed but not under moderate–heavy grazing (Jones and Jones 2003).

Brachiaria brizantha

One paddock was sown to *Brachiaria brizantha* CPI 15890 in the 1960s. Leucaena was successfully established along cultivated strips in the paddock in 1981. The brachiaria persisted well and formed a dense pasture.

Cynodon nemfluensis *(star grass)*

This species was included in small-plot experiments on alluvial or gleyed podsolic soils and persisted and spread into adjacent areas under farm grazing. In one area of higher fertility, near a gate into a paddock, it slowly spread into and dominated Bahia grass.

Digitaria didactyla *(Queensland blue couch)*

This species was present on the station in the 1950s and was still an important species on more closely grazed areas on better drained sites in 2002. On unfertilised areas it was progressively being dominated by Bahia grass, but on areas that were fertilised with N for many years it excluded Bahia grass, even for some years after fertiliser application ceased (Jones and Jones 2003).

Digitaria eriantha

Pangola grass (formerly *D. decumbens*) was planted out vegetatively, mainly on alluvial areas. On these areas it was generally heavily grazed and sometimes was invaded and dominated by Bahia grass. In some years, productivity was apparently reduced by rust and pangola stunt virus.

Many other accessions of *Digitaria* spp. were sown at Samford (Strickland 1978; Strickland and Haydock 1978). In general, the tussock types did not persist whereas some of the more dense stoloniferous types, formerly known as *D. pentzii*, have persisted and spread, even in Bahia grass (*e.g.* Jones and Bunch 1995b).

Panicum maximum *var.* trichoglume *(green panic)*

Not widely sown at Samford, it did not persist well. It persisted in stands of leucaena where it was growing on well drained and fertile alluvial soils, sometimes under light shade, and not continuously grazed.

Panicum coloratum *var.* kabulabula

This tall tussock grass tended to be lightly grazed and formed large discrete tussocks. Our experience from one farm sowing is that it did not spread and slowly declined with time.

Paspalum dilatatum *(paspalum)*

Probably never sown in farm pastures, it was much less common in 2002 than in the 1950–60s. This could be due to invasion by Bahia grass as well as to cultivation and sowing of species such as setaria.

Paspalum notatum *(Bahia grass)*

To the best of our knowledge, this species was sown only in small plot experiments at Samford, *e.g.* Shaw *et al.* (1965), and not as a farm pasture. However, small areas of Bahia have occurred in south-east Queensland for many years, so it is possible that some of these were present on the station before the mid-1950s. By 2000 it was the dominant grass over much of the alluvial areas and some of the hillslope sites at Samford, especially under moderate-heavy grazing. There were several types but all were the broader-leaf type rather than the narrow-leaf type. However, it did not invade closely grazed pastures fertilised with 336 kg/ha N for many years (Jones and Jones 2003).

While it became somewhat unpalatable when allowed to grow rank, even when not seeding, it could be grazed reasonably effectively by using rotational grazing, ensuring that a paddock was well grazed before animals were moved off. Our experience was that it was then possible to have reasonable white clover growing with Bahia grass, given favourable cool season rainfall, but clover percentages were lower than when it was growing with carpet grass or blue couch. Small areas of *Desmodium incanum,* Bargoo*,* Amarillo peanut and, in favourable years, Shaw creeping vigna have also persisted with Bahia grass. This is in accord with results at Beerwah Research Station (Jones 1982; authors, unpublished data). Even though it may not be a preferred species, it will spread from the scattered sites where it has established in south-east Queensland.

Paspalum nicorae

This strongly rhizomatous species was sown only in small plots, where it gave very promising yields, particularly in winter (Strickland 1978). In a more recent experiment, small patches were slowly thickening up in dense Bahia grass (Jones 2001). It was not used on a large scale at Samford because of early concerns about its weed potential. However, it has persisted and apparently slowly expanded from isolated patches in Bahia grass swards and is usually grazed in preference to Bahia. Cultivar Blue Dawn has recently been released as a lawn grass, but could also be used in sown pastures.

Pennisetum clandestinum *(kikuyu)*

Kikuyu persisted only in areas that have had a history of N fertilisation. When sown in small plots without N, it persisted very poorly (Jones 2001). It persisted better with low levels of N (100–200 kg/ha/yr) on a low fertility site but even then declined with time (Jones 2001). However, once fertility was built up with sustained N application, it was able to persist and spread into weaker grasses (Jones and Evans 1989). This very positive response of kikuyu to high soil N levels, especially when compared with that of narrow-leaf carpet grass, has been well documented (*e.g.* Bryan 1967, at Maleny, south-east Queensland).

Setaria sphacelata *(setaria)*

Setaria was the main sown grass at Samford. It persisted well in most farm sowings and experiments. In both situations, persistence was better with lighter grazing pressures, especially when grown without N fertiliser or a vigorous legume. It was possible to eliminate setaria from pastures by sustained heavy grazing (Jones and Jones 2003). However, provided it was still present in overgrazed pastures, it could be restored by resting during late summer-autumn (Jones and Jones 2003). The more the setaria had degenerated through sustained heavy grazing pressure, the longer the time taken for recovery (Jones 1992). Kazungula was the least acceptable cultivar as it flowered early in the growing season, unless controlled by grazing pressure or regular slashing, and then remained stemmy for a long period. In contrast, Nandi and Narok seed heads were not so persistent.

Narok tolerated light frosts better than Nandi, but its topgrowth succumbed to heavy frosts (terrestrial minimum temperatures < 0°C). CPI 32930 has persisted well in one sowing and is seemingly more frost-resistant than Narok (Jones and Bunch 1995b).

Experience in farm pastures suggests that it may be more difficult to maintain Siratro with setaria than with lower-growing and less-competitive grasses. Experimental studies suggested that this could be partly due to competition for potassium (Hall 1971), but we have no field evidence to support this.

Sporobolus creber *(Parramatta grass)*

This native unpalatable grass was present on Samford for many years, but became more of a problem in the 1990s where it has even thickened up in Bahia grass pastures. No formal experimentation has been carried out, but we believe that the best control would be through slashing and/or wick wiping after close grazing, possibly with application of some N fertiliser.

Sporobolus pyramidalis *(giant rat's tail grass)*

This unpalatable grass established in pastures sown to setaria in the 1960–1970s but did not appear in areas used for early stage evaluation. Thus, we assume that it came in as a contaminant in commercial seed. In retrospect, the problem was not recognised early enough and initial control measures were too half-hearted and it continued to spread till about 1990. Since then its occurrence was reduced, but at considerable cost. Isolated plants or small patches were dealt with by spraying with glyphosate. Usually other grasses, especially *Paspalum notatum*, colonised the sprayed patches.

Paddocks with dense areas of giant rat's tail were sprayed in summer with glyphosate, and then burnt when topgrowth had died. They were then roughly cultivated to trap moisture and oats was sown in autumn using a minimum-till approach as far as possible. The oats, fertilised with 75 kg/ha N, was only lightly-moderately grazed over winter-early spring so that significant stubble remained. Strategic boom spraying of rat's tail plants and seedlings was continued in the following summer and oats was sown again in the following cool season. If necessary, this procedure was repeated for a third oat crop or until there were few seedlings of giant rat's tail emerging. At this stage the treated areas, which were on hillside sites, were roughly cultivated and sown to a mixture of Wynn cassia, Siratro, rhodes grass and setaria. Further inspections and spot spraying within the newly sown pastures were still required. This approach of using successive crops of N-fertilised oats and strategic spraying was effective but costly. Care had to be taken to leave adequate stubble and to avoid cultivation during the summer months when rainfall of high intensity can be expected.

How did farm experience relate to research results?

Generally speaking, experience with farm pastures was in accord with research results provided that the research was done for long enough.

All the main botanical changes in farm pastures, such as the good persistence of leucaena on suitable soils, the better persistence of Siratro than of desmodium and the eventual decline in Siratro that can be partially avoided through autumn resting were in accordance with research results. However, short-term results could be misleading. For example, desmodium pastures were very productive for 3 years and Siratro persisted well for 4 years under heavy grazing. Similarly, some tussock forms of *Digitaria* spp. yielded well for 3–4 years, but did not persist as well as stoloniferous forms under farm grazing in the long term. Short-term results may not give a "wrong" result, but can easily give a misleading result if extrapolated to the long term. However, even 10 years may sometimes be too short — in some experiments Siratro persisted at an adequate level for more than 12 years before it markedly declined at Narayen Research Station (Mannetje and Jones 1990) and at Samford (Jones and Jones 2003).

Similar trends have been noted in periodic inspections by the authors on other former research sites in south-east Queensland. For example, some tussock grasses were rated highly after 5 years (1965–1971) of experimental grazing at Nanango in a 750 mm rainfall area of south-east Queensland (Jones and Rees 1972). By the late 1990s, they had largely disappeared after 20 years of intensive farm grazing whereas *Arachis glabrata* and some prostrate grasses, such as *Digitaria pentzii*, which were not rated highly in 1972, were still productive and spreading (authors, unpublished data).

To a large extent, the failure of short-term experiments to predict long-term results, especially for herbaceous legumes, relates to the fact that they usually do not last long enough to see if the inevitable death of the original plants can be compensated for by reliable sexual or vegetative recruitment, given normal variability in climate and grazing pressure. Furthermore, short-term experiments usually do not experience extreme conditions, such as very dry years or, less commonly, excessively wet years, which can have major impacts on both death of plants and recruitment. This limitation of the short term in predicting long-term results also applies to experience from commercial pastures. It accounts for some of the early enthusiasm by research scientists, extension officers, farmers and graziers for improved tropical pastures in the 1960s and early 1970s, usually based on only a few years experience, which was replaced by a much more considered view, as documented in a publication edited by Brown (1983) about Siratro in south-east Queensland.

What can be done to avoid or reduce this problem? Obviously, it would be impossible to run all experiments for 10 years, or even 5 years. Perhaps the main point is to be more aware of the limitations of short-term experiments, and to be appropriately cautious. It may be possible to take measurements at the end of an experiment that would serve as an indicator of future trends — for example, the measurements of soil seed reserves of Siratro taken by Jones (1979) gave an indication of probable future trends in Siratro density in relation to the different grazing management treatments imposed. This topic has been considered in more detail by Jones *et al.* (1995).

However, it may be that the best accessions have to be selected from preliminary evaluation trials over 2–3 years and further evaluation carried out on a reduced number of accessions. Pressure to do this may be more acute now (2003) than it was some decades ago as there is more reliance on non-government funding. Such funding sources tend to demand results within an unrealistically short time frame.

If this is the case, the preliminary evaluation trial should be maintained under realistic farm grazing even after the follow-up experiment has started — even if only observations are made rather than measurements. This may give advance warning that some of the species chosen for later stage evaluation may not persist. It may also show that some of the species initially rejected have “come good”. It was such an event that led to the release of Shaw creeping vigna (Cook and Jones 1987). Even if these observations merely reinforce the results from the short-term trial, this is still useful knowledge.

The grazing management imposed on small-plot trials should reflect, as closely as possible, that which will apply in practice. It is easiest to do this in terms of stocking rate as our experience has been that it is easy to generate realistic stocking rate effects on small plots. For example, the trial on “legumes for heavy grazing” (Cameron *et al.* 1989) had a grazing regimen imposed on it that gave results in 5 (1982–1987) years that still held in 2002, after 15 years of farm grazing. Even experiments with different cutting regimens can give a good indication of the likely effect of different grazing intensities (Jones 1974; Jones 1979). However, it may be harder to reproduce the effects of different frequencies of rotational grazing in small plots (Norton 1998).

It was encouraging that the grazing systems using flexible stocking rates in different seasons on Siratro and white clover, developed in part from research projects, were reasonably effective on farm pastures. The powerful impact of seasonal grazing pressure has been known for decades. For example, Jones (1933) noted that this can “bring about extremely wide variations in the botanical composition of the sward”, but this approach has probably been under-used in research on grazing management. This could be partly due to the decisions about changing grazing pressure inevitably being somewhat subjective, depending on presentation yield and likely growth rates based on temperature and rainfall, and so being “unscientific”.

Acknowledgements

We appreciate the comments made by Walter Scattini and Raymond Jones on this paper. We also appreciate all the contributions made by staff working at Samford over the 40-year history of the station and to the funding given by the different rural industry funds.

References

BECKMANN, G.G. (1957) Soil survey of the CSIRO experimental farm, Samford, Queensland. *Divisional Report 5/57, Division of Soils, CSIRO, Australia.*

BLUMENTHAL, M.J., BOWMAN, A.M., COLE, A., JONES, R.M., KELMAN, W.M., LANDERS, T.E. and NICOL, H.I. (1999) Establishment, growth and persistence of greater lotus (*Lotus uliginosus*) at six sites in eastern Australia. *Australian Journal of Experimental Agriculture*, **30**, 819–827.

BRAY, R.A. and WOODROFFE, T.D. (1991) Effect of the leucaena psyllid on yield of *Leucaena leucocephala* cv. Cunningham in south-east Queensland. *Tropical Grasslands,* **25**, 356–357.

BROWN, R.F. (1983) Siratro in south-east Queensland. *Conference and Workshop Series QC83002, Department of Primary Industries, Queensland.*

BRYAN, W.W. (1967) Botanical changes following application of fertilizer and seed to rundown paspalum, kikuyu and mat grass pastures on a scrub soil at Maleny, south-east Queensland. *Tropical Grasslands*, **1**, 167–170.

BRYAN, W.W. and EVANS, T.R. (1973) Effects of soils, fertilizers and stocking rates on pastures and beef production in the Wallum of south-eastern Queensland. 1. Botanical composition and chemical effects on plants and soils. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **13**, 516–529.

CAMERON, D.G., JONES, R.M., WILSON, G.P.M., BISHOP, H.G., COOK, B.G., LEE, G.R. and LOWE, K.F. (1989) Legumes for heavy grazing in coastal subtropical Australia. *Tropical Grasslands*, **23**, 153–161.

CLEMENTS, R.J. (1989) Rates of destruction of growing points of pasture legumes by grazing cattle. *Proceedings of the XVI International Grassland Congress, Nice, 1989.* pp.1027–1028.

CLEMENTS, R.J., JONES, R.M., VALDES, L.R. and BUNCH, G.A. (1996) Selection of *Chamaecrista rotundifolia* by grazing cattle. *Tropical Grasslands*, **30**, 389–394.

COOK, B.G. (1988) Persistent new legumes for heavy grazing 2. Wynn round-leafed cassia. *Queensland Agricultural Journal*, **114**, 119–121.

COOK, B.G. (1992) *Lotononis bainesii* Baker. In: Mannetje, L. 't and Jones, R.M. (eds) *Plant Resources of South-East Asia. 4 Forages.* pp.154–155. (Pudoc:Wageningen).

COOK, B.G. and SHAW, K.A. (1985) Rugose leaf curl in Kenya white clover. *Tropical Grasslands*, **19**, 3–4.

COOK, B.G and JONES, R.M. (1987) Persistent new legumes for intensive grazing. 1. Shaw creeping vigna. *Queensland Agricultural Journal*, **113**, 89–91.

COOK, B.G. and BENJAMIN, A.K. (1992) *Vigna parkeri* Baker. In: Mannetje, L. 't and Jones, R.M. (eds) *Plant Resources of South-East Asia. 4 Forages.* pp.232–234. (Pudoc:Wageningen).

COOK, B.G., WILLIAMS, R.J. and JONES, R.M. (1994) Regional experience with forage *Arachis* in Australia. In: Kerridge, P.C. and Hardy, W. (eds) *Biology and Agronomy of Forage* Arachis. pp. 158–168. (CIAT:Cali, Colombia).

COOK, S.J. and RUSSELL, J.S. (1983) The climate of seven CSIRO field stations in northern Australia. *Technical Paper No. 25, Division of Tropical Crops and Pastures, CSIRO, Australia.*

EAGLES, D.A. and PENGELLY, B.C. (1996) Morphological and agronomic attributes of a collection of the genus *Teramnus*. *Genetic Resources Communication No. 25, Division of Tropical Crops and Pastures, CSIRO, Australia.*

FIRTH, D.J., JONES, R.M., MCFADYEN, L.M., COOK, B.G. and Whalley, R.B.D. (2002) Selection of pasture species for groundcover suited to shade in mature macadamia orchards in subtropical Australia. *Tropical Grasslands*, **36**, 1–12.

HACKER, J.B. (1992) *Desmodium incanum* DC. In: Mannetje, L. 't and Jones, R.M. (eds) *Plant Resources of South-East Asia. 4 Forages.* pp.112–114. (Pudoc:Wageningen).

HALL, R.L. (1971) The influence of potassium supply on competition between Nandi setaria and Greenleaf desmodium. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **11**, 415–419.

HUTTON, E.M. and BEALL, L.B. (1977) Breeding of *Macroptilium atropurpureum*. *Tropical Grasslands*, **11**, 15–31.

JONES, M.G. (1933) Grassland management and its influence on the sward III The management of a "grassy" sward and its effects. *Empire Journal of Experimental Agriculture*, **1**, 221–232.

JONES, R.J. (1973a) The effect of frequency and severity of cutting on yield and persistence of *Desmodium intortum* cv. Greenleaf in a subtropical environment. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **13**, 171–177.

JONES, R.J. (1973b) The effect of cutting management on yield, chemical composition and *in vitro* digestibility of *Trifolium semipilosum* grown with *Paspalum dilatatum* in a subtropical environment. *Tropical Grasslands*, **7**, 277–284.

JONES, R.J. (1974) Effect of an associate grass, cutting interval and cutting height on yield and botanical composition of Siratro pastures in a subtropical environment. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **14**, 334–342.

JONES, R.J., BLUNT, C.G. and HOLMES, J.H.G. (1976) Enlarged thyroid glands in cattle grazing leucaena pastures. *Tropical Grasslands,* **10**, 113–116.

JONES, R.M. (1979) Effect of stocking rate and grazing frequency on a Siratro (*Macroptilium atropurpureum*)/*Setaria anceps* cv. Nandi pasture. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **19**, 318–324.

JONES, R.M. (1980) Survival of seedlings and primary taproots of white clover (*Trifolium repens*) in subtropical pastures in south-east Queensland. *Tropical Grasslands*, **14**, 19–22.

JONES, R.M. (1982) White clover (*Trifolium repens*) in subtropical south-east Queensland. I. Some effects of site, season and management practices on the population dynamics of white clover. *Tropical Grasslands*, **16**, 118–127.

JONES, R.M. (1984) White clover (*Trifolium repens*) in subtropical south-east Queensland. III Increased clover and animal production by use of lime and flexible stocking rates. *Tropical Grasslands*, **18**, 186–194.

JONES, R.M. (1986) Persistence of legumes oversown into grass pasture. *Annual Report 1985/86, Division of Tropical Crops and Pastures, CSIRO, Australia.* p. 70.

JONES, R.M. (1988) The effect of stocking rate on the population dynamics of siratro in siratro (*Macroptilium atropurpureum*)/setaria (*Setaria sphacelata*) pastures in south-east Queensland. III Effects of spelling on restoration of siratro in overgrazed pastures. *Tropical Grasslands*, **22**, 5–11.

JONES, R.M. (1989) Productivity and population dynamics of Silverleaf desmodium (*Desmodium uncinatum*), Greenleaf desmodium (*D. intortum*) and two *D. intortum x D. sandwicense* hybrids at two stocking rates in coastal south-east Queensland. *Tropical Grasslands*, **23**, 43–55.

JONES, R.M. (1992) Resting from grazing to reverse changes in sown pasture composition: application of the "state and transition" model. *Tropical Grasslands*, **26**, 97–99.

JONES, R.M. (1993) Persistence of *Arachis pintoi* cv. Amarillo on three soil types at Samford, south-eastern Queensland. *Tropical Grasslands*, **27**, 11–15.

JONES, R.M. (2001) Evaluation of legumes and grasses in coastal south-east Queensland. *Tropical Grasslands*, **35**, 85–95.

JONES, R.M. and Rees, M.C. (1972) Persistence and productivity of pasture species at three localities in subcoastal south east Queensland. *Tropical Grasslands*, **6**, 119–134.

JONES, R.M. and DATE, R.A. (1975) Studies in the nodulation of Kenya white clover (*Trifolium semipilosum*) under field conditions in south-east Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **15**, 519–526.

JONES, R.M. and EVANS, T.R. (1984) Problems associated with grazing experiments involving the integration of different pastures — a case study in south-east Queensland. *Tropical Grasslands*, **18**, 39–45.

JONES, R.M. and JONES, R.J. (1984) The effect of *Leucaena leucocephala* on liveweight gain, thyroid size and thyroxine levels of steers in south-eastern Queensland. A*ustralian Journal of Experimental Agriculture and Animal Husbandry*, **24**, 4–9.

JONES, R.M. and CLEMENTS, R.J. (1987) Persistence and productivity of *Centrosema virginianum* and *Vigna parkeri* cv. Shaw under grazing on the coastal lowlands of south-east Queensland. *Tropical Grasslands*, **21**, 55–64.

JONES, R.M. and EVANS, T.R. (1989) Live weight gain from four nitrogen fertilized grasses grazed over the growing season in coastal south-east Queensland. *Tropical Grasslands*, **23**, 75–79.

JONES, R.M. and BUNCH, G.A. (1995a) Yield and population dynamics of *Chamaecrista rotundifolia* cv. Wynn in coastal south-eastern Queensland as affected by stocking rate and rainfall. *Tropical Grasslands*, **29**, 65–73.

JONES, R.M. and BUNCH, G.A. (1995b) Long-term records of legume persistence and animal production from pastures based on Safari Kenya clover and leucaena in subtropical coastal Queensland. *Tropical Grasslands,* **29**, 74–80.

JONES, R.M., JONES, R.J. and MCDONALD, C.K. (1995) Some advantages of long-term grazing trials with particular reference to changes in botanical composition. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **35**, 1029–1038.

JONES, R.M. and BUNCH, G.A. (2000) A further note on the survival of plants of *Leucaena leucocephala* in grazed stands. *Tropical Agriculture* , **77**, 109–110.

JONES, R.M. and JONES, R.J. (2003) Effect of stocking rates on animal gain, pasture yield and composition, and soil properties from setaria–nitrogen and setaria–legume pastures in coastal south-east Queensland. *Tropical Grasslands*, **37**, 65–83.

MANNETJE, L. 't and JONES, R.M. (1990) Pasture and animal productivity of buffel grass with Siratro, lucerne or nitrogen fertilizer. *Tropical Grasslands*, **24**, 269–281.

MEARS, P.T., GARDEN, D.L. and DICKER, R.W. (1993) Evaluation of pastures for sustained beef production in subtropical New South Wales. *Proceedings of the XVII Internationcal Grasslands Congress, Rockhampton.* **III**, 1898–1900.

NORTON, B.E. (1998) The application of grazing management to increase sustainable livestock production. *Animal Production in Australia*, **22**, 15–26.

OSTROWSKI, H. (1972) White clover (*Trifolium repens*) in subtropical Australia — a review. *Tropical Grasslands*, **6**, 97–106.

PENGELLY, B.C. (1992) *Desmodium triflorum* (L.) DC. In: Mannetje, L. 't and Jones, R.M. (eds) *Plant Resources of South-East Asia. 4 Forages.* p. 116. (Pudoc:Wageningen).

PENGELLY, B.C. and BENJAMIN, A.K. (1992) *Vigna parkeri* Baker. In: Mannetje, L. 't and Jones, R.M. (eds) *Plant Resources of South-East Asia. 4 Forages.* pp. 232–234. (Pudoc: Wageningen).

ROE, R. and JONES, R.M. (2000) Research note: Relative persistence of a range of lespedeza (*Kummerowia*) accessions, *Aschynomene falcata* cv. Bargoo, and other legumes in two-long-term trials in southern Queensland. *Tropical Grasslands*, **34**, 99–102.

SHAW, N.H., ELICH, T.W., HAYDOCK, K.P. and WAITE, R.B. (1965) A comparison of seventeen introductions of *Paspalum* species and naturalised *P. dilatatum* under cutting at Samford, south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **6**, 150–156.

SPROULE, R.J., SHELTON, H.M. and JONES, R.M. (1983) Effects of summer and winter grazing on growth habit of Kenya white clover (*Trifolium semipilosum*) cv. Safari in a mixed sward. *Tropical Grasslands*, **17**, 25–30.

STACE, H.C.T., HUBBLE, G.D., BREWER, R., NORTHCOTE, K.H., SLEEMAN, J.R., MULCHAY, M.J. and HALLSWORTH, E.G. (1968) *A Handbook of Australian Soils.* (Rellim:Adelaide).

STIRK, G.B. (1963) Estimation of frequency of drought days at Samford, south-east Queensland. *Divisional Report 5/63, Division of Soils, CSIRO, Australia.*

STOBBS, T.H. (1976) Kenya white clover (*Trifolium semipilosum*) — a promising legume for milk production in subtropical environments. *Proceedings of the Australian Society of Animal Production*, **11**, 477–480.

STRICKLAND, R.W. (1978) The cool season production of some introduced grasses in south-east Queensland. *Tropical Grasslands*, **12**, 109–112.

STRICKLAND, R.W. and HAYDOCK, K.P. (1978) A comparison of some twenty *Digitaria* accessions at four sites in south-east Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **18**, 817–824.

THOMPSON, C.H. and MURTHA, G.G. (1960) Soils of the CSIRO Pasture Research Station, Samford East, Queensland. *Divisional Report No. 11/60, Division of Soils, CSIRO, Australia.*

VOS, G. and JONES, R.M. (1986) The role of stolons and rhizomes in legume persistence. *Annual Report 1985–86, Division of Tropical Crops and Pastures*, *CSIRO*, *Australia*.

WILSON, G.P.M., JONES, R.M. and COOK, B.G. (1982) Persistence of joint vetch (*Aeschynomene falcata*) in experimental sowings in the Australian subtropics. *Tropical Grasslands*, **16**, 155–156.

WILSON, G.P.M. and BOWMAN, A.M. (1993) *Trifolium* species on the New South Wales north coast: 2. African species. *Genetic Resource Communication No. 19, Division of Tropical Crops and Pastures, CSIRO, Australia.*

(Received for publication July 26, 2002; accepted March 21, 2003)