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The effect of band-seeding legumes into para grass (*Brachiaria mutica*) on pasture production, sustainability and animal productivity in Vanuatu

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Abstract

A band-seeding method was utilised to oversow a suite of legumes into an established para grass (*Brachiaria mutica*) pasture. Twining legumes *Pueraria phaseoloides* and *Centrosema pubescens* persisted productively in the dense para grass sward but *Neonotonia wightii* cvv. Malawi and Cooper persisted weakly and *Aeschynomene americana* cv. Glenn, *Stylosanthes guianensis* cv. Cook and *Vigna parkeri* cv. Shaw failed to persist.

The legume-oversown para grass pasture was compared with a legume-deficient para grass pasture (control) for botanical stability and animal production under continuous grazing. The oversown treatment was significantly more robust than the control pasture, resisting weed invasion and tolerating adverse seasonal conditions. Animal production from the oversown legume treatment was, on average, 22% higher than the control over a 3-year grazing period.

Introduction

Para grass (*Brachiaria mutica*) is recognised as one of the highest quality tropical grasses in Vanuatu but requires careful grazing management due to its intolerance of heavy grazing (Cameron and Kelly 1970). It is well suited to the high rainfall, humid-tropical climate and moderately fertile soils of the Santo plateau in northern Vanuatu (Coulon *et al.* 1983). However, graziers consider para grass pastures are less robust and no more productive than the prevalent improved pasture, signal grass (*Brachiaria decumbens*). Most existing stands of para grass are legume-deficient, appear nitrogen stressed and are commonly weed-infested. Maximum cattle liveweight gains from these pastures have been estimated at 390-440 kg/ha/yr, with stocking rates of 1.8 AU/ha, and individual liveweight gains of 0.44-0.5 kg/hd/d have been reported (Coulon *et al.* 1983). However, cattle liveweight gains reported elsewhere are high, ranging from 0.6 kg/hd/d from unfertilised, dryland para grass pastures (Crowder *et al.* 1970) to 0.96 kg/hd/d from irrigated para grass-centro (*Centrosema pubescens*) pastures (Evans 1969). Suitable companion legumes should improve not only pasture and cattle production but also the ability of para grass to resist weed invasion.

Band-seeding is a rapid, cost-effective sod-seeding technique in which pasture seed can be placed accurately into a furrow and surrounding plant competition controlled using a systemic herbicide spray over the planted furrow (Cook *et al.* 1993a). In the experiment reported here, a legume-deficient para grass pasture was oversown with a suite of legumes using a band-seeding technique. Subsequently, a study was conducted to investigate the effects of sown pasture legumes on botanical stability of and animal production potential from para grass pastures.

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Materials and methods

Site

The grazing trial was conducted at the Institut de Récherches pour les Huiles et Oléagineux (IRHO), Espiritu Santo, Vanuatu (168°00′E, 15°30′S) as part of the applied research program of the Vanuatu Pasture Improvement Project (Macfarlane *et al.* 1993). Climate is humid-tropical, with 2900 mm annual rainfall and a

1–3 month dry season (<50 mm rainfall/month). Average monthly wet and dry season temperatures range from 23–30°C and 20–26°C, respectively. Soils at the IRHO site are typical of Santo's eastern plateau, being red-brown, ferralitic alfisols, 1–2 m in depth, overlying uplifted calcareous parent material. Soil pH is 6.1 and soil P concentration is 22 ppm (BSES method). With the exception of nitrogen, soil nutrients were adequate for growth of pasture grasses (CFL 1983), although P may be marginal for legumes with high P requirements.

Band-seeding

An 18-year-old para grass pasture was fenced into 2 paddocks of 2 ha each. One paddock was randomly selected for oversowing with a suite of legumes. The paddock was heavily stocked for a 3-month period prior to planting to reduce grass competition. A Mason-Deere "Maxi-strike" band-seeder was used to plant 6.25 kg/ha of inoculated legume seed into this paddock in May 1989 (Table 1). Twin rows, 90 cm apart, were planted every 5 m. A 1.5 m-wide band of glyphosate (720g glyphosate/sprayed ha) was applied at planting to kill para grass and allow establishment of legumes. Both paddocks were destocked for a 6-month period following planting. The control paddock was spot sprayed with fluoroxypyr (0.5% in water) in late 1989 to remove naturalised centro. From December 1989, the paddocks were grazed rotationally for a 6-month period, prior to the commencement of the liveweight gain study, to stabilise the pastures. The variable cost of pasture establishment was 8000 VT/ha (approx. US$80.00).

Legume establishment was assessed 6 weeks after planting by counting emerged seedlings. Botanical analysis of pasture was assessed every 3 months using the BOTANAL, non-destructive sampling method (Tothill *et al*. 1992) from January 1990 to May 1993.

Cattle

Two drafts of steers were used in the trial. The first draft were Brahman-Charolais × "local", with an average initial weight of 300 kg. The second draft were Limousin-Illawarra × "local", with an average initial weight of 290 kg. "Local" cows have originated from Shorthorn and Channel Island dairy breeds, first introduced into Vanuatu in 1845 (Weightman 1989). In June 1990, 5 steers were assigned at random to each paddock, giving a stocking rate of 2.5 hd/ha. Complete mineral salt blocks were supplied *ad libitum*. Steers were grown to a turnoff weight of 520–550 kg, which reflected normal Japanese export market slaughter requirements. Steers were weighed at least every 3 months depending on the commitments of IRHO staff. Liveweight gain data were analysed using QUASP (Queensland University Agricultural Statistical Package). Individual steers were used as replicates.

Results and discussion

Legume establishment

A satisfactory kill of para grass within the planted bands was achieved with the glyphosate spray, but para grass rapidly invaded from the unsprayed inter-rows and had re-established within 6 weeks from planting. Competition from perennial pastures can reduce survival of oversown legumes greatly, and legumes that germinate and establish rapidly have a greater chance

Table 1. Legume species, cultivars and seeding rates used for oversowing para grass.

Species	Cultivar	Seeding rate	Seedlings emerged	Emergence
		(kg/ha)	(No/m row)	(%)
Neonotonia wightii	Cooper	0.75	1.8	6.4
N. wightii	Malawi	0.75	1.4	5.7
Centrosema pubescens	common	2.0	3.7	15.5
Pueraria phaseoloides		0.75	2.2	14.5
Aeschynomene americana	Glenn	1.0	3.1	3.9
Vigna parkeri	Shaw	0.5	0.1	1.1
Stylosanthes guianensis	Cook	0.5	0.3	0.4

of survival (Cook *et al.* 1993b). Legume establishment from the band-seeding operation was poor, with only 5% of sown seed emerging in the first month (Table 1). Centro, the largest seeded legume planted, established satisfactorily, but other species had poor establishment. Prior to planting, pasture edible dry matter (EDM) was estimated to be 5000 kg/ha. The heavy grazing pressure applied to reduce pasture bulk caused considerable trampling and ultimately, a thick trash layer (grass debris, predominantly stem) through which the band-seeder could not cut. Seedling emergence was considerably better in areas of minimal trash. In a related experiment, 27% of viable seed established using the band-seeding method, planting into heavily grazed buffalo grass (*Stenotaphrum secundatum*) with little surface trash (Macfarlane *et al.* 1993). Furthermore, insects active in the soil and litter, including earwigs, mole crickets and army worms, killed establishing seedlings, but their effects were not quantified. We consider that the pre-plant grazing period should be of sufficient duration to allow breakdown of this trash layer and to reduce pasture height to 5 cm.

Pasture on offer

The oversown legume treatment consistently produced more edible dry matter than the control (Figure 1). Dry season (July–September) EDMs of the control treatment were less than half those of the oversown treatment in 1991 and 1992 and, for long-term stability, a reduced stocking rate would be required during the dry season in the control treatment. During the 1991 dry season, EDM in the control paddock dropped below 1000 kg/ha, reducing sward density and percentage ground cover, and allowing significant weed invasion. Past experience at IRHO has indicated that 1.8 hd/ha (maintaining 500 kg/ha EDM) is a sustainable stocking rate for legume-deficient para grass pastures (Coulon *et al.* 1983).

In contrast, the EDM of the oversown treatment remained above 2000 kg/ha and 100% ground cover was maintained throughout the trial. The extra bulk of pasture in the oversown treatment that was carried into the dry season prevented the need to destock, and presented an opportunity for increasing the stocking rate. By May 1992, the oversown treatment contained almost 2000 kg/ha more EDM than the control

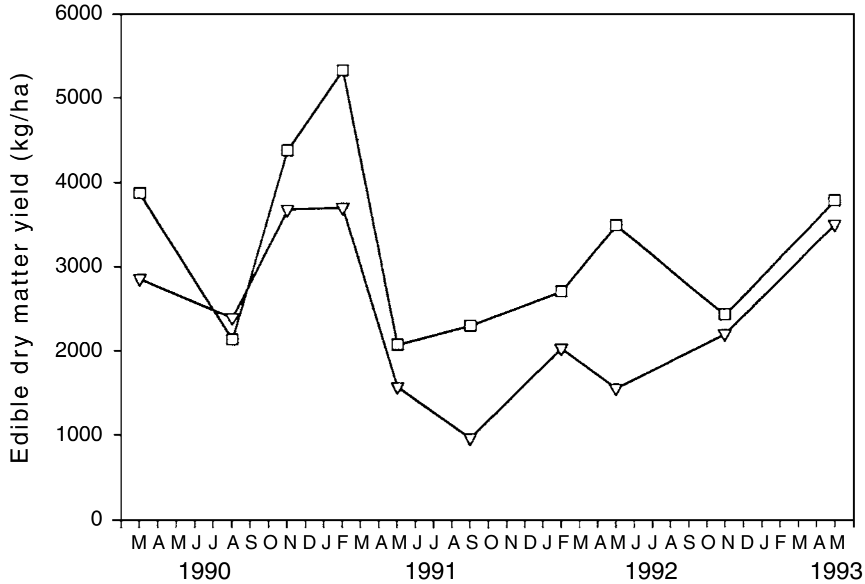

Figure 1. Edible dry matter yields of Control (,) and Legume-oversown (h) treatments during the grazing period.

(Figure 1). The lenient grazing pressure allowed the para grass to seed freely (95% seeding) whereas the heavily grazed control para grass seeded very lightly (5% seeding). A decline in steer growth rate coincided with heavy seeding and the stocking rate of the oversown treatment was increased from 2.5 to 3.0 hd/ha (October 1991) to control seeding and to utilise available forage better. This increased stocking rate was sustained continuously for at least 12 months after the conclusion of the experimental period in May 1993.

Botanical composition

The botanical composition of the control and legume-oversown treatments is presented in Figures 2a and 2b, respectively. Para grass dominated both treatments throughout the trial but significant invasion by undesirable species occurred in the control treatment. Invader grass species in the control treatment were dominated initially by Embu (*Panicum maximum* cv. Embu) which persisted poorly under grazing. T-grass (*Paspalum conjugatum*) became the dominant invader grass in early 1992, contributing 2–10% of pasture EDM. Invader grasses were of no significance in the legume oversown treatment.

The control treatment contained a small, but increasing amount of legume, predominantly mimosa (*Mimosa pudica*). Mimosa is a naturalised legume of low palatability but is generally well accepted late in the season. Legumes contributed up to 35% of sward presentation yield in the oversown treatment but the percentage varied dramatically with season. Initially, centro dominated the sown legume component of the pasture but puero steadily increased over the trial period, finally contributing 5–30% of pasture on offer

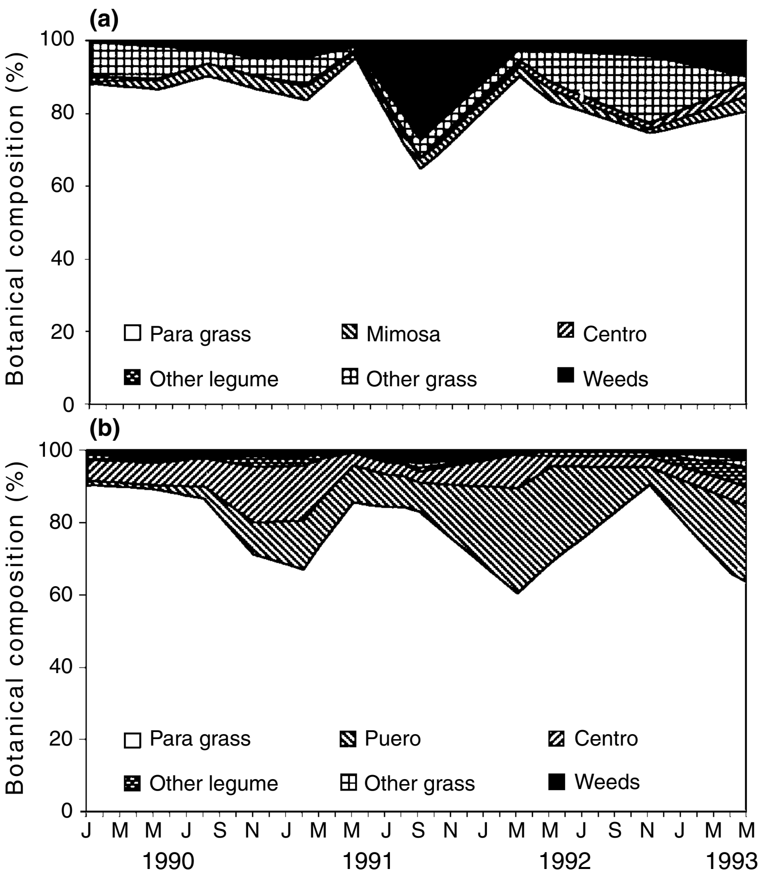

Figure 2. Botancial composition of (a) Control and (b) Legume-oversown treatments during the grazing period.

(Figure 2b). Puero was accepted by stock only moderately well during the wet season but acceptability increased towards the end of the dry season. Elsewhere in Vanuatu, increased stocking pressure has been required during the wet to prevent puero from smothering grass pastures (Macfarlane *et al*. 1993). Mimosa did not invade the oversown treatment.

Cooper and Malawi glycines persisted but contributed little to yield. Soil pH and P concentration were marginal for Cooper glycine (Skerman *et al*. 1990) but Malawi is better suited to lower pH and soil phosphorus conditions. Glenn joint vetch, Cook stylo and Shaw vigna did not establish well from oversowing. To persist, Glenn joint vetch must be spelled following heavy grazing at the end of the dry season to allow recruitment from seed with the on-coming wet season (Macfarlane *et al*. 1993). Shaw vigna has performed satisfactorily in heavily grazed signal grass and buffalo grass (*Stenotaphrum secundatum*) pastures (Macfarlane *et al*. 1993), but the high mean temperatures and rainfall of the Santo plateau may be supra-optimal for Shaw vigna. Glenn joint vetch and Cook stylo are also unlikely to be suited to the grazing management required for stable para grass in the wet tropics, *viz*. continuous maintenance of a dense sward, generally under continuous grazing management, to prevent weed invasion.

Weed invasion in the control treatment tended to increase over time, particularly following each dry season. The dominant weed, *Sida rhombifolia*, became a serious problem during the dry season of 1991, and 3.5 man days/ha were expended controlling the weed. Although *S. rhombifolia* is browsed by stock, it has dominated pastures elsewhere in Vanuatu. Future invasion by unpalatable weeds (*e.g. Cassia tora*) into the control paddock is probable and would have more serious consequences for pasture sustainability. Weed invasion into the oversown treatment was of no consequence, never exceeding 5% of presentation yield.

Animal production

Individual cattle liveweight gains varied greatly due to season and weight of steers and ranged from 0.06–1.29 kg/hd/d. Large variations in steer growth rates occurred within treatments and may be related to genetic variability of the cattle. All steers had grazed native pasture previously and some initial compensatory gain occurred. This was most notable in the second draft which came off shaded native pasture and averaged 1.16 kg/hd/d for the first 48 days, dropping to 0.8 kg/hd/d over the following 2 months. During extreme wet or extended, overcast conditions, cattle growth rates declined, probably due to a range of factors resulting in reduced intake of digestible dry matter. In the Solomon Islands, a similar reduction in liveweight gains was linked to excessive rainfall (>500 mm/month) (Macfarlane and Whiteman 1983). In southern Queensland, liveweight gains were correlated negatively with rainfall (under non-stressed soil moisture conditions) and positively with solar radiation, and this was related to lower pasture dry matter digestibilities (Evans and Wilson 1984). Continuously high rainfall conditions are normally associated with increased intra-cellular water contents. While dry matter percentages were not determined in this experiment, Keith and Ranawana (1971) showed that intake of kikuyu by dairy cows in Sri Lanka was depressed by 0.4 kg/hd/d for each per cent decline in dry matter content below 18%.

Heat stress has been well researched with dairy cattle and occurs at relatively low ambient temperatures, when relative humidity is high. A Temperature Humidity Index (THI) used to predict heat stress in dairy cattle (Mawson and White 1971) indicates that cattle in Santo would commonly experience severe heat stress during the wet season (THI >90). Mawson and White (1971) reported reduction in milk production of 20% as THI climbed above 80. Other research in Vanuatu has highlighted the genetic limitations of local, crossbred steers, with growth potential declining above 450 kg liveweight, whereas large-framed 1/4–3/8 Brahman × European crossbreds have maintained constant growth rates from 350 to 500 kg biomass (Macfarlane *et al*. 1993).

Growth rate of steers was generally higher in the oversown legume treatment. As liveweight gain was poorly correlated with EDM (r^2=0.14) (data not presented), the superior gains of the oversown treatment may be attributed to its higher forage quality. Crude protein concentrations of plucked leaf from the control and oversown treatments were 12 and 14%, respectively. Further, the legume component of the oversown treatment had high crude protein levels (puero-24%; centro-26%; glycine-23%).

Steers from control and oversown treatments gained, on average, 199 and 236 kg/hd/yr over the 3-year experimental period (Table 2). However, due to the large variation in individual cattle growth rates within treatments, liveweight gains of the oversown treatment steers were not significantly higher (P>0.05) than those of the control treatment. The oversown treatment consistently produced an extra 22% (110 kg/ha) liveweight annually. A comparable result was achieved in the Solomon Islands, where steers grazing para grass-legume pastures gained 204 kg/hd/yr at a stocking rate of 2.7 hd/ha (Watson 1977). At IRHO, by increasing the stocking rate to 3 hd/ha, the oversown treatment would be expected to sustain at least a 25% advantage over the control.

Table 2. Individual daily liveweight gains and annual liveweight gains per hectare from steers grazing para grass (control) and para grass oversown with legumes.

Year	Control		Oversown with legumes	
	(kg/hd/d[1])	(kg/ha/yr)	(kg/hd/d[1])	(kg/ha/yr)
1	0.49	444	0.61	552
2	0.66	659[2]	0.68	711[2]
3	0.49	429[3]	0.66	600[3]
Mean	0.55	511	0.65	621

[1]s.e. of mean for individual gains/hd: Yr 1=0.060; Yr 2=0.048; and Yr 3=0.062.
[2]Stocking rate was temporarily increased to 3.0 hd/ha to control excess pasture growth.
[3]Delays in replacing turned-off stock reduced annual stocking rates.

Conclusions

The band-seeding technique showed potential as an effective method of oversowing legumes into para grass in this experiment, but for best results, it is essential to minimise standing herbage and reduce the trash layer of the pasture. The twining legumes centro and puero and to a lesser extent Malawi glycine, combined well with para grass. The contribution of puero greatly increased over the experimental period. Glenn joint vetch, Cook stylo and Shaw vigna did not persist in the dense para grass sward.

A 22% increase in liveweight gain was achieved by oversowing compatible legumes into legume-deficient para grass. The effect of oversown legumes on para grass pasture sustainability is perhaps most important. At moderate stocking rates (2.5 hd/ha), the addition of legumes greatly improved the tolerance of the para grass pasture to adverse seasons and reduced management demands for weed control.

Three years after the conclusion of development assistance support, this trial site is still maintained by IRHO collaborating with the Ministry of Agriculture, Forestry and Fisheries, Livestock Division as a demonstration site for extension activities. The direct-seeding technology has been adopted by plantation managers and entrepreneurial smallholders to rehabilitate 4000 ha of degraded pastures.

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