IMPERATA CYLINDRICA FOR CATTLE PRODUCTION IN PAPUA NEW GUINEA

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ABSTRACT

Economic and practical farming considerations on smallholder farms in Papua New Guinea preclude replacement of lowly-productive Imperata cylindrica *with fully improved pastures, although a great increase in beef production could be obtained by full pasture improvement.*

A pasture cutting trial showed that Imperata cylindrica *cut every four weeks contained 1.5% N, but productivity rapidly declined. At six, eight or twelve week cutting intervals, yields of dry matter were greater than for nine improved species cut at six week intervals but N was less (0.93-1.14%).*

A grazing trial over three years showed higher production by fully improved pastures and a small increase due to Stylo + Imperata *over unimproved* Imperata. *A more suitable legume is needed for this soil type. Unimproved* Imperata *produced the same cattle weight gains at all stocking rates, indicating that at lower stocking rates cattle were unable to select a better diet.*

A nylon bag digestibility trial showed that Imperata *was about two thirds as digestible as Buffel grass, Setaria or Elephant grass, at three, five, seven and nine weeks. The rate of digestion was low. These data indicate that* Imperata *is never a high quality pasture and consequently no pasture management technique can produce rapid gains. Only substitution, partially with legumes or totally with fully improved pastures can produce rapid growth.*

On smallholder cattle farms with Imperata*-dominant pastures, breeding rate in cows ranged from 75 to 100%. Growth rates were variable and age at turnoff of steers at 450 kg ranged from 25 to 44 months; management was an important component in this variation.*

We conclude that Imperata *pastures can support a viable extensive beef production system which can be improved with broadcasting of those legumes appropriate to the environment. Low stocking rates are necessary in Papua New Guinea; but the large areas of unutilized grassland make this no obstacle.*

INTRODUCTION

Although the area of Kunai (*Imperata cylindrica*) dominant grassland in Papua New Guinea covers millions of hectares, very little research has been carried out on its productivity for beef cattle raising. Most effort here, and elsewhere in the tropics, has been devoted to the assessment of introduced species of grass and legumes (e.g. Hoshino 1975). This concentration on new species ignores a number of factors:

(a) the *Imperata* grasslands are there, already established,

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(b) the cost of establishing new grasses is high, the results uncertain and the economics very dubious,

(c) for the smallholder cattle raiser, with 10-50 breeding cows, full pasture improvement is just not feasible, due to lack of capital and skill, as well as representing a gross over-capitalisation.

Imperata dominant grasslands are found from sea level to nearly 2,000 m, with rainfalls varying from 1,250 mm at Erap to 4,000 mm at Situm, and on soils with pH ranging from 5 at Urimo in the Sepik to 9 at Erap. The definition of productivity of *Imperata* over this range of conditions will take an enormous amount of work. This paper reports some trials carried out at Erap and near Lae in Morobe Province, Papua New Guinea.

MATERIALS AND METHODS

Erap Beef Cattle Research Centre is situated in the Markham Valley, 50 km from the sea at an altitude of 100 m. The terrain is flat; the soils are recent alluvial sandy loams and gravelly loams, very free draining, with a pH of up to 9. There are no major mineral deficiencies although legumes respond to sulphur sometimes, and occasionally to phosphorus application (Chadhokar 1974). The high pH appears to be the main soil chemistry problem, limiting normal legume growth. Rainfall of 1,250 mm per annum falls in a major wet season from December to April and a minor wet season in July and August. Temperatures range from 23 to 35°C in December and from 18 to 30°C in July. Frequent strong winds in dry periods dry out the light soils very quickly.

TRIAL 1: PRODUCTIVITY OF DRY MATTER AND NITROGEN

A cutting trial was carried out at Erap over a 12 week period, from April to July. A block of 0.2 ha was divided into 20 plots, each 10 m × 10 m, and the whole area slashed to a height of 7.5 cm on 18 April. Five plots were cut three times at four week intervals, five more cut twice at six week intervals, five once at eight weeks and five once at twelve weeks (*Table 1*). Each cut was to a height of 7.5 cm; total yield, dry matter (DM) and nitrogen (N) were determined.

TRIAL 2: BEEF PRODUCTION: STOCKING RATE TRIAL

A grazing trial using a factorial design was set up. Four pastures: *Imperata*, *Imperata* + legumes, *Panicum maximum* (var. Hamil) + initial N (50 kg in 1st year as ammonium sulphate) and Hamil + legumes, were grazed each at four stocking rates (*Table 2*). The legumes initially sown were *Glycine javanica, Stylosanthes guyanensis* and *Phaseolus atropurpureus* (Siratro), but only *Glycine* in Hamil, and Stylo and Siratro in *Imperata* have persisted, and the proportion of legume in the *Imperata* is low. The stocking rates were not the same for all pastures since it was already known that Hamil grass could be grazed more heavily than *Imperata*. Within each pasture, one stocking rate was replicated. Initial grazing group size was three Brahman-cross heifers, 12 months old in each plot. Live weights were recorded each four weeks. All animals were removed when 20-30% reached 300 kg and were replaced with a new group. Each group remained about six or seven months. After 14 months, the stocking rate in the *Imperata* paddocks was increased by addition of a fourth heifer per paddock because the quantity of feed available indicated that the stocking rates were too low. The trial has continued for another 22 months at the time of writing.

TRIAL 3: NYLON BAG DIGESTIBILITY OF IMPERATA

A factorial trial, four grasses (*Imperata, Setaria sphacelata* (var. Nandi), *Cenchrus ciliaris* (var. Biloela), *Pennisetum purpureum* (Elephant grass)) × four ages of grass (3, 5, 7 and 9 weeks) × three digestion times (20, 48 and 72 hours) was run using two rumen fistulated steers, with two replicates of each treatment in each steer.

Table 1.— **Dry matter production (kg ha^{-1}) and N concentration, (%), of *Imperata*, cut at 4, 6, 8 or 12 weeks**

Frequency (weeks)		Cutting dates 16 May	30 May	13 June	11 July	Mean DM production (kg weeks^{-1})	Mean N (%)
4	DM	586 ab		829 b	411 a	152	1.48
	N	1.54%		1.30%	1.59%		
6	DM		1,524 c		1,531 c	255	1.14
	N		1.01%		1.26%		
8	DM			2,490 d		311	0.97
	N			0.97%			
12	DM				3,836 e	320	0.93
	N				0.93%		

a, b, c, d, e Numbers with different superscripts are significantly different at $P < 0.05$, S.E.M. = 90 kg DM.

Table 2.—**Growth rate (kg day^{-1}) of heifers on 4 pastures grazed at 4 stocking rates at Beef Cattle Research Centre, Erap**

Species	Stocking rate (ha beast^{-1})	Gain (kg day^{-1}) in grazing period: 5.12.74 to 18.12.74	18.12.74 to 31.7.75	31.7.75 to 7.4.76	Weighted mean growth rate (kg day^{-1})	Growth rate (kg ha^{-1} day^{-1})
Imperata	1.29	0.26	0.20	0.22	0.22	0.17
	1.06	0.25	0.23	0.27	0.25	0.24
	0.83	0.24	0.16	0.24	0.21	0.26
	0.61	0.20	0.18	0.23	0.20	0.34
Imperata + legumes	1.06	0.34	0.32	0.33	0.33	0.31
	0.89	0.26	0.27	0.24	0.26	0.29
	0.72	0.25	0.16	0.24	0.22	0.31
	0.56	0.19	0.22	0.23	0.21	0.38
Hamil + Nitrogen	0.68	0.44	0.38	0.42	0.41	0.60
	0.55	0.45	0.28	0.40	0.38	0.69
	0.42	0.44	0.32	0.31	0.35	0.83
	0.29	0.37	0.29	0.38	0.35	1.21
Hamil + legumes	0.76	0.43	0.30	0.42	0.38	0.50
	0.59	0.53	0.38	0.45	0.45	0.76
	0.46	0.55	0.39	0.43	0.45	0.98
	0.33	0.38	0.37	0.34	0.36	1.09

LSD for significant ($P < 0.05$) differences between individual periods and grasses = 0.058

Grass plots of *Imperata*, Nandi *Setaria*, Biloela Buffel and Elephant grass (4 m² of each) were cut back to 15 cm high. Square metre samples were then recut back to 15 cm after three, five, seven and nine week intervals. The grass samples were dried at 70ºC for 24 hours and ground through the 4 mm screen of a Retsch K.G. Hammer Mill (a lower screen size gives greater particle loss through the bags other than by digestion (Playne *et al.* 1978)). On average 4-7 g of dried sample were used per nylon bag. After filling, the nylon bags containing the grass samples were redried at 70ºC for 24 hours and weighed to give the actual DM content per bag. The method of bag manufacture and the digestion technique were as used by Playne *et al.* (1978) but with some modifications due to resources available.

Two two-year-old Droughtmaster steers with rumen fistulas were used in the trial. Three iron rings with 32 nylon bags attached to each of them were placed in the ventral sac of the rumen. One ring was removed after 20, 48, and 72 hours. There were four bag replications per treatment as this is thought to be sufficient to detect biologically important differences between treatments (Playne *et al.* 1972). Each steer held half of these replicates. The steers were fed a basal diet of Buffel:Siratro hay.

On removal from the rumen the bags plus undigested residues were rinsed in two changes of water for a few minutes, dried for 36 hours at 80ºC, weighed, and the % DM loss calculated. There were no corrections made for loss of particulate matter from the bags or additions of rumen DM to the bags.

TRIAL 4: PRODUCTIVITY OF SMALLHOLDER CATTLE ON IMPERATA *PASTURES*

The growth rates and reproduction rates on smallholder cattle farms were determined over 1974-1975. The five farms studied, all at 0-300 m, are described in *Table 4*. None had significant pasture legume present. At intervals of 3-4 months, all new cattle (births or purchases) were identified, all were weighed and females were examined for pregnancy and lactation. No weaning is practised on any of these farms; animals up to 225 kg or 10 months old are assumed to be still sucking their dams and are classified as calves. Most cows lactate for at least 10 months after calving, and some for 15 months. Castrated males were retained until they reached 450 kg, which occurred at 2-3½ years of age. Data for growth of steers were collected over periods of at least 9 months and up to 2 years for individual animals. Growth data for heifers are presented for the period from 9-10 months of age until conception occurred. Weight of cows is the last weight prior to calving, this being the only weight collected when all cows were in the same physiological status, i.e. late pregnancy and non-lactating. An analysis by seasons is beyond the scope of this paper, although marked variations did occur between years on farms 4 and 5.

All farms were in the initial stages of development and were still purchasing cattle to build up herd size. Farms 1 and 2 bought heifers in 1973, while farms 3, 4 and 5 bought groups of steers in 1973 and farm 3 bought steers in 1974.

RESULTS

TRIAL 1

The data in *Table 1* show the lower yield of DM and higher N% of cuts made at 4 and 6 weeks, while at 8 and 12 weeks, production per week and N concentration are very similar. Although rainfall in consecutive 4 week periods increased (40 mm, 55 mm and 58 mm), production in the third 4 week period was markedly depressed, probably due to the sensitivity of *Imperata* to too-frequent defoliation.

TRIAL 2

Growth rate of heifers is presented for a period of 22 months subsequent to the stocking rate adjustment at 14 months (*Table 2*). During these 22 months, 3 groups of heifers were used, for 196, 225 and 251 days respectively. There was a significant difference between growth rate of groups due to season. Overall, the *Imperata* was least productive and the Hamil + legumes pasture was most productive. Growth rate increased (but production per ha decreased) with increased area available per heifer.

TRIAL 3

The percentage disappearance of DM for each grass at each age and time of digestion (*Table 3*) shows the lower relative digestibility of *Imperata* at all ages ($P < 0.001$) while the other 3 grasses were not significantly different. The increase in digestion % with increase in digestion time ($P < 0.001$) and the decrease in digestion % with age of grass ($P < 0.001$) are as expected. A significant interaction ($P < 0.01$) between grasses and digestion times revealed that the rate of digestion of *Imperata*, although slower than the other grasses, did not decline with time as much. The significant age by time interaction was due to the similar situation with older grasses: a slower initial rate of digestion but less reduction in rate with time. This suggests that lignification, which increases with age, renders digestible material less accessible to fermentation, so that digestion will continue steadily but slowly for a long time rather than rapidly at first then slowly as the most digestible material is used up. Even at 3 weeks of age, *Imperata* suffers from the same restraints upon digestion rate as affect other grasses at 7-9 weeks.

TRIAL 4

The growth rates of male and female calves, steers and heifers (*Table 5*) showed wide differences between farms, even when these were adjacent to one another, on similar soil and with no apparent difference in pastures, as were farms 1 and 2 and farms 4 and 5. A marked deficiency of dietary sodium has been demonstrated on farms 1 and 2 and the difference in performance reflects the differing diligence of the owners in making salt blocks available to their animals. The best growth rates were recorded at Tararan, farm 3, where the soils are heavier than on the other farms or at Erap, and green *Imperata* is available almost all the year round. Even on farm 2, where sodium deficiency retarded growth, steers and heifers grew faster than the heifers in Trial 2, due to the constant availability of green feed. The performance of growing animals on farms 4 and 5 was depressed in the second year due to seasonal variations in time and amount of rain, so that feed was

Table 3.—**Nylon bag digestibility (%) of four tropical grasses at four ages**

Age of grass	Grass	Duration of digestion (hours)		
		20	48	72
3 weeks	*Imperata*	11.0	30.8	42.6
	Setaria	24.1	47.9	58.7
	Buffel	24.2	43.5	57.5
	Elephant	18.6	43.7	57.5
5 weeks	*Imperata*	11.4	31.6	41.1
	Setaria	22.8	46.3	63.0
	Buffel	20.5	43.0	56.2
	Elephant	20.5	49.9	59.4
7 weeks	*Imperata*	8.5	25.5	36.4
	Setaria	19.2	31.5	49.5
	Buffel	18.4	37.4	53.8
	Elephant	21.1	42.2	57.5
9 weeks	*Imperata*	13.2	21.4	32.6
	Setaria	20.7	43.9	53.0
	Buffel	14.3	37.9	51.7
	Elephant	20.5	38.2	50.6

Table 4.—**Details of smallholder cattle farms examined**

No.	Site	Rainfall	Terrain	Soil	Pasture	Area	Number of cattle	Area per beast
1	Situm near Lae	4,000 mm	Gentle slope	Recent alluvium Free draining Sodium deficient	*Imperata* dominant Stylo less than 1%	360 ha	100	3.6 ha
2	Situm near Lae	4,000 mm	Gentle slope	Recent alluvium Free draining Sodium deficient	*Imperata* dominant Stylo less than 1%	240 ha	80	3.0 ha
3	Tararan Markham Valley	1,250 mm	Flat	Recent alluviums Free draining alkaline Sandy loams	*Imperata* dominant Stylo less than 5%	200 ha	154	1.3 ha
4	Adjacent to Erap	1,500 mm	Gentle & steep slopes	Recent alluviums, calcareous, free draining. Shallow soils on steep slopes	*Imperata* dominant on gentle slopes. *Themeda* dominant on steep slopes. Stylo and *Leucaena* less than 5%	119 ha	70	1.7 ha
5	Adjacent to Erap	1,500 mm	Gentle & steep slopes	Recent alluviums, calcareous, free draining. Shallow soils on hills	*Imperata* dominant on gentle slopes. *Themeda* dominant on steep slopes. Stylo and *Leucaena* less than 5%	100 ha	50	2.0 ha

Table 5.—**Growth rate of cattle on 5 smallholder cattle farms grazing *Imperata*-dominant pastures in Morobe Province (kg day^{-1} ± S.E.M.). Number of animals in brackets**

Class of animal	Farm No. 1	2	3	4	5
Female calves to 9-10 months	0.50 ± 0.02 (19)	0.39 ± 0.04 (14)	0.60 ± 0.02 (26)	0.49 ± 0.02 (21)	0.51 ± 0.03 (12)
Heifers to first. conception or 2 yrs	0.36 ± 0.03 (15)	0.27 ± 0.04 (11)	0.39 ± 0.01 (19)	0.35 ± 0.03 (12)	0.35 ± 0.05 (9)
Male calves to 9-10 months	0.52 ± 0.02 (23)	0.40 ± 0.04 (17)	0.69 ± 0.01 (38)	0.51 ± 0.02 (28)	0.57 ± 0.03 (12)
Steers to 450 kg	0.32 ± 0.02 (22)	0.30 ± 0.02 (26)	0.46 ± 0.01 (82)	0.26 ± 0.02 (30)	0.33 ± 0.03 (16)
Steers: age at 450 kg	37 months	44 months	25 months	44 months	35 months

Table 6.—**Calving % per annum and weight of cows before calving (kg ± S.E.M.) on 5 smallholder cattle farms with *Imperata* dominant pastures. Number of animals in brackets**

Class of female		Farm No. 1	2	3	4	5
1973 heifers calving in 1975	Calving %	88%	67%	73%	89%	100%
	Liveweight	312 ± 17	305 ± 26	353 ± 21	343 ± 10	332 ± 12
	Number	(9)	(6)	(11)	(9)	(7)
1972 heifers, bought in 1973, calving 1974-1975	Calving %	62%	77%	—	—	—
	Liveweight	364 ± 10	318 ± 12			
	Number	(16)	(11)			
Mature cows calving in 1974-1975	Calving %	82%	78%	75%	86%	100%
	Liveweight	403 ± 11	341 ± 9	417 ± 7	394 ± 9	394 ± 8
	Number	(20)	(12)	(44)	(23)	(15)

in very short supply, but in the first year growth approached that of farm 3.

Reproductive rates in all herds were satisfactory, and on farms 4 and 5 were extremely good. The liveweight of cows before calving reflects the same nutritional factors as the growth rates of young stock (*Table 6*).

The non-agreement between number of calves born and number of calves contributing to the growth data is due to some calves being born too late in the two year period to contribute data over a minimum of 150 days, but also is due to incomplete mustering of cattle on occasion. Owing to the incomplete musters, no estimate can be made of calf or adult mortality. Many heifers conceived at about 12 months so there was little if any time between the animal being classified as a calf and as a pregnant heifer, hence the small numbers of non pregnant heifers available.

DISCUSSION

TRIAL 1

Maximum productivity of *Imperata*, at 8-12 week cutting intervals is in excess of that recorded by Chadhokar (1974) for introduced grasses in a sustained (1 year) 6 week intervals cutting trial at Erap (*Table 7*) but N concentration in *Imperata* was lower. At 6 week cutting intervals, *Imperata* outyielded all these grasses but still had a low N concentration. It is doubtful whether these yields could be sustained over a longer period, but nevertheless this trial shows that the DM productivity of the much despised *Imperata* can be higher than that of introduced pasture grasses. When defoliated with sufficient frequency to keep N concentration as high as the improved grasses, however, *Imperata* rapidly declined in production.

TRIAL 2

Production per animal and production per ha were considerably greater for Hamil grass pastures than for *Imperata* pastures. The productivity per heifer on pure *Imperata* (no legumes), changed very little with halving of the stocking rate and consequently more than doubling the amount of feed available. Availability is therefore not limiting intake and performance. When a legume is included in the *Imperata* pasture, both growth per animal and growth per ha increase, and there is a marked increase of growth rate with increased area per heifer and increased availability. This suggests that the pure *Imperata* pasture is uniformly inadequate in N or digestible energy (DE) so that, regardless of the degree of selection available, cattle cannot select a diet sufficiently high in N or DE to support rapid growth. If a legume is present, growth of cattle is improved to a degree dependent on the amount of selection available, but at the highest stocking rates used here, legume availability was inadequate and growth was no better than

Table 7.—**DM production and mean N concentration of "improved" grasses at Erap, Morobe Province (Chadhokar 1974)**

Variety	DM ha^{-1} $week^{-1}$	N concentration
Boorara Buffel	152	1.23
Molopo Buffel	180	1.22
Biloela Buffel	181	1.21
Green Panic	179	1.26
Hamil	191	1.23
Rodds Bay Plicatulum	195	1.32
Hartley Plicatulum	191	1.37
Nandi Setaria	180	1.51
Rhodes Pioneer	54	1.54

on the no-legume pastures. The greatest increase in production per ha was at the lowest stocking rates where the amount of legume available per beast was greatest. Although the main legume component in the *Imperata* pasture was Schofield Stylo, this cultivar is not considered satisfactory on the highly alkaline soils at Erap. Establishment is slow; in pot trials establishment is much improved by acidification of the soil to pH 6.5-7.0 but this is not a practical management procedure. The search for a more suitable legume is continuing, with emphasis on newer cultivars of *Stylosanthes*.

The results of this trial are in close agreement with animal production data from *Imperata* produced by Magadan *et al.* (1974) (*Table 8*) who were working in a higher rainfall area and possibly with more fertile volcanic soils. Production on "improved" grass and grass + legume was also almost identical at similar stocking rates. Magadan *et al.* (1974) point out that at current Philippines prices there is no financial advantage of fertilizing over establishing a grass-legume mixed pasture.

TRIAL 3

The nylon bag digestion technique used can only rank grasses in order of digestibility; true digestion data cannot be obtained consistently. A number of sources of error, i.e. loss or gain of DM through the bag not as a result of digestion and the use of a basal diet different from some of the experimental diets, render the use of these data in other than a relative fashion, quite unreliable (Playne *et al.* 1978).

With these restraints, the data presented show the problem with *Imperata*; digestibility is low and digestion slow. Even at 3 weeks, digestibility at 48 hours (usually considered to approximate true digestibility) is only ⅔ that of other tropical grasses. To ingest equivalent digestible DM of *Imperata*, cattle must consume 50% more DM and excrete 100% more DM yet the rate of passage of ingesta will be very slow, due to the slow rate of breakdown of ingesta particles, so intake will be reduced. Digestibility, rate of

Table 8.—**Comparison of grazing trials at Erap and in the Philippines (Magadan *et al.* 1974)**

Pastures	Site	Stocking rate ha beast^{-1}	Gain beast^{-1} kg day^{-1}	Gain ha^{-1} kg day^{-1}
Imperata	Erap	1.06	0.22	0.24
		0.83	0.21	0.26
	Bukidnon	1.00	0.27	0.27
"Improved grass" + *legumes*	Erap (Hamil + *Glycine*)	0.59	0.45	0.76
		0.46	0.45	0.98
	Bukidnon (Para + Centro)	0.50	0.36	0.72
"Improved grass" + fertilizer	Erap (Hamil + N)	0.55	0.38	0.69
		0.42	0.35	0.83
		0.29	0.35	1.21
	Bukidnon (Para + N + P)	0.50	0.42	0.84
		0.33	0.28	0.84

digestion and rate of passage are difficult, if not impossible, to alter under grazing conditions. The only way to achieve high rates of gain is to increase the proportion of more digestible material in the pasture, e.g. by introducing legumes. The addition of nitrogen to the rumen in this way may accelerate digestion of the *Imperata*, but the main effect will be that of replacing poor quality feed with better quality feed. Since *Imperata* is practically *never* of truly high quality as pasture *no* technique of intensive management to cause consumption of very young feed will result in rapid weight gains. *Imperata* will support slow gains: these will be maximised by a low stocking rate allowing maximum selection, which is also conducive to pasture survival. Increased weight gains above this can only be achieved by replacing *Imperata* in the diet, partially, by legume introduction or totally, by introducing new grasses.

TRIAL 4

The data from these farms shows that *Imperata* pastures under field conditions are capable of supporting high reproduction and acceptable growth rates. On soils which dry out rapidly, such as farms 4 and 5, and at Erap in Trial 2, growth rate can be quite poor due to cessation of growth, and a consequent lack of young growing green feed. When the *Imperata* has dried right out it appears so harsh and unpalatable that cattle will not eat it and there is an actual shortage of feed.

The growth rates achieved indicate that a large proportion of the diet must have consisted of other species, even though *Imperata* made up the bulk of the available feed.

At Situm, even on farm 1, salt was not available continuously, and had it been so, more rapid growth rates and a reduction in age at turn-off would be achieved. Differences between managers on adjacent farms produce differences in production of the same order as differences between areas. The small sample size means that these data do not accurately reflect the productive capacity of the 3 areas. The amount of work involved in collection of these data shows that a different data collection procedure and greater sample is needed to measure the productivity of each area.

GENERAL DISCUSSION

The utilization of *Imperata* pasture must be considered in the light of the alternatives available, which are as in Trial 2, addition of a legume, or the complete establishment of improved pastures, either grass-legume or grass plus fertilizer. Bunning (1975) commented in an economic analysis of pasture improvement in PNG; "Pasture improvement is a high risk exercise. It requires a high resource input and, as in all agriculture programmes, the benefits are uncertain. It should, then, only be attempted where necessary and where other alternatives have been considered first. A weed free Kunai pasture should not be replaced by a high carrying capacity Elephant grass pasture as a matter of course. An improved pasture takes almost a year before it can carry any cattle so there is an opportunity cost involved; it is not certain it will establish successfully; it requires careful management. While a natural pasture is present and productive, the project will continue successfully without the expense and risk of attempting pasture improvement. Once the natural pastures have been cropped out or grazed out and weed invasion is high, then the cattle owner should consider ploughing up a block."

Bunning estimated the cost of improving pastures by ploughing and sowing as K170 per ha (US$210 per ha). Considering the middle stocking rates in Trial 2, *Imperata* produced 0.25 kg per ha per day, *Imperata* + legumes 0.30 kg per ha per day and Hamil + legumes 0.87 kg per ha per day. Full improvement returned 0.62 kg per ha per day, about 125 kg of carcass currently valued at K100 (K0.8 per kg) (US$140). When allowance is made for 1 year for establishment, it takes three years to recoup the initial cost. With the legumes employed for improving the *Imperata*, we achieved a return of 0.05 kg per ha per day, 10 kg of carcass and K8 per annum against a cost of K5-12 per ha for seed. Allowing a year for establishment, the initial cost is recouped in 1½-2½ years. Since the PNG smallholder usually does not have access to a tractor and implements and the necessary expertise to do his own pasture improvement, nor K170 per ha to pay someone else to do so, full pasture improvement is not a realistic consideration. The return on legume broadcasting into *Imperata* is very small in the lower Markham Valley; further research is needed to find a more suitable legume for these alkaline soils. In the upper Markham Valley on less alkaline soils, ph 7, Stylo broadcast onto burnt *Imperata* pastures has established well and on occasions the pasture is almost Stylo-dominant.

The establishment of legumes in *Imperata* is done most efficiently and economically after burning the *Imperata*. Chadhokar (1974) found a population of 0 plants per m² for three varieties of Stylo broadcast into *Imperata*, and 7.7, 2.5 and 6.8 plants per m² for Schofield, Cook and Endeavour broadcast after *Imperata* was burnt.* Javier (1973) found Schofield Stylo plants were twice as big at 4 months if broadcast onto burnt rather than grazed *Imperata*. Practical experience on PNG cattle ranches confirms that it is essential to burn *Imperata* to establish a strong stand of Stylo in the pasture. Once the Stylo is established and has seeded, a second burn may be used to produce a thick stand of Stylo which will support rapid cattle growth rates. If the soil is of a crumbly nature many seeds lodged in cracks will survive the fire and germinate rapidly after rain. To maximise growth per beast to obtain the earliest possible turnoff, and to minimise weed invasion, *Imperata*-Stylo pastures should be lightly stocked, but not to the extent that the *Imperata* crowds out the Stylo. If it does, another burn is indicated.

* These low germinations were related to failure of rains.

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