Ruminant Feeding Strategies for Sustainable Agricultural Production in Upland Mixed Farming Systems of Indonesia

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Abstract

Ruminants are an integral part of smallholder farming systems in Indonesia. However the extent and continuous nature of cropping on densely populated islands such as Java leaves little land available for grazing. Most livestock are therefore permanently housed and fed indigenous forages cut from field margins and roadsides. Cut-and-carry feeding is labour-intensive and the supply of forage is often the most expensive input to ruminant production. Surprisingly, farmers collect quantities of forage greatly in excess of the appetites of their livestock. In Experiment 1, indigenous forage dominated by *Axonopus compressus*, was offered to sheep at increasing rates: 25, 50 or 75 g DM/kg liveweight (W) daily (d). The results showed that although DM intake and W rose with increasing offer-rate, the incremental improvements from 50 to 75 were non-significant (P>0.05) and less than from 25 to 50. Rice bran is a cheap and readily available feed. It could be used to substitute for a large proportion of the expensive forage on offer. In Experiment 2, rice bran was fed to sheep at 0, 15 or 30 g DM/kg W0.75.d in combination with indigenous forage offered at 30 or 60 g DM/kg W.d. Sheep fed the lowest cost 30/30 (forage/rice bran) diet achieved similar total DM intakes as those receiving the 60/0 diet and W gains as those receiving the 60/15 diet (P>0.05). Even when using supplements Javanese farmers persist in offering excess levels of forage to their livestock. It is unlikely that they justify this excess feeding on the basis of marginal gains in animal productivity alone. The rationale for excess feeding may lie in greater yields of manure-compost produced from a mixture of refused forage and excreta which accumulates in pits beneath the slatted floors of their animal barns.

KEY WORDS: Excess feeding, cut-and-carry, ruminant, manure, compost, Indonesia

Introduction

Over 60% of Indonesia's 194 million people live on the island of Java which occupies only 7% of the country's total land area. Half of Java's population are farmers (Biro Pusat Statistik, 1991) cultivating less than 0.5 ha per household (Booth, 1988). Cropping is continuous. Java is thus not only one of the most densely populated areas of the world with around 800 person/km2 , but one of the most intensively cultivated (Kepas, 1985).

Ruminant livestock are an integral part of these intensive farming systems. In 1991, over 30 and 60% of Indonesia's large and small ruminant populations respectively were located on Java despite intensive cropping leaving little land for grazing (Direktorat Jendral Peternakan, 1992). Ruminants are instead permanently housed (around two large ruminants and/or up to five small ruminants per household) in backyards and cut-and-carry fed indigenous grasses and broadleaves collected from roadsides and field margins. Cut-and-carry feeding is labour intensive making forage the most expensive input to livestock production.

Surprisingly, farmers collect large quantities of forage, often greatly in excess of the appetites of animals (Mathius & van Eys, 1983) with as much as 400 g/kg DM of that offered being refused (Little, Petheram & Boer, 1988).

The forage refusals are not wasted, they combine with faeces and urine falling through the slatted floors of the animal barns into pits where they decompose to produce manure-compost. High forage offer-rates maximise manure-compost yield. It is possible that farmers adjust their feeding rates to optimise total output from the livestock enterprise i.e. including manure-compost, as opposed to animal production per se. Manure-compost is ranked by Javanese farmers alongside offspring as the most important outputs from livestock production (Ifar, 1996).

It is hypothesized that livestock integration into Javanese agriculture is essential to the sustainability of some of the most intensive cropping cycles in the world. As intensive smallholder agriculture expands onto more marginal soils world-wide there is urgent need for developing strategies for closer integration of crops and livestock. Excess-feeding, an effective means of improving intake and productivity of ruminants fed low quality forages by providing greater opportunity for selective feeding (Osafu, Owen, Methu, Abate, Tanner & Aboud, 1996) and also generates high quality composts, may be one such strategy. The biological and economic relationships between excess-feeding, animal productivity and manure-compost production are reported in this paper.

Experiments Undertaken

Experiment 1: Effect of Quantity of Indigenous Forage Offered on Intake and Growth by Sheep and Manure-compost Yield.

Materials and methods:
Thirty Javanese Thin-tailed rams (aged 18 months, mean W 29.1 kg, s.e. 0.3) were blocked according to initial W and then randomly allocated to one of three forage offer levels: 25, 50 or 75 g DM/kg W.d. Indigenous forage, cut each morning from roadsides and field margins, comprised largely of grasses (71% of fresh weight offered) dominated by *Axonopus compressus*, with the remainder as sedges, broadleaved plants and dead plant material. The daily ration was split into two equal meals offered at

8.00 h and 12.00 h, salt licks and water were freely available. The feeding trial lasted 70 days during which intake was measured daily and W changes weekly.

Refused forage, faeces and urine were collected daily from three rams per diet, mixed and stored in slat-sided composting bins measuring 1.5x1.5x1.5m. The waste materials were collected in this manner for the last 50 days of the feeding trial and then left to compost for a further 50 days, turning every 3 days to assist aeration, before weighing and sampling for DM content.

Experiment 2: Effect of Quantity of Indigenous Forage and Rice Bran Offered on Intake and Growth by Sheep and Manure- compost Yield.

Materials and methods

Thirty-six Javanese Thin-tailed rams (aged 30 months, mean W 28.8 kg, s.e. 0.03) were blocked according to initial W and then randomly allocated to one of six feeding regimes in a 2x3 factorial design: 30 or 60 g DM/kg W.d or indigenous forage in combination with either 0, 15 or 30 g DM/k gW0.75.d of rice bran. The diets were coded as follows (forage/rice bran): 30/0, 30/15, 30/30, 60/0, 60/15 and 60/30. The daily ration of indigenous forage (of similar species composition to that fed in Experiment 1) and rice bran was again split into two meals and fed at 8.00h and 12.00h. Water and salt licks were freely available. The feeding trial lasted 42 days during which intake was measured daily and W changes weekly.

Refused forage, faeces and urine were collected from three different pairs of rams per diet over three 14-day periods. Accumulated waste materials from each pair of rams were mixed at the end of each 14-day period and composted for 50 days, turning every 3 days as described above. A quantity of forage equivalent to that which would be fed to two, 30 kg W rams on the 60/0 diet was also collected over each 14 day period to assess the profitability of composting grass directly in the absence of livestock.

Results

Table 1 shows that the DM intake and growth rate of the rams in Experiment 1 improved with offer-level but that the incremental improvement from 50 to 75 g DM/kg W.d was non significant (P<0.05) and less than that from 25 to 50. The quantity of grass refused increased substantially as a proportion of that offered from 0.109 to 0.526 by raising the offer level from 25 to 75. Allowing the rams greater opportunity for selective feeding by raising the offer-level improved the estimated N content of the diet consumed from 21.2 to 22.5 and 23.8 g/kg DM. Not surprisingly, manure-compost production rose with forage offer-level.

Table 1: Effects of increasing forage offer level on intake, ram growth rate and manure-compost yield.

Quantity of forage offered (g DM/kg W.d)	25	50	75	s.e.d
Number of rams	10	10	10	
Initial W (kg)	29.2	29.1	28.9	0.33
Growth rate (g/d)	-16.5	25.8	28.5	4.73
Intake:				
Forage offered (g/d)	3627	7772	11616	
Forage offered (g DM/d)	671	1438	2149	
Forage refused (kg DM/kg DM offered)	0.109	0.359	0.526	
Forage intake (g DM/d)	598	922	1019	
Forage intake (g DM/kg W.d)	22.1	31.7	34.9	1.16
Manure-compost yield (g/ram.d)	540	1620	2320	

In Experiment 2 (Table 2), forage and rice bran offered both had significant effects upon forage DM intake, total DM intake and forage refused as a proportion of that offered ($P<0.05$). Increasing the level of rice bran on offer increased bran intake but as a consequence substituted for forage intake. Increasing the rice bran offered caused a significant ($P<0.05$) rise in W gains at each level of forage on offer. It should be noted that rams fed the 30/30 (forage/rice bran) diet grew faster but produced less manure compost than those fed the 60/0 diet.

Table 2: Effects of increasing forage and rice bran offer levels on intake, ram growth rate and manure compost yield.

Forage offered (g DM/kg W.d)			30			60	
Rice bran (g DM/kg W0.75.d)	0	15	30	0	15	30	s.e.d
Number of rams	6	6	6	6	6	6	
Initial W (kg)	28.9	29.7	28.8	28.9	28.4	28.9	0.73
Growth rate (g/d)	-21.0	13.2	37.5	-2.4	34.5	53.6	22.8
Intake:							
Forage offered (g DM/d)	810	853	848	1702	1683	1750	
Forage refused (kg DM /kg DM offered)	0.174	0.246	0.277	0.463	0.516	0.539	
Forage intake (g DM/d)	670	644	616	909	815	804	51.6
Forage intake (g DM/kg W.d)	24.3	22.3	21.3	31.6	28.5	27.1	0.62
Rice bran intake (g DM/kg W0.75.d)	-	13.7	25.4	-	14.4	23.5	
TOTAL INTAKE (g DM/kg W.d)	24.3	28.2	32.3	31.6	34.7	37.2	1.49
Manure-compost yield (g/ram.d)	607	964	1107	2750	3071	3357	

In Experiment 1, although the high feeding levels produce the best W gains and manure-compost yields these benefits must be offset against the extra time required to supply the feed (Table 3). The most profitable ration would be that which yields the highest returns to labour (calculated as: [Value of outputs - Non labour costs]/hours of labour). The financial analysis reveals that feeding at 50 gDM/kg M.d was most profitable irrespective of whether manure-compost was considered as an output or not. The lowest level of feeding was unprofitable with the costs of production alone (excluding labour inputs) exceeding the value of growth and manure-compost production.

Table 3: Estimated cost of production (Rp1/ram.d), value of outputs (Rp/ram.d) and returns to labour (Rp/hour) when feeding indigenous forage to rams at increasing levels of offer.

	COSTS		OUTPUTS		RETURNS TO LABOUR	
Offer -rate	Labour*2 (h)	Other*3 (Rp/d)*1	Compost*4 (Rp/d)	Weight*5 (Rp/d)	Including compost (Rp/h)	Excluding compost (Rp/h)
25	0.42	18.6	18	-50	-120	-163
50	0.83	18.6	54	77	135	70
75	1.2	18.6	77	86	120	56

*1: USD 1 = Indonesian Rupiah (Rp) 2110 (1993 rate)
*2: The lowest cost of forage input corresponds to the lowest forage offer level (25 g DM/kgW.d) and the highest forage cost to the highest forage offer level (75 gDM/kgW.d) assuming it takes 5.9 minutes to cut 1 kg of grass (derived from van Eys *et al.*, 1984 and Amir *et al.*, 1985).
*3: Non-labour costs, in decreasing order of magnitude, including depreciation on the sheep barn, minerals, anthelmintics and miscellaneous expenses on ropes etc.
*4: On average, a 30 kg sack of manure-compost fetches Rp 1000 (Holden *et al.*, 1993), equivalent to Rp. 33/kg.
*5: Assuming a sale price of Rp. 3000/kg (or Rp 3/g) (Biro Pusat Statistik, 1991).

In Experiment 2, feeding unsupplemented forage diets gave negative returns to labour when outputs did not include manure-compost. Supplementing rams improved profitability through higher animal growth rates. Including manure-compost as an output substantially improved the profitability of all diets. However, it should be noted that it is more profitable to compost forage directly than to feed that quantity to an animal. Greater returns could however be achieved through supplementation. At the highest rate of supplementation (Diet 60/30) a farmer could increase returns to labour by around 50% compared with composting the same quantity of grass directly.

Conclusions

Excess-feeding strategies have been demonstrated to be an effective means of improving intake and productivity of small ruminants and cattle fed low nutritive value fodders such as cereal crop residues (Osafo, Owen, Methu, Abate, Tanner & Aboud, 1996). Offering excessive levels of feed inevitably produces large quantities of refusals which appears wasteful. In many smallholder situations excess-feeding may only be economically rational if other uses can be found for refusals.

Excess-feeding indigenous forages led to higher intakes and growth rates which raised returns to labour (Experiment 1). It was demonstrated that the profitability of the livestock enterprise could be significantly improved however by using the refusals and excreta to produce compost. Although, feeding at the highest offer-level yielded a positive return to labour, the calculated 'hourly wage rate' was 11% less than that obtained from feeding the 50 g DM/kg W/day diet where compost is included in the total output and 20% less where compost is excluded from outputs. A cheaper alternative to feeding high levels of expensive cut-and-carry forage might be to replace part of the diet with rice bran. In Experiment 2, feeding rams the 30/30 diet resulted in better returns to labour than the 60/0 diet. However, the most expensive diets, 60/15 and 60/30, where rice bran is fed in addition to excess levels of forage, turned out to be the most profitable. This suggests that even in circumstances where Javanese farmers are feeding rice bran they will persist in offering high levels of forage to maximise not only W gain but also manure-compost output.

The need to maximise manure-compost output is particularly acute on smallholder farms in densely populated areas where intensive cropping patterns place heavy demand upon soil nutrient status. The research shows that excess-feeding represents a financially rational feeding strategy for such production systems permitting the optimisation of animal and fertiliser outputs.

As the price of inorganic fertilisers continues to rise beyond the means of smallholder farmers, greater reliance will be placed upon livestock wastes to maintain soil fertility. However, even when the yield of organic fertiliser outputs from livestock is maximised by excess-feeding for example, the quantity of plant nutrients may not be sufficient to totally replace artificial fertilisers in a manner which is economically viable. Animal scientists should be aware that excreta is often used in combination with inorganic fertilisers. There is a need to be able to predict the influence of diet upon excreta quality and the consequences of manure handling upon nutrient loss. A better understanding of the degree to which livestock management practices influence the plant nutrient contents of animal "wastes" would provide agronomists with greater confidence to make integrated fertiliser recommendations which could, for example, capitalise upon the reported synergy between limited quantities of inorganic and organic fertilisers. The development of livestock feeding strategies for mixed-farming systems should therefore take into account not only livestock requirements but also the nutrition of soils and crops.

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