Sale of fresh forage — a new cash crop for smallholder farmers in Yasothon, Thailand

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Abstract

This paper describes the emergence of a new cash-crop enterprise — the sale of fresh forage — for smallholder farmers in Yasothon, north-east Thailand. In 1999, a group of 13 farmers started to produce forages for sale to beef cattle producers and traders. By 2006, this had grown to the extent that more than 600 farmers were growing and selling fresh forage. A study was carried out to describe the forage-for-sale production system and to evaluate its profitability and sustainability. Methods used included farmer group discussions, semi-structured interviews with individual farmers, weighing of forage samples and soil and plant analyses.

The main forage species grown for sale was *Panicum maximum* cv. Simuang (purple guinea grass), a high-yielding, upright, leafy grass. Production was very intensive with plants grown at a spacing of 50 × 50 cm, with high rates of both organic and inorganic fertilisers and some irrigation. Average forage yields were 33 t DM/ha/yr in the establishment year and 46 t DM/ha/yr in subsequent years. Mean protein concentration (DM basis) in forage offered for sale was 10% in the wet season and 14% in the dry season. Net returns were very high (US$2500–3800/ha/yr), which far exceeded the gross return of US$590/ha/yr from rice production. Farmers replanted guinea grass after 2–3 years. Prices for fresh forage were highest in the late dry season (US$0.042/kg), when prices were almost twice those during the peak of the wet season (US $0.025/kg). Only farmers with access to irrigation could supply during this time and, by 2006, the production of forage for sale had shifted towards irrigated areas.

An issue of concern is the imbalance between nutrient off-take by removal of cut forage and current fertiliser applications, which are urea and chicken manure. Chicken manure has an N:P:K nutrient ratio of 1:1:0.7. The use of these fertilisers results in an oversupply of 200–400 kg/ha of phosphorus per year and a large deficit of potassium. One possible solution would be to substitute cattle manure, with a more suitable N:P:K ratio of 1:0.3:0.8, for chicken manure. Cattle manure is available locally and used on-farm by farmers raising cattle but is not traded extensively. Another option would be to make use of single-nutrient fertilisers to better balance fertiliser applications and nutrient off-take. Unfortunately, these are not readily available in north-east Thailand.

The sale of fresh forage has emerged as a new farm enterprise, providing high returns for smallholder farmers with access to markets and irrigation facilities. The system must be 'fine tuned' by balancing nutrient supply more closely with nutrient off-take to ensure the long-term sustainability of the venture.

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Introduction

The production of fresh grass forage for sale started in Yasothon province, north-east Thailand, in 1999. At that time, the Thai Government was actively promoting livestock production by encouraging the formation of livestock farmer groups. Many farmers in Yasothon joined such groups and one group of 13 farmers in Kwang

village decided to supply a niche market by growing grass for sale as fresh forage to livestock traders rather than engaging in cattle production. These traders needed feed for cattle in holding pens at the Yasothon livestock market. Previously, farmers had supplied traders with naturally occurring grasses cut along roadsides.

Recognising green feed as a major factor limiting dairy and beef production, the Division of Livestock Nutrition, Department of Livestock Development (DLD), started the "Paddy Fodder Project" in 2002. This project encouraged farmers in 3 provinces in central and north-east Thailand to grow grass in fields, previously used for paddy rice production, for sale to livestock producers as fresh feed, hay or silage. Farmers in central Thailand, an area experiencing seasonal flooding, plant mainly *Digitaria eriantha* (pangola grass), while those in north-east Thailand grow mostly *Panicum maximum* cv. Simuang (also known as purple guinea) or *Brachiaria ruziziensis* (ruzi grass) (Khemsawat and Phaikaew 2007). The paddy fodder project assisted with the formation of farmer groups, and provided them with a revolving fund of US$11 400 for purchase of seed and fertiliser and to assist with planting, harvesting and marketing. DLD also supplied some equipment such as brush cutters, forage choppers and hay balers to newly established groups to assist with production in the first year. This equipment was intended to assist farmers with conserving pangola grass as hay and silage. In practice, forage conservation was not adopted widely and the vast majority of sales occurred as fresh forage (Khemsawat and Phaikaew 2007). In north-east Thailand, equipment needs for harvesting the bunch-type grass Simuang were simple with many farmers harvesting by hand. By the second or third year of selling fresh forage, most farmers had purchased the basic equipment needed for efficient growing and marketing of fresh forages. DLD also provided technical advice and in some cases assisted with transport for marketing. Government support was reduced as the new enterprise became viable and by 2005 was limited to technical advice only.

The rapid expansion of sale of grass and increasing numbers of farmers changing from growing paddy rice to growing grass raised many questions: How beneficial to farmers is the growing of grass for sale? Is it sustainable or are farmers depleting soil nutrients? Are smallholder farmers exposing themselves to excessive risks? This study attempted to obtain the necessary information to answer these questions and especially to provide some insights into the likely environmental sustainability of this new enterprise.

Methods

Yasothon province, north-east Thailand (16°N, 104°E) was chosen as a focus for the study as 'forage-for-sale' was pioneered in this province, and many farmers had extensive experience in this enterprise, which has continued to expand.

The study team visited a range of villages in the study area and collected data on the importance of agriculture, agricultural activities, income from rice and other agricultural activities, development of livestock and forage production and the number of farmer groups and farmers planting grass for sale by interviewing key informants from the provincial government services, traders, buyers and farmers engaged in the production of forage for sale.

The study team visited 2 villages, which had started producing forage for sale within the previous 2 years (Noenpueng village in Mahachanachai district and Maichumporn village in Mueng district) to discuss details of the forage-for-sale enterprise with key farmers and leaders of the forage-for-sale farmer groups. The team then visited 2 villages that had been engaged in this enterprise for more than 5 years (Kuengkam and Kwang villages in Mueng district) and held farmer-group discussions with 13 farmers from Kwang village, who were members of the Kuengkam livestock farmers group, who pioneered the development of the new enterprise. In these meetings, the study team discussed the forage-for-sale enterprise in great detail, including costs and benefits.

Following these discussions, a semi-structured questionnaire was designed and used to collect individual household data from 10 experienced farmers over the following days. The questionnaire was designed to elicit information on: years of experience; area planted; number of harvests; yield per harvest; sale prices in the dry and wet seasons; production inputs such as machinery, labour, organic and inorganic fertilisers and irrigation; cost of inputs such as transport for marketing, land preparation, labour for planting, weeding and harvesting, seed, manure and inorganic fertiliser and irrigation; and open

questions on advantages and disadvantages of this enterprise, problems encountered, benefits to the household and future plans. Several buyers and traders were also interviewed individually to obtain information on the buyers' perspective.

The weight of fresh forage bundles was established by weighing bundles on farms and at roadsides during both wet (May–September) and dry (October–April) seasons. Dry matter concentration was also measured. Soil and plant samples were collected for chemical analyses. The soil samples were collected from 5 farmers' fields. Plant samples of grass tops (leaves + stems) as sold were collected from numerous farmers and sellers, and were sent for chemical analyses. A total of 252 samples were analysed for N and 16 samples for P, K and S. Only a small number of samples were analysed for P, K and S since variability was low and the result similar to those from on-station experiments with *P. maximum* cv. Simuang by the Department of Livestock Development in north-east Thailand.

The field work for the study was conducted in October and November 2004, and several follow-up visits were conducted to clarify particular points.

Results

Site description

Yasothon is a predominantly rural province with cultivation of paddy rice accounting for 84% of agricultural land use (Yasothon Province Agricultural Extension Office 1999). Mean annual rainfall is 1600 mm, concentrated in May–September (>200mm per month) with a dry season from November to April with little or no rainfall. This rainfall pattern allows for only a single rice crop in rain-fed areas, while 2 rice crops are grown in irrigated areas. Other agricultural crops grown include fruit trees, vegetables, flowers and field crops such as cassava. Approximately 4.5% of agricultural land can be irrigated in the dry season from irrigation channels. Additionally, farmers in some areas use electric pumps to access underground water for irrigation of high-value crops.

From 2000 to 2006, while the total number of large ruminants in Yasothon province remained stable, the proportion of beef cattle increased and the number of buffalo declined (Figure 1). The decline in the buffalo population, which had traditionally been used for draught purposes, was possibly related to an increase in the level of mechanisation. In 2006, the mean number of beef cattle owned per household in Yasothon was 3.7 animals (Department of Livestock Development 2004). These were mainly cross-bred Brahman types, although some cattle breeders raised highly priced Hindu-Brazil (also known as Indo-Brazil, a large-framed zebu-type breed with very large ears) cattle for sale.

Development of the forage-for-sale enterprise in Yasothon

In 1999, a farmer group in Kwang village pioneered the growing of grasses for sale to

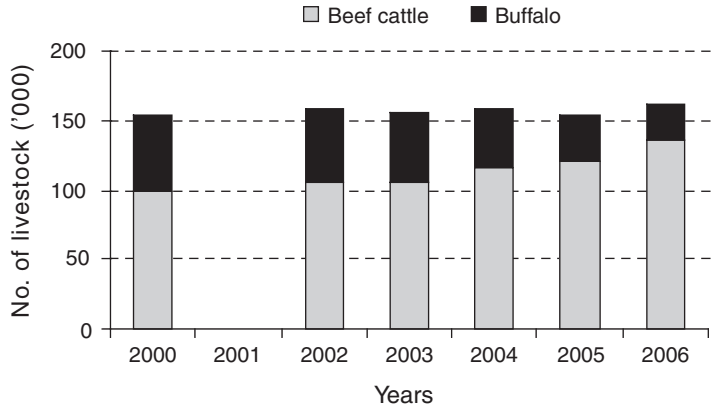

Figure 1. Number of buffalo and beef cattle in Yasothon province, 2000–2006 (Department of Livestock Development 2007, previous years).

livestock traders. These forages were fed to cattle in holding pens at the 3 local livestock markets. In the first year, the farmers grew a total of only 1.3 ha of a small range of grasses, but by the end of the second year, they had expanded production to more than 6 ha. The main grass species selected for expansion was *P. maximum* cv. Simuang. In 2001, more farmers realised the income potential of selling fresh forage and joined the original farmer group, while others started a second group (Table 1). In 2002, the 'Paddy Fodder Project', already mentioned in the introduction, provided a boost to planting forages for sale and other government agencies started to encourage farmers to produce fodder for sale. By 2006, there were 9 farmer groups, with 637 members planting pastures for sale as fresh forage on 179 ha.

As the new enterprise developed, production progressively moved from rain-fed areas to irrigated areas, so farmers could sell forage year-round, not only during the rainy season. More than 100 farmers, who originally started to produce forage for sale in rain-fed areas, subsequently stopped production while others started in irrigated areas.

Table 1. Number of farmer groups and farmers and planted forage area in Yasothon Province, 1999–2006.

Year	Number of farmer groups	Number of farmers	Area planted (ha)
1999	1	13	1
2000	1	13	7
2001	2	71	31
2002	2	228	83
2003	2	228	83
2004	8	466	167
2005	8	466	167
2006	9	637	179

Marketing of fresh forage

The main buyers of fresh forage were farmers who raised cross-bred Brahman cattle for fattening, livestock traders feeding cattle in holding pens and in transit, cattle breeders who produced Hindu-Brazil cattle and, in some years, government offices, which bought fodder (fresh and hay) for disaster feed relief for flooded areas. At the time of the survey, most buyers were from nearby areas in Yasothon, with beef cattle farmers accounting for 81%, traders 10% and cattle breeders 9% of the total sales of approximately 130 t/month fresh weight.

Farmers sold forage along roadsides in bundles weighing approximately 10 kg in the rainy season and 5–6 kg in the late dry season. These were easy to handle and transport, and allowed buyers to make a quick calculation of how many bundles of fodder they needed. In 2004, the price per bundle was Baht 10 (US$ 0.25) throughout the year, which effectively almost doubled the price of forage during the dry season. The weight of bundles measured on roadsides was relatively consistent (weight was within one kg of the mean) despite the absence of weighing balances. Dry matter concentration of samples varied considerably, depending largely on the amount of time elapsed from cutting in the field to the time of sale along roadsides. While freshly cut samples in the field often had dry matter concentrations of 16–20%, those sold on roadsides were considerably higher at 20–25%.

The main ways of selling fresh forage were:

Direct sales along roadsides. Farmers harvested and bundled fresh forage in the field, transported the bundles to a shady place along the road and sold them directly to buyers, who were responsible for transport from the point of sale to their farm. Some producers formed groups with 1–2 people acting as sellers on the roadside. The commission paid for this service was US$ 0.025 per bundle.

Direct sales at livestock markets. On market days, some farmers harvested and bundled fresh forage in the field and transported the bundles to 1 of the 3 livestock markets in the province. When the supply of forage for sale in the rainy season exceeded local demand, some farmers transported their bundles long distances for sale at livestock markets in adjoining provinces.

Sales at farm gate. During the dry season, when supply of feed was limited, many buyers went directly to farmers to buy forage in the fields. The buyer was responsible for harvesting and bundling the forage. Often, these buyers were middlemen, who then sold fresh forage along roadsides or transported it to other villages and provinces for sale.

Sales to other villages and provinces. During the wet season, when supply exceeded demand in the area where forages were grown, some farmers and middlemen purchased bundles for transport and sale in distant villages and provinces.

Sale to government for disaster relief operations. At times of natural disasters, such as severe flooding, the Department of Livestock Development (DLD) provided assistance to severely affected areas by supplying feed to save breeding stock and other valuable animals. DLD bought feed from farmer groups producing fodder for sale and transported it to affected areas for distribution. This was mostly for flood relief in the wet season.

Farmers were flexible and used all of these methods of selling fresh forage at different times of the year.

Production system

The soils in the survey area were acidic sandy loams with low organic carbon (Yasothon series). Soil pH (1:1 H_2O) was in the range 4.5–5.3, organic carbon 0.24–0.39%, total N 0.01–0.02%, available P (Bray II) 2–15 ppm and exchangeable K 24–38 ppm.

Land preparation was carried out with a 2-wheel hand tractor in March or April. At planting, farmers applied approximately 12.5 t/ha of poultry manure/litter purchased from nearby broiler production units. In early March, farmers prepared a seedbed to produce grass seedlings, which were transplanted at about 1 month old at a spacing of 50 × 50 cm, and irrigated if early rains were late. Reasons cited for using this labour-intensive planting system were that seeding rates were low, only strong seedlings were transplanted and transplanting allowed for an early start in the growing season with minimal irrigation.

Fields were weeded during the establishment period and the first harvest made approximately 60 days after transplanting. Most farmers harvested grass at a height of 5–15 cm by hand, using sickles, and bundled it immediately for sale. Fields were cut sequentially to enable a daily (or at least 2–3 times/week) supply of fodder for sale. Forages were treated like high-value vegetable crops with each plant receiving individual attention.

After harvesting, farmers applied inorganic fertiliser and irrigated the harvested area to stimulate regrowth. Fertiliser applications varied widely but most farmers applied 125–310 kg/ha urea (46% N) or 160–310 kg/ha compound N:P:K fertiliser (16:7:6.7) after each harvest. In addition, farmers applied poultry manure at a rate of 2.8–5.6 t/ha every 2–3 harvests. Some farmers, who also raised beef cattle, used cattle manure instead of poultry manure. In the dry season, fields were irrigated to maximise grass production. In most cases, fields were flood-irrigated once per week (7-day intervals). Farmers located in areas serviced by irrigation channels have continued to use flood irrigation but there has been a move towards sprinkler irrigation in areas where farmers have to pump ground-water. The average harvest frequency was 25–35 days in the peak of the wet season and 30–45 days in the dry season; this enabled farmers to harvest their forage area 6–7 times in the establishment year and 8–10 times in Years 2 and 3. Fields were replanted every 2–3 years.

Forage yields

Forage yields were estimated during group discussion (range 41–56 t DM/ha/yr). A second estimate was attempted by collecting information from 10 individual farmers. As farmers harvested their fields daily on a rotational basis, complete data sets could not be collected from all farmers and full-year data sets were available from only 4 farmers. Instead, calculations of yield were based on the median number of harvests during the dry and wet seasons, the median number of bundles harvested per cut and the median fresh weight of bundles during the wet and dry seasons. Based on the responses, annual dry matter yields were 33 t/ha in the establishment year and 46 t/ha in subsequent years (Table 2).

These are very high yields and we used 2 additional information sources to verify forage yields. The first estimates were made during farmer group discussions and these ranged from 41–56 t/ha DM per year. The second comparison was the yields from the 4 farmers with year-round sale data (number of bundles and income from the sale of forage from particular fields), where mean yield was 50 t/ha per year. These comparisons gave us confidence that our yield estimate presented in Table 2 was realistic.

Price of fresh forage

The price of fresh forage fluctuated from US$0.025/kg in the peak of the wet season (July–October) to US$0.042/kg in the late dry season

Table 2. Average[1] yields of *Panicum maximum* cv. Simuang estimated from survey data.

	Establishment year			Years 2 and 3		
	Rainy season	Dry season	Full year	Rainy season	Dry season	Full year
Number of harvests	3	4	7	5	4	9
Number of bundles harvested (bundles/ha/harvest)	2812	2656	—	2812	2656	—
Fresh weight of bundles (kg)	10	6	—	10	6	—
Fresh weight yield (t/ha)	84.4	63.7	148.1	140.6	63.7	204.3
Dry matter yield[1] (t/ha)	19.0	14.3	33.3	31.6	14.3	45.9

[1] Based on median values for parameters from survey.
[2] Dry matter concentration estimated at 22.5%.

(February) (Figure 2). Interestingly, the system that evolved was that farmers charged the same price per bundle throughout the year (Baht 10/bundle) but varied the weight of bundles from approximately 10 kg in the wet season to 5–6 kg in the late dry season. This system of fixed prices for a variable amount of vegetables is common in Thai markets.

Protein concentration in bundles offered for sale varied considerably depending on season and farm. Chemical analyses of 108 forage samples collected and analysed by DLD in 2005 showed an average crude protein concentration of 10% in the wet season of 2004 and 14.7% in the following dry season (P. Pholsen, personal communication). The lower protein content in the wet season may be the result of a dilution of nutrients caused by rapid growth. Initially, prices paid by buyers seemed to be independent of quality, but this is changing and buyers are becoming more discriminating, paying higher prices for young, leafy forages than for older, more mature material.

Some farmers obtained additional income from the sale of rootstocks and seedlings to other farmers who wanted to establish forage crops quickly. Forage areas planted from rootstocks or seedlings can be harvested for the first time approximately 60 days after planting, which is considerably quicker than for forage crops established from seed. Rootstocks were sold in bundles of similar size to fresh forage bundles (up to 10 kg) and for the same price (US$0.25 per bundle).

Production costs and net income

Average production costs (calculated from data collected during semi-structured interviews in October 2004 and verified with farmer groups) were US$2250/ha in the establishment year and US$2274/ha in Years 2 and 3 (Table 3). Major

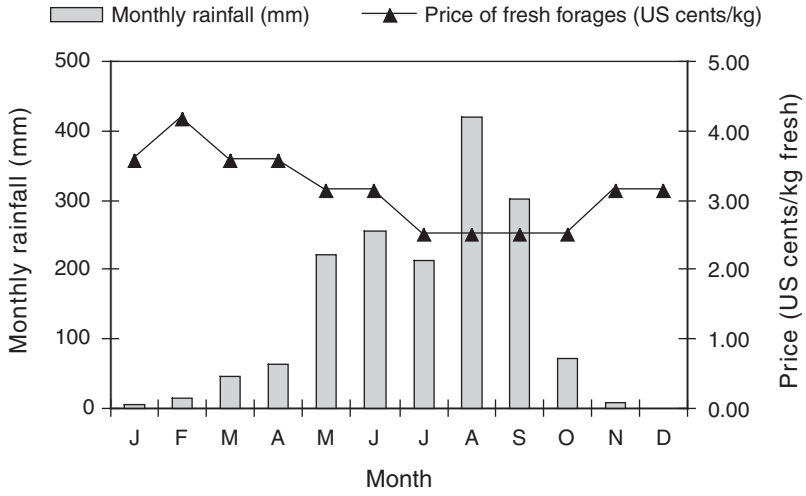

Figure 2. Price of fresh forage (US cents/kg fresh weight), as related to average monthly rainfall in Yasothon (1999–2003).

Table 3. Production costs of fresh forage in Yasothon.

Type of expense	Timing and frequency	Unit cost	Year 1	Years 2 and 3
			(US$/ha)	(US$/ha)
Establishment	*Replant after 3 years*			
Land preparation		$40/ha	40	—
Manure	12.5 t/ha at planting	$20/t	250	—
Seed	1 kg/ha	$2.25/kg	2	—
Planting and weeding	Labour for seed-bed maintenance and transplanting of seedlings	$102/ha	102	—
Harvesting	*No. of harvests*			
	— wet season		3	5
	— dry season		4	4
	— total		7	9
Inorganic fertiliser	218 kg/ha urea applied after each harvest	$0.325/kg	425	638
Manure	4.2 t/ha applied every third harvest	$20/ton	168	252
Irrigation	Weekly	$310/yr	310	310
Cutting & bundling	2812 bundles per harvest in rainy season and 2656 bundles per harvest in dry season	$0.05/bundle	953	1234
Total production cost (US$/ha/yr)			2250	2274

cost factors were harvesting, carried out using either family or hired labour, and fertilisers.

Mean net income from the sale of fresh forage was US$2515/ha in the establishment year and US$3897/ha in Years 2 and 3 (Table 4). This resulted in benefit:cost ratios of 2.1:1 in Year 1 and 2.7:1 in Years 2 and 3. Since the average area planted to forage for sale was 0.72 ha per household in the survey, net family income was US$1810 in Year 1 and US$2805 in Years 2 and 3. The households included in the survey had larger forage areas than the mean of all households in 2006 (0.28 ha). New households tended to start with smaller forage areas to evaluate the costs and benefits of the enterprise and then increased their area as their confidence increased.

Table 4. Net income from production of *Panicum maximum* cv. Simuang for sale as fresh forage.

	Establishment year	Years 2 and 3
Grass bundles produced	19 060	24 684
Price per bundle (US$)	0.25	0.25
Gross income (US$/ha)	4 765	6 171
Production costs (US$/ha)	2 250	2 274
Net income (US$/ha)	2 515	3 897
Benefit:cost ratio	2.1:1	2.7:1

Nutrient balance

Forage grasses contain large amounts of nutrients that are removed under a cut-and-carry system. Farmers indicated that yields declined rapidly, unless they applied fertiliser. However, applying only urea also resulted in declining yields and chicken manure, which was available locally, was regarded as the most suitable fertiliser to maintain yields. Some farmers applied a combination of urea and compound N:P:K (16:7:6.7) fertiliser to address this problem.

An estimation of nutrient balance based on mean forage yields, average nutrient concentrations in the analysed forage samples and nutrient inputs from mean fertiliser applications described in earlier sections is presented in Table 5. The calculated partial nutrient balance was positive for N, excessive for P, very negative for K and negative for S in both the establishment and subsequent years. The oversupply of P and undersupply of K is related to the use of chicken manure, which has an N:P:K ratio of 1:1:0.7. These calculations are crude estimates at best but are an attempt to identify major imbalances.

Discussion and conclusions

This study has highlighted the excellent returns for farmers from growing purple guinea grass for sale as fresh forage in north-east Thailand. Clearly, the high returns were a major driver of the development of forage-for-sale production in Yasothon. The fields used for forage production had previously been used to grow 2 crops of paddy rice per year, which realised a gross income of US$590/ha/yr (Office of Agricultural Economics 2005). This was much less profitable than growing grass forage for sale with net returns

Table 5. Partial nutrient balance in the establishment and subsequent years[1].

	N	P	K	S
Establishment year				
Nutrients removed				
Dry matter yield = 33.3 t/ha				
Nutrient concentration in forage (%)	2.0	0.18	1.51	0.19
Nutrients removed (kg/ha)	666	60	503	63
Nutrients applied				
— urea (1308 kg/ha)	602	0	0	0
— chicken manure (20.9 t/ha @ 85% DM[1])	471	478	329	32
Total nutrients applied (kg/ha)	1072	478	329	32
Partial nutrient balance[2] (Year 1)(kg/ha)	*+ 406*	*+ 418*	*– 175*	*– 32*
Years 2 and 3				
Nutrients removed				
Dry matter yield = 46.0 t/ha				
Nutrient concentration in forages (%)	2.0	0.18	1.51	0.19
Nutrients removed (kg/ha)	920	83	694	87
Nutrients applied				
— urea (1962 kg/ha)	902	0	0	0
— chicken manure (12.6 t/ha @ 85% DM[1])	284	288	198	19
Total nutrients applied (kg/ha)	1186	288	198	19
Partial nutrient balance[1] (Years 2 and 3) (kg/ha)	*+ 267*	*+ 205*	*– 496*	*– 68*

[1] Department of Agriculture (2005): Information on DM content and nutrient composition of chicken manure.
[2] Partial nutrient balance does not include some, mostly small, inputs (from rain, irrigation water, *etc.*) and some more important losses (from volatilisation of N, and leaching of all nutrients).

of US$2500 — 3800/ha/yr. The high price paid for fresh forage (US$0.025–0.042) was both surprising and unexpected. Initially, cattle breeders producing highly priced Hindu-Brazil cattle may have been responsible for the high prices paid for fresh forage but the high prices have been largely maintained in Yasothon, even though most of the feed is now used for rearing and fattening cattle for slaughter. Prices are slightly lower in other provinces, with the average price in Thailand in the range US$0.014 — 0.037/kg fresh forage (Khemsawat and Phaikaew 2007). As would be expected, prices are related to supply and demand, with lower prices in the wet season, when there is an oversupply of fresh feed. Farmers with access to irrigation are able to capitalise on the high demand for fresh forage, and correspondingly higher prices, in the dry season.

Returns in our study far exceed the average net return of US$938/ha reported by Khemsawat and Phaikaew (2007) for farmers growing *P. maximum* cv. Simuang for sale as fresh forage in north-east Thailand. Their calculations were based on 3.8 cuts per year (compared with 9 harvests in Yasothon), which indicates that the data were collected mainly from rain-fed areas, that can produce fresh grass only during the wet season. The ability to irrigate and produce fresh grass year-round, and so take advantage of the higher prices for fresh forage in the dry season, was the key for the high returns reported in our study.

Apart from high income, farmers mentioned 2 other factors that enticed them to grow forages for sale. Firstly, they valued the daily, year-round income they received from the sale of fresh forages, which contrasted with the once-a-year income from the sale of food crops. The second factor was that forages did not require the application of insecticides or herbicides, which was seen as a hazard in rice and vegetable production. Forages were seen as being a 'healthy' cash crop.

While the enterprise is highly profitable, opportunities exist to make fresh forage production even more profitable. One option is to reduce the high costs of production. Harvesting costs and bundling accounted for 42–54% of total production costs in this study and may be reduced by mechanising harvesting (*e.g.* forage choppers) and selling fresh forage by trailer (based on weight or volume) rather than in small bundles. The second option relates to reducing the impact of supply and demand variations and their effect on price by making alternative use of the excess forage in summer. Many farmers have started to

engage in beef cattle production as a complementary enterprise, fattening cattle during times of oversupply of feed and so making better use of the excess forage.

The demand for fresh forage is likely to continue to expand. The beef cattle population in Thailand has grown rapidly from 4.9 M cattle in 2000 to 8.0 M cattle in 2006 (Department of Livestock Development 2007). This increase in cattle numbers is driven by increasing demand for high-quality livestock products such as good-quality beef in an increasingly affluent country. The demand for feed has increased correspondingly. Khemsawat and Phaikaew (2007) reported that areas in Thailand devoted to fresh forage production had grown from 3163 ha in 2004 to 5271 ha in 2006, when there were forage production groups in 43 provinces.

Forage yields and fertiliser applications were exceptionally high in this production system and were most likely a consequence of the high profitability of the fresh forage enterprise. Maximising forage yields to meet the high demand for fresh forage was the first priority of farmers and frequently applying very high levels of fertiliser and irrigation resulted in extremely high yields while having little effect on profitability. Grass yields of 20–30t/ha DM per year are commonly reported in the literature, but annual yields of 60 t/ha have been reported for *Panicum maximum* and 85 t/ha for *Pennisetum purpureum* (Bogdan 1977; Cook *et al*. 2005). In Thailand, Udchachon *et al*. (1998) reported an annual dry matter yield of 50.5 t/ha for *Panicum maximum* cv. Simuang supplied with 46 t/ha of cattle manure, 930 kg/ha of compound fertiliser and 500 kg/ha of urea, and irrigated 3 times per week during the dry season. To achieve the high yields, farmers in Yasothon applied very high levels of fertiliser with urea (or compound fertiliser) applications after every cut and manure every 3 months as well as using frequent irrigation.

Nutrient management requires attention in areas where chicken manure is used as a major part of the fertiliser regime. The current system is likely to become deficient in K and S and is at best very inefficient with respect to P and at worst a source of ground-water pollution. Losses of N from volatilisation would have substantially reduced the potential for build up of N in the soil. Although phosphorus is considered largely immobile in soils, in the sandy soils of north-east Thailand a build up of P in the soil will result in leaching losses, again posing problems of low efficiency of nutrient use and a threat to quality of ground-water. The negative K balance is likely to reduce forage yield at some stage, although it is hard to predict how quickly this will happen. With reduced annual tillage and large inputs of organic matter in roots and dead leaves, soil organic matter should increase, albeit gradually. This may decrease some of the negative impacts of nutrient imbalances by reducing leaching losses.

Other opportunities to improve efficiency exist. Chicken and other poultry manures contain high levels of phosphorus, which are not taken up by grasses. Balancing fertiliser applications with off-take in fresh forage is critical in ensuring the long-term sustainability of the fresh forage-for-sale business. Potential solutions include a partial substitution of cattle manure for chicken manure, with a more suitable N:P:K ratio of 1.0:0.3:0.8 (Busch *et al*. 2000). While this may increase the cost of handling and application, a well balanced organic fertiliser source will avoid pollution and ensure sustainability of the fresh forage production enterprise. Other options include the use of a range of inorganic fertilisers including potash to provide a more balanced nutrient supply.

The development and adoption of this new enterprise is a good example of smallholder farmers seeing an opportunity (the need for feed by traders and cattle producers) and being able to capitalise on the opportunity. Examples of forage production for on-farm use already existed, the farmers had the land and skills needed to grow forages, they were already using fertiliser on crops, and there was a strong ‘promoter’ of the new enterprise (the government) providing advice and assistance with setting up farmer groups to facilitate production and marketing of the product. These are key ingredients for successful technology adoption (Shelton *et al*. 2005).

In conclusion, the sale of fresh grass has emerged as a new farm enterprise in Thailand, which provides high returns for farmers with access to markets, especially those with irrigation facilities. The system must be ‘fine-tuned’ by balancing nutrient supply more closely with nutrient off-take to ensure the long-term sustainability of the venture.

Acknowledgements

We thank Mr Chirawat Khemsawat, Deputy Director General, Department of Livestock

Development, Thailand and Dr Chaisang Phaikaew for their support during the planning of the survey; Mr Paiboon Polboon for providing information; Mr Sontaya Nga-kom for his helpful support during the field survey; and Dr Rod Lefroy for his help with nutrient balance issues. We also thank the participating farmers for sharing their experiences and providing data on the forage-for-sale enterprise. Their enthusiasm for the forage-for-sale enterprise was 'catching' and motivated the study team. We thank the Asian Development Bank (ADB) for providing funding for this study as part of RETA 6067 — Livelihood and Livestock Systems Project, which was managed by CIAT and the Division of Animal Nutrition, Department of Livestock Development in Thailand.

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(Received for publication April 11, 2007; accepted December 7, 2007)