20

Future developments in feeding management in the humid tropics

This chapter:

Discusses some of the priority areas for research and extension in dairy feeding management.

The main points in this chapter:

- the advances in feeding management achieved in temperate dairy systems over the last two decades have not been replicated on tropical small holder farms
- it is important to determine optimum stocking rates for each small holder farm and not exceed them
- cows use nutrients, not feeds, to produce milk. Therefore, knowing feed quality then feeding for production targets are the two major elements of good nutritional management
- whole crop maize silage or greenchop is an ideal feed to incorporate into dairy feeding systems
- profitability depends on marginal milk responses and marginal feed costs. These are the additional milk produced from the next kilogram of feed and its cost
- the causes of poor farm profitability can be diagnosed, using nine key questions on feeding management
- it is energetically more efficient and generally more profitable to feed fewer cows better.
- attention to improved genetics should only be considered once feeding management can adequately supply the required additional nutrients
- cassava and cowpea hays have been incorporated into an innovative dairy feeding system
- research priorities should be directed more towards risk minimisation rather than just to income generation
- the priority list for future dairy nutrition research and extension needs is presented.

Over the last 20 years of dairy research, development and extension, many Western countries have produced sophisticated dairy production systems. Herd sizes have grown, efficient feeding systems have evolved and many farmers routinely test their cows for milk production, composition and quality and for mastitis. They then use this information for making decisions on culling milking cows and for breeding genetically improved stock. High labour costs have led to much mechanisation, such as machine milking and forage conservation, while grazing cows can harvest their own forages far more efficiently than can farmers. Low population pressures, hence relatively cheap land, has allowed farms to expand in both size and cow numbers.

Unfortunately this has not been the case for small holder dairy farmers in most countries in South-East Asia. Being in the tropics, feed quality suffers from high temperatures and strongly seasonal rainfall patterns. Dairy cows are temperate animals with thermoneutral (comfort) zones closer to 10°C than to 30°C. Furthermore, high humidities reduce feed intakes which exaggerate the adverse effects of high fibre forages on appetite. A good measure of heat stress, the Temperature Humidity Index, shows milking cows in the lowlands of the humid tropics to be in the 'high stress' and 'reduced performance' zones for much of most days throughout the year. Many dairy specialists argue that potentially high performance dairy breeds, such as Friesians, may not necessarily be the best dairy cattle genotype for tropical regions, except in highland areas or those with low humidities.

There are many socioeconomic reasons why the efficiency of small holder dairy farming has not greatly improved over the last two decades. Granted, numbers of cows has greatly increased in most South-East Asian countries, largely through government support for social welfare and rural development programs. The increased demand for milk (accentuated through school milk programs) and the concept of national food security are the driving forces behind dairy development initiatives. However, in terms of feed inputs per litre of milk produced, improvements have been slow.

Much of the technical progress in Western dairy countries has not been relevant to South-East Asia, and some of it may have been unwisely transplanted. Commercial interests selling 'improved genetics' often do not explain the need for 'the feeding to go with the breeding'. Granted, milking cows must get back in calf to keep producing milk, so good herd fertility is essential. However, poor early lactation feeding will not allow these 'improved' cows to express their potential for good fertility.

This chapter discusses many of the key obstacles to improving current feeding management practices that face institutional managers, educators, dairy advisers and dairy farmers.

20.1 Determining optimum on-farm stocking capacities

Very rarely do farmers and advisers calculate the optimum stocking capacity of any one farm. Unfortunately herd sizes are usually the result of 'trial and error' whereby farmers increase cow numbers until they become too expensive to feed or their milk yields decline below acceptable levels. Estimated farm forage yields must be taken into account when determining how many cows and young stock can be fed adequately from a particular sized small holder dairy farm.

The following scenarios are to assist in such a mathematical exercise. To calculate stocking capacitities, a series of assumptions have to be made:

1 Forages contain 15% DM (not the 20% as often assumed) and yield:
   - 10 t DM/ha per year (67 t fresh/ha per year) under poor management such as only fertilising with cow manure, no supplementary irrigation, no harvest program
   - 20 DM/ha per year (130 t fresh/ha per year) under typical management such as fertilising with cow manure and limited inorganic fertiliser, typical approach to forage management
   - 30 t DM/ha (200 t fresh/ha per year) under good management such as fertilising with sufficient inorganic nitrogen and phosphorus fertilisers to match forage requirements, water supplies and harvest program for optimum yield and quality.

2 The management allows for forage conservation to transfer wet season excess pastures for dry season feeding.

3 Small holder farmers use their forages to rear replacement heifers as well as feed their adult cows, when lactating and dry. Farmers rear 20% of their milking herd as replacements, which first calve at 27 months of age.

4 An adult cow milking unit is, therefore, one adult cow plus 20% of a replacement heifer.

5 In year-round calving systems, only 75% of the adult cows are milking at any one time. Therefore each year, adult cows milk for 275 d and are dry for 90 d.

6 The forage feeding program allows for feeding:
   - 50 kg/d of fresh forage (7.5 kg DM/d) to milking cows
   - 30 kg/d of fresh forage (4.5 kg DM/d) to dry cows
   - 20 kg/d of fresh forage (3.0 kg DM/d) to heifers, averaged over a full 24 mth of feeding weaned stock

7 Concentrates and purchased forages are fed to provide the balance of the diet to achieve target milk yields. However, such feed inputs are not relevant to these scenarios.

The annual forage requirements for each milking unit are then:

- 13,750 kg fresh (or 2065 kg DM) for the milking cow (71% of total)
- 2,700 kg fresh (or 405 kg DM) for the dry cow (14% of total)
- 2,920 kg fresh (or 438 kg DM) for 20% of a replacement heifer (15% of total)

or a total of 19,370 kg fresh (or 2,905 kg DM) for each milking unit.

The stocking capacities, or numbers of stock that could be fed from one hectare of forage, are presented in Table 20.1.

Table 20.1 Optimum stocking capacities for small holder dairy farms with different levels of forage management

One milking unit is one adult cow plus 20% of a replacement heifer. Assumed forage intakes: 7.5 kg DM/d for 275 d/yr for milking cows; 4.5 kg DM/d for 90 d/yr for dry cows; 3.0 kg DM/d for 365 d/yr for 20% of a replacement heifer.

Level of farm forage management	Poor	Typical	Good
Forage yield			
t DM/ha year	10	20	30
t fresh/ha year	67	130	200
Milking units/ha forage	3.4	6.9	10.3
Adult cows/ha forage	4.0	8.1	12.1

Therefore, to provide sufficient quality home grown forage for a well-balanced diet to all stock, the typical 0.5 ha small holder farm should have no more than two to five milking cow units, that is two to five adult cows plus one replacement heifer, depending on management of the forage production area.

This is further evidence that farmers should feed fewer cows better. With increasing dependence on purchased forages, feed costs are invariably more expensive and dietary quality generally poorer than when basing dairy production systems on home-grown forages.

20.2 Research and extension priorities in feeding management

20.2.1 Variability in nutritive value

Cows use nutrients, not feeds, to produce milk. There is little point in producing large amounts of forages if it is too low in quality to produce milk. It may be suitable for dry cows or growing out young stock, but the best feed should be reserved for milking cows, with the higher producing cows receiving the best quality.

This manual has highlighted the importance of knowing the nutritive value of the variety of feeds used for small holder dairy production. The range of growing conditions of forages means their energy, protein and fibre contents can vary widely. Not only do these depend on the stage of maturity at harvest, but the soil nutrient status, which is largely affected by the use of fertilisers (both inorganic and organic), also has a marked effect. Many of the by-products fed originate from a range of agro-industrial processes, meaning that they can also vary widely in feeding value.

Without good knowledge of their nutritive values, it is not possible to develop optimum feeding strategies, particularly for forages. Feeding strategies should be based on the cost of feed nutrients, those that are most limiting cow performance. On the whole these are energy, although if protein supplies do not balance the energy, protein also becomes a limiting nutrient. Hence, cost per unit of energy or protein should be the major decider, in conjunction with Neutral Detergent Fibre content, when purchasing feeds to overcome short falls in forage quality and quality. This is particularly important during the dry season as supplementary forage prices will increase with demand. It may be cheaper to purchase dry season supplements at other times of the year, provided quality does not deteriorate during storage. Certainly, using silage to store wet by-products as well as forages is one way to maintain feed supplies during such periods.

Computer aids to ration formulation are described in Chapter 12, with one particular program, named DRASTIC worthy of particular mention. DRASTIC is the abbreviation for **D**airy **RA**tioning **S**ystem for the **T**rop**IC**s, a program developed by tropical dairy specialists in the United Kingdom.

The program uses qualitative and visual indicators in forages that can be undertaken easily by farmers, such as leaf: stem ratio, days after defoliation, forage colour, pest or disease damage, odour, moisture content, length of chop and general assessment. These are related directly to actual measures of energy and protein contents for specific forage species of grasses, legumes, silages and hays/crop residues which are then used to calculate nutrient intakes, to predict cow performance. The program even allows for grazing in predicting forage intakes.

DRASTIC then provides a tool to assist rationing dairy cows where access to technical knowledge is limited but practical experiences are considerable. The program is freely available from Dr Peter Stirling at drastic@stirlingthorne.com or www.stirlingthorne.com/about_drastic.html.

20.2.2 Seasonality of quality forage supplies

For cows to produce milk throughout the year, they must have a year-round supply of nutrients, particularly forages. In much of South-East Asia, rice straw is the basis for feeding livestock, particularly those without high nutrient requirements. Milking cows have high nutrient requirements, too high to be economically viable unless alternative, much better quality dry season forages are readily available. Even chemically treated rice straw is hardly, what many nutritionists would call, a 'milking feed' (see Chapter 10).

The location of farms can influence their success in producing profitable milk, particularly when dry season forages cannot be grown or sourced locally. For example, Karnjanasirm *et al.* (1999) described a situation in Thailand's Nakorn Pathom province where the least successful dairy farmers were those with insufficient areas for growing forage. They had to source forages, mainly maize stover, from a long distance, making the feeds very expensive. In comparison, farmers in North-East Thailand who had larger areas for forage cultivation benefited more from forage than did farmers with smaller areas (Bunyanuwat *et al.* 1995). Most innovative small holder dairy farmers try to establish their own pasture to be less dependent on purchased forages.

As many peri-urban farmers have discovered, producing milk without adequate quality forages requires high levels of concentrates. Milk composition can suffer unless there is a correct balance of forages and concentrates. Low fat content, which is quite common in small holder dairying, is a syndrome of low intakes of quality fibre. Low protein, which is even more common, is an indicator of low energy intakes, and hardly influenced by protein intake. Poor milk composition costs money through reduced unit price of milk (see Chapter 17). Therefore, improper feeding management costs both in terms of milk volume and composition.

In some countries, where labour has little value, virtually every available source of forage is harvested, generally by hand, for livestock feeding. Such countries even have 'grass markets' where such forage harvesters can sell their wares, be they native grasses or tree leaves, to small holder farmers as a mainstay fodder source for their stock. In most countries there are areas in rural regions, for example beside major roads and railways or around rice paddy fields, where forages could be readily harvested for many months of the year. But as labour becomes more costly, such forages become too expensive to be cost-effective in small holder systems.

20.2.3 Maize and its by-products

Over the last two decades, maize (or corn) is producing increasing tonnages of milk throughout the world. Not only is maize forage and forage by-products integral in many dairy systems, but the grain and grain by-products are too (see Chapter 9). Maize is the only forage that does not decrease in quality as it matures, because the deposition of grain on the cob compensates for increasing fibre levels in the leaf and stem. Granted protein levels are not high, only 6% to 8% in whole crop silage; however these can be easily improved through incorporating urea with the silage or greenchop.

As maize is a basic feed for many communities, research attention is being given to improving the nutritive value of the maize stover. The stover is that part of the plant left over following harvest of the cob for grain or sweet corn. The plant is less mature when harvested for sweet corn than for grain, making sweet corn stover is a better quality forage then corn stover following grain harvest.

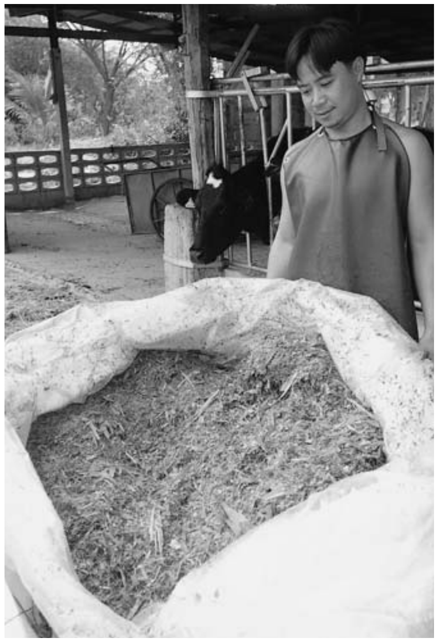
To produce milk from a moderate-quality forage such as maize stover, additional nutrients must be included from energy and protein-rich concentrates. If the whole plant (including the cob) is chopped and fed to milking cows, fewer concentrates are required. Whole crop maize silage has an additional feature in that it has a low dietary cation–anion balance (see Chapter 13), making it an excellent forage for feeding dry cows just prior to calving, as a precaution against milk fever.

The Nong Yai feed centre managed by the Banbueng dairy cooperative in southern Thailand. This centre stores maize silage in tower and pit silos and prepares total mixed rations for delivery to cooperative members.

Inside the Nong Yai feed centre where the mixer waggon directs rations into bags for direct delivery to farmers. (Banbueng, southern Thailand).

In Thailand's Banbueng province large areas of maize, destined for whole crop silage, are grown by dairy cooperatives, ensiled in large cement towers or bunkers, then sold to individual farmers at cost price (at 1.25 Bt/kg fresh). This approach is proving very profitable in increasing local milk production through a relatively cheap year-round source of quality forage. Even though the forage may appear expensive, a true cost comparison should be to calculate milk income less feed costs for the various alternative dry season rations (see Table 17.6).

As well as selling maize silage, in large (500 kg) hessian sacks, the Banbueng cooperative has a feed centre where they prepare a variety of total mixed rations, based on the silage, for direct sale to small holders to feed their cows in various stages of lactation (see photograph on page 244). The maize silage is particularly useful in restoring body condition on cows during the late lactation and dry period. The cooperative also has a calf rearing unit and yards for heifer rearing close to the feed centre, thereby allowing the farmers to stock their farms predominantly with milking cows, hence to concentrate all their efforts in producing milk.



A cooperative dairy farmer member receiving a 500 kg bag of maize silage (Banbueng, southern Thailand).

20.2.4 Milk to concentrate ratios in production rations

Many dairy advisers in South-East Asia use a general 'rule of thumb' that for every 2 L of milk produced, farmers should feed 1 kg concentrate. This is a safety measure because of lack of knowledge on the nutritive value of the feeds, particularly the forages. It also provides supplemental energy to cows when fed only limited amounts of forage. In any dairy system, whether in temperate grazing systems or South-East Asian small holder systems, the principles for feeding milking cows should be:

1 feed sufficient quality forages first, then
2 supplement with concentrates, which are
3 formulated to overcoming specific nutrient deficiencies
4 to achieve target milk yields.

With knowledge of the feeding value of the forages and concentrates, and their costs, more objective hence better decisions, can be made on how much concentrates should be fed to achieve target milk yields. Granted this requires more knowledge and greater effort than following the 'feed 1 kg concentrate per 2 L milk' rule, but such decisions can greatly reduce feed costs, hence improve profitability, when expressed as milk income less feed costs.

In Chapter 11, Table 11.6 listed the level of concentrates required to achieve target milk yields with varying forage qualities. These feeding decisions have been converted into milk:concentrate ratios in Table 20.2. When cows are fed better quality forages, more milk is produced per kilogram of concentrate fed. The 2:1 (1 kg concentrate:2 L milk) rule is only applicable with very low quality forages, namely those with Metabolisable Energy contents of 7 to 8 MJ/kg DM.

Table 20.2 Milk:concentrate ratios (L milk produced/kg concentrate fed) to achieve target milk yield in cows fed forages of varying quality
dry matter (DM); metabolisable energy (ME). (Source: Devendra 1975)

Milk yield (L/d)	Forage quality (MJ of ME/kg DM)			
	7.3	8.2	9.0	9.9
6	1.8	8.6	–	–
10	2.0	4.0	12.5	–
14	2.1	2.9	12.7	46.7
18	2.2	3.0	6.0	25.7
22	2.2	2.9	4.1	12.9

Milk production is very responsive to nutrient intake. Among livestock producers, dairy farmers are very fortunate in that their cow's milk yield today is directly affected by their feeding management yesterday. No other type of livestock provides such a rapid feedback to herd management. Once farmers set their target milk yields, so long as they are realistic to their farming system, they can monitor their success or failure in achieving these by gradually changing one of the feeds in the cows' ration. If the additional milk produced, as feeding levels are improved, returns more than the additional feed inputs, then that was a profitable management decision.

Farmers can change their feeding program, but only one feed at a time, say once per week then note the milk response. They should also note changes in other feed inputs. For example, if they increase concentrates and find cows eat less forage, and know the cost of energy or protein in the various feeds, they can then decide on the most profitable combination of these feeds.

20.2.5 Marginal milk responses

The definition of substitution in Chapter 11 is 'the reduction in forage dry matter intake per kilogram supplement DM offered'. This is a marginal measure of change because substitution rates change as forage and concentrate intakes vary. This is a very important concept in biological responses, particularly for milking cows. Biological (output/input) ratios are rarely constant, varying with changes in inputs. So too with milk output.

As discussed in Chapter 11, better fed cows have poorer milk responses than do those less well fed. Hence, their marginal milk response decreases with level of feeding, and so does their milk production. Partition of dietary nutrients into body reserves, rather than towards milk synthesis in the udder, is a major reason why better fed cows have poorer marginal milk responses. Provided some of this redirected energy is repartitioned back into milk in the following lactation, it is still a useful contributor to the cow's production. This is why it is important to fully understand, from Chapter 11, that milk responses to changes in feeding management are both immediate (show up next week) and delayed (show up next year).

20.2.6 Marginal cost of production

In Chapter 17, it was explained that high yielding cows may need to be fed better quality rations as well as more total dry matter. This may mean that every kilogram of dry matter may be more costly to grow or purchase. Forage quality depends on stage of maturity, with frequently harvested forages having higher nutritive value than those less frequently harvested. Such a measure is based on dry matter, not fresh weight, because immature forages have lower dry matter contents, meaning that more fresh forage must be fed to achieve the same intake of dry matter. If this then means that less is harvested, because the forage is cut earlier and because more of it must be fed to achieve the same intake of dry matter, then each kilogram of dry matter is likely to cost more to grow. However, if more milk is produced from each kilogram of forage, then earlier harvesting may be an economic decision.

Better quality concentrates are also more costly to purchase. For example, Table 10.2 details two grades of rice bran (with 11 v 8 MJ/kg DM of ME and 14% v 8% CP). From Table 17.1, rice bran Grade 1 (or A) in Thailand has been costed at 4.5 Bt/kg fresh whereas Grade 2 (or B) may only cost 1 or 2 Bt/kg.

Feeding more expensive feeds increases the cost of production. For cows to produce more milk they may have to be fed more expensive feeds, and hence the marginal cost of production increases. This additional cost is offset by a reduced maintenance component, hence converting more feed nutrients into milk. Improved feeding can also improve milk composition, hence unit price for milk. If the marginal milk return increases at a faster rate than the marginal cost of production, then cows should be fed at a higher rate.

20.2.7 Diagnosis of poor farm profitability

With regards feeding practices, the causes of poor farm profitability can be diagnosed as follows:

1. Stocking capacity. Is the farm carrying too many stock for the available forage supplies?
2. On-farm forage production. How much of the farm's annual forage supplies must be purchased each year?
3. Forage quality. Is the forage being harvested or purchased at its optimal stage of quality?
4. Concentrate feeding program. What is the quality of the concentrate being fed and how is it being allocated to each cow?
5. Total feed costs. Are the forages and concentrates costing too much per MJ of energy or kg crude protein?
6. Percentage of productive cows. What is the % of adult cows that are milking? What is the % of milking cows in the entire herd (including young stock)?
7. Pattern of milk production of the cows. What are their peak milk yields and lactation persistencies?
8. Milk income over feed costs. How do these compare with those of other farmers with good feeding management?
9. Reproductive performance. How many days after calving do cows cycle? What is the herd's 100-day in-calf rate and 200-day not-in-calf rate?
10. Heifer management. What is the calf mortality rate and wastage rate from birth to second lactation? What is the age and live weight at first calving of the replacement heifers?

Answers to these ten questions should be sought to better understand the farmer's skills in feeding management.

20.2.8 Feeding fewer cows better

Farm development equates to increasing annual farm milk production. Unfortunately too much emphasis has been placed on sourcing more cows to increase herd size, then trying to feed them on the same total feed resources. Rather than purchase more cows, it is always more profitable in the long run, to feed fewer cows better. As cows produce more milk, their maintenance energy requirements (ie the non-profitable component of the feed costs) become more diluted. From Chapter 17 (Tables 17.3, 17.5, 17.7), increasing milk production from 10 to 13 to 17 L/d reduces the maintenance energy component from 51% to 44% to 38% of total energy requirements and increases the proportion of total farm energy converted to milk from 76% to 78% to 81% respectively. Table 17.7 clearly demonstrates that to produce the same annual production of milk, larger herd sizes require rearing more replacement heifers and feeding more dry cows, both non-productive uses of their often limited feed resources.

Nakamanee *et al*. (1999) agree that strategies for increasing milk production per farm should aim at increasing yield per cow rather than increasing herd size. Lack of good quality forage in the dry season is the major problem of most farmers. Appropriate technologies such as improved feed conservation techniques and intensive forage management (eg fertilisation and irrigation) should be transferred to farmers. Farmers need to decrease cost of production in order to compete in the market place.

20.2.9 Breeding versus feeding dairy stock

A major business decision that farmers must make when developing their small holder farms is the emphasis they should place on improving the genetic quality of their milking stock. There is little point in breeding and rearing potentially more productive stock, then underfeeding them following their first calving.

Most Friesian-type cows, purebred and three-quarter bred, are genetically capable of producing at least 20 L, if not 30 L/d of milk at peak production. In most small holder farms, why then do most of them produce no more than 15 L/d at peak? Because they have been underfed, and have not been fed to their genetic potential. The extra herd and feed management skills required to best utilise high genetic merit cows is discussed in Chapter 19.

20.2.10 Growing young stock

In many instances, Friesians imported into South-East Asia may produce well, but their progeny do not. These animals are imported at great expense with expectations that they and their progeny will also outperform local stock. Therefore, farmers are likely to provide sufficient feed for them to produce well while milking. However, unless the feeding management of their progeny is of similar enthusiasm, they will not perform well. As discussed in Chapter 16, smaller heifers are less productive than heavier, better grown heifers. For the progeny of genetically superior cows to also produce well, greater attention needs to be given to their feeding management as young stock.

Chapter 19 has highlighted the more important business decisions farmers should make if they consider that genetic merit is a major limiting factor to their farm productivity and profitability. Greater attention should be given to improving feed supplies to these 'superior' stock both while growing and milking, particularly during early lactation.

20.2.11 Farmer research

The rapid milk response to any changes in feeding management means that dairying is the only form of livestock production that allows farmers to closely monitor animal performance on a day-to-day basis. Every farmer undertakes some form of research whether it is actually measuring daily variations in milk yield with measured changes in the amount of feed offered, or subjectively assessing gross changes in milk output over several weeks with seasonal changes in feed quality.

The future for small holder dairy development will rely on continued research and education of the farmers themselves. Applied research orientated to small holder needs cannot be met solely by importing technologies. Research must acknowledge integrated systems and the role of these farmers while focusing on technical parameters such as feeding, herd recording, management of reproduction and health, milk harvesting and breeding systems. However, its future is often more dependent on national sociopolitical decisions, such as the location of dairying areas in relation to feed resources as well as milk markets, policies on local market protection, compared to free trade from imports. Furthermore, the very perishable nature of the end product, raw milk, when produced in a tropical climate, often with minimal milking hygiene, dramatically influences its end use as fresh, chilled, dried or frozen dairy products.

20.2.12 Demonstration or model farms

To improve adoption of better feeding practices, greater use could be made of model farms. Virtually every day small holder farmers deliver their raw milk to milk collection centres. Such centres, whether run by cooperatives or milk processors, could establish a model farm to extend the principles of good farming practice, such as improved forage agronomy, ration formulation for milking cows, calf and heifer rearing, milking hygiene and other aspects of herd management. Ideally, the model farm should be similar in herd size and forage production area to those in the area from where the milk is sourced.

For example, simple field trials could be set up, such as using fertiliser strips (see Chapter 8) to visually demonstrate yield responses to inorganic fertilisers. Associated data collection and feed analyses could quantify the additional nutrients which could then be followed up with economic analyses to allow farmers to decide for themselves whether to try such practices on their own farms. Similarly, various milking rations could be formulated for comparisons of profit margins, using milk income less feed cost, and to explain the concept of marginal cost of production. With thorough data collection, an entire economic analyses, such as those described in Vietnam (in Chapter 17), could be undertaken to provide guidelines for future policies on rural development in the region. Collaborative studies could be undertaken with government and university dairy researchers, who are usually very short of research facilities, in a more controlled environment than a commercial small holder farm.

Such farms would provide excellent opportunities to evaluate different shed designs and cooling systems, such as those described in Chapter 19. For example, using local materials to construct sheds of various roof heights, insulation materials and internal plans, appraisals could be made of the number of years for such costs to be returned through improved cow milk and reproductive performance.

Not only would these ventures increase the credibility of the milk processors in the area, they could also attract new suppliers to improve their milk quality and daily throughput. Such a venture may even attract additional support from agribusiness, government or even international funding agencies, providing a 'win-win' situation for all those involved in such technology transfer and adoption.

20.2.13 Minimising complexities in feeding management

Not only must farmers work harder to intensify their small holdings, they must also work smarter to comprehend the many new technologies being thrust upon them. Poor adoption rates are often due to the complexities of these new technologies. The policy makers and advisers must fully understand them before they can expect farmers to want to incorporate them into their systems. For example, Multiple Ovulation and Embryo Transfer (MOET) is a technology hardly adopted by western farmers, primarily because the high cost hardly justifies the investment, except possibly for stud farmers who sell pedigree cows, an elite product, rather than raw milk, a bulk commodity. Nevertheless some developing countries (eg China) have taken up MOET, then finding it requires a more sophisticated level of herd and feeding management than exists there.

Many of the 'new' feeding technologies, such as chemically treated rice straw, molasses urea blocks and even silage making, have poor adoption rates because of the extra skills required or the extra time input required. Inorganic fertilisers are also slow to be adopted, presumably because farmers do not believe the extra costs are returned in extra milk. Cassava hay (see Section 20.3) is a new technology but since it requires field curing of the forage to remove the hydrocyanic acid, it requires greater time input. Feeding out formulated concentrates is much simpler than purchasing the raw ingredients and mixing them prior to feeding, even though this practice may save money and allow greater flexibility in supplementary feeding programs.

Generally speaking farmers do not like to double handle forages, just harvest it fresh then feed it directly to their stock. The catchcry with new technology is 'KIS', or 'keep it simple'.

20.2.14 The role for forage legumes

Many benefits are claimed for forage tree legumes. Apart from their value for livestock, they are recognised for their contributions to farming systems, the welfare of rural populations and the protection of the environment (Shelton and Gutteridge 1994). Adoption remains unsatisfactory despite years of promotion. Many reasons have been put forward for the poor levels of uptake, such as lack of understanding of specific needs of farmers and of their socioeconomic environment and mismatches between the environmental goals of development organisations and personal goals of farmers.

There is often inappropriate planting material and support infrastructure provided. Uptake could be advanced, firstly through raising awareness (through workshops and farmer-orientated publications) then secondly, working on-farm where any important social (risks, relevance, labour) and economic (incentives, markets, returns) constraints can be identified and overcome.

There are several examples of successful alley cropping of *Gliricidea* and *Leucaena* on dairy research and farmer training centres in Indonesia, where both fresh and ensiled forages supplement Napier grass. However, to date, there has been little adoption by surrounding small holder dairy farmers.

Forage legumes such as lucerne, berseem or cowpea have a role when undersown into, or sown in rotation with or as a fallow crop, to food crops. They can be exclusive within animal production systems, such as fodder banks and grass legume mixtures, or they can be a component of crop–animal systems providing feeds and improving soil fertility hence food crop yields (Devendra 2001b). Forage legumes also have a role as cover crops in tree plantations, such as oil palm, rubber and coconut, as a means of integrating animals into such systems. Furthermore, they reduce weeds, control erosion and improve soil physical and chemical properties to the benefit of the plantation crop.

As discussed in previous chapters, legumes can significantly improve milk yields and reproductive performance through increases in appetite, digestibility, provision of additional rumen degradable, bypass protein and minerals. These benefits are complemented through reduced feed costs, compared to other protein sources.

20.2.15 An alternative approach to developing feeding systems

The Metabolisable Energy system is considered by many as the most up to date, practical system for describing energy requirements of ruminants, on which to base feeding systems. In most countries, it has replaced the Total Digestible Nutrients (TDN) system for reasons discussed in Chapter 4. In the search for the 'perfect' feeding system, which has been going on for over a century, other systems are being tried and tested.

Researchers working with dairy cows in the humid tropics of Central America have questioned the validity of the Metabolisable Energy system in predicting milk responses to molasses and sugarcane based diets (Preston and Leng 1987). They argue that feeding systems should be based on the principles of:

- maximising rumen function by providing nutrients required by rumen microbes and supplying small amounts of readily digestible fibre
- optimising the balance of nutrients for metabolism through bypass nutrients (eg undegradable dietary protein and bypass starch)
- increasing potential intake of nutrients through improved digestibility
- optimising the balance of minerals through strategic supplementation.

This approach places less emphasis on laboratory and more on actual livestock measurements. In summary, its quantification involves:

- measuring the disappearance of test feeds placed inside small nylon bags that are then inserted inside cows rumens
- feeding small groups of livestock with the test feeds and recording voluntary feed intake

- taking a sample of rumen liqueur and analysing it for ammonia concentration, to assess the adequacy of rumen degradable protein
- feeding livestock with the test feed with and without supplements providing additional undegradable dietary protein to test the adequacy of bypass protein.

Such an approach may not describe the nutritive value of a particular feed or the animals requirements, however it should lead to the development of feeding systems incorporating supplements to ensure more efficient rumen utilisation, hence feed efficiency and/or animal performance.

Quantifying feed intake potential

A similar concern has been expressed by Professor Ørskov of Macaulay Research Institute in Scotland (Ørskov 2002), who considers that current feeding systems may be good for rapidly digested concentrates but do not work well for roughages, particularly those of low quality. A good feed evaluation system should provide farmers with not only an indication of the exchange rate of feeds, but also any feed intake limitations. Developing a measure of intake potential, rather than just feed value (expressed as ME or TDN), would provide a basis on which to match feed potential and animal potential. In other words, it would allow farmers to decide on the most appropriate production systems in different regions to match their feed resources.

Ørskov (2002) uses modern tropical dairying as one example of an unsuitable high potential system. Importing Friesian cows into the humid tropics, where the quality of feed resources often falls far short of enabling these stock to meet their production potential, has all too frequently led to reduced performance (milk and reproduction), poorer disease resistance and their eventual culling from the milking herd. Therefore if the genotype does not match the feeding system, the feeding system should be changed to fit the genotype, in this case by only using better quality feeds for such high genetic merit stock.

Such a feed intake index could indicate whether animals can only consume sufficient for maintenance or additional for production. The index should vary with animal type, such as for buffaloes with their larger rumen volume, and for feeds with specific characteristics, such as anti-nutritional factors limiting appetite. The index could be based on a simple laboratory test such as the rate of gas production when feeds are incubated in a test tube with rumen liqueur. Ørskov's research team (2002) found this measure was closely related to feed intake and growth rate in lambs.

20.3 Cassava–cowpea rotation: An innovative dairy feeding system

Since the 1990s, Professor Metha Wanapat and his team at Khon Kaen University in north-eastern Thailand have been developing dairy feeding systems based on cassava and cowpea hays (Wanapat 1999).

Cassava or tapioca (*Manihot esculenta*) is an annual tuber crop widely grown in tropical regions. It can easily thrive in sandy-loam soils with low organic matter, receiving low rainfall and high temperature. The roots (tubers) are an important cash crop for exporting to livestock feed importing countries, such as Netherlands. A by-product of cassava, their leaves, can be collected from the lower 50% to 60% of the plant, yielding 470 kg fresh/ha or 160 kg DM/ha, without adversely affecting tuber yield. The leaves can be collected every 9 to 10 weeks, allowing two collections during each dry season. About 6 kg fresh (or 2 kg sun dried) leaves can be collected each hour. The leaves are protein rich (up to 25%) with the tannin increasing the proportion that escapes rumen digestion. Cassava leaves do, however, contain high levels of hydrocyanic acid (HCN), a compound toxic to livestock, although sun drying the leaves does reduce hydrocyanic acid levels.

Planting the crop in rows using stems with 30 cm × 30 cm spacing, and harvesting after three months (and then 5 times every 2 mths) by cutting the whole plant at 15 cm above ground yields 11.8 t DM/ha per year. *Leucaena* can also be densely planted in strips (1 m wide and 20 strips /ha) to help fix soil nitrogen. The fresh cassava forage can be left in the field for 1 to 3 days before being collected and made into a 15 kg bale. This bale should be further sun dried to 80% to 90% DM to reduce hydrocyanic acid content and/or sprinkled with 0.5% urea solution to prevent mould growth.

Professor Wanapat's team found the hay contained 24.9% CP and 44% NDF with a dry matter digestibility of 71%, equivalent to 10.1 MJ of ME/kg DM. Voluntary intake was 3.2% LWT, equivalent to 500 kg cow consuming 16 kg DM/d. Milk thiocyanate levels were increased, which could reduce the rate of milk deterioration by activating lactoperidoxidase (a naturally occurring milk enzyme). The condensed tannin in the cassava leaves was found to increase the populations of rumen bacteria and protozoa (ie enhance rumen ecology) and also reduce the faecal excretion of gastrointestinal nematode eggs. Hence, cassava leaves provide more than just feed nutrients, in that they can improve milk quality, through reducing bacterial contamination post-harvest, and reduce worm infestations (Wanapat 1999).

In two feeding trials, cassava hay replaced concentrates as supplements to cows fed a basal ration of urea-treated rice straw. In the first trial, cows had 0%, 15% and 30% cassava hay in the concentrate mix, fed at the rate of 6 to 8 kg/cow per day. They produced 14.2, 15.7 and 14.9 L/d, respectively, of 3.5% fat corrected milk, with the higher level of cassava hay feeding leading to higher milk fat and protein contents.

In the second trial, cows were fed increasing amounts of cassava hay to partially replace the concentrate mix, producing 12.6 L milk/cow per day on each feeding level; again the highest level of cassava hay feeding produced milk with higher milk fat and protein levels. Therefore, cassava hay can replace some of the concentrate in milking diets without adversely affecting cow performance.

Cassava hay was a more profitable feed as well. With milk returning 11.2 Thai Bt/L, and the concentrate and cassava hay costing 6.0 and 0.5 Bt/kg, respectively, the milk income less feed cost increased from 80 to 116 to 122 Bt/cow per day as cassava hay feeding increased from 0 to 2.8 to 4 kg/cow per day.

Cowpea (*Vigna unguilata*) can be grown as a rotation crop together with the cassava, thus providing additional legume hay to contribute to the home-grown forage base. Cowpea, being a legume crop, will also fix atmospheric nitrogen into the soil, providing as much as 70 to 80 kg N/ha per crop.

These feeding systems have recently been evaluated on 24 farms in North-East Thailand over 60 days in the dry season (Petlum *et al.* 2004). Their results confirmed higher milk yields (13.8 v 12.1 L/cow per day) and higher milk fat contents (3.6% v 3.0%)

when 2 kg/cow per day cassava hay replaced some of the cowpea and *Stylosanthes* hay. On-farm yields of cassava hay averaged 6.8 t DM/ha (Petlum *et al*. 2004) and the level of concentrate fed to the cows was not reported.

20.4 Research priorities in tropical dairy nutrition

20.4.1 An inventory for dairy research in the humid tropics

Chantalakhana (1999) categorised factors limiting farm productivity in the humid tropics into:

- institutional factors, such as dairy cooperatives, suppliers of credit, training, extension services
- government policies, such as development programs, milk promotion, dairy boards
- socioeconomic factors, such as farmer education, off-farm jobs, traditional beliefs
- technical factors, which can be further categorised into feeding, breeding, health
- post-farm gate factors, such as milk processing, marketing and consumption.

He identified the scarcity of good quality forages during the dry or summer season as the most important nutritional problem since most farmers must use whatever is available, sometimes at very high price. Such sources consist of agricultural fibrous residues by-products (eg rice straw, maize stover, soybean stems, pineapple peel, sugarcane tops) and forages or fodder leaves, either produced on-farm or collected from outside the farm.

Further research is required to document the nutritive value of fibrous residues by-products and to develop the logistics to collect, store and feed them in sufficient amounts to provide sufficient supplemental feed for milk production. There is also a need to adapt current hay and silage making systems to small holder operations to conserve forages when required, from one season to another.

A further limiting factor identified by Chantalakhana (1999) was the need to understand the nutrient requirements of, and to develop feeding standards for, tropical dairy cattle. This would allow the formulation of the most suitable and economic rations for small holder cattle in the range of climatic environments encountered in the tropics.

The non-conventional feed source was another area requiring further research into the quality and methods of utilisation. Such feeds include by-products from soybean product factories, oil palm cake and other agro-industrial operations.

Finally Chantalaknana (1999) identified mineral deficiencies adversely affecting milk production and reproduction as key issues, with the need to formulate mineral supplements to prevent deficiencies due to poor quality roughages.

It is one thing researching a problem. If a solution can be found, it is another thing for it to be adopted by the farmers with that problem. The term ‘appropriate technology’ was developed to describe practical solutions to problems that could be readily accepted, hence undertaken by farmers, particularly traditional ones with minimal resources. Chantalaknana (1999) listed some examples of adoption rate of improved management practices by small holder dairy farmers in Thailand. For nutrition-related technology, there is:

- straw chemical treatment, 0% to 1%
- mineral blocks, 0% to 1%
- pasture, 0% to 1%

- fodder/forage, 11% to 50%
- concentrate supplements (presumably mineral additives), 0% to 1%.

Such poor adoption rates were also highlighted by Shamsuddin *et al.* (2003) who considered throughout South-East Asia that treatment of rice straw with urea was technologically unsuitable for resource-poor farmers while the many attempts to introduce molasses-urea blocks have been unsuccessful in the farmers' communities. Clearly for several reasons, these feeding management innovations should be queried as being 'appropriate technology'.

So why has there been so much research interest and attempted technology transfer over the last two decades in the chemical treatment of rice straw, yet small holder dairy farmers have failed to integrate it into their feeding systems? Might the answer simply be that the small improvement of its nutritive value hardly justifies the effort. Granted, it may have a role in feeding dry cows or young stock, but its potential to improve milk yields must be questioned. It may be a cheaper forage source, but the increased labour input through double handling the straw, into the stack and then into the feed trough, has been a barrier to its adoption.

For interest sake, Chantalakhana (1999) noted the following non-nutrition technologies that have been adopted by more than 1% of farmers:

- crossbreeding, 11% to 50%
- selection, 11% to 50%
- artificial insemination, 1% to 10%
- castration, >50%
- vaccination, 11% to 50%.

Perhaps the most perceptive comment made by Professor Chantalakhana was, 'Science has much to contribute to small holder dairy farming but to do so, researchers must be unusually adept at seeing the world from the farmer's vantage point'.

Figure 20.1 summarises the key priority areas with further research requirements in italics.

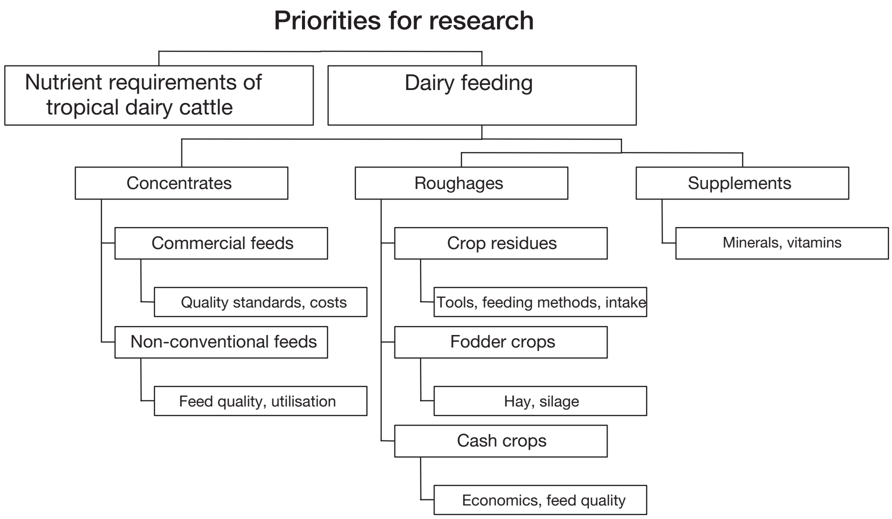


Figure 20.1 A summary of priority research areas in dairy nutrition (Chantalakhana 1999).

20.4.2 The goals for dairy research in the humid tropics

Throughout the world, livestock farmers differ in why they raise and milk dairy stock. Chapters 2 and 3 of this manual discuss many of the many benefits that small holder farmers in the peri-urban and rural areas of the humid tropics derive through dairying. These range from:

- sale of milk, meat and manure
- integration into their cropping systems
- improving the nutritional welfare of their children
- providing employment for their neighbourhood
- providing income for landless farmers
- providing regional industrial development through post-farm gate milk handling and processing
- contributing to social and cultural activities, such as material security and dowries for daughters.

In contrast, dairy farmers from the developed, temperate countries would have income generation from the sale of milk and dairy beef as their major (and often only) objective.

Consequently the goals for dairy research in the humid tropics should also differ to those in temperate countries. With essentially subsistence farmers, such research should be driven towards risk minimisation, whereas in fact most of this research, being conducted by western trained scientists, is directed towards the market orientated dairy systems of free market economies. The objective of much of this research is to increase efficiency and profitability of resource use. Granted this is also relevant to development of the business skills of small holder tropical farmers, but what other goals should tropical dairy specialists have in their research proposals?

Ørskov (2002) has succinctly compared the research strategies and methodologies of these two different research philosophies, as presented in Table 20.3.

Table 20.3 Research goals for market orientated and subsistence dairy production systems
(Source: Ørskov 2002)

Research goals	Market orientated systems	Subsistence systems
Farmer's goal	Profit maximisation Cash generation Productivity	Risk minimisation Family support Stability and sustainability
Scientist role	Design of systems	Management of ecosystem
Intermediate targets	Genetic homogeneity Increased productionpotential Single purpose animals Nutrient mobilisation	Biological diversity Improved maintenancepotential Multi purpose animals Nutrient storage
Philosophical approach	Specific	Holistic
Scientific approach	Single discipline	Multi and trans discipline
Statistical emphasis	Mean Main effects	Variance Interactions

With risk minimisation being the major goal for dairy researchers in the humid tropics, an analysis of risk minimisation has been presented in Table 20.4. The management of risk involves planning for the unexpected that could drastically reduce the farm's profitability, hence its long-term viability or at worst, decimate the farm (eg an outbreak of virulent disease or zero reproductive performance). Table 20.4 presents the likelihood of various risks impacting on the farm, the ability of the farmer to address the problem, the strategy to rectify it and the chapter in this manual in which this is discussed.

Table 20.4 Analyses of risk minimisation for tropical small holder dairy farmers
The last column lists the Chapter (Chap) in this manual in which the risk is discussed.

Ease of influencing	Risk	Likelihood of occurrence	Strategy to rectify risk	Chap
Difficult	Adverse climate	High	Cannot be overcome	–
Outside farmer control	Poor industry infrastructure	Moderate	Government policy and investment	2, 3
	Uncertain industry future in region	?	Government policy	–
	Poor industry technical support	Moderate	Government training programs	1
Probable	Inappropriate breed	Moderate	Government support	19
Farmer has some influence	Low base milk price	Moderate	Government, agribusiness & cooperative negotiations	17
	Poor dairy genetic merit	Moderate	Government importation programs	19
	Low post-farm gate milk quality	Moderate	Cooperative infrastructure	17
Possible	Low farm income	Moderate	Feeding and herd management	17
Farmer has great influence	Inadequate water	Moderate	Farm development	6
	Poor forage quality	High	Agronomic practices	8
	Low forage availability	High	Farm development	8
	Poor concentrate quality	Moderate	Cooperative program	11
	Low concentrate feeding	Moderate	Feeding management	11
	Adverse diseases	Moderate	Herd management & cooperative programs	13
	Low farm milk price	Moderate	Feeding management	17
	Poor milk composition	Moderate	Improved feeding	14
	Poor on-farm milk quality	Moderate	Improved hygiene	17
	Inefficient effluent system	Moderate	Facilities and herd management	19
	Adverse heat stress	High	Shed design and herd management	19
	Poor reproductive performance	Moderate	Herd management	15
	High cost of production	Moderate	Farmer management skills	17
	Poor young stock performance	Moderate	Feeding management	16
	Low farm profitability	Moderate	Farm and herd management	17
	Increased farm investments	Moderate	Cooperative advice	–

Most of the on-farm risks over which farmers have great influence have a moderate to high likelihood of occurring and also have some nutritional basis. Many of the actions to rectify each problem are discussed in this manual, although some not in great detail.

With regards modifying herd and farm management to minimise risk, some of the actions not specifically discussed in this manual include:

- minimising the number of milking cows that are non pregnant and not lactating as these animals will not contribute to farm incomes for many months
- ensuring sufficient replacement heifers are reared, at least 20% of the milking herd
- initiating simple recording systems for the most useful economic measures such as daily milk yields per cow, when cows calved and showed heats, veterinary and medicine treatments of sick stock
- developing an annual feed budget (for both forages and concentrates) and plan to purchase feeds well in advance of when they are needed
- prioritising farm investment, for example, develop forage production areas and sheds before purchasing 'superior', higher genetic merit stock
- concentrating efforts on low cost management practices that return the most in milk income, such as providing hot water for washing and sterilising milk handling equipment
- becoming an active member of farmer cooperatives, since their farm management and profits can greatly benefit through more effective services
- becoming an information seeker, both male and female farming partners, and making full use of what sources of technical information are provided by government, cooperatives and agribusiness – many of them are free
- investing in farm infrastructure requires professional support, which should be sought via cooperative management
- farmers being forced to increase farm outputs, due to farm costs increasing and the likelihood of milk returns not increasing; hence farmers must intensify their production systems just to remain viable.

20.5 Improving current dairy feeding systems in the humid tropics

To improve current feeding management, it should be viewed in a farming system perspective (Devendra 2001a). The following prerequisites are important:

- knowledge of the availability of the totality of feeds (forages, crop residues, agro-industrial by-products, non-conventional feed resources) throughout the year
- synchronise their availability with herd requirements
- assess the extent to surpluses and feed deficits
- develop strategies to cope with the shortfalls
- increase feed production, such as multipurpose tree legumes and development of food-feed systems
- justify purchasing concentrates, either as ingredients or already formulated, and prioritise their use with different types of dairy stock and at different times of the year
- develop feed conservation measures to reduce seasonal variability in on farm forage supplies
- strategically supplement for milk production, especially during dry seasons.

These prerequisites need to be considered in holistic terms to maximise efficiencies of feed resource use. In the absence of such a holistic focus, research and development concerning feed resource use will continue to be a piecemeal approach, mainly component technology intervention with variable success (see also Table 20.3).

Ruminant production systems are unlikely to change in the foreseeable future. New proposed systems and returns from them would therefore have to be demonstrably superior and supported by massive capital input and other resources. However, Devendra (2001a) considers that there will be increasing and predictable intensification and a shift within production systems. This is increasingly likely with decreasing availability of arable land. The major objective for improved feeding and nutrition should then be to maximise the use of available feed resources, such as crop residues and low quality roughages. Unfortunately their potential to intensify small holder dairy systems is limited.

During the recent Asian economic crisis, the small holder dairy farms that collapsed were those dependent on imported feeds, notably maize and supplements. Good profits still accrued from systems based on indigenous feeds. Therefore, approaches to promote and maximum their use and self-reliance are essential for the long-term viability of small holder livestock farming.

Unfortunately much of the improvements in small holder dairy production through crossbreeding and interventions with nutrition and health have been supply driven, without farmer participation, and on government experiment stations. Many of these have been seldom adopted, mainly because there was a lack of farming systems perspective. This has led to incomplete awareness, hence consideration, of the important interactions between nutrition, genotype and disease. In addition the interactions between animals and crop production have been underinvestigated, given that most dairy animals are found on mixed farms (Devendra 2001a).

Much of current small holder dairying is found in irrigated areas, where land is already overused. Opportunities exist for expansion into rain-fed lowland areas where soil moisture, hence crop production, is relatively high. Within Asia, 82% of the available land is rain-fed with much of that in subhumid zones, where over 50% of the large and small ruminant animals are located. Poverty is all too common in these areas while natural resource degradation is intense.

The close link between small holder dairying and urban development, resulting from community awareness of the nutritional and health benefits of dairy products, should benefit resource-poor farmers. Of all the livestock industries, dairying has the largest 'multipier effect' in that every dollar generated on farm from milk production generates more dollars post-farm gate than for meat, fibre and egg production. The income generated by such farmers provides many employment opportunities, hence additional income:

- post-farm gate through the handling, storage and processing of raw milk then
- post processing plant through cooperative and government support and the frequent distribution of dairy products to consumers.

The role of dairy cattle in integrated farming systems is often overlooked by dairy specialists. Small holders may not consider becoming primarily dairy producers until they find an assured market yielding a reliable income. Many still prefer to integrate their dairy enterprise with other farming activities. This creates efficiencies in family labour usage, use of residues and farm recycling. Small holders should then view their dairy cows as fertiliser producers, potential power supply for cultivation, companions, users of easily grown or procured fodder, a self-replacing crop, saleable assets from time to time, an acceptable livestock enterprise, and various other modes (Devendra 1999). Such an integrated approach then creates a complex enterprise requiring a better understanding of the interactions with other socioeconomic aspects of small holder farming.

There is no other system of tropical agriculture that allows virtually landless farmers the opportunity to generate a substantial daily income through harvesting wasted forage from the roadside, rice paddies or plantations, particularly there is government support through credit schemes for supplying livestock. Their integration into dairy cooperatives provides further services, such as veterinary, artificial insemination and formulated concentrates, and can guarantee good farmer returns. Nutrient transfer via cow manure improves crop yields while integrated management of natural resources ensures a more sustainable industry.

The major limiting factor when feeding dairy cows on small holder farms in the humid tropics is, and will be for many years, the supply, intake and utilisation for dietary energy. Unfortunately there is no such thing a 'magic bullet' with regards improving milk responses or feed efficiency, meaning that there are no short cuts to improving the feeding management of dairy cows. Production response to such feed additives (specific vitamins or minerals), rumen modifiers or other single action supplements depend largely on the nutritional well being of the rumen microflora, the blood metabolites and the mammary gland. These are largely influenced by the major feed nutrients – water, energy, protein and fibre – in that order.

Basically improving the profitability of small holder dairying, as quantified by milk income less feeding costs, can only be achieved through following the basic principles described in this manual. Such improvements are incremental, depending on current feeding management skills.

In the dairy industries of most Western countries, environmental sustainability is becoming a major concern of legislators, government and practitioners in research, development and extension. This has yet to happen in the humid tropics and hopefully it will also occur and in the not too-distant future. But to quote a new catchcry, 'it is hard to be green when you are in the red'. Such an excuse is likely to delay these concerns in South-East Asia.

20.6 Future directions for small holder dairy production in the humid tropics

The following are some of the key issues in feeding management that require further attention at both the research and extension levels (Moran 2004):

Feed nutrients

- As forage supplies are of paramount importance, cost effective, year-round and sustainable supplies of quality roughages must be developed for every system of small holder dairy farming.

- Because dry season forages are poorer in nutritive value, conserved excess wet season forages often form the basis of most profitable dairy systems.
- Tropical forages are high in fibre, so farmers will always require concentrate supplements.
- Energy will continue to be the major limiting feed nutrient in small holder dairying. Improving the energy status of milking cows will be of benefit to both the production of milk and milk solids and a regular supply of calves.
- Home-grown forages will almost always be cheaper sources of feed nutrients than purchased forages, particularly when managed to provide optimum yields and quality.

Feeding management

- The high nutrient demands of milking cows negates many of the recommended feeding systems based on chemically treated low quality roughages.
- Agro-industrial by-products will always form the basis of concentrate supplements, because of increasing demand for land to grow crops for human consumption.
- With continuing emphasis on increasing the domestic milk production in all South-East Asian countries, it is important not to 'overstock' any developing dairy region. Feed audits, particularly of 'home-grown' forage supplies, should be undertaken and adhered to when projecting optimum numbers of dairy stock for any particular region.
- In addition to encouraging farmers to improve agronomic practices on their own small holder farms, 'home-grown' forages can be produced on communal areas, utilising the expertise of cooperative staff to oversee management to optimise fertilising, harvesting and, if necessary, conservation of quality forages for use by nearby farmers. If there are economic justification for cooperatives to bulk purchase ingredients and formulate concentrates, similar benefits could arise with managing forage production areas.
- High yielding cows are very susceptible to heat stress. Every effort should be made to alleviate the adverse effects of heat stress on appetite, fertility, hence milk production and profitability.
- An underutilised measure of feeding management is the persistency of the lactation curve. It is one thing to feed for high peak yields, but it is just as important for good milk yields to be maintained throughout the lactation. Farmers should feed cows to allow milk yields to fall by no more than 10% from peak yield per month.

Other issues

- There is little sense in importing 'improved genetics' or growing out bigger heifers if they cannot be fed well when milking.
- Dairying is a business, so feeding decisions should be based on logical and appropriate economic information with 'milk income above feed costs' being the single most useful measure of success.
- Improving the knowledge of basic ruminant nutrition will greatly assist many dairy advisers to formulate more profitable milking rations, because generic recipes are notoriously unreliable.

- Farm development is often limited by inefficient (and even inappropriate) technology transfer, in that extension procedures do not always acknowledge farmer skills and adult learning principles.

Concern is often expressed that most countries in South-East Asia are not in a position to develop large scale intensive livestock industries without the importation of feed stuffs. This certainly applies to pig and poultry but for dairying, another relatively intensive industry, the future is not for large farms requiring high tonnages of fresh forages and imported concentrates. Unlike Europe, North America and Australasia, where dairying evolved from small holders to larger and often corporate farms, I believe the future for dairying in South-East Asia is with the small holder sector. For these systems, fresh quality forages can be sourced close by while local by-products will form the bulk of concentrates.

Even in one of the most densely populated island in the world, Java, there are large tracts of underutilised land such as forest plantations and aging coffee and rubber plantations, where small holder dairy farmers can freely harvest limited amounts of forage for their stock. In recognising their potential, Indonesian policy makers place high priority in developing such resources through providing greater access to farmers and plantings of improved forage species (Burrell and Moran 2004). With better feeding management skills, small holder farmers can profitably increase raw milk supplies, to the nutritional benefits of their fellow consumers and the improved food security of their nations.