# Assessment of Technical and Socioeconomical Feeding Practices in Semiarid and Arid Areas in North India (Haryana), and Implications for Dairy Rural Development

V. Alary[1*] D. Teynier[1] S. Messad[1]
P. Lecomte[1] B. Barbier[2]



***Keywords***

Dairy cattle – Farming system – Animal feeding – Milk – Productivity – Work organization – Role of women – India.

***Summary***

To satisfy Indian consumers' rising demand for milk products, Indian breeders will have to boost their production rapidly, especially through improved feeding practices. Many experts point out that currently used crop by-products will not be sufficient to meet increasing feed requirements from cow and buffalo herds and that it will be necessary to turn to grains such as wheat and maize. But other experts think that grain will not be enough and that the increasing animal consumption of grain will affect human consumption, unless India decides on massive grain imports, putting pressure on the world grain market. The present survey carried out in two districts of Haryana showed that grain was not an essential feed for cattle and buffaloes, and that improving cotton and mustard by-products, and green fodder had great potential. A second finding was that wealthier farmers tended to underuse the genetic potential of milk cows and buffaloes. Moreover, biotechnical management of the herd, in particular the feeding system, was closely related to the socioeconomic management of the family farming system; family strategies aimed at ensuring sufficient milk production for the family in larger farms and to provide a regular income in smaller ones. This paper also stressed out the need to design, implement, and monitor development programs that integrate sociocultural and, especially, gender issues, to facilitate technological innovation with respect to forage storage.

## ■ INTRODUCTION

Since the end of the 1990s, India has become the world first producer of milk, before the United State, with a production close to 74 million tons in 1998 [92 million in 2004 (13)]. Over the period 1973-1995, the average daily availability of milk per inhabitant increased from 112 g (1973-74) to 194 (1994-95)**. This performance is partially the result of Operation Floods, launched by the National Dairy Development Board (NDDB) in the 1970s. NDDB has been created and managed by Dr Kurien since 1970-71, after the success of the Kheda District Cooperative Milk Producers' Union in Gujarat State where farmers decided to sell milk themselves and bypassed middlemen. Today NDDB counts more than 9.7 millions of producers and 75,000 societies at the village level. NDDB is in charge of collecting and transforming milk, and ensures different services to the farmers (veterinary and social services, feed supply or advice, etc.). This is the achievement of numerous technical and organizational efforts to tap a scattered supply system and make the product accessible to the urban population. These achievements have been obtained on farms that register very low animal performance.

1. Cirad, UPR Systèmes d'élevage et produits animaux, Montpellier, F-34398 France.
2. Cirad, UMR Gestion de l'eau, acteurs et usages, Montpellier, F-34398 France.
* Corresponding Author
Cirad, UPR Systèmes d'élevage et produits animaux, TA 30/A, Campus international de Baillarguet, 34398 Montpellier Cedex 5, F-34398 France.

** Ministry of Agriculture, Department of Animal Husbandry and Dairying, New Delhi

India, along with China and Latin America, has today the fastest milk production expansion (12) with a growth rate expected to reach around 3% in 2007 (13). This expansion is mainly boosted by the rapid domestic demand (boosted by the income growth) and demographic growth.

In the Indian context, dairy production helped improve millions of small farmers' diet, generated income, created savings and provided security for the poorer section of the rural population. In spite of this spectacular increase, the milk supply hardly ensures one fourth of the minimum protein recommendation per inhabitant (according to FAO) and increase in milk production constitutes a major challenge in a country with a fast growing population, which is mainly vegetarian. According to India's National Sample Survey Organization in 1994, the population with a low purchasing power, i.e. less than 458 rupees (Rs)/month/inhabitant (17), grows by 2.1% per year.

But, for the last two decades, the main increase in milk production is due to the livestock population increase. Around 300 million buffaloes and cows produce each around 2-3 L/day, against 20 in developed countries, and milk productivity *per se* has not shown a spectacular increase. Many factors explain this low productivity: feeding, health, management, the agroclimatic environment, socioeconomic factors like labor, and sale opportunity. Feed shortage is considered to be the main challenge for the future decades in developing countries (7). Since the 1990s, NDDB has reinforced feeding systems by making access to concentrates easier through village societies, by developing new techniques of feed conservation and by training communities.

In this study the authors focused on the trans-Gangetic zone, the major grain production area of India, which covers the states of Haryana, Punjab, Delhi and some districts of Rajasthan and Uttar Pradesh (16). In this area, milk production represented already 20% of the national production and was increasing in 2000. The region and Bombay hinterland are the only areas to have a positive availability of forage per animal thanks to rice and wheat crop residues. The objective was to understand feeding practices and identify the main factors that explain low productivity by examining both biotechnical and socioeconomical management strategies. What is the balance between producing milk for home consumption and for sale? Is there a link between the feeding system and milk use? What is the importance of non-market functions?

## ■ MATERIALS AND METHODS

A sampling procedure and questionnaire was designed to characterize determinants of feeding practices in two villages from a database of 90 farmers surveyed in 13 villages of two districts in Haryana in 1998-99. The selection of the state and different districts was based on agroclimatic considerations (4), combining pedoclimatic features (soil, climate, relief) with production systems and diversification.

The trans-Gangetic zone is one of the large agroclimatic zones with a cultivated area of 14.8 million hectares. In the 1990s, Punjab and Haryana provided 70% of the buffer stock of wheat and rice in the country and 16.6% of milk production (16). The state of Haryana is subdivided into three large zones: an arid zone, a semiarid zone and a subhumid zone that represent the main agroclimatic conditions of North India. In the large arid and semiarid zones, two main production systems dominate: 1) the "wheat and rice" system which is characteristic of semiarid areas and covers a large part of the alluvial zones in the north of India; and 2) the more diversified system comprising traditional food crops (millet, sorghum) and cash crops (cotton, rapeseed, mustard), which is characteristic of the arid zones of the rest of India. These two zones are also distinguished by their irrigation systems (presence of canal or not).

The two agroclimatic zones selected in Haryana (arid zone and semiarid zone) are subdivided into districts which are the administrative regions of the state (basic planning unit at the state level). In the semiarid zone represented by the district of Karnal, the wheat and rice system is intensive, characterized by high levels of fertilizers and irrigation from individual wells. Population density is about 355 inhab./km$^2$ and more than 87% of the land is cultivated. In the arid zone represented by the district of Hisar, the population density is 236 inhab./km$^2$ and the system is more diversified with wheat and some cash crops such as cotton, rapeseed and mustard. Irrigation is provided by canals, not wells.

Three surveys were conducted in two districts of Haryana State, Karnal and Hisar, in 1998, 1999 and 2000, respectively (1, 2, 7, 20). Ninety farms were surveyed in 13 villages in 1998. This survey identified five mixed farming systems in these two districts according to land size, main cropping and livestock systems, and the level of intensification. From this classification, a sample of 40 farmers was selected to focus on their feeding systems (2). The survey conducted in 1999 showed the importance of feeding systems as the main factor of the strategies of milk valuation (sale or self consumption). The survey conducted in 2000 included 30 farmers in two villages chosen in each district (Faridpur in Karnal District and Ludhas in Hisar District) to study milk production and feeding of 274 cows, and to understand the technical and socioeconomical parameters of dairy systems. This last survey constituted the main material for analyzing the biotechnical and socioeconomical determinants of the different feeding systems.

This survey was based on a questionnaire divided into three parts: 1) characteristics of the family and head of the family (including information on the involvement of family workers or paid workers in livestock management); 2) management of agricultural and off-farm activities at the household level; and 3) livestock management and performances. This third part included the reconstitution of monthly milk production and the composition of feed ration intake from May 1999 to June 2000. The data on milk yield and feed ration were collected per animal and based on the declarations of the farmers, validated with periodic measurements on milk production and feed intake performed randomly. Moreover with farmers' authorization, the authors were able to collect data on individual sales from the dairy society or private middlemen.

The monthly data on milk production and feeding systems collected over one year (May 1999 to June 2000) allowed a comparative analysis of the different feeding practices and milk performances between the different types of animals (local cow, crossbred and she-buffalo) and agroclimatic zones (semiarid and arid zones).

A multiple factorial analysis was used to describe simultaneously the cropping systems, the household structure and objective, and the main strategies concerning dairy activities at the farm level. It helped to analyze causal relationships or dependent effects between groups of variables that reflected one subsystem (socioeconomic or biotechnical) of the whole farm system (9, 11, 14). The analysis helped to interpret the main determinants of the feeding systems at the farm and household levels, and addressed the types of interrelations between the biotechnical and socioeconomic parameters, and the feeding systems.

## ■ RESULTS

### *Biotechnical management of the herd*

#### *Individual curve of lactation*

From the individual curves of lactation per animal, an average curve of lactation per category of animal and per zone was

estimated by a mathematical regression based on the principle of the minimization of the weight of the extreme points from the main scatter of points (5, 6). Three groups of curves were produced. The first group allowed comparison of daily milk production throughout lactation for each category of animals, namely B for she-buffalo, C for local cow and XB for crossed cow (Figure 1). The second group helped to compare daily milk production for the two zones, Karnal in the semiarid area and Hisar in the arid area (Figure 2). Finally, the third group compared simultaneously the curves of lactation by type of animal and by zone (Figure 3).

Most of the results confirmed common knowledge. Milk productivity in the state of Haryana exceeded the average productivity at the national level because buffaloes and crossbreds, well represented in this state, were more productive than local cows, and because the feeding was more abundant and of better quality. However, the comparative study between the different types of animals and agroclimatic zones in Haryana underlined differences in productivity.

Firstly, differences were observed in the lactation curves according to the types of animals (Figure 1). Crossbred cows produced more milk with a peak of lactation around 10 kg/day after four months, whereas milk production of she-buffaloes reached 9 kg/day and local cows 8 kg/day, both two or four months after calving. She-buffaloes reached their peak of lactation earlier than local cows and crossbred cows, but their milk productivity decreased faster than that of local cows or crossbreds. On average, annual milk productivity was around 2340 L for crossbreds, 2030 L for she-buffaloes, and 1899 for local cows.

Secondly and surprisingly, farmers from the arid zone registered higher milk performances (2462 L/animal/year on average) than farmers from the semiarid zone (2047 L/animal/year), which comprised a third of crossbreds. This result was mainly explained by the better milk performance of she-buffaloes in the arid zone (Hisar) compared to the semiarid zone (Karnal). Moreover, from the two curves of lactation per zone, the peak of lactation was not reached before the fourth month in Karnal, compared to the second month in Hisar.

How could one explain the difference in milk performance for she-buffaloes between the semiarid and the arid zones, when agroclimatic conditions in the semiarid zone were supposed to be as much advantageous to the cropping system as to livestock management?

***Characterization of the feeding systems***

The feeding systems in both zones were relatively complex because of the use of many products and by-products from the cropping system, the household system and the market. To simplify, the sources of feed were classified into six categories: dry feed, green feed, concentrates, grain, oil cake, and residues and scraps

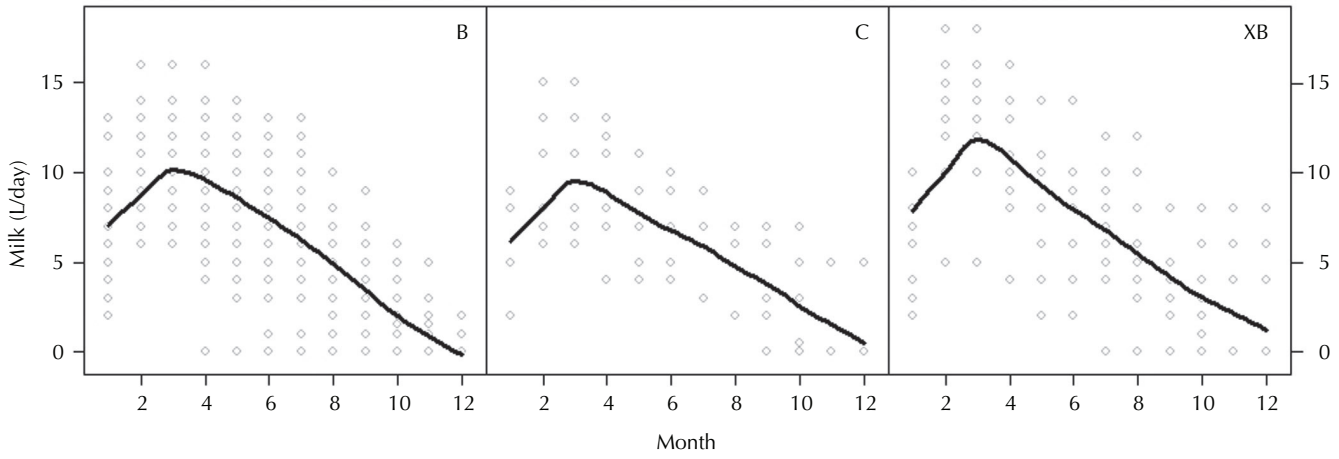


***Figure 1:*** *Comparison of curves of lactation between the different types of animals (C: local cow; B: she-buffalo; XB: crossbred).*

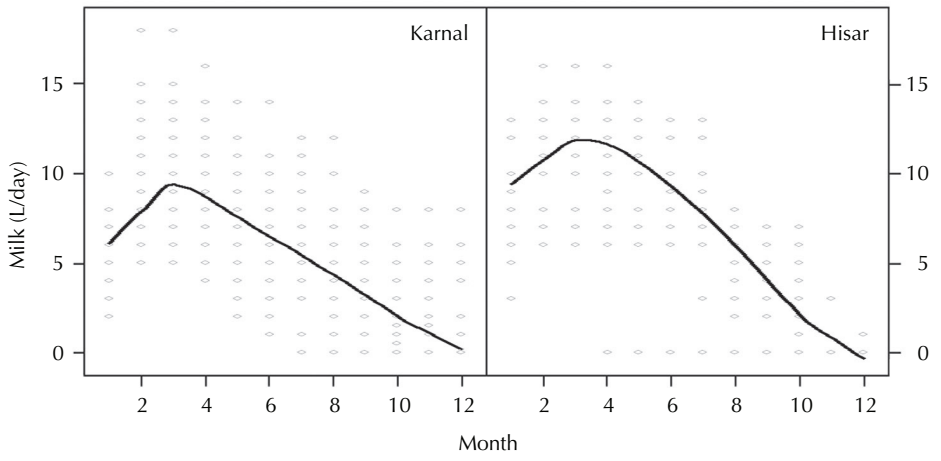


***Figure 2:*** *Comparison of curves of lactation between zones (Karnal in semiarid area and Hisar in arid area).*

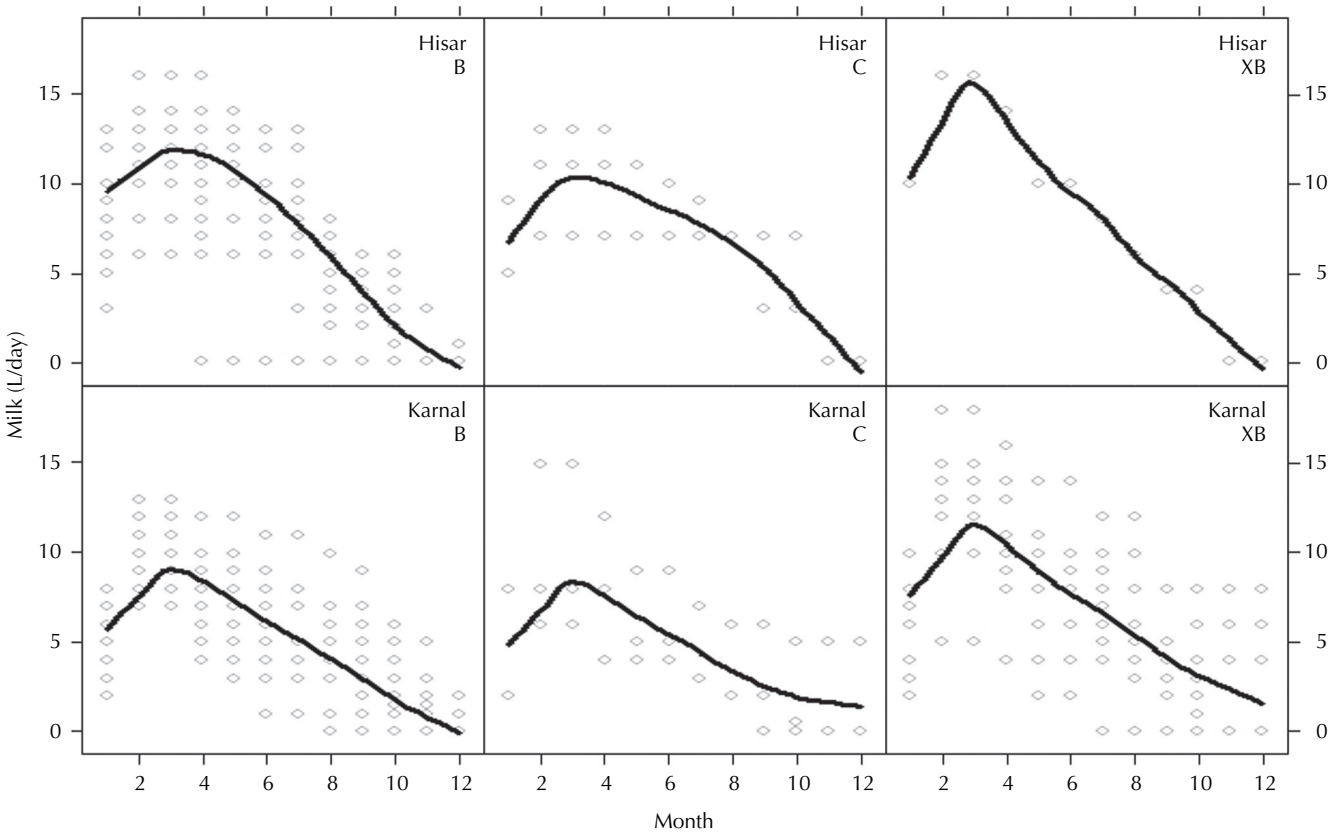


***Figure 3:*** *Comparison of curves of lactation between animal types and agroclimatic areas.*

(including milk, ghee, crop residues, peel of fruits and vegetables). In both zones, dry feed, mainly crop by-products such as straw and hay, represented 60% of the dry matter intake; green feed represented around 20%, while wheat grain, cotton and mustard seeds, and purchased concentrates represented less than 20% (with less than 3% for grain). Residues and scraps accounted for only 0.1% of the feed intake in both zones. Hypotheses proposing that the feeding system in India was mainly based on the residue of human consumption were not supported. Furthermore, grain, a very controversial issue, represented less than 3% of the ration, with an average of 2.4% (Table I).

The authors identified possible deficit in dry matter (DM), metabolic energy (ME), total digestible nutrient (TDN) and digestible crude protein (DCP) from the reconstitution of the nutritive value of the rations for each category of animals and each zone (Figures 4, 5, 6).

**Table I**

Sources of dry matter in the feed intake for the semiarid and arid zones (sample: 274 milk cows; 2000)

| | **Semiarid zone (Karnal) (%)** | **Arid zone (Hisar) (%)** |
|---|---|---|
| Dry fodder | 73.43 | 67.04 |
| Green fodder | 20.32 | 24.26 |
| Concentrate | 1.4 | 0.17 |
| Oil | 2.72 | 5.65 |
| Grain | 1.89 | 2.85 |
| Residue and scraps | 0.24 | 0.03 |

They compared the feed intake with recommendations established by the Indian research for the different types of animals (3, 15, 18). Feed recommendations were established for a certain level of milk productivity with a minimum fat percentage of 4%. The maximum values of recommendations were based on the level of the peak of lactation: 9, 8 and 10 L/day for she-buffaloes, local cows and crossbreds, respectively. The minimum values of recommendations were based on the average milk productivity observed in the survey: 6, 5 and 7 L/day for she-buffaloes, local cows and crossbreds, respectively. Recommended values only concerned the lactation period and excluded the periods of drying up and gestation.

The results showed that feeding management was more adequate in the arid zone than in the semiarid zone. In the arid zone, breeders rightly focused on the first two months of lactation that determine partially the performance for all the lactation.

With regard to she-buffaloes, the dry matter content of the feed ration was very high in the arid zone during the first two months and was quite stable from the fourth month to the end of the lactation. If the TDN content covered minimum requirements during all the lactation period, DCP and EM contents were below the minimum level during the major part of the lactation. In the semiarid zone, the nutrient content of the ration was very low and stayed below minimum requirements in terms of energy or protein. In summary, requirements in DCP were not ensured in any of the zones although the breeders of the arid zone registered a lower deficit thanks to the complementation with mustard seed, cotton cake and cotton seeds. The TDN deficit in the semiarid zone could be explained by the lower content of grain in the ration. According to the database, the breeders in the arid zone gave twice as much grain and oil, such as *bajra* (sort of millet) and mustard oil, both rich in TDN, than those in the semiarid zone.

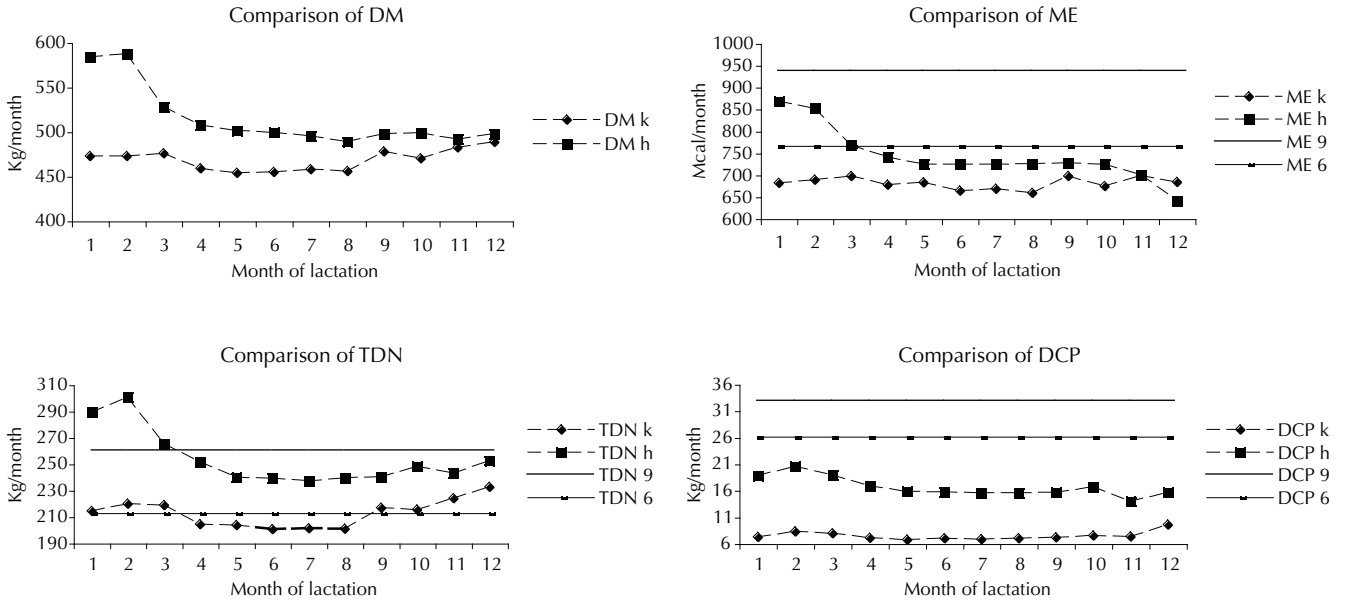


***Figure 4:*** *Comparison of nutrient intake for buffalo between Karnal (k) and Hisar (h) (sample: 57 buffaloes). DM: dry matter; ME: metabolic energy; TDN: total digestible nutrient; DCP: digestible crude protein.*

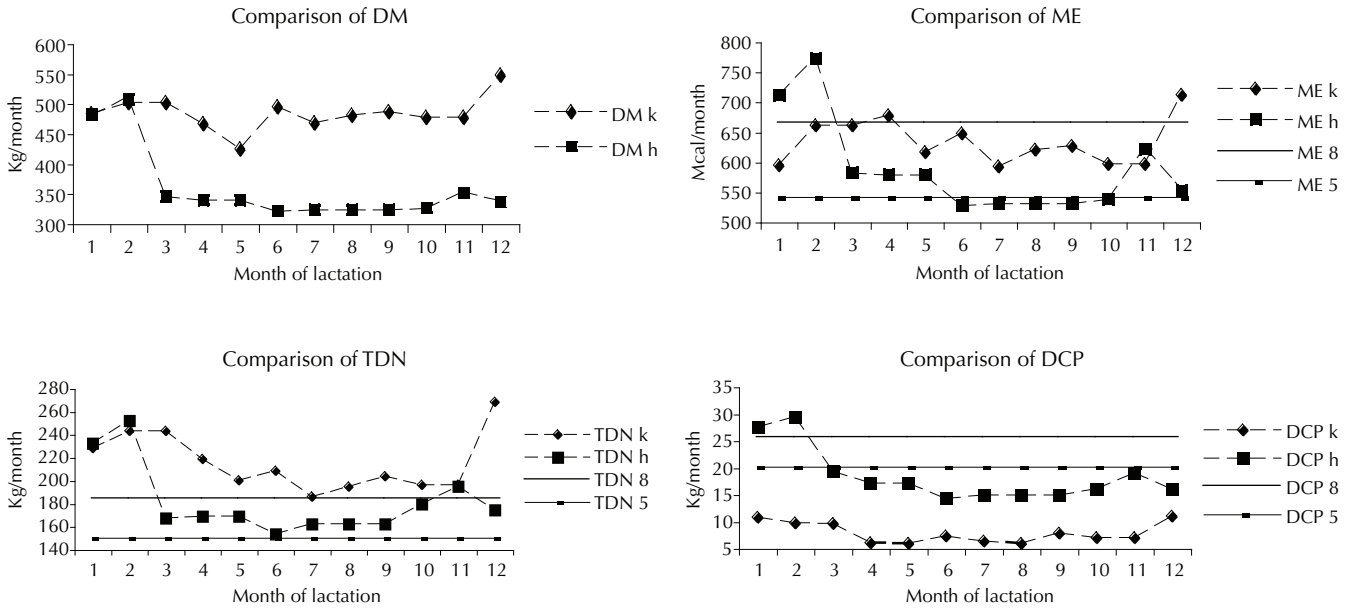


***Figure 5:*** *Comparison of nutrient intake for local cow between Karnal (k)and Hisar (h) (sample: 6 local cows). DM: dry matter; ME: metabolic energy; TDN: total digestible nutrient; DCP: digestible crude protein.*

The main difference between the zones was related to the major cropping systems. In the arid zone, berseem productivity during the dry season (winter) was very low and the breeders usually supplemented the ration with cotton and mustard seeds, and oil cakes. Cotton seeds as well as mustard seeds (sown generally in association with wheat) were produced on the farms, and were given to animals in association with oil cakes. This feed ration was more nutritious than classical rations in the semiarid zone based on by-products and concentrates. In the semiarid zone, although some mustard was also cultivated with wheat, it was reserved entirely for human consumption. Furthermore, supplementation in Karnal was mainly made with concentrates that were less nutritious than oil cakes.

But the results differed for local cows. In the semiarid zone, minimum requirements in ME and TDN were covered, as well as those in TDN for a high production. However, none of the farmers covered recommended needs for DCP. It seemed that the feeding system was similar for all types of animals, without taking into account the specific needs of each type. But, if the basic ration was similar for all the animals, the supplementation varied from type to type.

The rations of crossbred cows could not be compared between the two agroclimatic zones because of the quasi-absence of crossbreds in the arid zone. Nevertheless, in the semiarid zone an important deficit in protein was observed. But, contrary to the other types of animals, ME and TDN needs were covered. This showed that, in the semiarid zone, farmers paid more attention to crossbreds due to their high potential.

Important variations of the feed ration were also noted depending on the seasons. During the hot and dry period (May to June),

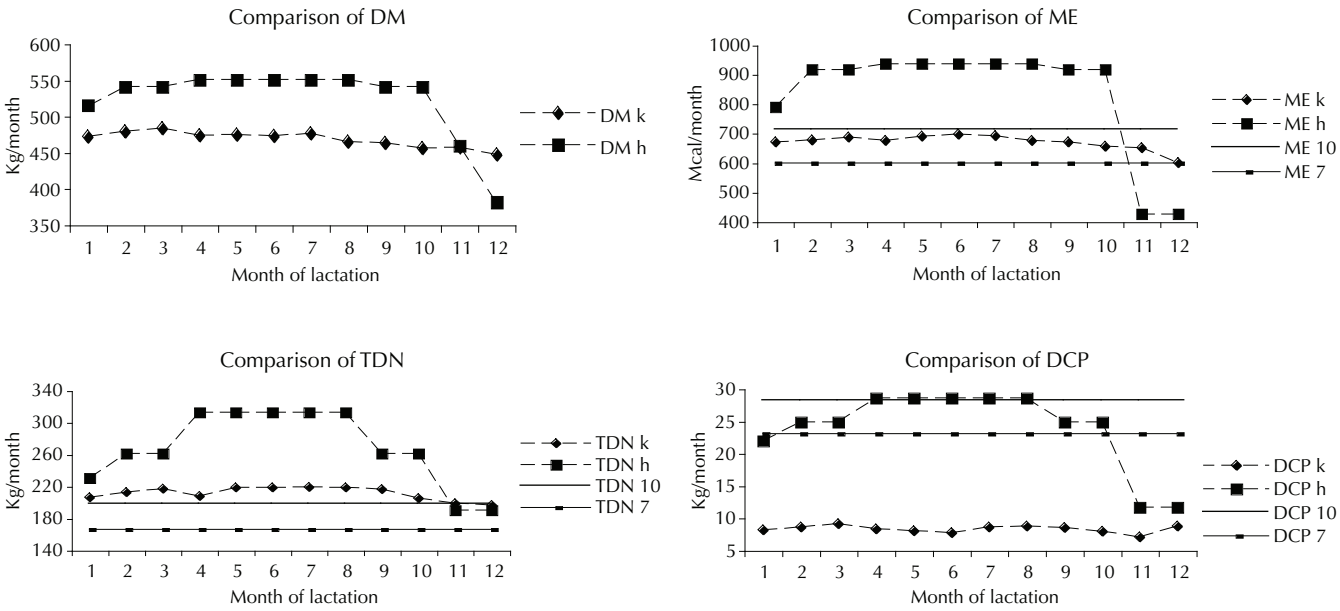


***Figure 6:*** *Comparison of nutrient intake for crossbred cows between Karnal (k) and Hisar (h) (sample: 14 head). DM: dry matter; ME: metabolic energy; TDN: total digestible nutrient; DCP: digestible crude protein.*

breeders in the semiarid zone mitigated the lack of fodder by giving concentrates and increasing the grain part in the ration, as well as residues and scrap (notably gram cover). In the arid zone, farmers replaced the cotton cake by grain and oil, which were more nutritive in protein and energy than concentrates in the semiarid zone.

These results were quite surprising and questioned the research. If the sale of milk was most developed in the semiarid zone, the feed ration was also the most unbalanced in the zone, compared to the arid zone. In other words, milk profit could not be the main reason to improve the feed ration. Similarly, few farmers who invested in high performance genetic cows sold their milk production. So, beyond agroclimatic conditions, it was important to extend the analysis to the different farming system.

## *Socioeconomical parameters in biotechnical management*

To identify relations between biotechnical management, in particular the feeding system, and socioeconomic characteristics of the farms, the authors used a multiple factorial analysis on K-tables that allowed analyzing key links between groups of farmers or groups of variables (10). Each group of variables constituted one table that represented one function or profile of the farm. Data were divided into four groups that represented the different subsystems of the whole farm, as follows:

– the household system, which gathered a set of variables on the characteristics of the household (schooled children, source of off-farm incomes, number of members, etc.);

– the cropping system, which gathered a set of variables on land allocation (including food and fodder crops) and the degree of intensification;

– the livestock system, which gathered a set of variables on herd structure, animal expenses, milk use between sales or self consumption;

– the feeding system, which gathered a set of variables on the different sources of feed (green and dry feeds, concentrates, oil, grain, etc.) and the average content of the feed ration in DM, DCP, TDN and ME.

The projection of the Eigen values of the four tables allowed to estimate the contribution of each table to the identification of the main axis of differentiation of the population. The first axis was mainly explained by the structure of the "household" and the "cropping system", and the second axis by the "livestock system" and "feeding system" (Figure 7). The feeding system was surprisingly quite distant from the cropping system. But, the feeding system was not only based on fodder production but also on external supply, which could explain the main differences of feeding systems between the farmers. Strong relationships were also noted between livestock and feeding management, and were related to the farm size.

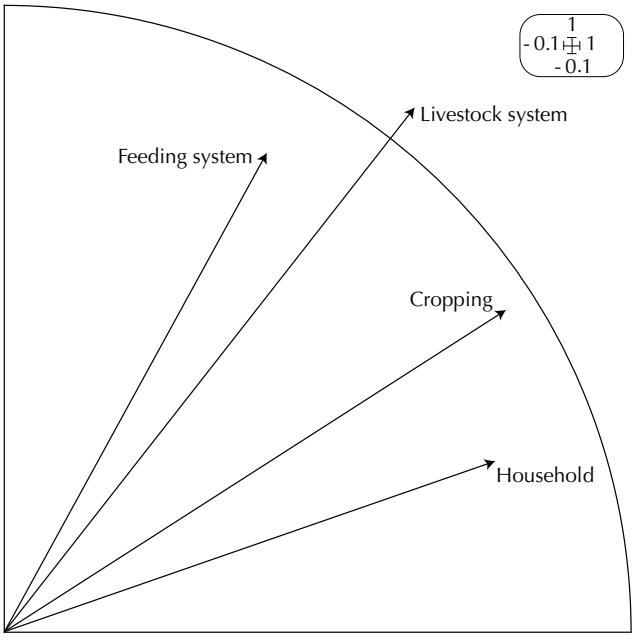


***Figure 7:*** *Projection of the Eigen value of each group of variables on the first two factorial axes of the multiple factorial analysis.*

The first axis differentiated between large farmers of the semiarid zone, characterized by their wheat and rice system and a herd made up of crossbred animals, and medium farmers of the arid zone, characterized by a more diversified system (generally wheat and cotton with mustard, *bajra*) and a traditional herd made up of buffaloes. The second axis opposed the large breeders with more than two buffaloes from the landless who had only one cow or one she-buffaloe. The first ones produced between 4000 and 6000 L/year (thanks to a nutritious intake of oil cake and grain), the second ones produced less than 2000 L/year, mainly because of poor feeding. But, milk was mainly consumed by the large breeders and sold by the landless.

An ascendant hierarchical classification based on the main axis of the multiple factorial analysis allowed identifying four types of farmers in the two districts (Table II). Type 1 mainly gathered the large farmers with more than 5 ha of wheat and rice, and at least 0.3 ha of sorghum and berseem. The herd comprised on average 1-2 milk buffaloes and one crossbred. In this farm type, the household included four members and two family workers. Livestock management was often entrusted to a permanent worker. Milk consumption was proportionately very high and comprised liquid milk, ghee and other home-made dairy products that are mainly self-consumed at the farm level.

**Table II**

Socioeconomic and biotechnical characteristics of each type of farming systems

| | Type 1 | Type 2 | Type 3 | Type 4 |
|---|---|---|---|---|
| **Num. of farms per group** | **30%** | **30%** | **27%** | **13%** |
| **Characteristics of the household** | | | | |
| Schooling level of the head of the family | High school | Illiterate | Primary | Primary |
| Average family size | 4.33 | 10.78 | 5.88 | 6.75 |
| Num. of children (on average) | 1.44 | 6.22 | 2.75 | 4.75 |
| Area (ha) | 5.86 | 4.03 | 3.16 | 0.75 |
| Milk consumption (kg/capita) | 1073 | 265 | 342 | 140 |
| Income (Rs/capita) | 133,844 | 20,192 | 46,732 | 14,805 |
| Income from agriculture | 63% | 65% | 62% | 45% |
| Income from milk | 8% | 11% | 8% | 24% |
| Income from other agricultural activities | 2% | 3% | 3% | 4% |
| Off farm income | 27% | 20% | 27% | 28% |
| **Herd composition (average numbers)** | | | | |
| Buffalo | 1.78 | 1.22 | 1.25 | 1.50 |
| Local cow | 0.11 | 0.22 | 0.25 | – |
| Crossbred | 1.22 | 0.11 | – | 0.75 |
| **Ration intake** | | | | |
| DCP (kg/day) | 0.30 | 0.68 | 0.44 | 0.14 |
| ME (Mcal/day) | 22.74 | 28.26 | 22.80 | 10.89 |
| DM (kg/day) | 16.55 | 18.61 | 16.98 | 7.11 |
| TDN (kg/day) | 7.40 | 9.29 | 7.74 | 3.38 |
| **Milk productivity (L/day/animal/season)** | | | | |
| Milk yield in rainy season | 5.13 | 7.35 | 4.95 | 1.02 |
| Milk yield in dry and cold season (winter) | 6.84 | 8.21 | 5.54 | 3.20 |
| Milk yield in dry and hot season | 4.47 | 4.19 | 3.31 | 1.36 |
| **Milk activity** | | | | |
| Permanent paid workers (number) | 0.67 | – | – | – |
| Sale price (Rs/L) | 11.13 | 11.77 | 10.96 | 10.50 |
| Annual milk production in 1999/2000 (L/cow) | 6400 | 4533 | 3032 | 3045 |
| Sale part | 37% | 34% | 41% | 48% |
| Veterinary expenses (Rs/TLU) | 305 | 272 | 796 | 178 |
| Food expenses (Rs/TLU) | 6408 | 7285 | 5413 | 4482 |
| Production cost (Rs/L) | 6.37 | 8.23 | 4.56 | 2.37 |
| **Cropping system** | | | | |
| Input/fodder (Rs/ha) | 1764 | 3903 | 2980 | 481 |
| Input/crop (Rs/ha) | 3715 | 3271 | 4474 | 1319 |

Sample: 30 households

DCP: digestible crude protein; ME: metabolic energy; DM: dry matter; TDN: total digestible nutrient; Rs: rupees

Type 2 gathered small and medium farmers from the arid zone with 2-3 ha of wheat and cotton, and 0.15 ha of fodder crops like glove (berseem) and sorghum. The herd was made up of 1-2 she-buffaloes. The feed contained a high level of protein (0.68 kg/day against 0.3 for type 1) and energy (28.26 Mcal/day against 22.74 for type 1), because of a large supply of oil cake (cotton and mustard cake) and grain (*bajra*). Unlike in type 1, women were wholly involved in herd management, especially in animal feeding. Children (on average 6-7 against 1-2 in type 1), usually not schooled, were involved in the daily collection of green fodder and in watching the animals. Farmers invested three times more per hectare on fodder crops (around 3900 Rs/ha against 1760 Rs/ha for type 1), and the cost of feed per adult animal was around 7285 Rs/year against 6400 Rs/year in type 1. Milk sales in total income were proportionately more important in this group than in the first. The average milk productivity per day was much higher (7.35 kg/day/animal) than in type 1 (5.13) during the rainy season as well as during the dry season (8.21 against 6.84) (Table II), which was explained by the feed ration. In this type, women were involved in dairy activities. They carefully adjusted feeding to animal needs according to the milk lactation period and milk expectations for self-consumption. In type 1, largely dominated by high casts, women were less or not at all involved in agricultural activities, and even less so in livestock management which was mainly ensured by permanent workers.

Type 3 gathered small and medium farmers from both agroclimatic zones with 2-3 ha of wheat and rice in the semiarid area, and cotton in the arid area. The herd was similar to the other two types with 1-2 buffaloes and one local cow. But milk productivity was lower than in the previous types (around 5 kg/day/animal for the two main seasons, the rainy and dry seasons), although feed was more nutritious than in type 1. Protein intake was around 0.44 g/day against 0.33 in type 1. The difference in milk productivity per cow can be explained by the genetic factor, in particular between local and crossbred cows, but also by the lack of forage during the dry season.

Type 4 gathered landless or marginal farmers with less than 1 ha and 1-2 she-buffaloes. For these farmers, if the fodder crops covered less than 0.1 ha, this area represented around 13% of the total owned or rented area, against less than 6-7% for the other types. Milk production per animal was very low (less than 1 kg in the rainy season and 3.2 kg in the dry season) because of the poor nutritive value of the feed. But, surprisingly, if the first source of income was agricultural wages (28% of total income), the second main source of income was milk output (24% of the total income). Around half of milk production was marketed against one quarter for the other three types. Women were involved in dairy activities and when they worked off-farm, animal care was entrusted to children.

## ■ DISCUSSION

This study identified contrasted strategies of dairy livestock management according to the agroclimatic conditions of the zones and the socioeconomic characteristics of the farms. The strategies were related to the cropping systems in place and their respective by-products (cotton or other oil cake in the arid zone and mainly cereal straw in the semiarid zone), but to comprehend livestock management, it is essential to integrate socioeconomic parameters such as food habits, social status, initial endowment in land and live capital, etc.

The analysis underlined the importance of oil seed (mustard, cotton) to improve the protein level of the feed ration. Grain intake represented a low part of energy intake and was made of poor quality of wheat that could be neither sold nor self-consumed. Competition between livestock and human population for grain was low, although farmers will probably face a growing dilemma, when, in the near future, they will have to make choices in land allocation between fodder and food crops.

Data also showed the importance of by-products in the feed ration. Improving by-products quality and storage techniques with low-cost techniques (e.g. ensilage) would help to increase milk production (keeping in mind that complementation mainly concerned large farmers) and to maintain a certain level of nutrition during the summer period. Farmers had the tendency to neglect feed intake during the summer period, i.e. the drying-up period. This practice had negative effects on the reproductive performance of the total milk herd.

The multidimensional analysis of biotechnical management with socioeconomic management linked the biotechnical performances with social and economic parameters. This analysis confirmed the important and positive relations between the feeding system and milk production, and between livestock management and the rest of the farm. While the feed ration, in particular the nutrient intake, depended on milk destination (self-consumption or marketing), the nutrient intake increased when milk was essentially set aside for family consumption. This relation was totally in keeping with the social structure of farming systems in India's rural society. The large farmers mainly belonged to high casts, where milk products and by-products occupy a large share in consumption habits and in religious and sociocultural events.

But some differences were noted between high casts depending on the agroclimatic zone and the social status, mainly the cast of the farmer. Types 1 and 2 consumed the majority of milk production, and type 2 in the arid area registered the highest milk performances. This was explained by the human labor factor, which constituted a major determinant in herd management, especially with regard to feeding practices. In type 2, women were wholly involved in feeding management. In type 1, when the farm belonged to high casts in the Indian social system, livestock management was ensured by permanent workers.

Moreover, when comparing sale price and production cost, the benefit increased from large and medium farms to the landless and it was well correlated with the milk-oriented strategies between self-consumption and sale. The benefit was the highest for types 3 and 4 who sold more than 40% of the milk production. This reflected the differentiated role of dairy products and milk cows at the farm and household levels according to the different types that represented different social entities. For the semi-medium and small types (types 3 and 4), milk activity was mainly oriented to market to ensure the basic needs of the family, with the economic function prevailing thus on the social function. Besides, in the wealthier types (types 1 and 2), milk contributed to ensure the social rituals of their status in the Indian society.

Finally, one striking feature of the results was that off-farm activities were important for all groups and represented around 25% of the farm income. Farmers increasingly diversified their activities, in small trade or paid work or agricultural work, the latter being the main activity of the landless. In the more remote district, since non-agricultural activities were less important, farmers tended to invest more time and money in milk production.

So, if the feeding system was closely correlated to the cropping system in each type of farm (including the fodder system), its improvement with oil cakes, concentrates or grain was not only determined by economic or biotechnical parameters but also by

social parameters; the implication of women were important factors in decision-making at the farm level, in particular in feeding system practices; it should be integrated in programs of rural development and extension services. Improving milk productivity could most successfully be achieved by training women in all aspects of milk production (e.g. management practices, feeding, housing and equipment, basic knowledge of specific features of cow physiology, etc.). Training and education, especially that of women in the Indian rural society, are difficult and time-consuming tasks: women are generally illiterate and have many other activities. Special training should be organized and children should sometimes be included.

## ■ CONCLUSION

If some precautions must be addressed when evaluating the feed ration per type of animal based on a retrospective survey, the present study provides relevant indicators on feeding strategies based on socioeconomic parameters and constitutes interesting material to orient extensive researches.

Firstly, this study of feeding practices in Haryana showed that milk production could be increased substantially in the near future without jeopardizing national food self sufficiency, especially with regard to grain production. This could be done first by increasing assistance to women in the household because they are well involved in animal care. Another way would be to improve the nutritious quality of grain by-products.

Secondly, this rapid study confirmed that it will be difficult to improve milk productivity, or more generally dairy cow performances, without integrating socioeconomic practices and strategies that differ depending on the social status and capital.

**Acknowledgments**

The present study was jointly organized with BAIF, a non-governmental association in India. We thank particularly Mr Ramesh Rawal, Vice-President of BAIF, for his support in this research.

## REFERENCES

1. ALARY V., 1999. Politiques de prix et l'offre agricole – Réponses des producteurs en Haryana et au Gujarat (Inde). New Delhi, India, Centre des sciences humaines/MAE, 50 p.

2. ALARY V., DEGAIL A.C., RIVIERE R., 2004. Explaining the production of milk in Gujarat and Haryana - A matter of scale. In: Landy F., Chaudhuri B., Eds, Globalization and local development in India. Examining the spatial dimension. New Delhi, India, Manohar/Centre des sciences humaines, 249 p.

3. ARORA S.P., 1997. Feeding of dairy cattle and buffaloes. New Delhi, India, Indian Council of Agricultural Research, 126 p.

4. ARPU, 1998. Agro-climatic regional planning. Recent developments. Ahmedabad, India, ARPU, p. 50-59. (Working paper No 10)

5. CLEVELAND W.S., 1981. LOWESS: A program for smoothing scatter plots by robust locally weighted regression. *Am. Stat.*, **35**: 54.

6. CLEVELAND W.S., GROSSE E., SHYU W.M., 1992. Local regression models. In: Chambers J.M., Hastie T.J., Eds, Statistical models in S. Pacific Grove, CA, USA, Wadsworth & Brooks/Cole.

7. DEGAIL A.C., RIVIERE R., 1999. Etude de la place de l'élevage laitier dans les exploitations du Gujarat et de l'Haryana. Mémoire Agronomie, INAPG, Paris, France, 74 p.

8. DELGADO C., ROSEGRANT M., STEINFELD H., EHUI S., COURBOIS C., 1999. Livestock to 2020. The next food revolution. Rome, Italy, FAO, 72 p. (Food, Agriculture, and the Environment No 28)

9. ESCOFIER B., PAGES J., 1983. Méthodes pour l'analyse de plusieurs groupes de variables. Application à la caractérisation des vins rouges du Val de Loire. *Revue Stat. appl.*, **31** : 43-59.

10. ESCOFIER B., PAGES J., 1984. Multiple factor analysis (AFMULT package). *Comput. Stat. Data Anal.*, **18**: 121-140.

11. ESCOFIER B., PAGE J., 1984. L'analyse factorielle multiple : une méthode de comparaison de groupes de variables. In: Diday E., Ed., Data analysis and informatics III. Amsterdam, The Netherlands, Elsevier, p. 41-55.

12. EUROPEAN COMMISSION, 2007. Prospects for agricultural markets and income in the European Union 2007-2014. Brussels, Belgium, European Commission, July 2007, Directorate for Agriculture and Rural development, 55 p.

13. FAO, 2007. Milk and milk products, food outlook: Global market analysis, June 2007. http://www.fao.org/docrep/010/ah864e/ah864e10.htm#32

14. FAYE B., GRELET Y., 1990. Type d'élevage et profil de santé. Deux stratégies statistiques. In : Actes Coll. Agro-industrie et méthodes statistiques, Angers, France, 14-15 juin 1990, p. 111-125.

15. ICAR, 1997. Handbook of animal husbandry. New Delhi, India, Indian Council of Agricultural Research, p. 275-318.

16. MINISTRY OF AGRICULTURE, 1997. Basic animal husbandry statistics. New Delhi, India, Department of Animal Husbandry & Dairying, p. 19-26 (AHS Series 6)

17. NSSO, 1994. Level and pattern of consumer expenditure, 5th Quinquenal survey 1993-1994. New Delhi, India, NSSO, 34 p.

18. RANJHAN S.K., 1991. Chemical composition and nutritive value of Indian feeds and feeding of farm animals. New Delhi, India, Indian Council of Agricultural Research, 132 p.

19. RANJHAN S.K., 1998. Nutrient requirements of livestock and poultry. New Delhi, India, Indian Council of Agricultural Research, 72 p.

20. TEYNIER D., 2000. Etude des pratiques d'élevage et caractérisation de la fonction de production de lait (Haryana, Inde). Montpellier, France, Cirad.

Reçu le 03.08.2007, accepté le 12.03.2008

## *Résumé*

**Alary V., Teynier D., Messad S., Lecomte P., Barbier B.** Evaluation technique et socio-économique des pratiques d'alimentation en zones aride et semi-aride au nord de l'Inde (Haryana) et implications pour le développement laitier

Pour satisfaire la demande croissante des consommateurs en produits laitiers en Inde, les producteurs doivent augmenter rapidement la production laitière, et ce, par le biais de l'amélioration des pratiques alimentaires. De nombreux spécialistes pensent que la production actuelle de sous-produits agricoles ne sera pas suffisante pour satisfaire la demande croissante des besoins du troupeau laitier et que le recours aux céréales sera nécessaire. Mais d'autres spécialistes pensent que la production de grain risque aussi d'être insuffisante et que l'augmentation de la part de grain dans l'alimentation animale pourrait affecter la consommation humaine en céréales à moins que l'Inde n'ouvre son marché à l'importation avec des risques de perturbation du marché mondial. Une étude empirique sur les pratiques d'alimentation des animaux laitiers (vaches de race locale et améliorée, bufflesses) en Haryana a montré que les céréales n'étaient pas un aliment essentiel et qu'il existait encore un grand potentiel par l'amélioration des fourrages verts et des sous-produits des cultures de coton et de moutarde. Cette étude a aussi montré que les plus grands producteurs tendaient à sous-utiliser le potentiel génétique des vaches et des bufflesses. Ainsi, il est mis en évidence des liens étroits entre les pratiques de gestion du troupeau, en particulier les pratiques d'alimentation et la gestion socio-économique du système d'exploitation familiale ; les stratégies étaient fortement orientées vers la satisfaction des besoins en lait de la famille chez les grands producteurs et la génération de revenu quotidien chez les plus petits. Enfin, il est possible de mettre en évidence le besoin d'élaboration, de mise en place et de suivi de programmes de développement qui prendraient en compte les facteurs socio-culturels pour faciliter l'adoption technique en matière de valorisation et de stockage des fourrages.


***Mots-clés :*** Bovin laitier – Système d'exploitation agricole – Alimentation des animaux – Lait – Productivité – Organisation du travail – Rôle des femmes – Inde.


## *Resumen*

**Alary V., Teynier D., Messad S., Lecomte P., Barbier B.** Asesoría de las prácticas de alimentación socio-económicas y técnicas en áreas semi áridas y áridas en el norte de la India (Haryana) e implicaciones para el desarrollo lechero rural

Con el fin de satisfacer la demanda creciente de productos lácteos de los consumidores hindúes, los productores hindúes tendrán que impulsar rápidamente la producción, especialmente a través de la mejoría de las prácticas alimenticias. Muchos expertos señalan que los sub productos de cultivos utilizados actualmente no serán suficientes para colmar los crecientes requerimientos alimenticios de los hatos de vacas y búfalos y que será necesario utilizar granos como trigo y maíz. Pero otros expertos piensan que los granos no bastarán y que el creciente consumo animal de granos afectará el consumo humano, a menos que India decida la importación masiva de granos, presionando el mercado mundial de granos. La presente encuesta llevada a cabo en dos distritos de Haryana mostró que el grano no es un alimento esencial para ganado y búfalos y que la mejora de los sub productos de algodón y mostaza y forraje verde tiene gran potencial. Un segundo hallazgo fue que los finqueros más ricos tienden a sub utilizar el potencial genético de las vacas de leche y búfalos. Aún más el manejo biotécnico del hato, en particular el sistema alimenticio, se relacionó de cerca con el manejo socioeconómico del sistema de manejo familiar. Las estrategias familiares se orientaron hacia asegurar suficiente producción de leche para la familia en las fincas más grandes y a proveer un ingreso regular en las más pequeñas. El presente artículo también subraya la necesidad de diseñar, implementar y monitorear programas de desarrollo que integren aspectos socioculturales y particularmente de género para facilitar la innovación tecnológica con respecto al almacenamiento de forraje.


***Palabras clave:*** Ganado de leche – Systema de explotación – Alimentación de los animales – Leche – Productividad – Organización del trabajo – Papel de la mujer – India.