Analysis of dairy farming systems in the Sahelian zone of Burkina Faso

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Abstract
The insufficiency and variability of pasture production is a determining factor in milk production, particularly in the Sahelian zone. The objective of this study was to characterize dairy production systems and their relationship with crops to meet livestock needs. It consisted of surveys of 120 farmers in four communes in the Séno province. The results show three groups of dairy farmers that are essentially differentiated by the main activity and the sex of the farmers as well as the size of the cattle herd on the farm. The first group is made of male agropastoralists, with herds averaging 12 cattle. Group 2 consists of male agropastoralists with an average of 22 cattle. Group 3 consists of female pastoralists (96.15%), with a herd size of about 19 head. The cows are fed on pasture and supplemented with crop residues and cottonseed cake. The supplementation is more important in group 2, where more farmers have hayloft for fodder conservation and manure pits compared to the other two groups. Crop residues are used primarily as feed in all groups from January to May. This supplementation allows the maintenance of milk production in the dry season and group 2, with more dairy cows, records more milk milked (6.5 and 3.8 l) and consumed in wet and dry seasons compared to the other two groups. The results suggest that the farmers in the area have low technical level and need capacity building in improved agro-pastoral production techniques to increase their production.

Keywords Milk production · Feed supplementation · Crop residues · Cattle · Survey

Introduction
In Burkina Faso, livestock activities involve nearly 87% of the active population and constitute the main insurance against risks for poor populations, whose livelihoods are based on rainfed agriculture (CSAO-OCDE/CEDEAO 2008). The animal population is large and diversified, with approximately 9 million cattle, 14 million goats, 9.3 million sheep, and 44 million poultry (MRAH 2015). This livestock allows the production of about 0.35 million tons of meat and 264 000 tons of milk per year (FAO 2019). However, this contribution is relatively low in relation to the sector’s potential and could be explained by the low productivity of the animals, the low processing of products, and the low marketing of raw products. In fact, Burkina Faso’s livestock production is largely based on traditional extensive systems (87%), which lead to low animal productivity.

The Sahelian region of Burkina Faso is home to a large cattle population estimated at more than 2 million heads in 2018, which provides most of the milk produced. However, the environment marked by a high human population pressure, increasing urbanization, climate change, and variability leads to a more or less pronounced pauperization of the Sahelian populations. Thus, the transformation of agricultural production systems has emerged as a response to the deterioration in the purchasing power of the most vulnerable population. Indeed, several studies show that agricultural performance can be improved in a sustainable manner by developing synergies between crop and livestock production activities (Alary et al. 2011; Staal, 1995; Camara et al. 2015). In this dynamic of evolution of the agricultural systems, livestock and particularly milk production occupy a prominent place, as a factor of poverty reduction and economic growth. Milk is one of the few speculations that allows a daily inflow of money, without damaging the system that produces it (Boukary et al. 2007).
Thus, to face the growing demand for meat and milk in general, animal husbandry has a major role to play in food security policies, although its future will depend on the mechanisms of its spatial and temporal integration in the agricultural areas, the forms of integration with other activities (soil fertility management, effect on the environment), and the insurance systems in the adaptation strategies to go beyond the stage of survival strategy (Alary et al. 2011).

The aim of this study was to characterize dairy farming systems and their relationship with crops in the Sahelian zone of Burkina Faso in order to identify avenues for improvement.

**Material and method**

**Study area**

This study was conducted in the Sahel region of Burkina Faso, more specifically in the Séno province located between 13th and 14th degrees of the north latitude. This province is bordered at the north by the province of Oudalan, at the northwest by the province of Soum, at the south by the provinces of Namentenga, Gnagna, and Gourma, and at the east by the Republic of Niger. It is composed administratively of the urban commune of Dori and the rural communes of Bani, Falagountou, Gorgadj, Sampelga, and Seytenga (DREP/Sahel 2014).

The study involved four sites including three rural communes that are Bani, Gorgadj, and Seytenga and the village of M’Bamga belonging to Dori Department (Fig. 1).

**Methodology**

It has consisted in the elaboration of questionnaires to collect information related to the following:

- The socioeconomic characteristics of farmers (identity, age, sex, socio-economic activities, household size, level of education, herd size)
– The means and strategies of animal production (type of habitat, management methods, health practices, supplementation practices)
– The type of crop produced and use of crop residues
– The relation between crop and livestock productions
– The milk production and use

These questionnaires were first tested with few farmers before the actual survey phase, which involved all four sites. The sampled population consisted of 120 farmers, with 30 farmers per site. The snowball sampling method was applied, starting with the target farmers (12 per site) who were asked to suggest other farmers to be included in the sample.

Statistical analysis of the data

SPSS software was used to analyze the data. A hierarchical ascending classification was applied to the main variables characteristic of the dairy production units. This resulted in three groups with a similarity level of 19.7%. The Chi-square test was then used to compare the different groups of farmers, with a significance level of 5%.

Results

Farm typologies

The result of the ascending hierarchical classification of observations allows to discriminate the farms into three groups (Fig. 2). The main variables that had a significant effect on this distribution were gender, main activity, membership in a farmer organization (FO), beneficiary of support and training, herd size, and the existence of a hayloft. The three groups are as follows:

– Group 1, with 57 farmers (47.50%), is composed mainly of male agropastoralists (98.25%), the majority of whom are not affiliated to a FO and do not receive support, but all have received training (100%).
– Group 2 comprises 37 farmers (30.83%), all of whom are male agropastoralists (100%); the majority are members of a FO (94.59%) and received support (94.59%), but few have received training (40.54%).
– Group 3 accounts 26 farmers (21.67%), mainly female pastoralists (96.15%), who have received training (88.46%); half of them are affiliated with a FO (57.69%) and have received support (50%).

General characteristics of farmers surveyed

Table 1 shows the general characteristics of the three groups of farmers surveyed. The first two groups are made up mainly of men, while the third group is made up mainly of women. There is no significant difference between the three groups with respect to the age of the respondents or their level of education. We note that the group of age 30 to 50 years old is more represented in all groups with 56.14, 56.76, and 61.54% of respondents, respectively, in groups 1, 2, and 3. For the level of education, the majority of groups 1 and 2 are illiterate (56 and 65%, respectively); however, group 3 has more educated respondents (58%).

The main activity practiced differs significantly between the groups. The first two groups are agropastoralists, while group 3 consists mainly of women who practice livestock farming as their main activity. The proportion of farmers who are members of a FO and who receive support is
significantly higher in group 2 (95%). For the capacity building in dairy production techniques, farmers in groups 1 and 3 benefited the most ($p<0.001$) from training (100% and 84%, respectively).

**Characteristics of the cattle farms**

The characteristics of the farms are presented in Table 2. In the three groups, the herd size between 10 and 20 heads of cattle dominates ($p<0.01$) with 43.86%, 45.95%, and 50% for groups 1, 2, and 3, respectively. The category of farmers with more than 40 heads of cattle is only observed in groups 2 (16.22%) and 3 (3.85%). About 40% of the farmers in group 2 have herds of more than 20 cattle, while in group 1, the herd size of less than 10 heads is important (43.86%); thus, group 2 is considered to be the large farmers group and the herd size of 22 heads is recorded, which is significantly different from herd size in group 1 (12 heads), but not different from that of group 3 (19 heads).

The production system is dominated by the extensive ones (>80%) in the three groups of farmers. The animals, especially the dairy cows, are fed on pasture and supplemented with crop residues and sometimes cotton cake in the dry season. The techniques for distributing and processing roughage

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**Table 1** Socioeconomic characteristic of farmers surveyed (%)

| Parameters                  | Group 1 | Group 2 | Group 3 | $p$-value |
|-----------------------------|---------|---------|---------|-----------|
| Sex                         |         |         |         |           |
| - Male                      | 98.25   | 100     | 03.85   | ***       |
| - Female                    | 01.75   | 0       | 96.15   |           |
| Age (years)                 |         |         |         |           |
| - Less than 30              | 12.28   | 0       | 11.54   | ns        |
| - 30 to 50                  | 56.14   | 56.76   | 61.54   |           |
| - More than 50              | 31.58   | 43.24   | 26.92   |           |
| Main activity               |         |         |         |           |
| - Pastoral                  | 0       | 0       | 96.15   | ***       |
| - Agropastoral              | 100     | 100     | 03.85   |           |
| Level of instruction        |         |         |         |           |
| - Illiterate                | 56.14   | 64.86   | 34.61   | ns        |
| - Literate                  | 10.53   | 21.62   | 07.69   |           |
| - Educated                  | 33.33   | 13.51   | 57.69   |           |
| Member of farmer’s organiza-|         |         |         |           |
| tion                       | 33.33   | 94.59   | 57.69   | ***       |
| Beneficiary of support      | 22.81   | 94.59   | 50      | ***       |
| Beneficiary of training     | 100     | 40.54   | 88.46   | ***       |

*ns*, not significant; ***: $p<0.001$

**Table 2** Characteristics of farms

| Parameters                        | Group 1 | Group 2 | Group 3 | $p$-value |
|-----------------------------------|---------|---------|---------|-----------|
| Herd size (number of heads) (%)   |         |         |         |           |
| - ≤ 10                            | 43.86   | 13.51   | 19.23   |           |
| - 10 to 20                        | 43.86   | 45.95   | 50      | **        |
| - 20 to 40                        | 12.28   | 24.32   | 26.92   |           |
| - More than 40                    | 0       | 16.22   | 03.85   |           |
| Average number of cattle          | 11.91   | 22.19   | 18.96   | ***       |
| Production system (%)             |         |         |         |           |
| - Extensive                       | 89.47   | 81.08   | 80.77   | ns        |
| - Semi-intensive                  | 10.53   | 18.92   | 19.23   |           |
| Feeding method: pastures + supplements (%) | 100     | 100     | 100     | ns        |
| Fodder distribution technique (%) |         |         |         |           |
| - Whole crop residues             | 42.11   | 56.76   | 46.15   | ns        |
| - Chopped crop residues           | 57.89   | 43.24   | 53.85   |           |
| Amount of cottonseed cake (bags)  | 20.90a  | 44.44b  | 17.44a  | **        |
| Existence of hayloft (%)          | 07.02a  | 24.32b  | 03.85a  | *         |
| Type of habitat (%)               |         |         |         |           |
| - Pens                            | 56.14   | 56.76   | 57.69   |           |
| - None                            | 42.11   | 40.54   | 38.46   | ns        |
| - Fencing                         | 01.75   | 02.70   | 0       |           |
| - Covered habitat                 | 0       | 0       | 03.85   |           |
| Management of manure (%)          |         |         |         |           |
| - Storage in piles                | 21.67   | 14.17   | 04.17   |           |
| - Storage in manure pit           | 05      | 10      | 04.17   | *         |
| - Disposed in the field           | 20.83   | 6.67    | 13.33   |           |

*ns* not significant; *: $p<0.05$; **: $p<0.01$
do not differ significantly between the three groups. More than half of the farmers in groups 1 and 3 (58% and 54%, respectively) process the roughage physically (chopping or cutting) before serving it to the animals. The supplementation with cottonseed cake is known in all groups, although the quantities are significantly higher in group 2 (44 bags of about 50 kg).

For fodder conservation, very few farmers have a hayloft; this is observed only in group 2 with 24% of farmers, and this proportion is significantly different from that of the other two groups. Most farmers store their fodder in various uncovered places.

Regarding the housing, we observe that the majority of farmers in all groups do not have any or use basic means to shelter their animals: pens made of thorny tree branches. Only about 4% of farmers in group 3 have a covered habitat.

**Crop residue management**

The main crops grown in the study area are cowpea, millet, and sorghum by 98%, 97%, and 93% of respondents, respectively. Maize is also grown by 52% of respondents on small areas, and groundnuts by 40% (Table 3).

**Types of crop residue use**

Various types of use are made of the residues from these crops. Animal feeding (100% of respondents) is the main type of use in the households of the farmers surveyed; it is followed in descending order of importance by the production of potash (87%), use as fuel (58%), construction of housing (28%), and sale (28%) of a part as fodder.

**Storage of crop residues**

The devices used to store crop residues for use as livestock feed in the dry season consist mainly of sheds (65% of respondents). Other means are tree branches (48%), fences made of thorny branches (42%), and house roofs (34%). A small proportion of respondents use a hayloft to store their fodder.

For the majority (90%) of respondents, storage in the field (trees, fences with thorny branches) and distribution of fodder are done in situ.

**Periods of forage stocks distribution**

The period of distribution (from start to depletion of stocks) of forage stocked is presented in Fig. 3. Overall, crop residues are used from January to June. The majority of farmers (54%) began using their forage stock in March. April is the second period when more farmers distributed crop residues to animals (27% of respondents). Forage stocks are generally depleted during the months of May (46%) or June (46%).

**Characterization of milk production and its uses on the farms**

Table 4 shows the different parameters related to milk production on the surveyed farms. There is a variation in the average number of cows in the farm and the number of lactating cows in all groups. Group 2 shows higher values for these parameters than group 1 \((p<0.05)\), and group 3 has intermediate values between the two groups. Thus, 7.14 cows were noted in group 2, 3.7 cows in group 1, and 5.88 cows in group 3. These numbers of cows represent 31–32% of the herd size.

The average amount of milk per day and per cow did not differ significantly between groups; it ranged from 0.81 l in group 3 to 1.19 l in group 2.

The farms recorded on average 4.56, 5.35, and 6.51 l of milk in the wet season against 2.46, 3.0, and 3.78 l in the dry season, respectively, in groups 1, 3, and 2, showing a decrease of 46, 44, and 42% in the same direction. Most of this production is self-consumed in the farms, with averages of 3.58, 3.92, and 5.19 l in the wet season, representing 78%, 73%, and 79% of total production in groups 1, 3, and 2, respectively.

The quantities of milk sold are low and do not differ significantly between groups in either the wet or dry seasons; they represent 24.76% and 21% of total production in the wet and dry seasons, respectively.

| Parameters          | Proportions of farmers (%) |
|---------------------|----------------------------|
| Type of crop produced |                            |
| Cowpea             | 98                         |
| Millet             | 97                         |
| Sorghum            | 93                         |
| Maize              | 52                         |
| Groundnut          | 40                         |
| Uses of crop residues |                        |
| Feeding            | 100                        |
| Construction of habitat | 28                     |
| Potash production  | 87                         |
| Fuel (firewood)    | 58                         |
| Sale               | 28                         |
| Mode of storage    |                            |
| Hayloft            | 12                         |
| Shed               | 65                         |
| Fence/thorny branches | 42                     |
| House              | 34                         |
| Tree               | 48                         |
Discussion

General characteristics of farmers and cattle farms

The results of this study showed three types of dairy farms in the zone, two of which are male agropastoralists, i.e., 78% of the population surveyed. This assumes that milk production is now dominated by agropastoralism, even though we are in the Sahelian zone. Dassou et al. (2017) also noted a dominance of agropastoralists (68%) over Fulani herders (32%) in their study in the Linguère Department of Senegal. In our study, the farmers engaged in livestock production only were mainly women. This result could be explained by the difficulty of access to land for these women or sociocultural habit of Fulani women who are known to be less involved in crop production. Moreover, this result on the dominance of agropastoralists confirms a transformation of pastoralist societies that are becoming increasingly sedentary, due to various constraints they encounter in their activity. This corroborates the observations of CCF (2019), which reports that pastoralists are evolving towards the agropastoral peasant model that integrates agriculture with livestock.

The low proportion of women in the survey population could be explained by the fact that men are involved in the production of milk, while women are more involved in the processing and marketing of milk. Indeed, a study conducted in Kaolack (Senegal) by Dieng et al. (2014) on the socio-economic profile of actors in the local milk value chain showed that men were more involved in the production sector, while women were in the marketing and processing of milk.

Most farmers (54%) were illiterate in the present study. These results are similar to those of Dieng et al. (2014), who reported 57.4% illiteracy. Sanon et al. (2020) also reported 73% illiteracy in the study on fattening activities in the same zone. This low level of education among respondents would have an impact on farm management and would constitute a barrier to the intensification of milk production and genetic improvement of cattle in the Sahel of Burkina Faso.

The results on membership in a farmer organization (58%) corroborate those of Zorma (2017) and Sanon et al. (2014), who reported 58% membership in an organization in their studies of fattening activities. This proportion would be an asset to benefit from various support/funding of their activities by some development agencies/projects.

The information on farms shows that the extensive system is dominant (85% of respondents). Indeed, the feeding system consisting of pasture and feed supplements is common in the area, and is one of the characteristics of extensive
dairy farming. This supplementation, consisting of crop residues and cottonseed cake, allows to maintain milk production to some extent and prevents undernutrition in the household. The higher level of cottonseed cake contribution in group 2 could be explained by the larger herd size in this group and/or the purchasing power of farmers; it could be explained also by the fact that the farmers in this group are aware of the importance of this supplementation in the management of their animals.

In the Sahel, and in extensive farming in general, the cattle herd does not have a habitat per se, which explains the results observed. The animals lie down on the outskirts of the concessions; these areas constitute the farmers’ home fields and are fertilized by organic manure throughout the dry season. The cattle herd is generally driven away from the farms in the wet season and returns after the harvest. Only the core herd remains and is supervised by children who drive it to pasture daily.

Crop residues are an important feed resource in the Sahelian zone. Thus, all farmers use these resources to feed their animals. This represents a real factor in the integration of crop and livestock productions, insofar as animal manure is also used to fertilize the fields.

However, there is a lack of appropriate infrastructure for storage, which remains a limiting factor for improving production. Indeed, the majority of farmers (88%) stored the fodder in various locations that do maintain the nutritional value of the fodder. Yet, proper storage of these forages could improve the production capacity of animals (Hanzen et al. 2013). The result on sheds (65%) corroborates those of Lawal et al. (2017), who reported that the storage mode on sheds is the most practiced in the urban community of Niamey. Only group 2 records a relatively appreciable rate of farmers who own a hayloft (24.32%). This infrastructure is of capital importance for preserving the nutritional value of fodder and ensuring adequate animal feed. However, the cost of construction remains a limiting factor for the adoption of this technology. Thus, some farmers, aware of the need to conserve the quality of their forages, keep them in unused granaries. The development of a less expensive and therefore more accessible means of fodder conservation is essential for small-scale farmers.

**Use of crop residues**

With regard to the mode of crop residues utilization, we note that the technique of physical treatment (chopping or cutting) is fairly well known to farmers in groups 1 (57.89%) and 3 (53.85%) who applied this technique to roughage before distributing it to the animals. This result is very interesting, because it improves the use of these feeds by the animals. Indeed, studies have shown that chopping improves straw intake by about 20% (Rokbani and Nefzaoui 1995).

Better adoption by farmers of this roughage processing technique would allow better use of crop residues and could thus contribute to solving the livestock feed deficit in the Sahelian zone of Burkina Faso. In addition, the processing of fodder to reduce the bulky volume by techniques such as grinding and/or granulation could give more value, while facilitating the conservation in the bags.

The length of the period of use of crop residues would be correlated with the availability of natural fodder on pasture. Indeed, Sanon et al. (2015) noted a reduction rate in pasture herbaceous biomass of 76–85% depending on pasture types, as early as January compared to the optimum recorded in September–October. Furthermore, crop residues distributed early to animals from January would be intended for dairy cows to maintain milk production and milking (Coulibaly et al. 2007), and thus improve the production capacity of dairy cows (Hanzen et al. 2013).

**Milk production and its uses on the farms**

The average amount of milk per cow (0.81 to 1.19 l depending on the group) is within the range of 0.71 and 1.57 l obtained by Diao et al. (2002) in the peri-urban area of Kolda, Senegal, with or without dry season supplementation. The value of 1.19 l obtained with group 2 is similar to the value (1.14 l) noted by Gbenou et al. (2020) on crossbred cows (Gir x Borgou) fed on Panicum maximum pasture. For all groups, the quantities obtained are lower than the results reported by Sissao et al. (2016) with two (1.7 l) and three (3.2 l) milking per day in the west of Burkina Faso. These differences could be explained by the rearing conditions, particularly the level of feed supplementation provided to the cows, as the same Zebu breed was used. It should be noted that the amount of milk obtained does not take into account the quantity consumed by the calves, and therefore does not reflect the potential production of the cows. In fact, the farmer sometimes modulates the withdrawals of cow’s milk, so that the calves do not suffer. The rhythm and intensity of milking may depend on the food and/or financial needs of the household. Overall, the decrease in milk quantities in the dry season compared to the wet season can be explained by the decrease in the availability of good quality fodder and water during this period. In fact, in the wet season, the availability of a variety of highly palatable forage species allows an increase in milk production, whereas in the dry season, only the provision of a supplement in the form of concentrated feed allows the maintenance of milk production. Moreover, studies have shown that adequate supplementation could remove the influence of the season on milk production (Hama, 2005 in Kassa et al. (2016)). The production observed in the dry season in our study would
be the result of this supplementation, as all the farmers stated they practiced it. However, the level of this supplementation would be low to induce sufficient production.

The total quantities of milk per farm of 4.56 to 6.5 l, depending on the group, obtained in the wet season are within the range of 0–10 l reported by Boukary et al. (2007) for the majority of households in rural Niger.

The very high proportion of milk consumed, 73–78%, would be related to the ethnic group present, the Fulani, whose dietary habits are based on the consumption of milk and derived products. Diop et al. (2009) also reported a significant proportion of milk consumed by the Fulani (35.4%), which is lower than our results. We agree with these authors that the amount of milk used is a function of the ethnic group, marketing opportunities, and the amount of milk available from the herd.

In conclusion, this study allowed to distinguish three types of dairy farms in the Sahelian zone of Burkina Faso, dominated by agropastoralism. Thus, crop residues are systematically used to feed the animals, while manure is collected to fertilize the fields. However, the technical level of farmers is low, as most use rudimentary techniques in the areas of fodder conservation, fodder use, and manure storage. This would mean that the technologies generated by research in these fields are either unknown to farmers or not applied for various reasons. Capacity building through training in various agropastoral fields such as crop residues conservation and treatment and compost production is needed to boost milk production. Supports for the construction of fodder storage infrastructure and equipment for fodder processing of in order to enhance its value would be of great help.

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Author contribution • SHO: contribute to conceive the study, analyze data, and write the paper
• NBS: contribute to performed research and to write the paper
• KS: contribute to performed research and to write the paper
• BVMC: supervise the work and read the manuscript

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Ethics approval The authors declare that the work is original and the manuscript has not been submitted elsewhere to another journal.

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