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REGULAR ARTICLES

Cattle management practices and milk production on mixed smallholder organic pineapple farms in Central Uganda

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Abstract A longitudinal study to assess animal management practices and milk production was conducted for a period of 12 months on 30 smallholder farms keeping dairy cattle and certified organic pineapple production in Luwero and Kayunga districts, based on questionnaire and on-farm collected data. Farm sizes were 9.3 ± 6.7 acres in tethering system and 4.3 ± 2.6 acres in zero-grazing. Fifty-four percent of the zero-grazing herds had animal housing facilities. All farmers in tethering system kept cows on earthen floors and calves without bedding. Hygiene level in existing farms was low. Majority of calves were fed once a day by restricted suckling (77 %). Seventy-four percent of tethered cows were only fed on natural grass, while cows under zero-grazing system had a more diversified diet but with 82 % feeding mainly Napier grass. Most farms (87 %) used bulls for breeding. Milk production was higher ($P < 0.05$) in zero-grazing (6.5 L/cow/day) than tethering system, and higher ($P < 0.05$) for Holstein-Friesian crossbred cows (5.2 L/cow/day) than local breed cows (2.6 L/cow/day). Less than 1 L of milk per farm per day on average was sold. Disease treatments were exclusively for helminths, East Coast fever, and trypanasomiasis. Spraying of ticks and deworming were important control measures of vector-borne diseases. There is potential to develop alternative feed resources for dairy cattle and biorational pesticides for control and treatment of vector-borne diseases.

Keywords Cattle management · Milk production · Organic

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Introduction

By 2010, Uganda had about 200,000 certified organic farmers with about 230,000 ha of land (FiBL and IFOAM 2013; Willer and Lernoud 2015). Currently, over 400,000 organic farmers with 350,000 ha are certified covering 2 % of agricultural land (Rukundo 2014). Great potential for growth of organic agriculture continues to exist in Uganda due to its comparative advantage of good weather and low inorganic fertilizer use (Zenere 2014).

In a recent study in Luwero and Kayunga districts in Uganda, farms with certified organic pineapple production were found to be diversified with various livestock and crops (Nalubwama et al. 2014). The integration of crop and livestock production is considered to be a key pathway to improved productivity, efficiency, and sustainability (Powell et al. 2004). Livestock production contributes to nutrient balance of the whole farming system, which is very relevant for organic agriculture where the system approach is emphasized (Henning 1998). Furthermore, potential to market organic animal products has recently been identified in local and regional markets (Anecho 2015). However, studies indicate that organic farmers in Uganda continue to rear livestock without adherence to organic principals and standards (Kiggundu et al. 2014; Nalubwama et al. 2011). This has been attributed to various livestock production challenges faced in smallholder farming systems such as endemic animal diseases and pests which are still controlled using conventional methods; insufficient supply of certified organic feeds; and limited land and

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scanty knowledge on improved farm management practices (Nalubwama et al. 2014; Odhong et al. 2015).

Documented information and in-depth understanding of livestock production and conditions under which smallholder organic farms operate in Uganda is scanty. This calls for recommendations for improvements for better management of dairy cows and future adoption of organic dairy farming as specified by East Africa Organic Product (EAOP) Standards (EAOPS 2007). The aim of this article was to assess cattle management practices and conditions on smallholder certified organic pineapple farms with dairy cattle and their potential effects on milk production and animal health.

Materials and methods

Study area and sampling methods

The study was conducted in Luwero and Kayunga districts in central Uganda. Both districts are major areas for organic pineapple production (FIT 2006). Kayunga district is situated about 74 km east of Kampala and Luwero district is located about 75 km north of Kampala. The rainfall pattern is bimodal with the rainy seasons in March to May and October to November.

A longitudinal survey was conducted for a period of 12 months (August 2013–July 2014) to gather data from 30 mixed smallholder certified organic pineapple farms. The farms were purposefully selected from a larger sample in the previous study based on certified organic pineapple production and presence of at least one dairy cow (Nalubwama et al. 2014). Eleven zero-grazing farms from the previous study were included, and random sampling was used to select the remaining 19 farms from a group of 61 farms with tethering system.

Data collection

A baseline study to asses land size, land use, cropping, livestock management practices, challenges as well as coping strategies and farmers' perceptions to organic livestock production was conducted 2 months before onset of milk recordings. In addition to following up on all lactating cows, in-calf cows which were expected to calve during the study period were also monitored. A total of 56 cows were included in the study, and out of these, 44 cows had milk recordings taken. One farm was followed without any lactating cow because the only cow found at that farm did not give birth as expected. Milk production (milk consumed at home, milk given away, milk sold and its prices, and milk fed to calves), calving, and disease treatments were recorded by farmers on pre-formatted record sheets. Two trained field assistants crosschecked and reinforced record keeping, and the authors visited each farm every month.

Data analysis

Questionnaire data was analyzed using SPSS software (Statistical Package for Social Sciences for Windows, version 16.0) for descriptive statistics. *t* test was used to assess differences in size of land and reproductive parameters of dairy cattle in the two management systems. Farmers' perceptions were ranked according to their Likert average scale values. Estimation of effects of known fixed factors (breed, management system, and season) on milk production was analyzed using PROC MIXED Models of Statistical Analysis System (SAS 9.1). In the calculations of the lactation curves, 41 cows with a known calving date were included. The average milk yield per 2 weeks period was calculated by the integer part of ((milking date − calving date)/14) + 1. To calculate the number of Tropical Livestock Units (TLU), the different categories of cattle and other livestock were converted as 1 cow or bull = 1.2 TLU, 1 heifer or steer = 0.7, 1 calf = 0.3, 1 sheep or goat = 0.15, 1 chicken or duck = 0.01, and 1 pig = 0.2 TLU (conversion factors were based on livestock demographic structure and mean weights according to Jahnke (1982)).

Results

Herd structure

Majority of households owned one or two dairy cows, and 7 % of the farms owned a bull as presented in Table 1. Apart from cattle, the farms also kept other livestock including goats, pigs, chickens, and ducks. Tethering systems had a total of 6.81 TLU, while zero-grazing systems had 2.36 TLU on average.

Average age at first calving was relatively lower ($P < 0.001$) for cows under zero-grazing systems compared to cows under tethering systems as presented in Table 2. During the study period, 26 cows gave birth, and of these, only 19 % were of first parity. Some of the cows which did not calve during the study period had no milk recordings for more than a year. These calving intervals were much longer than indicated by the combined information about cows' age and parity numbers given by the farmers.

Breeds and breeding

Cattle were specified as local or crossbred (indigenous × Holstein-Friesian of unknown percentage of genetic composition). All cows in zero-grazing system were crossbred while under tethering both local and crosses were kept. Majority of the study farms (87 %) used bulls for breeding and 13 % of the

Table 1 Means (and SD) and tropical livestock units (TLU) of livestock on mixed smallholder certified organic pineapple farms in tethering and zero-grazing systems

Variable	Management systems							
	Tethering ($n = 19$)				Zero grazing ($n = 11$)			
	Mean + SD	Median	Range	TLU[a]	Mean + SD	Median	Range	TLU
Herd structure								
Cows	2.3 ± 3.2	1	1–15	2.7	1.2 ± 0.4	1	1–2	1.4
Heifers (1 year or older)	0.3 ± 0.6	0	0–2	0.2	0.2 ± 0.4	0	0–1	0.1
Female calves (<1 year)	1.1 ± 1.4	1	0–6	0.3	0.5 ± 0.8	0	0–2	0.2
Male calves (<1 year)	0.8 ± 1.0	1	0–4	0.3	0.8 ± 0.6	1	0–2	0.2
Steers	0.6 ± 1.2	0	0–4	0.4	0.3 ± 0.6	0	0–2	0.2
Bulls	0.1 ± 0.2	0	0–1	0.1	0.1 ± 0.3	0	0–1	0.1
Other livestock species								
Goats	3.8 ± 2.3	3	0–8	2.8	0.8 ± 1.9	0	0–6	0.1
Chickens	4.4 ± 4.4	5	0–15	0.0	1.4 ± 3.2	0	0–10	0.01
Pigs	0.2 ± 0.7	0	0–3	0.0	0.2 ± 0.6	0	0–2	0.0
Sheep	0.2 ± 0.6	0	0–2	0.0	–	0	–	0.0
Ducks	0.5 ± 2.3	0	0–10	0.01	–	0	–	0.0

[a] Tropical livestock unit is equivalent to an animal of 250 kg live weight, 1 TLU = 1.2 cattle, 0.15 sheep/goat, 0.01 chicken and duck, 0.2 pig. Author's conversion factors are based on livestock demographic structure and mean weights of ages (Jahnke 1982)

farms, all of which were zero-grazing, used artificial insemination. Farmers ranked high milk yield (score 3.0) and robustness (score 2.7) as the most important factors for breeding. None of the farms kept record on use of bulls, dates when cows were on heat and when mated.

Animal housing and hygiene

Results of on-farm observations related to hygiene and housing of cattle is presented in Table 3. Only 20 % of the farms had animal housing facilities and all these were under zero-grazing system. The remaining farms had their cows kept in shades of trees. The cowsheds were made of local wooden materials, which were observed to be poorly maintained. On most farms, exercise areas were soggy due to lack of drainage. Calf pens were soiled in most farms. Less than half of the farmers washed the cows' udders before milking.

Outdoor access and feeding management

Farm sizes were bigger ($P < 0.05$) in tethering system (9.3 ± 6.7 acres) compared to zero-grazing systems (4.3 ± 2.6 acres). In tethering system, animal were grazed with ropes tied around their neck or leg and were grazed solely on natural pastures (74 %). Others (26 %) supplemented the pastures with crop residues

Table 2 Averages of age and parity numbers of cows on smallholder certified organic pineapple farms in tethering and zero-grazing systems

Variable	Management systems			SEM	*P* value
	Tethering		Zero grazing		
	Cross $n = 12$	Local $n = 22$	Cross $n = 11$		
Age of cows (year)[a]	6.0	6.3	7.3	0.765	0.247
Age at first calving (year)[a]	3.2	3.1	1.9	0.135	<0.0001
No. of parity	2.5	3.6	4.6	0.546	0.067
Weaning age (months)[a]	5.5	6.0	6.6	0.577	0.361

[a] Data for these parameters of the cows expected to be in the milk recording was collected before the beginning of the longitudinal study

Table 3 Available housing and equipment related to housing system and hygiene on smallholder certified organic pineapple farms in tethering and zero-grazing systems

Parameter	Observations	Tethering ($n = 19$)		Zero grazing ($n = 11$)	
		Number	Percent	Number	Percent
Cow shed		0	0.0	6	54
Calf staying area/pen		16	84	11	100
Feed troughs		3	16	7	64
Water troughs		1	5	6	54
Floor type in calf staying area or pen[a]	Concrete floor	1	6	4	36
	Wooden slatted floor	0	0.0	3	27
	Earthen floor (soil)	15	94	4	36
Calf bedding	Straw/grass	0	0.0	1	9
	Polythene	0	0.0	1	9
Cleanliness of calf staying area or pen[a]	Clean	7	37	5	45
	Dirty	9	47	6	54
Floor type of cow Kraal/shed	Concrete floor	0	0.0	3	27
	Wooden slatted floor	0	0.0	4	36
	Earthen floor (soil)	19	100	4	36
Floor type in the milking area	Concrete floor	0	0.0	3	27
	Wooden slatted floor	0	0.0	1	9.
	Earthen floor (soil)	19	100	7	64
Frequency of cleaning cow staying area	More than once a day	2	10	4	54
	Once a day	4	21	6	36
	Once a week	13	68	1	9.

[a] Three farmers in the tethering system had no separate calf staying area or pen

which comprised of banana peels, sweet potato vines, pineapple wastes, maize stover, and banana pseudo stems. All zero-grazing farms provided an exercise yard so that cattle had outdoor access. Majority of the farms (82 %) used Napier grass as the basal fodder for cattle. In addition, 64 % of the farms provided crop residues and maize bran as supplements.

Calf management

Majority of the farms (87 %) reared at least one calf during the study period. Farmers used an isolation calf area to restrict suckling. Seventy-seven percent of the calves were separated from the cows and only allowed suckling after morning milking. Farmers who bucket fed calves (23 %) reported 0.5–3 L of milk for the calf per day, depending on its age. In addition to milk, farmers provided calves with natural pastures, Napier grass, and/or crop residues. Water was not provided to the calves ad libitum. In tethering system, 84 % of the calves were weaned between 6 and 10 months compared to 91 % in zero-grazing system. While 18 % of the farmers used bedding materials in calf pens under zero-grazing system, none of them used it under tethering system.

Daily milk recorded

Fifty-seven percent of the cows (6 cross breed cows and 13 local breed cows) were milked twice a day and 43 % of the cows once a day, in the morning or alternating from morning to evening milking in some farms. According to the milk recordings, 16 % of the cows had lactations of less than 150 days; another 23 % had just short milk recordings since the study had come to an end. Besides 79 % of cows in the milk recordings, another 21 % were present on the farm but not expected to calve during the study period and hence not included in this record. While the bulk of milk produced during the rainy and dry seasons (63–70 %) was sold to generate household income, 28–34 % was consumed at home, 2 % was given to the calves, and up to 1 % was given away. Milk prices ranged between 0.2 and 0.3 USD per liter in both rainy and dry season and no milk was sold as certified organic.

Mean daily milk production was higher ($P < 0.05$) for crossbred cows (5.2 ± 0.19 L/cow/day) compared to local breeds (2.6 ± 0.19 L/cow/day) (Fig. 1). The two curves for crossbred cows showed that much of the difference in daily milk yield was due to four highest yielding cows that produced more than 10 L/cow/day.

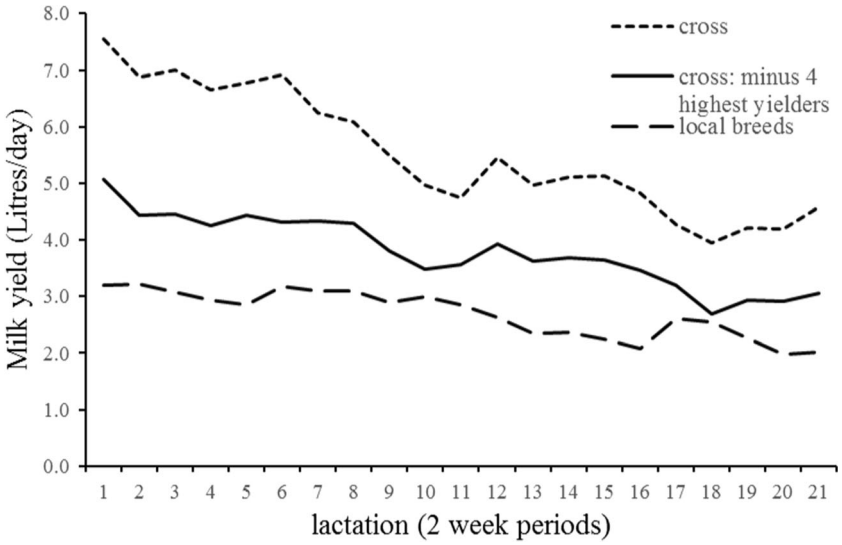

Fig. 1 Average daily milk recorded after every 2 weeks period of lactation for cross and local bred cows. "Cross" indicates milk yield of all cross bred cows. "Cross: minus 4 highest yielders" indicates recorded milk production of cross bred cows excluding the four highest yielding cows. "Local" indicates the recorded milk production of the local breeds

Effect of management on daily milk recorded

Although crossbred cows produced more milk than local breeds, their production varied with management system (Fig. 2). The mean daily milk production was higher ($P < 0.001$) for crossbred cows under zero-grazing system (6.5 ± 0.24 L/cow/day) compared to 3.0 ± 0.14 from crossbred cows kept under tethering system.

Effect of calving season on daily milk recorded

Crossbred cows that calved in wet season had higher ($P < 0.05$) milk production (6.0 ± 0.32 L/cow/day) compared to those that calved in the dry season (4.2 ± 0.32 L/cow/day) (Fig. 3). However, local cow breeds that calved during dry season had higher ($P < 0.05$) recorded milk production (2.8 ± 0.11 L/cow/day) compared to those that calved in wet season (2.3 ± 0.11 L/cow/day).

Diseases and parasites

Farmers only recorded diseases treated with veterinary drugs (Table 4). The treatments were recorded on individual animal or group level. Trypanasomiasis was mostly reported on the zero-grazing farms, while helminthiasis and East Coast fever were mainly reported on tethering farms. The number of treated mastitis cases was remarkably low. Eighty-nine percent of the cases were treated by farmers themselves using chemical or herbal remedies.

Farmers' strategies to animal health problems

The study revealed that farmers used various coping strategies to handle animal health and disease-related problems. Farmers' response to an open question "What do you do to keep your animals healthy?" is summarized in Fig. 4.

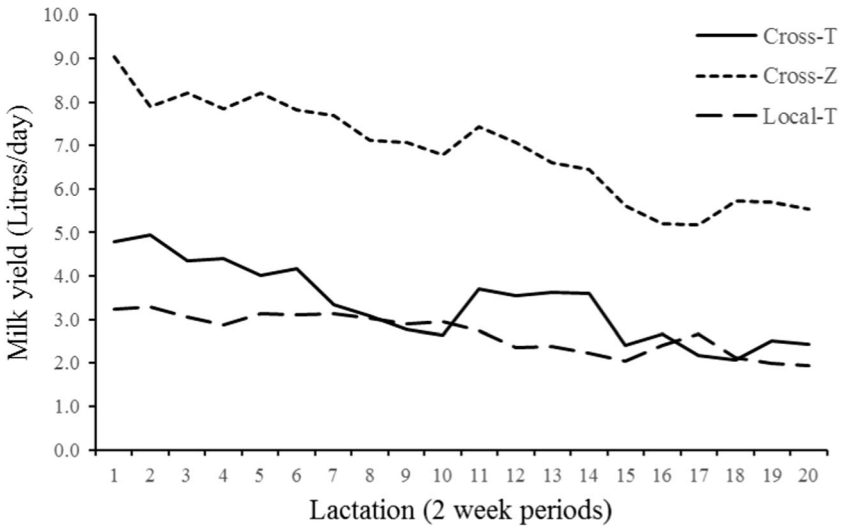

Fig. 2 Average daily milk recorded after every 2 weeks period of lactation for different breed of cows in the two management systems. (Tethering indicated with a "T" and zero grazing indicated with a "Z")

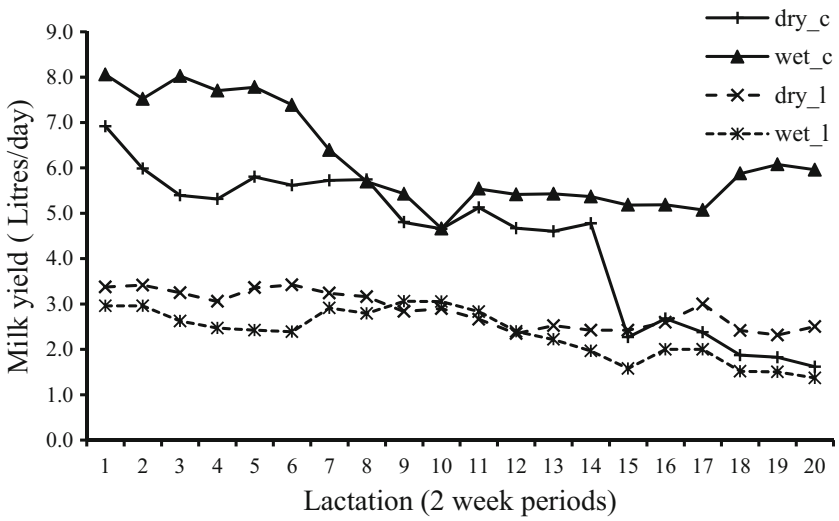

Fig. 3 Average daily milk recorded after every 2 weeks period of lactation for cows calving in dry and wet season (Crossbreed cows indicated with "c" and local bred cows "l")

Discussion

Farm structures and hygiene

Most farms did not have housing and troughs for feed and water for the animals. In addition, the level of hygiene of both cow and calf areas was low. This is inconsistent with the East African Organic Products Standards (EAOPS) which stipulates that animals shall have living conditions that prevents abnormal behavior, injury plus disease and managed according to their natural needs (EAOPS 2007).

Feeding management

Crossbred cows kept under tethering system and fed with only natural pastures yielded less than those under zero-grazing systems. Generally, cows were fed with higher quality feeds that possibly met the cows' requirements to a higher degree. However, the major challenge with depending on natural pastures is the seasonal variation of its quality and availability (Okello and Sabiiti 2006). The use of pastures and fresh fodder as the main feed fits well in the requirement of the EAOPS, which stipulates that diets of dairy cattle should comprise of at least 60 % dry matter as organic feeds (EAOPS 2007).

Grazing and outdoor access

Since the majority of farmers under tethering system solely grazed cattle on natural pastures which is labor intensive, there could be a risk of competition between the livestock enterprise and crop production. For example, the high demands on family labor due to diversified farm enterprises, tethered cows might stay in the fields for long hours without access to water or change in grazing location. Moreover, tethering is an acceptable practice in the East African Organic Standards, but should not affect the well-being of the animals including access to adequate feed, shade, and water (EAOPS 2007). Zero-grazed cows, on the other hand, were provided all the feed

Table 4 Type and number of disease treatments, number of cattle, and the number of treatments per head in tethering and zero-grazing systems during the study period

Type of disease	Reported symptoms	Disease treatments	
		Tethering Number	Zero grazing Number
Helminths infestation	Soft feces, potty belly, rough coat, coughing	16	6
Trypanasomiasis	Dull skin, weight loss, loss of appetite	2	6
East Cost fever	Loss of appetite, fever, Swollen lymph nodes, Presence of ticks	13	1
Mastitis	Swollen, hard and warm udder	1	0
Number of cattle[a]		96	34
Treatment per head		0.33	0.38

[a] Number of cattle which were in the system during the study period including cows, heifers, calves, steers, and bulls

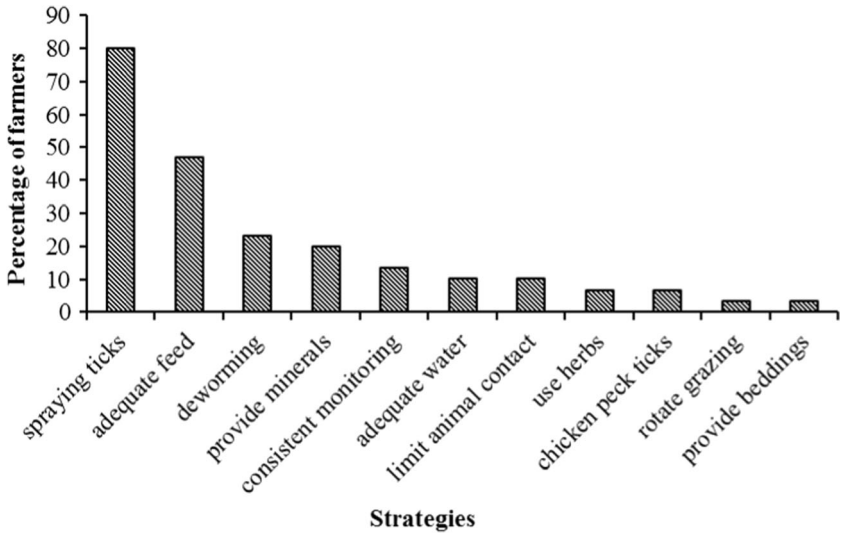

Fig. 4 Farmers' strategies to cope with animal health problems as obtained from their response to the question "What do you do to keep your animals healthy?"

indoor but had an exercise yard to encourage outdoor access and free movement.

Factors influencing milk production

Feeding is well-known as a very influential factor for milk yield. In the study area, cattle mainly depended on natural pastures, yet in the wet season, tropical pastures grow fast and deteriorate in quality, while in the dry seasons, the decrease in pasture yields forces dairy cows to face episodes of food scarcity (Grimaud et al. 2007) when no feed has been conserved and stored. To ensure stable milk production during all seasons, farmers should ensure feed availability. This can be achieved through ensiling pineapple wastes and storing crop wastes and agro industrial by-products as supplements to the natural pastures (Negesse et al. 2009; Kiggundu 2015). This can allow cows to maintain productivity and farmers to access milk markets for the biggest part of the year.

If the farmers were able to sell milk as certified organic for a higher price, this could possibly be an incentive to prioritize higher milk production. However, low milk production per day from both crossbreds and local breeds is a major challenge which might be attributed to management. Therefore, even if the price of organic milk doubled (from 0.3 to 0.6 USD per liter), the current milk yield could still result into low profits which cannot allow farmers to access a more stable and high quality feed supply.

Calf management

Although suckling enables the cow and the calf to express natural behavior and ensures natural communication between the cow and calf (Grondahl et al. 2000; Flower and Weary 2003), restricted calf feeding was used by majority of the farmers irrespective of the system. While calves under tethering system were only allowed to suckle after morning milking, under zero-grazing system calves were bucket fed. This restriction is inconsistent with the natural living of calves recommended in organic dairy production that involves cow-calf contact and natural feeding (EAOPS 2007).

Breeds and breeding

No systematic information on breeding bulls was available for selection purposes. Therefore farmers decided which local bull to use depending on the cost and availability. This possibly influenced the length and variability of the calving intervals. Although majority of the farmers indicated high milk production as their major breeding aim, other important traits such as adaptation to local environment and utilization of available feed resources are important in meeting the health and welfare needs of the animals (Odhong et al. 2015).

Disease management and health promotion strategies

Treatment of helminths and ECF was more in the tethering system than zero-grazing system. Exposure of grazed cattle to parasites potentially increased their risk to infection. However, the low number of treatments could be attributed to efforts in controlling vectors through routine spraying, which is the main strategy used in the control of endemic vector-borne diseases in the tropics (Zilberman et al. 2011; Shaw et al. 2013). The East African Organic Standard allows for treatment using veterinary drugs; however, emphasis is on preventive measures including use of appropriate breeds, animal husbandry, and good quality feeds (EAOPS 2007).

A healthy animal is known to be incredibly resilient and has the ability to react, restore balance or homeostasis, and therefore is capable of healing itself from a range of ailments to a certain degree (Doring et al. 2015). The less than optimal

management practices of dairy cattle in this study irrespective of management system cannot possibly allow the animals to exploit their natural potential of self-healing. Improved dairy animal health and welfare in many of the farms will require additional knowledge and capital investment. The question, however, is whether smallholder farmers are willing to invest for the long-term benefit of the animals if no immediate economic improvements are realized.

Future perspectives

Our recommendations are to (1) develop alternative feed resources for dairy cattle, (2) promote a better system of selection for local bulls for higher milk production, but taking into account trait such as adaptation to the local environment and feed resources, (3) shift the focus from disease treatment to health promotion practices, and (4) explore biorational pesticides for control and treatment of vector-borne diseases.

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Compliance with ethical standards

Statement of animal rights The manuscript does not contain clinical studies or patient data

Conflict of interest The authors confirm that they have no conflict of interest and no part of this is submitted anywhere else for publication.

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