Adoption of Supplementary Feeding in Smallholder Dairy Cattle Production in Mbarara District

Article *in* American Journal of Alternative Agriculture · June 2022

DOI: 10.47672/aja.1069

3 authors:

Twesigye Gilbert
Bishop Stuart University (BSU)
1 PUBLICATION **0** CITATIONS
SEE PROFILE

Edward Ssemakula
Bishop Stuart University (BSU)
10 PUBLICATIONS **39** CITATIONS
SEE PROFILE

Bahame David
Bishop Stuart University (BSU)
1 PUBLICATION **0** CITATIONS
SEE PROFILE

American Journal of
Agriculture
(AJA)

ADOPTION OF SUPPLEMENTARY FEEDING IN SMALLHOLDER DAIRY CATTLE PRODUCTION IN MBARARA DISTRICT

Gilbert Twesigye, Edward Ssemakula and Bahame B. David

AJP

American Journal of Agriculture
ISSN 2520-4678 (Online)
Vol.4, Issue 1, pp 58 - 88, 2022

www.ajpojournals.org

Adoption of Supplementary Feeding in Smallholder Dairy Cattle Production in Mbarara District

Gilbert Twesigye

Post Graduate Student, Faculty of Agriculture, Environmental Sciences and Technology, Bishop Stuart University

Corresponding Author's Email: gilberttwesigye6@gmail.com

Prof. Edward Ssemakula

Lecturer, Faculty of Agriculture, Environmental Sciences and Technology, Bishop Stuart University

Email: essemakula121@gmail.com

Mr. Bahame B. David

Lecturer, Faculty of Agriculture, Environmental Sciences and Technology, Bishop Stuart University

Email: dbahame@as.bsu.ac.ug

Abstract

Purpose: This study sought to assess the level of adoption of supplementary feeding, associated socioeconomic factors and the relationship between supplementary feeding and dairy cattle production among smallholder dairy farmers in Mbarara District.

Methodology: The study adopted a mixed approach to collect both quantitative and qualitative data from 198 smallholder farmers and 12 key informants using a semi-structured interview guide and key informant interview guide respectively. Cluster sampling was used to divide the target population into clusters and then selected elements from each cluster using Simple Random Sampling technique. Collected data was compiled, sorted, and entered into Statistical Package for Social Scientists (SPSSv26.0) for analysis.

Findings: The study revealed that 81.3% of smallholder farmers adopted supplementary feeding. However, the level of supplementary feeding varied among smallholder farmers of different socioeconomic characteristics. Basically, there was low level of adoption of supplementary feeding among farmers with few household members, having little knowledge about supplementary feeding and little funds to finance the costs involved in application of supplementary feeds. In relation to dairy cattle production, there was a positive significant relationship between the level of adoption of supplementary feeding and milk yield.

Unique contribution to practice and policy: This study suggests to policy makers and other relevant authorities to formulate polices that emphasize adoption of supplementary feeding among dairy farmers in order to increase milk production in cattle.

Keywords: *Supplementary, feeding, smallholder, adoption, production*

1.0 Introduction

Worldwide, dairy farming plays a very important livelihood role to about 20% of the world population mostly the rural and peri-urban dwellers (McDermott *et al*., 2010). In particular, dairy farming safeguards food security, enhances access to animal protein, improves household income and empowers the resource-poor rural communities mainly women through selling of surplus milk and dairy products (Food and Agriculture Organisation (FAO), 2011). In developed countries such as USA, grazing management is the foundation of a successful and profitable pasture-based system. In order to improve livestock production, smallholder dairy farmers put emphasis on improving efficiency at the farm level by relying on supplementary feeds such as hay and silage (Muller, 2012).

In developing countries in Africa, dairy animals depend on crop residues to produce milk. To improve dairy production, smallholder farmers in Africa have devised methods of feeding cattle varying from cut-and-carry to pen-fed and zero grazed animals in the mixed crop–livestock systems (Nalubwama *et al.*, 2019). Regardless of this method of feeding, most cattle are partially dependent on crop residues for feed (Steinfeld & Mack, 2015). In the East African region, dairy farming is constrained by limited land for grazing causing competition for pasture. Smallholder dairy farmers often comprises less than 5 ha land, keeping 1-5 dairy cows that are often improved breed mixed with local breeds (Maleko *et al.*, 2018). Like other African countries, feeding in the smallholder dairy farming system in East Africa is mainly 'cut and carry' whereby crop residues (maize and sorghum stover, rice and bean straws), natural grasses and sometimes weeds are brought to the animals at the stall as supplementary feeds. The average milk production per farm under smallholder dairy production is about 10 litres per day of which 25% is for home consumption and the rest is for sale to mainly neighbours and to a limited extent to traders and processors (Maleko *et al.*, 2018).

In Uganda, cattle contribute to over 40 percent to the value of livestock production and to about 7 percent to the value of agricultural production ((Uganda Bureau of Statistics (UBOS), 2017)). A small number of households keeping improved dairy cattle make effort to plant improved pastures, mainly Napier but also grasses such as *Chloris guyana, Brachiaria spp*, Kikuyu grass, and various other grasses and legumes species are cultivated at small scale which is cut and given to cattle as supplementary feeds (Kabirizi *et al.*, 2015). A few commercial farms carry out serious fodder production and conservation which helps them to adequately cater for the feed requirements of the herds during dry seasons. Some commercial farms utilize only conserved forage, mainly silage and hay throughout the year (Balikowa, 2011).

The most common method of feeding cattle in Uganda is by grazing on natural or planted pastures. Indigenous cattle kept under the traditional extensive management system rely on grazing natural pastures for their entire nutritional requirements. Stall feeding of indigenous cattle with cut fodder or concentrate feeds is not widely practiced in Uganda. Studies indicate that most smallholder farmers in Uganda graze exotics and crossbred cattle in the wet season and introduce stall feeding only in the dry season (East Africa Dairy Development (EADD), 2009).

In South Western Uganda, Balikowa (2011) in his study on grazing systems revealed that 85.6% of the farms keep cattle on fenced pastures while 9.7% rely on unfenced communal and private grazing land to feed their cattle and only 5% of the farms were zero-grazing (stall feeding or tethering). Over time, the number of fenced farms and stall-feeding units has been increasing as

seminomadic pastoralism is phased out. In the cattle corridor, where Mbarara district is inclusive, livestock production has grown faster than agricultural production and this trend is likely to continue with growth rates over the next 20 years estimated at 4.5 percent per annum. Historically, growth has come primarily from the expansion of livestock numbers rather than an increase in production. If this trend continues, it puts tremendous pressure on the available feed resources hence limiting dairy production and growth (Tenywa, 2014).

In Mbarara district, the urban and peri-urban areas of Mbarara town have experienced increased human population (58.7%) and decreased land for production than in rural areas (41.3%) where they have considerably large pieces of land for grazing of animals (UBOS, 2014; Mbarara District Statistical Abstract for 2016/2017). Yet the increased human population in urban areas of Mbarara comes along with increased demand for livestock products and this means readily available market for the livestock products. This implies that smallholder farmers in these areas need to adopt supplementary feeding if they want to increase dairy cattle production so as to meet the increased demand for the products at the same time increasing the household incomes and standards of living (Tibayungwa, 2010).

It is against the above background that the study sought to assess the adoption of supplementary feeding in smallholder dairy cattle production in Mbarara District

1.1 Problem Statement

The Ugandan government has provided enormous efforts in provision of advisory and dairy development services by encouraging smallholder dairy farmers to adopt supplementary feeding in order to increase dairy production and to satisfy the expectations of the food industry and consumers. Despite these efforts, utilization of supplementary feeding practices by smallholder dairy farmers in Uganda is still low. According to Wangalwa, Casim, Rugunda and Wafula (2016), about 93.9% of the farmers in Mbarara district still feed their cattle on natural fodder while only 6.1% feed their animals on supplementary feeds like hay (Wangalwa *et al.*, 2016). Milk productivity is still low and this affects the expected income to the dairy farmers. However, there are little published studies that have examined the social economic factors affecting adoption of supplementary feeding among smallholder dairy cattle farmers in Mbarara district and the effect of supplementary feeding on dairy cattle production. Hence this study sought to fill this gap.

1.2 Objectives of the study

i. To determine the level of adoption of supplementary feeding among smallholder dairy cattle farmers in Mbarara District

ii. To determine the relationship between level of adoption of supplementary feeding with milk yield among smallholder dairy farmers in Mbarara District

iii. To examine the socio-economic factors associated with adoption of supplementary feeding in smallholder dairy cattle production among dairy farmers in Mbarara District.

2.0 Literature Review

This study was based on the diffusion of innovations theory (DOI) to explain the utilization of supplementary feeding in dairy cattle production. Diffusion of Innovation (DOI) theory is a popular theory developed by Rogers (1995) used this theory to explain the adoption of users to new technologies. According to DOI, the rate of diffusion of an innovation such as supplementary

feeding in a sector such as Dairy sector is affected by an innovation's relative advantage, complexity, compatibility, trialability and observability. In relation to the current study, the relevance of the DOI theory is that it explains the reason why smallholder dairy cattle farmers adopt supplementary feeding as an innovative strategy for increasing dairy cattle production if it offers more benefits over traditional grazing. This means that dairy farmers who adopt technical innovations have relatively better milk output than those who do not. This theory was therefore applicable to this study because it has been applicable in other related studies.

2.1 Empirical review

2.1.1 Adoption of Supplementary Feeding Among Smallholder Dairy Farmers

Banana peelings can be used by farmers to complement on the pastures especially during the dry season when the pasture quality and quantity are greatly reduced. Substituting elephant grass with banana peelings in diets should be accompanied with strategic supplementation to be able to meet the animals' requirements (Kasozi, Sabiiti, Bareeba & Sporndly, 2014). Large quantities of banana peelings are produced in many parts of Uganda where the cooking type of bananas is the staple food. Ugandans are the world's greatest consumers of bananas and so plenty of banana peelings are produced by Ugandans (Nowakunda & Tushemereirwe, 2004).

Crop residues play a vital role in feed provision to livestock under the tropical crop-livestock mixed farming systems (McIntire *et al*., 2016). In Uganda, the practice of collecting and storing crop residues including maize Stover, bean and rice straw from farms after harvest for dry season feeding is widespread among smallholder farmers (De Groote *et al.*, 2013). McDowell (2008) reported that crop residues including maize, beans and rice straws contributed about 35–45% of the livestock feed demand in Kenya and about 25% of the energy required by ruminants. Hay can be fed to beef cattle, dairy cattle, goats and sheep. Intake depends on hay quality and availability of other feeds (Lukuyu, Gachuiri & Lukuyu, *et al*., 2012). Hay is fodder conserved through drying to reduce the amount of water content so that it can be stored without rotting or becoming mouldy (Mubiru, Namirimu and Owino *et al*., 2013). Sundstol (2013) also noted that efforts aimed at reducing dry season feed stresses include promotion of hay making.

Silage is high-moisture fodder preserved through fermentation in the absence of air in order to preserve forage nutrients for feeding at a later date. According to Mtengeti *et al.,* (2013), silage-making provides opportunities to store surplus forages even during the wet season and allow pasture regrowth. In Uganda, efforts to promote proper mixing of concentrates including maize bran, cotton seedcake, sunflower seedcake, leaf meals and mineral–vitamin premixes to supplement the poor roughages have been in place since the earlier 1980s. This practice aims at ensuring that the nutritional requirements of dairy cattle for both maintenance and optimal production are met throughout the year. However, the practice is still limited to few commercial dairy farms while most smallholder farmers do not supplement their dairy cattle. Similar studies done by Lukuyu *et al* (2015) indicate that those who are supplementing often provide a small amount of unbalanced concentrates with the intention of calming the cow during milking or improving milk yield.

According to Kienzle, Ashburner and Sims (2013), leaf-meal is composed of dry leaves from protein-rich fodder legumes. It is essential for supplementing protein poor roughages especially during dry season. A study done by Kienzle et al., (2013) reported that dairy cattle which were supplemented with *Leucaena leucocephala* leaf-meal, cotton seed hull and maize bran at a

proportion of 2.6, 1.8 and 1.8 kg DM/day increased milk yield by 6.7L per cow per day. Multi-nutrient fodder blocks (MFBs) are compounded feeds which are moulded into blocks of various sizes depending on target species and technology used. According to FAO (2012), MFBs if well manufactured can supply balanced feeds to the dairy cattle and other livestock hence improving dairy production. In East Africa, Multi-nutrient fodder blocks technology was tested in some farms in Uganda, Kenya, Burundi and Tanzania and 10% milk yield increase was reported (ASARECA, 2013).

2.1.2 Supplementary Feeding and Dairy Cattle Production

The amount of milk a cow can produce is directly related to the quality and quantity of feed intake by cattle. If quality and/or quantity is lacking, the animal responds by producing less milk and if the cow is not sufficiently fed over a longer period, milk yield reduces (FAO, 2017). This implies that supplementary feeding is directly related with dairy cattle production.

Kasozi, Sabiiti, Bareeba and Sporndly (2014) examined the effect of feeding varying levels of banana peelings supplemented with maize bran, cotton seed cake and *Gliricidia sepium* on the performance of lactating dairy cows. The study findings revealed that daily milk yields ranged from 10 to 11 ltrs after feeding lactating cows on banana peelings. Correlation and regression analysis revealed that dairy milk production is positively related with supplementary feeding. Stojanovic, Grubic and Dordevic, *et al*. (2018), in their study about supplementary feeding of grazing dairy cows, revealed that milk production of high producing grazing dairy cows in early lactation increases linearly as the amount of concentrate increases to 10 kg dry matter/day with a milk response of 1 kg milk/kg concentrate. In late lactation, increases are with a lower milk response per kilogram of supplemented concentrate. Supplementation of ruminally inert fat could have positive effect on milk production with concentrate supplemented at a lower rate.

In East Africa, the performance of the dairy animals in terms of milk yield is still very poor especially in countries like Tanzania, Kenya and semi-arid areas of Uganda (Gillah *et al.,* 2012; Kavana *et al.,* 2005). A study done by Cadilhon *et al.,* (2016) indicated that the average milk production of a crossbred cow (Friesian×Boran) under smallholder conditions in Tanga region was estimated to be 4 and 8L of milk in the dry and wet seasons respectively whereas according to Lukuyu *et al.,* (2015), the recommended milk production potential for such animals in East Africa is 15–20L per cow per day. Inadequate supply of good-quality animal feeds is among the major hindrances for constant year-round high milk production in East Africa at large (Kabirizi *et al.,* 2013; Njarui *et al.,* 2011; Swai & Karimuribo, 2011).

According to Kabwanga and Atila (2015), dairy production could play a greater role in the economy considering its strong potential to provide rural employment and regular income to the many resource-poor households, however, it is still largely subsistence due to limited land for grazing and failure to supplement pasture with other animal feeds. Many studies have discovered major constraints to dairy production in Uganda as breed factors, feed resources, climatic factors, particularly high ambient temperature, socio- cultural factors, and dominant informal sector in milk marketing (Balikowa, 2011; FAO, 2010; Kabwanga *et al.,* 2015).

In Uganda, the south western region and Mbarara district in particular produces a significant surplus of marketable milk particularly in the wet season than other regions due to availability of enough pasture. In the dry season, there is an apparent scarcity of milk due to shortage of pasture. Balikowa (2011), on a study of dairy development in Uganda noted that the scarcity of milk during

the dry season was severe during the months of August and September of 2009 and 2010 due to shortage of pasture. In another study by Dillon *et al.*, (2007), it was found out that supplementing grazing dairy cows with 1.8 or 3.6 kg/day of concentrate increased milk yield, milk fat yield and milk protein yield. Reis and Combs (2010) also found out that using 5.0 and 10.0 kg of corn in diets for grazing cows increased milk production.

Tibezinda, Wredle, Sabiiti and Mpairwe (2016), in their study about feed resource utilization and dairy cattle productivity in the agro-pastoral system of South Western Uganda, found out that natural pastures were the major feed resource throughout the year for all households and the majority (71%) did not provide any feed supplement during dry season or conserve the excess pasture produced in the rainy season. The annual dry matter requirement for maintenance of an average herd was 167 tonnes /year while the annual dry matter availability from natural pasture was 139 tonnes. The study therefore concluded that the farms needed to increase feed availability in order to have high milk yields.

2.1.3 The Socio-economic Factors Associated with Adoption of Supplementary Feeding

Orodho (2005) reported that knowledge on proper feed production, processing and formulation is limited among most smallholder farmers in East Africa and this has contributed to a reduction in dairy cattle production. Derpsch *et al.*, (2016) also reported a poor adoption of agricultural conservation technologies by smallholder farmers in Paraguay due to lack of entrepreneurial knowledge despite many governmental and international agency technological interventions. The reason for the existence of poor technical knowhow among small holder dairy farmers include; poor connection between research, extension and farmer, according to Owen (2012). Franzel and Wambugu (2007) underscored the role of extension service and duration in facilitating knowledge/innovation uptake by smallholder dairy farmers and increasing dairy cattle production. According to Geerts (2014), lack of subsidies for enabling smallholder dairy farmers' access to inputs such as quality seeds, fertilizer and pesticides poses an unformidable challenge to adoption of improved dairy feeding technologies. While in Uganda and Kenya, lack of certified commercial pasture seeds and formal fodder markets (for instance hay markets) is a great challenge (Lukuyu *et al.*, 2015).

In East Africa, the average farm size under smallholder farming systems is 0.9 ha (FAO, 2015). According to Thornton (2010), human and cattle populations are projected to increase at rates of 3% and 4% per annum, respectively. Landholdings are diminishing due to human and animal population increase hence increased land use competition which poses an unformidable challenge to smallholder dairy farmers to choose whether to grow crops or pasture in limited land units. Mwango *et al.*, (2014) in their study also found out that in Usambara Mountains in northern Tanzania the average farm size of 1.4 ha and farmers have opted to grow food crops and vegetables with pasture being restricted only around farm boundaries and contour strips. In Uganda and the East African region, most rural households are poor and cannot afford feed technological costs given the high poverty incidences (Aikaeli, 2010). For example, due to low incomes most smallholder dairy farmers are unable to purchase pasture seeds, forage choppers, tractors, balers, ensiling materials and milking machines. This is further exacerbated by the lower productivity of dairy cows and lower milk prices which trap smallholder dairy farmers on poverty (Cadilhon *et al.*, 2016). Low milk prices and other animal outputs from the farms are among the major constraint

in the dairy sector. The low prices are said to have started since 2004 as was documented in 2008 (MAAIF/UBOS, 2017).

Lack of access to credits by smallholder dairy farmers renders them unable to purchase improved dairy cattle, manage and feed them properly including feed supplement provision. Similarly, Derpsch *et al.,* (2016) observed in Paraguay medium and large-scale farmers managed to adopt conservation agriculture practices while small-scale farmers failed due to inability to purchase less labour demanding machines such as tractors. Owen *et al.,* (2012) stated that better milk prices offered to peri-urban dairy farmers prompted them to be more receptive and responsive to new technologies/practices including supplementation than resource-poor rural small-scale farmers. Thus, finance inadequacy (poverty) among smallholder dairy farmers poses a great challenge towards sustainable adoption of improved dairy technologies.

In Uganda, in particular rural areas where rain-fed agriculture is dominant, rural water infrastructure including boreholes, wells and pipelines are poorly developed (Jimenez & Perez Foguet, 2011). In addition, most smallholder farms lack water storage facilities such as tanks, dams and underground reservoirs, thus rainwater harvesting and storage is limited. The current climate change that is characterized by erratic rainfalls in Eastern Africa with extended drought periods poses a great challenge to smallholder dairy farmers (Adhikari *et al.,* 2015). It is well known that about 85% of milk is water and without water an animal is incapable of digesting and assimilating feeds. It is also well known that a high producing cow can drink up to 60 litres of clean fresh water per day. Nonetheless, water is needed for pasture growth, cleanness, pesticides (acaricides) spraying and in biogas plants. Hence, water shortage especially during dry seasons poses a huge challenge in promoting feed technologies such as irrigated pasture and hydroponic fodder.

Most rural roads in Uganda are underdeveloped and that limits market access to the farms especially during rainy season. This also limits sharing of farm machinery and technology between dairy farms. Poor rural transport infrastructures hinder sustainable development of dairy sector in rural and remote areas. In which, efficient dairy farming is currently limited to peri-urban and urban areas where access to markets and farm inputs is reliable. Other infrastructural constraints include lack of skilled labour, poor buildings like cowsheds, lack of processing facilities, for instance milk cooling tanks, lack of storage facilities, like barns and warehouses. Additionally, lack of electrical power supply for driving forage choppers, poor marketing systems, limited advisory and health services do constrain smallholder dairy farmers towards adoption of improved feed technologies (Kivaria *et al.,* 2005).

3.0 Methodology

The study used a cross sectional study design which involves collecting data from a particular category of the population at a single point in time. This design assisted the researcher to obtain an overall picture as it stood at the time of the study regarding adoption of supplementary feeding and dairy cattle production among smallholder farmers in Mbarara District. This was done by conducting a survey around Mbarara district where smallholder farmers were given an opportunity to describe based on their own knowledge and experience, the levels of adoption of supplementary feeding, the extent to which supplementary feeding has influenced milk yield, the socioeconomic factors associated with supplementary feeding adoption. Respondents were also asked to describe the type of cattle and conditions under which supplementary feeding is given by having participants complete a survey or questionnaire. The study exploited a mixed approach involving

both quantitative and qualitative approaches in order to collect adequate data about supplementary feeding and dairy cattle production. Quantitative approach involved the use of questionnaire while qualitative approach involved the use of interviews, focus group discussions and observations in data collection.

The study was conducted in Mbarara District located in the South-Western region of Uganda. Mbarara District is bordered by Ibanda district to the North, Kiruhura district to the East, Isingiro district to the Southeast, Rwampara District to the Southwest, Sheema District to the West and Buhweju District to the Northwest.

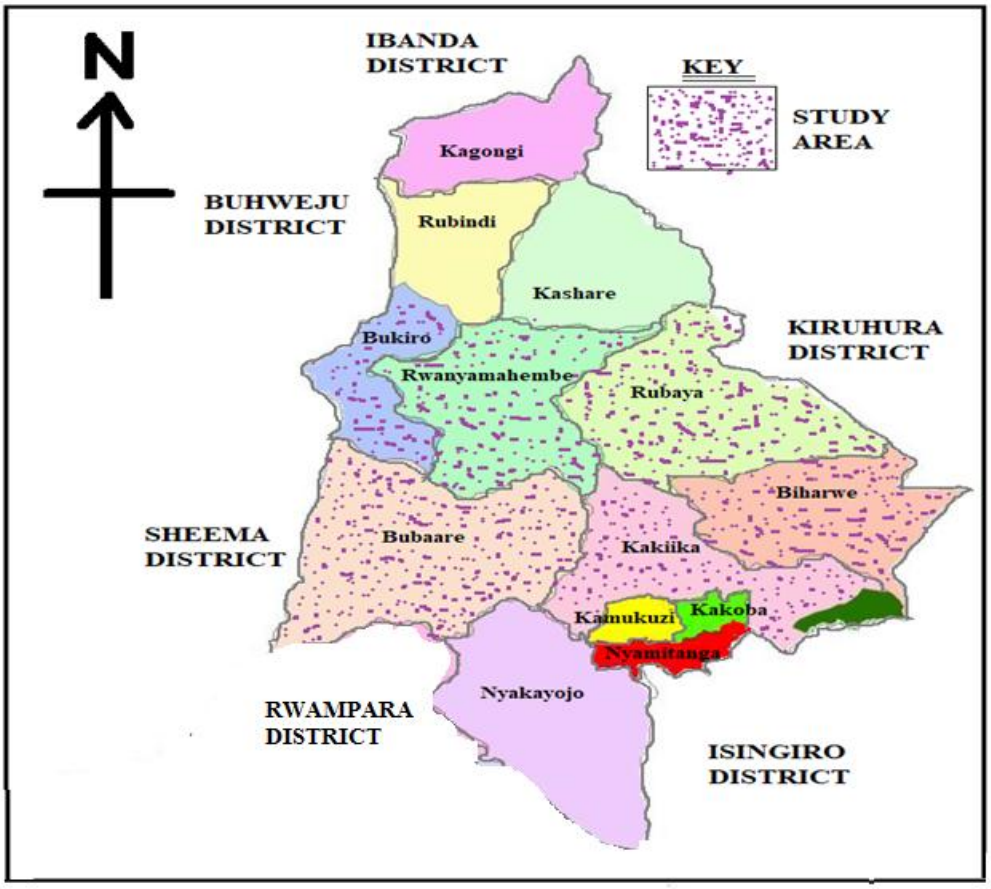

Figure 1: Map of Mbarara District showing the study area

The study population size was 6,930 smallholder dairy farmers who comprised of 1,378 from Rubaya Sub County, 1723 farmers from Bubaare Sub County, 1091 from Bukiro, 2,211 farmers from Rwanyamahembe, 257 farmers from Biharwe and 270 farmers from Kakiika Sub County (Mbarara District Statistical Abstract, 2016/17). The sample size included 210 respondents who comprised of 198 smallholder dairy cattle farmers (both males and females), 6 local leaders (1 per sub-county) and 6 veterinary/agricultural extension officers (1 per sub-county). The dairy farmers comprised of 39 from Rubaya S/C, 49 Bubaare S/C, 31 from Bukiro, 63 from Rwanyamahembe, 8 from Biharwe division and 8 from Kakiika division.

The study used cluster sampling to divide the target population into clusters (sub counties involved in dairy cattle farming) and then selected elements (smallholder farmers) from each cluster using

the Simple Random Sampling technique. Therefore, the different sub counties that formed the clusters include Rubaya (39), Bubaare (49), Bukiro (31), Rwanyamahembe (63), Biharwe (8) and Kakiika (8). Simple random sampling was applied to select participants from each cluster at the sub county level where every participant had an equal chance of being selected. Random sampling was done using a table of random numbers arranged in a series of digits (0 to 9) through the rows and columns. The researcher picked an arbitrary starting point poking the table with his eyes closed and read down the columns from the arbitrary starting point, accepting any integers within the sampling range. The process was continued following rows and columns on the table until when all the 198 respondents were selected.

The researcher used semi-structured interviews, the answers to which were recorded by researcher or research assistants through a face to face interaction with the respondent. This is less expensive in terms of time, human and financial resources compared to an interview. These were administered to each household head in form of a survey. In addition, interview method was used to collect data from smallholder dairy farmers in order to collect in-depth information regarding the process of application of supplementary feeds to cattle, factors affecting adoption of supplementary feeding, any difficulties encountered and changes in milk yield after adoption of supplementary feeding. Interviews were also applied while collecting data from key informants like sub county extension staff, district extension officers and veterinary officers. On the other hand, observation was used to witness the types of supplementary feeds given to cattle and the levels of the feeds taken per cattle, quantity of uptake of these feeds and instruments used in preparing these feeds.

Collected data was compiled, sorted, edited and coded to have the required quality, accuracy and completeness. Quantitative data from both questionnaires and interview guides were then entered into Statistical Package for Social Scientists (SPSSv26.0) to aid in easy generation of frequency tables and figures. Statistical analyses such as frequencies, percentages, mean and standard deviation were used to quantify the levels of adoption of supplementary feeding among smallholder dairy farmers and levels of milk yield resulting from adoption of supplementary feeding. In addition, inferential statistics such as Chi-square, Pearson correlation and regression coefficients were used to measure the degree of relationship between supplementary feeding and dairy cattle production. To understand these statistics better, the quantitative statistics were supported with qualitative narratives from interviews with key informants.

Validity of the instruments was measured using expert judgment method where a sample of questionnaire was given to a research expert who rated the relevancy of the questions to the study. The researcher then computed the content validity index (CVI) by calculating the ratio of total items marked relevant (R) by judges (which was represented by ‘n’) to total items in the instrument (which was represented by ‘N’). The instrument was considered valid when the average CVI was found to be greater than 0.70 as recommended by Amin (2005). On the other hand, the reliability of the research instruments was tested by pretesting them among a sample of five (5) farmers one week before the actual data collection to determine the average time spent to complete the instrument, after which the collected data was analyzed using SPSS Version 26.0. Using this system, the researcher tested for internal consistence by running a reliability analysis using Cronbach’s (1951) alpha co-efficient. When the alpha value was found to be greater than 0.70, the instrument was considered to be reliable.

4.0 Presentation and Interpretation of Findings

The study findings on gender of the respondents revealed that majority 118 (59.6%) of the respondents were males. Of these, majority 93 (78.8%) had adopted supplementary feeding while only 25 (21.2%) had not adopted supplementary feeding in their cattle. In addition, 80 (40.4%) of the respondents were females out of which 68 (85.0%) had applied supplementary feeds while only 12 (15.0%) had not applied supplementary feeds. These findings imply that the highest proportion of smallholder farmers who adopt supplementary feeds is among females (85.0%) as compared to males (78.8%). This is may be because females are constrained by shortage of land for grazing and therefore see it important to supplement their cattle with other fodder.

As regards to age, the study findings revealed that majority 81 (40.9%) of the respondents were aged 19-35 years out of which 64 (79.0%) had applied supplementary feeds to their cattle while 17 (21.0%) did not apply supplementary feeding to their cattle. In addition, 78(39.4%) of the respondents were aged 36-65 years out of which 64 (82.1%) had applied supplementary feeds while only 14 (17.9%) did not apply supplementary feeds. However, only 39(19.7%) of the respondents were aged above 65 years and out of these, 33 (84.6%) had applied supplementary feeds while only 6 (15.4%) had not. The above findings imply that majority of the respondents who had adopted supplementary feeding were adults aged 65 years (84.6%) followed by middle age 36-65 years (82.1%) while the least were those in the youthful age between 19-35 years (79.0%).

The study findings on marital status of the respondents revealed that majority 117 (59.1%) of the respondents were married. Of these, majority 86 (73.5%) had adopted supplementary feeding while only 31 (26.5%) had not adopted supplementary feeding to their cattle. In addition, 42 (21.2%) of the respondents were single and all of them 42 (100.0%) had applied supplementary feeds. However, only 39 (19.7%) of the respondents were widowed and out of these, 33 (84.6%) had applied supplementary feeds while only 6 (15.4%) had not applied supplementary feeds. The above findings imply that farmers who are still single are more involved in supplementary feed adoption compared to those married and widowed. This is because in most cases, such farmers are still very young and have not secured enough land to facilitate natural pasture grazing, hence try to adopt supplementary feeding.

As regards to the highest level of education of the smallholder farmers, the study findings revealed that majority 73 (36.9%) of the respondents had studied up to secondary level. Of these, majority 67 (91.8%) had adopted supplementary feeding while only 6 (8.2%) had not adopted supplementary feeding to their cattle. In addition, 55 (27.8%) of the respondents were primary leavers out of which 42 (76.4%) had applied supplementary feeds while only 13 (23.6%) had not adopted supplementary feeding. Furthermore, only 43 (21.7%) of the respondents had studied up to tertiary/university level and out of these 31 (72.1%) had applied supplementary feeds while only 12 (27.9%) had not applied supplementary feeds. The above findings imply that of all the education levels, adoption of supplementary feeding is dominant among farmers with secondary level of education compared to other levels.

American Journal of Agriculture
ISSN 2520-4678 (Online)
Vol.4, Issue 1, pp 58 - 88, 2022

www.ajpojournals.org

Table 1: Biodata of the respondents

Biodata of the respondents		The respondent applies supplementary feeds to cattle during feeding				Total (N=198)	
		Yes (N=161)		No (N=37)			
		Freq	(%age)	Freq	(%age)	Freq	(%age)
Gender	Male	93	78.8%	25	21.2%	118	59.6%
	Female	68	85.0%	12	15.0%	80	40.4%
Age	19-35 years	64	79.0%	17	21.0%	81	40.9%
	36-65 years	64	82.1%	14	17.9%	78	39.4%
	above 65 years	33	84.6%	6	15.4%	39	19.7%
Marital status	Single	42	100.0%	0	0.0%	42	21.2%
	Married	86	73.5%	31	26.5%	117	59.1%
	Widowed	33	84.6%	6	15.4%	39	19.7%
Highest level of education	None	21	77.8%	6	22.2%	27	13.6%
	Primary	42	76.4%	13	23.6%	55	27.8%
	Secondary	67	91.8%	6	8.2%	73	36.9%
	Tertiary/university	31	72.1%	12	27.9%	43	21.7%
Monthly Income	100,001-200,000	28	100.0%	0	0.0%	28	14.1%
	200,001-300,000	55	74.3%	19	25.7%	74	37.4%
	> 300,001	78	81.3%	18	18.8%	96	48.5%
Sources of income	Agriculture/farming	127	84.1%	24	15.9%	151	76.3%
	Business/selling produce	14	70.0%	6	30.0%	20	10.1%
	Salary/employment	13	100.0%	0	0.0%	13	6.6%
	Agriculture/business	7	100.0%	0	0.0%	7	3.5%
	Agriculture and salary	0	0.0%	7	100.0%	7	3.5%
Household Members	<3 members	9	47.4%	10	52.6%	19	9.6%
	4-6 members	35	74.5%	12	25.5%	47	23.7%
	7-9 members	43	81.1%	10	18.9%	53	26.8%
	>10 members	68	86.1%	11	13.9%	79	39.9%

Type of cattle	Ankole (local)	4	28.6%	10	71.4%	14	7.1%
	Exotic	51	89.5%	6	10.5%	57	28.8%
	Cross breed	96	75.6%	31	24.4%	127	64.1%
Type of production	Zero grazing	19	100.0%	0	0.0%	19	9.6%
	Paddocking system	142	79.3%	37	20.7%	179	90.4%

The study findings on monthly income of the respondents revealed that majority 96 (48.5%) of the respondents were earning more than Ugx 300,000 out of which 78 (81.3%) had applied supplementary feeds while 18 (18.8%) were not applying supplementary feeds. In addition, 74 (37.4%) of the respondents were earning Ugx 200,001-300,000 out of which 55 (74.3%) had applied supplementary feeds while only 19 (25.7%) did not apply supplementary feeds. However, only 28 (14.1%) were earning 100,001-200,000 and all of them (100%) were applying supplementary feeds. According to the findings, it is shown that of all the smallholder farmers who were applying supplementary feeds to their cattle, the level of supplementary feed adoption was directly proportional to the level of income. Hence, those with higher level of income were more likely to adopt supplementary feeds compared to those with low levels of income.

As regards to the sources of income, the study findings revealed that majority 151 (76.3%) of the respondents were involved in agriculture/farming. Of these, majority 127 (84.1%) had adopted supplementary feeding while only 24 (15.9%) had not adopted supplementary feeding to their cattle. In addition, 20 (10.1%) of the respondents were involved in business of selling agricultural produce. Out of these, 14 (70.0%) were applying supplementary feeds while only 6(30.0%) had not adopted supplementary feeding. Furthermore, the findings indicate that 13 (6.6%) of the respondents were in employment/ salary workers and all these (100%) were adopting supplementary feeds. The findings further indicate that 7 (3.5%) were involved in agriculture and business and all of them were using supplementary feeds. Contrary to the above, the findings indicate that majority 7 (3.5%) were involved in agriculture and salary and all of these had not adopted supplementary feeds. The above findings imply that supplementary feed adoption is high among smallholder farmers involved in formal employment or business alongside agriculture but low among those involved in agriculture and salary.

The study findings revealed that majority 79 (39.9%) of the respondents had more than 10 household members out of which majority 68 (86.1%) were applying supplementary feeds while only 11 (13.9%) were not applying supplementary feeds. In addition, 53 (26.8%) of the respondents had 7-9 members out of which 43 (81.1%) were applying supplementary feeds while only 10 (18.9%) were not applying supplementary feeds. Furthermore, 47 (23.7%) of the respondents had 4-6 members out of which 35 (74.5%) were applying supplementary feeds while only 12 (25.5%) were not applying supplementary feeds. Lastly, the findings show that 19 (9.6%) of the respondents had less than 3 members out of which only 9 (47.4%) were applying supplementary feeds while 10 (52.6%) were not applying supplementary feeds. The above findings imply that adoption of supplementary feeds is dominant among smallholder farmers who have high number of household members compared to those with fewer members.

As regards to the type of cattle, the study findings revealed that majority 127 (64.1%) of the respondents were keeping crossbred cattle. Of these, majority 96 (75.6%) had adopted

supplementary feeding while only 31 (24.4%) had not adopted supplementary feeding in their cattle. In addition, 57 (28.8%) of the respondents were keeping exotic cattle out of which 51 (89.5%) had applied supplementary feeds while only 6(10.5%) were not applying supplementary feeds. However, only 14 (7.1%) of the respondents were keeping Ankole local breeds and out of these, only 4 (28.6%) were applying supplementary feeds while 10 (71.4%) were not applying supplementary feeds. The above findings imply that farmers who keep exotic cattle are more involved in supplementary feed adoption compared to those rearing crossbred and Ankole cattle.

The study findings on type of production of the respondents revealed that majority 179 (90.4%) of the respondents were involved in paddocking system. Of these, majority 142 (79.3%) had adopted supplementary feeding while only 37 (20.7%) had not adopted supplementary feeding in their cattle. On the other hand, 19 (9.6%) of the respondents were involved in zero grazing system and all of them (100.0%) were applying supplementary feeds. The above findings imply that supplementary feeding adoption is dominant among smallholder farmers who use zero grazing system than paddocking system.

4.1 Levels of adoption of supplementary feeds

Table 2: Level of supplementary feeding among smallholder cattle farmers

Adoption of supplementary feeding among dairy farmers		Frequency	Percentage
Whether supplementary feeds are applied (N=198)	No	37	18.7
	Yes	161	81.3
Period the respondent has spent giving cattle supplementary feedsB(N=161)	< 1 year	19	11.8
	1-2 years	33	20.5
	3-4 years	28	17.4
	Above 5 years	81	50.3
Amount of supplementary feeds the respondent gives per cow (N=161)	<3kg	54	33.5
	4-6 kg	53	32.9
	7-9 kg	40	24.8
	10kg and Above	14	8.7
How often does the respondent apply supplementary feeding (N=161)	1-3 times a day	122	75.8
	Once a week	27	16.8
	Once a month	6	3.7
	Every day	6	3.7

	Banana peelings	62	38.5
Major types of supplementary feeds applied (N=161)	Crop residues	42	26.1
	Hay	20	12.4
	Silage	13	8.1
	Roughages	6	3.7
	Others (salt and water)	18	11.2
Major sources of supplementary feeds (N=161)	From the farm	128	79.5
	From markets	7	4.3
	Any other (hotels in town)	26	16.1
Type of cattle to which supplementary feeds are given (N=161)	All cattle	94	58.4
	Milking cows only	60	37.3
	Exotic /crossbred Cattle only	7	4.3
Under what conditions do the respondent give supplementary feeds to the cattle (N=161)	Low milk production	64	39.8
	During dry season	43	26.7
	When land for grazing is limited	33	20.5
	To have cows fatten and look good	21	13.0

The study findings revealed that majority 161 (81.3%) of the respondents applied supplementary feeds to their cattle. The major reasons for application of supplementary feeds was the need for increasing milk production, to have good looking cows, scarcity of pastures, to kill liver flukes and other diseases, to fully get cattle satisfied when they are not satisfied, to stimulate the cows' appetite, to increase cows' size, because of the large number of animals reared on the farm and to avoid over grazing. On the other hand, only 37 (18.7%) reported that they were not applying supplementary feeds. The major reasons for not applying supplementary feeds is because farmers have a large piece of land for the cows so do not need to supplement and because it needed a lot of money to inject in supplements. In an interview with Musiimenta, a female dairy farmer in Biharwe division, she noted "*abantu barimu abari kuhereza ente zaabo ebyokurya ebindi nk'ebibingo, ebicori, konka eitwe eza'eitu titukuzihereza kintu kyoona. Mbweshi eitwe, obunyantsi katubweine, kaniziza okwe ziketara zikeija zeigutsi. Nambwenu we muriranwa wangye nazihereza ebinyansi ebyarikuhinga, nobaasa kumuhikyirira*." Literally meaning that *"there are people that give cattle supplementary feeds such as Napier grass, maize stalk but for us, we do not apply any supplementary feeds. For us we have enough land, cows go all over and come when they are satisfied. Actually, my neighbor gives them to his cows so you can approach him."*

The study findings further revealed that majority 81 (50.3%) had spent above five years giving their cattle supplementary feeds. On the other hand, 33 (20.5%) had spent 1-2 years, 28 (17.4%) had spent 3-4 years while 19 (11.8%) had spent less than a year.

As regards to the amount of supplementary feeds given per cow, the findings indicate that majority 54 (33.5%) of the respondents gave their cattle less than 3kg per cow, 53 (32.9%) of the respondents gave their cattle above 4-6 kgs of cattle feeds per cow, 40 (24.8%) gave their cattle 7-9 kg per cow while 14 (8.5%) gave their cattle 10kgs and above per cow. This indicates that much as most farmers give their cattle supplementary feeds, the amount of feeds given is usually very low (<3kg). The study findings revealed that majority 122 (75.8%) of the respondents reported that they applied supplementary feeds at least 1-3 times a day, 27 (16.8%) applied supplementary feeds once a week, 6 (3.7%) applied supplementary feeds once a month while another 6 (3.7%) applied supplementary feeds every day so long as they are available. The number of times of giving supplementary feeds depended on the farm size owned by the dairy farmer and the knowledge they had about supplementary feeds. In an interview with one of the farm managers of the dairy farm in Bwizibwera town council, he said "*our cows here feed on silage twice a day, we give every cow as long as it's above 8 months*."

The study also inquired about the major types of supplementary feeds applied. On this issue, majority 62 (38.5%) of the respondents reported that they applied banana peelings, 42 (26.1%) applied crop residues, 20 (12.4%) applied hay, 13 (8.1%) applied silage, 6 (3.2%) applied roughages while 18 (12.2%) applied other feeds like green leaf commodities, jackfruit residues, salt, sweet potato leaves and water.

Figure 2: Banana peelings

Figure 3: Cattle feeding on crop residues

Figure 4: Banana peelings mixed with other crop residues

Figure 5: Napier grass

Figure 6: Hay for feeding cattle

Majority of the respondents 128 (79.5%) reported that they got supplementary feeds from the farm, 26 (16.1%) got supplementary feeds from other sources specifically hotels in town while 7 (4.3%) got supplementary feeds from markets.

As regards to the type of cattle, majority 94 (58.4%) of the respondents reported that they gave supplementary feeds to all types of cattle that is a mixture of exotic, crossbred and local cattle. However, prior results on bio data had shown that priority is given to exotic cattle, followed by crossbred cattle and least in Ankole cattle. In addition, 60 (37.3%) of the respondents gave supplementary feeds to milking cows only while 7 (4.3%) gave supplementary feeds to exotic/crossbred cattle only. Most respondents gave all types of cattle supplementary feeds so as to boost their growth rate while those who only gave cows that were milked eyed an increase in the amount of milk produced. "*Here we give cattle feeds depending on the category to which they belong. We have a Lumen 08 program with SNV which is a special program for cow feeding. In this program different cattle are fed differently, we for example feed them on different feeds such as maize brand, sun flower, brewing residues and lime among others feeds for animals at different levels. We only give hay to calves up to a period of two months when they are introduced to outside pastures. Our cattle are categorized in stages to which they belong that is; first calvers, 2nd calvers, 3rd calvers and 4th calvers,*" said Philomena, a dairy farmer in Rwanyamahembe Sub-county.

The study findings revealed that majority of the respondents 64 (39.8%) reported that a farmer may adopt supplementary feeding when he/she wants to increase or maintain the high yields of milk and animal products with more nutrients which increase sales level from milk and milk products. On the other hand, 43 (26.7%) reported that a farmer may adopt supplementary feeds when there is dry spell that leaves pastures in low quantity. Furthermore, 33 (20.5%) of the respondents reported that a farmer may adopt supplementary feeds in order to supplement on pasture when there is a small piece of land while 21 (13.0%) reported that supplementary feeds may also be given in order to have the cows fatten and look good especially when a cow has just produced/ given birth.

4.3 The Relationship between Level of Adoption of Supplementary Feeding and Milk Yield among Smallholder Dairy Farmers in Mbarara District

The study findings revealed that majority 47 (29.2%) of the smallholder dairy farmers who participated in the study produced 4-6 litres of milk per cow before application of supplementary feeds. In addition, 42 (26.1%) of the respondents reported that they produced 10 litres and above in each cow after adoption of supplementary feeds, 40 (24.8%) produced 7-9 litres before adoption of supplementary feeds while 32 (19.9%) produced 1-3 litres of milk before using supplementary feeds. This implies that there is a positive significant relationship between supplementary feeding and smallholder dairy cattle production since farmers experienced an increase in milk yields after application of supplementary feeds (table 3).

Table 3: Level of milk yield resulting from supplementary feeding

Level of milk yield resulting from supplementary feeds		Frequency	Percent (%)
No of litres produced by each cow before supplementary feeds (N=161)	1-3 litres	32	19.9
	4-6 litres	47	29.2
	7-9 litres	40	24.8
	10+ litres	42	26.1
No of litres produced by each cow after supplementary feeds (N=161)	1-3 litres	14	8.7
	4-6 litres	52	32.3
	7-9 litres	21	13.0
	10+ litres	74	46.0
Percentage increase in milk yield per cow after introduction of supplementary feeds (N=161)	No significant change	14	8.7
	1-25%	86	53.4
	26-50%	61	37.9
Milk price per litre of milk (N=161)	Ugx 501-999	86	53.4
	Ugx 1000-1499	75	46.6
Average earnings from milk sales per month when using supplementary feeds (N=161)	<500,000	19	11.8
	500,001-1,000,000	59	36.6
	1000,001-1500,000	35	21.7
	Above 1500,000	48	29.8
Number of cattle milked (N=161)	Less than 5 cattle	26	16.1
	5-10 cattle	68	42.2
	11-15 cattle	38	23.6
	Above 15 cattle	29	18.0

The study findings revealed that majority 74 (46.0%) of the smallholder dairy farmers who participated in the study produced 10+ litres of milk per cow after application of supplementary feeds. In addition, 54 (32.2%) of the respondents reported that they produced 4-6 litres in each cow after adoption of supplementary feeds, 21 (13.0%) produced 7-9 litres after adoption of supplementary feeds while 14 (8.7%) produced 1-3 litres of milk before using supplementary feeds. This implies that there is a positive significant relationship between supplementary feeding and smallholder dairy cattle production since farmers experienced an increase in milk yields after application of supplementary feeds (table 3).

When asked to present the percentage increase in milk yields per cow after introducing supplementary feeds, majority 86 (53.4%) of the respondents reported that they experienced an increase in milk yield of 1-25% after introduction of supplementary feeds, 61 (37.9%) experienced an increase of 26-50% while 14 (8.7%) experienced no significant change in milk yields per cow

after introduction of supplementary feeds. As regards to the milk price per litre of milk, majority 86 (53.4%) of the respondents reported that they sold their milk at Ugx 501-999 per litre while 75 (46.6%) sold their milk at Ugx 1,000-1499 per litre. At these price ranges, majority 59 (36.6%) of the respondents earned an average of Ugx 500,001-1,000,000 from milk sales per month, 48 (29.8%) earned above 1,500,000 from milk per month, 35 (21.7%) were earning Ugx 1,000,001-1,500,000 and lastly, 19 (11.8%) of the respondents earned less than 500,000 per month.

As regards to the number of cattle milked, it was found out that majority 68 (42.2%) of the respondents milked between 5-10 cows, 38(23.6%) milked between 11-15 cows, 29 (18.0%) milked more than 15 cows while 26 (16.1%) of the respondents milked less than 5 cows.

4.3.1 Correlation between Level of Adoption of Supplementary Feeds and Level of Milk Yield

The relationship between level of adoption of supplementary feeding and level of milk yield was further determined statistically using Pearson Product moment correlation coefficient which was determined using SPSS version 26.0.

Table 4: Relationship between level of adoption of supplementary feeds and milk yield

		Level of adoption of supplementary feeds	Level of milk yield
Level of adoption of supplementary feeds	Pearson Correlation	1	.267**
	Sig. (2-tailed)		.000
	N	161	161
Level of milk yield	Pearson Correlation	.267**	1
	Sig. (2-tailed)	.000	
	N	161	161

**. Correlation is significant at the 0.01 level (2-tailed).

According to the table above, it is shown that there is a positive significant relationship (r=.267**) between level of adoption of supplementary feeds and level of milk yield among smallholder dairy farmers in Mbarara district. This is because the probability value (sig. 2-tailed value) associated with r is below the critical value (0.05) which shows that the correlation is significant at 99% level.

4.4 The Socio-Economic Factors Associated with Adoption of Supplementary Feeding in Smallholder Dairy Cattle Production among Dairy Farmers in Mbarara District

The study findings revealed that gender is not a significant factor that affects level of supplementary feeding adoption. The regression 'R' indicates that there is a very weak relationship (R=0.078) between gender and level of supplementary feeding adoption. The coefficient of determination 'R^2' also indicates an insignificant value (R^2=0.006) which implies that gender explains only 0.6% of the variations in level of supplementary feeding. The F-statistic (F=1.196), beta value (β=.078) and t-value (t=1.094) are very small and p-value greater than the significance (sig.>0.05) implying that gender has no significant influence on level of supplementary feeding.

The study findings revealed that age is not a significant factor that affects level of supplementary feeding adoption among smallholder dairy farmers in Mbarara district. The regression 'R' indicates that there is a moderate positive relationship (R=0.058) between age and level of supplementary feeding adoption, which is insignificant since the p-value (sig.=0.467) is above the threshold (0.05). The coefficient of determination (R^2=0.003) is very small and close to zero an indication that age does not explain any change in the level of supplementary feeding among farmers in Mbarara district. The F-statistic (F= 0.532) and t-statistic (t=-0.729) are very small indicating an insignificant variation in level of adoption of supplementary feeding among farmers of different age groups. Indeed, the cross-tabulated values on age and level of adoption of supplementary feeding indicate that there are lower variations in the proportion of farmers of different age groups as regards to adoption of supplementary feeding as shown in table 1.

It is shown from the findings that marital status just like gender and age, is also not a significant factor that affect level of supplementary feeding adoption. The regression 'R' indicates that there is a very weak relationship (R=0.069) between marital status and level of supplementary feeding adoption. The coefficient of determination 'R^2' is also very small and insignificant value (R^2=0.005) which implies that marital status explains only 0.5% of the variations in level of supplementary feeding. The F-statistic (F=0.951), beta value (β= -.069) and t-value (t= -0.975) are very small and p-value is greater than the significance (sig.>0.05) which implies that marital status has no significant influence on level of supplementary feeding. Previously, the biodata indicates no significant variations in adoption of supplementary feeding between singles, marrieds and widows since the percentage of adoption is higher among singles, marrieds and adults (table 1)

The study findings revealed that there is no relationship between highest level of education and level of supplementary feeding adoption. The regression 'R' is close to zero (R=0.009) and coefficient of determination 'R^2' is also zero (R^2=0.000) which implies that highest level of education does not influence the level of supplementary feeding. The F-statistic (F=0.016), beta value (β=.009) and t-value (t=.125) are very insignificant and p-value greater than the significance (sig.>0.05) which implies that level of education has no significant influence on level of supplementary feeding. The cross-tabulated findings had also shown no significant change in the percentage of farmers of different levels of education who apply supplementary feeds. The percentage is higher for all levels (table 1).

Table 5: Socioeconomic factors associated with supplementary feeding

Socioeconomic Factors associated with supplementary feeding		**Chi-square**			**Regression**		**Anova and Coefficients**			
		OBS N	EXP N	Residual	R	R^2	F	β	t	Sig.
Gender (N=196)	Male	118	99.0	19.0	. .078	.006	1.196	.078	1.094	.275
	Female	80	99.0	-19.0						
Age(N=198)	19-35 years	81	66.0	15.0	.058	.003	.532	-.058	-.729	.467
	36-65 years	78	66.0	12.0						
	Above 65 years	39	66.0	-27.0						

Marital Status (N=198)	Single	42	66.0	-24.0	.069	.005	.951	-.069	-.975	.331
	Married	117	66.0	51.0						
	Widowed	39	66.0	-27.0						
Highest education level (n=198)	None	27	49.5	-22.5	.009	.000	.016	.009	.125	.900
	Primary	55	49.5	5.5						
	Secondary	73	49.5	23.5						
	Tertiary	43	49.5	-6.5						
Monthly income (N=198)	100,001-200,000	28	66.0	-38.0	.096	.009	1.830	.096	1.353	.178
	200,001-300,000	74	66.0	8.0						
	> 300,001	96	66.0	30.0						
Household size (N=198)	<3 members	19	49.5	-30.5	.143	.020	4.080	.143	2.020	.045
	4-6 members	47	49.5	-2.5						
	7-9 members	53	49.5	3.5						
	>10 members	79	49.5	29.5						
Type of cattle (N=198)	Ankole (local)	14	66.0	-52.0	.206	.042	8.687	-.206	-2.947	.004
	Exotic	57	66.0	-9.0						
	Cross breed	127	66.0	61.0						
Production Type (N=198)	Zero grazing	19	99.0	-80.0	.156	.024	4.901	-.156	-2.214	.028
	Paddocking	179	99.0	80.0						
Milk yield (N=161)	1-3 litres	32	40.3	-8.3	.118	.014	2.771	.118	1.665	.038
	4-6 litres	42	40.3	1.8						
	7-9 litres	40	40.3	-.3						
	10+ litres	47	40.3	6.8						
Number of cattle milked (N=161)	Less than 5	26	40.3	-14.3	.171	.029	5.744	.171	2.397	.018
	5-10	68	40.3	27.8						
	11-15	38	40.3	-2.3						
	Above 15	29	40.3	-11.3						

Knowledge on supplementary feeding(N=198)	No	124	99.0	25.0	.387	.150	33.450	.387	5.784	.000
	Yes	74	99.0	-25.0						
Average cost of supplementary feeds(N=161)	Free	26	40.3	-14.3	.382	.146	30.457	.382	5.519	.000
	<500	20	40.3	-20.3						
	500-1000	60	40.3	19.8						
	Above 1000	55	40.3	14.8						
Average cost of labour(N=161)	Free labour	37	40.3	-3.3	.318	.101	20.086	.318	4.482	.000
	<50,000	18	40.3	-22.3						
	50,000-100,000	27	40.3	-13.3						
	Above 100,000	79	40.3	38.8						

Dependent variable: Level of supplementary feeding

OBS N = Observed frequency, EXP N = Expected frequency, R= Regression, R^2= Coefficient of determination

As regards to monthly income, the study findings revealed that there is no significant relationship between farmers' monthly income and level of supplementary feeding adoption. The regression 'R' indicates that there is a very weak relationship (R=0.096) between farmers' monthly income and level of supplementary feeding adoption. The coefficient of determination 'R^2' also indicates an insignificant value (R^2=0.009) which implies that farmers' monthly income explains only 0.9% of the variations in level of supplementary feeding. The F-statistic (F=1.830), beta value (β=-.096) and t-value (t=1.352) are very small and p-value greater than the significance (sig.>0.05) which implies that monthly income has no significant influence on level of supplementary feeding. The bio-demographic characteristics of the respondents also indicate that the percentage of supplementary feeding adoption is more than 70% for farmers with different levels of monthly income. Surprisingly, the percentage is even highest among farmers with the lowest level of income as compared to those with highest level of income (*See Table 1*).

The study findings revealed that household size is a significant factor that affects the level of supplementary feeding adoption among smallholder dairy farmers in Mbarara district. The regression 'R' indicates that there is a weak relationship (R=0.143) between household size and level of supplementary feeding adoption which is significant at 95% level (sig.<0.05). However, the coefficient of determination 'R^2' indicates a weak influence (R^2=0.020) which implies that household size explains only 2.0% of the variations in level of supplementary feeding. However, this percentage is significant since the F-statistic (F=4.080) and t-value (2.020) are a bit large an indication that there is a wide significant difference in the variations in the level of adoption of supplementary feeds amongst households of different sizes. The cross-tabulated findings had also revealed that adoption of supplementary feeds is dominant among smallholder farming households with more than 10 household members compared to those with less than 3 household members

(*See Table 1*). The table also shows that the proportion of farmers who give supplementary feeds increases with increase in the number of household members.

The study findings revealed that type of cattle is a significant factor that affects the level of supplementary feeding adoption among smallholder dairy farmers in Mbarara district. The regression 'R' indicates that there is a weak relationship (R=0.206) between household size and level of supplementary feeding adoption which is significant at 99% level (sig.<0.01). However, the coefficient of determination 'R^2' indicates a weak influence (R^2=0.042) which implies that type of cattle explains only 4.2% of the variations in level of supplementary feeding. However, this percentage is significant since the F-statistic (F=8.687) and t-value (-2.947) are a bit large an indication that there is a wide variation in the level of adoption of supplementary feeds amongst farmers with different type of cattle. When type of cattle was cross-tabulated with level of adoption of supplementary feeding, it was revealed that level of supplementary feeding was most common among Exotic cattle, followed by Crossbreed and least among Ankole (local) cattle (*See Table 1*).

The study findings revealed that production type is a significant factor that affects level of supplementary feeding adoption. The regression 'R' indicates that there is a very weak relationship (R=0.156) between production type and level of supplementary feeding adoption. The coefficient of determination '(R^2=0.024)' also indicates that production type explains only 2.4% of the variations in level of supplementary feeding. The F-statistic (F=4.901), beta value (β= -0.156) and t-value (t=-2.214) are very small and p-value less than the significance (sig.< 0.05) which implies that production type has a significant influence on level of supplementary feeding. The cross-tabulated findings show that adoption of supplementary feeding is most dominant among farmers who use zero grazing system and less among those who use paddocking system (*See Table 1*).

The study findings revealed that milk yield is also a significant factor that influences the level of supplementary feeding adoption. The regression 'R' indicates that there is a weak positive relationship (R=0.118) between milk yield and level of supplementary feeding adoption. The coefficient of determination (R^2=0.014) also indicates that milk yield explains only 1.4% of the variations in level of supplementary feeding. The F-statistic (F=2.771), beta value (β= .118) and t-value (t=1.665) are very small and p-value less than the significance (sig.< 0.05) which implies that milk yield has a significant influence on the level of supplementary feeding. Indeed, most farmers reported having given supplementary feeds in order to increase milk yield. Prior findings have also shown that amount of milk yield was low before adoption of supplementary feeds and increased after adoption of supplementary feeds.

The study findings revealed that number of cattle milked is a significant factor that affects level of supplementary feeding adoption. The regression 'R' indicates that there is a very weak relationship (R=0.171) between number of cattle milked and level of supplementary feeding adoption. The coefficient of determination (R^2=0.029) which implies that number of cattle milked explains only 2.9% of the variations in level of supplementary feeding. The F-statistic (F=5.774), beta value (β=.171) and t-value (t=2.397) are big and p-value less than the significance (sig.<0.05) which implies that number of cattle milked has a significant influence on level of supplementary feeding.

The study findings revealed that knowledge on supplementary feeding is a significant factor that influences level of supplementary feeding adoption. The regression 'R' indicates that there is a significant relationship (R=0.387) between knowledge on supplementary feeding and level of supplementary feeding adoption. The coefficient of determination (R^2=0.150) which implies that

knowledge on supplementary feeding explains only 15% of the variations in level of supplementary feeding. The F-statistic (F=33.450), beta value (β=.387) and t-value (t=5.784) are very big and p-value less than the significance (sig.< 0.05) which implies that knowledge on supplementary feeding has a highly significant influence on the level of supplementary feeding. Indeed, the chi-square distribution indicates that most farmers have limited knowledge on supplementary feeding. Less than 50% of the farmers access information on supplementary feeding from farmer groups (32.3%), followed by conferences and workshops held with extension staff (29.0%), the media (14.0%), agriculture subjects (3.8%) while 21.0% got knowledge from other sources such as SNV, pearl dairies, friends and traditional knowledge got from parents.

The study findings revealed that average cost of supplementary feeds is also one of the significant socioeconomic factors that influence the level of supplementary feeding adoption. The regression 'R' indicates that there is a significant relationship (R=0.386) between average cost of supplementary feeds and level of supplementary feeding adoption. The coefficient of determination 'R^2' also indicates a significant value (R^2=0.146) which implies that average cost of supplementary feeding explains only 14.6% of the variations in level of supplementary feeding. The F-statistic (F=30.457), beta value (β=.382) and t-value (t=5.519) are very big and p-value is less than the significance (sig.<0.05) which implies that average cost of supplementary feeds has a highly significant influence on level of supplementary feeding. The observed frequencies indicate that majority of the smallholder farmers incurred a cost of 500-1000 and above 1000 to purchase a kilogram of supplementary feeds to give to cattle. This implies that those who afford this cost are likely to adopt supplementary feeding while those who do not afford are not likely to use supplementary feeds. During observations by the researcher, it was revealed that farmers needed to stock huge sacks of hay to feed cattle and purchase machines to chop grass for making silage as shown in the figure below;

Figure 7: Stock of hay

Figure 8: Machine to chop grass for making silage

However, most of the farmers (82.2%) reported that they did not have any external sources of funds used to purchase supplementary feeds or finance its operations rather than their own equity. This indicates that a lot of money is required to buy more than 1000 kgs of supplementary feeds that can feed the cattle for some good time.

The study findings revealed that average cost of labour is also one of the significant socioeconomic factors that influence the level of supplementary feeding adoption. The regression 'R' indicates that there is a significant relationship (R=0.318) between average cost of labour and level of supplementary feeding adoption. The coefficient of determination 'R^2' also indicates a significant value (R^2=0.101) which implies that average cost of labour explains only 10.1% of the variations in level of supplementary feeding. The F-statistic (F=20.086), beta value (β=.318) and t-value (t=4.482) are very big and p-value less than the significance (sig.<0.05) which implies that average cost of labour has a significant influence on level of supplementary feeding. The observed frequencies indicate that majority of the smallholder farmers incurred more than Ugx 100,000 as the cost of labour. This implies that those who afford this cost of labour are likely to adopt supplementary feeding while those who do not afford the cost of labour are not likely to adopt supplementary feeds. Observations during data collection revealed that preparation process of some feeds such as Hay and Silage requires a lot of labour to do the chopping of grass, digging silage holes, constructing houses among others as shown in the pictures below;

Figure 9: Labour at work digging a hole to make silage

Figure 4.10: Chopped grass

5.0 Discussion, Conclusions and Recommendations

5.1 Discussion of Findings

The study findings revealed that over 80% of the smallholder cattle farmers in Mbarara district give their cattle supplementary feeds especially during a dry season when pasture is low in order to increase milk production. A similar study in Southwestern Uganda by Tibezinda *et al.*, (2016) had found that only 29% provided supplementary feeds during dry season or conserved the excess pasture produced in the rainy season. Compared to the current findings, it is shown that the percentage of smallholder dairy farmers who adopt supplementary feeding has increased over the last five (5) years. This can be attributed to increased population that puts pressure on land, hence reducing the land available for grazing.

However, the findings indicate that much as most farmers give their cattle supplementary feeds, the amount of feeds supplemented is very low usually less than 3kg per cow which is usually applied at least 1-3 times a day. Because of the limited amount, most farmers gave supplementary feeds majorly to milking cows only to increase milk yield. The major types of supplementary feeds

applied are banana peelings and crop residues while modern feeds like hay and silage are not usually applied. The above findings are in agreement with Kasozi, *et al.,* (2014) who explained that banana peelings can be used by farmers to complement on the pastures especially during the dry season when the pasture quality and quantity are greatly reduced. Substituting elephant grass with banana peelings in diets should be accompanied with strategic supplementation to be able to meet the animals' requirements. In a similar manner, McIntire *et al.,* (2016) reported that crop residues play a vital role in feed provision to livestock under the tropical crop-livestock mixed farming systems.

Banana peelings and crop residues are readily available in the farms and households and cheap to make compared to commercial feeds. There was a high level of adoption of supplementary feeds during dry season than in wet season due to shortage of pasture and low milk production. In agreement with the above findings, Nowakunda et al., (2004) also reported that large quantities of banana peelings are produced in many parts of Uganda where the cooking type of bananas is the staple food. Ugandans are the world's greatest consumers of bananas and so plenty of banana peelings are produced by Ugandans. Likewise, De Groote *et al.,* (2013) asserted that in Uganda, the practice of collecting and storing crop residues including maize Stover, bean and rice straw from farms after harvest for dry season feeding is widespread among smallholder farmers. Furthermore, McDowell (2008) reported that crop residues including maize, beans and rice straws contributed about 35–45% of the livestock feed demand in Kenya and about 25% of the energy required by ruminants.

The study findings revealed that there is a positive significant relationship ($r=0.267^{**}$) between level of adoption of supplementary feeding and milk yield among smallholder dairy farmers in Mbarara district. The above findings imply that an increase in level of adoption of supplementary feeding results to a significant increase in milk yield. Indeed, the descriptive statistics indicate that most smallholder dairy farmers who participated in the study produced 4-6 litres of milk per cow before application of supplementary feeds, but after application of supplementary feeds, milk yield increased to 10 litres and above in each cow. At least half (53.4%) of the smallholder farmers reported that they experienced an increase in milk yield of 1-25% after introduction of supplementary feeds, 37.9% experienced an increase of 26-50% while 8.7% experienced no significant change in milk yields per cow after introduction of supplementary feeds.

The above findings are in agreement with FAO (2017) which reported that the amount of milk a cow can produce is directly related to the quality and quantity of feed intake by cattle. If quality and/or quantity is adequate, the animal responds by producing more milk and if the cow is not sufficiently fed over a longer period, milk yield reduces. This implies that supplementary feeding is directly related with dairy cattle production. The above findings also agree with Kasozi *et al.,* (2014) whose findings revealed that dairy milk production is positively related with the level of supplementary feeding. In their study, it was revealed that daily milk yields increased from 10 to 11 litres after feeding lactating cows on banana peelings. Additionally, the findings agree with Stojanovic *et al.,* (2018) whose findings revealed that milk production of high producing grazing dairy cows in early lactation increases linearly as the amount of concentrate increases to 10 kg dry matter/day with a milk response of 1 kg milk/kg concentrate.

The study findings revealed that amongst all socioeconomic characteristics of smallholder dairy cattle farmers, the most significant socioeconomic factors associated with supplementary feeding

adoption are household size (p=.045), type of cattle (p=.004), production type (p=.028), number of cattle milked (p=.018), knowledge on supplementary feeding(p=.000), average cost of supplementary feeds(p=.000), average cost of labour (p=.000) and milk yield (p=.038). Farmers' gender (p=.275), age (p=.467), marital status (p=.331), highest education level (p=.900) and monthly income (p=.178) were not significantly associated with level of adoption of supplementary feeding. The findings indicate that application of supplementary feeding is dominant amongst farmers with large number of household members (>10 members), keeping Exotic cattle under a zero-grazing system with lower milk yields before adoption of supplementary feeding, with a big number of milking cattle, having prior knowledge about application of supplementary feeds and having adequate funds to finance the costs involved in application of supplementary feeds. On the other hand, level of adoption of supplementary feeding is low among smallholder farmers with less than 3 household members, keeping cattle under paddocking system, without adequate knowledge and funds to finance the costs involved in supplementary feeding.

The above findings are in agreement with Orodho (2005) who reported that knowledge on proper feed production, processing and formulation is limited among most smallholder farmers in East Africa and this has contributed to a reduction in dairy cattle production. In the same way, the findings agree with Derpsch *et al.,* (2016) in Paraguay who reported a poor adoption of agricultural conservation technologies by smallholder farmers is due to lack of entrepreneurial knowledge.

The above findings also are in agreement with Aikaeli (2010) and Cadilhon *et al.,* (2016) who pointed out high cost of inputs as one of constraints to adoption of supplementary feeding. According to Aikaeli (2010), most rural households in Uganda and the East African region are poor and cannot afford feed technological costs given the high poverty incidences. Due to low incomes most smallholder dairy farmers are unable to purchase pasture seeds, forage choppers, tractors, balers, ensiling materials and milking machines. Cadilhon *et al.*, (2016) attributed this challenge to lower productivity of dairy cows and lower milk prices which trap smallholder dairy farmers on poverty, hence unable to purchase supplementary feeds.

5.2 Conclusions of the Study

At least 80% of the smallholder cattle farmers in Mbarara District give their cattle a limited amount of supplementary feeds usually less than 3kg per cow with high priority being given to milking cows only in order to increase milk yield. Banana peelings and crop residues are the major types of supplementary feeds applied especially during a dry season while feeds like hay and silage are rarely applied.

There is a positive highly significant relationship (sig.= .000) between level of adoption of supplementary feeding and milk yield among smallholder dairy farmers in Mbarara district. An increase in the level of adoption of supplementary feeding results to a significant increase in milk yield. Hence, smallholder farmers who had adopted supplementary feeding and giving their cattle adequate amount of supplementary feeds were producing more milk yields than those who did not apply supplementary feeds or applying limited number of supplementary feeds. Amongst all socioeconomic characteristics of smallholder dairy cattle farmers, the most significant socioeconomic factors associated with supplementary feeding adoption are household size, type of cattle, production type, number of cattle milked, knowledge on supplementary feeding, average cost of supplementary feeds, average cost of labour, and milk yield. Farmers' gender, age, marital

status, highest education level and monthly income were not significantly associated with level of adoption of supplementary feeding.

5.3 Recommendations of the study

When asked to indicate the major challenges encountered by farmers while adopting supplementary feeding, most smallholder farmers summarized these challenges as bush burning, costly and unreliable supplementary feeds, labour shortage, time consuming, disunity amongst animals that are greedy, scarcity of supplementary feeds, insufficient knowledge and awareness on application of supplementary feeds, insufficient capital, lack of machines to use and low-quality feeds. In order to find viable recommendations to solve the challenges highlighted above, smallholder farmers recommended the following solutions;

- Although banana peelings may be nutritious to cattle, hay and silage may contribute significantly to increased milk yields than banana peelings yet the adoption rate of hay and silage was still low. The study therefore recommends the government through agencies and ministries like NAADs, Operation Wealth Creation and NARO to provide more sensitization to smallholder cattle farmers on how to make hay and silage as feed supplements in order to increase dairy milk production.
- To ensure the sustainability of smallholder dairy production, pasture management and utilization have to be improved. This will enable farmers to satisfy the nutritional requirements of an improved herd without sacrificing soil fertility and environmental sustainability.
- Smallholder dairy farmers should adopt use of family labour in supplementary feeding. This saves costs of hiring labour, which was cited as one of the major constraints limiting supplementary feeding.
- Smallholder dairy farmers should form cooperatives in order to access cheaper credit to use in purchasing supplementary feeds and facilitating costs of labour. Farmer groups also assist in accessing good market with competitive prices for dairy products and accessing extension visits to teach about supplementary feeding.

References

Adhikari, U., Nejadhashemi, A. P., & Woznicki, S. A. (2015). Climate change and eastern Africa: A review of impact on major crops. *Food and Energy Security*, 4(2), 110–132.

Aikaeli, J. (2010). Determinants of rural income in Tanzania: An empirical approach (Research Report 10/4). Dar es Salaama, Tanzania: REPOA. Retrieved from www.repoa.or.tz/documents/rr10_4.pdf

Amin, M.E. (2005), Social Science Research: Conception, Methodology and Analysis. Makerere University Press, Kampala.

ASARECA. (2013). Ensuring that livestock get adequate feeding even in drought. Retrieved from http://www.asareca.org/~asareca/printpdf/3963

Beers B. and Anderson S. (2021). Regression Definition. https://www.investopedia. com/terms/r/regression.asp Updated Apr 16, 2021

Kenton W. and Walters T. (2021). Analysis of Variance (ANOVA). https://www. investopedia.com/terms/a/anova.asp Updated Feb 8, 2021

Balikowa. (2004). Participation of Small-Scale Dairy Producers in Rationalization and Harmonization of Dairy Sector Policies and Regulations in Eastern Africa, Southwestern Uganda Milk-Shed Study Report, RELMA/ ECAPAPA, January 2004.

Balikowa. (2011). Dairy development in Uganda: A review of Uganda's dairy industry, Dairy Development Authority (DDA). *Journal of Agricultural And Forestry Sciences.*

Cadilhon, J. J., Pham, N. D., & Maass, B. L. (2016). The Tanga dairy platform: Fostering innovations for more efficient dairy chain coordination in Tanzania. *International Journal on Food System Dynamics*, 7(2), 81–91.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika* 16 (3), 297-334.

De Groote, H., Dema, G., Sonda, G. B., & Gitonga, Z. M. (2013). Maize for food and feed in East Africa – The farmers' perspective. Field Crops Research, 153, 22–36.

Derpsch, R., Lange, D., Birbaumer, G., & Moriya, K. (2016). Why do medium-and large-scale farmers succeed practicing CA and small-scale farmers often do not?–experiences from Paraguay. *International Journal of Agricultural Sustainability*, 14(3), 269–281.

Dillon P., Crosse S. and O'Brien B. (2007). Effect of concentrate supplementation of grazing dairy cows in early lactation on milk production and milk processing quality. Irish *J. Agric. Food Res*.36, 145–159.

EADD, (2009): Project Baseline Survey Report No. 3, Heifer International/East Africa Dairy Development Project (EADD), Kampala, Uganda

FAO. (2010). Status and prospects for smallholder milk production: A global perspective. Food and Agriculture Organization of the United Nations (FAO). Rome: FAO. Retrieved from www.fao. org/docrep/012/i1522e/i1522e.pdf

FAO. (2011). World Livestock 2011 – Livestock in food security. Food and Agriculture Organization of the United Nations (FAO). Rome: FAO. Retrieved from www.fao.org/docrep/014/i2373e/i2373e.pdf

FAO. (2012). Crop residue based densified total mixed ration – A user-friendly approach to utilise food crop by-products for ruminant production. (FAO Animal Production and Health Paper No. 172). Rome: Food and Agriculture Organization of the

FAO. (2015). The economic lives of smallholder farmers: An analysis based on household data from nine countries, Rome: Food and Agriculture Organization of the United Nations (FAO). Retrieved from www.fao.org/3/a-i5251e.pdf

FAO. (2017). Pastures for Dairy Production. www.fao.org/ag/againf o/themes/documents /PUB6/ P611.htm

Franzel, S., & Wambugu, C. (2007). The uptake of fodder shrubs among smallholders in East Africa: Key elements that facilitate widespread adoption. In Forages: a pathway to prosperity for smallholder farmers. Proceedings of an international symposium (pp. 203–222), Faculty of Agriculture, Ubon Ratchathani University, Thailand.

Geerts, A. (2014). An evaluation of the compound feeds manufactured in Tanzania (Doctoral thesis). University of Reading, UK.

Gillah, K. A., Kifaro, G. C., & Madsen, J. (2012). Urban and peri urban dairy farming in East Africa: A review on production levels, constraints and opportunities. Livestock Research for Rural Development, 24(11), 198.

Hayes A. (2020). Chi-Square ($\chi 2$) Statistic Definition. https://www.investopedia.com/terms/c /chi-square-statistic.asp Updated Oct 7, 2020

Jimenez, A., & Perez-Foguet, A. (2011). Water point mapping for the analysis of rural water supply plans: Case study from Tanzania. Journal of Water Resources Planning and Management, 137(5), 439–447

Kabirizi, J., Ziiwa, E., Mugerwa, S., Ndikumana, J., & Nanyennya, W. (2013). Dry season forages for improving dairy production in smallholder systems in Uganda. Tropical Grasslands-Forrajes Tropicales, 1(2), 212–214.

Kabirizi, J.; Muyekho, F.; Mulaa, M; Msangi, R.; Pallangyo, B.; Kawube, G.; Zziwa, E.; Mugerwa, S.; Ajanga,S.; Lukwago, G.; Wamalwa N.I. E; Kariuki, I.; Mwesigwa, R.; Nannyeenya-Ntege, W.; Atuhairwe, A.; Awalla, J.; Namazzi, C.; Nampijja, Z. (2015). Napier grass feed resource: production, constraints and implications for smallholder farmers in Eastern and Central Africa. ISBN: 978-9970-9269-1-6

Kabwanga I. T. and Atila Y. (2015). Dairy Cattle and Dairy Industry in Uganda: Trends and Challenges. International Science Congress Association. *Research Journal of Agriculture and Forestry Sciences.* 3(10), 14-18

Kasozi N.J., Sabiiti E.N., Bareeba F.B. and Sporndly E. (2014). Effect of feeding varying levels of banana peelings supplemented with maize bran, cotton seed cake and *Gliricidia sepium* on the performance of lactating dairy cows. *African Journal of Agricultural Research* Vol. 9(8), pp. 720-727

Kavana, P. Y., & Msangi, B. S. J. (2005). On farm dairy cattle feeding experience in Eastern Zone of Tanzania. *Livestock Research for Rural Development*, 17(6)

Kavana, P. Y., Kizima, J. B., Msanga, Y. N., Kilongozi, N. B., Msangi, B. S. J., Kadeng'uka, L. A., Shimba, P. K. (2005). Potential of pasture and forage for ruminant production in Eastern zone of Tanzania. *Livestock Research for Rural Development*, 17(144)

Kienzle, J., Ashburner, J. E., & Sims, B. G. (Eds.). (2013). Mechanization for rural development: A review of patterns and progress from around the world (p. xxiii). Rome: Food and Agriculture Organization of the United Nations.

Kivaria, F. M., Noordhuizen, J. P. T. M., Kapaga, A. M., & Hogeveen, H. (2005). Risk indicators associated with Staphylococcus aureus subclinical mastitis in smallholder dairy cows in Tanzania. Mastitis in Dairy production; current knowledge and future solutions. Wageningen: Wageningen Academic Publishers.

Lukuyu B, Gachuiri CK, Lukuyu MN, Lusweti C and Mwendia S (eds). (2012). *Feeding dairy cattle in East Africa.* East Africa Dairy Development Project, Nairobi, Kenya.

Lukuyu, B.A., Ravichandran, T., Maass, B., Laswai, G., Bwire, J., & Duncan, A. J. (2015). Enhancing livestock productivity through feed and feeding interventions in India and Tanzania (ILRI Project Report). Nairobi, Kenya: ILRI.

MAAIF/UBOS. (2017). *National Livestock Report Cencus 2008 , Ministry of Agriculture Animai Industry and Fisheries.* Entebbe

Maleko D., Msalya G., Mwilawa A., Pasape L. and Mtei K. (2018). Smallholder dairy cattle feeding technologies and practices in Tanzania: failures, successes, challenges and prospects for sustainability. International *Journal of Agricultural Sustainability*, 2018.

Mbarara District Statistical Abstract. (2016/17). Mbarara District Local Government Statistical Abstract 2016/2017. Report Prepared with support from Uganda Bureau of Statistics. June 2017.

McDermott, J. J., Staal, S. J., Freeman, H. A., Herrero, M., & Van de Steeg, J. A. (2010). Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science*, 130(1), 95–109.

McDowell, R. E. (2008). Importance of crop residues for feeding livestock in smallholder farming systems. In Plant breeding and the nutritive value of crop residues. Proceedings of a workshop, ILCA, Addis Ababa (Ethiopia) (pp. 3–27).

McIntire, J., Bourzat, D., & Prabhu, P. (2016). Crop-livestock interaction in sub-Saharan Africa. Washington, DC: World Bank.

Mtengeti, E. J., Lyimo, B. J., & Urio, N. A. (2013). Effects of additives and storage positions on in-bag grass silage quality under smallholder farmer conditions in Mvomero district Tanzania. *Livestock Research for Rural Development*, 25(197).

Mubiru R., Namirimu T., Owino S., Kyalingonza L., Nyadoi P. and Buyinza J. (2013). From Extensive to Semi-Intensive Livestock Production Systems in Uganda's Albertine Rift Practical Interventions Manual. Uganda Wildlife Society and Buliisa District Local Government Uganda

Muller D.L. (2012). Managing to Get More Milk and Profit from Pasture. https:// extension. psu. edu/ managing-to-get-more-milk-and-profit-from-pasture

Mwango, S. B., Msanya, B. M., Mtakwa, P. W., Kimaro, D. N., Deckers, J. Bethuel, I. (2014). Root properties of plants used for soil erosion control in the Usambara Mountains, Tanzania. *International Journal of Plant & Soil Science*, 3(12), 1567–1580.

Nalubwama S., Kabi, F. Vaarst, M., Kiggundu M. & Smolders G. (2019). Opportunities and challenges for integrating dairy cattle into farms with certified organic pineapple production as perceived by smallholder farmers in Central Uganda. *Organic Agriculture* volume 9, p29–39

Njarui, D. M. G., Gatheru, M., Wambua, J. M., Nguluu, S. N., Mwangi, D. M., & Keya, G. A. (2011). Feeding management for dairy cattle in smallholder farming systems of semi-arid tropical Kenya. Livestock Research for Rural Development, 23(111).

Nowakunda K, Tushemereirwe W (2004). Farmer acceptance of introduced banana genotypes in Uganda. *Afr. Crop Sci. J.* 12(1):1-6.

Orodho, A. B. (2005). Intensive forage production for smallholder dairying in East Africa. Reynolds & Frame (eds.) Grasslands: Developments Opportunities Perspectives, FAO and Science Publishers Inc, 433–459.

Owen, E., Smith, T., & Makkar, H. (2012). Successes and failures with animal nutrition practices and technologies in developing countries: A synthesis of an FAO e-conference. Animal Feed Science and Technology, 174(3), 211–226.

Reis RB and Combs DK (2010). Effects of increasing levels of grain supplementation on rumen environment and lactation performance of dairy cows grazing grass-legume pasture. *J. Dairy Sci.* 83, 2888–2898.

Roger, E. M. (1995). Diffusion of Innovations, Fourth edition, New York: Free Press.

Steinfeld H. and Mack S. (2015). Livestock development strategies. http://www. fao.org/ docrep/ V8180T/v8180T0a.htm

Stojanovic B., Grubic, G., Dordevic, N., Božickovic, A. Ivetic, A. (2018), Supplementary Feeding of Grazing Dairy Cows. *Proceedings of the International Symposium on Animal Science 23-25th September 2014, Belgrade-Zemun, Serbia*

Sundstøl, F. (2013). East African farmers benefit from quality hay. Appropriate Technology, 40(1), 61.

Swai, E. S., & Karimuribo, E. D. (2011). Smallholder dairy farming in Tanzania current profiles and prospects for development. *Outlook on Agriculture*, 40(1), 21–27.

Tenywa, G. (2014). Prolonged dry spell ravages cattle corridor. Available online from: https://www.newvision.co.ug/new_vision/news/1338440/prolonged-dry-spell-ravages-cattle-corridor

Thornton, P. K. (2010). Livestock production: Recent trends, future prospects. Philosophical Transactions of the Royal Society of London B: *Biological Sciences*, 365(1554), 2853–2867.

Tibayungwa, F. (2010). Modelling livestock for forage systems with Nitrogen cycling in the smallholder dairying.

Tibezinda M., Wredle E., Sabiiti E.N. and Mpairwe D. (2016). Feed resource utilization and dairy cattle productivity in the agro-pastoral system of South Western Uganda. *African Journal of Agricultural Research.* 11(32), 2957-2967

UBOS. (2017). Statistical abstract 2017. Uganda Bureau of Statistics. Kampala. Uganda.

UBOS (2014). National Population and Housing Census-Mbarara district. Uganda Bureau of Statistics. Kampala. Uganda.

Wangalwa R, Casim Umba T. C, Rugunda K. G and Wafula M. J (2016). Assessment of on-farm milk handling practices in Mbarara District Southwestern Uganda. *African Journal of Dairy Farming and Milk Production.* 3(2), 141-148

Yamane, Taro. (1967). Statistics. An Introductory Analysis, 2nd Ed., New York: Harper and Row.