Vol. 17(4), pp. 697-704, April, 2021
DOI: 10.5897/AJAR2020.15341
Article Number: B9689BD66680
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

*Review*

# Evaluation of the on-farm dairy technologies in Ethiopia: A review

**Endale Yadessa[1, 2*], Ulfina Galmessa[1], Lemma Fita[1] and Temesgen Jembere[1]**

[1]Ethiopia Institute of Agricultural Research, Holeta Agricultural Research Center, Holeta, P. O. Box: 2003 Addis Ababa, Ethiopia.

[2]College of Veterinary Medicine and Agriculture Bishotu, Addis Ababa University, Ethiopia.

Received 17 November, 2020; Accepted 24 February, 2021

**The objective of this review is to provide an overview of the major achievements of on-farm dairy technologies in Ethiopia by reviewing a variety of documents from proceedings, articles, journals, and original research papers. Following the on-station generation and evaluation of dairy technologies, on-farm participatory verification of improved dairy cattle production packages has started. Since then, there are available livestock production technologies for smallholder farmers mainly generated by the National Agricultural Research Systems including Ethiopian Institute of Agricultural Research, Regional Agricultural Research Institutes, Higher Learning Institutes, and some international organizations, such as International Livestock Center for Africa/International Livestock Research Institute. Even though large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country, the rate of adoption of dairy technologies by farm households varies widely based on the technologies to be adopted.**

**Key words:** Dairy, on-farm, technologies, milk yield, reproductive performance, feed intake, mastitis

## INTRODUCTION

The first nationwide and systematic national dairy cattle crossbreeding experiment was designed in 1972 at four research stations (Holeta, Bako, Werer and Adami Tulu) that represent different agro-ecological zones and dairy production systems in Ethiopia (Fikre, 2007; Kefena et al., 2016; Yohannes et al., 2017). Several researches have been conducted to evaluate the productive and reproductive performance of indigenous and crossbred cattle for different exotic blood levels of dairy cows under relatively controlled conditions at research centers, government-owned farms and in some urban and peri-urban dairy areas of a country (Beyene et al., 2018; Fikre, 2007). As a result of several years of improvements, on station performances of crossbred (50% and 75%) animals improved for daily milk yield, lactation milk yield, and lactation length (Kefena et al., 2016; Kefale et al., 2019; Yohannes et al., 2017). Following the on-station encouraging results, it was agreed to verify the performance of improved dairy cows and associated dairy production packages at on-farm through verification

*Corresponding author. E-mail: endaleyadessa@gmail.com Tel: +251-913173457.

trial using a participatory approach. However, the participatory on-farm verification of improved dairy cattle and their associated packages has registered remarkable achievements in pilot project areas in West, Southwest and North Shoa. Accordingly, on-farm participatory verification of improved dairy cattle production packages has begun since 2000 (Kefena et al*.,* 2016). Since then, there are available livestock production technologies for smallholder farmers mainly generated by the National Agricultural Research Systems including Ethiopian Institute of Agricultural Research, Regional Agricultural Research Institutes, Higher Learning Institutes and some international organizations, such as International Livestock Center for Africa/International Livestock Research Institute (ILCA/ILRI) (Agajie et al*.,* 2016). Even though large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country, the rate of adoption of dairy technologies by farm households varies widely based on the technologies to be adopted (Agajie et al*.,* 2016; Dehinenet et al*.,* 2014). Therefore, the objective of this review is to provide an overview of the major achievements of on-farm dairy technologies evaluation in Ethiopia for future improvement.

## LITERATURE REVIEW

### On-farm production performance of crossbred dairy cows

Crossbreeding of the indigenous breeds with imported temperate breeds has been practiced to improve the milk productivity of the local breeds through the exploitation of high genetic potential for milk production of exotic breeds and the adaptability to the local environment of indigenous breeds (EARO, 2001). As a result of so many years of crossbreeding efforts and improvements of overall management, the milk yield of crossbred dairy cows improved three to five-folds of local cows. Habtamu et al. (2012) reported that the total daily milk yield of Friesian-Horro crosses was improved by five-fold; as a result daily milk yield was 12.4, 6.9 and 7.8 L/day at Nekemte, Bako and Gimbi towns respectively.

### Milk production performance of 50% crossbred dairy cows

#### *Daily milk yield*

The milk production performance of 50% crossbred dairy cows at the on-farm level is summarized in Table 1. The daily milk yield of a crossbred cow at the on-farm level was in the range of 6.2-11.8L (Megersa, 2016; Niraj et al*.,* 2014) with a mean daily milk yield of 8.64 L which is better than the daily milk yield reported for dairy cows at on-station (Deneke et al., 2000; Kefena et al., 2016). The higher daily milk yield performance at the farm level might be due to the management given at the farm level is better than on station as farmers maintain few numbers of animals at a time.

#### *Lactation milk yield*

According to Dessalegn et al. (2016), the highest was 3202 L while Beyene et al. (2018) reported the lowest (2057 L) lactation milk yield. The lactation milk yield reported for on-farm evaluation of crossbred dairy cows was still higher than on-station performance. Similar to the daily milk yield, Dessalegn et al*.* (2016) and Megersa (2016) reported the highest lactation milk yield for 50% crossbred dairy cows at the on-farm level (Table 1).

#### *Lactation length*

The other important reproductive or economical trait evaluated was lactation length which was in the range of 234 to 331.5 days (Gebrekidan et al*.,* 2012; Niraj et al*.,* 2014). Except for a few findings, the reported lactation length was close to 305 days and lower than the on-station lactation length performance of 50% crosses. As indicated in Table 1, the mean lactation length of 50% crossbred dairy cows at the on-farm level was 286.19 days.

### On-farm reproduction performance of crossbred dairy cows (50% crosses)

#### *Age at first service (AFS)*

As presented in Table 2, the mean age at first service of 50% crossbred dairy cow was 22.55 months with the range of 18.7 to 24.9 months (Dessalegn et al*.,* 2016; Hunduma, 2012). The mean age at first service at on-farm level was by far better than the on-station performance of dairy cow for 50% crosses (Gebeyehu et al*.,* 2005; Sisay, 2015).

#### *Age at first calving (AFC)*

The on-farm evaluation of 50% crosses for age at first caving was in the range of 26.5 to 36.6 months (Belay et al*.,* 2012; Nuraji et al*.,* 2017). This performance at the on-farm level was much better than on-station performances that were in the range of 34.6-43.9 for 50% crosses (Kefena et al*.,* 2011; Zelalem et al*.,* 2015) and 27.9 - 43.9

**Table 1.** Daily milk yield, lactation milk yield, and lactation length for 50% crossbred dairy cows.

| Blood level | | Daily milk yield/L | Lactation milk yield/L/year | Lactation length /day | Source |
|---|---|---|---|---|---|
| **50% crossbred dairy cows** | Friesian x Boran | 11.8 | 3202.0 | 270.0 | Megersa (2016) |
| | Friesian x Boran | 11.6 | 3208.0 | 276.0 | Dessalegn et al. (2016) |
| | Friesian x Local | 7.8 | 2441.4 | 313.0 | Melku et al (2017) |
| | Friesian x Boran | 7.6 | 2057.0 | 269.7 | Beyene et al. (2018) |
| | Friesian x Local | 6.2 | 2069.0 | 331.5 | Niraj et al. (2014) |
| | Friesian x Local | 6.8 | - | 234.0 | Gebrekidan et al. (2012) |
| | Friesian x Local | 8.8 | - | 315 | Yitaye (2008) |
| | Friesian x Boran | 8.5 | - | - | Belay et al. (2012) |
| | Friesian x Boran | 8.7 | - | - | Marta (2012) |
| | Friesian x Horo | 9.0 | - | - | Habtamu et al. (2012) |
| | Friesian x Boran | - | 2503.6 | 309.1 | Nuraji et al. (2017) |

**Table 2.** On-farm reproductive performance of 50% crossbred dairy cows.

| Blood level | | AFS (month) | AFC (month) | CI (month) | SPC | Source |
|---|---|---|---|---|---|---|
| **50% Crossbred** | Friesian x Boran | 21.8 | 31.2 | 429.2 | 1.8 | Megersa (2016) |
| | Friesian x Boran | 18.7 | 27.0 | 390.0 | - | Dessalegn et al. (2016) |
| | Friesian x Boran | 24.9 | 34.8 | 372.8 | 1.2 | Hunduma (2012) |
| | Friesian x Boran | 24.3 | 36.6 | 640.0 | 1.5 | Belay et al. (2012) |
| | Friesian x Boran | - | 33.6 | 468.0 | - | Marta (2012) |
| | Friesian x Boran | - | 26.5 | 463.1 | 1.8 | Niraj et al. (2017) |
| | Friesian x Local | - | 32.2 | 417.0 | 2.0 | Yitaye (2008) |

*AFS: Age at first service; AFC: Age at first calving; CI: Calving interval; SPC: Service per conception.

months for 75% crosses at different management levels. This large variation of age at first calving between on station and on-farm was attributed to the management level provided to individual cows at the farm level.

### *Calving interval (CI)*

The average calving interval observed during this review was in the range of 372.8 - 640 days (Belay et al., 2012; Hunduma, 2012) with a mean calving interval of 460.5 days. Contrary to these results, the on-station calving interval was relatively lower (381 - 473 days) for 50% crosses (Sisay, 2015; Wondossen et al., 2018). This indicates that at on-station, there might be a good follow-up of a cow to detect cows in heat in order to be bred at an appropriate time or the farmers might lack the knowledge of how and when to detect cows in heat or the cows do not come back to heat due to lack of nutrition.

### *Number of service per conception (NSPC)*

The average number of service per conception of 50% crossbred cows at on-farm condition was 1.66 with a range of 1.2-2.0 (Hunduma, 2012; Megersa, 2016; Nuraji et al., 2017; Yitaye, 2008). The reported NSPC was almost closer to 1.5 which was within the normal reproductive value of dairy cows. On the other hand, the average service per conception of 50% crosses at on station level was 1.78 with a range of 1.2 to 2.05 and that of 75% had a mean SPC of 1.8 and in the range of 1.3 - 2.15 (Alewya, 2014; Yohannes et al., 2017; Zelalem et al., 2015).

## FEEDS AND NUTRITION AND IMPROVED FORAGE TECHNOLOGIES

### Animal feeds and nutrition

A series of studies on the status of Ethiopian feed resources, feeding management, and feed resource characterization has been carried out for the last many years (Getnet et al., 2016). Of that technologies, urea-treating of poor quality roughage and UMB making (Table 3 and 4) has been widely used as a strategy to improve

**Table 3.** Effect of feeding urea treated straw on feed intake and milk yield.

| Variable | Location | Feed intake (kg) | | Daily milk yield (kg) | | % age of milk yield improvements | Source |
|---|---|---|---|---|---|---|---|
| | | Control/farmers practice | Urea treated straw group | Control/farmers practice | Urea treated straw group | | |
| Effect of urea treated straws on feed intake and daily milk yield of dairy cows | On-station | 6.3 | 7.9 | 2.3 | 2.4 | 2.5 | *Lemma and Endalew (2017) |
| | | 9.6 | 10.0 | 8.1 | 8.9 | 10.7 | Rehrahie and Getu (2010) |
| | On-farm | 10.3 | 11.2 | 8.7 | 10.2 | 24.2 | Getahun et al. (2018) |
| | | 9.5 | 9.5 | 1.6 | 2.1 | 35.4 | *Adebabay et al. (2009) |
| | | 4.0 | 5.6 | 1.1 | 2.4 | 111.0 | *Mesfin et al. (2009) |
| | | 10.1 | 10.1 | 8.7 | 9.6 | 10.4 | Gelane and Mitiku (2018) |
| | | 6.5 | 9.0 | 3.6 | 7.1 | 95.08 | Mesfin et al. (2009) |

* Local cow.

**Table 4.** Effect of feeding Urea Molasses Block on feed intake and milk yield.

| Variable | Location | Feed intake (kg) | | Daily milk yield (kg) | | %age of milk yield improvements | Sources |
|---|---|---|---|---|---|---|---|
| | | Control/farmers practice | Urea Molasses Block | Control/farmers practice | Urea Molasses Block group | | |
| Effect of Urea Molasses Block on feed intake and daily milk yield of dairy cows | On-station | 8.0 | 8.9 | 3.6 | 4.9 | 34.9 | Tekeba (2012) |
| | | 9.2 | 9.5 | 6.5 | 6.6 | 2.1 | Getu et al. (2010) |
| | | 13.7 | 14.5 | 12.5 | 14.4 | 15.4 | Demoz et al. (2018) |
| | On-farm | 10.3 | 13.5 | 8.7 | 11.1 | 28.2 | Getahun et al. (2018) |
| | | 7.3 | 8.1 | 1.9 | 2.3 | 23.6 | *Tekeba (2012) |
| | | - | - | 7.0 | 8.1 | 15.3 | Tesfay et al. (2014) |
| | | 10.1 | 10.5 | 8.7 | 10.0 | 15.6 | Gelane and Mitiku (2018) |

* Local cow.

rumen microbial fermentation and animal performances which are cost-effective options for smallholder farmers to improve the nutritive quality of on-farm available feeds and reduce the level of concentrate consumption (Getahun et al., 2018). Adebabay et al., 2009; Gelane and Mitiku, 2018; Mesfin et al., 2009) found higher dry matter intake and higher milk yield at the on-farm level. The feeding of urea molasses block as dairy cow feed improved total dry matter intake both at on-station and on-farm and also daily milk yield of an animal improved by up to 28% for crossbred dairy cows (Getahun et al., 2018).

## Improved forage technologies

For the past decades, several forage crops have been tested in different agro-ecological zones and considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. So far, about 33 improved forage varieties have been registered and released for different agro-ecologies of the country (Getnet et al., 2016). As a result, improved forage crops have been grown and used in government ranches, state farms, farmers' demonstration plots, and dairy and fattening areas (Mengistu et al., 2017). The most commonly grown forage crops were Oats, vetch, oats and vetch mixtures, fodder beet, Elephant grass, Rhodes, Sesbania, Leucaena, and tree-lucerne being the most common. The average on-station dry matter yield of Oat (*Avena sativa* L.) was 7.72 t/ha with the highest (9.14 t/ha) reported by Gezahagn et al. (2017). Relatively lower (5.21 t/ha) dry matter yield was reported at the on-farm level (Table 5). The dry matter yield of Vetch (*Vicia sativa* L.) at on-farm was 1.38 - 4.28 t/ha (Adebabay et al., 2014; Gezahagn et al., 2013; Tekleyohannes et al., 2004; Usman et al., 2019). The dry matter yield performance of Alfalfa (*Medicago sativa* L.) at the on-farm level was highest (11.77 t/ha) as compared to on-station performance (6.4 t/ha) (Tewodros and Meseret, 2013). Napier grass (*Pennisetum purpureum* L.) gave the highest dry matter yield (23.4

**Table 5.** On station and on-farm performance of improved forage crops.

| Improved forage crops | DM yield of forage crops (t/ha) On-farm performance | Source |
|---|---|---|
| Oats (*Avena sativa* L.) | 4.2 | Adebabay et al. (2014) |
| | 2.4 | Tekleyohannes et al. (2004) |
| | 9.2 | Amanuel et al. (2019) |
| | 4.9 | Gezahagn et al. (2016) |
| Vetch (*Vicia sativa* L.) | 4.2 | Adebabay et al. (2014) |
| | 1.3 | Tekleyohannes et al. (2004) |
| Alfalfa (*Medicago sativa* L.) | 11.7 | Tewodros and Meseret (2013) |
| | 8.5 | Zeray et al. (2018) |
| Napiergrass *(Pennisetum purpureum* (L.) | 7.2 | Adebabay et al. (2014) |
| | 12.5 | Likawent et al. (2007) |
| | 14.0 | Solomon et al. (2019) |
| Rhodes grass (*Chloris gayana*) | 22.9 | Tewodros and Meseret (2013) |
| | 10.4 | Zeray et al. (2018) |
| | 10.6 | Mohamed and Gebeyew (2018) |

**Table 6.** Time taken to churn and butter yield among churners.

| Time taken (h) | Butter yield (g) | Milk churned (L) |
|---|---|---|
| **Traditional (Pot type churner)** | | |
| 1:05 | 174.7 | 3.3 |
| **Improved (Plastic-type churner)** | | |
| 0:39 | 180.5 | 3.3 |

Source: Fetiya et al. (2017).

t/ha) at on-station than on-farm (14.06) level (Solomon et al*.,* 2019; Temesgen et al*.,* 2014). The dry matter yield of most improved forage except Alfalfa, at farm level, was relatively lower than on station performance which is attributed to the experience of the farmers in managing low improved forage and this can be improved through continuous training and demonstration.

## DAIRY PROCESSING (MILK CHURNER) TECHNOLOGY

Research has generated and disseminated milk churner technologies which are believed to be time and energy-saving, efficient, and easy to operate (Agajie et al*.,* 2016). According to Fetiya et al. (2017), on-farm evaluation of an improved churner has significantly reduced the amount of time taken to churn milk with an improved plastic churner (Table 6). Further findings by Dagninet et al. (2016) reported that it takes on average, 38 and 23 min to extract butter using the modern churner for a diary milk of the same size during summer and winter, respectively. The increase in labor productivity was also calculated as the amount of output per unit time of labor input for both traditional and modern churning systems.

## ANIMAL HEALTH INTERVENTION PRACTICES

For some decades, the livestock resources development effort of the country did not get the right support from the research side in developing and delivering technologies, methods, and other decision support tools for disease control and prevention. This resulted in incompetent and

**Table 7.** Mastitis incidences in crossbred dairy cows.

| Location | Mastitis Infection | Pre-intervention [No. (%)] | Post-intervention [No. (%)] |
|---|---|---|---|
| On-station | Clinical | 6 (3) | 2 (0.01) |
| | Subclinical | 116 (58) | 62 (31) |
| On-farm | Clinical | 10 (5) | 6 (0.03) |
| | Subclinical | 145 (72.6) | 92 (46) |

Source: A prospective study - EAAPP (2011-2015).

weak veterinary services and regulations that do not comply with the animal health and food safety standards needed to export live animal and animal products into lucrative global markets (Gebremeskel et al*.,* 2016). The same author also stated that the extent of animal health technologies/practices utilization in Ethiopia is meager and the previous and existing research focus on the development and/or adoption of such technologies has also been slow. Among the animal diseases, mastitis has been known to cause a great loss of productivity to influence the quality and quantity of milk yield and to cause culling of animals at an unacceptable age (Vaarst and Envoldsen, 1997). According to some studies, the economic loss from mastitis in the urban and peri-urban areas of Addis Ababa are 58 and 78.65 US Dollars per lactation, respectively (Mungube et al*.,* 2005; Tesfaye et al*.,* 2010). Studies on animal health management interventions indicated that mastitis infection has significantly reduced in some dairy farms (Table 7).

## ADOPTION OF DAIRY TECHNOLOGIES BY SMALLHOLDER FARMERS

The major dairy technologies generated and disseminated to smallholder farmers include improved dairy breed, improved feeds and feeding, dairy processing, and value addition technologies, and improved animal health management practices (Agajie et al*.,* 2016). Even though large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country, the rate of adoption of dairy technologies by farm households varies widely across different agro-ecologies and within the same agro-ecology based on various technical and non-technical factors. For instance, the overall average adoption rate of crossbred dairy cows (28%), forage crops (10%), urea treated straw (5%), multi-nutrient block (2%), and milk churner technology (1.3%) are obtained in the Oromiya region which is perceived to be encouraging as compared to other parts of the country. Lower (15%) adoption of dairy technologies was also reported by Chanie et al*.* (2018) in and around Gonder town, Amhara region, Ethiopia.

## CONCLUSION AND RECOMMENDATIONS

The dairy cattle research has generated a handful of dairy technologies and information targeted different dairy production systems in Ethiopia. The reviewed proceedings, articles, journals, and original research papers indicated that most of the evaluated economic traits like daily milk yield, lactation milk yield, lactation length, age at first service, age at first calving, calving interval, and a number service per conception are improved at on-station level due to several researches that have been done on animal breeding, feed and nutrition, dairy processing technologies and animal health practices. Consequently, plenty of dairy and related technologies and associated packages have been generated, but few of these technologies are popularized to target beneficiaries in the form of verification trials and pre-extension demonstrations since 2000. Furthermore, on-farm evaluation of these technologies and practices has registered encouraging results, but due to multifactorial reasons its rate of adoption is very low. Therefore, in addition to generating new dairy and related technologies, the concerned organizations should focus on the popularization and demonstration of already proven dairy technologies and associated production packages.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

### REFERENCES

Adebabay K, Firew T, Zeleke Me, Azage T (2009). On-Farm Evaluation of the Effect of Concentrate and Urea Treated Wheat Straw Supplementation on Milk Yield and Milk Composition of Local Cows. Proceedings of the 17th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, September 24 to 26, 2009

Adebabay K, Yihalem D, Habtemariam A, Wondimeneh M (2014). On-farm Evaluation and Demonstration of Improved Forage Crops in

Small Scale Model Dairy Villages of Bahir Dar Milk Shed. Proceedings of the 22ndAnnual Conference of the Ethiopian Society of Animal Production (ESAP) Held In Addis Ababa, Ethiopia.

Agajie T, Tadele M, Tesfaye S, Yared D, Wudineh G, Tolesa A, Diriba H, Tamirat F, Seyoum B (2016). Adoption Analysis of Smallholder Dairy Production Technologies in Oromiya Region, Ethiopia. Research Report No.115.

Alewya H (2014). Comparative study of reproductive and productive Performance of holstein friesian dairy cows at holeta bull dam station and genesis farms. College of Veterinary Medicine and Agriculture of Addis Ababa University. MSc. Thesis, Bishoftu, Ethiopia.

Amanuel W, Kassa S, Deribe G (2019). Biomass Yield and Nutritional Quality of Different Oat Varieties (*Avena sativa*) Grown Under Irrigation Condition in Sodo Zuriya District, Wolaita Zone, Ethiopia. Agricultural Research and Technology: Open Access Journal 20(4):556138. DOI: 10.19080/ARTOAJ.2019.20.556138.

Belay D, Yisehak K, Janssens G (2012). Productive and Reproductive Performance of Zebu X Holstein-Friesian Crossbred Dairy Cows in Jimma Town, Oromia, Ethiopia Global Veterinaria 8(1):67-72.

Beyene A, Alilo A, Halango K, Said A (2018). Production Performances of Holstein Friesian Crossbred Dairy Cows in Hadiya Zone, (Southern Ethiopia). Dairy Research Journals 6:216. doi:10.4172/2329-888X.1000216

Chanie D, Minwagaw L, Tesfaye E, Yiblet M (2018). Dairy technology adoption in small holder farmer in and around Gondar town, Amhara region, Ethiopia. Online Journal of Animal and Feed Research 8(2):39-45. www.ojafr.ir

Dagninet A, Menale W, Meseret T, Tegegne D, Awole M, Negesse Y, Dessie M, T/Giorgis M (2016).Integrating Feeding And Productivity: Scaling Out Livestock Input And Output Processing Technologies For Smallholders. International Multilingual Journal of Science and Technology 1(1).

Dehinenet G, Mekonnen H, Ashenafi M, Kidoido M, GuerneBleich E (2014). The impact of dairy technology adoption on small holder dairy farmers livelihoods in selected zones of Amhara and Oromia National Regional States, Ethiopia. Global Journal of Agricultural Economics and Econometrics 2(1):104-113.

Demoz Y, Assefa A, Endale K (2018). Effect of feeding urea-molases treated teff straw on milk yield and composition of cross bred dairy cows. Online Journal of Animal and Feed Research 8(6):175-179. www.ojafr.ir

Demeke S, Neser FWC, Schoeman SJ, Erasmus GJ, Wyk JBV, Gebrewolde A (2000). Crossbreeding Holstein-Friesian with Ethiopian Boran cattle in a tropical highland environment: preliminary estimates of additive and heterotic effects on milk production traits. South African Journal of Animal Science 30(Supplement 1).

Dessalegn G, Berhan T, Gebreyohanes B (2016). Study of productive and reproductive performance of cross breed dairy cattle under smallholders management system in Bishoftu and Akaki Towns. International Journal of Agricultural Sciences 6(2):913-917.

EARO (Ethiopian Agricultural Research Organization) (2001). Back ground paper on developing animal breeding policy working paper. January. 21p.

Fetiya M, Estefanos T, Tesfaye G (2017). On-Farm Demonstration and Evaluation of Improved Plastic Milk Churner in West Arsi Zone of Oromia Regional State, Ethiopia. International Journal of Research Studies in Agricultural Sciences 3(3).

Fikre L (2007). Reproductive and Lactation Performance of Dairy Cattle in the Oromia Central Highlands of Ethiopia with Special Emphasis on Pregnancy Period. Doctoral thesis Swedish University of Agricultural Sciences.

Gebeyehu G, Asmare A, Asseged B (2005). Reproductive performances of Fogera cattle and their Friesian crosses in Andassa ranch, Northwestern Ethiopia. Addis Ababa University, Faculty of Veterinary Medicine. Livestock Research for Rural Development 17(12).

Gebrekidan TW, Zeleke MZ, Gangwar SK (2012). Reproductive and productive performance of dairy Cattle in central zone of Tigray, Northern Ethiopia. International Journal of Advanced Biological Research 2(1): 58-63.

Gebremeskel M, Aster Y, Bewket S (2016). Animal Health Research:The Ethiopian Experience and Future Prospects. Proceedings of the National Conference on Agricultural Research for Ethiopian Renaissance held on January 26-27, 2016, in UNECA, Addis Ababa to mark the 50th Anniversary of the establishment of the Ethiopian Institute of Agricultural Research (EIAR).

Gelane K, Mitiku E (2018). On-farm Effect of Urea Treated Straw and Urea Molasses Block on Cross-Bred Dairy Cows at Lume District, Ethiopia. Agricultural Research and Technology Open Access Journal 17(3):556024. DOI: 10.19080/ARTOAJ.2018.17.556024.

Getahun K, Alemayehu G, Fantahun D (2018). Characterization of Dairy Farms, Farmers' Training and On-Farm Evaluation of Urea-Treated Straw and Urea-molasses-block (UMB) feeding on Performances of Lactating Crossbred cows in Ada District of East Shoa Zone, Ethiopia. World Journal of Agricultural Sciences 14(3):81-88.

Getnet A, Solomon M, Fekede F, Seyoum B (2016). Animal Feeds Research in Ethiopia: Achievements, Challenges and Future Directions. Proceedings of the National Conference on Agricultural Research for Ethiopian Renaissance held on January 26-27, 2016, in UNECA, Addis Ababa to mark the 50th Anniversary of the establishment of the Ethiopian Institute of Agricultural Research (EIAR).

Getu K, Solomon M, Eyasu S, Mesfin D (2010). Supplementary value of vetch (*vicia dasycarpa*) hay As a replacement to concentrate mix in the Diet of lactating crossbred cows. Ethiopian Journal of Science 33(1):31-40.

Gezahagn K, Fekede F, Getnet A, Muluneh M, Tadesse T (2016). Agronomic Performance and Nutritive Values of Napier Grass in the Central Highland of Ethiopia.

Gezahagn K, Getnet A, Alemayehu M Hussein M (2013). Evaluation of Vetch Species and their Accessions for Agronomic Performance and Nutritive Value in the Central Highlands of Ethiopia. Ethiopian Journal of Science 24(1):99-121.

Gezahagn K, Getnet A, Fekede F, Alemayehu M, Muluneh M, Mamaru T (2017). Determination of appropriate seeding rate for oats/vetch mixtures grown under different drainage conditions of vertisols in the central highlands of Ethiopia. Journal of Agricultural and Crop Research 5(5):85-95.

Habtamu A, Ulfina G, Jiregna D, Mulugeta K, Gizaw K (2012). Impact distribution of crossbred (Friesian- Horro) heifers on livelihoods per-urban dairy farm of Nekemte, Bako and Gimbi towns, Western Oromia, Ethiopia. Journal of Agricultural Extension and Rural Development 4(16):423-427.

Hunduma D (2012). Reproductive performance of crossbred dairy cows under smallholder condition in Ethiopia. International Journal of Livestock Production 3(3):25-28.

Kefale G, Million T, Direba H, Yosef T (2019). Milk Production in the Long-term Genetic Improvement of Crossbred Dairy Cattle Maintained at Holetta Agricultural Research Center. Proceedings of the 7th Annual National Review Workshop on Results of Livestock Research, May 2019, Holetta Research Center, Holetta.

Kefena E, Mengistu A, Zewdie W, Diriba H, Getnet A (2016). Dairy Cattle Research and Development Demands for Ethiopia .Proceedings of the National Conference on Agricultural Research for Ethiopian Renaissance held on January 26-27, 2016, in UNECA, Addis Ababa to mark the 50th Anniversary of the establishment of the Ethiopian Institute of Agricultural Research (EIAR).

Kefena E, Zewdie W, Tadelle D, Aynalem H (2011). Genetic and environmental trends in the long-term dairy cattle genetic improvement programmes in the central tropical highlands of Ethiopia. Journal of Cell and Animal Biology. 5(6):96-104.

Lemma G, Endalew W (2017). Evaluation of milk production performance of lactating Fogera cows fed with urea and effective micro-organisms treated rice straw as basal diet. International Journal of Scientific and Research Publications 7(5).

Likawent Y, Nake Z, Ameha S, Agraw A (2007). Napier grass (*Pennisetum purpureum* L.) on the edge of irrigation canals in the lowlands of Kewot woreda (Shewarobit), Ethiopia: a promising entry point. Proceedings of the 15th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia.

Marta K (2012). Crossbreding strategies for dairy cattle: Introduction, development and impact on smallholder farmers in North Gonder, Ethiopia. M.Sc Thesis submitted to University of Natural Resource and Life Sciences Vienna, Department of Sustainable Agriculture System.

Megersa A (2016). Reproductive and Productive Performance of Crossbred and Indigenous Dairy Cattle under Rural, peri-urban and Urban Dairy Farming Systems in West Shoa Zone, Oromia, Ethiopia. M.SC. Thesis, College of Agriculture and Veterinary Medicine, Jimma University, Ethiopia.

Melku M, Kefyalew A, Solomon G (2017). Milk Production Performances of Local and Crossbred Dairy Cows in WestGojam Zone, Amhara Region, Ethiopia. Journal of Applied Animal Science 10(1): 35-46.

Mengistu A, Kebede G, Feyissa F, Assefa G (2017). Review on Major Feed Resources in Ethiopia: Conditions, Challenges and Opportunities. Academic Research Journal of Agricultural Science and Research 5(3):176-185.

Mesfin D, Seyoum B, Aemiro K, Getu K, Kedir N (2009). On-farm evaluation of lactating crossbred (*Bos taurus* x *Bos indicus*) dairy cows fed a basal diet of urea treated teff (*Eragrostis tef*) straw supplemented with escape protein source during the dry season in crop-livestock production system of north Shoa, Ethiopia. Livestock Research for Rural Development 21(5).

Mohamed A, Gebeyew K (2018). On-farm Performance Evaluation of Selected Perennial Grass under Rain-Fed Conditions at Deghabour District, Cherer Zone, Ethiopian Somali Region. Journal of Poultry, Fisheries and Wildlife 6:201. doi: 10.4172/2375-446X.1000202.

Mungube EO, Tenhagen BA, Regassa F, Kyule MN, Shiferaw Y, Kassa T Baumann MPO (2005). Reduced milk production in udder quarters with sub-clinical mastitis and associated economic losses in crossbred dairy cows in Ethiopia. Journal of Tropical Animal Health and Production 37:1573-7438.

Niraj K, Kbrom T, Desalew T, Awot T (2014). Productive Performance of Crossbred Dairy Cows and constraints faced by dairy farmers in Mekelle, Ethiopia. Journal of Agriculture and Veterinary Science. 7(1):62-66.

Niraj K, Berihu G, Nigus A Etsay K (2017). Performance of Crossbred Dairy Cows under Farmers' Management in and Around Debre Zeit, Ethiopia. Ethiopian Journal of Veterinary Science and Animal Production 1(1):66-72.

Rehrahie M, Getu K (2010). Effect of feeding urea treated wheat straw based diet on biological performances and economic benefits of lactating Boran-Friesian crossbred dairy cows. Livestock Research for Rural Development 22(12).

Sisay E (2015). Productive and reproductive performance of dairy cows (Horro, Horro X Friesian and Horro X Jersey) at Bako agricultural research center, MSc. Thesis. Haramaya University, Ethiopia.

Solomon T, Bimrew A, Firew T (2019). Farmers' utilization practice, yield and chemical composition of selected improved forages grown in natural resource management areas of Farta District, South Gondar Zone, Ethiopia, Cogent Food and Agriculture 5(1):686-961.

Tekeba E (2012). Effects of dietary supplementation with Urea Molasses Multi-nutrient Block in local Ethiopian and crossbred dairy cows in North-western Ethiopia. Doctoral Thesis.

Tekleyohannes B, Teshome A, Solomon B, Bekele M, Dawit A and Dagnachew W (2004). Herbage yield Potential of annual forage crops grown under minimum tillage system in fallow season of the Bale highlands. Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia.

Temesgen J, Wakgari K, Mekonin D (2014). Advanced Screening of Napier grass genotypes under Bako condition, west Ethiopia. Proceedings of the 22$^{nd}$Annual Conference of the Ethiopian Society of Animal Production (ESAP) Held In Addis Ababa, Ethiopia.

Tesfay H, Yohanse T, Teshale T, Temesgen T, Tesfay B, Awet E (2014). On-farm Demonstration and Benefit of Urea Molasses and Cactus Blocks in Small Scale Dairy Farms. The Case of Souththern Zone of Tigray Region. Proceedings of the 22ndAnnual Conference of the Ethiopian Society of Animal Production (ESAP) Held In Addis Ababa, Ethiopia.

Tesfaye GY, Regassa FG, Kelay B (2010). Milk yield and associated economic losses in quarters with subclinical mastitis due to Staphylococcus aureus in Ethiopian crossbred dairy cows. Tropical Animal Health and Production 42(5):925-931.

Tewodros M, Meseret M (2013). Production Constraints, Farmers Preferences and Participatory on Farm Evaluation of Improved Forage Technologies in Selected Districts of Southern Ethiopia. Greener Journal of Agricultural Sciences. 3(9):628-635.

Usman S, Tamirat D, Bedasa E (2019). Performance Evaluation of Improved Vetch Varieties/Accessions at the Highland of Guji Zone, Bore, Ethiopia. Journal of Agricultural Science and Technology: Open Access Journal. 20(5):556141.

Wondossen A, Mohammed A, Enyew N (2018). Reproductive Performance of Holstein Friesian Dairy Cows in a Tropical Highland Environment. Journal of Advances in Dairy Research 6(2):203. doi:10.4172/2329-888X.1000203

Yitaye A (2008). Characterization and analysis of the urban and peri-urban dairy production systems in the North western Ethiopian highlands. A thesis submitted to BOKU - University of Natural Resources and Applied Life Sciences, Vienna, Austria for the award of Doctor Rerum *Naturalium Technicarum*. Vienna.

Yohannes G, Million T, Kefena E, Direba H (2017). Performance of Crossbred Dairy Cows Suitable for Smallholder Production Systems at Holetta Agricultural Research Centre. Ethiopian Journal of Agricultural Sciences 27(1): 121-131.

Zelalem A, Biniam M, Tilaye D (2015). Reproductive and Lactation Performance of Crossbreed Dairy Cows in Bishoftu, Ada'a Distict of East Shoa, Eastern Ethiopia. Science, Technology and Arts Research. Science, Technology and Arts Research Journal 4(4):113-119.

Zeray Z, Birhanu M, Philimon T, Tagel A (2018). Participatory Evaluation and Demonstration of Improved Forage Technologies under Small Scale Irrigated Condition in Amibara District of Afar Region. Global Journal of Science Frontier Research: Agriculture and Veterinary 18(2).