Milk yield performance of two and three breed crosses of dairy cattle in the central highlands of Ethiopia

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Abstract

Two and three way rotational crossing was carried out at the Holetta Research Center using the indigenous Boran (Bos indicus) and exotic dairy cattle breeds of Friesian and Jersey (Bos taurus). The Jersey was used as third breed, to produce three way crosses from Boran Friesian crosses. The Friesian was used as third breed for Boran cross Jerseys. All herds were allowed to graze 8 hours per day during dry seasons (September-June) and fed indoors during the wet season (July-August). Cows were hand milked twice per day and data were collected and recorded for each milking. A total of 226 two way and 131 three way records were used to analyze lactation length, total milk yield, average daily milk yield and 305 days milk yield. Least square mean of 305 days milk yield for two and three breed crosses was 1827.00±40.68 and 1704.00 ±368 liters, respectively. Parity and calving season had marked effect on lactation length (P<0.05). Total milk yield was affected only by parity (P<0.05). Milk yield during 305 days lactation was affected by parity and exotic blood level. Cows with higher exotic blood level exceeded cows with low exotic blood levels for both crosses. Therefore, using three breed crossings accompanied with upgrading maintains heterosis achieved in two breed crossing and further improves with milk yield.

Key words: milk yield, two breed cross, three breed cross, dairy cattle

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Introduction

The largest proportion of milk produced in Ethiopia is obtained from unimproved local zebu cattle (*Bos indicus*). Zebu cattle used for milk production are estimated at 8,310,427 heads in Ethiopia (CSA, 2003). However, they are estimated to produce 3.0 liters/head/day. Earlier reports also indicate lactation milk yield of 675, 561 and 682 liters and lactation length of 184, 177, and 181 days for *Boran, Horro*, and *Barca* zebu cows, respectively (I.A.R., 1976). Therefore, milk yield performances of zebu cattle are generally low. However, these cattle types have evolved through generations and are well adapted to harsh environmental conditions of the tropics and have developed resistance to certain diseases and parasites.

On the other hand, exotic (*Bos taurus*) cattle types have superior milk yield performance, but low disease resistance and adaptation. Two way crossing to produce heterozygous breeds of 50% crosses and high grades was initiated in 1974 to combine milk-producing ability of *Bos taurus* cattle with disease resistance and adaptation to tropical environments by Zebu breeds. Milk yield, reproductive performance and growth performance of the two breed crossing activity has been reported earlier (Beyene, 1992, Sendros *et al*, 1987a, 1987b, Azage *et al*, 1981).

Three way crossing was initiated (Merha and Alemu, 1989) after reviewing the two way crossing. In the two-way crossing, 50% crosses were found better than high grades (75%, 87.5%) under low standard of management and feeding. However, it was felt that a continuous supply of 50% crosses is required. Otherwise, if the 50% crosses are backcrossed to Zebu bulls, these crosses will be down graded and lose their heterosis. Threfore, a third sire breed was suggested to be superimposed producing three way crosses in order to maintain heterosis. Additionally, production of two-way crosses was suggested for contemporary comparison. The objective of this paper is to evaluate milk yield performance of three way crosses and their contemporary two-way crosses under the same environment.

Materials and methods

Animals and management

The local zebu *Boran* (*Bos indicus*) breed and exotic breeds of Jersey and Friesian (*Bos taurus*) were used in the crossbreeding experiment during 1990 - 1997. Calves were reared using bucket milk, hay and calf starter feeding indoors. They were allowed to graze outdoors at the age of 6 months. Heifers and mature cows were allowed to graze 8 hours per day and fed hay indoors during evenings. Water was available *ad lib* all the time for all groups of animals. During pregnancy and parturition cows were supplemented concentrate in addition to hay. The progenies were maintained at the Holetta Research Center in the Central Highlands of Ethiopia. Milk yield was recorded during morning and evening milking. Milk yield was measured by weighing milk from each cow, using scales. Morning and evening milk data were added to get daily milk yield. Total lactation and 305 days milk yields were obtained by summing up daily yields. Daily milk yield was computed by dividing total lactation yield by lactation length. Lactation length was computed by deducting calving dates from dry off dates. In this paper 357 records were used for milk yield.

Heterosis (percent) achieved during 305 days milk yield for the two and three breed cross progenies were computed using the formula (Pirchner, 1985).

$$\frac{G_1 - (P_1 + P_2)/2}{(P_1 + P_2)/2} X100$$

Where,

G_1 = Progeny, P_1 = First Parent, P_2 = second parent

Mating plan

The cattle were bred using two mating systems through natural mating and AI (Artificial Insemination). Local zebu cows were bred by AI while *inter se* mating between crossbreeds was by natural mating. Local zebu cows were purchased and used as foundation herd during the first phase of the crossbreeding program. Their progenies were used for mating in the three way crossing programs (Fig. 1 and 2).

Foundation generation **First generation** **Second generation** **Third**

(Dam (Sire) Offspring (Dam/sire) Offspring Dam/Sire) Offspring

XF → F_{1BOF}* → XF_{1BOF} → F_{2BOF} X_{BOF} → F_{3BOF}

Boran → XF → 75% $_{BOF}$ X_{BOF} → 62.5%BOF

XJ → F_{1BOJ} → X F_{1BOJ} → F_{2BOJ} X_{BOJ} → F_{3BOJ}

→ XJ → 75% $_{BOJ}$X F_{1BOJ} → 62.5%BOJ

Fig. 1. Two way crossing

* Legend = F=Friesian = J=Jersey = BO= Boran = BOF=Boran = X Friesian = BOJ=Boran X Jersey = crossing lines = off springs

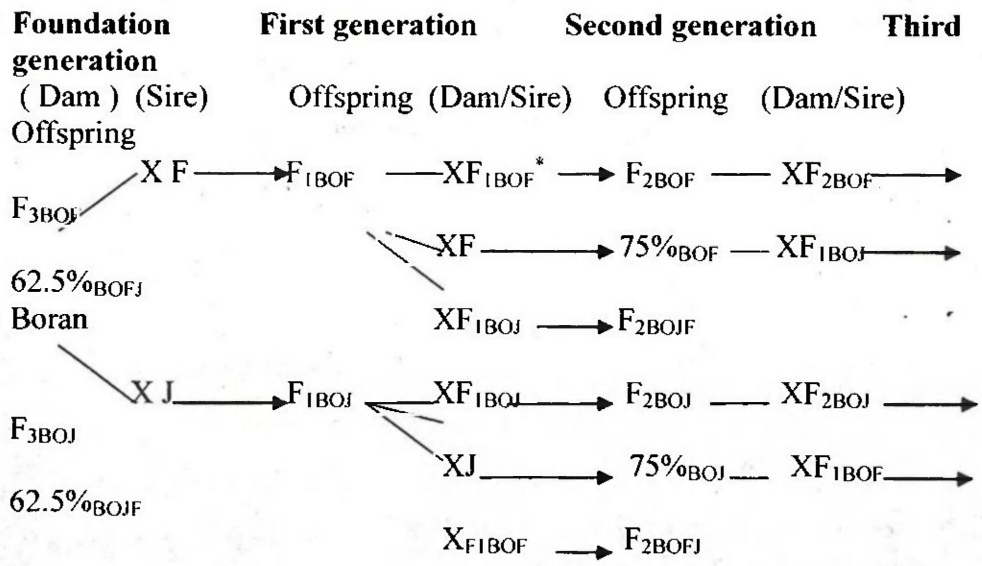

Fig. 2. Three way crossing

Data groupings

All breed types were grouped into major genotypes for analysis. F_1 and F_2 crosses were grouped as 50% crosses. Seventy five percent crosses were not used in this analysis. The seasons of the year during the recording period are grouped into dry (October to May) and wet (June to September).

Statistical analysis

Data collected were analyzed using General Linear Models of SAS (SAS 1998). Cross, blood level, parity and season were considered as independent variables. Duncan multiple range test was used to separate means. P values < 0.05 were used for test of significance.

* Legend: BOFJ=BOXFXJ; BOJF=BOXJXF; ——— = crossing lines; ——► = off springs

Results

Lactation lengths and 305 days milk yield performance of crossbred cows are presented in Table1. Lactation length was affected by parity, where by lactation length for 2nd parity was higher than 4th parity by 23% ($P<0.05$). Lactation length increased up to 2nd parity and then dropped at 3rd and 4th parities. However, lactation length didn't show a marked difference among crosses and exotic blood levels ($P>0.05$). *Boran* Friesian crosses of 50% and 62.5% blood level showed numerically higher lactation length than all other exotic blood level groups ranging from 0.2-10%. However, their difference was not significant ($P>0.05$). Seasons of calving didn't show a pronounced effect on lactation length ($P>0.05$), though, cows calved during the wet season exceeded those that calved during the dry season by 16.5%.

Table 1. Least squares means and lactation length, and 305 days milk yield

Variable	Number	Lactation length (days)	305 days milk yield (kg)
Overall mean	357	368	1779.9
Type of cross			
Two-way	226	368 ± 10.71	1827 ± 40.68
Three-way	131	368 ± 8.15	1704 ± 51.46
Parity			
1st parity	141	387 ± 12.01[b]	1683 ± 53.90[a]
2nd "	103	411 ± 13.74[b]	1882 ± 62.42[b]
3rd "	70	389 ± 17.35[b]	1934 ± 82.68[b]
4th "	43	333 ± 20.54[a]	1989 ±107.69[b]
Exotic Blood level*			
50%BOF	65	403 ± 16.84	2033 ± 81.10[c]
50% BOJ	87	367 ± 14.71	1677 ± 70.66[a]
62.5%BOF	50	392 ± 18.64	2113 ± 92.97[c]
62.5%BOJ	24	368 ± 26.33	1733 ± 118.74[ab]

Variable	Number	Lactation length (days)	305 days milk yield (kg)
25%boF 25%BO J	85	379 ± 15.33	1698 ± 69.95^{ab}
37.5%BOF 25%BO J	22	366 ± 26.67	1968 ±130.4^{bc}
37.5%BO J 25%BO F	24	385 ± 25.11	1882 ±118.29^{abc}
Calving season			
Dry	307	351 ± 8.33^{a}	1863 ± 41.92
Wet	50	409 ± 18.41^{b}	1881 ± 84.19
C.V. %		32.4	27.2

Means with different superscripts within the same category are significantly different (P <0.05)
* F = Friesian, J = Jersey, BO=*Boran*

Milk yield of cows during 305 days for two and three breed crosses had no marked difference (P<0.05). Though, 305 days milk yield was numerically higher for two way crosses than three way crosses by 7.2%, it wasn't statistically significant (P>0.05) Parity and exotic blood level had a marked influence on 305 days milk yield. Milk yield during 305 days of lactation showed an increasing trend with increased parity. Cows in the 2nd to the 4th lactation had markedly higher 305 days milk yield than during the first lactation, ranging from 11.8% to 18.2% (P<0.05). Milk yield during 305 days was highest for 62.5% Boran Friesian crosses and lowest for 50% Boran Jersey cross cows (P<0.05). Crosses of 62.5% Boran Jersey and 25% Friesian 25% Jersey had intermediate milk yield. Heterosis (the degree that offspring exceed the average of the performance of parents) achieved for 305 days milk yield expressed in percentage for two breed BOF, BOJ and three breed BOFJ, BOJF, computed as 72.35%, 65.02% and 73.24%, 60.75%, respectively. Calving season didn't play a significant role for 305 days milk yield. However, cows that calved during the wet season had slightly higher milk yield.

Total lactation milk yield and average daily milk yield for all lactations are summarized in Table 2. Among factors considered only parity markedly affected total milk yield. Cow that calved for the third time had 21% higher milk yield than cows that calved for the first time. Similarly, total milk yield varied by 22% between the high producer 50%Boran Friesian crosses to low producer 25%F25%J crosses.

Table 2. Least squares means and se of total lactation and average daily milk yield

Variable	Number	Total milk yield (kg)	Average daily milk yield (kg)
Overall mean	357	1986	5.3
Type of cross			
Two-way	226	1899 ± 86.90	5.4 ± 0.11
Three-way	131	2038 ± 66.16	5.3 ± 0.14
Parity			
1st parity	141	1926 ± 98.75[a]	5.0 ± 0.16[a]
2nd "	103	2191 ± 112.97[bc]	5.4 ± 0.18[ab]
3rd "	70	2331 ± 142.69[c]	5.7 ± 0.23[bc]
4th "	43	1920 ± 168.86[ab]	6.0 ± 0.27[c]
Exotic Blood level			
50% BOF	65	2320 ± 138.49	5.8 ± 0.22
50% BOJ	87	1938 ± 120.96	5.0 ± 0.19
62.5% BOF	50	2255 ± 153.31	5.8 ± 0.25
62.5%BOJ	24	1965 ± 216.45	5.1 ± 0.35
25% F 25% BOJ	85	1901 ± 126.08	5.2 ± 0.20
37.5% F 25% BOJ	22	2190 ± 219.29	6.1 ± 0.40
37.5% J 25%BOF	24	2074 ± 206.49	5.8 ± 0.30
Calving season			
Dry	307	1992 ± 68.47	5.6 ± 0.11
Wet	50	2190 ± 151.40	5.4 ± 0.24
C.V. %		49.3	29.6

Means with different superscripts within the same category are significantly different ($P < 0.05$)

These variations were not statistically significant ($P > 0.05$). Total lactation milk yield between calving seasons were similar, howeyer cows that calved during the wet season exceeded those that calved during dry season only by 9.9%.

Average daily milk yield for all lactation records had indicated no significant difference between crosses, blood levels and calving seasons. But parity played a significant role in average daily milk yield throughout the whole lactation. Average daily milk yield for the 4th parity was markedly higher than for the first parity by 20% ($P<0.05$). Average daily milk yield for cows calved during wet season was only slightly higher (3.6%) than cows calved during dry season.

Discussion

The similarity in lactation length between two and three way crosses in this study indicates that lactation length could be maintained if three way crossing is used. On the other hand, lactation length for both two and three way crosses in this report is higher than earlier reports by Goshu (1983), where lactation length of 302±7.74 and 256±15.18 days were obtained for Boran cross Friesian (50%) cows at 1st and 2nd lactations, respectively. On the other hand, higher calving interval of 429, 450, and 459 days were reported for 50%, 75%, and 87.5% crosses (Syrstad, 1996), which could be indicative of increased lactation length as exotic blood level increased.

In this study lactation length increased up to second parity and showed diminishing trend after third parity for all crosses, where the shortest lactation length was recorded during 4th parity. The shorter lactation length manifested during 4th parity in this study may be related to age of cows as reported earlier (Moges and Baars, 1998, Friggens *et al*., 1999; Rekaya *et al*., 2001). In both two and three breed crosses, similar lactation lengths were observed for different exotic blood levels, indicating that this parameter is not affected due to breed and blood level.

Calving season was the most important factor that affected lactation length, where all cows calved during wet season exceeded those that calved during dry season. This indicates that cows calved during wet season had better opportunity to sustain lactation due to availability of green grass as compared to cows that calved during dry season. The shorter lactation length observed during dry season calving is most probably associated with poor nutrition. Cows that calved during the dry season consumed conserved hay, while those that calved during the wet season consumed green grass using cut and carry system, and were grazing during June and early September. However, earlier works indicated no seasonal difference in lactation length due to season (Moges and Baars, 1998). The variation between earlier report and the result of the current work might be due to difference in feeding system rather than season alone.

Milk yield during 305 days period was not affected by type of cross and calving season. However, two way crosses and cows that calved during the wet season had slightly higher milk yield. In another study, Moges and Baars (1998) found slightly higher 305 days milk yield for cows that calved during the wet season than the dry season. Seasonal variation in 305 days milk yield might be associated with nutrition. Absence of significant difference over 305 days of lactation between two breed and three breed crosses indicate that there is no loss in milk yield due to heterosis obtained during two way crossing. However, 305 days milk yield was found diminishing as the Jersey exotic blood level increases and Friesian exotic blood level decreases. Breed variation in 305 days milk yield was reported earlier (Moges and Baars, 1998). Therefore, the main determinant factors in three breeds crossing are the performances of superior breeds used to improve the inferior breeds. Breed effects have been shown to affect milk yield and lactation curves (Friggens *et al.*, 1999; Rekaya *et al.*, 2001). Parity and exotic blood level showed marked difference in 305 days milk yield. Cows in the 1st parity had lower 305 days milk yield than all other parities. Similar reports were made in which cows in 3rd and 4th parity produced higher 305 days milk yield than cows in 1st and 2nd parities (Moges and Baars, 1998). Heterosis achieved in 305 days milk yield in the three breed crosses indicate that at least 50% of the average yield of parents used in the crossing can be achieved. This indicates that heterosis was maintained through three way crossing.

First generation crosses (50% BOF) exceeded both two and three way crosses in total lactation milk yield as expected, because it is universally accepted that higher level of heterosis is achieved in F_1 crosses. Although, similar heterotic effect is expected in 50% BOJ crosses, they were outsmarted due to Friesian blood, which is higher than Jersey blood (Cole and Ronning, 1974). Total lactation milk yield didn't show significant variation (P>0.05) between two and three way crosses, exotic blood levels and calving seasons. Absence of a difference in total milk yield (P>0.05) was similar to the findings reported by Sendros *et al*, (1978b) for two way crosses in which milk yield per annum at wetter stations was 1848±55 and 1749±52 liters for *Boran* Friesian and *Boram* Jersey crosses, respectively. However, three way crosses, 50 % Friesian crosses and cows that calved during the wet season numerically exceeded their counterparts most probably due to nutrition and feeding system. Cows that calved during the wet season, outweighed those calved during the dry season due to nutrition that has a marked effect on milk yield. On the other hand, animal factors such as breed, age, stage of lactation, parity and even milking frequency, have also been reported in other studies to affect milk production (Tekerli *et al,* 2000; Johnson et al, 2002). Cows with longer lactation length had better advantage to have more total milk yield than those with short lactation lengths.

In our study, parity had a marked effect on total milk yield, where milk yield steadily increased up to third parity and plateaud thereafter. Moges and Baars (1998) had reported similar findings earlier where milk yields plateaud after fourth parity. Total lactation milk yield variation due to parity in this study is also related to lactation length, where lactation lengths were shorter during first and fourth parities. Parity effects have been shown to exist on lactation curves (e.g. Wood, 1980; Collins, 1991; Friggens et al., 1999; Rekaya et al., 2001).

Average daily milk yield was not markedly affected by type of cross, exotic blood level and calving season. However, parity played significant role in daily milk yield. Average daily milk yield difference between 1st and 4th parity was 1 litre. Average daily milk yield for cows in fourth parity was higher due to shorter lactation length. Earlier reports had indicated average daily milk yield difference of 2.2 litres per day between first and fourth parity (Moges and Baars, 1998). It has also been reported that cows in fourth and more lactations were no longer better producers as compared to those in their third lactation (Epaphras *et al*, 2004). The older age may contribute to reduced milk production through turnover rate of secretory cells, with higher numbers dieing compared to the newly produced active secretory cells. Fat tissue cells usually replace dead secretory cells

(Epaphras *et al*, 2004). Therefore, total lactation milk yield followed similar trend in most of the exotic genotypes considered.

Conclusion

Introducing the third breed to utilize three ways crossing maintained heterosis in lactation length, total milk yield, and 305 days milk yield. Parity is an important factor in affecting lactation length, total milk yield, average daily milk yield and 305 days milk yield.

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