# Heterosis and Percent Improvement in Survivability, Reproduction and Production Performance of Various Genetic Groups of Temperate x Zebu Crosses in Tropics

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**ABSTRACT :** A study was conducted on 2102 records of 808 crossbred cows of various genetic groups maintained under "All India Coordinated Research Project on Cattle" at C C S Haryana Agricultural University, Hisar, over 25 years period (1968-1993) with an objective to assess and compare the amount of percent improvement and heterotic effect for different performance traits in various genetic groups produced under this programme. Survivability sharply and significantly declined from 1/2 to 3/4$^{th}$ bred and further from 3/4$^{th}$ to inter-se bred. This may be due to periodic and management differences in addition to the higher level of exotic inheritance and decreased heterotic effect over the filial generations. Jersey and Holstein Friesian crosses among 1/2 breds and their 50% inheritance among 3/4$^{th}$ and inter-se breds had highest improvement and heterosis in reproduction and production traits respectively. Among inter se bred genetic groups, BFH (I) had no recombination loss in SP and CI, while FJH (I), JFH (I) and FBH (I) had on recombination loss in AFC, LY, LL and PE. The crossbreeding of zebu cows with exotic breeds brings about spectacular improvement in comparison to the performance of zebu breed, while conventional selection over several generation would lead to only modest improvement. In addition to additive effect, there was sufficient heterosis in Jersey crosses for reproduction and Holstein Friesian crosses for production performance. Three breed crosses with exotic inheritance between 50 and 75 percent incorporating genes (25 to 50%) from both of these breeds is the best combination for stabilization. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 6 : 794-799)***

**Key Words** : Heterosis, Recombination Loss, Percent Improvement, Survivability, Reproduction, Production, Temperate x Zebu Crosses, Tropics

## INTRODUCTION

The major cattle breeding programmes for enhancing milk production in India were directed towards evolving the new cattle strains through cross breeding with superior exotic dairy breeds of temperate countries. In the process of evolving strains/breeds, a breeder has to keep in mind the agro-climatic suitability, choice of exotic breed, fraction of exotic inheritance, possibility of combining more than one exotic breed for getting additional advantage of heterosis, etc. In order to answer these questions, a systematic cross breeding programme entitled 'Behaviour Pattern of Zebu Crossbreds' was initiated with "All India Coordinated Research Project on Cattle" during the 4$^{th}$ Five Year Plan in 1968 by ICAR. This University was one of the centers with Hariana as Zebu breed and Holstein Friesian, Brown Swiss and Jersey as Exotic breeds. The first generation crosses were a success with first calving at a younger age, produced two to three times more milk, shorter calving interval, longer lactation and productive life than the native breed. Under this programme the 1/2 bred, 3/4$^{th}$ bred (two exotic breeds) and their inter-se crosses were produced. The present investigation was undertaken to assess and compare the amount of percent improvement and heterotic effect for different performance traits in various genetic groups produced under this programme.

## MATERIAL AND METHODS

Data on 2102 records of first three lactations of 808 crossbred cows of the various genetic groups were compiled from the "All India Coordinated Research Project on Cattle" at the Animal Breeding Farm, C C S Haryana Agricultural University, Hisar, India, over 25 years period from 1968 to 1993. The traits studied were survivability: (i) For different age groups of animals on the basis of the total number of animals available at initial age and (ii) Cumulative up to an age on the basis of total number of animals at birth, birth weight (BW), age at calving (AC), service period (SP), calving interval (CI), lactation yield (LY), lactation length (LL), dry period (DP) and lactation yield per day of calving interval (PE).

Most probable producing ability (MPPA) was calculated to compare the pooled effect of LY, CI and PE as below:

$$MPPA=HA+\frac{nr}{1+(n-1)r}(CA-HA)$$

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**Table1.** Genetic group, sire and dam group codes and number of cows included

| Sr. No. | Genetic group (GG) | Code | Sire's GG | Dam's GG | No. of cows |
|---|---|---|---|---|---|
| Half-bred groups | | | | | |
| 1 | 1/2F+1/2H | FH | F | H | 186 |
| 2 | 1/2B+1/2H | BH | B | H | 97 |
| 3 | 1/2J+1/2H | JH | J | H | 84 |
| Three fourth bred groups | | | | | |
| 4 | 1/2B+1/4B+1/4H | FBH | F | BH | 72 |
| 5 | 1/2B+1/4F+1/4H | FJH | B | FH | 70 |
| 6 | 1/2F+1/4J+1/4H | FJH | F | JH | 68 |
| 7 | 1/2J+1/4F+1/4H | JFH | J | FH | 74 |
| Inter-se bred groups | | | | | |
| 8 | 1/2F+1/2H ($F_2$) | FH (I) | FH | FH | 47 |
| 9 | 1/2F+1/4B+1/4H ($F_2$) | FBH (I) | FBH | FBH | 30 |
| 10 | 1/2B+1/4F+1/4H ($F_2$) | BFH (I) | BFH | BFH | 13 |
| 11 | 1/2F+1/4J+1/4H ($F_2$) | FJH (I) | FJH | FJH | 34 |
| 12 | 1/2J+1/4F+1/4H ($F_2$) | JFH (I) | JFH | JFH | 33 |

where, HA is the herd average,

CA is the cow average,

r is the repeatability of the trait estimated as intra-cow correlation.

n is the number of completed records.

Lactation records with lactation length less than 120 days and lactation yield less than 500 kg were excluded from the study. Records with incomplete lactation due to culling, mortality or abortion were also excluded.

The crossbred genetic groups (half-bred, two exotic breeds three fourth bred and their inter-se crosses) involving Hariana (H) as zebu breed and Holstein Friesian (F), Brown Swiss (B) and Jersey (J) as exotic breeds were compared for improvement over Hariana and their maternal breed/genetic group, heterotic effect and recombination loss for the various traits. The genetic group, sire and dam group code along with the number of cows in each genetic group are presented in table 1.

Percent Improvement over the maternal breed/genetic group and Hariana breed: were calculated as follows:

$$\frac{\text{CB-MG}}{\text{MG}} \times 100 \quad \text{and} \quad \frac{\text{CB-H}}{\text{H}} \times 100$$

Where, CB is least squares mean of crossbred genetic group, MG is least squares mean of maternal breed/genetic group, and H is weighted mean of Hariana breed.

Since, contemporary data on Hariana cows was not a vailable in the herd under study, averages for the various traits were calculated as weighted averages of the various reports on Hariana herd of Government Livestock Farm, Hisar. Average birth weight was 22.70 kg. The first lactation averages for age at calving, service period, calving interval, lactation yield, lactation length, dry period and production efficiency were 1,456.10, 211.05, 497.25 days, 1,247.61 kg, 271.44, 231.95 days and 2.49 kg/day, respectively. The corresponding averages for these traits were 1,976.35, 135.95, 419.23 days, 1,247.80 kg, 251.44, 162.66 days and 3.14 kg/day in the second lactation and 2,406.69, 88.67, 367.24 days, 1,188.92 kg, 236.96, 129.70 days and 3.38 kg/day in the third lactation.

Percent heterosis for first crosses and percent recombination loss for inter-se crosses: were calculated as

**Table 2.** Survivability (per cent) in different age groups and crossbred genetic groups

| Genetic groups | Age groups | | | | Cumulative | | |
|---|---|---|---|---|---|---|---|
| | 0-3 mo. | 3 mo.-1yr | 1yr-1st lact. | 1st-2nd lact. | Up to 1yr | Up to 1st lact. | Up to 2nd lact. |
| FH | 94.17 | 100.00 | 95.13 | 96.28 | 94.17 | 89.58 | 86.25 |
| BH | 90.00 | 99.07 | 91.59 | 95.92 | 89.16 | 81.66 | 78.33 |
| JH | 93.97 | 99.08 | 92.59 | 97.00 | 93.10 | 86.21 | 83.62 |
| FBH | 83.82 | 97.24 | 79.43 | 84.82 | 81.50 | 64.74 | 54.91 |
| BFH | 78.21 | 95.08 | 89.66 | 80.77 | 74.36 | 66.67 | 53.85 |
| FJH | 84.42 | 98.46 | 81.25 | 78.85 | 83.12 | 67.53 | 53.25 |
| JFH | 82.76 | 99.31 | 80.42 | 73.91 | 82.18 | 66.09 | 48.85 |
| FH (I) | 85.26 | 91.98 | 78.42 | 59.55 | 59.73 | 46.84 | 27.89 |
| FBH (I) | 81.34 | 89.91 | 77.55 | 64.47 | 73.13 | 56.72 | 36.57 |
| BFH (I) | 83.72 | 98.61 | 63.38 | 46.67 | 82.56 | 52.33 | 24.42 |
| FJH (I) | 81.25 | 94.87 | 75.68 | 73.21 | 77.08 | 58.33 | 42.71 |
| JFH (I) | 82.35 | 98.57 | 81.16 | 66.07 | 81.18 | 65.88 | 43.53 |

* H-Hariana, F-Holstein Friesisan, B-Brown Swiss, J-Jersey, I-Inter-se crosses.

**Table 3.** Lactation wise least squares means of reproduction and production traits for different genetic groups

| trait | Genetic group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FH | BH | JH | FBH | BFH | FJH | JFH | FH (I) | FBH (I) | BFH (I) | FJH (I) | JFH (I) |
| No. of Obs. | 186 | 97 | 84 | 72 | 70 | 68 | 74 | 47 | 30 | 13 | 34 | 33 |
| First lactation | | | | | | | | | | | | |
| BW | 25.88$^{e}$ | 26.47$^{e}$ | 21.22$^{b}$ | 28.22$^{b}$ | 29.59$^{a}$ | 24.45$^{de}$ | 24.06$^{de}$ | 24.48$^{cde}$ | 26.20$^{cd}$ | 27.40$^{abc}$ | 22.97$^{e}$ | 22.82$^{e}$ |
| AC | 953.02$^{cd}$ | 1022.69$^{ab}$ | 894.13$^{d}$ | 994.13$^{bc}$ | 1066.81$^{d}$ | 939.18$^{d}$ | 977.01$^{bc}$ | 1063.90$^{ab}$ | 1071.67$^{a}$ | 1135.03$^{a}$ | 1023.20$^{abc}$ | 1026.10$^{abc}$ |
| SP | 14.92$^{cd}$ | 129.10$^{d}$ | 117.90$^{d}$ | 202.45$^{ab}$ | 218.14$^{a}$ | 182.68$^{ab}$ | 169.59$^{bc}$ | 209.59$^{ab}$ | 191.20$^{ab}$ | 139.68$^{cd}$ | 192.83$^{ab}$ | 165.93$^{bcd}$ |
| CI | 422.6$^{cd}$ | 412.66$^{d}$ | 402.99$^{d}$ | 486.16$^{ab}$ | 502.07$^{a}$ | 465.55$^{ab}$ | 449.24$^{bc}$ | 484.47$^{ab}$ | 452.64$^{abc}$ | 399.26$^{d}$ | 471.38$^{ab}$ | 440.93$^{bcd}$ |
| LY | 2628.09$^{a}$ | 2146.66$^{cd}$ | 2018.01$^{d}$ | 2630.00$^{a}$ | 2618.45$^{ab}$ | 2610.71$^{ab}$ | 2380.97$^{b}$ | 2660.68$^{ab}$ | 2678.71$^{ab}$ | 2422.25$^{bc}$ | 2650.62$^{ab}$ | 2548.32$^{ab}$ |
| LL | 326.27$^{b}$ | 306.10$^{c}$ | 302.13$^{c}$ | 349.86$^{a}$ | 363.56$^{a}$ | 335.78$^{ab}$ | 311.53$^{c}$ | 373.02$^{ab}$ | 344.49$^{ab}$ | 313.63$^{bc}$ | 356.51$^{ab}$ | 346.59$^{abc}$ |
| DP | 104.26 | 110.45 | 102.23 | 103.19 | 137.22 | 127.32 | 137.97 | 110.67 | 106.17 | 8369 | 111.26 | 90.58 |
| PE | 6.13b | 4.80$^{cd}$ | 4.45$^{d}$ | 4.83$^{cd}$ | 4.79$^{cd}$ | 5.41$^{bcd}$ | 5.07$^{cd}$ | 7.00$^{ab}$ | 6.66$^{abc}$ | 5.74$^{bcd}$ | 8.74$^{a}$ | 6.27$^{bc}$ |
| Second lactation | | | | | | | | | | | | |
| AC | 1485.62 | 1519.29 | 1386.52 | 1517.55 | 1602.31 | 1424.15 | 1419.82 | 1502.83 | 1458.27 | 1566.21 | 1466.19 | 1413.05 |
| SP | 151.19$^{bc}$ | 149.55$^{bc}$ | 122.53$^{c}$ | 158.69$^{abc}$ | 199.28$^{a}$ | 174.75$^{ab}$ | 180.53$^{ab}$ | 143.40$^{bc}$ | 161.12$^{abc}$ | 154.06$^{abc}$ | 175.50$^{abc}$ | 157.26$^{abc}$ |
| CI | 423.05$^{bc}$ | 424.54$^{bc}$ | 399.99$^{bc}$ | 431.57$^{bc}$ | 476.28$^{a}$ | 451.06$^{ab}$ | 459.99$^{ab}$ | 427.16$^{bc}$ | 458.72$^{ab}$ | 432.96$^{abc}$ | 452.76$^{abc}$ | 424.46$^{abc}$ |
| LY | 2772.61$^{ab}$ | 2363.70$^{d}$ | 2159.25$^{e}$ | 2880.79$^{a}$ | 2856.38$^{a}$ | 2939.74$^{a}$ | 2573.72$^{cd}$ | 2625.20$^{bc}$ | 2736.73$^{ab}$ | 2818.71$^{abc}$ | 2774.29$^{ab}$ | 2677.90$^{bcd}$ |
| LL | 309.06$^{d}$ | 302.26$^{d}$ | 333.86$^{c}$ | 36.66$^{b}$ | 352.42$^{bc}$ | 340.48$^{bc}$ | 334.80$^{bc}$ | 336.14$^{bc}$ | 357.57$^{bc}$ | 342.59$^{bcd}$ | 341.38$^{bc}$ | 464.03$^{a}$ |
| DP | 118.56 | 131.23 | 114.73 | 115.35 | 129.38 | 117.28 | 126.06 | 110.42 | 133.25 | 84.52 | 125.40 | 99.37 |
| PE | 7.12 | 5.95 | 5.90 | 7.28 | 6.65 | 7.00 | 6.26 | 6.86 | 6.61 | 7.09 | 6.74 | 6.99 |
| Third lactation | | | | | | | | | | | | |
| AC | 1826.20$^{cd}$ | 1887.37$^{bc}$ | 1721.20$^{e}$ | 1947.58$^{ab}$ | 2030.00$^{a}$ | 1861.47$^{bc}$ | 1901.19$^{bc}$ | 1919.99$^{abcd}$ | 1969.26$^{ab}$ | 2074.8$^{ab}$ | 1893.50$^{bcd}$ | 1795.62$^{de}$ |
| SP | 144.55 | 127.32 | 125.24 | 147.58 | 140.79 | 132.05 | 123.86 | 104.24 | 119.59 | 80.24 | 118.60 | 106.66 |
| CI | 421.37 | 410.79$^{cd}$ | 408.48 | 424.20 | 418.29 | 408.48 | 399.51 | 403.81 | 403.15 | 359.42 | 402.10 | 397.81 |
| LY | 3123.66$^{a}$ | 2628.93 | 2414.08$^{cd}$ | 2934.50$^{bc}$ | 2666.54$^{bc}$ | 2829.04$^{bc}$ | 2636.06$^{bc}$ | 2597.3$^{c}$ | 2765.07$^{abc}$ | 2249.79$^{d}$ | 2875.65$^{abc}$ | 2582.46$^{cd}$ |
| LL | 324.87 | 303.78 | 306.08 | 328.54 | 316.42 | 326.73 | 316.46 | 313.27 | 325.57 | 264.19 | 319.17 | 311.21 |
| DP | 95.81 | 103.09 | 102.89 | 99.33 | 103.38 | 77.73 | 78.44 | 84.55 | 77.06 | 82.37 | 102.29 | 77.78 |
| PE | 7.47$^{a}$ | 6.47$^{bc}$ | 5.91$^{c}$ | 6.95$^{ab}$ | 6.47$^{bc}$ | 7.08$^{ab}$ | 6.71$^{b}$ | 6.86$^{ab}$ | 7.21$^{ab}$ | 6.51$^{abc}$ | 7.41$^{ab}$ | 6.60$^{abc}$ |

* H-Hariana, F-Holstein Friesisan, B-Brown Swiss, J-Jersey, I-Inter-se crosses.
Row-wise means bearing different superscripts differd significantaly ($p<0.005$) from each other.

follows:

$$\frac{\text{CB-MG}}{\text{MG}} \times 100$$

Where MP is the average of the least squares means of the two parental breeds/genetic groups as mid-parental least squares mean.

The least squares means were estimated by Harvey (1979) model for fitting constants with disproportionate sub-class frequencies incorporating genetic group, period, season and period x season interaction as fixed effects. Duncan's Multiple Range Test with Kramer (1957) modification was applied for pair means comparison. The genetic group comparison for Survivability was conducted using contingency Chi-square test.

## RESULTS AND DISCUSSION

### Survivability

Survivability (percent) for different age groups and crossbred genetic groups is presented in table 2. Among 1/2 bred genetic groups, FH had the highest survivability in general in all the age groups followed closely by JH and BH respectively. However, the differences among 1/2 bred genetic groups were also statistically non-significant ($p<0.05$). Similarly, the genetic group differences within 3/4$^{th}$ bred and inter se bred were also statistically non-significant, while no definite trend over the genetic groups was observed. Survivability sharply and significantly ($p<0.05$) declined from 1/2 to 3/4$^{th}$ bred and further from 3/4$^{th}$ to inter-se bred. This may be due to periodic and management differences in addition to the higher level of exotic inheritance and decreased heterotic effect over the filial generations. The perusal of the results indicated that the 1/2 bred had the higher survivability rate than 3/4$^{th}$ and inter se bred for and up to all ages. The survivability pattern up to completion of second lactation showed that more number of the 1/2 bred cows was retained for longer time in the herd as compared to the 3/4$^{th}$ and inter se bred. Cows completing the 2$^{nd}$ lactation in the inter-se genetic groups were fewer indicating a higher rate of culling or disposal from the herd because of poor performance of these genetic groups. In conformity to the present results, Taneja and Bhat (1989) observed that the higher grades of crossbreds did not show any further improvement in

**Table 4.** Percent improvement in different crossbred genetic groups performance over Hariana breed

| Genetic group trait | FH | BH | JH | FBH | BFH | FJH | JFH | FH (I) | FBH (I) | BFH (I) | FJH (I) | JFH (I) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| First lactation | | | | | | | | | | | | |
| Birth weight (BW) | +14.0 | +16.6 | -6.5 | +24.3 | +30.4 | +7.7 | +6.0 | +7.8 | +15.4 | +20.7 | +1.2 | +0.5 |
| Age at Calving (AC) | -34.6 | -29.8 | -38.6 | -31.7 | -26.7 | -35.5 | -32.9 | -27.1 | -26.4 | -22.1 | -29.7 | -29.5 |
| Service period (SP) | -33.2 | -38.3 | -44.1 | -4.1 | +3.4 | -13.5 | -19.7 | -0.7 | -9.4 | -33.8 | -8.6 | -21.4 |
| Calving interval (CI) | -15.0 | -17.0 | -19.0 | -2.2 | +1.0 | -6.4 | -9.6 | -2.6 | -9.0 | -19.7 | -5.2 | -11.3 |
| Lactation yield (LY) | +110.6 | +72.0 | +61.8 | +110.8 | +109.9 | +109.3 | +90.8 | +113.3 | +114.7 | +94.2 | +112.5 | +104.3 |
| Lactation length (LL) | +20.2 | +12.8 | +11.3 | +28.9 | +34.0 | +23.7 | +14.8 | +37.5 | +26.9 | +15.6 | +31.4 | +27.7 |
| Dry period (DP) | -55.1 | -52.4 | -55.9 | -43.9 | -40.8 | -45.1 | -40.5 | -52.3 | -54.3 | -63.9 | -52.0 | -61.0 |
| LL/CI (PE) | +146.2 | +92.8 | +78.7 | +94.0 | +92.4 | +117.3 | +103.6 | +181.1 | 167.5 | +130.5 | +251.0 | +151.8 |
| Second lactation | | | | | | | | | | | | |
| AC | -24.8 | -23.1 | -29.8 | -23.2 | -18.9 | -27.9 | -28.2 | -24.0 | -26.2 | -20.8 | -25.8 | -28.5 |
| SP | +11.2 | +10.0 | -9.9 | +16.7 | +46.6 | +28.6 | +32.8 | +5.5 | +18.5 | +13.3 | +29.1 | +15.7 |
| CI | +0.9 | +1.3 | -4.6 | +2.9 | +13.6 | +7.6 | +9.7 | +1.9 | +9.4 | +3.3 | +8.0 | +1.3 |
| LY | +122.2 | +89.4 | +73.1 | +130.9 | +128.9 | +135.6 | +104.8 | +110.4 | +119.3 | +125.9 | +122.4 | +114.6 |
| LL | +22.8 | +20.1 | +32.6 | +43.3 | +40.0 | +35.3 | +33.0 | +33.5 | +42.0 | +36.1 | +35.6 | +84.3 |
| DP | -27.1 | -19.3 | -29.5 | -29.1 | -20.4 | -27.9 | -22.5 | -32.1 | -18.1 | -48.0 | -22.9 | -38.9 |
| PE | +126.8 | +89.5 | +87.9 | +131.8 | +111.8 | +122.9 | +99.4 | +112.7 | +110.5 | +125.8 | +114.6 | +122.6 |
| Third lactation | | | | | | | | | | | | |
| AC | -24.4 | -21.9 | -28.8 | -19.4 | -16.0 | -23.0 | -21.3 | -20.5 | -18.5 | -14.1 | -21.6 | -25.7 |
| SP | +63.0 | +43.6 | +41.2 | +66.4 | +58.8 | +48.9 | +39.7 | +17.6 | +34.9 | -9.5 | +33.7 | +20.3 |
| CI | +14.7 | +11.9 | +11.2 | +15.5 | +14.2 | +11.2 | +8.8 | +10.0 | +10.0 | +2.1 | +9.5 | +8.3 |
| LY | +162.7 | +121.1 | +103.1 | +146.8 | +124.3 | 138.0 | +121.7 | +118.5 | +132.6 | +89.2 | +141.9 | +117.2 |
| LL | +37.1 | +28.2 | +29.2 | +38.7 | +33.5 | +37.9 | +33.6 | +32.2 | +37.4 | +11.5 | +34.7 | +31.3 |
| DP | -26.1 | -20.5 | -20.7 | -23.4 | -20.3 | -40.1 | -39.5 | -34.8 | -40.6 | -36.5 | -21.1 | -40.0 |
| PE | +121.0 | +91.4 | +74.9 | +105.6 | +91.4 | +109.5 | +98.5 | +103.0 | +113.3 | +92.6 | +119.2 | +95.3 |

* H-Hariana. F-Holstein Friesisan. B-Brown Swiss. J-Jersey. I-Inter-se crosses.

mortality. Touchberry (1992) reported that the Holstein and Guernsey crossbreds were much superior in survivability to that of Guernsey and survivability increased with increase of 1/8 in heterozygosity in crossbreds than purebreds, former having a higher survival rate (15.6%).

**Reproduction and production traits**

Table 3 depicts the least squares means of birth weight, reproduction and production traits over the first three lactations for different genetic groups. The genetic group differences were significant ($p<0.05$) for all the traits except DP in first lactation; AC, DP and PE in second lactation; and, SP, CI, LL and DP in the third lactation. Comparison among the half breds showed that, the Jersey cross had better reproduction in terms of shorter AFC, SP and CI, while for the production traits, the Friesian crosses were superior. Among the 3/4$^{th}$ breds, the FJH and JFH groups were superior for reproduction while, FBH and BFH groups were superior for production performance. Among inter-se crosses, JFH (I) had the lowest AC, BFH (I) the lowest SP and CI and FJH (I) and FBH (I) groups had higher LY and PE in the three lactations.

**Percent improvement**

Percent improvement in performance of different crossbred genetic groups over Hariana breed and the maternal breed/genetic group is presented in Table 4 and 5 respectively. Perusal of the percent improvement over Hariana zebu breed for the various performance traits showed that among the 1/2 bred genetic groups, JH crosses had the highest improvement in reproduction traits i. e. AC (-38.6 to -28.8), SP (-44.1 to -9.86) and CI (-19.0 to -4.6), except SP and CI in 3$^{rd}$ lactation and FH crosses had the highest improvement in the production traits i. e. LY (+162.7 to +110.7), LL (+37.1 to +20.2), DP (-55.1 to -

**Table 5.** Percent improvement in different crossbred genetic groups performance over their maternal breed/ genetic group

| Genetic group<br>Trait | FBH | BFH | FJH | JFH | FH (I) | FBH (I) | BFH (I) | FJH (I) | JFH (I) |
|---|---|---|---|---|---|---|---|---|---|
| First lactation | | | | | | | | | |
| Birth weight (BW) | +6.6 | +14.3 | +15.2 | -7.0 | -5.4 | -7.2 | -7.4 | -6.1 | -5.2 |
| Age at calving (AC) | -2.8 | +11.9 | +5.8 | +2.5 | +11.4 | +7.8 | +6.4 | +9.0 | +5.0 |
| Service period (SP) | +56.8 | +54.8 | +54.9 | +20.3 | +48.7 | -5.6 | -36.0 | +5.6 | -2.2 |
| Calving interval (CI) | +17.8 | +18.8 | +15.5 | +6.3 | +14.6 | -6.9 | -20.5 | +1.3 | -1.9 |
| Lactation yield (LY) | +22.5 | -0.4 | +29.4 | -9.4 | +1.2 | +1.9 | -7.5 | +1.5 | +7.0 |
| Lactation length (LL) | +14.3 | +11.4 | +11.1 | -4.5 | +14.3 | -1.5 | -13.7 | +6.2 | +11.3 |
| Dry period (DP) | +17.9 | +31.6 | +24.5 | +32.3 | +6.2 | -18.5 | -39.0 | -12.6 | -34.4 |
| LL/CI (PE) | +0.6 | -21.9 | +21.6 | -17.3 | +14.2 | +37.9 | +19.8 | +61.6 | -23.7 |
| Second lactation | | | | | | | | | |
| AC | -0.1 | +7.9 | +2.7 | -4.4 | +1.2 | -3.9 | -2.3 | +3.0 | -0.5 |
| SP | +6.1 | +31.8 | +42.6 | +19.4 | -5.2 | +1.5 | -22.7 | +0.4 | -12.9 |
| CI | +1.7 | +12.6 | +8.7 | +9.7 | +6.3 | -9.1 | +0.4 | -7.7 | |
| LY | +21.9 | +3.0 | +36.1 | -7.9 | -5.3 | -5.0 | -1.3 | -5.6 | +4.9 |
| LL | +19.3 | +14.0 | +2.0 | +8.3 | +8.8 | -0.9 | -2.8 | +0.3 | +38.6 |
| DP | +12.1 | +9.1 | +2.2 | +6.3 | -6.9 | +15.5 | -34.7 | +6.9 | -21.2 |
| PE | +22.4 | -6.6 | +18.6 | -12.1 | -6.2 | -9.2 | +6.6 | -3.7 | +11.7 |
| Third lactation | | | | | | | | | |
| AC | +3.2 | +11.2 | +8.2 | +4.1 | +5.1 | +1.1 | +2.2 | +1.7 | -5.6 |
| SP | +15.9 | -2.6 | +5.4 | -14.3 | -27.9 | -19.0 | -43.0 | -10.2 | -13.9 |
| CI | +3.3 | -0.5 | 0.0 | -5.2 | -4.2 | -5.0 | -14.3 | -1.6 | -0.4 |
| LY | +11.6 | -14.6 | +17.2 | -15.6 | -16.9 | -5.8 | -15.6 | +1.7 | -2.0 |
| LL | +8.2 | -2.6 | +6.8 | -2.6 | -3.6 | -0.9 | -16.5 | -2.3 | -1.7 |
| DP | -3.7 | +7.9 | -24.5 | -18.1 | -11.8 | -22.4 | -20.3 | +31.6 | -0.8 |
| PE | +7.4 | -13.4 | +19.8 | -10.2 | -8.2 | +3.7 | +0.6 | +4.7 | -1.6 |
| Most probable producing ability (MPPA) | | | | | | | | | |
| CI | +6.9 | -7.2 | +17.0 | -11.9 | -13.8 | -1.7 | -1.7 | -0.7 | +3.8 |
| LY | +2.5 | +2.5 | +2.3 | +0.5 | -0.5 | -2.1 | -3.8 | -1.0 | -1.2 |
| PE | +0.6 | -6.5 | +4.4 | -6.4 | -6.7 | +1.1 | +0.9 | +1.4 | +3.1 |

* H-Hariana, F-Holstein Friesisan, B-Brown Swiss, J-Jersey, I-Inter-se crosses.

26.1) and PE (+146.2 to +121.0) in all the three lactations. Among 3/4$^{th}$ and inter-se bred genetic groups, FJH and JFH had the highest improvement in the reproduction traits as compared to other genetic groups. For birth weight BFH and BFH (I) performed the best. For production traits, the FBH, FJH and their inter-se crosses performed higher than other genetic groups (Table 4). Similar trends over the genetic groups were also obtained for the various performance traits on the basis of percent improvement over the maternal breed/GG. However, the improvement was comparatively lesser obviously because the maternal groups were of one or the other crossbred genetic group already having attained the benefit of cross breeding.

The percent improvement over the maternal GG for MPPA (table 5) showed that MPPA of LY and PE was highest in FJH among the 3/4$^{th}$ bred and in JFH (I) among inter se bred genetic groups. MPPA for CI slightly increased in all 3/4$^{th}$ bred, while slightly decreased in all the inter se bred genetic groups.

It may be inferred from the present results that introduction of Holstein Friesian and Jersey inheritance both to the level of 25 to 50 % in crossbreds is desirable to improve production and reproduction traits respectively. In conformity to the present results Deshpande and Sakhare (1989) also reported that there was a distinct improvement in the performance of Jersey x Red Kandhari 1/2 bred over zebu. The percent improvement obtained was -4.8, -29.4, -11.1, 323.9, 26.6, -54.9 and 381.4 in BW, SP, CI, LY, LL, DP and PE respectively.

*Heterosis and Recombination Loss* : Heterosis (percent) in first lactation traits for different first crosses genetic groups and the recombination loss in inter-se crosses is presented in table 6. It was in desirable direction for all the genetic groups for AC (-25.1 to -5.2), LY (+20.0 to +3.5), LL (+25.8 to +0.5) and DP (-45.7 to –9.7), except for LY in BH (-2.1), while for SP, CI and PE the trend was irregular. Among 1/2 bred genetic groups, JH showed the highest negative heterosis in AFC, SP, CI and DP, which was in the desired direction. The FH had the highest positive heterosis for production traits. Among 3/4$^{th}$ bred genetic groups, FJH had higher heterosis for reproduction as well as in production traits. Among inter se bred genetic groups, BFH (I) had no recombination loss in SP and CI, while there was considerable recombination loss in other genetic groups for these traits. There was no

6. Heterosis/recombination loss (percent) in first lactation traits for different crossbred genetic groups

| Genetic group | Heterosis | | | | | | | Recombination Loss | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trait | FH | BH | JH | FBH | BFH | FJH | JFH | FH (I) | FBH (I) | BFH (I) | FJH (I) | JFH (I) |
| Age at Calving | -19.2 | -15.9 | -25.1 | -17.0 | -10.9 | -20.8 | -17.6 | -10.0 | -10.5 | -5.2 | -13.7 | -13.5 |
| Service period | -18.1 | -19.8 | -23.9 | +21.6 | +31.0 | +11.7 | +3.7 | +21.9 | +14.8 | -16.1 | +17.9 | +1.5 |
| Calving interval | -5.6 | -8.4 | -9.6 | +8.3 | +11.8 | +4.2 | +0.6 | +8.3 | +0.8 | -11.1 | +5.5 | -1.3 |
| Lactation yield | +5.6 | -2.1 | +4.6 | +12.4 | +11.9 | +18.2 | +7.8 | +6.9 | +14.4 | +3.5 | -20.0 | +15.4 |
| Lactation length | +10.0 | +4.8 | +0.5 | -18.9 | +23.6 | +12.5 | +4.4 | +25.8 | +17.1 | +6.6 | +19.4 | +16.1 |
| Dry period | -30.3 | -30.3 | -34.5 | -15.5 | -10.9 | -16.7 | -9.7 | -26.0 | -31.1 | -45.7 | -27.2 | -40.7 |
| Production efficiency | +3.4 | -6.4 | -2.2 | -12.7 | -13.4 | +3.2 | -3.2 | +18.0 | +20.4 | +3.8 | +66.8 | +19.7 |

* H-Hariana. F-Holstein Friesisan. B-Brown Swiss. J-Jersey. I-Inter-se crosses.

recombination loss in FJH (I). JFH (I) and FBH (I) genetic groups for AFC. LY. LL and PE. It may be inferred from the present results that introduction of Holstein Friesian and Jersey inheritance both to the level of 25 to 50% in crossbreds is desirable to utilize the heterotic effect for production and reproduction traits respectively. Martinez et al. (1988) reported that replacement of pure zebu by Holstein Friesian genes reduced the AFC by 6 month and CI by 37 days. while in $F_1$ this heterotic effect was obtained as 2 month and 39 days respectively. Sharma and Pirchner (1991) obtained 29 and 8% heterosis for AFC and CI respectively. Roy and Tomar (1989) observed desirable heterotic effect for first LY. LL and PE in crossbreds of Holstein Friesian and Jersey with Sahiwal.

while it was non-significant for DP. Sharma and Pirchner also obtained desirable heterotic effect for the milk yield. For birth weight. BH and FH had improvement (+16.6 and +14.0), while there was a decline in JH (-6.5).

It may be inferred from the forgoing discussion that the crossbreeding of zebu cows with exotic breeds brings about spectacular improvement in comparison to the performance of zebu breed. while conventional selection over several generation would lead to only modest improvement. In addition to additive effect. there was sufficient heterosis in Jersey crosses for reproduction and Holstein Friesian crosses for production performance. Three breed crosses with exotic inheritance between 50 and 75 percent incorporating genes (25 to 50%) from both of these breeds is the best combination for stabilization.

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