CROSSBREEDING EFFECTS IN FRIESIAN, JERSEY AND SAHIWAL CROSSES IN PAKISTAN

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ABSTRACT

Data on 4023 lactation records on purebred Sahiwal cows and 2391 lactation records of Holstein Friesian X Sahiwal (FS) and Jersey X Sahiwal (JS) crossbreds from Livestock Production Research Institute (LPRI) Bahadurnagar, District Okara and Qadirabad District Sahiwal for the period 1973-1995, in Punjab, Pakistan were analysed. Crossbreeding effects were studied for production and reproduction traits: lactation milk yield (LMY), calving interval (CI), milk yield per day of calving interval (MCI), days open and days dry. Heterosis effects were significant (P<.01) and in a favourable direction for all production and fertility traits in all groups. Compared with the mid-parent mean, the F1 would increase LMY by 31% in FS and by 41% in JS crosses. The MCI would be increased in these crosses, by 49% and 51%, respectively. For reproduction traits there was a decrease in days open: 35 and 60%; days dry: 41 and 72% and CI: 15 and 20% for FS and JS crosses, respectively. Heterosis effects were larger than breed additive effects. Additive breed effects for FS crosses were larger than for JS crosses, and FS crossbreds were superior to JS crossbreds in LMY and MCI. The recombination effects were found significant (P < .01) for most of the traits in this study.

Keywords: Bos indicus, Bos taurus, Crossbreeding, Heterosis, Recombination loss.

INTRODUCTION

The Sahiwal breed is considered more productive among indigenous species (Khan et al. 1992). The improvement in genetic potential through within breed selection is very slow. Van Vleck et al. (1986) reported that efficient breeding programme even under optimal conditions in temperate areas may produce changes in genetic merit for milk from 1 to 2 per cent per year. Such rates are insufficient to improve production from indigenous breeds for a fast growing human population in the country. A possible solution is crossbreeding by combining the desired characteristics of two species; milk production from Bos taurus (BT) and adaptability from Bos indicus (BI: indigenous) cattle. For developing a dairy programme in Pakistan, Sahiwal local cattle could be used for crossbreeding with Bos taurus (BT: Friesian or Jersey) breeds. Cunningham and Syrstad (1987) noted that the improvement in genetic potential in BT X BI crossbreeding could be equal to 100 years of selection. The present investigation was undertaken to calculate the crossbreeding effects in Friesian X Sahiwal and Jersey X Sahiwal crosses in Pakistan. These parameters would be needed to predict the possible improvement made in crossbreds with respect to various production, reproduction and fitness traits and would help to assess the potential for crossbreeding programmes.

MATERIALS AND METHODS

The data set included 4023 lactation records (parity 1 to 5) on 1172 purebred Sahiwal cows, 2182 lactation records on 748 Friesian crossbreds and 209 records on 76 Jersey crossbreds for the period 1973-1995, from LPRI Bahadurnagar and Qadirabad in Punjab, Pakistan. Five economically important traits: lactation milk yield (LMY), calving interval (CI), milk yield per day of calving interval (MCI), days open and days dry were included in this study. Data were split in two sets, one for Sahiwal and its crossbreds with Holstein Friesian (FS) and another for Sahiwal and its crossbreds with Jersey (JS). Two models were compared: a regression model where additive breed, heterosis and epistatic (recombination loss) effects were fitted as regression coefficients, and a breed group model. The term heterosis is defined as the superiority of the crossbreed individual over the means of its parents, whereas recombination is defined as deviation from linear
relation of performance with heterosis, such that the coefficient of recombination describes the average fraction of independently segregating pairs of loci in gametes from both parents which are expected to be non-parental combinations. Fixed effects of herd-year-season, parity, and calving age within parity were common in both models. These models were fitted using ASREML (Gilmour and Thompson, 1998).

In mathematically terms the regrssion model is written as under:

\[ y_{ijkl} = \mu + h y_s + p a r i t y_j + b_i a g e(p a r i t y)_k + b_2 a_i + b_3 a_2 + b_4 h_{13} + b_5 h_{23} + b_6 r_{13} + b_7 r_{23} + c_{ijkl} \]

Where,

- \( \mu \) = Overall population mean,
- \( h y_s \) = 1th herd-year-season interaction,
- \( p a r i t y_j \) = 1th parity,
- \( age(p a r i t y)_k \) = Calving age within parity,
- \( b_1 \) = Regression coefficient of age at calving within parity,
- \( b_2 \) = Additive genetic effect of Friesian breed (relative to Sahiwal),
- \( b_3 \) = Additive genetic effect of Jersey breed (relative to Sahiwal),
- \( b_4 \) = Heterotic effect of F1 cross Friesian and Sahiwal breeds,
- \( b_5 \) = Heterotic effect of F1 cross Jersey and Sahiwal breeds,
- \( b_6 \) = Epistatic effect of F1 cross Friesian and Sahiwal breeds,
- \( b_7 \) = Epistatic effect of F1 cross Jersey and Sahiwal breeds,

\( A_1, A_2 \) = Breed coefficients of the trait (calculated as percentage of genes from fiesian and Jersey breeds).

\( H_{13}, H_{23} \) = Heterotic coefficients of the trait (calculated as percentage of heterozygous loci as \( b_{ij} \)).

\( R_{13}, R_{23} \) = Recombination coefficients of the trait as \( b_{ij} \).

The breed group in mathematically terms can be written as under:

\[ y_{ijkl} = \mu + h y_s + p a r i t y_j + b g + b_2 a_i + b_3 a_2 + b_4 h_{13} + b_5 h_{23} + b_6 r_{13} + b_7 r_{23} + c_{ijkl} \]

All the other terms are already explained except \( b g \) = Breed groups. The breed group representation is given in Table 1.

**RESULTS**

Heterosis effects were significant (\( P < .01 \)) for all traits of Sahiwal and Jersey crosses with Friesian and Jersey (Table 2). Additive genetic differences between Sahiwal and Jersey were not significant for any of the traits but between Holstein and Sahiwal they were significant for most of the traits. Generally, heterosis effects were larger than breed differences, especially for Jersey crosses. The effects of recombination was also significant for both crosses except for production traits in JS crosses (Table 2). The regression model and the breed group model were compared for MCI having the highest level of heterosis (49 %) in Friesian crosses. The predicted least squares means for this trait in Friesian crosses from both models is given in Fig. 1. This figure shows that predicted means for both models were reasonably similar.

Differences with the least square estimates obtained from breed group model were larger for Jersey (Fig. 2). An explanation is that breed group estimates from the regression model were inaccurate due to the fact that regression coefficients in Jersey crossbreds had very high standard errors and some genetic groups had a small number of observations. Least squares means indicate that almost all crossbreds were superior to Sahiwal for having shorter CI, less days dry and days open. MCI was also improved in all the crossbreds. LMY was better in crosses having 
\( \geq 50 \% \) BT in case of FS crosses. In case of JS crosses there was an improvement in LMY only in F1 crosses. FS crosses were superior to JS crosses for production and MCI but JS were better for reproduction traits.

**DISCUSSION**

In our study, heterosis effects were larger than additive breed effects, indicating that a 50 % composite breed would outperform purebred Friesians. This might be typical for harsh tropical environments. Martinez et al. (1988) reported higher estimates for the additive genetic than for the heterosis effects in farms where management practices appeared to support higher level of production (>2800kg/lactation). The substantial milk depression observed in the F1 relative to F, (indicated as recombination) has been well documented by others (McDowell, 1985 and Syrrstad, 1989). Syrrstad (1989) attributes this decline to a reduction in the epistatic effects. An F2 cross would retain only 50 % of the heterosis and have an additional loss due to recombination effects. Significant recombination effects would have a negative effects on composites. However, such losses might be recovered by a selection program within the composite. Talbott et al. (1994) also studied additive and heterosis effects for Friesian X Sahiwal and Jersey X Sahiwal crossbred cattle (with different model and data set) in Punjab, Pakistan. Their study showed lower estimates for additive effects in some traits in both crossbreds but their estimates for
Table 1: Different breed groups and their non-additive genetic effects

<table>
<thead>
<tr>
<th>Breed groups</th>
<th>% BT*</th>
<th>Percent heterosis</th>
<th>Percent Recomb</th>
<th>No. of records Friesian x Sahiwal</th>
<th>No. of records Jersey x Sahiwal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>75</td>
<td>50</td>
<td>25</td>
<td>61</td>
<td>21</td>
</tr>
<tr>
<td>5/8</td>
<td>62.5</td>
<td>50</td>
<td>44</td>
<td>113</td>
<td>8</td>
</tr>
<tr>
<td>F1</td>
<td>50</td>
<td>100</td>
<td>0</td>
<td>934</td>
<td>138</td>
</tr>
<tr>
<td>F2</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>465</td>
<td>12</td>
</tr>
<tr>
<td>F3</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>F4</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>3/8</td>
<td>37.5</td>
<td>50</td>
<td>44</td>
<td>43</td>
<td>5</td>
</tr>
<tr>
<td>1/4</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>91</td>
<td>25</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4023</td>
<td>4023</td>
</tr>
</tbody>
</table>

* BT = Bos taurus (Friesian or Jersey breeds).

Table 2: Additive and non-additive breed effects for Friesian X Sahiwal and Jersey X Sahiwal crosses

<table>
<thead>
<tr>
<th>Trait</th>
<th>Sahiwal Means</th>
<th>Estimates + Standard error</th>
<th>Friesian X Sahiwal Crosses</th>
<th>Jersey X Sahiwal Crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMY (kg)</td>
<td>1770</td>
<td>783.0 ± 200.0***</td>
<td>670.0 ± 110.0***</td>
<td>650.0 ± 143.0**</td>
</tr>
<tr>
<td>CI (days)</td>
<td>482</td>
<td>32.3 ± 24.0</td>
<td>-78.9 ± 11.4**</td>
<td>-93.7 ± 10.7**</td>
</tr>
<tr>
<td>MCI (kg)</td>
<td>3.94</td>
<td>1.52 ± 0.48**</td>
<td>2.32 ± 0.26**</td>
<td>-0.46 ± 0.35**</td>
</tr>
<tr>
<td>Days open</td>
<td>196</td>
<td>60.7 ± 25.8*</td>
<td>-80.4 ± 14.0**</td>
<td>-98.1 ± 19.3**</td>
</tr>
<tr>
<td>Days dry</td>
<td>209</td>
<td>11.4 ± 26.4</td>
<td>-88.0 ± 14.2*</td>
<td>-80.4 ± 19.5**</td>
</tr>
</tbody>
</table>

** P < .01  * P < .05

Fig. 1: Comparison of two models for prediction of MCI in Friesian crossbreds
CONCLUSIONS

This study emphasises the importance of developing a breeding strategy that maintains a high level of heterosis to maximise both milk production and fitness in sub tropical environment of Pakistan, where inputs are limited. Heterosis effects were significant and in a favourable direction for all traits, whereas additive effects from Bos Taurus were smaller. Continuously producing F1 crosses is practically not optimal because producers have to constantly rely on external sources to purchase replacements. The development of two breed composite, for example a Friesian-Sahiwal composite, may be a more practical way for improvement of dairy stock in the country. Feasibility of such an endeavour under resource poor small farmer set up and consideration of indigenous genetic resources would require further studies.

REFERENCES


