



Sire evaluation based on predicted first lactation 305-day milk yield using monthly test day milk yield values of Karan Fries cattle

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ABSTRACT

The present investigation was carried out using data of first lactation monthly (MTDY) test day milk yield records of 1345 Karan Fries cows sired by 84 bulls from 1984–2006 maintained at the NDRI, Karnal. The breeding values of Karan Fries sires were estimated for predicted first lactation 305-day by step-wise backward multiple regression using monthly test day milk yields. The breeding values were estimated by 4 methods, viz. least squares method (LSQ), simple regressed least squares method (SRLS), contemporary comparison method (CC) and best linear unbiased prediction (BLUP). The effectiveness of LSQ, SRLS and BLUP methods of sire evaluation was compared on the basis of rank correlations, error variance, coefficients of determination (R^2) and coefficients of variation (CV). The rank correlation for LSQ with SRLS (0.92–0.99) was highest followed by LSQ with BLUP (0.89–0.91) and SRLS with BLUP (0.81–0.91) which were very close. The lowest rank correlation was observed in LSQ with CC (0.10–0.16) and SRLS with CC (0.10–0.17). It was observed that all the rank correlations between CC with BLUP were negative. The relative efficiency of LSQ and SRLS in comparison with BLUP was more than 95%. The coefficient of determination (R^2) for LSQ and SRLS was nearly equal (16.30% to 17.58%) and BLUP had lower R^2 (13.10% to 14.75%) than LSQ and SRLS. The narrow range of coefficient of variation (CV) for LSQ, SRLS and BLUP (23.5% to 24.5%) and small deviation from CV of unadjusted data (25.35%) indicated that all the 3 methods were almost equally stable. The BLUP method which had lower error variance was found to be more efficient than the LSQ and SRLS methods using the 305-day milk yield predicted by regression equation considering fourth, sixth and ninth MTDYs.

Key Words: Karan Fries cattle, Test day milk yield, Sire evaluation

The accuracy of estimating the breeding value of an animal is the major factor that affects the genetic progress due to selection. The success of a breeding programme depends on how early and how accurately young bulls can be proved. If the time required for ranking the sires on the basis of their breeding values can be shortened, it will reduce the generation interval and enhance the selection intensity. Therefore an accurate evaluation of the bull at minimum possible cost becomes of paramount importance for bringing about rapid genetic progress in dairy cattle. To reduce possible cost and rapid genetic progress in dairy cattle, evaluation of sires on the basis of part lactation milk yield (Iype 1979, Jain and

Dhillon 1986, Singh 2006) and test day milk yield (Singh 1992, Appannayar 1997, Iype 2005, Rana 2008, Dongre *et al.* 2011) were carried out. There is a need to determine the best sire evaluation method for early and economic sire evaluation using test day milk yield records. Accordingly, the present investigation was undertaken with the objective to estimate breeding value of sires based on predicted first lactation 305-day milk yield using monthly test day milk yield values (MTDY) by different sire evaluation methods.

MATERIALS AND METHODS

The relevant data on first lactation monthly test day milk yield were collected from the history-cum-pedigree sheets and daily milk yield recording registers of 1345 KF cattle sired by 84 bulls maintained at the institute from year 1984 to 2006. For first lactation 305-day milk yield, only those Karan Fries cattle were considered for study which had produced milk for at least 100 days. The breeding values of Karan Fries sires were estimated for best predicted equations by Step-wise backward multiple regression using monthly

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test day milk yields. These best prediction equations are used for sire evaluation because of high association between these test day milk yields and 305-day milk yield. These best prediction equations were (M₁)- 273.24 + 44.24 X₂ + 46.50 X₄ + 39.26 X₅ + 55.92 X₆ + 63.81 X₉ + 25.57 X₁₁; (M₂)- 302.90 + 47.97 X₂ + 61.55 X₄ + 72.48 X₆ + 64.59 X₉ + 25.72 X₁₁; (M₃)- 278.93 + 50.37 X₂ + 60.00 X₄ + 72.38 X₆ + 82.96 X₉; (M₄)- 508.96 + 92.31 X₄ + 74.73 X₆ + 84.72 X₉.

Statistical methods

For accurate evaluation of sires, it was decided to include only those sires, which had a minimum of five daughters. A total of 84 sires having 1345 daughters with first lactation milk yield records were evaluated by the following methods:

Contemporary comparison method: The contemporary of a cow are considered to be the daughters of the other sires performing at the same time period in the same herd. The formula by Jain and Malhotra (1971) for estimating sire index was used.

Least squares method: The least squares means of sire were estimated by adjusting the data for significant effect of non-genetic factors. The least squares method given by Harvey (1979) was used to estimate the breeding value of bulls.

Simple regressed least squares (SRLS): The simple regressed least squares technique (SRLS) was applied which is given by Harvey (1979).

Best linear unbiased prediction (BLUP) method: The breeding value of sires was estimated by best linear unbiased prediction (BLUP) method as given by Henderson (1975).

The general model of BLUP estimation was considered as follows:

$$Y_{ijk} = X h_i + Z s_j + e_{ijk}$$

where, Y_{ijk}, observation vector of trait with dimension (n × 1); X, incidence matrix for fixed effects (periods and season) with dimension (n × p); Z, incidence matrix for random effect (sire) with dimension (n × q); h_i, a vector for fixed effects of dimension (p × 1); s_j, a vector of random effect with mean zero and variance Gσ_s² with dimension (q × 1); e_{ijk}, random error vector with dimension (n × 1) with mean zero and variance (0, σ_e²).

The assumptions of the model are:

$$E(y) = Xh; E(s) = 0; E(e) = 0; \text{Var}(s) = G\sigma_s^2; \text{Var}(e) = I\sigma_e^2.$$

From the above model the mixed model equations can be written as follows (Searle *et al.* 1961).

$$\begin{bmatrix} (X'R^{-1}X) & (X'R^{-1}Z) \\ (Z'R^{-1}X) & (Z'R^{-1}Z + G^{-1}) \end{bmatrix} \begin{bmatrix} h \\ s \end{bmatrix} = \begin{bmatrix} (X'R^{-1}Y) \\ (Z'R^{-1}Y) \end{bmatrix}$$

where, G⁻¹ is the diagonal matrix of σ_e²/σ_s² pertaining to sire effect, I is the identity matrix, the σ_e² is the error component and σ_s² is the sire component of variance. Mixed model BLUP equations were derived and solved to predict the EBV of sires using Model 8 given by Harvey (1990)

using PC-2 version of least squares and maximum likelihood (LSML).

Criteria for judging the effectiveness of various sire evaluation methods

After the sires were evaluated by different procedures these were ranked as per their genetic merit for first lactation predicted 305-day milk yield. The effectiveness of different sire evaluation methods was judged by using the criteria: Spearman's rank correlations, within sire variance or error variance, coefficient of determination (R²), coefficient of variation (%).

Spearman's rank correlations

The correlations between the rankings of the sires based on their breeding values estimated by the above methods were tested by using Spearman rank correlation (Steel and Torrie 1960) as:

$$r_{(s)} = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

where,

r_(s), Spearman's rank correlation; n, number of sires under observation; and d_i, difference between the ranking of a sire by the 2 methods.

The significance of rank correlation was tested by:

$$t = r \sqrt{\frac{n-2}{1-r^2}}$$

This has a student t-distribution with n-2 degree of freedom.

Within sire variance or error variance

The efficiency of Least squares, SRLS and BLUP methods was judged by within sire variance (error variance). The method giving lowest error variance was considered more efficient.

Relative efficiency (RE) of method II with respect to method I (most efficient method) was calculated by following equation:

$$RE (\%) = \frac{\text{Error variance of method I}}{\text{Error variance of method II}} \times 100$$

Coefficient of determination (R²)

The coefficients of determination (R² value) of different methods were estimated for judging the accuracy of sire evaluation methods. The model, which showed the highest R² value, was considered to be most accurate.

Coefficient of variation (%)

The coefficient of variation (CV%) of part and 305-day milk yield from different models of sire evaluation was

estimated for knowing the stability. In case of ideal adjustment of records, the structure of population as indicated by CV should not deviate from the CV of unadjusted data.

RESULTS AND DISCUSSION

The overall estimated breeding values BY LSQ method for predicted 305-day milk yield based on of M_1 , M_2 , M_3 , M_4 equations, were 2827 kg, 2827 kg and 2958 kg 2934 kg and the proportion of sires that had EBVs above the average breeding value were 50% (42 sires), 50% (42 sires), 50% (42 sires) and 48% (41 sires) out of a total of 84 sires respectively. The overall estimated breeding values by SRLS method for predicted 305-day milk yield based on M_1 , M_2 , M_3 , M_4 equations were 2828 kg, 2829 kg, 2960 kg and 2934 kg and the proportion of sires that had EBVs above the average breeding value were 46.42% (39 sires), 51.19% (43 sires), 48.8% (41 sires) and 50% (42 sires) out of a total of 84 sires respectively. The overall estimated breeding values by CC method for predicted 305-day milk yield based on M_1 , M_2 , M_3 , M_4 equations, were 2866 kg, 2861 kg, 2992 kg and 2975 kg and the proportion of sires that had EBVs above the average breeding value were 57.14% (47 sires), 59.52%, 64.28% (54 sires) and 58.33% (49 sires) out of a total of 84 sires respectively. The overall estimated breeding values by BLUP method for predicted 305-day milk yield based on M_1 , M_2 , M_3 , M_4 equations were 2843 kg, 2837 kg, 2970 kg and 2969 kg and the proportion of sires that had EBVs above

the average breeding value were 48.8% (41 sires), 53.57%, 48.6% (41 sires) and 53.57% (45 sires) out of a total of 84 sires respectively.

The effectiveness of different sire evaluation methods was compared on the basis of rank correlations, error variance, relative efficiency, coefficient of determination (R^2) and coefficient of variation (CV).

The rank correlations between breeding values of sires estimated by different sire evaluation methods for predicted 305-day milk yield based on M_1 , M_2 , M_3 , M_4 by multiple regression method are given in Table 1. In all the MTDYs combinations, the rank correlation for LSQ with SRLS (0.92–0.99) was highest followed by LSQ with BLUP (0.89–0.91) and SRLS with BLUP (0.81–0.91) which were very close. The lowest rank correlation was observed in LSQ with CC (0.10–0.16) and SRLS with CC (0.10–0.17). It was observed that all the rank correlations between CC with BLUP were negative. Singh (2006) also observed negative rank correlation for CC with BLUP.

The error variance and relative efficiency of different sire evaluation methods given in Table 2 that the error variance of BLUP in predicted 305-day milk yield by stepwise backward regression methods using MTDYs combination had lower error variance than the other methods except M_3 combination (LSQ was more efficient) had lower error variance. Thus, on the basis of error variance the BLUP is more efficient in predicted yields. Hagggar and Dempfle

Table 1. Rank correlations between breeding values estimated by different sire evaluation methods based on best prediction equations

Methods	LSQ with SRLS	LSQ with CC	LSQ with BLUP	SRLS with CC	SRLS with BLUP	CC with BLUP
(M_1)- 273.24 + 44.24 X_2 + 46.50 X_4 + 39.26 X_5 + 55.92 X_6 + 63.81 X_9 + 25.57 X_{11}	0.92	0.16	0.89	0.17	0.81	-0.18
(M_2)- 302.90 + 47.97 X_2 + 61.55 X_4 + 72.48 X_6 + 64.59 X_9 + 25.72 X_{11}	0.99	0.15	0.89	0.16	0.89	-0.21
(M_3)- 278.93 + 50.37 X_2 + 60.00 X_4 + 72.38 X_6 + 82.96 X_9	0.99	0.13	0.89	0.14	0.89	-0.21
(M_4)- 508.96 + 92.31 X_4 + 74.73 X_6 + 84.72 X_9	0.99	0.10	0.91	0.10	0.91	-2.10

Table 2. Relative efficiency of different sire evaluation methods

	Methods	Error variance	Relative efficiency
(M ₁)- 273.24 + 44.24 X_2 + 46.50 X_4 + 39.26 X_5 + 55.92 X_6 + 63.81 X_9 + 25.57 X_{11}	LSQ	451387	96.13
	SRLS	451348	96.14
	BLUP	433943	1
(M ₂)- 302.90 + 47.97 X_2 + 61.55 X_4 + 72.48 X_6 + 64.59 X_9 + 25.72 X_{11}	LSQ	449166	96.59
	SRLS	449127	96.60
	BLUP	433851	1
(M ₃)- 278.93 + 50.37 X_2 + 60.00 X_4 + 72.38 X_6 + 82.96 X_9	LSQ	511588	1
	SRLS	531588	97.30
	BLUP	517376	97.31
(M ₄)- 508.96 + 92.31 X_4 + 74.73 X_6 + 84.72 X_9	LSQ	516759	96.93
	SRLS	516726	96.94
	BLUP	500940	1

Table 3. Comparison of effectiveness of LSQ, SRLS and BLUP methods

Milk yield	Method	R ² (%)	CV (%)
(M ₁)- 273.24 + 44.24 X ₂ + 46.50 X ₄ + 39.26 X ₅ + 55.92 X ₆ + 63.81 X ₉ + 25.57 X ₁₁	LSQ	17.13	23.72
	SRLS	16.32	23.71
	BLUP	15.80	23.90
(M ₂)- 302.90 + 47.97 X ₂ + 61.55 X ₄ + 7 2.48 X ₆ + 64.59 X ₉ + 25.72 X ₁₁	LSQ	17.10	23.71
	SRLS	17.13	23.61
	BLUP	14.95	23.14
(M ₃)- 278.93 + 50.37 X ₂ + 60.00 X ₄ + 7 2.38 X ₆ + 82.96 X ₉	LSQ	16.62	24.61
	SRLS	17.10	24.67
	BLUP	14.33	24.73
(M ₄)- 508.96 + 92.31 X ₄ + 74.73 X ₆ + 84.72 X ₉	LSQ	16.27	24.54
	SRLS	17.66	24.56
	BLUP	13.82	23.90

(1981) also reported that the BLUP method was most efficient than the CC, LSQ and SRLS (Simplified regressed least squares) methods. The relative efficiency (RE) of LSQ and SRLS in comparison to BLUP (most efficient method) for EBVs for predicted milk yields by (M₁) combination was 96.13% and 96.14, respectively, and for (M₂) combination was 96.59 and 97.30%, respectively, and for (M₄) combination was 96.93 and 96.94%. The relative efficiency (RE) of SRLS and BLUP in comparison to LSQ (most efficient method) for EBVs for predicted milk yields by (M₃) combination was 97.30 and 97.31% respectively.

The coefficient of determination (R² value) of fitting LSQ, SRLS and BLUP were estimated to judge the accuracy of these methods. The higher the R² value, the higher is the accuracy of fitting the model. The R² values for LSQ, SRLS and BLUP are presented in Table 3. The R² values of the SRLS and LSQ, in general, were relatively higher than the BLUP. The coefficient of variation (%) for 305-day and predicted 305-day milk yield were estimated from LSQ, SRLS and BLUP. The nearer the CV (%) of the population for sire evaluation to the CV (%) of unadjusted data, the more stable is the method. The CV (%) of unadjusted data for 305-day milk yields was 25.35 per cent. The CV (%) from the LSQ, SRLS and BLUP methods has been presented in Table 3. The coefficient of variation for LSQ, SRLS and BLUP ranged between 23.0% and 24.5%, indicating nearly equal stability for these methods.

It was concluded that either of 3 methods, viz. LSQ, SRLS and BLUP, could be used for genetic evaluation of Karan Fries sires using the 305-day yield predicted by regression equation considering fourth, sixth and ninth MTDYs due to high rank correlations between them and comparable efficiency and accuracy of these sire evaluation methods. On the basis of error variance, in general the BLUP method which had lower error variance was more efficient than the LSQ and SRLS methods.

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