

Comparison of sire evaluation methods for first lactation milk yield and lifetime traits in Sahiwal cattle

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ABSTRACT

The least squares method (LSM), best linear unbiased prediction (BLUP) and animal model of derivative free restricted maximum likelihood (DFREML) were used to estimate breeding values (EBVs) of Sahiwal sires by analyzing first lactation and lifetime records of their daughters maintained at 3 different farms. The highest overall average breeding value (1581.80 kg) for first lactation 305 days milk yield (FL305DMY) was obtained by BLUP method and the lowest breeding value (1522.53 kg) was obtained by least squares method. The average breeding value of Sahiwal sires for stayability were 2164.18, 1510.02 and 1927.45 days, respectively, using LSM, BLUP and DFREML methods of sire evaluation, whereas the average breeding value for lifetime milk yield (LTMY) were 9432.79, 6054.39 and 7437.27 kg, respectively, using 3 methods of sire evaluation. The derivative free restricted maximum likelihood (DFREML) method had the minimum error variance (16031.49 kg²) and was adjudged as the most efficient method of sire evaluation on the basis of FL305DMY. On the other hand, the least squares method (LSM) of sire evaluation had minimum error variances (5497332.00 kg² and 181327.00 days²) for lifetime milk yield and stayability, and was found to be most efficient over other 2 methods of sire evaluation. The lowest range of breeding values for FL305DMY and stayability using sire model (BLUP) indicated that this method was least capable to discriminate amongst bulls to the highest extent in comparison to LSM and DFREML. Also the least squares method had highest R² value hence most accurate for evaluating sires on the basis of lifetime traits. The daughters of sires selected for higher FL305DMY would tend to produce higher LTMY up to reasonable extent. However sires selected for higher breeding value for first lactation milk yield may not produce daughters with longer herd life.

Key words: BLUP, DFREML, Lifetime milk yield (LTMY), Rank correlation, Sahiwal, Stayability

Mostly sires are evaluated on the basis of first lactation 305-days milk yield of their daughters with the rationale to minimize generation interval. The overall productivity and stayability of cows in the herd could be another criterion of cow/sire selection. Stayability is an important lifetime trait with significant impact on the profitability of dairy cows. An improvement in stayability can result in decreased replacement costs and a higher production of herd attributed to larger number of mature cows. So, the feasible option is to select the cows on the basis of their performance in early lactation (s) as it is well reported in literature that some of the early lactation traits, viz. age at first calving and first lactation milk yield have significant genetic and phenotypic correlations with life time yield traits (Gandhi and Gurnani 1988, Pundir and Raheja 1997, Mukherjee 2005, Bajetha 2006). Also some of the workers (Dubey *et al.* 2006, Bajetha

2006) reported significantly positive rank and simple correlations between EBVs for first lactation milk yield and lifetime milk yield but these correlations were lower and nonsignificant between EBVs for first lactation milk yield and stayability. In present investigation an attempt is made to evaluate Sahiwal sires on the basis first lactation and lifetime traits using 3 different methods of sire evaluations and to compare these methods.

MATERIALS AND METHODS

The records of 2032 pedigreed Sahiwal cows maintained at National Dairy Research Institute (NDRI), Karnal, Government Livestock Farm (GLF), Chak Ganjaria, Lucknow and Government Cattle Breeding Farm (GCBF), Anjora, Durg, were collected for last 39 years (1967–2005).

Traits under investigation

First lactation 305 days milk yield (FL305DMY): Milk produced in first lactation 305 days or its mature equivalent days.

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Stayability: Stayability was defined as total number of days from the date of first calving to the date of disposal or death or termination.

Lifetimes milk yield (LTMY): Life time milk production was the total milk produced by a cow, from initiation of first lactation till the day of last completed lactation.

Statistical analysis

Sahiwal sires were evaluated on the basis of first lactation 305 days milk yield, stayability and lifetime milk yield using 3 methods of sire evaluation, viz. least squares method (Harvey 1990), best linear unbiased prediction (Henderson 1975) and DFREML version 3.0- β (Mayer 1998). The four seasons, 13 periods and 3 farms were used as fixed effects and age at first calving was used as linear covariable. Sires in all 3 methods and dams along with sires in DFREML were considered as random effects. The effectiveness of different sire evaluation methods was judged by using the various criteria like within sire variance or error variance, coefficient of determination (R^2), coefficient of variation (%) and rank/simple product moment correlations. The sire evaluation method with lowest error variance was considered as most efficient and appropriate. The most accurate method showed the highest coefficient of determination (R^2 -value). The coefficient of variation (CV %) of traits under study (FL305DMY, stayability and lifetime milk yield) from different models of sire evaluation were estimated for judging the stability of sire evaluation methods. The nearer the CV (%) of adjusted data to CV (%) of unadjusted data traits under study, the more stable was the method (Banik and Gandhi 2006). The Spearman's rank correlations and product moment correlations between breeding values of sires derived by various methods for different traits were also used to judge the effectiveness of different methods.

RESULTS AND DISCUSSION

In present investigation, 114 Sahiwal sires with 5 or more daughters were evaluated and ranked on the basis of their breeding values estimated from FL305DMY using 3 sire evaluation methods, i.e. LSM, BLUP and DFREML. For lifetime traits (stayability and lifetime milk yield) 107 Sahiwal sires having 5 or more daughters were used for estimation and comparison of breeding values.

Sire evaluation by different methods

Least squares method (LSM): The average breeding value of sires for FL305DMY was 1522.53 kg from least squares method (Table 1). The minimum and maximum breeding values were 848.79 kg and 2326.68 kg, respectively. Seventy-two out of 114 sires (63.15%) had breeding values above the average, while 42 Sahiwal sires (36.85%) had breeding values below the average breeding value. The top ranking sire had 52.81% higher genetic superiority over the overall average, whereas the bottom ranking sire had 44.25% low breeding

value than overall average breeding value (Table 1). Least squares method of sire evaluation had produced the largest range in breeding value compared to other methods. The top ranking sire had more than twice the breeding value of the bottom ranking sire.

The average breeding value of Sahiwal sires for stayability using least squares method (LSM) was 2164.18 days (Table 1). The minimum and maximum breeding values were 1768.10 days and 2951.27 days, respectively. It was found that estimated breeding values of 46 Sahiwal sires (43%) were above the average breeding value, while 61 sires (57%) were having their breeding values below the average breeding value. Top ranking sire had the highest estimated breeding value of 2951.27 days, which was 36.36% higher than the overall average breeding value; whereas the lowest breeding value was observed as 1768.10 days, which was 18.30% lower than the average breeding value. Bajetha (2006) reported that the breeding values estimated by least squares analysis ranged from 1092.37 to 2018.20 days for stayability in Sahiwal and its crosses.

The average breeding value of Sahiwal sires on the basis of lifetime milk yield using least squares method was 9432.79 kg (Table 1). The minimum and maximum breeding values were 4472.93 kg and 12192.30 kg, respectively. It was observed that estimated breeding values of 61 Sahiwal sires (57%) were above the average breeding value, while 46 sires (43%) were having their breeding values below the average breeding value of sires. Top ranking sire had the highest estimated breeding value of 12192.30 kg with 29.25% higher than the overall average breeding value, whereas the lowest breeding value was observed as 4472.93 kg, which was 52.58% lower than the average breeding value. Deulkar and Kothekar (1999) reported EBV of Sahiwal sires for LTMY ranged from 1451.15 kg to 6056.61 kg using least squares method of sire evaluation. Bajetha (2006) reported breeding values ranged from 5580.68 to 11014.63 kg estimated by LSM for lifetime milk yield in Sahiwal and its crosses.

Best linear unbiased prediction (BLUP): The average breeding value of Sahiwal sires for FL305DMY estimated by BLUP method was 1581.80 kg (Table 1). The highest and lowest breeding values of sires were 2023.62 and 1101.70 kg, respectively. The top ranked sire had 27.94% higher genetic superiority above the overall average; whereas bottom ranked sires was inferior by 30.35% than the overall mean. Sixty out of 114 sires (52.63%) had estimated breeding value above the average, while 54 Sahiwal sires (47.37%) had breeding value below the average breeding value.

The average estimated breeding value of Sahiwal sires for stayability by best linear unbiased prediction method was 1510.02 days (Table 1). The lowest ranking sire was having estimated breeding value of 1409.26 days, which was 6.67% below the overall average breeding value, whereas top ranking sire had the maximum breeding value of 1623.99 days, which was 7.54% above the overall average breeding

value. It was found that EBVs of 55 out of 107 sires (51.40%) were above the average breeding value, while EBVs of 52 sires (48.60%) were below the overall average breeding value. Bajetha (2006) reported that breeding values estimated by method ranged from 1233.86 to 1748.62 days in sires for stayability in Sahiwal and its crosses.

The average breeding value of Sahiwal sires estimated from LTMY by best linear unbiased prediction method was 6054.39 kg (Table 1). The lowest estimated breeding value was 4875.13 kg, which was 19.47% below the overall average breeding value; whereas the maximum breeding value was 6894.48 kg, which was 13.87% above the overall average breeding value (Table 1). EBVs of 51 sires (47.66%) were above the average breeding value, while the EBVs of 56 sires (52.34%) were below the overall average breeding value. Deulkar and Kothekar (1999) reported EBV of Sahiwal sires from LTMY ranged from 3710.79 to 4621.42 kg using BLUP method. Bajetha (2006) reported that the breeding values estimated by BLUP method ranged from 8129.97 to 10115.45 kg for lifetime milk yield in Sahiwal and its crosses.

Derivative free restricted maximum likelihood (DFREML): The estimated average breeding value of Sahiwal sires for FL305DMY by DFREML was 1523.78 kg (Table 1). It was also observed that estimated breeding values of 56 out of 114 sires (49.12%) were above the average breeding value, while remaining 58 sires (50.88%) were having breeding value below the overall average. The highest and lowest breeding values were estimated as 2063.26 and 667.42 kg, respectively. The sires with highest breeding value had superiority of 40.4% above the average breeding value. On the other hand, the inferior sire had 22.1% lower breeding value than the average breeding value.

The average EBVs of 107 Sahiwal sires for stayability estimated by DFREML method taking univariate model (stayability) was 1927.45 days (Table 1). The highest and lowest breeding values were 1987.12 and 1847.20 days, respectively. It was found that estimated breeding values of

54 sires (50.46%) were above the average breeding value, while breeding value of 53 sires (49.54%) were below the overall average breeding value. The highest estimated breeding value (1987.12 days) was 3.09% above the overall average, while the lowest breeding value was estimated of 1847.20 days, which was 4.16% below the overall average breeding value (Table 1).

The average EBVs of 107 Sahiwal sires by DFREML method for life time milk yield was 7437.27 kg (Table 1). The highest and lowest breeding values were 8694.78 and 5594.78 kg, respectively. It was found that estimated breeding values of 52 Sahiwal sires (48.60%) were above the average breeding value, while 55 sires (51.4%) were having their breeding values below the overall average breeding value. The highest estimated breeding value (8694.78 kg) was 16.90% above the overall average breeding value, while the lowest breeding value of 5594.78 kg was 24.77% below the overall average breeding value (Table 1).

Comparison of sire evaluation methods for traits under study

Within sire variance or error variance: The error variances from different methods of sire evaluation along with their relative efficiencies were summarized in Table 2. The results indicated that for FL305DMY the derivative free restricted maximum likelihood (DFREML) method had minimum error variance (168031.49 kg²) and was adjudged as the most efficient method of sire evaluation followed by LSM and BLUP methods of sire evaluation. The relative efficiencies of LSM and BLUP with respect of most efficient method (DFREML) were 79.45 and 79.44%, respectively. Various workers have compared different methods of sire evaluation on the basis of relative efficiency and differed in their conclusion. For example, BLUP method has been advocated by various workers (Harvey 1987, Chauhan 1991, Raheja 1992, Dubey *et al.* 2006, Bajetha 2006) recommended that BLUP was one of the most efficient methods of sire evaluation compared to LSM. However, similar to present

Table 1. Average breeding value of Sahiwal sires for first lactation 305 days milk yield and lifetime traits

Methods	Average BV	Minimum BV (% below average BV)	Maximum BV (% above average BV)	Number of sires above average BV (% of sires)	Number of sires below average BV (% of sires)
<i>First lactation 305 days milk yield (FL305DMY)</i>					
LSM	1522.53	848.79 (44.25)	2326.68 (52.81)	72 (63.15)	42 (36.85)
BLUP	1581.80	1101.70 (30.35)	2023.62 (27.94)	60 (52.63)	54 (47.37)
DFREML	1523.78	667.42 (56.19)	2063.26 (35.40)	56 (49.12)	58 (50.88)
<i>Stayability</i>					
LSM	2164.18	1768.10 (18.30)	2951.27 (36.36)	46 (43.00)	61 (57.00)
BLUP	1510.02	1409.26 (6.67)	1623.99 (7.54)	55 (51.40)	52 (48.60)
DFREML	1927.45	1847.20 (4.16)	1987.12 (3.09)	54 (50.46)	53 (49.54)
<i>Lifetime milk yield (LTMY)</i>					
LSM	9432.79	4472.93 (52.58)	12192.30 (29.25)	61 (57.00)	46 (43.00)
BLUP	6054.39	4875.13 (19.47)	6894.48 (13.87)	51 (47.66)	56 (52.34)
DFREML	7437.27	5594.78 (24.77)	8694.78 (16.90)	52 (48.60)	55 (51.40)

findings, Sahana and Gurnani (1999), Mukherjee (2005) and Banik and Gandhi (2006) reported that DFREML was more efficient compared to LSM and BLUP method of sire evaluation. Banik and Gandhi (2010) reported higher error variance (191111 kg²) for FL305DMY by univariate DFREML model. The least squares method (LSM) of sire evaluation had minimum error variances of 181327.00 days² and 5497332.00 kg² for stayability and lifetime milk yield, respectively, and found to be most efficient over other 2 methods, i.e. DFREML (335042.62 days² and 9042523.13 kg²) and BLUP (336199.57 days² and 9650388.45 kg²) (Table 2). The relative efficiency of BLUP and DFREML as compared to most efficient LSM for EBVs of sire for life time milk yield were 56.96 and 60.79%, respectively. Similarly, for stayability the LSM was the most efficient

followed by DFREML (54.12%) and BLUP (53.93%).

Coefficient of determination (R^2): The higher the R^2 value the higher the accuracy of fitting the model. On the basis of FL305DMY the least squares method had highest (35.61%) R^2 -value followed by BLUP (31.80%) and DFREML (31.25%), respectively (Table 2). Therefore, least squares method of sire evaluation was found to be more accurate over BLUP and DFREML. Similar to ours findings, Gandhi and Gurnani (1991) compared accuracy of LSM, SRLSM and BLUP method using R^2 -value and revealed that LSM was most accurate. On the other hand, Banik (2004) found highest R^2 -value from DFREML method (33.39%) followed by BLUP (24.54%) and LSM (11.07%). Also, for life time traits the LSM was found to be most accurate with highest R^2 values of 84.84 and 88.84%, respectively for life time milk yield and stayability followed by DFREML (83.90% for LTMV and 87.01% for stayability). The BLUP method was least accurate with R^2 value of 77.60 and 71.40% for stayability and LTMV, respectively (Table 2).

Coefficient of variation: The nearer the CV (%) of adjusted data to CV (%) of unadjusted data of the trait the more stable the method. For FL305DMY and lifetime traits (stayability and LTMV) the DFREML method was most stable being its CV (%) closest to CV (%) of unadjusted data for all the traits under investigation (Table 2).

Agreement among top ten sires: In present investigation, 6 sires were present in top 10 sires listed on the basis of EBVs from FL305DMY in all 3 methods of sire evaluation. But breeding values estimated on the basis of FL305DMY, stayability and LTMV, only 2 sires were present in top 10 sires in all the 3 methods (LSM and BLUP and DFREML) of sire evaluation.

Rank and product moment correlations

The rank and product moment correlations between and within different methods of sire evaluation for FL305DMY, stayability and LTMV are being summarized in Table 3. The

Table 2. Effectiveness of different sire evaluation methods for first lactation 305 days milk yield and lifetime traits in Sahiwal cattle

Methods	Error variance	Relative efficiency	Coefficient of determination	Coefficient of variation [#]
<i>First lactation 305 days milk yield (FL305DMY)</i>				
LSM	211470.36 kg ²	79.45	35.61	30.20
BLUP	211506.09 kg ²	79.44	31.80	30.21
DFREML	168031.49 kg ²	100.00	31.25	31.98
<i>Stayability</i>				
LSM	181327.00 days ²	100.00	88.84	22.07
BLUP	336199.57 days ²	53.93	77.60	30.08
DFREML	335042.62 days ²	54.12	87.01	30.38
<i>Lifetime milk yield (LTMV)</i>				
LSM	5497332.00 kg ²	100.00	84.84	31.48
BLUP	9650388.45 kg ²	56.96	71.40	41.47
DFREML	9042523.13 kg ²	60.79	83.90	42.57

[#]Coefficient of variations (%) for unadjusted records of FL305DMY, stayability and LTMV were 34.40, 63.30 and 77.60%, respectively.

Table 3. Rank correlations (above diagonal) and product moment correlations (below diagonal) among EBVs of sires estimated by different methods of sire evaluation from FL305DMY and lifetime traits

Traits	FL305DMY				Stayability			LTMV		
	Methods	LSM	BLUP	DFREML	LSM	BLUP	DFREML	LSM	BLUP	DFREML
FL305DMY	LSM	1.00	0.959**	0.895**	−0.081	0.138	0.192	0.355*	0.571**	0.539**
	BLUP	0.934**	1.00	0.925**	−0.050	0.157	0.222*	0.359*	0.605**	0.574**
	DFREML	0.904**	0.892**	1.00	−0.091	0.076	0.133	0.334*	0.572**	0.586**
Stayability	LSM	0.173	−0.154	−0.192	1.00	0.615**	0.517**	0.137	0.184	0.157
	BLUP	0.140	0.175	0.079	0.576**	1.00	0.931**	0.037	0.510**	0.502**
	DFREML	0.172	0.239*	0.116	0.450*	0.923**	1.00	−0.021	0.454*	0.476*
LTMV	LSM	0.398**	0.497**	0.348*	0.136	−0.048	−0.085	1.00	0.568**	0.557**
	BLUP	0.644**	0.694**	0.668**	0.219	0.471**	0.409**	0.573**	1.00	0.932**
	DFREML	0.608**	0.639**	0.692**	0.189	0.465**	0.438**	0.489**	0.935**	1.00

** Significant at 1% level; *, significant at 5% level.

rank and product moment correlations were highly significant and high for EBVs on the basis of FL305DMY. However, these correlations were moderate for EBVs on the basis of stayability and LTMV. The rank and simple correlations for EBVs of FL305DMY with EBVs of stayability were low (some negative values) and mostly nonsignificant, whereas these correlations for EBVs of FL305DMY with EBVs of LTMV were moderate and mostly significant within or between different methods of sire evaluation. Similar to our findings, Dubey *et al.* (2006) reported rank and product moment correlation of 0.48 and 0.54 between EBVs of Sahiwal sire's on the basis of stayability and LTMV using BLUP method of sire evaluation. However, Pundir and Raheja (1994) reported a higher rank and product moment correlation of 0.87 and 0.78 between EBVs of Sahiwal sire's on the basis of stayability and LTMV using BLUP method of sire evaluation.

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