



Sire evaluation using conventional methods and animal models in Sahiwal cattle

DHANRAJ G GIRIMAL¹, D KUMAR^{1✉}, B N SHAHI¹, A K GHOSH¹ and SUNDIP KUMAR¹

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145 India

Received: 9 April 2020; Accepted: 27 December 2021

ABSTRACT

Sire evaluation is one of the most important aspects of dairy cattle genetic improvement programme which involves the estimation of breeding value of the bulls on the basis of first lactation 305-day milk yield. The present study was undertaken to evaluate the Sahiwal sires on the basis of observed and predicted first lactation 305-days milk yield. The study was conducted utilizing 19 Sahiwal sires with three or more daughters per sire which were evaluated and ranked on the basis of first lactation 305-day milk yield. Three different sire evaluation methods, viz. Simple daughter average, Least squares method (LSM), Best linear unbiased prediction method (BLUP) were compared. The BLUP method was found to be superior followed by LSM and Simple Daughter Average Method for evaluating the sires for first lactation 305-day milk yield.

Keywords: Breeding value, BLUP, Least Square method, Rank correlation, Sahiwal cattle, Sire evaluation

The productivity of the cows can be increased by using the high quality sires. Therefore, there should be a genetic evaluation of sires for milk production. The genetic improvement in the population through sire selection depends on the accuracy of selection, selection intensity, genetic variability of the trait and the generation interval. Breeders are interested in the appropriate methodology for bringing faster possible genetic improvement through selection of traits of economic importance for which the animal must be chosen for their superior breeding values. The breeding values can be estimated on the individual, family or combined phenotypic data. There are few methods which are available for evaluation of sires such as Simple Daughter Average ($\bar{D}$), Least Squares Method (LSM), Best Linear Unbiased Prediction Method (BLUP), Restricted Maximum Likelihood Method (REML) and Derivative Free Restricted Maximum Likelihood Method (DFREML).

There exist some problems in proper implementation of all these methods in India because progeny testing is limited to the organized herds which are few in numbers and maintaining small herds. Hence, there is a need to compare different methods so that appropriate methods can be suggested for evaluating the sires under various conditions. The important objective of the sire evaluation is to identify the sires for their merit by unbiased estimation of the breeding value of bulls and ranking them. These enable the breeder to choose proven bulls for subsequent improvement of the herd. The present study was carried out to estimate the breeding value of sires for milk yield

by using the methods-Simple Daughter Average ($\bar{D}$), Least squares methods (LSM) and Best linear unbiased prediction (BLUP). Total 19 Sahiwal sires with three or more daughters per sire were evaluated and ranked on the basis of first lactation 305-day milk yield.

MATERIALS AND METHODS

The data on performance traits in Sahiwal cattle were collected from history sheets and daily milk record registers maintained at Instructional Dairy Farm, Nagla of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The data consisted of 166 Sahiwal cattle, spread over a period of 40 years from 1977-2016. Incomplete records due to some causes like abortion, dystocia, premature birth and health ailments were not considered. The loose and open housing system are being practiced at the farm. The separate sheds were provided to the dry, lactating and pregnant animals. Milking was done twice a day (morning and evening) and daily milk yield was recorded. All animals were kept under high level of sanitary conditions and all prophylactic health measures were followed. Balanced ration was provided to animals as per NRC nutrient requirement. In order to rectify non-orthogonality of data due to unequal subclass frequency, the mixed model likelihood programme (Harvey 1990) was used. The sires were evaluated from different methods as detailed below and ranked on the basis of the breeding values.

Simple Daughter Average ($\bar{D}$): Sire were evaluated by simple Daughter's Average as proposed by Edward (1932). This method is easy to compute the breeding value of sires for predicting the performance of future daughters of the sire born to cows of the same genetic potential. The breeding value of sires were computed using:

Present address: ¹College of Veterinary and Animal Sciences, Pantnagar, Uttarakhand. ✉Corresponding author email: dkumargenetics@gmail.com

$$I = \bar{D}$$

Where, $\bar{D}$ is the average milk yield of all daughter of a sire.

Least squares methods (LSM): The least squares method as described by Harvey (1990) was used to estimate the breeding value of sires.

Duncan's Multiple Range Test (DMRT): Duncan's multiple range tests as modified by Kramer (1957) was used for testing differences among least squares means (using inverse coefficient of the matrix). The differences were considered significant, if

$$(X_i - X_j) \sqrt{\frac{2}{C_{ii} + C_{jj} - C_{ij}}} > \sigma_e Z_{p, n_2}$$

Where X_i and X_j are the least squares means for i^{th} and j^{th} treatment and C_{ii} , C_{jj} and C_{ij} are diagonal and off-diagonal elements in the inverse of a coefficient matrix in the least-squares normal equations. Z_{p, n_2} was studentized ranged value in Duncans's table (0.05) at n_2 degrees of freedom for error.

Best linear unbiased prediction (BLUP): This method used was as proposed by Misztal *et al* (2004) to estimate the breeding values of sires for first lactation traits. BLUPF90 and related programs were with the purpose of providing comprehensive computing capabilities to problems related with mixed models in animal breeding. The main objective of BLUPF90 Dairy Pack, 2004 version-2 is to accomplish various models generally used in dairy cattle evaluation with friendly graphic interface for PC and windows users.

Criteria for judging the effectiveness of various sire evaluation method

After the sires were evaluated by different methods, they were ranked as per their genetic merit. The effectiveness of different sire evaluation methods used in the present study was tested by using two statistical criteria, namely:

Efficiency of different methods: This was done by comparing within sire variance or error variance of different methods. This method which had a lowest error variance was adjusted as the most efficient method. Then the efficiency of other methods relative to the most efficient method under the present study was calculated by the formula:

$$\text{Relative efficiency of method (\%)} = \frac{\text{Error variance of most efficient method}}{\text{Error variance any other method}} \times 100$$

Spearman's coefficient of Rank correlation: Spearman's coefficient of rank correlation (Spearman 1904) was applied to data in the form of ranks. The sires were ranked based on their estimated breeding values through different methods. After the ranking, the most efficient method was estimated using Spearman's rank correlation expression (Steel and Torrie 1960) using formula:

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

Where r_s , Rank correlation coefficient; n , Number of sires under evaluation; d_i , Difference of rank between paired items under two methods.

The significance of rank correlation was tested by using student t- test as given below:

$$t = r \sqrt{\frac{(n-2)}{(1-r^2)}} \text{ with } (n-2) \text{ degree of freedom}$$

RESULTS AND DISCUSSION

The breeding values of 19 Sahiwal sires estimated on the basis of actual and predicted first lactation 305-day milk yield by different methods along with their ranks are given in Tables 1 and 2.

Actual first lactation 305-day milk yield (FL305DMY) in Sahiwal: Estimated breeding values of Sahiwal sires based on observed FL305DMY by different methods is given in Table 1. The highest estimated breeding value was 1866 kg and minimum breeding value was 1309 kg. The estimated breeding values of 10 sires out of 19 sires (52.63%) were above the average breeding value; while, the remaining 9 sires (47.36%) had breeding value lower than the average breeding value. The top-ranking sire (Sire no.1) had highest breeding value, whereas the bottom ranked sire (Sire no.18) had lowest breeding value. The difference between highest and lowest breeding values was 557 kg in Sahiwal cattle.

The average breeding value of Sahiwal breed sires evaluated on the basis of actual first lactation 305-day milk yield by least squares method was 1587.368 kg, which was lower than Basu *et al.* (1979), Kannan (2002), Kumar (2007), Raja and Narula (2007), Manoj (2009) and Raja (2010). The results revealed that the estimated breeding values of 10 (52.63%) sires were above the average breeding value, while the remaining 9 sires (47.36%) had breeding value lower than the average breeding value. The top ranking sire (Sire no. 5) had highest breeding value of 1838.62 kg, whereas the Sire no.11 ranked at bottom with lowest breeding value of 1329.1 kg. The difference between highest and lowest breeding values was 509.62 kg.

The average breeding value of Sahiwal sires estimated by best linear unbiased prediction method was 1591.1 kg. The average breeding value obtained in the present study by this method was higher than the values reported by Pundir *et al.* (2004), Banik and Gandhi (2010), Kumar (2007), Kathiravan (2009) and Raja (2010) in Sahiwal cattle. The highest estimated breeding value was 1724 kg and the minimum breeding value was estimated to be 1453.23 kg. The estimated breeding values of 7 sires out of 19 sires (36.84%) were above the average breeding value, while the remaining 12 sires (63.15%) had breeding value lower than the average breeding value. The top ranking sire (Sire no.3) had highest breeding value (1724 kg), whereas the bottom ranked sire (Sire no.10) had lowest breeding value of 1453 kg. The difference between highest and lowest breeding values was 271.16 kg in Sahiwal cattle.

Predicted first lactation 305-day milk yield (FL305DMY) in Sahiwal: The estimated breeding values of Sahiwal sires based on predicted FL305DMY by different methods is given in Table 2. The average breeding value of Sahiwal as estimated by simple daughter average was 1573.7 kg.

The highest estimated breeding value was 1862 kg and the minimum breeding value was found to be 1333.0 kg. The estimated breeding values of 8 sires of Sahiwal breed out of 19 sires (42.10%) were above the average breeding value, while the remaining 11 sires (57.89%) had breeding value lower than the average breeding value. The top ranking sire (Sire no.03) had highest breeding value, whereas the bottom ranked sire (Sire no.13) had lowest breeding value. The difference between highest and lowest breeding values was 529 kg in Sahiwal cattle.

The average breeding value of Sahiwal breed sires evaluated on the basis of predicted first lactation 305-day milk yield by least squares method was 1585.637 kg. This value was lower than the estimates reported by Basu *et al.* (1979), Kannan (2002), Kumar (2007), Raja and Narula (2007), Manoj (2009) and Raja (2010). The results revealed that the estimated breeding values of 9 sires (47.36%) were above the average breeding value, whereas the remaining 10 sires (52.63%) had breeding value lower than the average breeding value. The top ranking sire (Sire no.5) had highest breeding value (1833 kg), whereas the bottom ranked sire (Sire no.1) had lowest breeding value of 1337 kg. The difference between highest and lowest breeding values was 496 kg in Sahiwal cattle.

The average breeding value of Sahiwal sires estimated by best linear unbiased prediction method was 1591.533 kg. The average breeding value obtained in the present study by this method was higher than the values reported by Pundir *et al.* (2004), Kumar (2007), Kathiravan (2009), Banik and Gandhi (2010) and Raja (2010) in Sahiwal cattle. The highest estimated breeding value was 1720.76 kg and the minimum breeding value was

estimated to be 1469.7 kg. The estimated breeding values of 10 sires out of 19 sires (52.63%) were above the average breeding value, while the remaining 9 sires (47.36%) had breeding value lower than the average breeding value. The top ranking sire (Sire no.15) had highest breeding value (1720.76 kg), whereas the bottom ranked sire (Sire no.06) had lowest breeding value of 1469.7 kg. The difference between highest and lowest breeding values was 251 kg in Sahiwal cattle.

Comparison of effectiveness of various sire evaluation methods: The effectiveness of different sire evaluation methods was compared using various criteria i.e. efficiency, accuracy and stability for actual and predicted first lactation 305-day or less milk yield. The error variance was used to judge the efficiency along rank correlation. The results of error variance are given in the Table 3. An efficient method of sire evaluation should have minimum within sire variance or error variance. BLUP method had lowest error variance 19.06 and 17.68 for actual and predicted first lactation 305-day milk yield, respectively in Sahiwal cattle. Therefore, this methods considered to be the most efficient out of all the three sire evaluation methods. The maximum error variance was observed using simple daughter average (33.75, 32.74) followed by LSM (31.93, 31.45). Henderson (1973), Raheja (1992) and Shahi and Kumar (2010) reported that BLUP method was one of the most efficient methods of sire evaluation as compared to LSM. While, Taneja and Rai (1990) reported LSM as the most efficient method as compared to BLUP method.

Rank correlations: The Spearman's rank correlations were estimated using the ranks of sires based on their breeding values estimated by three different sire evaluation

Table 1. Estimated breeding values of Sahiwal sires based on observed FL305DMY by different methods

Sire No.	No. of daughters	Simple daughter average ($\bar{D}$)	Rank	LSM	Rank	BLUP	Rank
1	4	1866.25	1	1819.96	2	1527.18	15
2	8	1541	12	1744.11	3	1626.49	7
3	5	1658.6	5	1608.24	7	1724.39	1
4	12	1589.58	9	1443.3	16	1718.39	2
5	15	1607.87	7	1838.62	1	1687.89	4
6	8	1514.88	13	1528	14	1586.33	8
7	6	1816.83	2	1518.47	15	1487.96	17
8	9	1606.33	8	1605.22	8	1586.13	9
9	5	1460.4	16	1720.24	4	1584.43	11
10	12	1558.25	10	1584.98	11	1453.23	19
11	10	1347.1	18	1329.1	19	1663.83	5
12	12	1726.42	3	1680.74	5	1585.48	10
13	8	1498.38	15	1399.63	18	1471.72	18
14	13	1500	14	1536.29	12	1703.18	3
15	11	1386.18	17	1594.97	10	1582.98	12
16	10	1713.6	4	1602.54	9	1496.75	16
17	8	1550.75	11	1400.56	17	1629.17	6
18	5	1309	19	1674.9	6	1535.2	14
19	5	1654.8	6	1530.12	13	1580.38	13

Table 2. Estimated breeding values of Sahiwal sires based on predicted FL305DMY by different methods

Sire No.	No. of daughters	Simple daughter average ($\bar{D}$)	Rank	LSM	Rank	BLUP	Rank
1	4	1343.09	18	1337.93	19	1602.05	9
2	8	1823.5	2	1567.07	11	1494.29	17
3	5	1862.25	1	1809.52	2	1543.46	14
4	12	1565	9	1450.31	17	1640.72	6
5	15	1610.83	7	1833.01	1	1672.49	3
6	8	1614.33	6	1497.72	15	1469.7	19
7	6	1543.38	11	1458.58	16	1711.87	2
8	9	1473.4	16	1686.03	5	1576.93	12
9	5	1407.6	17	1588.87	9	1500.27	15
10	12	1533.2	12	1702.68	4	1593.32	10
11	10	1608.6	8	1609.89	8	1588.48	11
12	12	1547.5	10	1572.94	10	1573.45	13
13	8	1333	19	1538.13	14	1618.51	7
14	13	1728.6	3	1770.96	3	1663.26	5
15	11	1688.42	5	1619.6	7	1720.76	1
16	10	1690.4	4	1636.35	6	1499.74	16
17	8	1478.75	15	1350.25	18	1490.83	18
18	5	1528.08	13	1543.6	13	1607.04	8
19	5	1522.13	14	1553.66	12	1671.95	4

methods from actual and predicted first lactation 305-day milk yield in Sahiwal cattle. In Sahiwal, the rank correlation for ranking of sires from simple daughter average in case of LSM and BLUP methods were for actual first lactation 305-day milk yield as 0.988 and 0.9216, respectively. The corresponding values for predicted first lactation 305-day milk yield were 0.985 and 0.872. The rank correlation of LSM with BLUP was 0.95 for observed milk yield and 0.89 using predicted milk yield.

Table 3. Comparison of various sire evaluation methods in terms of error variance and relative efficiency in Sahiwal cattle

Sire evaluation method	Error variance	Relative efficiency (%)
<i>Actual lactation 305 day milk yield</i>		
Simple daughter average	33.75	56.47
Least squares method	31.93	59.69
Best linear unbiased prediction	19.06	100
<i>Predicted lactation 305 day milk yield</i>		
Simple daughter average	32.74	54.80
Least squares method	31.45	56.21
Best linear unbiased prediction	17.68	100

These results revealed that BLUP method was found to be superior followed by LSM and Simple Daughter Average Method for evaluating the sires for first lactation 305-day milk yield.

ACKNOWLEDGEMENTS

Authors are thankful to the Director, Experiment

Research; Dean, College of Veterinary Science and Animal Husbandry; and Dean, PGS for providing all the necessary facility to carry out this work.

REFERENCES

- Banik S and Gandhi R S. 2010. Animal model versus conventional methods of sire evaluation in Sahiwal cattle. *Asian-Australasian Journal of Animal Sciences* **19**(9): 1225–28.
- Basu S B, Bhatnagar D S, Taneja V K and Rao V P. 1979. Comparative performance of Indian dairy breeds. *Indian Journal of Dairy Science* **32**(4): 497–99.
- Edward J. 1932. The progeny test as a method of evaluating the dairy sire. *Journal of Agricultural Sciences* **22**: 810–37.
- Harvey W R. 1990. Guide for LSMLMW, PC-1 Version, mixed model least squares and maximum likelihood computer programme, January 1990. Mimeograph Ohio State University, USA.
- Henderson C R. 1973. Sire evaluation and genetic trends. *Proceedings of Animal Breeding and Genetics Symposium in honor of Dr. J.L. Lush*, pp. 10–14. *American Society of Animal Science* Association, Champaign, Illinois.
- Kannan D S. 2002. 'Lifetime performance evaluation of Sahiwal cattle.' M.Sc. Thesis, NDRI, (Deemed University), Karnal, Haryana, India.
- Kathiravan P. 2009. 'Genetic evaluation of lifetime performance of Sahiwal cattle.' Ph.D. Thesis, National Dairy Research Institute, Karnal, Haryana, India.
- Kramer C R. 1957. Extension of multiple range tests to group correlated means. *Biometrics* **13**: 13–18.
- Kumar A. 2007. 'Genetic analysis of stayability in Sahiwal cattle.' Ph.D. Thesis, NDRI, (Deemed University), Karnal, Haryana, India.
- Manoj M. 2009. 'Evolving multi-trait selection criteria using body weights and first lactation traits in Sahiwal cattle.' M.V.Sc. Thesis, NDRI (Deemed University), Karnal, Haryana, India

- Misztal I, Duangjinda M and Tsuruta S. 2004. BLUPF90. Dairy pack Version 2: Genetic Evaluation Program for Dairy Cattle, Department of Animal and Dairy science, The University of Georgia, Athens, GA30602. (<http://nvr.ads.uga.edu/~igncy>).
- Pundir R K, Malik R P S and Prakash B. 2004. Comparison of different sire evaluation methods in Sahiwal cattle. *Indian Journal of Animal Sciences* **74**(2): 229–31.
- Raheja K L. 1992. Comparison of progeny testing of Sahiwal sires by the different methods of sire evaluation. *Indian Journal of Dairy Science* **45**(2): 64–69.
- Raja K N and Narula H K. 2007. Effects of non-genetic factors on production traits of Sahiwal cattle. *Indian Veterinary Journal* **84**(4): 374–76.
- Raja T V. 2010. 'Part lactation records for Sahiwal sire evaluation.' PhD. Thesis, NDRI, (Deemed University), Karnal, Haryana, India.
- Shahi B N and Kumar D. 2010. Sire evaluation using first lactation traits and univariate animal model in Sahiwal and Jersey × Sahiwal cattle. *Indian Journal of Animal Sciences* **76**(10): 853–54.
- Spearman C. 1904. The proof and measurement of association between two things. *American Journal of Psychology* **15**: 88.
- Tajane K R and Rai A V. 1990. Efficiency of sire evaluation methods to improve milk yield of Sahiwal × Holstein-Friesian cattle. *Indian Journal of Animal Sciences* **60**(1): 183–91.