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Comparison of sire evaluation methods in Vrindavani cattle

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A number of sire evaluation methods were used to evaluate dairy cattle. The most common among these are simple daughters average, contemporary comparison, least squares and best linear unbiased prediction (BLUP). The first sire index in India was proposed by Krishnan (1956), which was, however, similar to the CC of Robertson and Rendel (1954). The contemporary comparison method, in addition to adjusting for environment factors, in some cases also accounts for performance of dams of daughters. The ordinary least squares' and BLUP procedures have the ability to account for systematic differences among sires and to adjust for fixed effects (farm and year-season) simultaneously. The present study was designed to evaluate the sires of Vrindavani cattle and compare the accuracy and efficiency of three methods of sire evaluation namely contemporary comparison, least square method and best linear unbiased prediction.

First lactation of 914 first lactation records of Vrindavani cows born out of 66 sires, maintained at Indian Veterinary Research Institute, Izatnagar were used. The data were spread over 23 years form 1984–2006. Sire evaluation methods were used to estimate the average breeding value of sires. Sires were evaluated and on the basis of their estimated breeding values considering first lactation 305 days milk yield of their progeny using three sire evaluation methods. The record of sire having at least three or more daughters with first lactation recorded was used for sire evaluation. The methods used were: contemporary comparison (CC) method, least square method (LSM) and best linear unbiased prediction (BLUP) methods. For CC adjustment in period differences in daughter's performance can be taken care of. The contemporaries of a cow were considered to be daughters of the other sires performing at the same time period in the same herd. Sire index proposed by Robertson *et al.* (1956) was used for this purpose.

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The following formula was used for preparing the sire index:

$$I = \mu + Q (D_i - C_{Di})$$

where, I_i, Sire index method for i^{th} sire; μ, herd average; D_i, daughter's average for the i^{th} sire; C_{Di}, contemporary daughter's average for of the i^{th} sire; and

$$Q\text{-}2nh^2/ (4 + (n–1) h^2)$$

where, 'n' is the number of daughters of the sire under evaluation and h^2 is the heritability of the trait.

The least squares' method was used for estimation of sire merit after adjusting the data for significant non genetic factors using LSMLW computer program, PC-2 Version (Harvey 1990). The breeding values of sires were calculated by BLUP method given by Henderson (1975). Before estimation of breeding values, data were adjusted for significant non genetic factors. This included, periods. 1984–1987, 1988–1991, 1992–1995, 1996–1999, 2000–2003 and 2004–2006. Moreover, each year was divided into 3 seasons depending upon prevailing climatic conditions — rainy (July to September), winter (October to February), summer (March to June).

The comparison of sire evaluation was done using various criteria— within the sire variance or error variance (the method giving lowest error variance had higher efficiency and was considered most appropriate), coefficient of determination (higher R^2 value of fitting the model indicated higher accuracy); coefficient of variation (the method that would least alter the CV as compared to unadjusted data was considered more stable) and rank correlation. The sires were given rank as per their genetic merit Spearman's rank correlations (Steel and Torrie 1960) and product moment correlations between breeding values of sires derived by various methods were also used to judge efficacy of different methods. Higher rank correlation amongst the sires from different sire evaluation methods revealed higher degree of similarity of ranking from different methods.

Out of the total 66 sires, the proportion of sires as reflected by simple numbers with breeding values (BV) below

population mean were 29, 33 and 35 and above population mean were 37, 33 and 31 respectively for LSM, BLUP and CC methods Table 1. The percentage of sires above the population mean comes to around 43.9, 50.0 and 53.0%, respectively. Similarly, the proportion of the total sires below the population mean comes to be 56.1, 50.0 and 46.9%, respectively (Table 2).

Mean, minimum and maximum breeding value and range are presented in Table 2. The highest breeding value was observed as 2656.17 kg; whereas the lowest breeding value was 1180.7 kg. Therefore, it may be concluded that as far as discrimination is concerned the LSM was the best amongst the used methods of sire evaluation.

Results of error variance, coefficient of determination and

Table 1. Genetic merit of sires estimated though various sire evaluation methods with their respective ranks

Sire code	LSM	BLUP	CC	No. of progenies	Sire code	LSM	BLUP	CC	No. of progenies
1	323 (8)*	192 (19)	136 (8)	8	77	–6.58 (39)	–22.6 (38)	–0.7(32)	15
3	392 (5)	294 (7)	212 (3)	24	79	–322 (59)	–308 (59)	–134 (56)	8
4	261 (13)	169 (21)	–89.4 (51)	25	81	–161 (51)	–157 (50)	–158 (59)	8
5	–60 (43)	–141 (49)	–86.4 (49)	23	86	–141 (47)	–140 (48)	–148 (58)	8
6	73.9 (32)	–12.2 (36)	55.8 (21)	3	87	275 (12)	255 (11)	84.7 (17)	8
9	20.7 (36)	–58.2 (43)	–80.5 (47)	19	94	281 (10)	216 (16)	150 (7)	3
10	205 (18)	117 (24)	–37.3 (41)	13	102	568 (1)	519 (1)	86.2 (16)	6
12	36.0 (34)	–41.9 (40)	21.4 (27)	31	103	118 (26)	127 (23)	–15.4 (33)	22
14	–205 (55)	–275 (57)	–41.4 (44)	22	110	108 (27)	116 (25)	20.1 (28)	10
21	85.4 (29)	9.61 (33)	–23.9 (36)	7	112	481 (3)	432 (3)	116 (10)	4
22	349 (6)	270 (9)	16.4 (30)	42	116	–455 (63)	–415 (63)	–196 (61)	6
34	307 (9)	230 (13)	18.7 (29)	7	125	476 (4)	447 (2)	88 (15)	5
36	–300 (56)	–310 (60	–87.3 (50)	4	132	–94.6 (45)	–62 (44)	–196 (60)	12
45	–155 (49)	–198 (53)	–25.9 (38)	58	136	–311 (57)	–268 (56)	–120 (55)	8
46	260 (15)	211 (17)	108 (11)	27	139	–1010 (65)	–807 (65)	–254 (63)	4
47	–32.1 (40)	–72.5 (47)	–66. 3 (46)	17	140	237 (16)	233 (12)	160 (6)	5
54	–312 (58)	–339 (61)	–144 (57)	24	141	–1193 (66)	–957 (66)	–295 (66)	3
55	–152 (48)	–179 (51)	–37 (40)	13	146	166 (21)	196 (18)	–24.1 (37)	19
56	77 (31)	39 (31)	51 (22)	7	147	334 (7)	348 (6)	169 (5)	12
57	151 (22)	103 (26)	228 (2)	6	164	–814 (64)	–666 (64)	–287 (65)	5
58	533 (2)	431 (4)	62.8 (20)	4	171	98 (28)	134 (22)	7.72 (31)	4
59	131 (25)	88 (29)	–40.1 (43)	8	215	–158 (50)	–51 (42)	–39.9 (42)	13
60	31.7 (35)	–3.55 (35)	104 (53)	44	218	–121 (46)	–17 (37)	44.3 (23)	7
61	–179 (52)	–204 (55)	–286 (64)	12	219	134 (23)	221 (15)	95.6 (14)	8
62	132 (24)	95.6 (28	96 (13)	26	221	169 (20)	264 (10)	–33.9 (39)	5
65	66 (33)	33.5 (32)	–22 (35)	10	227	–62 (44)	64 (30)	81.3 (18)	6
66	–42.3 (42)	–65.4 (45)	–105 (54)	8	228	–329 (60)	–18 0 (52)	–200 (62)	3
67	261 (14)	226 (14)	187 (4)	21	230	281 (11)	358 (5)	235 (1)	4
70	–202 (54)	–200 (54)	–64 (45)	6	232	–438 (62)	–280 (58)	–102 (52)	4
73	–5.34 (38)	–25.4 (39)	78 (19)	10	233	–199 (53)	–68 (46)	30.3 (24)	3
74	–405 (61)	–409 (62)	–81.2 (48)	23	236	85.2 (30)	171 (20)	23.8 (25)	3
75	16.8 (37)	–2.38 (34)	–17.2 (34)	19	239	206 (17)	274 (8)	23 (26)	3
76	–33.5 (41)	–48.1 (41)	98.9 (12)	36					

*Figures in parenthesis is rank of respective sire.

Table 2. Descriptive details of sires and relative efficiency of different sire evaluation methods

Sire evaluation method	Average breeding value (kg)	Number of sire equal or above average value	Maximum BV (kg)	Minimum BV (Kg)	Difference	Total no. of sire	Error variance (kg^2)	R^2 (%)	CV (%)
CC	2134.43	31 (53.0)	2369.43	1839.43	530	65	-	-	-
LSM	2137.20	37 (43.9)	2705.2	944.2	1761	65	366049.81	25.8	28.31
BLUP	2137.17	33 (50.0)	2656.17	1180.17	1476	65	372196.48	18.7	28.55

*Figure in parenthesis is % of sires.

coefficient of variation were not available for contemporary comparison method. Thus, comparison was not made against contemporary comparison.

The error variance of the different methods of sire evaluation studied along with their relative efficiency is summarized in Table 2. The results indicated that LSM had lower error variance and was adjudged as the more efficient method compared to BLUP method. The values for coefficient of determination were 18.7% for BLUP to 25.8% for LSM indicated that LSM was more accurate method of sire evaluation. Gandhi and Gurnani (1991) compared accuracy of LSM, SRLSM and BLUP methods using R^2 value and revealed that LSM methods was most accurate (R^2 of 15.34) followed by SRLSM and BLUP in that order. Banik (2004) on the other hand found higher R^2 value in DFRML method followed by CC, LSM and SRLSM. The estimates of coefficient of variation were used as criterion to compare the constancy of sire evaluating methods for milk yield. In all the methods of sire evaluation the alteration of coefficient of variation of adjusted data to unadjusted data was very close and similar. As variation was not significant for the different sire evaluation methods therefore, it may be concluded that LSM and BLUP have similar degree of stability. Gandhi and Gurnani (1991) reported that CC and BLUP methods were the least stable methods of sire evaluation while contrary to that Banik (2004) suggested BLUP as the most stable method.

The rank correlations among breeding values of sires estimated from different methods of sire evaluation were all high, and all the values were highly significant (P<0.01) (Table 3).The rank correlation of BLUP with LSM and CC were 0.97 and 0.79, respectively, indicating that BLUP and LSM sire evaluation could select the same set of bulls with almost similar ranking. Raheja (1992), Singh and Parekh (1995), Gaur *et al.* (2001), Banik (2004) and Mukharji (2005) reported high rank correlations between LSM, SRLSM and BLUP methods and recommended that these methods were more or less similar in ranking of dairy sires and any of the methods could be used to obtain unbiased estimates of breeding values of sires. Pundir *et al.* (2004) reported that top 10 sires were common with widely variable ranks in all 4 methods of sire evaluation, viz. simple daughter, LSM, CC and BLUP, based on first lactation yield in Sahiwal cattle. Amongst the used sire evaluation methods LSM and BLUP selected top 6.00% sires (4 out of 66) with same efficiency but with slightly changed ranks. The sire placed at second rank by BLUP was ranked at fourth place by LSM. The top third sire was also ranked same by both the methods. The poorest ranking sire with lowest breeding value was accurately captured by all the 3 methods of evaluation.

Table 3. Product moment correlations (above diagonal) and rank correlations (below diagonal) among different methods of sire evaluation

Methods	CC	LSM	BLUP
CC	1	0.78**	0.79**
LSM	0.78**	1	0.97**
BLUP	0.79**	0.98**	1

The criteria used to compare the sire evaluation methods indicated that LSM was more efficient and more accurate method of sire evaluation compared to BLUP. Sire evaluation methods indicated that we could get top sires by any of these methods with slight change in ranks. Therefore, based on accessibility and computational suitability any of three methods can be used for sire evaluation.

SUMMARY

Three methods of sire evaluation were compared using data on 914 first lactation 305– days milk yield records of Vrindavani cows born out of 66 sires and spread over 23 years to examine the efficiency, accuracy and stability of 3 sire evaluation methods, viz contemporary comparison method (CC), least squares' method (LSM) and best linear unbiased prediction (BLUP). The average breeding value of LSM and BLUP was almost similar; however CC expressed slightly lower value. LSM had the lower error variance compared to BLUP. The values for coefficient of determination were 18.7% for BLUP and 25.8% for LSM. The CV values computed by different method were 28.31 and 28.55% for LSM and BLUP respectively. The used sire evaluation methods indicated that LSM was more efficient and more accurate method of sire evaluation compared to BLUP. All the estimates of simple correlation coefficients along with rank correlation coefficients were high and statistically highly significant, indicated that these sire evaluation methods could select the top bulls with almost similar ranking.

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