



Genetic analysis of trends in production and reproduction traits over years using regression methods in Sahiwal cows

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ABSTRACT

The present study was conducted on first lactation performance records of 820 Sahiwal cows maintained at NDRI, Karnal spread over 54 years (1962–2015) to study the effect of genetic and non-genetic factors on production and reproduction traits, to estimate genetic parameters and the genetic trends by different methods. The traits considered were age at first calving (AFC), first lactation 305 days milk yield (FL305DMY), first lactation total milk yield (FLTMY), first lactation length (FLL) and first calving interval (FCI). The effect of genetic and non-genetic factors like sire, month of birth/calving, period of birth/calving, AFC group and first service period group on normalized production and reproduction traits was assessed by GLM function of Statistical Analysis System (SAS Institute Inc., version 9.2). Paternal half sib correlation method was used to estimate the heritability of different characters. Phenotypic trend per year was estimated as the linear regression of the phenotypic value (P) on time (year). The genetic trend were estimated by Smith I, Smith II, BLUP (Sire Model), BLUP Animal Model methods respectively. The effect of sire was significant for all traits except calving interval. Effect of month was significant for all the traits except for FLTMY. Effect of period was significant for all the traits except FCI. Effect of AFC group was not significant on FCI. The heritability estimates of AFC, FL305DMY, FLTMY, and FLL were 0.45 ± 0.14 , 0.18 ± 0.11 , 0.19 ± 0.10 , 0.16 ± 0.09 , respectively. The repeatability estimate for FL305DMY was 0.45 ± 0.17 . The phenotypic trend of FL305DMY, FLTMY, FLL, AFC and FCI was -19.85 ± 2.17 kg, -26.06 ± 2.4 kg, -3.22 ± 0.26 days, -0.05 ± 0.31 days and 0.041 ± 0.47 days respectively per year and were statistically significant. Genetic trends were positive, significant and in desirable direction in production traits. Regression methods used for the estimation of genetic trends BLUP (Sire Model), BLUP Animal Model are superior to traditional methods because of small standard error. Low magnitude of genetic trend and unfavorable environmental trends indicated the need to increase herd size and improvement in managerial practices. Thus, dairy genetic improvement programmes needed to be redesign appropriate strategies that would be more beneficial to the currently changing scenarios.

Key words: Sahiwal, Trends, BLUP Sire model, BLUP Animal model

In order to maximize genetic gain per unit of time for various traits of economic importance in a breed improvement programme, evaluation of a breeding programme in terms of assessing change in the genetic constitution as well as environmental conditions over time is obligatory. The magnitude and direction of performance trends (phenotypic, genetic and environmental) in a herd indicates effectiveness of breeding programme and helps in developing or modifying appropriate strategies for bringing further genetic improvement. Phenotypic, genetic and environmental trends in production and reproduction

traits are important as these allow for the evaluation of the efficacy of selection and management schemes.

Phenotypic trends are the changes in yearly means over the longer periods which include both the genetic as well as environmental component. Genetic trend reflects the change in mean breeding value due to selection and environmental trend due to cumulative change in various non-genetic factors. The estimates of the trends are essential because they permit comparison of realized trends with expected one in the experimental situation and assessment of progress in a particular trait. Hence, there is a need to periodically evaluate the genetic, environmental and phenotypic parameters and trends in dairy cattle and monitor whether these parameters and trends are progressing in desirable direction for traits of economic importance.

Therefore, it is imperative to separate genetic change from environmental as accurately as possible. So, keeping in view these facts and to fill the gap in information available on genetic trends, the present investigation was planned in Sahiwal cattle.

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MATERIALS AND METHODS

Source of data: The information related to the present study was collected from records on Sahiwal cattle maintained at Animal Genetics and Breeding Division, National Dairy Research Institute (NDRI), Karnal. A total calving record pertaining to 6000 lactations of 1247 Sahiwal cows, spread over 54 years from 1962 to 2015 were collected for the present study.

Editing and normalization of data: The records of the Sahiwal cows with known pedigree were taken for the present study. The animals with abnormal records like abortion, still birth, delayed calving and other reproductive problems were not considered.

The data was edited and normalized by $\text{mean} \pm 2 \text{ S.D.}$ Total 820 Sahiwal cows with first calving normal, 305 days milk yield more than or equal to 500 kg and lactation length more than or equal to 100 days were selected for the study.

Classification of data: The traits considered were age at first calving (AFC), first lactation 305 days milk yield, (FL305DMY), first lactation total milk yield (FLTMY), first lactation length (FLL) and first calving interval (FCI).

Two data sets were prepared and used separately in the analysis. Data set 1 consisted of data structured in to periods and Data set 2 consisted of data structured in years. To estimate least square means and genetic parameters for different traits, Data set 1 was used where as to compute estimated breeding value for the estimation of genetic and environmental trends for different traits Data set 2 was used.

The data were classified and coded on the basis of sire (78 sires), month of birth/calving (12 levels; Jan, Feb, Mar, April, May, June, July, Aug, Sep, Oct, Nov & Dec), year of birth/calving (54 levels), period of calving/birth (4 levels; Before 1962 and 1962–1975, 1982–1996, 1997–2005 & 2006–2014), AFC group (9 levels; taking class interval as 59 viz. <943, 943–1002, 1003–1062, 1063–1121, 1122–1181, 1182–1241, 1242–1301, 1302–1361 and >1362) and FSP group (10 levels; <73, 73–114, 115–156, 157–198, 199–240, 241–282, 283–324, 325–366, 367–409 and >409). The data on AFC and FSP were classified in to groups using the Sturges's formula (Sturges 1926) after normalizing the distribution of data in the population using mean and two standard deviation.

The whole data was classified according to the month of birth/month of calving. One reason behind this classification was vast variation in the environmental temperature status of every month under tropical conditions. Moreover, it is seen that within season also there is monthly variation in the production and reproduction parameters of the animals.

The data considered for this study were spread over a period of 54 years (1962–2015). There could be variation in the expression of different performance traits over the years due to changes in climate, feeding and managerial practices. Therefore, the data were classified in to 45 years (year of birth) and into 48 years (year of calving) to assess the effect of year on different production and reproduction parameters. During the classification of data in to year of

birth/calving and period of birth/calving some of the years were excluded due to a few number of observations in that particular year.

Statistical analysis: The statistical analysis involved three steps.

In the first step of statistical analysis, least square analysis was carried out to compare the effect of genotype and to identify environmental factors that have significant effect on the production and reproduction traits using the GLM function of Statistical Analysis System (SAS Institute Inc., version 9.2). For all models, the significance of the fixed effects was analyzed by using the Tukey test with a significance level of $P < 0.05$.

The mixed linear model equation for the analysis of the effect of genetic and non – genetic factors on AFC was as follows:

$$Y_{ijkl} = \mu + s_i + M_j + P_k + e_{ijkl}$$

where, Y_{ijkl} , Observation on l^{th} cow that is progeny of i^{th} sire and born in j^{th} month, k^{th} period; μ , Overall population mean; s_i , Random effect of i^{th} sire; M_j , Fixed effect of j^{th} month of birth; P_k , Fixed effect of k^{th} period of birth; e_{ijkl} , Random error, which is NID $(0, \sigma_e^2)$

The mixed linear model equation for the analysis of the effect of genetic and non – genetic factors on FL305DMY, FLTMY and FLL was as follows:

$$Y_{ijklmn} = \mu + s_i + P_j + M_k + A_l + D_m + e_{ijklmn}$$

where, Y_{ijklmn} , Observation on the n^{th} animal that is progeny of i^{th} sire, calved in k^{th} month, j^{th} period, and belongs to l^{th} age group, and m^{th} service period group; μ , Overall population mean; s_i , Random effect of i^{th} sire; P_j , Fixed effect of j^{th} period of calving; M_k , Fixed effect of k^{th} month of calving; A_l , Fixed effect of l^{th} AFC group; D_m , Fixed effect of m^{th} FSP group; e_{ijklmn} , Random error, which is NID $(0, \sigma_e^2)$

The following model was used to analyze the effect of genetic and non – genetic factors on FCI:

$$Y_{ijklm} = \mu + s_i + P_j + M_k + A_l + e_{ijklm}$$

where, Y_{ijklm} , Observation on the m^{th} animal that is progeny of i^{th} sire calved in k^{th} month, j^{th} period and belongs to l^{th} age group; μ , Overall population mean; S_i , Random effect of i^{th} sire; P_j , Fixed effect of j^{th} period of calving; M_k , Fixed effect of k^{th} month of calving; A_l , Fixed effect of l^{th} age group; e_{ijklm} , Random error, which is NID $(0, \sigma_e^2)$

In the second step of statistical analysis genetic parameters were estimated. The heritability of different production and reproduction traits were estimated by Paternal Half Sib Correlation Method as per Henderson's Method-3 (Henderson 1953) using Model-2 of the "Mixed Model Least Square and Maximum Likelihood (LSML) Computer Program PC-2" version Harvey (1990). For this, the sire was taken as a random effect and other non-genetic factors (month, period, AFC group, FSP group) were taken as fixed effects.

In the third step, phenotypic, genetic and environmental trends were estimated for each trait. Phenotypic trend per

year was estimated as the linear regression of the phenotypic value (P) on time (year) using the Statistical Analysis System (SAS Institute Inc., version 9.2).

Estimation of genetic trend: Genetic trends was estimated by following methods.

Smith's Methods (I and II): Smith (1962) developed the method of estimation of genetic trends based on the comparison of mean performance of paternal half – sister, in different years.

$$\hat{g} = 2 (b_{PT} - b_{PT/S}) \text{ (SMITH I)}$$

$$\hat{g} = -2 (b_{(P-P)PT/S}) \text{ (SMITH II)}$$

where, $b_{P,T}$, Linear regression of population performance (P) on time; $b_{P,T/S}$, Within sire regression of progeny performance (P) on time (t); $b_{(P-P)T/S}$, Within sire regression of progeny performance on time, each record being expressed as deviation from population mean; g , Genetic trend.

Best Linear Unbiased Prediction Sire Model (BLUP-SM): The expected breeding values of sires were estimated by BLUP mixed model using Model 8 given by Harvey (1990) using PC-2 version of Least Squares Maximum Likelihood (LSML).

$$Y = XB + Z\mu + e$$

where, Y, Vector of observations for trait; β , Vector of observations of fixed effects; μ , Vector of observations of random effect (Sire); X and Z, Incidences matrices pertaining for fixed and random effect.

After predicting the breeding values, genetic trends were estimated by regression of weighted average of sire's transmitting abilities (WAETA) for each year on birth year using the Statistical Analysis System (SAS Institute Inc., version 9.2).

$$WAETA = \sum_{i=1}^n n_{jk} S_i / n.k$$

where, n_{jk} , Number of daughter of i^{th} sire in k^{th} year; S_i , Estimated transmitting ability (ETA) of i^{th} sire; $n.k$, Total number of daughters.

Best Linear Unbiased Prediction Animal Model (BLUP-AM): Best Linear Unbiased Prediction estimates of breeding values of individual animals were estimated by fitting animal model using WOMBAT Statistical Analysis software as;

$$Y = XB + Z\mu + e$$

where, Y, Vector of observations for trait; β , Vector of observations of fixed effects; μ , Vector of observations of random effect (animal); X and Z, Incidences matrices pertaining for fixed and random effect.

After predicting the breeding values of animals, genetic, environmental, phenotypic trends were estimated by regressing mean of breeding values, environmental values and phenotypic values on birth year using the Statistical Analysis System (SAS Institute Inc., version 9.2).

The environmental trend was estimated by subtracting the genetic trend from the phenotypic trend for Smith I and Smith II methods.

$$\Delta E = \Delta P - \Delta G$$

For BLUP (sire model) and BLUP (animal model) the environmental values were estimated as the difference of breeding value from phenotypic value. The environmental trend was then obtained by regressing the environmental value over the birth year for age at first calving and calving year for other traits.

The estimates of trends obtained by different methods were compared by their standard errors.

RESULTS AND DISCUSSION

Estimates of genetic and non-genetic factors: The overall least square means of AFC, FL305DMY, FLTMY, FLL and FCI of Sahiwal cows are presented in Table 1.

Effect of month of birth/calving was significant ($P < 0.01$) in all the traits except FLTMY. Perusal of Table 1 indicated lower FL305DMY during the months of April to September in Sahiwal cattle. Higher overall FL305DMY were obtained in the months of January, February, March, October, November and December. The results revealed that during the cooler months of the year i.e. October – March when there is *ad lib.* availability of lush green fodders, there was an increase in the average milk yield of the animals whereas during hotter months of the year i.e. April -September when the temperature is higher and the availability of lush green fodders is scarce decrease in the average milk yield of the animals was observed. Similar results were reported by many workers (Rehman *et al.* (2008), Dongre *et al.* (2013) and Munde *et al.* (2015)).

Period of birth/calving was also a significant source of variation ($P < 0.01$) for AFC, FL305DY, FLL & FLTMY. The results are in conformity with the findings of Mohanty and Gandhi (2003), Kannan and Gandhi (2004), Kumar *et al.* (2004), Raja and Narula (2005), Banik and Gandhi (2007), Sentitula *et al.* (2008), Manoj *et al.* (2010), Verma *et al.* (2015), Prakash *et al.* (2015) and Singh and Singh (2016).

Age at first calving have significant effect on all the traits except FCI where as service period have significant effect on all the traits included in the model. Similar results were reported by Sentitula *et al.* (2008), Raja *et al.* (2009), Kumar *et al.* (2009), Kathiravan *et al.* (2009), Manoj *et al.* 2010, Monalisa *et al.* 2010, Dongre *et al.* (2013) and Singh and Singh (2016).

Estimates of variance components and genetic parameters: Table 2 represents variance components and heritability estimates for production and reproduction traits. Heritability estimates were higher for AFC (0.45), medium for FL305DMY (0.18), FLTMY (0.19) & FLL (0.16) where as low for FCI (0.03). The heritability estimate for AFC, FL305DMY, FLMY, FLL and FCI obtained in the present study were low to medium and had reasonably low standard errors. The results indicated that these production traits are influenced more by additive genetic variability and hence there is a scope for improvement by selection. Moderate to high estimates of heritability for various production traits were documented by Iiatsia *et al.* (2007) and Chander *et al.* (2008). Comparatively higher estimates of heritability than

Table 1. Least-squares means and SE of first lactation traits in Sahiwal cattle (period of birth in mixed model)

| Effect | AFC (days) | FL305DMY (kg) | FLTMY (kg) | FLL (days) | FCI (days) |
|--------------------------------|-----------------------------------|-------------------------------------|--------------------------------------|------------------------------------|----------------------------------|
| Overall mean | 1114.21±9.14 (820) | 1972.50±65.72 (820) | 2070.41±79.20 (820) | 323.17±7.22 (820) | 444.40±5.41 (820) |
| <i>Month of Birth/Calving</i> | | | | | |
| Jan | 1116.36 ^a ±12.73 (100) | 1845.56 ^a ±76.72 (106) | 2221.93±119.77 (106) | 330.61 ^a ±11.94 (106) | 497.90 ^a ±11.54 (106) |
| Feb | 1110.08 ^b ±14.08 (70) | 1912.63 ^a ±76.59 (98) | 2100.08±117.85 (98) | 338.96 ^a ±11.72 (98) | 476.19 ^b ±11.56 (98) |
| Mar | 1103.24 ^b ±11.84 (104) | 1835.99 ^a ±76.86 (104) | 2252.09±116.24 (104) | 338.20 ^a ±11.54 (104) | 449.32 ^c ±11.34 (104) |
| April | 1107.06 ^b ±13.21 (80) | 1545.43 ^c ±77.86 (103) | 2269.38±116.78 (103) | 345.81 ^a ±11.60 (103) | 439.67 ^d ±11.31 (103) |
| May | 1104.60 ^b ±18.7 (36) | 1477.21 ^c ±91.75 (74) | 2149.68±131.92 (74) | 276.09 ^b ±13.29 (74) | 434.10 ^d ±13.61 (74) |
| June | 1098.47 ^b ±16.18 (52) | 1635.56 ^b ±112.01 (44) | 2256.10±155.71 (44) | 307.79 ^b ±15.91 (44) | 432.41 ^d ±16.92 (44) |
| July | 1087.03 ^c ±18.36 (84) | 1642.56 ^b ±112.07 (41) | 2048.56±159.78 (41) | 307.44 ^b ±16.36 (41) | 431.15 ^d ±17.29 (41) |
| Aug | 1072.25 ^c ±14.80 (60) | 1685.89 ^b ±126.87 (32) | 1942.50±178.97 (32) | 315.6 ^b ±18.45 (32) | 439.38 ^d ±19.75 (32) |
| Sep | 1095.8 ^b ±17.75 (42) | 1599.79 ^c ±189.17 (42) | 2003.54±234.02 (42) | 321.98 ^b ±24.38 (42) | 447.27 ^c ±26.65 (42) |
| Oct | 1111.22 ^a ±18.54 (88) | 1832.21 ^a ±180.68 (70) | 1678.38±223.54 (70) | 321.98 ^b ±23.25 (70) | 453.88 ^c ±25.29 (70) |
| Nov | 1112.62 ^a ±16.25 (49) | 1740.05 ^a ±158.71 (51) | 1912.02±196.09 (51) | 323.65 ^b ±20.30 (51) | 491.82 ^a ±22.28 (51) |
| Dec | 1114.88 ^a ±15.91 (55) | 1760.03 ^a ±121.16 (55) | 2010.33±149.13 (55) | 350.11 ^a ±15.19 (55) | 499.40 ^a ±15.55 (55) |
| <i>Period of Birth/Calving</i> | | | | | |
| <1962 and 1962–1975 | 1072.93 ^a ±55.89 (220) | 2385.21 ^c ±454.69 (193) | 3316.56 ^c ±569.51 (193) | 458.23 ^d ±60.09 (193) | 526.20±66.96 (193) |
| 1982–1996 | 1049.46 ^b ±24.30 (227) | 2053.20 ^c ±171.86 (227) | 2355.33 ^c ±228.82 (227) | 325.84 ^c ±23.83 (227) | 409.19±25.85 (227) |
| 1997–2005 | 1121.43 ^c ±24.29 (213) | 1286.17 ^a ±188.26 (213) | 1408.65 ^a ±248.15 (213) | 254.33 ^a ±25.90 (213) | 427.61±28.30 (213) |
| 2006–2011 | 1213.33 ^a ±26.01 (160) | 1125.43 ^b ±192.78 (187) | 1200.89 ^b ±250.77 (187) | 254.29 ^b ±26.18 (187) | 414.59±28.66 (187) |
| <i>AFC Group</i> | | | | | |
| <943 | - | 1686.88 ^{ba} ±161.85 (51) | 2150.63 ^c ±199.97 (51) | 332.92 ^{bc} ±20.72 (51) | 439.64±22.06 (51) |
| 943–1002 | - | 1599.79 ^{abc} ±131.31 (70) | 1968.61 ^{abc} ±161.83 (70) | 321.48 ^{ab} ±16.58 (70) | 454.96±17.39 (70) |
| 1003–1062 | - | 1456.09 ^a ±109.42 (68) | 1752.74 ^a ±134.42 (68) | 294.52 ^a ±13.57 (68) | 450.35±14.00 (68) |
| 1063–1121 | - | 1644.56 ^a ±91.02 (134) | 1979.78 ^{ab} ±111.28 (134) | 327.53 ^a ±10.98 (134) | 439.86±10.71 (134) |
| 1122–1181 | - | 1743.40 ^{ab} ±86.28 (149) | 2125.18 ^{ab} ±105.30 (149) | 333.07 ^{ab} ±10.30 (149) | 453.67±9.87 (149) |
| 1182–1241 | - | 1677.71 ^{ab} ±94.08 (113) | 1965.54 ^{ab} ±115.14 (113) | 313.71 ^a ±11.41 (113) | 430.82±11.16 (113) |
| 1242–1301 | - | 1861.51 ^{abc} ±112.98 (65) | 2263.58 ^{bc} ±138.88 (65) | 323.96 ^{ab} ±14.06 (65) | 445.61±14.48 (65) |
| 1302–1361 | - | 1979.89 ^c ±119.92 (101) | 2355.79 ^c ±147.58 (101) | 353.01 ^c ±15.02 (101) | 435.00±15.77 (101) |
| >1362 | - | 1762.69 ^{ab} ±112.22 (69) | 2071.83 ^{ab} ±137.93 (69) | 308.53 ^a ±13.96 (69) | 449.65±14.34 (69) |
| <i>Service Period Group</i> | | | | | |
| <73 | - | 1461.39 ^a ±84.21 (29) | 1515.05 ^a ±102.68 (29) | 237.90 ^a ±10.00 (29) | - |
| 73–114 | - | 1469.55 ^{ab} ±77.69 (154) | 1512.03 ^{ab} ±94.44 (154) | 255.09 ^{ab} ±9.04 (154) | - |
| 115–156 | - | 1705.96 ^{abc} ±87.30 (185) | 1895.28 ^{abc} ±106.59 (185) | 288.38 ^{bc} ±10.45 (185) | - |
| 157–198 | - | 1671.07 ^{abc} ±98.52 (119) | 1899.47 ^{bc} ±120.72 (119) | 299.36 ^{bcd} ±12.04 (119) | - |
| 199–240 | - | 1738.60 ^{abc} ±114.02 (88) | 2016.75 ^{bc} ±140.18 (88) | 316.92 ^{cde} ±14.21 (88) | - |
| 241–282 | - | 1762.67 ^{abc} ±136.28 (55) | 2161.78 ^c ±168.04 (55) | 340.98 ^{de} ±17.26 (55) | - |
| 283–324 | - | 1831.91 ^{bc} ±184.04 (36) | 2416.06 ^{de} ±228.88 (36) | 382.36 ^f ±23.83 (36) | - |
| 325–366 | - | 1825.23 ^{ab} ±200.04 (68) | 2266.98 ^{bc} ±248.01 (68) | 355.35 ^{de} ±25.89 (68) | - |
| 367–409 | - | 1601.45 ^{abc} ±177.41 (40) | 2210.96 ^{cd} ±219.03 (40) | 352.06 ^{ef} ±22.77 (40) | - |
| >409 | - | 2057.22 ^c ±149.52 (46) | 2809.73 ^c ±184.58 (46) | 403.34 ^f ±19.06 (46) | - |

Categorization according to date of birth was used for AFC column only. Figures in parentheses are number of observations. As degree of freedom will be one less than number of observations. Means bearing different superscripts among subclasses differed significantly at P<0.05. Effect of sire was found to be significant (P<0.01) in all the traits except calving interval.

the present study was reported by Kumar *et al.* (2009) and Hussain *et al.* (2014). However, lower estimates of heritability were reported by Javed *et al.* (2001), Rehman *et al.* (2008), Khan *et al.* (2008), Dongre *et al.* (2013), Shinghare *et al.* (2015), Verma *et al.* (2015) and Singh and Singh (2016).

Genetic and environmental trends: The year wise trends for production and reproduction traits are presented in Figs 1–4. The estimates of phenotypic, genetic and

Table 2. Estimates of variance components and genetic parameters for production and reproduction traits

| Estimate | AFC | FL305DMY | FLTMY | FLL | FCI |
|--------------|-----------|-----------|------------|----------|----------|
| σ_s^2 | 2471.3463 | 23468.21 | 41760.4576 | 418.01 | 88.55 |
| σ_e^2 | 12707.48 | 585957.87 | 818533.84 | 10011.00 | 10639.24 |
| h^2 | 0.45 | 0.18 | 0.19 | 0.16 | 0.03 |
| S.E. | 0.14 | 0.11 | 0.10 | 0.09 | 0.08 |

environmental trends are presented in Table 3.

Age at first calving: The estimate of phenotypic trend was -0.05 ± 0.315 days/year. The decreasing trend in AFC as observed in present study is desirable. The opposite direction of genetic trend of age at first calving obtained by Smith I, Smith II and BLUP animal model in this study is desirable and indicates the good managerial status of the farm. Similar negative genetic trend in age at first calving was obtained by Vergera *et al.* (2009), Effa *et al.* (2011), Balasubramaniam *et al.* (2013), Osman *et al.* (2013), Chaudhari *et al.* (2014), Bernardes *et al.* (2015), and Shinghare *et al.* (2015). Present results are in contrary to the results of Raja and Narula (2005) and Prata *et al.* (2015).

First lactation 305 days milk yield: The estimate of phenotypic trend was -19.85 ± 2.17 kg/year and was significant. The estimate of genetic trends for FL305DMY was positive in all the methods exhibiting positive genetic improvement in the trait.

First lactation total milk yield: The estimate of phenotypic trend was -26.06 ± 2.4 kg/year and is significant.

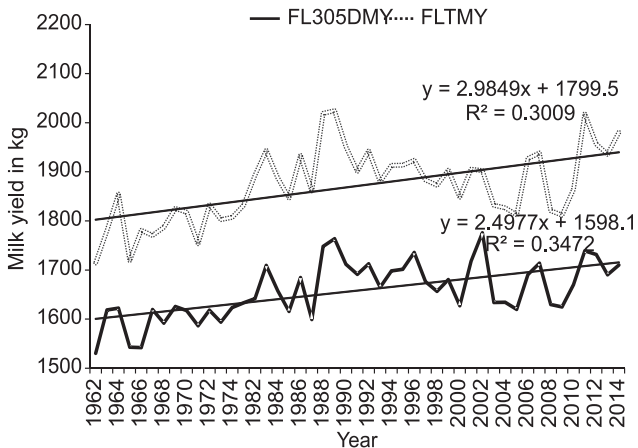


Fig. 1. Yearly mean EBV for FL305DMY & FLTMY and trends over years

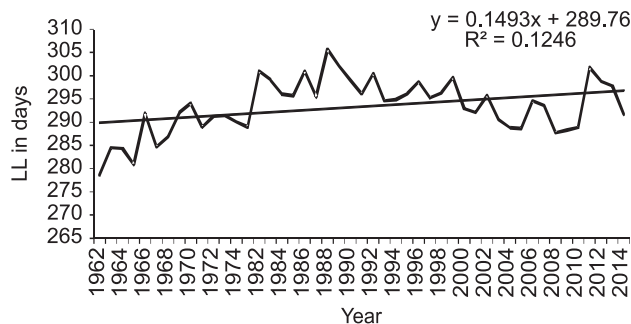


Fig. 2. Yearly mean EBV for FLL and trends over years

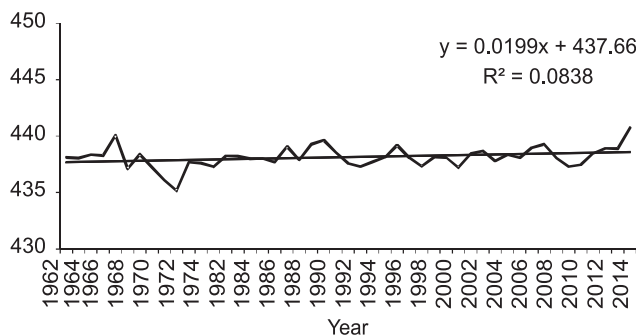


Fig. 3. Yearly mean EBV for FCI and trends over years

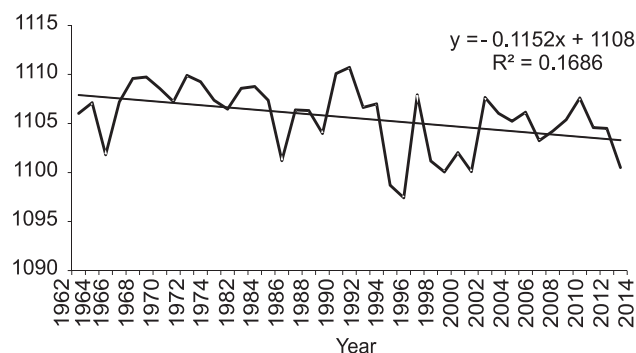


Fig. 4. Yearly mean EBV for AFC and trends over years

Table 3. Phenotypic, genetic and environmental trends for first lactation traits using different methods in Sahiwal cows

| Trait | Trend | Smith I | Smith II | BLUP Sire Model | BLUP Animal Model |
|---------------|----------|------------------------|------------------------|-------------------|-------------------|
| AFC (days) | <i>p</i> | -0.05 ± 0.315 | | | |
| | <i>g</i> | $-17.90 \pm 2.76^{**}$ | $-13.56 \pm 3.65^{**}$ | $1.97 \pm 0.05^*$ | -0.09 ± 0.02 |
| | <i>e</i> | 17.95 ± 2.77 | 13.61 ± 3.66 | -2.02 ± 0.31 | 0.04 ± 0.31 |
| FL305DMY (kg) | <i>p</i> | $-19.85 \pm 2.17^{**}$ | | | |
| | <i>g</i> | $18.88 \pm 7.9^*$ | 20.95 ± 9.49 | 0.021 ± 0.22 | $1.72 \pm 0.50^*$ |
| | <i>e</i> | -38.73 ± 8.19 | -40.80 ± 9.49 | -19.87 ± 2.17 | -21.57 ± 2.2 |
| FLTMY (kg) | <i>p</i> | $-26.06 \pm 2.4^{**}$ | | | |
| | <i>g</i> | 20.31 ± 23.4 | 22.86 ± 25.41 | 0.13 ± 0.27 | $2.08 \pm 0.68^*$ |
| | <i>e</i> | -46.37 ± 23.60 | -48.92 ± 25.50 | -26.19 ± 1.82 | -28.14 ± 2.49 |
| FLL (days) | <i>p</i> | $-3.22 \pm 0.26^{**}$ | | | |
| | <i>g</i> | $20.31 \pm 3.48^{**}$ | -0.50 ± 2.8 | 0.005 ± 0.02 | 0.03 ± 0.04 |
| | <i>e</i> | -23.53 ± 3.48 | -3.72 ± 2.81 | -3.225 ± 0.06 | -3.25 ± 0.26 |
| FCI (days) | <i>p</i> | 0.041 ± 0.47 | | | |
| | <i>g</i> | 1.48 ± 0.87 | $2.19 \pm 0.09^*$ | 0.105 ± 0.06 | 0.031 ± 0.007 |
| | <i>e</i> | -1.43 ± 0.98 | -2.14 ± 0.47 | -0.06 ± 0.47 | 0.01 ± 0.46 |

*indicates significance at $P < 0.05$ and ** indicates significance at $P < 0.01$

The estimate of genetic trends for FLTMY was positive in all the methods exhibiting positive genetic improvement in the trait.

The present study indicates that the desirable genetic improvement was achieved in FLTMY & FL305DMY at National Dairy Research Institute (NDRI) farm over the period of 54 years of the study. However the environmental trend in negative direction nullified the genetic gain. In other words the negative environmental trends indicate that the genetic potential of the Sahiwal animals was increased over years but environmental factors have reduced its effect on phenotypic values. Thus the production potential of animals can be increased by improving managerial practices. Similar positive genetic trend in FL305DMY and FLTMY was obtained by Singh and Nagarcenkar (2000), Hansen (2000), Mohsen *et al.* (2000), Marquez *et al.* (2003), Raja and Narula (2005), Kunaka *et al.* (2005), Peixoto *et al.* (2006), Kumar *et al.* (2007), Gaidarska (2009), Bakir *et al.* (2009), Zafer *et al.* (2010), Ali (2010), Yaeghoobi *et al.* (2011), Sarkul *et al.* (2011), Bujko *et al.* (2011), Golverdi *et al.* (2012), Osman *et al.* (2013), Hussain *et al.* (2014), Ramatsoma *et al.* (2014), Cayo *et al.* (2015), Prata *et al.* (2015), Shinghare *et al.* (2015), Dash *et al.* (2016) and Pezeshkian *et al.* (2016), where as negative genetic trend in these traits were obtained by Effa *et al.* (2011), Hossen *et al.* (2012), Sahin *et al.* (2012) and Chaudhari *et al.* (2014).

First lactation length: The estimate of phenotypic trend for FLL was -3.22 ± 0.26 day/yr and is significant. Positive genetic trend in the trait indicated slight genetic improvement in the traits over year. Positive genetic trend in the trait was also obtained by Osman *et al.* (2013), Chaudhari *et al.* (2014) and Shinghare *et al.* (2015) in contrary to the result of the present study the negative trends was obtained by Mohsen *et al.* (2000), Effa *et al.* (2011) and Sahin *et al.* (2012).

First calving interval: The estimate of phenotypic trend for FCI was 0.041 ± 0.47 days/yr with high standard error the phenotypic gain is negligible. In this study positive genetic trend in the trait was obtained that is non-desirable. This trait was having low heritability thus highly dependent on environmental factors and can be improved by appropriate managerial practices. Positive genetic trends similar to the present study were also reported by Osman *et al.* (2013), Chaudhari *et al.* (2014), Ramatsoma *et al.* (2014), Bernardes *et al.* (2015), Prata *et al.* (2015) and Shinghare *et al.* (2015) where as negative genetic trend was obtained by Mohsen *et al.* (2000), Vergera *et al.* (2009), Effa *et al.* (2011) and Ghiasi *et al.* (2016).

Regression methods used for the estimation of genetic trends, viz. BLUP (Sire Model), BLUP Animal Model respectively were superior to traditional methods because of small standard error and give authentic trends value over years. Low magnitude of genetic trend and unfavorable environmental trends indicated that there is need to increase herd size and improvement in managerial practices. The herd size can be increased by associating the institute herd with the other organized herds and which will ensure

increase intensity and accuracy of selection.

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