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Effects of non-genetic factors on production performance traits in Hardhenu crossbreed cattle

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Abstract
The data on 862 Hadhenu cattle sired by 63 pertaining to production performance traits up to five lactation were collected from history cum pedigree sheets maintained at Cattle Breeding Farm (CBF), Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar over a period of 20 years from 1997 to 2016. Analysis of variance done by restricted maximum likelihood method of Harvey (1990) using mixed linear model in which fixed effect of period, season of calving and random effect of parity was taken into consideration. The overall least-squares means for production performance traits viz. lactation milk yield (LMY), lactation milk yield-305 (LMY-305), lactation length (LL), peak yield (PY), average daily milk yield (AMY), milk yield per day of calving interval (MCI), milk yield per day of age at second calving (MSC) persistency, age at first calving (AFC), service period (S.P), calving interval (CI) and dry period (DP) were 3111.81± 110.17 kg, 2929.45±90.63 kg, 310.57±6.48 days, 14.65±0.48 kg/day, 9.92±0.24 kg/day, 7.80±0.23 kg/day, 1.93±0.07 kg/day, 208.94±5.86 days, 1235.22±19.53 days, 113.85±4.55 days, 401.65±5.53 days and 87.19±4.08 days, respectively. With regard to production performance traits, the effect of period of calving was statistically significant on all the traits except on AFC, SP, CI and DP. While, the effect of season of calving was non-significant on all the production performance traits except significant effect on AFC, SP, CI and DP. The effect of parity was found to be statistically significant ($p<0.01$), ($p<0.05$) on all the traits except on LL, PY, SP and CI. These differences in these traits might be attributed to variation in managemental practices and feeding regimes being followed at the farm. Moreover, the performance records of an animal should be corrected for classifiable non-genetic sources of variation, which is essential for obtaining precise estimates of genetic parameters.

Keywords: crossbreed cattle, genetic factors, non-genetic factors, production performance traits

Introduction

India occupies pre-eminent position in milk production with an annual output of 165.40 million tonnes accounting for 18.5 per cent of world production. Out of which, share of milk production by exotic/crossbred cows was 25% and that of indigenous/non-descript was 20% (BAHS, 2017). Out of the 190.90 million cattle population, crossbred population was 19.42 million while that of indigenous was 48.12 million (19th Livestock census). Crossing Zebu cattle (Bos indicus) with temperate breed (*Bos taurus*), undertaken for improving the milk production to cater the needs of ever increasing human population has led to the synthesis of several new crossbred strains of cattle. During late nineties Frieswal bulls were also used on synthetic dams having a composition of Friesian and indigenous Hariana cattle at Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS) formerly CCS, HAU, Hisar, animal farm. The principle objective was identification of superior breeding bulls and faster multiplication of their progenies in rural and urban farmers of Haryana state in particular and whole of country in general. Hardhenu, is a cross between North American Holstein Friesian, Hariana and Sahiwal breeds with a inheritance ratio of exotic to indigenous as 62.5%: 37.5%.

In fact, the economy of dairy industry mainly rely upon the performance parameters of dairy animals, therefore, it becomes more relevant to tackle out the means for ameliorating the performance parameters by developing certain guidelines for selection. In most of the genetic improvement programmes in the country selection has been focussed on production traits and fertility performance of the animal has not been given the due emphasis. Though such selection would slow down the rate of improvement in productivity of dairy cattle, however such reduction can be more than compensated by simultaneous improvement in fertility traits. Further, multi trait selection has been advocated under Indian conditions due to small number of daughters per sire; as such selection will improve the accuracy and efficiency of sire evaluation (Sahana and Gurnani, 1999) [34].

Therefore, including fertility along with production traits in sire evaluation would enable genetic improvement in production potential along with improvement in fertility traits. The non-genetic factors (e.g. environmental) have an important bearing on these traits and directly obscure recognition of genetic potential. Moreover, the performance records of an animal should be corrected for classifiable non-genetic sources of variation, which is essential for obtaining precise estimates of genetic parameters. Hence, knowledge of non-genetic factors and their influence on reproductive performance is important in formulation of management and selection decisions (Goyache *et al.*, 2003) [15].

2. Materials and Methods

The data on 862 crossbreed cattle pertaining to production performance traits up to five lactations were collected from history cum pedigree sheets maintained at Cattle Breeding Farm (CBF), Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar over a period of 20 years from 1997 to 2016 were analysed to study the genetic parameters. Animals having lactation shorter than 100 days, suspected outliers on the basis of histograms and abnormal records like abortion, mastitis and chronic illness were excluded from present study. Following production performance traits was recorded up to fifth lactations: LMY (Lactation milk yield in kg), LMY-305 (305 days milk yield in kg), LL (Lactation length in days), PY (Lactation peak milk yield in kg/day), AMY (Average daily milk yield = LMY/LL in kg/day), MCI (Milk yield per day of calving interval in kg/day), MSC (Milk yield per day of age at second calving in kg/day), persistency (Persistency in days), age at first calving (AFC), SP (Service period in days) and CI (Calving interval in days) and DP (dry period in days). Assuming that there is not much variation in adjacent years, entire period of twenty years was divided into five equal periods from 1997-2000, 2001-2004, 2005-2008, 2009-2012 and 2013-2016. Each year was further delineated into 4 seasons of calving according to the prevailing agro-climatic conditions in the region viz., Summer (April to June), Rainy (July to September), Autumn (October to November) and Winter (November to March). In order to overcome non-orthogonality of the data due to unequal subclass frequencies, least squares and maximum likelihood computer program of Harvey (1990) [16] was utilized to estimate the effect of various tangible factors on production performance traits. The following statistical model will be used to explain the underlying biology of the traits included in the study.

$$Y_{ijklm} = \mu + S_i + P_j + C_k + R_l + e_{ijklm}$$

Where, Y_{ijklm} = mthrecord of individual calved in jth period, kth season and lth parity pertaining to ithsire, μ= is the overall population mean, S_i = is the random effect of ith sire, P_j = is the fixed effect of jth period of calving, C_k = is the fixed effect of kth season of calving, R_l = is the fixed effect of lth parity, e_{ijkl} = is the random error associated with each and every observation and assumed to be normally and independently distributed with mean zero and variance σ^2 e.

3. Results and Discussion

The overall least- squares means for production performance traits viz. lactation milk yield (LMY), lactation milk yield-305 (LMY-305), lactation length (LL), peak yield (PY), average daily milk yield (AMY), milk yield per day of calving interval (MCI), milk yield per day of age at second calving (MSC), persistency, age at first calving (AFC), service period (SP), calving interval (CI) and dry period (DP) were 3111.81± 110.17 kg, 2929.45±90.63 kg, 310.57±6.48 days, 14.65±0.48 kg/day, 9.92±0.24 kg/day, 7.80±0.23 kg/day, 1.93±0.07 kg/day, 208.94±5.86 days, 1235.22±19.53 days, 113.85±4.55 days, 401.65±5.53 days and 87.19±4.08 days, respectively (Table 2). Similar results for LMY were reported by Singh *et al*. (2008) [36] in Sahiwal cross. The higher estimates are also available in the literature by Nehra *et al*. (2011) [29] and Al-Samarai *et al*. (2015) [2] in crossbreed cattle. Whereas, lower estimates were reported by Kharat *et al.* (2008) [21], Kumar *et al.* (2008) [32], Jadhav *et al.* (2010) [19], Saha *et al*. (2010) [37], Wondifraw *et al*. (2013) [47], Kumar *et al*. (2014) [24], Verma *et al.* (2016) [45, 46] in crossbreed and Basak *et al.* (2018) [5] in Deoni cattle. The overall least-squares means of present investigation for LMY-305 are in agreement with the findings of Kokate (2009), Dash *et al*. (2016) [14] and Kakati *et. al.* (2017) in crossbreed cattle. However, higher estimates were reported by Divya (2012) [11], Katok and Yanar (2012) [23], M'hamdi *et al*. (2012) [17] and Japheth *et al.* (2015) [20]. On the other hand, lower estimates were reported by Lakshmi *et al*. (2009) [28], Dandapat *et al*. (2010) [9], Saha *et al*. (2010) [37], Hassan and Khan (2013) [18], Wondifraw *et al*. (2013) [47], Kumar (2016) and Verma *et al*. (2016) [45, 46]. The overall least-squares mean for LL was obtained as 310.57±6.48 days is in approximation with Kumar *et al*. (2008) [32] and M'hamdi *et al*. (2012) [17]. Compare to present finding, Lakshmi *et al.* (2009) [28], Jadhav *et al*. (2010) [19], Saha *et al*. (2010) [37], Sawant *et al.* (2016) [41], Dash *et al.* (2016) [14] and Poudal *et al*. (2017) [31] reported higher estimates of LL than the present findings. Whereas, Ahmed *et al* (2007) [1], Wondifraw *et al*. (2013) [47], Bhutkar *et al*. (2014) [3], Kumar *et al*. (2014) [24], Japheth *et al.* (2015) [20], Narwaria *et al*. (2015) and Kakati *et. al.* (2017) reported lower estimates of LL than the present study. On the contrary, lower estimates for PY were obtained by many workers (Lakshmi *et al*. 2009; Singh *et al*. 2011, Bhutkar *et al*. 2014; Kumar, 2015 and Verma *et al.* 2016) [28, 38, 3, 25, 45, 46] in different breeds of cattle. However, slightly higher estimates for AMY were reported by Divya *et al.* (2014) [12] and Japheth *et al.* (2015) [20]. On the other hand, lower estimates for AMY are also available in the literature (Lakshmi *et al.* 2009; Verma and Thakur, 2013; Wondifraw *et al*. 2013; Dhawan *et al*. 2015; Dash *et al*. 2016 and Ratwan *et al.* 2017) [28, 44, 47, 14, 33]. However, slightly higher estimates for MCI were reported by Singh and Gurnani (2004) [35], Tekerli and Gundogan (2005) [43], Divya *et al.* (2014) [12], Japheth *et al.* (2015) [20] and Dash *et al.* (2016) [14]. On the other hand, lower estimates are also available in the literature (Das *et al*. 2002; Lakshmi *et al.* 2009; Verma and Thakur, 2013 and Ratwan *et al.* 2017) [7, 28, 44, 33]. However, slightly higher estimates were reported by Tekerli and Gundogan (2005) [43] in Holstein cattle. On the other hand, lower estimates for MSC were reported in literature by Dhaka *et al.* (2002) [8], Dhawan *et al*. (2015) and Verma *et al.* (2016) [45, 46]. However lower estimates for Persistency were reported in literature by Patond *et al*. (2014), Sahito *et al*. (2016) [40] and Sharma *et al.* (2018) in different breeds of cattle. Higher estimates were obtained by Singh *et al*. (2008) [36] and Hassan and Khan (2013) [18]. However, lower estimates for AFC were obtained by Kumar *et al.* (2008) [22], Nehra (2011) [29], Divya (2012), Chaudhari *et al.* (2013) [6], Singh *et al*. (2014) [39], Raja and Gandhi (2015) [32] and Kumar *et al.* (2017) [33]. The present findings for SP are in consonance as reported by Dash *et al* (2016) [14]. However, higher estimates were obtained by Saha *et al.* (2010) [37], Chaudhari *et al*. (2013) [6], Hassan and Khan (2013) [18], Divya *et al.* (2014) [12], Goshu *et al*. (2014), Kumar (2015) [25], Raja and Gandhi (2015) [32], and Basak *et al*. (2018) [5]. The present findings for CI were in unison with those reported by Dash *et al.* (2016) [14]. However, higher estimates were reported by Singh *et al*. (2008) [36], Saha *et al.* (2010) [37], Nehra (2011) [29], Divya (2012) [11], Chaudhari *et al.* (2013) [6] in crossbreed cattle. However, higher estimates for DP were reported in literature by many workers (Chaudhari *et al.* 2013; Hassan and Khan, 2013; Bhutkar *et al.* 2014; Dhawan *et al.* 2015; Kumar *et al*. 2015; Raja and Gandhi, 2015 and Sawant *et al.* 2016) [6, 18, 3, 32, 41] in crossbreed cattle. On the contrary, lower value was reported by Ahmed *et al.* (2007) [1] (Table 2).

In this present investigation, the effect of period of calving was statistically significant (p<0.01) on LMY (Table 1). Similar, findings were reported by Kumar *et al.* (2008), Singh *et al*. (2008) [36], Lakshmi *et al.* (2009) [28], Saha *et al*. (2010) [37], Wondifraw *et al*. (2013) [47], Al-Samarai *et al*. (2015) [2], Japheth *et al*. (2015) [20] and Verma *et al.* (2016) [45, 46]. Whereas, non-significant by Kharat *et al.* (2008) [21], Nehra *et al.* (2012) and Kumar (2014) [24] in crossbred cattle. The period wise least-squares mean for LMY indicated that it was the highest (3549.32±154.46 kg) for cows calved during fifth period (2013-2016) and the lowest (2829.82±148.96 kg) for cows calved during second period (2001-2004). The least-squares mean of LMY for cows calved during first, second, third and fourth period did not differ significantly among themselves. Also an increasing trend was obtained for LMY over periods yet it showed remarkably better performance for LMY during later period (third to fifth) indicating that selection for this trait was in desirable direction. It might be due to better management and feeding and practices followed at farm during the fifth period (2013-16). The significant (p<0.01) effect of period of calving on LMY-305 is in consonance with those reported by Kokate (2009), Lakshmi *et al.* (2009) [28], Saha *et al*. (2010) [37], M'hamdi *et al*. (2012) [17], Wondifraw *et al*. (2013) [47], Japheth *et al.* (2015) [20], Dash *et al.* (2016) [14] and Verma *et. al.* (2017) in crossbreed cattle. Whereas, Divya (2012) [11], Kumar (2015) [25] and Kokati *et. al.* (2017) reported non-significant effect of period of calving on LMY-305. The period-wise least-squares means for LMY-305 indicated that it was the highest (3427.28±146.51 kg) for cows calved during fifth period (2013-2016) and the lowest (2623.80±125.35) for cows calved during second period (2001-2004). The least-squares means of LMY-305 for cows calved during second, third and fourth period did not differ significantly among themselves, however, differed significantly from those cows calved during fifth period (2013 to 2016). An, increasing trend was obtained for LMY-305 over periods and it showed remarkably better performance for LMY-305 during later period indicating that selection for this trait was in desirable direction. Significant (p<0.01) effect of period of calving on LL was reported in present study. The present findings were supported by Kumar *et al*. (2008), Lakshmi *et al.* (2009) [28], M'hamdi *et al*. (2012) [17], Wondifraw *et al*. (2013) [47], Al-Samarai *et al*. (2015) [2], Japheth *et al.* (2015) [20], Narwaria *et al*. (2015), Dash *et al.* (2016) [14] and Kakati *et al.* (2017) in crossbreed cattle. Repugnant to above, non-significant effect of period of calving on LL was reported by Ahmed *et al.* (2007) [1], Jadhav *et al.* (2010) [19], Saha *et al*. (2010) [37] and Kumar *et al.* (2014) [24] in crossbreed cattle. The period wise least squares mean for LL indicated that it was the highest (325.78 days) for cows calved during fourth period (2009-2012) and the lowest (299.21 days) for cows calved during second period (2001-2004). However, no definite trend was obtained for averages of LL over different periods. The effect of period of calving on PY was found to be significant. Similar results were also reported by Lakshmi *et al.* (2009) [28], Bhuktar *et al.* (2014) [3] and Verma *et al.* (2016) [45, 46]. However, non-significant effect was reported by Kumar *et al.* (2014) [24] and Kumar (2015) [25]. The period wise least-squares mean for PY indicated that it was the highest (16.08±0.62 kg/day) for animals calving during fifth period (2013-2016) and the lowest (13.41±1.02 kg/day) for animals calving during first period (1997-2000). However, an increasing trend was obtained for averages of PY over different periods. Also, least-squares means for PY of the cows calved during first to fourth parity did not differ significantly among themselves. Similarly, PY of cows calved during third to fifth parity did not differ significantly among themselves. The effect of period of calving on AMY was found to be significant. The present results are in close agreement with the results of Lakshmi *et al.* (2009) [28], Wondifraw *et al*. (2013) [47], Divya *et al.* (2014) [12], Dhawan *et al.* (2015), Japheth *et al.* (2015) [20], Dash *et al.* (2016) [14] and Ratwan *et al.* (2017) [33]. Whereas, Verma and Thakur (2013) [44] found non-significant effect of period of calving on AMY in crossbred cattle. The period wise least-squares means for AMY indicated that it was the highest (11.53±0.40 kg/day) for cows calved during fifth period (2013-2016) and the lowest (9.15±0.29 kg/day) for cows calved during third period (2005-2008). The least-squares mean of AMY for cows calved during second, third and fourth period did not differ significantly among themselves, however, differed significantly from those cows calved during fifth period (2013 to 2016). The analysis of variance revealed that season of calving had significant effect on MCI. The results of present study are in congruence with those reported by Singh and Gurnani (2004) [35], Tekerli and Gundogan (2005) [43], Lakshmi *et al.* (2009) [28], Japheth *et al.* (2015) [20], Dash *et al.* (2016) [14] and Ratwan *et al.* (2017). While, the opposite results were reported by Divya *et al.* (2014) [12] and Verma *et. al.* (2017). The period wise least squares mean for MCI indicated that it was the highest (9.03 kg/day) for animals calved during fifth period (2013-2016) and the lowest (7.09 kg/day) for animals calved during second period (1997-2000). The perusal of results indicated that least-squares mean of MCI for cows calved during first to fourth period did not differ significantly among themselves, however, differed significantly from those calved during fifth period. Moreover, an increasing trend was obtained for means of MCI over second to fifth periods. The significant effect (p<0.01) of period of calving on MSC obtained under the present study in conformity to the results reported by Tekerli and Gundogan (2005) [43], Dhawan *et al.* (2011), Verma *et al.* (2016) [45, 46]. Repugnant to above, non-significant effect was reported by Dhaka *et al.* (2002) [8]. The period wise least-squares mean for MSC indicated that it was the highest (2.13 kg/day) for animals calved during fifth period (2013-2016) and the lowest (1.77 kg/day) for animals calved during second period (1997-2000). Similar to the earlier production traits, an increasing trend was obtained for means of MSC from third to fifth period which could be attributed to better management and feeding practices being followed at the farm. Significant effect of period of calving (p<0.01) on persistency was obtained under the present study. These results are in unison with those reported by Patond *et al* (2014) in Jersey and

Sharma *et al.* (2018) in crossbreed cattle. On the contrary, non-significant effect of period of calving was reported by Sahito *et al*. (2016) [40] in Red Sindhi cattle. The period wise least-squares mean for persistency indicated that it was the highest (227.30 days) for animals calved during fifth period (2013-2016) and the lowest (187.48 days) for animals calved during third period (2005-2008). Moreover, no definite trend was obtained for means of persistency over different periods. Non-significant effect of period of calving on AFC was reported in present study. These results were in unison with those reported by Nehra (2011) [29] in Karan-Fries cattle. Whereas, significant effect of period of calving on AFC was reported by many researchers (Kumar *et al.* 2008; Singh *et al*. 2008; Divya, 2012; Chaudhari *et al.* 2013; Raja and Gandhi, 2015; Kumar, 2015 and Kumar *et al.* 2017) [22, 36, 11, 6, 25, 27, 32]. The period wise least-squares mean for AFC indicated that it was the highest (1299.55 days) for animals calved during fifth period (2013-2016) and the lowest (1183.94 days) for animals calved during third period (2005-2008). Moreover, first decreasing trend up to third period then increasing trend were obtained for means of AFC over different periods. Non-significant effect of period of calving on SP was reported in present study. Likewise, non-significant effect of period of calving on SP was reported by Saha *et. al.* (2010) [37]. However, significant effect of period of calving on SP was reported in literature by many workers (Chaudhari *et al*. 2013; Hassan and Khan, 2013; Divya *et al.* 2014; Kumar, 2015; Raja and Gandhi, 2015 and Dash *et al*. 2016) [6, 18, 12, 11, 25, 32, 14]. The period wise least-squares mean for SP indicated that it was the highest (126.05 days) for animals calved during first period (1997-2000) and the lowest (103.55 days) for animals calved during third period (2005-2008). Moreover, no definite trend was obtained for means of SP over different periods. Non-significant effect of period of calving on CI was reported in present study. Similarly, significant effect of period of calving on CI was reported by Saha *et al.* (2010) [37] in Karan-Fries cattle. Repungent to the above, significant effect of period of calving on CI was reported by many workers (Singh *et al*. 2008; Nehra, 2011; Divya, 2012; Chaudhari *et al.* 2013 and Dash *et al.* 2016) [36, 29, 11, 6, 14]. The period wise least-squares mean for CI indicated that it was the highest (414.92 days) for animals calved during first period (1997-2000) and the lowest (389.30 days) for animals calved during third period (2005-2008). Moreover, no definite trend was obtained for means of CI over different periods. The non-significant effect of period of calving on DP was reported in present study. Similar results were reported by Ahmed *et al.* (2007) [1] and Sawant *et al.* (2016) [41] in different breeds of cattle. However, significant effect of period of calving on DP was reported by Chaudhari *et al.* (2013) [6], Hassan and Khan (2013) [18], Bhutkar *et al.* (2014) [3], Dhawan *et al.* (2015), Kumar *et al*. (2015) [25] and Raja and Gandhi (2015) [32] in different breeds of cattle. The period wise least-squares mean for DP indicated that it was the highest (95.64 days) for animals calved during second period (2001-2004) and the lowest (77.98 days) for animals calved during fourth period (2009-2012). Moreover, no definite trend was obtained for means of DP over different periods (Table 1).

The effect of season of calving was non- significant on LMY (Table 1). The present results are in agreement with those reported by Kharat *et al.* (2008) [21], Kumar *et al.* (2008) [22], Singh *et al.* (2008) [36], Kumar (2014) [24] and Al-samarai *et al.* (2015) [2]. Whereas, Lakshmi *et al.* (2009) [28], Jadhav *et al.* (2010) [19], Saha *et al.* (2010) [37], Nehra *et al.* (2012), Wondifraw *et al*. (2013) [47], Japheth *et al.* (2015) [20], Verma *et al.* (2016) [45, 46] in crossbreed cattle and Basak *et. al.* (2018) [5] in Deoni cattle reported significant effect on LMY. The season wise averages for LMY indicated that it was the highest (3175.99±118.04 kg) for cattle calved during winter season (Dec. to Mar.) and the lowest (3051.02±125.93 kg) for autumn season calvers (Nov. to Dec.). The better performance of winter calvers might be due to availability of lush green fodder in abundance like Barseem and Oats when animals were in their peak production in the winter and rainy season. In this present investigation, the effect of season of calving was non-significant on LMY-305 as supported by many other research workers (Divya, 2012; Nehra *et al.* 2012; Wondifraw *et al*. 2013; Kumar, 2015 and Verma *et. al.* 2016) [11, 47, 25, 45, 46] in crossbreed cattle. Whereas, significant effect of season of calving was reported by Katok and Yanar (2012) [23], M'hamdi *et al*. (2012) [17], Japheth *et al.* (2015) [20], Dash *et al.* (2016) [14] and Kokati *et. al.* (2017). The season wise averages for LMY-305 indicated that it was the highest (3006.43±97.75 kg) for cattle calved during winter season (Dec. to Mar.) and the lowest (2891.73±108.10 kg) for summer season calvers (Nov. to Dec.). Earlier explanation for LMY for winter calvers holds true for this trait also. Non-significant effect of season of calving on LL was obtained under the present study. The present findings were in close agreement as reported by Ahmed *et al* (2007) [1], Kumar *et al*. (2008), Lakshmi *et al.* (2009) [28], Jadhav *et al.* (2010) [19], Saha *et al.* (2010) [37], Wondifraw *et al*. (2013) [47], Bhutkar *et al*. (2014) [3], Kumar *et al*. (2014) [24], Al-Samarai *et al*. (2015) [2], Japheth *et al.* (2015) [20], Narwaria *et al*. (2015) and Sawant *et al.* (2016) in crossbreed cattle. While, Poudal *et al*. (2017) [31] in Murrah buffalo and Basak *et al.* (2018) [5] in Deoni cattle revealing the fact that season of calving had little effect on lactation period of the animal. Repugnant to above, significant effect of season of calving on LL was reported by M'hamdi *et al*. (2012) [17] and Dash *et al.* (2016) [14]. The season wise averages for LL indicated that it was the highest (315.27 days) for cattle calved during summer season (Apr. to June) and the lowest (301.42 days) for autumn season calvers (Oct. to Nov.). Non-significant effect of season of calving on PY was obtained under the present study. The present results are in agreement with those reported by Lakshmi *et al*. (2009) [28] in crossbreed cattle and Bhutkar *et al*. (2014) [3] in Deoni cattle. While, significant effect on PY was reported by Kumar *et al.* (2014) [24], Kumar (2015) [25] and Verma *et al.* (2016) [45, 46] in crossbreed cattle. The season wise averages for PY indicated that it was the highest (14.79 kg/day) for rainy season calvers and the lowest (14.53 kg/day) for autumn season calvers. Non-significant effect of season of calving on AMY obtained under the present study were in accordance with findings of Verma and Thakur (2013) [44]. On the contrary, significant effect of season of calving on AMY was reported by many workers (Wondifraw *et al*. 2013; Divya *et al.* 2014; Dhawan *et al*. 2015; Japheth *et al.* 2015; Dash *et al*. 2016 and Ratwan *et al.* 2017) [47, 12, 20, 14, 33]. The season wise averages for AMY indicated that it was the highest (10.17 kg/day) for winter season calvers (Dec. to Mar.) and the lowest (9.76 kg/day) for summer (April to March) season calvers. The effect of season of calving on MCI was non-significant. These results are in unison with those reported by Tekerli and Gundogan (2005) [43], Verma and Thakur (2013) [44], Divya *et al* (2014) [12] and Ratwan *et al.* (2017) [33]. Whereas, Singh and Gurnani (2004) [35], Lakshmi *et al.* (2009) [28], Japheth *et al.* (2015) [20] and Dash *et al.* (2016) [14]

reported significant effect of season of calving on MCI. The season wise averages for MCI indicated that it was the highest (7.99 kg/day) for cows calved during autumn season and the lowest (7.49 kg/day) for summer season calvers. The effect of season of calving on MSC was non-significant. The results of present study are in congruence with those reported by (Dhaka *et al.* 2002; Tekerli and Gundogan, 2005; Dhawan *et al*. 2015 and Verma *et al.* 2016) [43, 8, 45, 46]. The season wise averages for MSC indicated that it was the highest (1.95 kg/day) for cows calved during winter season and the lowest (1.92 kg/day) for autumn season calvers. The effect of season of calving on persistency was non-significant. The results were in agreement with those reported by Sahito *et al*. (2016) [40] and Sharma *et al.* (2018). On the other hand, significant effect of season of calving on persistency was reported by Patond *et al*. (2014). The season wise averages for persistency indicated that it was the highest (215.08±06.43 days) for cows calved during winter season and the lowest (205.59 days) for rainy season calvers (July-Sept.). The effect of season of calving was significant ($p<0.05$) on AFC. The results of present study are in congruence with those reported by Kumar *et al.* (2017) [27]. However, non-significant effect of season of calving on AFC was reported by Kumar *et al.* (2008), Singh *et al*. (2008) [36], Nehra (2011) [29], Divya, (2012) [11], Chaudhari *et al*. (2013) [6], Kumar, (2015) [25] and Raja and Gandhi, (2015) [32]. The season wise averages for AFC indicated that it was the highest (1298.93 days) for cows calved during autumn season and the lowest (1197.71±29.71 days) for rainy season calvers (July-Sept.). Significant effect ($p<0.01$) of season of calving on SP was reported in present study. The significant effect of season of calving on SP was reported in literature by many workers (Saha *et al.* 2010; Chaudhari *et al*. 2013; Hassan and Khan, 2013 and Dash *et al*. 2016) [18, 6, 37, 14]. Whereas, non-significant effect of season of calving on SP was reported by Divya *et al.* (2014) [12], Raja and Gandhi (2015) [32] and Kumar (2015) [25] in crossbreed cattle. The season wise averages for SP indicated that it was the highest (128.74 days) for cattle calved during summer season and the lowest (95.10 days) for autumn season calvers (Oct.-Nov). Better performance of autumn season calvers might be due to availability of lush green fodder in abundance to these animals in subsequent months. Significant effect ($p<0.01$) of season of calving on CI was reported. Similarly, significant effect of season of calving on CI was reported by Saha *et al.* (2010) [37], Chaudhari *et al.* (2013) [6] and Dash *et al.* (2016) [14] in crossbreed cattle. Contrarily, non-significant effect of season of calving on CI was reported by Singh *et al*. (2008) [36], Nehra (2011) [29] and Divya (2012) in crossbreed cattle and Basak *et al*. (2018) [5] in Deoni cattle. The season wise averages for CI indicated that it was the highest (418.56 days) for cows calved during summer season and the lowest (382.46 days) for autumn season calvers (Oct.-Nov). Earlier explanation for better performance of autumn season calvers also holds true for this trait also. Significant effect ($p<0.01$) of season of calving on DP was reported. The significant effect of season of calving on DP was reported in literature by many workers (Chaudhari *et al.* 2013; Hassan and Khan, 2013 and Raja and Gandhi, 2015) [6, 18]. Whereas, Bhutkar *et al.* (2014) [3], Dhawan *et al.* (2015), Kumar *et al*. (2015) [25] and Sawant *et al.* (2016) [41] reported non-significant effect on DP. The season wise averages for means of DP indicated that it was the highest (95.47 days) for cow calved during summer season and the lowest (79.74 days) for autumn season calvers (Oct.-Nov) (Table 1).

The effect of parity was statistically significant ($p<0.01$) on LMY. An increasing trends for LMY was obtained in present findings over first to fourth parity. The parity wise averages for LMY indicated that it was highest (3515.04±137.18 kg) for fourth parity calvers. While, lowest (2457.52±119.89 kg) for first parity calvers. That might be due to physiological age of maturity attained during third to fourth parity in animals. In addition to this, paritywise means for LMY from first to third parity did not differ significantly among themselves, however, differed significantly from those calved during fourth parity. The effect of parity on LMY-305 was found to be statistically significant in present investigation. Similar results were also reported by Lakshmi *et al*. (2009) [28], Katok and Yanar (2012) [23], M'hamdi *et al*. (2012) [17], Wondifraw *et al*. (2013) [47], Japheth *et al.* (2015) [20], Verma *et al*. (2016) [45, 46] and Kokati *et. al.* (2017). An increasing trends for LMY-305 was reported in present findings over first to fourth parity. The parity wise averages for LMY-305 indicated that it was highest for (3285.43 kg) fourth parity calvers and the lowest (2315.71 kg) during first parity calvers. This was due to attainment of physiological maturity by animals during third to fourth parity. Non-significant effect of parity on LL was obtained in present study**.** In conformity to the present findings, Jadhav *et al*. (2010) [19], Al-Samarai *et al*. (2015) [2], Narwaria *et al*. (2015) also reported non-significant effect of parity on LL in crossbreed cattle. However, reverse finding to the above had been reported by many workers (Ahmed *et al*. 2007; Lakshmi *et al.* 2009; M'hamdi *et al*. 2012; Kumar *et al*. 2014 and Dash *et al.* 2016) [1, 28, 17, 24, 14] in crossbreed cattle. The parity wise averages for LL indicated that it was highest (316.59 days) for fourth parity calvers and the lowest (299.95 days) for first parity calvers. Non-significant effect of parity on PY was obtained under present study. On the contrary, significant effect of parity on PY was reported by Lakshmi *et al*. (2009) [28], Singh *et al*. (2011) [38] and Kumar *et al.* (2014) [24] in crossbreed cattle. The parity wise averages for PY indicated that it was highest (15.05±0.57 kg/day) for fifth parity calvers followed by fourth and the lowest (14.23 kg/day) for first parity calvers. Also, an increasing trend was obtained for least-squares means of PY over periods. The significant effect of parity on AMY under present study were in agreement as reported by many workers (Lakshmi *et al.* 2009; Verma and Thakur, 2013; Wondifraw *et al*. 2013; Japheth *et al.* 2015; Dash *et al*. 2016 and Ratwan *et al.* 2017) [28, 44, 47, 20, 14, 33]. The parity wise averages for AMY indicated that it was the highest (11.09 kg/day) for fourth parity calvers followed by fifth and the lowest (8.02 kg/day) for first parity calvers. An increasing trend was obtained from first to fourth parity. Also, least-squares means of cows during third to fifth parity did not differ significantly among themselves, however, differed significantly from those calved during first and second parity. The effect of parity on MCI was found to be significant. Similar estimates were reported by many research workers (Tekerli and Gundogan, 2005; Lakshmi *et al.* 2009; Verma and Thakur, 2013; Japheth *et al.* 2015; Dash *et al*. 2016; and Ratwan *et al.* 2017) [43, 28, 44, 20, 14, 33]. The parity wise averages for MCI indicated that it was the highest (8.86 kg/day) for fourth parity calvers followed by fifth and the lowest (6.03 kg/day) for first parity calvers. Like other production traits, an increasing trend was obtained for means of MCI from first to the attainment of physiological maturity i.e. fourth parity. Significant ($p<0.01$) effect of parity on MSC was obtained in present study. Similar results were reported by Tekerli and Gundogan (2005) [43] in Holstein cattle. The parity wise averages for MSC indicated that it was the highest (2.19 kg/day) for fourth parity calvers followed by fifth and the lowest (1.50 kg/day) for first parity calvers. In addition to this, averages for MSC of cows calved from third to fifth parity did not differ significantly among themselves, however, differed significantly from those calved during first parity. Significant effect (p<0.01) of parity on persistency was obtained in present study. Similar results were reported by Patond *et al*. (2014) in Jersey cattle and Sahito *et al*. (2016) [40] in Red sindhi cattle. The parity wise averages for persistency indicated that it was the highest (230.38 days) for fourth parity calvers followed by fifth and the lowest (169.32 days) for first parity calvers. Effect of parity was found to be non-significant. On the contrary, Dash *et al* (2016) [14] reported significant effect of parity on SP in Karan-Fries cattle. While Basak *et al* (2018) [5] reported significant effect of parity on SP in Deoni cattle. The parity wise averages for service period indicated that it was the highest (122.29 days) for first parity calvers followed by fifth and the lowest (108.76 days) for second parity calvers. Effect of parity was found to be non-significant. On the other hand, significant effect of parity on CI was reported by Dash *et al.* (2016) [14] in crossbreed cattle. The parity wise averages for CI indicated that it was highest (408.21 days) for first parity calvers and the lowest (395.99 days) for second parity calvers. Moreover, no definite trend was obtained for the mean value of CI over different parities. Effect of parity was found to be significant (p<0.01). Ahmed *et al.* (2007) [1] reported significant effect of parity on DP in crossbreed cattle. On the other hand, Poudal *et al.* (2017) [31] reported non-significant effect of parity in Murrah buffalo. The parity wise averages for DP indicated that it was the highest (100.94 days) for first parity calvers and the lowest (80.71 days) for fourth parity calvers. Moreover, no definite trend was obtained for the mean value of DP over different parities. Critical perusal of results revealed that all the production performance traits under study shown remarkable improvement over periods indicating that selection for these traits was in desirable direction and the production performance traits under study exhibit improved performance over periods that could be attributed to better selection, improved management and nutrition followed at the farm over time.

Table 1: Analysis of variance for various production performance traits

Source of Variation	D.F.	Mean sum of squares							
		LMY	LMY-305	LL	PY	AMY	MCI	MSC	Persistency
Sire	62	1845160.18	1272023.13	6832.81	31.23	9.09	8.52	0.79	5595.43
Period	4	3834036.04**	5444200.33**	12368.40**	30.45**	58.01**	26.66**	0.97**	14236.48**
Season	3	518907.51	596230.01	6482.33	2.19	7.31	7.82	0.04	4398.76
Parity	4	21579725.20**	18816028.66**	5507.12	12.01	180.49**	157.01**	9.26**	76873.14**
Remainder	788	742363.57	553594.60	3572.19	6.28	4.41	4.09	0.28	2941.24

Where, p**<0.01

Table 1: Analysis of variance for various production performance traits (conti….)

Source of variation	df	MSS	d.f	MSS		
		AFC		SP	CI	DP
Sire	42	71009.13	62	4310.01	5771.76	3068.98
Period	4	22101.40	4	4463.06	6088.55	4565.12
Season	3	89325.74*	4	27957.02**	31233.48**	7464.35*
Parity	-	-	3	6506.82	4911.99	11748.23**
Remainder	240	33284.79	788	3843.90	4338.98	2205.29

Where (** P<0.01), (*P<0.05)

Table 2: Least-squares means and their standard error for various production performance traits

Effects	Production performance traits								
	Obs.	LMY (kg)	LMY-305 (kg)	LL (days)	PY (kg/day)	AMY (kg/day)	MCI (kg/day)	MSC (kg/day)	Persistency (day)
Over all mean	862	3111.81± 110.17	2929.45±90.63	310.57±6.48	14.65±0.48	9.92±0.24	7.80±0.23	1.93±0.07	208.94±5.86
Period of calving									
1997-2000	14	3196.71^{ab}±328.46	3072.81^{ab}±282.17	314.77^{a}±22.42	13.41^{b}±1.02	10.08^{ab}±0.79	7.83^{b}±0.76	2.06^{ab}±0.20	224.31^{a}±20.34
2001-2004	105	2829.82^{b}±148.96	2623.80^{b}±125.35	299.21^{b}±9.50	13.67^{b}±0.56	9.25^{b}±0.34	7.09^{b}±0.33	1.77^{b}±0.10	196.87^{b}±8.61
2005-2008	275	2857.56^{b}±128.98	2654.97^{b}±107.56	309.02^{ab}±7.97	14.98^{ab}±0.52	9.15^{b}±0.29	7.31^{b}±0.28	1.81^{b}±0.08	187.48^{b}±07.22
2009-2012	196	3125.62^{ab}±141.80	2868.41^{b}±118.99	325.78^{a}±8.96	15.08^{ab}±0.54	9.58^{b}±0.32	7.76^{b}±0.31	1.92^{b}±0.09	208.74^{ab}±08.12
2013-2016	272	3549.32^{a}±154.46	3427.28^{a}±146.51	304.09^{ab}±11.29	16.08^{a}±0.62	11.53^{a}±0.40	9.03^{a}±0.39	2.13^{a}±0.11	227.30^{a}±10.23
Season of calving									
Summer (Apr-Jun)	156	3105.32±129.59	2891.73±108.10	315.27±8.02	14.60±0.52	9.76±0.29	7.49±0.28	1.93±0.08	209.48±07.26
Rainy (Jul-Sept.)	252	3114.90±120.71	2901.97±100.15	314.63±7.33	14.79±0.50	9.79±0.27	7.79±0.26	1.94±0.08	205.59±6.63
Autumn (Oct-Nov)	173	3051.02±125.93	2917.68±104.84	301.42±7.74	14.53±0.51	9.95±0.28	7.99±0.27	1.92±0.08	205.60±07.00
Winter (Dec- Mar.)	281	3175.99±118.04	3006.43±97.75	310.97±7.11	14.66±0.49	10.17±0.26	7.96±0.25	1.95±0.08	215.08±06.43
Parity									
First	326	2457.52^{b}±119.89	2315.71^{b}±99.41	299.95±7.26	14.23±0.50	8.02^{b}±0.27	6.03^{c}±0.26	1.50^{c}±0.08	169.32^{c}±6.57
Second	216	2928.72^{b}±120.94	2781.19^{b}±100.35	308.47±7.34	14.35±0.50	9.43^{b}±0.27	7.43^{b}±0.26	1.82^{b}±0.08	201.11^{b}±06.65
Third	163	3240.73^{b}±125.82	3064.57^{b}±104.74	312.38±7.73	14.58±0.51	10.29^{a}±0.28	8.18^{ab}±0.27	2.02^{ab}±0.08	217.15^{ab}±06.99
Fourth	106	3515.04^{a}±137.18	3285.43^{a}±114.88	316.59±8.61	15.02±0.53	11.09^{a}±0.31	8.86^{a}±0.30	2.19^{a}±0.09	230.38^{a}±07.80
Fifth	69	3417.02^{ab}±154.46	3200.35^{ab}±130.22	315.48±9.92	15.05±0.57	10.75^{a}±0.36	8.52^{a}±0.34	2.15^{a}±0.10	226.73^{ab}±8.99

Means superscripted by different letters differ differently among themselves.

Table 2: Least squares means and their standard error for different production performance traits (conti….)

Effects	Production performance traits			
	AFC (days)	SP (days)	CI (days)	DP (days)
Over All Mean	1235.22±19.53 (290)	113.85±4.55 (862)	401.65±5.53 (862)	87.19±4.08 (862)
Period of calving				
1997-2000	1227.80±49.94 (35)	126.05±22.73 (14)	414.92±24.30 (14)	90.69±17.35 (14)
2001-2004	1191.29±48.47 (48)	106.80±8.53 (105)	402.28±9.45 (105)	95.64±6.82 (105)
2005-2008	1183.94±39.13 (87)	103.55±6.63 (275)	389.30±7.54 (275)	82.02±5.48 (275)
2009-2012	1273.49±43.28 (58)	118.93±7.87 (196)	404.81±8.79 (196)	77.98±6.35 (196)
2013-2016	1299.55±50.82 (62)	113.92±10.62 (272)	396.97±11.60 (272)	89.62±8.33 (272)
Season of calving				
Summer (Apr-Jun)	1207.50^{ab}±26.49 (85)	128.74^{a}±06.69 (156)	418.56^{a}±7.60 (156)	95.47^{a}±5.52 (156)
Rainy (July-Sep)	1197.71^{b}±29.71 (64)	114.92^{ab}±5.77 (252)	401.58^{ab}±6.70 (252)	83.34^{b}±4.89 (252)
Autumn (Oct-Nov)	1298.93^{a}±32.54 (48)	95.10^{b}±6.32 (173)	382.46^{b}±7.24 (173)	79.74^{b}±5.26 (173)
Winter (Dec-Mar)	1236.72^{ab}±25.82 (93)	116.64^{ab}±5.48 (281)	404.02^{a}±6.41 (281)	90.21^{ab}±4.69 (281)
Parity				
First	-	122.29±5.68 (317)	408.21±6.61 (317)	100.94^{a}±4.83 (317)
Second	-	108.76±5.79 (213)	395.99±6.72 (213)	84.36^{b}±4.90 (213)
Third	-	111.31±6.31 (159)	398.30±7.23 (159)	82.47^{b}±5.26 (159)
Fourth	-	109.59±7.43 (104)	403.20±8.35 (104)	80.71^{b}±6.04 (104)
Fifth	-	117.32±9.02 (69)	402.57±9.96 (69)	87.46^{b}±7.18 (69)

Means with different superscripts differ significantly among themselves.
Figures in parenthesis indicate number of observations

4. Conclusion

The study revealed performance evaluation of crossbred cattle for production performance traits is important in judging their relative merits in adaptation, health and productivity in given agro-climatic conditions. The production performance traits considering both the production and reproduction aspect of an animal are important parameters for ensuring profitability of dairy animal over longer period. The milk yield expressed as average daily milk yield (LMY/LL), milk yield per day of calving interval (MCI= first lactation milk yield/first calving interval) and milk yield per day of age at second calving (MSC= first lactation milk yield/age at first calving + first calving interval) are good measures of both the reproduction and production performance of an animal. These results also suggested that selection of relatives on the basis of production performance traits would lead to positive genetic responses and high genetic gain. The variations in performance traits may be more of environmental nature as opposed to genetics; sampling of population and data edits might have widened these ranges. For other production performance traits, reports disagree even to a great extent. Parity, Herd, year and season of calving affected most of the performance traits in Hardhenu cows. Herd variations represent managemental differences for most of the traits. The non-genetic factors (e.g. environmental) have an important bearing on these traits and directly obscure recognition of genetic potential. Moreover, the performance records of an animal should be corrected for classifiable non-genetic sources of variation, which is essential for obtaining precise estimates of genetic parameters.

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6. References

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