



Estimation of Least Squares Means and Non-genetic Factors for Production Traits in Frieswal Cattle under Field Progeny Testing

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ABSTRACT

Background: The production traits are quantitative traits governed by polygenic inheritance and influenced by non-genetic factors. The present study was under taken to study the effect of sire and some non-genetic factors on production traits of frieswal cattle under field progeny testing.

Methods: The study utilized data spanning nine years (2013-2021) on frieswal cattle maintained under the field progeny testing (FPT) programme at the Pantnagar centre of AICRP on progeny testing. Traits analyzed included FL305-DMY, TDPY, FP and FLL. Data were classified by year and season of calving. Statistical analysis was performed using SPSS (version 20) and the mixed model least squares and maximum likelihood programme to assess the effects of non-genetic factors.

Result: The overall means of 3086.28 ± 14.86 , 12.87 ± 0.07 , 3.48 ± 0.01 and 310.55 ± 0.40 with CV% of 19.95, 18.97, 11.68 and 4.47, respectively, for First lactation 305-days milk yield (FL305-DMY), Test day peak yield (TDPY), Fat percentage (FP) and First lactation length (FLL). The effect of sire and period was highly significant ($P < 0.01$) on all the traits under study whereas effect of season was non-significant on all the traits under study. The study revealed that the Frieswal herd under the under field progeny testing is performing well with the moderate performance status compared to other cattle genetic resource of country. Also, the prevailing microclimatic conditions of Uttarakhand, with respect feed and fodder availability influence reproduction performance. Further, these cattle are well adapted to the seasonal environmental fluctuation of area.

Key words: Fat percentage, Frieswal cattle, Lactation length, Test day peak yield.

INTRODUCTION

India's dairy industry has undergone significant transformations since the country's independence in 1947. During the 1950s and 1960s, the industry faced substantial challenges, including milk production deficiencies, reliance on imports and negative annual growth rates. The country's milk production grew at a multifarious rate of 1.64% (1950s and 1960) in the decade following independence, which further decreased to 1.15% in the 1960s. This slow growth rate resulted in a significant decline in per capita milk consumption, from 124 grams per day in 1950-51 to 107 grams per day by 1970, well below international nutritional standards (Tiwari *et al.*, 2024). Despite having the world's largest cattle population, India produced less than 21 million tonnes of milk annually, highlighting the inefficiency of the dairy industry (PIB Report, 2022), during the time. The country's inability to meet its domestic demand for milk and dairy products led to a significant reliance on imports, which further exacerbated the country's economic burden.

In response to these challenges, the government initiated several measures to improve the dairy industry's performance. One such initiative was the development of the Frieswal cattle, a synthetic breed created through the Frieswal Project, a collaboration between the Military Farms Service and the Indian Council of Agricultural Research-Central Institute for Research on Cattle. The Frieswal was developed by crossing Holstein Friesian cattle with Sahiwal

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cattle, a popular indigenous breed known for its heat tolerance and milk production capabilities (Annual Report, ICAR-CIRC, 2019). The Frieswal breed has recently gained recognition as a synthetic breed and its development is considered a significant milestone in India's dairy industry. The breed's genetic makeup is designed to combine the high milk production potential of Holstein Friesian cattle with the heat tolerance and adaptability of Sahiwal cattle. This unique genetic combination makes Frieswal cattle an attractive option for dairy farmers in India, particularly in

regions with harsh climatic conditions. Milk production traits are quantitative and polygenic, hence are influenced by polygenetic inheritance and environmental factors in which animals are raised. These milk traits are vital to dairy production profitability and their evaluation is essential for genetic improvement strategies. However, non-genetic factors like year and season of calving can significantly impact production traits, leading to deviations from an animal's genetic potential (Rather *et al.*, 2020). To accurately assess genetic merit and make informed breeding decisions, it's essential to adjust records for non-genetic factors. Therefore, this study aims to investigate the effects of year and season of calving on key production traits in Frieswal cattle, including: First lactation 305-days milk yield (FL305-DMY), Test day peak yield (TDPY), Fat percentage (FP) and First lactation length (FLL), which are crucial for determining milk production potential, quality and profitability. By understanding the impact of non-genetic factors on these traits, breeders can develop effective breeding strategies to enhance genetic improvement, leading to increased milk production, improved quality and enhanced profitability.

MATERIALS AND METHODS

Source of data and data collection

The study utilized data spanning nine years (2013-2021) from Frieswal cattle maintained at the Pantnagar centre under the All India Coordinated Research Project (AICRP) on progeny testing. The Field Progeny Testing (FPT) programme of Frieswal cattle was initiated by ICAR-CIRC, Meerut, in Udham Singh Nagar district of Uttarakhand. The district is located in the Tarai region of Kumaon division, between 29°1'N latitude and 79°31'E longitude, with an average elevation of 521 meters.

Data editing

The study used records of Frieswal cows with known pedigree, excluding animals with abnormal records such as delayed calving, abortion, stillbirth and other reproductive disorders. The data were classified into nine years (2013-2021) and three seasons (winter, summer and rainy). Sires with less than three progenies were excluded from the estimation of least squares means.

Traits studied

The study focused on four key traits:

1. First lactation 305-days milk yield (FL305-DMY).
2. Test day peak yield (TDPY).
3. Fat percentage (FP).
4. First lactation length (FLL).

Management and breeding

The animals were housed in shaded open yards or traditional animal sheds, managed in groups or households. Farmers followed a daily routine to optimize efficiency and performance. Pregnant animals were housed separately and calves were separated and fed colostrum for three

days, followed by whole milk for three months. Calves were also fed green fodders, wheat bran, rice bran and oil cakes, with mineral mixtures. Artificial insemination (AI) was performed and pregnancy diagnosis was conducted at 60 days using rectal palpation. Routine vaccination and deworming were practiced by expert veterinarian. The animals were provided with necessary veterinary care and treatment for diseases and ailments as needed, based on their morbidity.

Statistical analysis

Descriptive statistics were computed using SPSS Software (Version 20) by Snedecor and Cochran (1967) method. Due to non-orthogonal data, the Mixed Model Least Squares and Maximum Likelihood Computer Programme PC-2 (Harvey, 1990) was used to determine the effect of non-genetic factors on the traits under study. Following mathematical model was used for the purpose.

$$Y_{ijkl} = \mu + S_i + P_j + G_k + e_{ijkl}$$

Where

Y_{ijkl} = Observation on l^{th} progeny of i^{th} sire calved during j^{th} period and k^{th} season of calving.

μ = Overall mean.

S_i = Effect of i^{th} sire ($i = 1, 2, 3...69$).

P_j = Effect of j^{th} period of calving ($j = 1, 2, 3$).

G_k = Effect of k^{th} season of calving ($k = 1, 2, 3$).

e_{ijkl} = Random error $\sim NID(0, \sigma_e^2)$.

This model is used to analyze the effects of sire, period of calving and season of calving on the trait of interest (Y_{ijkl}), while accounting for random error. The model assumes that the effects of period and season are fixed and the random error is normally distributed. The statistical significance of various fixed effects in the least squares model was determined by 'F' test using SPSS software. For significant effects, the differences between pairs of levels of various fixed effect (period) were tested by Duncan's multiple range test (DMRT) as modified by Kramer (1957).

RESULTS AND DISCUSSION

The overall least squares means of 12.87±0.07 kg, 3086.28±14.86 kg, 3.48±0.01% and 310.55±0.40 days with CV% of 18.97, 19.95, 11.68 and 4.47, respectively were obtained for Frieswal cattle in the present study (Table 1). The coefficient of variations (CV %) of all these traits under study were low indicating that the traits had low variability. The highest CV (%) for (19.95) illustrated that this trait holds maximum variability among all the traits under study. On the other hand, the lowest CV (%) was observed for LL (2.06%). The least squares means observed for different production traits are in the range of reported estimates in different cattle genetic resources of the country. Comparatively higher estimates for FL305-DMY, were reported by Singh and Gurnani (2004) and Nehara (2012) in Karan Fries cattle. However, Shahi and Kumar (2010), Girimal (2020) and Vijayakumar *et al.* (2019) in crossbred cattle, Ambhore *et al.* (2017) in Phule Triveni cattle and Singh *et al.* (2022), Uttam

Table 1: Effect of genetic and non-genetic factors on production traits of Frieswal cattle.

Effect	N	TDPY (kg)	FL305-DMY (kg)	FP (%)	FLL (days)
Overall	1163	12.87±0.07	3086.28±14.86	3.48±0.01	310.55±0.40
CV(%)		18.97	19.95	11.68	4.47
Period	P value	0.0001**	0.0001**	0.0001**	0.0001**
2013 to 2015	370	11.50±0.12 ^a	2556.86±25.33 ^a	3.68±0.02 ^b	316.70±0.69 ^b
2016 to 2018	490	13.12±0.10 ^b	3210.19±22.14 ^b	3.37±0.02 ^a	309.29±0.60 ^{ab}
2019 to 2021	303	13.98±0.13 ^b	3491.78±28.38 ^c	3.41±0.02 ^a	305.66±0.77 ^a
Season	P Value	0.6755NS	0.0497NS	0.5837NS	0.1141NS
Winter (November-February)	416	12.80±0.11	3084.87±23.87	3.47±0.02	309.41±0.77
Summer (March-June)	462	12.76±0.10	3024.97±22.84	3.50±0.02	311.22±0.78
Rainy (July-October)	285	13.04±0.13	3149.00±29.16	3.48±0.02	310.74±0.85
Sire	P value	0.0000**	0.0000**	0.0000**	0.0000**

Means with different superscripts in the columns differ significantly.

NS indicates non-significant.

* indicates significant at 5% level.

** indicates significant at 1% level.

et al. (2023) and Ratwan *et al.* (2024) reported lower in Sahiwal cattle. The overall least squares means obtained for TDPY were in concord with the findings of Deshpande and Bonde (2009) and Prasanna *et al.* (2023) in Frieswal cattle, Ratwan *et al.* (2024) and Singh *et al.* (2022) in Sahiwal and Dutt and Bhusan (2001) in crossbred cattle. However, Hussain *et al.* (2015) and Girimal *et al.* (2020) observed lower estimates in crossbred cattle whereas Raja *et al.* (2018) and Lakshmi *et al.* (2009) reported higher estimates in Frieswal cattle. The FP obtained in the present study in Frieswal cattle was in concord with findings of Campos *et al.* (1994) in crossbred cattle and Kumar *et al.* (2017) in Frieswal cattle. However, Islam and Bhuiyan (1997), Kumar *et al.* (2023) and Wongpom *et al.* (2017) reported higher estimates in crossbred cattle. Baruah *et al.* (2021) in Sahiwal cattle and Yogi *et al.* (2017) and Pesek *et al.* (2005) in Holstein Friesian cattle also reported higher estimates for FP. The overall least squares means in crossbred cattle were reported by Varaprasad *et al.* 2013, Hassan and Khan (2013), Dubey and Singh (2005), Bajetha (2006), Singh (2008), Moges (2012), Vijayakumar *et al.* (2019), Gaur (2001), Narang *et al.* (2001), Mukherjee (2005). However, Ratwan *et al.* (2024), Uttam *et al.* (2023) and Singh *et al.* (2022) in Sahiwal cattle reported lower mean estimates. Gandhi *et al.* (2009) and Kumar *et al.* (2017) in Sahiwal, Pundir and Singh (2007) in Red Sindhi cattle, Parveen *et al.* (2018) in Sahiwal cattle, Gupta *et al.* (2019) in Kankrej cattle reported lower estimates for FL305-DMY and FLL.

The least squares analysis of variance revealed that the period of calving had a significant ($P<0.01$) impact on all production traits studied. This significant effect likely reflects differences in feed and fodder management provided to animals during their growth phase. In contrast, the season of calving had a non-significant effect on these traits, suggesting that Frieswal cattle are well adapted to the seasonal fluctuations in temperature and humidity of area. Additionally, the non-significant effect of season may be attributed to effective management practices by farmers, who provide extra

care during adverse conditions. These findings are consistent with previous studies, including Singh and Singh (2018) and Dash *et al.* (2023) in Sahiwal cattle and Gupta *et al.* (2019) in Kankrej cattle, which reported similar effects of period and season on FL305-DMY and FLL. The significant effect of period on FL305-DMY aligns with the findings of Prakash *et al.* (2015) and Singh and Singh (2016).

CONCLUSION

The study on Frieswal cattle revealed that these animals are well acclimatized to seasonal fluctuations in the study area. Furthermore, nutrition and management, as reflected by the effect of year, play a significant role in the expression of the animal's genetic worth.

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Conflict of interest

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