Random Regression Model as a tool for genetic evaluation of test day milk yields in animal breeding: A review

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ABSTRACT: Genetic improvement of animals for production traits especially the milk yield has always been a topic of concern for researchers all over the world. The concept of analyzing 305 days milk yield has now become obsolete. Developed countries had already started using test day (TD) model in their regular breeding program however in developing countries it is still an emerging concept and therefore extends further opportunities in areas of newer researches. The data of animal breeding can be analyzed by several analyzing methods like the repeatability model, the multiple trait model and the most recent random regression model (RRM). Random regression model is generally used for the analyzing longitudinal data that can be measured several times on trajectory of an individual. RRM allows drawing a personalized lactation curve for each cow with fixed regression explaining the general shape of lactation curve for all animals belonging to the same sub class and random regression describing the deviation which allows each cow to have differently shaped lactation curve and account for random genetic and permanent environmental effects. The article tries to gather all the information related to the past researches and future prospect of random regression model in genetic evaluation of cattle.

Key words: Breeding value, correlation, heritability, prediction, random regression model, test day.

Genetic improvement programs round the world have shown that proper genetic evaluation and selection of bulls can bring about 75% of the genetic improvement. For successful breeding program accurate and early selection of superior animals are the pre requisite. In India mostly first lactation 305 days or less milk yield is used to select or cull the animals which is time and money consuming, leads to increased generation interval, decreased genetic gain per unit of time and also is based on less number of records. All these constraints may be overcome by using test day milk yield records at monthly interval [Kokate *et al.*, 2013; Gupta, 2013; Singh, 2014].

Test day (TD) model is a statistical procedure which considers genetic and environmental effect directly on the test day basis [Swalve, 1995]. TD measurements do not need extension of records. The data on test day milk yield of dairy cows is a longitudinal data having correlation between tests on the same animal. It reduces residual variance by providing more information per sire by using all available test day of sire's daughters and by adjusting more environmental effects in genetic evaluation model. Also there is high genetic correlation between test day and complete milk production record. Above all the technical advantages, it is more feasible to maintain fortnightly, monthly, bimonthly milk yield records under field conditions where farmers are rarely involved in maintaining daily yield records. Test day recording approach can also reduce the cost of milk recording under field condition and thus field data can be incorporated in sire evaluation program. The genetic makeup of a population is reflected in the parameters like heritability, genetic and phenotypic correlations between the performance traits. However their estimates get altered by significant non genetic factors and hence the effect of these significant factors has to be corrected. [Chauhan, 1988; Kume and Devrishi, 1991; Gandhi and Gurnani, 1997; Atil and Khattab, 1999; Gandhi and Singh, 1999; Gandhi, 2000; Dawande *et al.*, 2007].

Now-a-days most of the developed countries are using monthly test day milk yield records using Random Regression Model (RRM) instead of 305 days milk yield for genetic evaluation of dairy animal as lactation curve of each animal is different. In this the fixed regression explains the general shape of lactation curve for all animals belonging to the same sub class of age - season of calving and random regression describes the deviation which allows each cow to have differently shaped lactation curve and account for random genetic and permanent environmental effects. Any number of test day milk yields during lactation can be used to evaluate a cow [Schaeffer and Dekkers, 1994]. The RRM for test-day can accounts more precisely for environmental factors that affect cows differently during lactation. In India, limited studies [Geetha *et al.*, 2006; Katneni, 2007] in Murrah buffaloes, [Singh, 2014] in Karan Fries, [Ved Prakash, 2015; Pandey, 2018] in Sahiwal cattle have been done using RRM for estimation of genetic parameters and EBVs for test day milk yields. This gives an opportunity to the researchers to explore more in the concerned field.

Test Day Milk Yield

Various researchers all over the globe have used weekly test day milk yields or monthly test day milk yields or bimonthly test day milk yields in their analysis. The average milk yields for different test days in different breeds have been reviewed in Table 1. The general pattern shows that the milk yield increases from test day one i.e. 5^{th} or 6^{th} day till test day three i.e. 65^{th} day and then decreases slowly. The peak is obtained in test day three in most of the cases. Initially the cow has to feed her newborn so the physiology of the animal is such that more milk is produced in the initial days to properly take care of the nutrition of the new born.

As every other phenotypic character, the test day milk yield is also the total sum of the genetic and environmental factors affecting it. One needs to find out which of the factors out of non genetic factors have significant effect and how many of them have non-significant effect. All those factors that are found to have significant effect needs to be adjusted for further analysis so that one can expect accuracy of their results out of any research. Most commonly one analyze the effect of season of calving, period of calving and age at first calving on test day milk yield. Season is one of the most important aspects. The temperature, humidity index, pressure etc all may be source of great stress if not within the physiological limits of the animal. The managemental practices do not vary on a daily basis but over a period of time they used to change. The quality, quantity and type of feed provided to the animal vary over period so the period of calving is yet another aspect which affects the test day milk yield.

There is an optimum age of every species when it is considered as sexually mature on the basis of physiological growth of the body that is able to support another life. If an animal calves very early then it has negative effect on its body, the hormonal levels are not such that they can give maximum production so the test day milk yield get affected. Even though the number of calvings will increase but the production per calving will decrease and also have negative effect on the immunological status of the animal. If the animal calves much later in life then it significantly affects the number of calvings. Thus, age at first calving affects the milk quantity and number of lactations. If the animals under study belong to different herds then effect of herd is also there as every herd has a different feeding style, health management and environmental control. Earlier studies showed that the effect of different non genetic factors on different test days is quite different. Some test days are significantly affected whereas others not.

Heritability estimates of test day milk yield

Heritability determines the fraction of the phenotypic character of the parent that is going to be transmitted to its progeny. Test day milk yield has been used for the prediction purpose thus its reliability depends much on its heritability because higher test day milk yield with low heritability will not serve the purpose of a breeder. The heritability of test day milk yield generally ranges from low to middle.

Danell (1982) found that the heritability of TD measurements ranged from 0.15 to 0.31 in different data sets. Rekaya *et al.* (1995) reported that the heritability estimates were higher in mid lactation test day yields in Holstein Friesian. Kettunen *et al.* (1998) found that the heritability estimates of test day record were highest at the beginning and end of lactation in Finnish Ayrshire cows. Olori *et al.* (1999) reported that the heritability estimate was highest in week 35 for cubic, quadratic, quartic models in Holstein Friesian.

Machado *et al.* (1999) reported that the highest estimates of milk yield were observed in MTDMY5- MTDMY6. Roose *et al.* (2004) reported that the heritability estimate for first, second, and third lactation as 0.29-0.48, 0.33-0.54, 0.24-0.54 respectively in dairy cattle of the Netherlands. Togashi *et al.* (2008) concluded that the first parity had lower daily heritability across lactation than second and third parity (0.40, 0.54 and 0.46 respectively). Bignardi *et al.* (2009) obtained higher heritability estimates at the beginning and at the end of lactation and lower during mid lactation in Iranian Holstein cattle.

Cobuci *et al.* (2011) obtained heritability values which increased from beginning until 210-240 days of lactation and decreased thereafter to end of lactation. Elahi Torshizi *et al.* (2012) reported the highest heritability estimate in the mid lactation between 180- 205 days with maximum heritability on 205 day (0.25-0.35) and minimum at the beginning of lactation (0.07) using different random regression test day models. Dongre (2012) worked on weekly test day milk yields in Sahiwal and found that the heritability ranged from 0.005±0.079 (WTDMY1) to 0.441±0.143 (WTDMY5). The other ranges of heritability for test days as determined by various researchers have been enlisted on Table 2.

Genotypic and Phenotypic Correlations between Test Days and 305 Day Milk Yield

The genetic correlation gives an idea about the nature and magnitude of relationship between two traits and also helps in indirect selection. Significantly positive correlation between the test day milk yield and 305 day milk yield indicates that both will increase or decrease in same direction. Anything having a positive effect on such test day milk yield will automatically have positive effect on 305 day milk yield also or in other words selecting an animal for higher test day milk yield by default selects it for higher 305 day milk yield also. On the other hand if the two have negative correlation then increase in one leads to decrease in the other and vice versa. It is not compulsory for all test days to be either positively or negatively correlated with the 305 day milk yield. Some of the test days of same lactation may be positively related and some may be negatively related. Correlation ranges from -1 to +1.Various workers estimated the correlation among the test day milk yields and 305 day milk yield which is reviewed in Table 3.

Utilization of Test Day Milk Yield for Predicting First Lactation 305 Days or Less Milk Yield

Test day milk yield of an animal can give an indication of animal's total 305 day milk yield and thus can be used to select or cull the animal in its early stage of lactation. This is used in day to day selection of animals in the breeding farms of developed countries. In developing countries, its use is in a very initial stage.

Deb and Gurnani (1994) reported that the R^2 values for TD-6 and TD-5 were 82.20% and 84.27% respectively for the prediction of 305 day milk yield in Murrah buffaloes. Dass (1995) found that the R^2 value for predicting FL305DMY using TD-2, TD-5, TD-8 was 85%. Joshi *et al.* (1996) reported the R^2 values ranging from 55.35% to 93.07% for different prediction equations in Hariana cows. The best equation gave R^2 value of 87.62%. Dalal (1997) reported that (R^2) among one variable equation was maximum for TD-3 (90.28%). Among two variables, R^2 value was maximum when TD-1 was combined with TD-2 (93.38%) followed by combining TD-3 with TD-5 (93.20%) in Hariana cows.

Mandal and Mehla (1997) reported that the accuracy of predicting 305DMY showed gradual increase from TD-6 to TD-8 in Murrah buffaloes. Dass (1995) observed that the prediction equation using 2^{nd}, 4^{th}, 5^{th} and 8^{th} test day milk gave an accuracy of about 85% in predicting 305DMY in Murrah buffaloes maintained at NDRI Karnal and PAU Ludhiana. Dass and Sadana (2003) reported that the accuracy of prediction increased upto four test-day milk yield records. The four test-day milk yield records along with 2^{nd}, 4^{th}, 6^{th} and 8^{th} month of lactation predicted FL305DMY with 89% accuracy in Murrah buffaloes.

Singh and Rana (2008) reported that the accuracy of prediction ranges from 42% (MTDY-1) to 67% (MTDY-6) in Murrah buffaloes. Equation involving 3^{rd}, 6^{th} and 9^{th} test day milk yields can be used for prediction of 305-day milk yield with accuracy of 91% in Murrah buffaloes. Kokate (2009) reported that the regression coefficients of various monthly test day yield in Karan Fries ranged from 83.18 (MTDY-11) to 189.65 kg (MTDY-5). The accuracy of prediction of 305-day milk yield was highest for MTDY-6 (61.32%) followed by MTDY-7(59.88%). Chakraborty *et al.* (2010) reported that the coefficient of determination (R^2) was maximum for TD-8 (38.89%) and minimum for TD-2 (4.69%) among all ten prediction equations. Equation involving 3^{rd}, 7^{th}, 8^{th}, 10^{th} test days was recommended for prediction of first lactation 305-day milk yield (R^2 = 56.79%).

Debbarma *et al.* (2010) used the multiple regression model to predict FL305DMY using test day milk records in Sahiwal. They reported that the accuracy of prediction from individual test day milk yields ranged from 11.38% (6^{th}day) to 72.34% (155^{th}day). The R^2-value was 93.74% when all ten test day records (6^{th}day to 275^{th}day) were incorporated in the prediction equation. Singh (2014) applied stepwise backward regression method and reported that 2^{nd}, 4^{th} and 6^{th} test days together gave the best accuracy of 82.76% in predicting FL305DMY. Rana (2017) reported that the accuracy of prediction of first lactation 305 days milk yield using monthly test day milk yields in Murrah was maximum when all the 11 test days were taken together in the prediction equation (R^2 =95.54).

Random Regression Test Day Model (Rr-Tdm)

The concept of random regression was first given by Henderson (1982) and Laird and Ware (1982). Random regression model is used in longitudinal data or repeated records where observation for a particular trait is collected several times during the course of an animal's life (Hill and Brotherstone, 1999). In recent years the use of test day records for the genetic evaluation of dairy animals has increased among the geneticists as it reduces the cost of recording the daily performance of an animal (Swalve, 2000). Earlier Anderson *et al.* (1989) reported that the estimation of 305 day milk yield using few test day records may lead to biasness and the extended records may be biased as each cattle has its own individual lactation curve (Shanks *et al.*, 1981 and Pander and Hill, 1993).

However, the extension procedure can be eliminated by using test day records directly instead of lactation data. It also accounts for temporary environmental effects of each test day (Meyer *et al.*, 1989 and Van Raden, 1997). The main advantages of test day models are- it can adjust the environmental effects of each test day more precisely, no need to extend short lactation, and genetic evaluation of animals is also possible. In random regression the lactation curve of individual cow is viewed as two sets of regression viz. fixed regression, which describes the general shape for all cows belonging to same sub-class of age-season of calving and random regression, which describes the deviation that allow each cow to have differently shaped lactation curve and account for random genetic and permanent environment effect.

Function in Random Regression Models

Random Regression Models describe the shape of lactation curves for groups of animals and for individual animals by using linear function of fixed and random regression coefficients and a set of covariates (Jamrozik *et al.*, 1997a). Jamrozik *et al.* (1997b) worked on Holstein cattle and suggested to use 5th order legendre polynomial function for both fixed and random regression as it had lower error variance of daily milk yields. Pool and Meuwissen (2000) compared the legendre polynomial of order 0 to 7 for modeling the lactation curves of Holstein Friesian cows and based on mean square error of predicting the test day milk yields concluded that 5th order legendre polynomial was best.

Jakobsen *et al.* (2002) found that 3rd order normalized Legendre polynomial function was best among Wilmink function, 2nd order and 3rd order normalized Legendre polynomial function for fitting the test-day milk yield data of Danish Holstein cattle. Reinhardt *et al.* (2002) suggested use of Wilmink's function for modeling fixed effects. He demonstrated the inadequacy of 3rd order Legendre polynomial function to model the fixed lactation curves of young German and Austrian Holstein, Red and Jersey cattle bulls having daughter with incomplete lactations.

Liu *et al.* (2006) used Legendre polynomials of orders three to eight as sub-models in RRM for first lactation milk yield of Canadian Holstein cattle and they found that residual variance decreased as the numbers of parameters increased. Orthogonal polynomial functions are becoming more popular for use in RRM (Jamrozik, 2004).Compared with other lactation curve function, Random regression models with orthogonal polynomials perform better even when parameter for additive genetic and permanent environmental effects are same in number (Jamrozik and Schaeffer, 2002).

Polynomial functions reduce the correlation among estimated regression coefficients as compared to other functions with the same number of parameters (Schaeffer, 2004). Meyer (2000) and Pool *et al.* (2000) showed that several types of orthogonal polynomials are available for permanent environmental effects, but Legendre polynomials are more commonly utilized (Kirkpatrick *et al.,* 1990). Strable and Jamrozik (2006) used 5th order legendre polynomial for fixed effects and 4th order polynomial legendre for random effects in random regression test day models in Polish Black and White. Geetha (2006) made use of wilmink function 2 for modeling fix lactation curve and also for modeling the random curve in Murrah buffalo. Katneni (2007) suggested using the 3rd order polynomial function for both fixed effects and random effects in Murrah buffalo.

Nazari *et al.* (2010) worked on Najdi cattle and found that 3rd, 4th and 5th order legendre polynomial works best for modeling fix lactation curve whereas 3rd and 4th order legendre polynomial for modeling additive genetic variation and permanent environmental variation.

Elahi *et al.* (2012) used Ali Schaeffer model (4) for modeling fix lactation curve and 3rd, 4th and 5th order legendre polynomial for modeling random curve in Iranian Holstein. Pereira *et al.* (2013) found that 3rd order legendre polynomial for fix lactation curve and 3rd, 5th and 6th order legendre polynomial works best in random regression test day models in Gyr.

Singh (2014) used random regression test day model in Karan Fries and suggested the use of 6th order legendre polynomial for fix lactation curve, 4th and 5th order legendre polynomial for additive genetic and permanent

Table 1: Mean ± SE of different test days in different breeds of cattle

Breed	TD-1	TD-2	TD-3	TD-4	TD-5	TD-6	TD-7	TD-8	TD-9	TD-10	References
Holstein	20.5 ± 4.7	26.5± 5.2	25.8 ± 4.5	23.8 ± 4.9	24.1 ± 5.2	21.8 ± 4.7	21.7 ± 5.1	20.3 ± 4.4	18.8 ± 4.5	18.1 ± 4.6	Jamrozik & Schaeffer (1997)
Holstein-Friesian	21.96 ± 4.86	22.32 ± 5.37	21.19 ± 5.50	20.15 ± 5.43	19.29 ± 5.33	18.38 ± 5.23	17.62 ± 5.10	16.78 ± 4.98	15.64 ± 4.88	14.11 ± 4.81	Rekaya *et al.* (1995)
Sahiwal	6.0 ± 0.0	6.4 ± 2.6	5.6 ± 2.5	4.8 ± 2.3	4.2 ± 2.1	3.7 ± 1.9	3.4 ± 1.8	3.0 ± 0.0	-	-	Ilatsia *et al.* (2007)
Sahiwal	6.1 ± 0.10	6.4 ± 0.12	6.0 ± 0.12	5.7 ± 0.11	5.3 ± 0.11	4.9 ± 0.12	4.8 ± 0.12	4.8 ± 0.14	4.6 ± 0.14	4.3 ± 0.18	Bilal *et al.* (2008)
Sahiwal	4.88 ± 0.14	7.8 ± 0.16	7.75 ± 0.15	7.38 ± 0.14	7.01 ± 0.14	6.54 ± 0.13	6.34 ± 0.13	6.15 ± 0.13	6.07 ± 0.13	5.73 ± 0.12	Debbarma *et al.* (2010)
KF	10.14 ± 0.10	12.83 ± 0.10	12.46 ± 0.10	11.71 ± 0.10	10.96 ± 0.09	10.37 ± 0.09	9.97 ± 0.09	9.49 ± 0.09	9.28 ± 0.09	9.13 ± 0.10	Rashia (2010)
Sahiwal	5.41 ± 0.09	8.22 ± 0.11	8.08 ± 0.11	7.61 ± 0.10	7.23 ± 0.10	6.77 ± 0.10	6.50 ± 0.11	6.23 ± 0.11	6.02 ± 0.11	5.63 ± 0.12	Gupta (2013)
Sahiwal	5.12 ± 0.09	8.14 ± 0.11	8.08 ± 0.10	7.52 ± 0.10	6.99 ± 0.09	6.57 ± 0.09	6.22 ± 0.09	5.99 ± 0.09	5.76 ± 0.09	5.42 ± 0.09	Ved Prakash (2015)
Sahiwal	4.54±0.13	8.06± 0.15	8.28±0.15	7.77±0.17	7.27±0.15	6.76±0.15	6.48±0.14	6.21±0.13	5.92±0.15	5.71±0.13	Pandey (2018)

Table 2: Heritability of test days in different breeds of cattle

Breed	Heritability	References
Australian Black and White cows	0.08-0.25	Meyer *et al.* (1989)
British Holstein Friesian	0.27 - 0.43	Pander *et al.* (1992)
Karan Fries	0.16-0.35	Singh (1992)
Karan Swiss	0.19-0.40	Singh (1992)
Holstein cows	0.40-0.57	Jamrozik and Schaeffer (1997)
Hariana cattle	0.04-0.31	Dalal *et al.* (1999)
Polish Black and White cattle	0.16-0.19	Strabel and Miszta (1999)
Holstein Friesian	0.08-0.28	Brotherstone *et al.* (2000)
Ayrshire cattle	0.19-0.34	Lidauer *et al.* (2003)
French Holstein	0.16-0.39	Druet *et al.* (2003)
Czech Holstein	0.13-0.52	Zavadilova *et al.* (2005)
Sahiwal	0.024 ± 0.046	Khan *et al.* (2008)
Karan Fries	0.11-0.37	Kokate L (2009)
Sahiwal	0.05-0.36	Debbarma *et al.* (2010)
Karan Fries	0.12-0.44	Rashia (2010)
Iranian Holstein cattle	0.074 - 0.23	Ashan *et al.* (2011)
Sahiwal	0.244-0.463	Gupta (2013)
Sahiwal	0.01-0.10	Ved Prakash (2015)

Table 3: Genotypic and phenotypic correlations between test day milk yields and first lactation 305 days milk yield

Breed	Genetic correlation	Phenotypic correlation	References
Australian black and White cows	0.39 to 0.95	0.20 to 0.63	Meyer *et al.* (1989)
Karan Swiss	> 0.948	0.95 to 0.98	Singh (1992)
Karan Fries	~ 1	0.96 to 0.98	Singh (1992)
Ayrshire	- 0.31 to 0.98	0.20 to 0.74	Kettunen *et al.*(2000)
German Holstein	0.50	0.27	Liu *et al.*(2000)
Danish dairy breed	0.63 to 0.97	-	Jakobsen *et al.* (2002)
Holstein Friesian	0.24 to 0.63	0.45 to 0.96	Lidauer *et al.* (2003)
Czech Holstein	0.12-0.94	-	Zavadilova *et al.* (2005)
Murrah	- 0.25 to 0.99	0.33 to 0.65	Katneni (2007)
Sahiwal	- 0.77 to 0.99	-0.56 to 0.72	Khan *et al.* (2008)
Karan Fries	0.46 to 0.99	0.17 to 0.82	Kokate (2009)
Karan Fries	0.14 to 0.96	0.20 to 0.78	Rashia (2010)
Simmental	0.13 to 0.99	-	Cobuci *et al.* (2011)
Iranian Holstein	0.502 to 1	0.24 to 0.77	ElahiTorshizi *et al.* (2012)
Sahiwal	- 0.001 to 0.999	-	Dongre (2012)
Sahiwal	- 0.12 to 0.99	0.21 to 0.84	Gupta (2013)
Karan Fries	0.29 to 0.99	0.15 to 0.82	Singh (2014)
Sahiwal	- 0.17 to 0.99	0.22 to 0.83	Ved Prakash (2015)
Murrah	- 0.35 to 0.99	0.38 to 0.79	Rana (2017)
Sahiwal	0.15 to 0.99	0.05 to 0.79	Pandey (2018)

environmental variations respectively of random curve. Ved Prakash (2015) reported that among the RRM-HOM model fitted for all lactation the model with 3rd order fit for additive genetic and 6th order fit for permanent environmental effect was the best model whereas among the RRM-HET model fitted for first lactation the model with 4th order fit for additive genetic effect and fifth order fit for permanent environment effect was the best model.

Estimation of Breeding Values Using Test-Day Milk Yields
In many studies estimated breeding value have been predicted using test day milk yields and then compared to EBVs obtained from 305 days lactation milk yields (Bilal and Khan, 2009; Kokate *et al.*, 2013; Dongre, 2012). The test day milk yield can be used for the genetic evaluation of dairy cattle instead of 305 days milk yield as these studies showed that there is higher correlation between EBVs for 305 days milk yield and test day milk yields. Schaeffer (1993) reported that this correlation ranges from 0.87 to 0.97 in Holstein Friesian.

Swalve (1995) estimated breeding values for 305 days milk yield and test day yield and compare the two. It indicated only minor change in the ranking of sire but major changes were noticed in the ranking of individuals. Shahrbabak (1997) reported that the correlation among EBV from 305 days and test day model for all animals and sire was 0.905 and 0.954 respectively. Pool and

Meuwissen (2000) compared the repeatability model and random regression test day model and concluded that the later predicted better EBVs for more persistent Holstein Friesian bulls. Schaeffer *et al.* (2000) found a strong correlation among the estimated breeding values of test day yield and 305 days milk yield for Holstein bulls (0.97) and cows (0.93).

Lidauer *et al.* (2003) reported the correlation as high as 0.99 between breeding values for milk yield from lactation model and random regression test day model. Kaya *et al.* (2003) reported correlation (more than or equal to 0.97) between the EBVs for TD milk yield and 305 days milk yields in Holstein cattle. Sawalha *et al.* (2005) found that the correlation of TD yield EBV and 305 days yield EBV ranged from 0.71 to 0.87 for sires and 0.80 to 0.87 for cows and concluded that the two are moderately correlated. Geetha (2006) reported the range of average monthly test day breeding value from 4.01 kg on 5^{th} day to 7.45 kg on 65^{th} day. Mostert *et al.* (2006) estimated the correlation between breeding values from lactation model and test day model for proven sires, unproven sires and measured cows. It was 0.91, 0.89, and 0.88 for Holstein, 0.82, 0.63, 0.72 for Guernsey, 0.89, 0.80, 0.86 for Ayrshire and 0.92, 0.89, 0.89 for jersey breed.

Khan *et al.* (2008) found that the breeding values for test day milk yield ranges from -0.51 to 0.74 and -0.53 to 0.80 kg in Sahiwal sires and cows respectively. Cilek *et al.* (2008) found correlation between breeding values of test day yield and 305 days milk yield as 0.876 in Simmental cattle. Farhangfar *et al.* (2008) found that the correlation of breeding values of 305 day milk yield was lowest with 1^{st} month test day (0.553) and highest with 6^{th} month (0.990). Singh (2014) reported a high correlation (0.99) between EBVs of 95^{th}, 125^{th} and 155^{th} day milk yields with EBVs of 305 days milk yield. Ved Prakash (2015) reported that the average sire breeding value ranged from 5.124 Kg (TD1) to 8.199 Kg (TD2) and average cow breeding value ranged from 5.103 Kg (TD1) to 8.163 Kg (TD2) for first lactation in Sahiwal cattle which was estimated using RRM-HOM model.

CONCLUSION

Genetic improvement through selection in a breeding program is a common practice and it depends on how early and how accurately animals can be selected. Using test day milk yield as the basis of selection reduces the time interval, increases the number of records and permits the evaluation of the genetic and environmental effect directly on the test day basis. Based on test day milk records, the cow can be selected or culled at an early stage of lactation. As far as analysis of breeding data is concerned random regression model outweighs repeatability model and multiple trait model as it can estimate the breeding value of test day milk yields and 305 days milk yield more accurately as it can model the additive and permanent environmental effects and also allows the variance to change along the trajectory. The whole review was to pin point the concept, previous utilization and future prospects of applying test day random regression model in animal breeding researches.

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