



Comparison of heritability estimates of first lactation traits by different methods in Phule Triveni cattle

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Received: 24 August 2015; Accepted: 5 October 2015

ABSTRACT

The first lactation records of 493 Phule Triveni cows sired by 55 sires on production traits viz. FL300DMY, FLL, FDP and reproduction traits like AFC, FCI and FSP were collected/generated from RCDP on cattle, MPKV, Rahuri. The effect of season of calving was found significant on FL300DMY and nonsignificant on FLTMY, FLL, FDP, AFC, FCI and FSP. The effect of period of calving had highly significant effect on all the first lactation traits except FSP. The effect of age groups on FLL was found significant and nonsignificant on rest of the first lactation traits. On AFC the effect of season of birth was found nonsignificant and the period of birth had highly significant effect. The heritability estimates of FLTMY by LSML, ST-SM and ST-AM were 0.35 ± 0.16 , 0.15 ± 0.11 and 0.18 ± 0.07 ; for FL300DMY 0.32 ± 0.15 , 0.23 ± 0.12 and 0.29 ± 0.07 ; for FLL 0.07 ± 0.11 , 0.02 ± 0.04 and 0.06 ± 0.02 ; for FDP 0.22 ± 0.13 , 0.18 ± 0.14 and 0.30 ± 0.10 ; for AFC 0.48 ± 0.19 , 0.07 ± 0.08 and 0.36 ± 0.06 ; for FCI 0.28 ± 0.17 , 0.05 ± 0.06 and 0.04 ± 0.03 ; for FSP 0.25 ± 0.17 , 0.06 ± 0.03 and 0.17 ± 0.02 , respectively. The heritability estimates of first lactation traits from single-trait animal model (ST-AM) were found more accurate and less biased than corresponding single-trait sire model (ST-SM) and LSML.

Key words: Heritability, LSML, Phule Triveni cattle, ST-AM, ST-SM, WOMBAT software

The main aim of any breeding programme is to improve the profitability through production of superior animals. Milk production and reproductive performance are the two major factors with respect to overall efficiency and profitability of the dairy animals. Nonetheless, for many years dairy cattle breeding programmes are mainly oriented towards improving the milk production traits and have not given due weightage to the reproduction traits. However, the rise in milk production shadowed by a decline in reproduction over the years (Pryce *et al.* 2004, Divya 2012). Therefore, it is high time that we consider reproduction traits also in our breeding objective as the reduction in reproduction will affect the overall performance of animals and thereby the profitability of livestock farming. It may also be pointed out that direct selection for reproduction traits may not be efficient because these traits have low heritability values (~ 0.04) resulting in low accuracy of

estimated breeding values and low genetic gain per unit of time. Further, the EBVs of the reproduction traits estimated using a model without combining information of milk production traits may lead to biased selection (Jamrozik *et al.* 2005).

Phule Triveni a triple crossbred cattle (50% HF + 25% Jersey + 25% Gir) were developed at Research-Cum Development Project (RCDP), Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, District Ahmadnagar (Maharashtra). In most of the studies in cattle, the heritability estimates were computed using either by paternal half sib correlation method after adjustment of data for significant non-genetic effects or by mixed model methodology taking sire as a random effect in the model (Harvey 1990). Very limited studies (Divya 2012 and Singh, 2013) are available on the effectiveness of BLUP sire and animal models for estimation of heritability estimates. In the absence of such studies in Phule Triveni cattle, an attempt was made to compare the magnitude and accuracy of heritability estimates of first lactation traits viz. FLTMY, FL300DMY, FLL, FDP, AFC, FCI and FSP using BLUP sire and animal models in Phule Triveni cattle using WOMBAT software advocated by Meyer (2007).

MATERIALS AND METHODS

The first lactation records on 493 Phule Triveni cows

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sired by 55 bulls maintained at RCDP on Cattle, MPKV, Rahuri were collected over a period of 37 years from 1976 to 2012. Since, the investigation involved a comparison of single-trait models with multi-trait models for estimation of genetic parameters of production and reproduction traits, the data from same set of animals were used. The information on production traits viz. FL300DMY (first lactation 300-day or less milk yield), FLL (first lactation length), FDP (first dry period) and reproduction traits like AFC (age at first calving), FCI (first calving interval) and FSP (first service period) were collected / generated. The minimum number of progeny per sire considered for the study was 5.

The data were classified into different sub-classes based on season and period of birth, season and period of calving and different age groups based on age at first calving for FL300DMY and different reproduction traits. The year was classified into 3 seasons viz. Winter - October to February, Summer- March to May, and Rainy- June to September, periods of calving into 7 groups viz. <1980, 1981–1983, 1984–1988, 1989–1993, 1994–1998, 1999–2004, >2005, periods of birth into 7 groups viz. <1980, 1981–1983, 1984–1988, 1989–1993, 1994–1998, 1999–2004, >2005 and age at first calving was classified using into 5 groups viz. <803 days, 804–901 days, 902–1,011 days, 1,012–1,147 days and >1148 days.

Least squares maximum likelihood (LSML) mixed model taking period, season and age as fixed effect and sire as a random effect was used for estimation of genetic parameters of first lactation production and reproduction traits (Harvey 1990).

Variance–covariance components were estimated from single and multi-trait animal model analysis by REML method using WOMBAT software (Meyer 2007). Under multi-trait models, the two-trait, three-trait and four-trait models combining FL300DDMY with production / reproduction traits were considered. As a part of data arranging duplicate IDs were checked using Pedigree Viewer software.

The following animal model was used: $Y = Xb + Zu + e$ For three traits, the model can be expressed as:

$$\begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} = \begin{pmatrix} X_1 & 0 & 0 \\ 0 & X_2 & 0 \\ 0 & 0 & X_3 \end{pmatrix} \begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix} + \begin{pmatrix} Z_1 & 0 & 0 \\ 0 & Z_2 & 0 \\ 0 & 0 & Z_3 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \\ e_3 \end{pmatrix}$$

where, Y vector of observations for traits under study;

b, vector of observations of unknown fixed effects of period and season; u, vector of observations of unknown random effects (animals); X and Z are the incidence matrices pertaining for fixed and random animal effect, respectively.

The following are the assumptions of the model:

$E(Y) = Xb$, $Var(s) = G$, $Var(h) = R$ and $Cov(s, e') = 0$ so that,

$$V(y) = ZGZ' + R$$

RESULTS AND DISCUSSION

Factors affecting first lactation traits and heritability estimates

First lactation total milk yield (FLTMY): The effect of season of calving on FLTMY was found to be nonsignificant in all the three models. The averages of FLTMY of seasons under different models showed marginal changes (LSML, ST-SM and ST-AM) as presented in Table 1. The nonsignificant effect of season of calving on first lactation total milk yield was also reported by Chavan (2010) in HF × Gir halfbred and their interbreds and Mhasade (2010) in FG crossbred cows.

The effect of period of calving on FLTMY was found to be highly significant ($P < 0.01$). No definite trend of increase or decrease was observed in FLTMY across the periods under different models (LSML, ST-SM and ST-AM). The significant effect of period of calving on FLTMY was also reported by Mhasade (2010) and Nikam (2010) in Phule Triveni cattle. The effect of age groups on FLTMY was nonsignificant in this study (Table 1).

The heritability estimate of FLTMY by LSML, ST-SM and ST-AM were found as 0.35 ± 0.16 , 0.15 ± 0.11 and 0.27 ± 0.07 , respectively. Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). However, the higher estimates of heritability of FLTMY were reported by Kale *et al.* (2001) and Gawari (1999) in FJG crossbred cattle as 0.41 ± 0.20 and 0.43 ± 0.20 , respectively. The heritability estimates of FLTMY by ST-AM were reported as 0.29 by Teepker and Swale (1998) and 0.34 by Meyer (1984) and Albuquerque *et al.* (1994) in HF cattle.

First lactation 300 day milk yield (FL300DMY): The effect of season of calving was significant ($P < 0.05$) on FL300DMY. The significant effect of season of calving on first lactation 300 / 305 days milk yield also reported by Pol *et al.* (2013) in Phule Triveni cow. The period of calving had highly significant ($P < 0.01$) influence on FL300DMY. No definite trend of increase or decrease was observed in FL300DMY across the periods under different models (LSML, ST-SM and ST-AM) as presented in Table 1. The significant effect of periods was also reported by Garudkar (2011), Shelke (2012) and Pol *et al.* (2013) in Phule Triveni cow. The effect of age groups on FL300DMY was found nonsignificant. The nonsignificant effect of age at first calving on FL300DMY was also reported by Mandakmale *et al.* (2002), Shinde *et al.* (2005), Garudkar (2011) and Shelke (2012) in Phule Triveni cows.

The heritability estimates of FL300DMY by LSML, ST-SM and ST-AM were 0.32 ± 0.15 , 0.23 ± 0.12 and 0.29 ± 0.07 , respectively. Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). The higher heritability estimates of FL300DMY in Phule Triveni

Table 1. Mean±SE offirst lactation traits affected by non-genetic factors under different models

Factors	N	FLTMY (kg)			FL300DMY (kg)			FLL (days)		
		LSML	SM	AM	LSML	SM	AM	LSML	SM	AM
Overall (μ)	493	2855±43	2858±46	2864±45	2647±39	2624±39	2627±36	331±3	336±2	336±4
<i>Season of calving</i>										
SEASON-1(Winter)	170	2899±37	2835±35	2868±34	2707±56 ^a	2635±55 ^b	2666±55 ^a	331±5	334±4	334±3
SEASON-2(Summer)	159	2801±70	2856±67	2869±69	2553±58 ^c	2578±57 ^c	2586±58 ^c	338±5	339±5	341±4
SEASON-3(Rainy)	164	2866±68	2886±67	2853±66	2681±57 ^b	2657±57 ^a	2627±55 ^b	324±5	336±4	334±3
<i>Period of calving</i>										
PERIOD-1(>1980)	56	3020±411 ^{ab}	2990±412 ^b	3302±410 ^b	2809±320 ^b	2843±312 ^a	3156±316 ^a	346±31 ^a	320±24 ^d	326±27 ^f
PERIOD-2(1981–1983)	81	2381±336 ^d	3185±321 ^a	2709±311 ^c	2246±262 ^c	2847±276 ^a	2559±265 ^d	338±26 ^a	345±24 ^b	333±27 ^e
PERIOD-3(1984–1988)	106	3287±286 ^a	2911±278 ^c	2789±289 ^d	2928±224 ^b	2675±221 ^c	2512±223 ^e	360±22 ^a	335±18 ^c	345±20 ^a
PERIOD-4(1989–1993)	83	2801±241 ^{bc}	2420±237 ^g	3533±238 ^a	2477±189 ^c	2175±180 ^f	3146±186 ^b	339±18 ^a	350±16 ^a	348±15 ^a
PERIOD-5(1994–1998)	63	2707±267 ^c	2525±266 ^f	2848±263 ^c	2394±208 ^c	2249±209 ^e	2620±206 ^e	357±20 ^a	336±22 ^c	336±21 ^d
PERIOD-6(1999–2004)	56	2550±343 ^{cd}	2839±321 ^d	2476±343 ^f	2478±267 ^c	2692±258 ^b	2300±256 ^f	302±26 ^b	323±24 ^d	339±25 ^c
PERIOD-7(>2005)	48	3243±463 ^a	2584±356 ^e	2450±366 ^g	3195±315 ^a	2442±312 ^d	2159±311 ^g	275±31 ^c	301±32 ^e	341±31 ^b
<i>Age at first calving</i>										
AGE-1(<803 days)	106	2839±91 ^b	3075±87 ^a	3071±89 ^a	2650±74	2877±69	2874±70	323±7 ^{ab}	333±5 ^d	332±8 ^c
AGE-2(804–901 days)	119	2800±81 ^c	2785±78 ^c	2819±79 ^b	2562±67	2554±65	2577±66	331±6 ^{ab}	337±5 ^c	337±3 ^b
AGE-3(902–1011 days)	117	2917±82 ^a	2796±81 ^c	2808±8 ^b	2661±67	2541±66	2534±66	342±6 ^a	345±6 ^a	346±4 ^a
AGE-4(1012–1147 days)	83	2818±94 ^{bc}	2741±90 ^d	2795±92 ^c	2646±76	2511±75	2563±74	318±7 ^b	323±6 ^e	326±7 ^d
AGE-5(>1148 days)	68	2904±112 ^a	2927±112 ^b	2795±110 ^c	2714±90	2511±89	2570±90	342±8 ^a	341±7 ^b	336±6 ^b
Overall (μ)	493	93±3	89±3	85±5	430±4	425±6	425±4	151±5	153±7	145±3
<i>Season of calving</i>										
SEASON-1(Winter)	170	94±4	87±3	85±2	423±7	421±3	425±1	149±7	145±5	140±3
SEASON-2(Summer)	159	88±4	88±4	82±1	425±7	425±6	424±4	143±8	158±4	139±3
SEASON-3(Rainy)	164	99±4	92±5	88±3	436±7	428±4	428±3	142±8	157±3	156±1
<i>Period of calving</i>										
PERIOD-1(<1980)	56	57±24 ^e	91±15 ^d	86±11 ^a	403±41 ^c	422±37 ^d	412±33 ^d	123±42 ^c	145±37 ^e	141±31 ^c
PERIOD-2(1981–1983)	81	57±20 ^e	80±17 ^e	83±13 ^b	395±34 ^c	423±34 ^d	412±29 ^d	115±35 ^c	147±21 ^d	142±17 ^c
PERIOD-3(1984–1988)	106	50±17 ^e	75±21 ^g	79±16 ^d	410±29 ^c	410±23 ^e	423±19 ^c	130±30 ^c	139±26 ^f	137±22 ^d
PERIOD-4(1989–1993)	83	77±14 ^d	78±11 ^f	81±7 ^c	415±24 ^c	422±23 ^d	429±21 ^b	142±25 ^c	148±27 ^d	149±25 ^b
PERIOD-5(1994–1998)	63	96±16 ^c	93±12 ^c	71±9 ^e	451±27 ^{ab}	440±22 ^b	406±16 ^e	171±28 ^{ab}	179±23 ^c	123±17 ^f
PERIOD-6(1999–2004)	56	123±20 ^b	132±5 ^a	81±3 ^c	425±34 ^{bc}	449±35 ^a	423±31 ^c	146±35 ^{bc}	185±32 ^b	134±31 ^e
PERIOD-7(>2005)	48	194±24 ^a	127±7 ^b	81±4 ^c	469±40 ^a	437±37 ^c	438±34 ^a	189±42 ^a	188±39 ^a	153±33 ^a
<i>Age at first calving</i>										
AGE-1(<803 days)	106	94±6	80±3	81±5	419±9	418±8	415±4	134±10	144±8	140±4
AGE-2(804–901 days)	119	94±5	89±5	84±3	422±8	420±5	421±3	143±9	147±6	141±4
AGE-3(902–1011 days)	117	97±5	90±7	87±5	436±8	434±7	436±5	155±9	160±5	155±3
AGE-4(1012–1147 days)	83	98±6	95±4	89±3	416±9	420±5	421±3	148±10	157±7	138±5
AGE-5(>1148 days)	68	89±7	94±3	90±4	434±11	435±7	436±4	148±12	162±5	149±3

LSML, Least squares maximum likelihood; SM, Single-trait sire model; AM, Single-trait animal model.

cattle were reported as 0.47±0.11 by Shelke (2012) and 0.47±0.21 by Gawari (1999) in FJG triple crossbred cattle. The heritability using animal model for 305 day milk yield was similar to that estimate (0.280±0.021) by Kadarmideen *et al.* (2003). Singh (2013) reported lower heritability of 0.053±0.024 by ST-SM and 0.238±0.087 by ST-AM, respectively, in Karan Fries cattle.

First lactation length (FLL): The effect of season of calving on FLL was nonsignificant by all the methods. The non-significant effect of season of calving on first lactation length was also reported by Zol *et al.* (2009) in Phule Triveni cow. The effect of period of calving on FLL was highly significant (P<0.01) by all the methods. The significant effect of period of calving on first lactation length was observed by Zol *et al.* (2009) in Phule Triveni cows. The effect of age at first calving groups on FLL was found significant (P<0.05) by all the methods (Table 1). The significant effect of age at first calving on FLL was also reported by Mandakmale *et al.* (2002) in Phule Triveni cows.

The heritability estimates of FLL by LSML, ST-SM and ST-AM were found as 0.07±0.11, 0.02±0.04 and 0.06±0.02,

respectively. Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). The heritability estimates of FLL were low by all the methods. The estimate of heritability of FLL was close to the estimate 0.07±0.12 (Gawari 1999) in FJG crossbred. Zulkadir *et al.* (2009) also reported heritability of lactation length by single trait animal model as 0.11 in Brown Swiss cattle.

First dry period (FDP): The effect of season of calving on FDP was nonsignificant. The non-significant effect of season of calving on FDP was also reported by Zol *et al.* (2009) in Phule Triveni crossbred cattle. The effect of period of calving on FDP was highly significant (P<0.01). The significant effect of period of calving on first lactation dry period was also observed by Zol *et al.* (2009) in Phule Triveni cattle. The effect of age at first calving groups on FDP was nonsignificant and the FDP registered no definite trend of increase or decrease in across the age groups (Table 1).

The heritability estimates of FDP by LSML, ST-SM and ST-AM were found as 0.22±0.15; 0.18±0.14 and 0.30±0.10, respectively, in the present study (Table 3). Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). The estimate of heritability of FDP was close to the estimate of heritability (0.20) reported by Deshmukh *et al.* (2003) in Holstein Friesian x Gir crossbreds.

Age at first calving (AFC): The effect of season of birth on AFC was found to be statistically nonsignificant in Phule Triveni heifers. The results were in agreement with those reported by Bhoite (1996) in Friesian-Jersey-Gir (FJG), Jersey-Friesian-Gir (JFG) and Brown Swiss-Friesian-Gir (BFG) crosses. The period of birth had highly significant (P<0.01) effect on AFC in Phule Triveni heifers (Table 2). The significant effect of period of birth on AFC was also reported by Bhoite (1996) in FG, JG, FJG, JFG and BFG 2 and 3 breed crosses.

The heritability estimates of AFC by all the three methods viz. LSML, ST-SM and ST-AM as 0.48±0.19; 0.04±0.08 and 0.36±0.06, respectively (Table 3).

Table 2. Mean±SE of age at first calving affected by non-genetic factors under different models

Factors	AFC(days)		
	LSML	SM	AM
Overall (μ)	985±2	953±3	948.978
Season of birth			
SEASON-1(Winter)	984±2	968±3	949±2
SEASON-2(Summer)	984±3	938±3	938±2
SEASON-3(Rainy)	988±3	952±2	961±1
Period of birth			
PERIOD-1(<1980)	972±22 ^c	835±19 ^f	862±17 ^f
PERIOD-2(1981-1983)	974±18 ^c	934±17 ^e	971±14 ^c
PERIOD-3(1984-1988)	954±15 ^d	934±12 ^e	864±11 ^f
PERIOD-4(1989-1993)	956±12 ^d	958±12 ^d	936±7 ^e
PERIOD-5(1994-1998)	981±14 ^c	1137±13 ^b	947±9 ^d
PERIOD-6(1999-2004)	998±18 ^b	1228±16 ^a	1094±13 ^a
PERIOD-7(>2005)	1063±21 ^a	991±21 ^c	1089±17 ^b

LSML, Least squares maximum likelihood; SM, Single-trait sire model; AM, Single-trait animal model.

Table 3. Heritability and REML estimates of (co) variance components under LSML, ST-SM and ST-AM

Parameters	LSML			Sire Model			Animal Model		
	Additive genetic variance	Residual variance	Heritability	Additive genetic variance	Residual variance	Heritability	Additive genetic variance	Residual variance	Heritability
FLTMY	186892	487259	0.35±0.16	100507	555269	0.15±0.11	109876	491394	0.18±0.07
FL300DMY	120168	339245	0.32±0.15	59859	341777	0.23±0.12	109862	267473	0.29±0.07
FLL	244	3309	0.07±0.11	72	3378	0.02±0.04	202	3217	0.06±0.02
FDP	456	1973	0.22±0.15	407	1759	0.18±0.14	846	1378	0.30±0.10
AFC	8372	15438	0.48±0.19	523	7060	0.07±0.08	5184	2288	0.36±0.06
FCI	1488	4971	0.28±0.17	27	5827	0.05±0.06	286	5580	0.04±0.03
FSP	1572	6040	0.25±0.17	404	6138	0.06±0.03	1120	5387	0.17±0.02

Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). The estimate was close to the estimates reported by Nehra (2011) as 0.43 ± 0.13 and Divya (2012) as 0.54 ± 0.17 in Karan Fries cattle. Singh (2013) reported heritability of AFC as 0.108 ± 0.031 and 0.156 ± 0.058 by ST-SM and ST-AM in Karan Fries cattle.

First calving interval (FCI): The effect of season of calving was nonsignificant on FCI. The nonsignificant effect of season of calving on first lactation calving interval was reported by Zol *et al.* (2009) in Phule Triveni cattle and Mhasade (2010) in FG crossbreds. The effect period of calving was highly significant ($P < 0.01$) on FCI. The significant effect of period of calving obtained in the study was in agreement with that of Zol *et al.* (2009) in Phule Triveni cattle and Kamble (2003) in FJG, JFG and BFG triple crosses. The effect of age at first calving groups had nonsignificant effect on FCI (Table 1). The non-significant effect of age at first calving groups on FCI was reported by Jadhav *et al.* (1991) in HF \times S/T crossbreds and Nehra (2011) in Karan Fries cattle.

The heritability estimates of FCI by LSML, ST-SM and ST-AM were as 0.28 ± 0.17 ; 0.05 ± 0.06 and 0.04 ± 0.03 , respectively (Table 3). Comparison of heritability estimates and residual variance from 3 different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). Divya (2012) observed the heritability estimate of FCI as 0.052 ± 0.084 by single trait animal model in Karan Fries cattle.

First service period (FSP): Season of calving had nonsignificant effect on FSP. The nonsignificant effect of season of calving on first lactation service period was reported by Bhoite (1996) and Kamble (2003) in Gir crossbreds. The period of calving had significant ($P < 0.05$) effect on FSP (Table 1). The significant effect of period of calving obtained in the study was in agreement with that of Zol *et al.* (2009) in Phule Triveni cows, Jadhav (2011) in HF \times Gir halfbreds and Mhasade (2010) in FG crossbreds. The effect of age at first calving groups was nonsignificant on FSP. Saha (2001) and Divya (2012) also reported nonsignificant effect of age groups on FSP in Karan Fries cattle.

The heritability estimates of FSP by LSML, ST-SM and ST-AM were as 0.25 ± 0.17 ; 0.06 ± 0.03 and 0.17 ± 0.02 , respectively (Table 3). Comparison of heritability estimates and residual variance from three different models revealed that the lowest standard error and residual variance was observed in ST-AM followed by ST-SM and LSML (Table 3). Lower heritability of FSP was reported as 0.047 ± 0.129 and 0.030 ± 0.082 from LSML and ST-AM by Divya (2012) and 0.003 ± 0.015 and 0.010 ± 0.047 from ST-SM and ST-AM by Singh (2013) in Karan Fries cattle.

It was concluded that single-trait BLUP animal model was more efficient and unbiased than single-trait BLUP sire model and least squares maximum likelihood mixed model

for estimation of heritability because BLUP animal model takes into account all the relationships among all the animals.

ACKNOWLEDGEMENT

The authors are thankful to the Director, ICAR-NDRI, Karnal for providing necessary facilities for conducting the research work and Vice-Chancellor, MPKV, Rahuri for permission to utilize research data on Phule Triveni without which this study could not have taken place.

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