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Productive performance of *Achai* and crossbred cows under different farm managements in Dir-Kohistan Hindukush Mountanious Range

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Abstract

The study was to understand the prevailing knowledge and applied practices regarding factors affecting the productive performance of *Achai* and Jersey X *Achai* cows under different farming systems in Hindukush Mountains of Pakistan. During survey, two types of rural housing systems were observed which were termed as rural traditional farming system (RFS) and rural progressive farming (PFS) system on the basis on differences in nutrition, health and general management and breeding planning. Overall, the productive performance of crossbred cows (except CSR) was significantly ($P<0.05$) better than *Achai* cows. Comparing different farm managements, both breeds had significantly ($P<0.05$) better performance in PFS. Regarding factors effect, the DMY, LL and LY was significantly better in good condition *Achai* cows in PFS particularly during summer season. Parity and age showed no effect on productive performance of *Achai* cows in any farming system. In crossbred cows, all the studied productive traits were significantly ($P<0.05$) better during summer season. Adult (4-6 years age) crossbred cows had significantly ($P<0.05$) higher DMY and LY due to longer LL in their 3rd and 4th parities. On the other side, the daily milk yield, Lactation Length, Lactation Yield and Calf Birth Weight was not affected ($P>0.05$) by BCS. The study revealed that crossbreeding of *Achai* cows with Jersey semen and improving farm managements markedly improved the productive performance in study area. Further, the introduction of *Achai* cows to intensive farm conditions (as in state farm) significantly affected its productive potentials.

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Introduction

Pakistan holds 42.6 million heads of cattle population among which 70% shares non-descript cattle. These cattle have dynamic economic performances under varying climatic conditions with in Pakistan but mostly have low production record (Sattar *et al.*, 2005). In-spite of low performance, livestock plays a significant role in national economy particularly in uplifting the socio-economic status of rural population (Khattak *et al.*, 2018). Farmers of Northern Hindukush region has substantial relation with livestock and rely on dairy products for basic life support (Saleem *et al.*, 2010). In Northern Hindukush region of Pakistan, the production and distribution system of livestock and livestock products are traditional and poorly developed. Livestock are reared under sedentary, semi-nomadic and nomadic systems (Sadiq *et al.*, 2003). Livestock farmers belong to small/landless farmers and remain under extensive production system. On the other side, utilization of inputs obviously influences the profitability of dairy industry because of substantial relationship with economic traits of cattle (Williams *et al.*, 2011).

Therefore selection of economic traits has traditionally paid more attention in breeding policies for profitability of dairy farming (Gonzalez Recio *et al.*, 2014). Recently, genetic improvement in economic traits with better resistance to non-genetic factors affecting its performance has been emphasized in many countries (Miglior *et al.*, 2005).

Lowered feed cost, higher and quality milk production and health issues are key factors for adopting genetic improvement programmes (Bell *et al.*, 2013; Connor, 2015) therefore the inclusion of economic traits in breeding and selection schemes to improve profitability estimates of different cattle breeds had been widely studied (Sölkner *et al.*, 2000; Fernández-Perea and Jiménez, 2004). In response, it was observed that expressing the economic traits primarily depend upon certain factors including basic genetic makeup, feed conversion efficiency, physiological condition of animals, adoptability to climatic conditions and heredity flow of specific breed immunity to certain diseases (Epaphras *et al*, 2004; Naceur *et al* 2014). Husbandry practices, nutrition, lactation, age and calving seasons are other prominent factors affecting productive and reproductive economic traits of cattle (Msanga *et al*, 2000). *Achai* cattle, a better choice of farmers rearing livestock in remote areas of Himalayan Hindukush Mountains are inherently slow-maturing and low-milk producers (Saleem, 2012). *Achai* cattle termed as an economical livestock in high altitudes of northern areas of Pakistan has some promising characteristics i-e impressive performance on suboptimal quality roughages, enhanced immunity and in some aspect showed comparatively good reproductive record than any other cattle breeds in Pakistan (Saleem *et al.*, 2012). High resistant and well adaptive to harsh climatic conditions make it more favourable to graze on rugged mountain terrain. Priority for increased milk production, progressive use of mechanized tools for agricultural purposes instead of cattle bull as draught animal, and easily accessibility to artificial insemination initiated crossbreeding services with exotic cattle specifically with Jersey breed.

Negligible research has been conducted on economic traits of *Achai* cattle, which is key source of income in the Northern Hindukush Region of Pakistan.

In addition, the increased demand of milk and meat production for human consumption has raised questions that whether *Achai* breed has the potentials to support current demand for milk and meat production or either crossbreeding of *Achai* cow with Jersey breed could be an alternate source for improved performance. Present study was designed with the objectives to acquire the knowledge regarding factors affecting economic traits of *Achai* and Jersey X *Achai* cattle in Hindukush Mountains of northern Khyber Pakhtunkhwa province of Pakistan.

Materials and methods

Study area

The broader home tract of the *Achai* cattle is spread over the North-Western Hindu Kush Mountains of Khyber Pakhtunkhwa, Pakistan (Fig. 1). The study area is situated 34° 10N latitude and 72°20E longitude.

The area falls in both subtropical dry temperate zone as well as moist temperate zone of Hindukush series in Pakistan. Geographically, Afghanistan lies in west, Swat in East, District Chitral in North and Dargai council of Malakand Division in South of the study area (Hazrat *et al*., 2015).

Climatic conditions of the area are moderate. Annual precipitation and relative humidity of the study area ranges from 70-300 mm and 15 to 60%, respectively while temperature ranges from 20 to 33°C and -1 to 15°C during summer and winter, respectively (Fayaz, 2017).

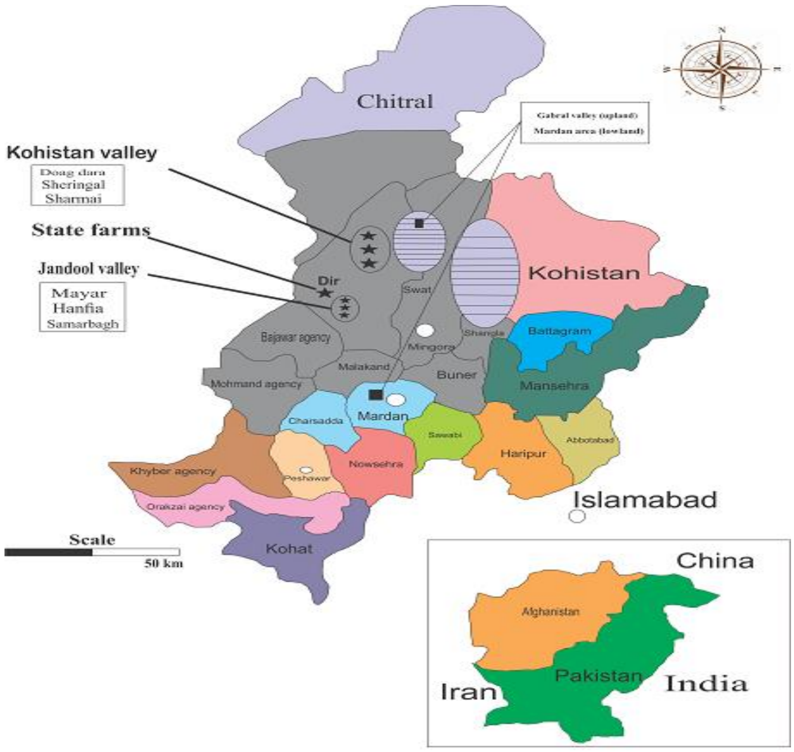

Fig. 1. Map of study area

Selection of animals

Pure *Achai* and Jersey X *Achai* cows were selected to study it productive performance under the effect of different factors i-e body condition score (BCS), Age, parity and calving season. Age of cow was determined through dentition formula as per the guidelines of Pace and Wakeman, (2003). Parity of animal was calculated as per information provided by respondents during the survey. Body condition score of animal was confirmed on five point scale as described by Peters and Ball (1987).

Classification of fixed factors

To evaluate the effect of different factors on productive performance of cows, each factor was further subdivided in to different levels in each farming system on the basis of 1: Age (young cows; 2-4 years age, adult cows: 5-6 years age, older cows: 7-8 years age), 2: Parity (early parity cows: 1st and 2nd parity, mid parities cows; 3rd and 4th parity, advanced parity cows; 5th and 6th parity), 3: Calving season (Summer and winter calvers) and 4; BCS (cow with BCS<2.5 and BCS>2.5). In addition to state farms, different kind of rural housing systems were observed on the basis of differences in nutrition, housing design and animal management, approach to address animal health and reproduction and orientation toward livestock marketing. The effect of fixed factors was therefore studied in each farming system.

Attributes of rural farming systems

Rural farmers adopted various approaches in rearing livestock which resulted in to rural traditional farming system (RFS) and rural progressive farming system (PFS).

RFS mainly existed on hilly areas with 6747±265.25ft altitude where farmers preferred mixed type herding with 3-5 cattle heads in extensive management practices and had limited market access due to remote hilly areas. The farming objectives were milk production, animal sale and gifting, ploughing, replacement and meat purposes for home consumption. RFS farmers practiced indiscriminate breeding mostly with *Achai* bull, occasionally inseminated cows with Jersey semen. Animals were kept in sheds made of clay walls or stones with soil floor. Animals chained with tree trunks were considered as open yard. Animals were stall fed during evening and allowed to graze during day time on rugged mountain terrains. Animal received suboptimal quantity and quality nutrition and occasionally supplemented for increased production. In RFS, mainly homemade remedies were used for treating animals. The trend of using de-wormers and vaccination was occasional.

PFS mostly prevailed on plain areas with an altitude of 4343±152.60ft. PFS farmers kept 5-10 cattle per household in an intensive management system focused on milk production for sale. Farmers adopted crossbreeding policy and prefer Jersey semen for insemination of *Achai* cows. For cattle housing, farmers used cemented blocks for walls and concrete or bricks for flooring. Generally wooden planks or tree branches were used for the construction of open paddock. In PFS, two times stall feeding with optimum quantity and quality feed is provided. Provision of concentrates and supplementation for increased production is common. For animal health, professional veterinarians are preferred however homemade remedies are also used. Contrary to RFS, regular vaccination and use of de-wormers was common in PFS.

Nutrition management

In the study area, cattle nutrition varied on the basis of farming system, season and breed of cow. Quantity and type of feed provided to pure *Achai* and crossbred cows in different farming systems during summer and winter seasons is detailed in the Table I. Briefly, crossbred cattle received comparatively more different kind of concentrates, green fodders, weed thinning and tree leaves in rural progressive farming system. While in winter, the quantity of concentrates increased in all farming systems for both breeds.

Further, cow grazing for a specific time in rural traditional farming system and provision of a special energy supplementation containing wheat flour, ghee and different herbs mixed in the fluid of locally produced sweetener from sugarcane as first diet for freshly parturated cows was also common in the surveyed households of study area.

Table 1. Quantity of feed (kg) received by animals during different seasons in study area.

	Summer season			
Feed Ingredients (kg)	RAFS[1]	RCFS[2]	PAFS[3]	PCFS[4]
Concentrate	1	0.86	1.53	1.95
Dry bread	0.50	0.53	1.06	1.00
Green Fodder	7.00	10.56	7.85	14.68
Wheat Straw	1.00	1.03	1.00	0.50
Weed Thinning	0.00	0.00	1.00	0.00
Tree Leaves	2.50	2.67	2.53	4.00
Maize Stover	0.00	0.52	1.00	0.00
Winter season				
Concentrate	1.00	2.00	2.00	3.00
Dry bread	0.73	1.40	1.00	2.00
Green Fodder	0.00	1.38	0.00	0.00
Wheat Straw	5.33	7.05	5.03	6.64
Weed Thinning	1.73	0.52	1.50	1.39
Tree Leaves	0.60	0.61	1.52	1.89
Maize Stover	2.60	4.57	4.20	5.50

[1]RAFS, Rural *Achai* farming system, [2]RCFS, Rural crossbred farming system, [3]PAFS, Progressive *Achai* farming system, [4]PCFS, Progressive crossbred farming system.

Collection of feed samples and chemical analysis

Seventy five (200-250g) representative samples of feed provided in each farming system (N=25 for each farming system) randomly collected in large paper bags were analysed for chemical composition including dry matter, moisture, crude protein and ash, crude fibre, EE, NFE and TDN content. Feed samples were analysed following the procedure of AOAC, (1995). All standard protocols for feed sample collection, processing and chemical analysis were ensured. The nutritive value of feed samples is detailed in the Table 2.

Table 2. Nutritive value of feed ingredients provided to animals in studied area.

Grasses	%DM	Moisture	%CP	%CF	Ash	%EE	%NFE	%TDN
Poa alpine	92.73	07.27	21.20	19.67	09.01	06.20	51.74	-
Trifolium repens	90.13	09.87	22.62	19.64	08.32	04.60	44.62	-
Plectranthus rogusus	93.20	06. 80	13.11	21.63	08.87	05.40	42.50	-
Concentrates								
Wheat Bran	88.72	09.37	12.03	09.84	04.63	03.12	68.73	74.05
Cotton seed cake	90.95	09.13	22.37	28.41	06.58	07.62	34.60	64.52
Mustard seed cake	91.76	08.32	32.08	19.84	12.02	09.64	26.21	84.63
Commercial. Concentrates	90.73	09.63	17.17	10.16	04.14	04.95	52.97	72.48
Crop Residues								
Wheat Straw	89.94	9.06	03.21	41.81	10.9	00.12	44.23	43.63
Maize Stover	93.66	6.42	04.60	45.72	12.3	01.75	39.72	54.38
Fodder								
Barseem	13.64	86.36	19.34	21.41	16.28	01.86	43.47	61.65

Data collection

Between December 2016 and November 2017, 720 households at Sheringal, Dogdara, Sharmai, and Jandool valley and 356 animals at two state farms i.e Livestock Research and Development Station and *Achai* Cattle Conservation Farm, Dir (Lower), were surveyed for data collection (Fig.1) through a structured questionnaire by face to face interacting farmers with repeated questioning to excerpt concrete information and tracking concerned animals for confirmation of breed, housing pattern and management, use of antiparasitic, growth promoting and milk boosting medicine, nutrition management and productive and reproductive performance. Data on productive performances include daily milk yield (DMY), lactation length (LL), lactation milk yield (LY), calf birth weight (CBW).

Daily milk yield was calculated by emptying cow udder completely through gentle hand milking in morning while practicing same procedure next day at evening and combining the weight of both times milking to determine the daily milk yield. The purpose of such practice was to ensure calf health and reluctance of local farmers to collect milk from cow by prohibiting calf from natural udder suckling. Lactation length was calculated as interval (in days) from parturition till complete cessation of milk yield either by cow or voluntarily by farmers. For calculation of lactation length, the trust upon the responses of farmers during survey was only option. However, during pooling of data, it was ensured to remove any unusual observation which exceeds normal ranges. Lactation yield was calculated by multiplying daily milk yield of each cow with its lactation length. Calf birth weight was calculated by weighing young calves within three (03) days after births mostly by spring balance due to lack of facilities to use electronic scale. However, electronic scale was also used where possible and average data was compared with records of spring balance before entering in record sheets.

Statistical analysis

Initially data was grouped as *Achai* vs crossbred cows to study the difference between breeds irrespective of farming or other fixed factors effect. For the difference between breeds two sample t-test at 5% level of probability was used. Upon significant differences observed in studied parameters between breeds, it was decided to analyse further data separately for each breed under all fixed factors. Therefore, during the 3rd step, within breed combined analysis of variance technique was followed separately for *Achai* and crossbred cows to study the main effect as well as the interaction effect between the farming systems and fixed effects (i.e. body conditions, age, parity and season) according to Annicchiarico (2002). Upon significant results for interaction effect the data was further analysed at individual level in each farming system to study the variation among the levels of fixed effects. In addition, to study the effect of farming systems on each level of fixed effects the data was also analysed within each level of body condition, age, parity and season across different farming systems. Mean separation was carried out using Least Significant Difference test (LSD) following Steel and Torrie (1985) where required.

Results

Overall productive performance of *Achai* and crossbred cows

The overall productive performance of *Achai* and crossbred cows studied during this investigation is presented in the Table 3.1. The crossbred cattle had significantly higher daily milk yield (P<0.05), longer lactation length (P<0.05), milk yield per lactation (P<0.05) and heavier calves (P<0.05) at birth than *Achai* cows.

Table 3.1. Overall productive performances of *Achai* and crossbred cows.

Productive traits	*Achai* cows	Crossbred cows	P-Value
Daily milk yield (L)	3.55 ± 0.07^b	4.57 ± 0.07^a	0.00
Lactation length (days)	222.94 ± 2.99^b	257.26 ± 2.93^a	0.00
Milk yield/lactation (L)	814.90 ± 21.16^b	1179.38 ± 20.73^a	0.000
Calf birth weight (kg)	15.20 ± 0.17^b	16.29 ± 0.16^a	0.04

Means with different superscripts are significantly different at P<0.05

Effect of farming systems on productive performance of Achai and crossbred cows

Productive performance of *Achai* and crossbred cows in different farming systems is presented in the Table 3.2. Farming systems showed significant (P<0.00) effect on productive performance of *Achai* and crossbred cows with better results in rural progressive farming system. It was also revealed from the present.

Study that introducing *Achai* cows to intensive farming systems i.e state farms significantly affected its productive performances.

Table 3.2. Productive performance of *Achai* and crossbred cows under different farming systems.

Performance	Breed	SF	RFS	PFS	P-value
DMY (litres)	*Achai*	2.00^c	2.40 ± 0.08^b	4.18 ± 0.23^a	0.00
	Crossbred	*	4.44 ± 0.02^b	5.53 ± 0.47^a	0.03
LL (days)	*Achai*	183.37^b	191.73 ± 3.05^b	244.78 ± 4.04^a	0.00
	Crossbred	*	236.73 ± 5.15^b	283.47 ± 3.05^a	0.00
LY (days)	*Achai*	381.87^b	462.50 ± 19.34^b	1019.56 ± 17.62^a	0.00
	Crossbred	*	1048.19 ± 22.66^b	1564.45 ± 24.43^a	0.00
CBW (kg)	*Achai*	15.27^a	$16.51\pm.08^b$	$16.56\pm.04^b$	0.05
	Crossbred	*	$15.56\pm.09^b$	$16.66\pm.07^a$	0.00

Means within rows with different superscripts differs significantly at P<0.05 separately for each breed.

Factors affecting the daily milk yield of Achai and crossbred cows under different management systems

The effect of body condition score, parity, season and age on daily milk yield of *Achai* and crossbred cows in SF, RFS and PFS is presented in the Table 3.3. BCS significantly (P<0.05).

Affect DMY of *Achai* cows reared under PFS with better production in cows with more than 2.50 BCS. Calving season also had significant (P<0.05) effect on DMY with higher production in *Achai* cows calved in summer season. The effect of parity and age on same trait was not significant (P>0.05). In crossbred cows, parity, season and age had significant (P<0.05) effect on DMY. Higher yield was observed in 3rd and 4th parity group, summer calvers and 4-6 years age group cows under both RFS and PFS. The effect of BCS on DMY of crossbred cows was not significant (P>0.05).

Table 3.3. Effect of BCS, parity, season and age on DMY (kg) of *Achai* and crossbred cows under different management systems.

Achai cows	Levels	SF	RFS	PFS	Mean
BCS	<2.5	1.56±0.63^{c}	2.81±0.88^{b}	3.18±0.58^{a}	2.51±0.62
	>2.5	1.90±0.48^{c}	3.17±0.63^{b}	4.18±0.47^{a}	3.08±0.47
	P-value	0.30	0.06	0.04	0.05
Parity	1st & 2nd	2.87±1.27^{c}	3.78±0.16^{b}	4.43±1.22^{a}	3.69±1.56
	3rd & 4th	2.79±0.94^{c}	3.89±0.14^{b}	4.34±1.06^{a}	3.67±0.98
	5th & 6th	2.92±0.82^{c}	3.72±0.18^{b}	4.61±0.87^{a}	3.75±1.25
	P-value	0.10	0.06	0.08	0.14
Season	Summer	2.50±0.16^{c}	3.03±0.26^{b}	3.80±0.76^{a}	3.21±0.54
	Winter	2.01±0.11^{bc}	2.37±0.52^{b}	3.22±0.51^{a}	2.51±0.48
	P-value	0.09	0.04	0.02	0.04
Age	< 4 years	2.32±0.61^{c}	3.31±0.16^{b}	3.93±1.06^{a}	3.18±0.74
	4-6 years	2.51±0.37^{c}	3.18±0.22^{b}	4.03±0.73^{a}	3.24±0.53
	7-8 years	2.28±0.28^{c}	2.95±0.20^{b}	3.88±0.50^{a}	3.03±0.39
	P-value	0.16	0.08	0.18	0.32
Crossbred cows					
BCS	<2.5	*	4.39±0.77^{b}	5.74±1.68^{a}	5.06±0.94
	>2.5	*	4.58±0.82^{b}	5.62±0.53^{a}	5.10±1.35
	P-value		0.09	0.14	0.07
Parity	1st & 2nd	*	3.95±1.06^{bB}	4.62±0.95^{aB}	4.28±1.74^{B}
	3rd & 4th	*	5.41±1.33^{bA}	6.35±1.72^{aA}	5.88±1.26^{A}
	5th & 6th	*	3.24±1.08^{bC}	4.41±1.24^{aBC}	3.82±0.95^{BC}
	P-value		0.03	0.00	0.02
Season	Summer	*	4.30±0.36^{b}	5.80±0.31^{a}	5.05±0.44
	Winter	*	3.51±0.21^{b}	4.43±0.47^{a}	3.97±0.23
	P-value		0.04	0.00	0.02
Age	< 4 years	*	4.07±0.92^{B}	4.62±0.95^{B}	4.34±1.86^{B}
	4-6 years	*	5.53±1.06^{A}	6.15±1.72^{A}	5.84±2.43^{A}
	7-8 years	*	3.41±1.10^{C}	4.41±1.24^{BC}	3.91±1.37^{BC}
	P-value		0.02	0.03	0.03

Significantly different means at P<0.05 within rows are expressed with small alphabets whereas means if significantly different at P<0.05 within columns are expressed with capital alphabets. * Data regarding crossbred cows was not available in state farms. SF=State farms, RFS=Rural traditional farming system, PFS=Rural progressive farming systems

Factors affecting the lactation length of Achai and crossbred cows under different management systems

The effect of body condition score, parity, season and age on lactation length (LL) of *Achai* and crossbred cows in state farms (SF), rural traditional farming system (RFS) and rural progressive farming system (PFS) in Dir-Kohistan mountains of Hindukush range is presented in the Table 3.4. BCS significantly (P<0.05) affect the LL of *Achai* cows under all farming systems with longer lactation period in good condition (BCS>2.5) cows reared under PFS. Calving season also had significant (P<0.05) effect on LL with longer period in *Achai* cows calved in summer season under PFS and RFS.

The effect of parity and age on same trait of *Achai* cows was not significant (P>0.05). In crossbred cows, parity, season and age had significant (P<0.05) effect on LL with longer period observed in 1st and 2nd parity group and age group of less than 4 years in both RFS and PFS and summer calvers in RFS. The effect of BCS on lactation length of crossbred cows was not significant (P<0.05).

Factors affecting the lactation milk yield of Achai and crossbred cows under different management systems

The effect of body condition score, parity, season and age on lactation yield (LY) of *Achai* and crossbred cows in state farms (SF), rural traditional farming system (RFS) and rural progressive farming system (PFS) in Hindukush mountains of Dir-Kohistan is presented in the Table 3.5. BCS significantly (P<0.05) affect the LY of *Achai* cows under all farming systems.

Higher lactation yield was observed in cows with body condition score more than 2.5. Calving season also had significant ($P<0.05$) effect on LY with greater yield in *Achai* cows calved in summer season. The effect of parity and age on same trait of *Achai* cows was not significant ($P<0.05$).

In crossbred cows, parity, season and age had significant ($P<0.05$) effect on LY with greater yield observed in 3^{rd} and 4^{th} parity group, summer calvers and age group of 4-6 years. The effect of BCS on lactation yield of crossbred cows was not significant ($P<0.05$).

Table 3.4. Effect of BCS, parity, season and age on lactation length (days) of *Achai* and crossbred cows under different management systems.

Achai cows	Levels	SF	RFS	PFS	Mean
BCS	<2.5	186.37±12.74	190.73±13.05	198.78±14.04	191.96±8.32
	>2.5	215.33±13.07	220.99±13.03	234.32±14.06	223.54±5.24
	P-value	0.00	0.00	0.01	0.02
Parity	1^{st} & 2^{nd}	234.31±7.87	213.67±4.54	225.33±11.37	224.43±8.41
	3^{rd} & 4^{th}	218.44±6.33	221.46±5.72	215.62±09.32	218.17±11.90
	5^{th} & 6^{th}	211.73±8.36	228.35±5.08	239.45±13.58	229.84±6.24
	P-value	0.14	0.21	0.12	0.26
Season	Summer	236.82±14.32^{bc}	241.91±11.85^{b}	259.72±09.11^{a}	249.08±12.56
	Winter	221.35±12.51	223.41±15.55	232.35±09.21	225.37±13.43
	P-value	0.07	0.04	0.03	0.04
Age	< 4 years	232.56±12.24^{c}	244.33±14.22^{ab}	247.71±13.45^{a}	241.53±15.77
	4-6 years	228.87±09.46^{c}	241.56±12.11^{b}	254.84±15.33^{a}	245.75±09.26
	7-8 years	219.98±08.68^{c}	245.38±15.81^{ab}	239.22±11.12^{b}	234.86±11.48
	P-value	0.10	0.08	0.16	0.09
Crossbred cows					
BCS	<2.5	*	246.52±7.13^{b}	285.47±6.07^{a}	265.99±9.23
	>2.5	*	253.43±5.12^{b}	290.82±8.23^{a}	272.12±7.78
	P-value		0.06	0.07	0.12
Parity	1^{st} & 2^{nd}	*	266.53±09.14^{bA}	281.11±09.14^{aA}	273.93±15.41^{A}
	3^{rd} & 4^{th}	*	247.26±13.11^{bBC}	268.37±17.51^{aB}	257.81±10.54^{BC}
	5^{th} & 6^{th}	*	251.71±11.21^{B}	261.02±15.00^{BC}	258.36±17.21^{B}
	P-value		0.02	0.01	0.04
Season	Summer	*	262.36±16.71^{b}	286.82±17.26^{a}	269.59±15.60
	Winter	*	241.47±11.47^{b}	275.35±15.52^{a}	253.41±13.42
	P-value		0.00	0.07	0.04
Age	< 4 years	*	269.53±09.14^{A}	284.21±09.91^{A}	276.87±14.59
	4-6 years	*	253.32±11.25^{B}	270.53±12.32^{B}	261.92±13.26
	7-8 years	*	245.71±08.33^{C}	258.74±11.10^{C}	252.22±09.50
	P-value		0.04	0.03	0.05

Significantly different means at $P<0.05$ within rows are expressed with small alphabets whereas means if significantly different at $P<0.05$ within columns are expressed with capital alphabets. * Data regarding crossbred cows was not available in state farms. SF=State farms, RFS=Rural traditional farming system, PFS=Rural progressive farming systems.

Table 3.5. Effect of BCS, parity, season and age on lactation yield (L) of *Achai* and crossbred cows under different management systems.

Achai cows	Levels	SF	RFS	PFS	Mean
BCS	<2.5	390.87±13.76^{c}	438.50±19.34^{b}	629.56±17.62^{a}	452.97±21.77
	>2.5	516.77±12.43^{c}	719.10±22.64^{b}	978.73±22.97^{a}	738.20±12.45
	P-value	0.04	0.01	0.00	0.00
Parity	1^{st} & 2^{nd}	624.88±14.37^{c}	719.99±18.99^{b}	996.75±17.22^{a}	780.54±15.37
	3^{rd} & 4^{th}	608.22±16.08^{c}	727.21±34.90^{b}	928.76±23.64^{a}	754.73±21.40
	5^{th} & 6^{th}	645.32±13.06^{c}	745.55±28.87^{b}	1007.40±15.48^{a}	799.42±9.53
	P-value	0.22	0.16	0.09	0.33
Season	Summer	530.67±53.42^{c}	748.71±25.36^{b}	961.87±56.02^{a}	767.08±27.61
	Winter	444.71±45.46^{bc}	540.56±43.91^{b}	747.44±39.26^{a}	577.57±16.36
	P-value	0.08	0.03	0.02	0.03
Age	< 4 years	539.53±23.59^{c}	808.73±18.99^{b}	973.50±13.17^{a}	773.92±14.21
	4-6 years	574.46±18.30^{c}	768.16±34.90^{b}	1027.05±23.73^{a}	789.89±19.60
	7-8 years	501.55±20.54^{c}	723.87±28.87^{b}	958.17±15.50^{a}	717.86±26.13

Achai cows	Levels	SF	RFS	PFS	Mean
	P-value	0.06	0.11	0.17	0.06
Crossbred cows					
BCS	<2.5	*	1079.52±19.51^{b}	1493.40±14.32^{a}	1286.46±20.21
	>2.5	*	1158.74±23.31^{b}	1629.80±27.54^{a}	1394.27±29.50
	P-value		0.07	0.13	0.60
Parity	1st & 2nd	*	1030.95±13.73^{bB}	1298.95±11.95^{aB}	1164.95±19.55^{B}
	3rd & 4th	*	1336.27±10.95^{bA}	1648.27±09.61^{aA}	1492.27±13.26^{A}
	5th & 6th	*	826.27±14.96^{bC}	1151.01±15.11^{aC}	988.64±21.78^{C}
	P-value		0.02	0.00	0.01
Season	Summer	*	1126.67±23.42^{b}	1660.67±24.42^{a}	1393.67±24.61
	Winter	*	845.71±13.26^{b}	1213.25±19.26^{a}	1009.83±15.48
	P-value		0.01	0.03	0.04
Age	< 4 years	*	1096.98±19.51^{B}	1313.28±21.44^{B}	1205.13±21.37^{B}
	4-6 years	*	1399.07±17.50^{A}	1645.30±15.20^{A}	1522.18±16.22^{A}
	7-8 years	*	837.87±12.22^{C}	1141.04±25.34^{C}	989.45±20.68^{C}
	P-value		0.02	0.00	0.02

Significantly different means at P<0.05 within rows are expressed with small alphabets whereas means if significantly different at P<0.05 within columns are expressed with capital alphabets. * Data regarding crossbred cows was not available in state farms. SF=State farms, RFS=Rural traditional farming system, PFS=Rural progressive farming systems

Table 3.6. Effect of BCS, parity, season and age on calf birth weight (kg) of *Achai* and crossbred cows under different management systems.

Achai cows	Levels	SF	RFS	PFS	Mean
BCS	<2.5	15.27±0.26^{c}	15.59±0.15^{b}	16.56±0.04^{a}	15.80±0.22
	>2.5	15.42±0.43^{bc}	15.50±0.11^{ab}	16.36±0.93^{a}	15.68±0.09
	P-value	0.06	0.10	0.21	0.11
Parity	1st & 2nd	15.41±0.15	16.20±2.27	16.43±1.31	16.01±0.15
	3rd & 4th	16.95±2.14	15.58±1.72	15.97±2.75	16.16±0.62
	5th & 6th	15.78±3.27	15.73±2.24	16.04±0.98	15.85±0.75
	P-value	0.06	0.06	0.11	0.26
Season	Summer	16.04±0.38	15.84±0.46	16.24±0.32	16.04±0.40
	Winter	15.95±0.35	16.15±0.67	15.89±0.49	15.99±0.53
	P-value	0.22	0.13	0.06	0.35
Age	< 4 years	16.31±0.15	16.18±2.32	16.03±1.78	16.17±1.54
	4-6 years	16.15±2.14	16.24±1.50	15.97±2.33	16.12±1.70
	7-8 years	15.98±3.27	16.53±2.28	16.24±1.64	16.25±2.04
	P-value	0.08	0.17	0.19	0.33
Crossbred cows					
BCS	<2.5	*	16.41±0.37	15.94±0.57	16.17±1.04
	>2.5	*	16.36±0.24	16.04±0.63	16.20±0.88
	P-value		0.23	0.13	0.47
Parity	1st & 2nd	*	15.93±0.14^{b}	16.73±0.43^{a}	16.33±0.82
	3rd & 4th	*	15.62±0.58^{b}	16.92±0.84^{a}	16.27±0.56
	5th & 6th	*	16.07±0.36^{b}	16.71±0.66^{a}	16.39±0.77
	P-value		0.30	0.15	0.19
Season	Summer	*	16.04±0.51	16.21±0.45	16.12±0.48
	Winter	*	15.42±0.23	15.55±0.71	15.48±0.47
	P-value		0.03	0.04	0.05
Age	< 4 years	*	15.88±0.47	16.53±0.70	16.20±0.86
	4-6 years	*	16.32±0.23	16.87±0.49	16.55±0.59
	7-8 years	*	16.13±0.77	16.64±0.31	16.38±0.42
	P-value		0.11	0.27	0.36

Significantly different means at P<0.05 within rows are expressed with small alphabets whereas means if significantly different at P<0.05 within columns are expressed with capital alphabets. * Data regarding crossbred cows was not available in state farms. SF=State farms, RFS=Rural traditional farming system, PFS=Rural progressive farming systems.

Factors affecting the calf birth weight of Achai and crossbred cows under different management systems

The effect of body condition score, parity, season and age on calf birth weight (CBW) of *Achai* and crossbred cows in state farms (SF), rural traditional farming system (RFS) and rural progressive farming system (PFS) in Hindukush mountains of Dir-Kohistan is presented in the Table 3.6. BCS, parity, calving season and age had no significant (P>0.05) effect on the CBW of *Achai* cows under all farming systems. In crossbred cows, calving season had significant (P<0.05) effect on CBW. Heavier calves were born in summer season under both RFS and PFS. The effect of BCS, parity and age on CBW of crossbred cows was not significant (P<0.05).

Discussion

Overall productive performance of Achai and crossbred cows

Crossbreeding of indigenous cows with exotic breeds improved productive performance (Mulugeta and Belayneh, 2013). Previous study (Buckley *et al.*, 2014) has demonstrated remarkable benefits of additive and non-additive genetic effects of crossbreeding on overall dairy cattle performance. Several studies reported significantly higher daily milk yield (Wakchaure *et al*, 2015), longer lactation length (Rokonuzzaman *et al.* 2009), greater lactation yield (Mulugeta and Belayneh, 2013) and calf birth weight (Prendiville *et al.*, 2010) in crossbred cows as compared to local cows. Mean daily milk yield recorded in present study was significantly (P<0.001) lower than crossbred cows. For *Achai* cows, Hayazuddin *et al.* (2014) reported slightly lower (2.81±0.12 litres/day) DMY than 3.55±0.77 litres in the present study. Several factors like animal diseases, unavailability of feeds in terms of quality and quantity, poor management are responsible for low production of local cattle (Hassan *et al*, 2016). The extended lactation length observed in crossbred cows as compared to local cows confirms the findings of Hayazuddin *et al.* (2014) regarding improvement in lactation length of local cattle through crossbreeding. However, the observed lactation period in both *Achai* as well as Jersey crossbred cows reported in this study is shorter than the recommended value of 305 days (Habib *et al*, 2003) which need improvement (De Vries, 2000). Lactation milk yield of *Achai* cow observed in this study was significantly lower than crossbred. In another study, Hayazuddin *et al.* (2014) recorded 813.07±113.39 litres in a lactation period of 263.14 ±24.53 days. Low lactation milk yield in local cattle are also reported by Amin, (2007) and Mulugeta and Belayneh, (2013) as compared to their crossbred with high yielding dairy cows. Average birth weight of crossbred calves (16.29±0.16) was significantly higher than *Achai* calves (15.20±0.17). *Achai* is light weight multipurpose breed reared under extensive production system (Khan, D., 2004) as compared to Jersey breed. Several researchers (Sørensen *et al.*, 2008; Prendiville *et al.*, 2010) worked on crossbreeding to improve calf birth weight in addition to other long term economic traits. The aim of dairy producers in practicing crossbreeding is to improve calving ease and to produce calf with optimum weight for cow to birth (Weigel and Barlass, 2003). In other perspective, many researchers concluded that crossbreeding has significant impact in reducing calving difficulties (Heins *et al.*, 2006a). Dhakal, *et al*, (2013) also reported less calving difficulty in crossbred as compared to purebred due to calf birth weight ratio to dam size.

Effect of farming systems on the productive performance of Achai and crossbred cows

Very few studies described the impact of housing systems on the performance of dairy cattle (Fregonesi and Leaver, 2002; Klopchich *et al.*, 2007; Simensen *et al.*, 2010). However, it is clearly evident that improving animal welfare through proper farming practices and housing conditions considerably improves dairy cattle performance (Lambertz, *et al*, 2014). Several researchers (Fregonesi and Leaver, 2001; de Vries *et al.*, 2011) has determined direct relationship between housings conditions and milk production. Different housing systems increase or decrease the impact of various environmental conditions which directly affect production of dairy cattle (Bohmanova *et al.*, 2007). Simensen *et al*, (2010) reported significant impact of tie and free-stall herding on milk production.

On the other hand, improved milk production in individual cows was observed when cows were moved from loose housing barns to tie stall barns (Hovinen *et al*. (2009). Several factors including more attention in milking practices (Hovinen *et al*. 2009), nutrition (Brun-Lafleur *et al*. 2010), bedding material effect on various genotypes (Mark and Lassen, 2007), housing design (Hristov *et al*., 2014) in tie-stall are responsible for higher milk production. In modern dairying, 305 days in lactation is considered as standard. However, such value is not practicable in rural and conventional dairy farmers where lactation length considerable extends or reduces from normal values (Msangi *et al*., 2005). Regarding farming practices, (Eicher, *et al*., 2013) analysed that improved animal welfare observed in grazing system compared to zero grazing and cows housed in straw yards compared to free stall significantly affected dairy cattle performance including extended milk yield duration and animal health. Lehmann *et al*., (2017) observed prematurely dry off due to insufficient feeding resulting short lactation length in dairy cattle. Albarrán-Portillo and Pollott, (2011) reported significant effect of general management on milk production and lactation period in diary animals. Calf birth weight is complex phenomenal trait associated with genetic and non-genetic factors (Kamal *et al*, 2014). Besides genetic factors, nutritional limitations significantly affect embryo and foetus development during gestation (Funston and Summers, 2013). Several researchers (Zhang *et al*., 2002; Symonds *et al*., 2010) demonstrated environmental and nutritional effect on calf birth. Other studies (Lundborg *et al*., 2003; Swali and Wathes, 2006) reported dam morphometrics as source of influence on birth weight of their calves. Similarly, early breeding management in heifers has potential effect on birth size and weight of calves (González-Recio *et al*., 2014).

Factors affecting the daily milk yield of Achai and crossbred cows under different management systems

The significant effect of BCS on DMY of *Achai* cows in PFS with higher production in cows with BCS of more than 2.5 may be due better nutrition in PFS. It has been observed that optimum nutrition result in better BCS (reflected by the degree of subcutaneous fatness) is correlated with energy balance and enhanced cow productivity (Gaillard, C. 2016). Nickerson (1995) observed strong association of milk production and body frame of cattle and revealed significant support of serum precursors for milk synthesis. Higher milk yield in good condition cows have also been reported in zebu and crossbred cows (Samarutel *et al*, 2009; Singh *et al*, 2015) as well as high producing cows (Roche *et al*, 2007). In crossbred cows, parity had significant effect on DMY with higher yield observed in 3rd and 4th parity group under all management systems. Sum higher yield in crossbred cows might be due to complete development and adoption of lactation physiology (Nickerson, 1995). Devery-Pocius and Larson (1983) further explained that better immunological adaptation in multiparous cows is responsible for increased milk production as compared to primiparous cows which yet to be adopted for certain physiological processes. The incomplete structural growth of udder and teats of cow is another reason for low in milk production in primiparous cows. According to Ihsanullah and Qureshi, (2019), the lower milk yield in crossbred cows of early and late parities compared to mid parities cows may possibly be due to the consumptions of more nutrients for maintenance instead of production (Ihsanullah and Qureshi, 2019).

Several studies (Lakshmi, *et al*, 2009; Islam and Kundu, 2011) have also reported significant effect of parity on DMY in crossbred cows from various regions of the world. Calving season had significant effect on DMY of *Achai* and crossbred cows with higher production in both breed cows calved in summer season under PFS while the effect of calving season on DMY of both breed was non-significant under state farming system. The significantly higher DMY of *Achai* and crossbred cows calved in RFS and PFS during summer season may be due to better feed availability in the summer season (Ihsanullah and Qureshi, 2019) as the winter season in the study area has harsh environmental conditions, severe shortage of fodders and the animals mostly rely on roughages (Saleem *et al*, 2012). Seasonal effect on DMY with higher production during the months of higher fodder availability has also been reported by Lakshmi, *et al.*, (2010) and Das *et al*, (2011). The significant increase in DMY of crossbred cows at the age of 4-6 years might be due to maturity of cattle body to support lactation stress while reduction in daily yield of older animals is due to ageing affect (Ihsanullah and Qureshi, 2019). The number and activity of alveoli in mammary gland reduces with age which causes reduction in milk yield (Auldist, *et al.* 2007). Brscic *et al*, (2015) revealed that initial increase in serum protein and glucose concentrations up to certain age followed by gradual decrease results variation in milk yield. Goff, (2008) further explained the phenomena of reduced milk production in young cows characterized by immunological suppression due to lack of adaptation to physiological stress leading to decline in several protein fractions.

The absence of age effect on DMY of *Achai* cows may be contributed due to breed specific characters. Local breeds which are usually low producers due to multipurpose selection are adapted without particular attention for milk production (Abera, 2016). Another reason for the absence of age effect on production performance may be such level of low production that further couldn't be affected by age (Amasiab *et al*, 2011). Constantly low milk production without any significant effect of age has also been reported by Kurtu, (2003) and Gurmessa *et al*, (2012).

Factors affecting the lactation length of Achai and crossbred cows under different management systems

The significantly longer LL in good condition (BCS >2.5) *Achai* cows may be due to improved nutrition reflected by degree of subcutaneous fatness providing significant amount of serum precursors to support milk production for longer period (Gillard, C., 2016). In study area, farmers don't follow the standard 305-day lactation length rather milk the cows till its production capacity which is greater in good condition cows. Janu's *et al.* (2007) observed that length of lactation period significantly depend upon postpartum body fat reserves. The authors noted that cows gained greater body reserves during dry period had longer lactation period.

Longer LL has also been reported in local and crossbred cows with good body condition scores by Samarutel *et al*, (2009) and Singh *et al*, (2015). The significant effect of parity on LL of the crossbred cows with longer LL in 1st and 2nd parity group may be due to the readily available body reserves of primiparous cows enabling them to produce milk for longer time (Ratnayake *et al.*, 1998).

Furthermore, better nutrition improves body condition of heifers which results in milk production for longer durations after parturition as compared to primiparous cows (Ihsanullah and Qureshi, 2019). Significant effect of parity on LL with longer LL in early parity cows have also been reported by many authors (Ahmad *et al*, 2007; Kolver *et al*, 2007; Phyn *et al*, 2008). The significant effect of calving season on LL of *Achai* as well as crossbred cows with longer LL in summer calvers seems to be due to availability of quality fodders during summer season (Amasiab *et al*, 2008; Ihsanullah and Qureshi, 2019). Several studies revealed extended lactations with provision of quality feed (Auldist *et al.*, 2007; Butler, *et al.*, 2010; Kolver, *et al.*, 2007; Phyn *et al.*, 2008; Grainger *et al.*, 2009). The non-significant effect of age on LL of *Achai* cows is consistent with the early reports of Habib *et al.*, (2010). However, the significant effect of age on LL in crossbred cows with longer LL in the age group <4 years and a decline afterward seems to be the development of size and activity of mammary glands up to this age followed by a decline in the number and progress of alveoli in mammary glands with the advancement of age of the cattle (Nickerson, 1995; Amasiab *et al.*, 2011). Several secondary factors including imbalance metabolism (Meikle *et al.*, 2004), DMI (Maekawa *et al.*, 2002) and physiological condition (Ingvartsen, 1994) has been strongly associated with age which causes variation in productive performance of dairy cattle. Some studies confirm gradual decrease in milk production of crossbred cows due to shorter lactation period with advancement up to 6 years (Mohamed, 2004; Kurtu, 2003). The effect of age on productive performance including LL has also been reported by Brscic *et al*, (2015), Abera, (2016) and Gurmessa, *et al*, (2012).

Factors affecting the lactation yield of Achai and crossbred cows under different management systems

The significant effect of BCS on LY of *Achai* cows with higher production in cows with BCS more than 2.5 may be due to higher DMY for longer lactation period (Gillard, C., 2016) because of better nutrition and management practices in PFS. Better nutrition associated with body condition provides significant amount of serum precursors to support higher milk yield for longer period (Nickerson (1995). According to Van Knegsel, *et al*.., (2014) body reserves significantly supports lactogenesis for the entire lactation thus cows with good body condition results higher yield per lactation. The effect of BCS on LY with higher production in good condition cows has also been reported by Dechow *et al.* (2002), Bewley and Schutz (2008) and Loker *et al.* (2012). The completion of mammary gland development with experiencing lactations might be the reason of higher LY in crossbred cows of 3rd and 4th parity group. In addition, the immunological adaptation to various physiological processes increases up to certain age with the experience of lactations which results higher LY in mid parities as compared to primiparous or older cows (Devery-Pocius and Larson, 1983). Bajwa *et al*, (2004) reported that LY increases up to 5th parity in Sahiwal cows followed by gradual decrease in later parities. The effect of parity on LY of cattle with higher yield up to 6th parity has also been reported in Pakistan (Dahlin, 1998; Ahmad *et al*, 2004) and other countries (Dhumal *et al*, 1989; Deshpande and Sakhare, 1984).

The availability of quality feed during favorable climatic conditions at the initiation of lactation stage results higher daily yield (Ihsanullah and Qureshi, 2019) for longer lactation period (Amasiab, *et al*., 2008) might be reason for higher lactation yield in summer calved cows. The nutrients availability supports the provision of volatile fatty acids and serum glucose for milk synthesis. The effect of calving season with higher yield in favorable climatic conditions due to better fodder availability has been reported by Bajwa *et al*, (2004), Dahlin (1998) and Talbott (1994) in Pakistan as well as other countries by Sorenson, *et al*, (2008), Jankowska, *et al*, (2012) and Steri, *et al*., (2012). The significant effect of age on lactation yield with higher production in 4-6 years age cows has been reported by Briscic *et al*, (2015) and Abera, (2016). The conclusion of these authors for higher milk yield per lactation was the development of size and activity of alveoli in mammary gland with advancement in age. According to Ihsanullah and Qureshi (2019) maturity of cattle significantly improves the production performance of dairy cattle. The immunological suppression in young and old cows also significantly affect milk yield of dairy cattle (Goff, 2008). Some studies confirmed the gradual decrease in lactation yield of crossbred cows particularly after 6 years (Mohammed, 2004; Kurtu, 2003). Gurmessa, *et al*, (2012) concluded similar reports regarding age effect on production traits of dairy cattle. To justify the variation in milk yield due to age, Briscic *et al*, (2015) observed significant increase in serum protein and glucose concentrations up to five years which then gradually decreased.

Factors affecting the calf birth weight (CBW) of Achai and crossbred cows under different management systems

The non-significant effect of BCS on CBW of *Achai* and crossbred cows might be due to greater proportion of nutrient partitioning for body maintenance during dry period which is common characteristic of all low producers (Reference). Furthermore, improving cows BCS during pre-partum nutrition planning has very little or no effect on CBW (Renquest *et al*, 2005). The non-significant effect of body condition of cattle at calving associated with nutrition has also been reported in many studies (Mulliniks *et al*., 2015; Lake *et al*., 2005). Parity had no significant (P>0.05) effect on the CBW of *Achai* and crossbred cows under all farming systems. The non-significant effect of parity on CBW has been reported by Addisu *et al*., (2010), Melaku *et al*., (2011a) and Tesfa, *et al*., (2016). Despite of significantly positive correlation between age of cow and internal and external pelvic measurements, Bures, *et al*., (2008) found insignificant effect of parity on weight of calves born. Similar results were reported by Nogalski (2003) for HF calves. The significant effect of calving season on CBW of crossbred cows with heavier calves born in summer might be due seasonal fodder availability (Renquest *et al.*, 2005) because proper climatic conditions significantly improves the nutrient composition of fodders in addition to greater quantity fodders production (Lammoglia *et al.*, 1996). Some studies revealed that concentrate supplementation during winter season have significant effect of CBW (Giday, 2001; Melaku *et al* 2011a; Almaz 2012). On the other side, restricted metabolism of pregnant cow due to fodder scarcity in extreme weather conditions may also results in lighter calf births (Kumar, *et al.*, 2017). The significant effect of calving season on CBW has also been reported by Habtamu, *et al*, (2010), Aynalem *et al.*, (2010), Demissu *et al*, (2013) and Tesfa *et al.*, (2016). However, some studies also reported non-significant effect of calving season on CBW (Getinet *et al.*, 2009; Addisu *et al.*, 2010).

Conclusions

1. *Achai* x Jersey (crossbreds) cows had significantly better DMY, LL, MYL and CBW than pure *Achai* cows.
2. Improving management practices significantly improved the productive performance of both breeds as observed in rural progressive farming system (PFS).
3. Age and parity had no effect on productive performance of *Achai* cows.
4. BCS had no effect on productive performance of crossbred cows.
5. Economics traits of both breeds were better in summer season.
6. Adult (4-6 years age) crossbred cows had better DMY and LY in their 3^{rd} and 4^{th} parities while longer LL was observed in young (<4 years age) cows in its early (1^{st} and 2^{nd} parity group) parities.
7. Introducing *Achai* cows to state farming systems significantly affected its performance.

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