Genetic Analysis of Milk Production Efficiency in Cattle and Buffalo in and Around Darbhanga, (Bihar)

THESIS

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IN

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By

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CERTIFICATE – I

This is to certify that the thesis entitled **"GENETIC ANALYSIS OF MILK PRODUCTION EFFICIENCY IN CATTLE AND BUFFALO IN AND AROUND DARBHANGA, (BIHAR)"** submitted in partial fulfilment of the requirements for the Degree of Master of Veterinary Science (Animal Breeding and Genetics) of the faculty of Post-Graduate Studies, Rajendra Agricultural University, Bihar, Pusa is the record of bonafide research carried out by **Dr. Niraj Kumar** under my supervision and guidance. No part of the thesis has been submitted for any other Degree or Diploma.

It is further certified that such help or information received during the course of this investigation and preparation of the thesis have been duly acknowledged.

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(Niraj Kumar)

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1. INTRODUCTION

1. INTRODUCTION

Indian economy is predominantly **agrarian** and Animal husbandry is an integral component of rapidly expanding diversified Agriculture. Dairy farming plays a vital role in terms of income, employment, equity as well as exchange earning and it is closely associated with socio-cultural fabric of millions of resource-poor families providing varying degrees of sustainable income and economic stability.

India is now the largest milk producer in the world producing about 80.8 million tones of milk per annum (*Indian Dairy Perspective-2010*). The major portion of the milk produced in the country comes through small producers scattered all over the country. In other words, for augmentation and sustainability in milk production, it is desirable to strengthen the small dairy units in private sector, where dairy animals are managed under farmer's managemental system.

After separation of Jharkhand area, consisting of 18 revenue districts, full of mines, minerals and industries, generating maximum employment opportunities and making major contribution to the state exchequer of undivided Bihar, Agriculture is the only left over resource to be utilized for economic development of truncated Bihar. Dairy farming, either alone or through its integration with crop production, is the most suitable proposition and a plausible option to attain a substantive and regular cash flow to the landless as well as small and marginal farm families of the present Bihar.

The truncated Bihar is a milk deficient state and there is a great need to augment milk production to cope with its increasing demand with rapid growth in human population. Milk production in Bihar is also predominantly a domain of small and marginal households contributing more than 65% to the state milk pool and thus, it is vivid that systematic studies are essentially required to know the present status of milk production in the state and formulate suitable strategies to maximize milk production in the small dairy units distributed throughout the state under farmer's managemental system.

Darbhanga, the historic city of Mithilanchal has its glorious background as the centre of Mithila culture and is located in Northern part of Bihar at 26.10° N latitude and 85.57° E longitude. The climate of this zone is hot-humid. Dahi (curd) and fish, the two important animal products, are of daily use in the families of all strata and its quality and quantity available at the dining table reflects the family status. In other words, these two animal products have been the symbol of Mithila culture. The growing population of Darbhanga city, due to unidirectional flow of population from rural to urban area, has significantly increased the demand of milk and this city has become a very good market for milk and milk products. Resultantly, a large number of dairy units (Khatals) have become operational in and around the city. Both, buffaloes as well as cows of different genetic makeup are maintained as dairy animals under farmer's managemental conditions. However, for formulating and recommending a suitable strategy to maximize profit in the dairy enterprises, the relative adaptability of dairy animals of different genetic constitutions in the agro-eco-socio-economical conditions of the area, measured in terms of their milk production efficiency, needs to be studied.

No systematic study has been undertaken to estimate the phenotypic parameters of milk production efficiency measures of the cows and buffaloes being maintained by the farmers in and around Darbhanga. Besides, the magnitude and direction of the effects of genetic as well as non-genetic factors on milk production efficiency traits of these animals, also needs to be known in order to formulate and suggest suitable package of dairy practices for economic milk production.

Further, profitability is the objective of any enterprises and the concept of profit provides an alternative approach to the analysis of production. In dairy enterprises also, it is essential to know the nature as well as magnitude of the determinants of the profit and for this it is necessary to study the economic aspect of dairy farming. Economic analysis is also needed for providing effective linkage among producers, consumers and policy makers for fixing prices of the inputs in a rational way.

Reports are available to indicate that high yielding dairy animals require some **hi-tech** management and as such farmers are facing several constraints in adoption and rearing of high yielding stock. Hence, it is necessary to study and enlist the different constraints perceived by the dairymen in adoption and rearing of high yielding dairy stock in priority order. It would facilitate in suggesting suitable solution to overcome these constraints by the dairymen. Besides that, the policy makers may also get feed back to make necessary amendments in the existing provisions in law pertaining to milk production.

The above considerations have been pivotal in planning this study with following objectives:

1. To estimate the phenotypic parameters of some measures of milk production efficiency of cows and buffaloes in and around Darbhanga (Bihar).
2. To estimate the nature as well as magnitude of variation in different measures of milk production efficiency due to genetic and non-genetic causes in the dairy animals of the study area.
3. To study the different constraints perceived by the farmers in rearing high yielding cows and buffaloes in the area of investigation.
4. To suggest a suitable package of dairy practices for economic milk production in and around Darbhanga (Bihar).

2. REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A. PRODUCTION AND REPRODUCTION TRAITS:

Chauhan *et al.* (1974) observed that in Karan-Swiss crossbred cows the season of calving had significant effect on peak milk yield. Cows calved during Cold (December-February) and Cold-comfort (September-November) seasons attained peak yield later than those calved during Hot-dry (March-May) and Hot-humid (June-August) seasons.

Rathi (1975) reported average value for days to attain peak yield in Haryana based Friesian crossbred cows to be 54.25 days.

Kaul *et al.* (1977) reported that on an average, Zebu based Friesian crossbred cows attained peak yield in 41.27±7.31 and 42.45±6.96 days respectively in their first and second lactations. However, the order of lactation did not have significant influence on this economic trait.

Sharma (1978) registered the average values for Milk Production Efficiency per kg. body weight (MPEK) and Milk Production Efficiency per kg. Body weight per day of Calving interval (MPEKD) in Friesian crossbred cows to be 6.52±0.25 and 0.01968±0.00051 kg. respectively.

Khanna *et al.* (1980) reported that among the various grades of Friesian x Sahiwal cows, the average MPEK varied from 4.3±0.22 in 7/8 HF crossbred grade to 5.7±0.13 in 3/4HF crossbred grade. There was a linear increase in MPEK with increase in Friesian inheritance up to 62.5 percent.

Raheja (1982) reported that on an average, Zebu based Friesian crossbred cows attained peak yield in 41.6±1.60 days after calving. The effect of season of calving on this economic trait was not significant. However, cows calved during Cold season were observed to attain early peak yield.

Raheja and Bhat (1982) reported that the overall average value, irrespective of their lactation sequence, for MY/CI in Friesian crossbred cows was 5.2 kg. However, their findings were based on half breds maintained in relatively better management of Military Dairy Farm as compared to those in small dairy units in private sector.

Singh (1984) reported the effect of genetic grades, zones, season of calving and parity to be significant on peak yield in Friesian x Zebu cows belonging unorganized herds in Ranchi. The size of the herd did not have significant influence on peak yield.

Singh *et al.* (1986[a]) made a comprehensive study on economics of milk production and effect of genetic and different non-genetic factors in Friesian crossbred cows maintained in small dairy units of private sector in and around Ranchi. Least squares mean for lactation length, lactation yield, dry days, calving interval, milk yield per lactation length, milk yield per calving interval and peak yield in high (≥50 % of Friesian), first (50 % of Friesian) and lower (≤50 % of Friesian) crossbred cows were recorded to be 310.2±1.6, 305.3±2.4 and 292.8±3.0 days; 3556.2±83.6, 3655.1±125.6 and 2288.8±158.5 kg.; 82.2±2.4, 82.4±3.7 and 105.9±4.6 days; 398.3±2.4, 388.0±3.5 and 398.8±4.6 days; 10.9±0.3, 11.2±0.2 and 9.3±0.4 kg.; 8.9±0.2, 9.4±0.3 and 5.7±0.4 kg. and 14.4±0.3, 16.0±0.3 and 13.6±0.5 kg. respectively.

Singh *et al.* (1986 [b]) reported that in local based Friesian crossbred cows of private sector in and around Ranchi the overall mean for lactation length, lactation yield, and calving interval were 302.8±1.4 days, 3166.7±74.4 kg. and 395.0±2.1 days respectively. Size of the unit had significant influence on all the traits under study. Genetic grade of the cows and location of the herd influenced lactation yield and calving interval significantly, but their effects on lactation length was not significant. Parity-effect was significant on lactation length and lactation yield but not significant on calving interval. The season of calving influenced calving interval significantly.

Singh *et al.* (1989) analysed the data on milk yield per day of lactation length and calving interval in Friesian crossbred cows. The overall mean for these two efficiency traits were estimated to be 7.929±0.216 and 5.916±0.418 kg. Period as well as season of calving and lactation order had significant influence on both the efficiency traits.

Singh *et al.* (1987) analysed the data on MPEK and MPEKD in Friesian crossbred cows and reported that the overall mean for these two traits were 6.412±0.603 and 0.181±0.0016 kg. respectively. Genetic constitution of the animals had significance influence on both the traits. However, the effect of season of calving was statistically not significant.

Kumar and Gupta (1992) worked out the economics of milk production in buffaloes maintained in different categories of households in Muzaffarnagar district (U.P.). The overall mean lactation period, inter-calving period and lactation yield were estimated to be 331 days, 484 days and 1648.38 lits. respectively. Findings revealed that buffalo milk production was not a lucrative enterprise in the study area.

Singh *et al.* (1993) estimated the average value for lactation length, lactation yield, dry period, daily yield, peak yield and days to attain peak yield in Jersey crossbred cows to be 298.5±7.31 days, 2286.20±77.8 kg., 120.0±8.74 days, 7.82±0.16 kg.,12.28±0.38 kg. and 41.46±1.70 days respectively. The effect of season of calving was statistically non-significant on all the traits under reference.

Dev Raj and Gupta (1994) found that in Churu district of Rajasthan, the buffalo rearing was relatively more economical as compared to local cows. Season effect was significant on average daily milk production and thus the cost of milk production. The average lactation length in buffalo and local cows were recorded to be 310 and 270 days respectively. The corresponding values for inter-calving period were 435 and 431 days. The dry period for the animals of the two genetic groups were 125 and 161 days respectively. The average daily milk yield in buffalo and local cows were estimated to be 4.47 and 2.13 lits. respectively.

Shah and Sharma (1994 [b]) conducted a comparative study on economic performance of milch animals of different genetic groups in typical rural conditions of Bulandshahar district of Uttar Pradesh. The district was divided into two areas, the one covered by Dugdh Utpadak

Sahkari Sangh (DUSS) and the other not covered by DUSS (NDUSS). The study revealed that the net income derived from different groups of bovines was much higher in DUSS area than in NDUSS area. The estimate of lactation length in Murrah buffaloes, local buffaloes, local cow and crossbred cows were 362±7.32, 343±7.68, 317±19.95 and 359±13.73 days in DUSS and 354±5.58, 334±6.30, 336±5.23 and 334±7.59 days in NDUSS. The corresponding dry period were estimated to be 95±3.04, 101±3.23, 134±10.02 and 80±5.56 days in DUSS and 100±2.73, 111±2.42, 131±8.12 and 99±9.68 days in NDUSS. The average calving interval were recorded to be 475±9.31, 444±10.06, 451±28.64 and 439±17.03 days for Murrah buffaloes, local buffaloes, local cow and crossbred cows respectively in DUSS whereas, 454±6.95, 445±8.22, 467±7.43 and 443±9.04 days in NDUSS respectively. The average lactation yield in Murrah buffalo, local buffalo, local cow and crossbred cow were 1795.25, 1456.33, 926.61 and 1972.99 lits. in DUSS and 1572.74, 1301.91, 918.61 and 1995.07 lits. in NDUSS respectively.

Chaudhary *et al.* (1995) estimated average calving interval in Jersey crossbred cows to be 451.70±7.76 days. The influence of season of calving and parity on calving interval was statistically not significant.

Deshmukh *et al.* (1995) reported the average values for lactation length, lactation milk yield and dry period in Jersey crossbred cows to be 309.87±3.56 days, 1954.53±68.99 Kg. and 141.18±6.02 days respectively. The season of calving did not have significant influence on all the three traits, while parity effect was significant on lactation milk yield.

Rao *et al.* (1995) reported the average estimates for lactation yield, lactation length, dry period and calving interval in graded Murrah buffaloes to be 1528 Kg., 341 days, 194 days and 566 days respectively. Season of calving did not have any significant effect on all the traits under study.

Singh (1995) reported that in Friesian X Zebu cows of organized herds in and around Ranchi (Jharkhand) the average values for lactation length, lactation yield, and peak yield were 324.7±6.4 days, 2370.8±66.0 kg. and 13.3±0.3 kg. respectively. The effect of the level of

Friesian inheritance was significant for all the traits except lactation length. Herd and period effects were significant for all the three traits under study, whereas the effect of season of calving was significant only on peak yield. Half-breeds were recommended to be the grade of choice for economic milk production in the study area.

Verma and Kherde (1995) studied the productive and reproductive performances of buffaloes in upper Gangatic plain. The estimates for average lactation length, dry period and calving interval were 329 days, 184 days and 513 days respectively.

Shrivastava *et al.* (1996) made a study to find out the effect of various genetic and non-genetic factors on dry period and calving interval in Friesian x Zebu crossbred cows maintained under farmers' managemental conditions in Chotanagpur. The estimates of overall mean dry period and calving interval were found to be 85.98±1.36 and 384.48±1.40 days respectively. The effects of zone and season of calving were non-significant on both the traits. However, the size of the herd had significant influence on dry days and inter calving period. Cows in smaller herds i.e. groups of 1-2, 3-5 and 6-8 cows, had significantly shorter dry and inter-calving periods as compared to those in herds of 9-11 and more than 12 cows.

Venkatasubramanian and Fulzele (1996) conducted a study involving 288 small dairy units under private sector distributed in villages of Tamilnadu and recorded average lactation yield of crossbred and indigenous cows to be 2075.00±20.26 and 950±7.86 litres respectively. The lactation length in the cows of both the genetic groups was 9.11±0.05 and 8.18±0.02 months respectively. The production performance was found to be greatly influenced by the feeding, housing and breeding management followed in the herds.

Mishra and Prasad (1998) reported the average values for first lactation peak yield, milk production efficiency per Kg. body weight and milk production efficiency per day of calving interval in crossbred cows to be 13.665±0.229 Kg., 8.202±0.182 Kg. and 6.060±0.140 Kg. respectively.

Shrivastava *et al.* (1998) studied the effect of genetic and different non genetic factors on some dairy traits in Friesian crossbred cows of un-organized herds. The estimates of overall mean lactation yield, lactation length and peak yield were recorded to be 2716.03±7.89 Kg., 298.73±0.48 days and 13.52±0.04 Kg. respectively. The herd size and parity had significant effect on all the traits under study. However, the season effect was non-significant. The cows in smaller herds (1-2 and 3-5 cows) had higher lactation and peak milk yield than those in larger herds (6-8, 9-11 and above 12 cows). The lactation length, lactation yield and peak yield increased linearly with increase in sequence of lactation up to fifth lactation.

Tomar *et al.* (1998) calculated the first lactation length, peak yield, calving interval, dry period, average milk yields per day of lactation length and calving interval in HF half-breds to be 234.49 Kg., 8.51 Kg., 403.72 days, 167.07 days, 6.75 Kg. and 4.18 Kg. respectively.

Rao *et al.* (2000) studied the performance of crossbred cows and buffalo under field conditions of Visakhapatnam district of Andhra Pradesh. The least squares mean for calving interval, lactation milk yield, lactation period and dry period in Jersey crossbred were 453.73 ±4.43 days, 1899.81±47.60 lits., 351.76±3.09 days and 83.93±3.10 days respectively. The corresponding values in HF crossbred were 472.82±10.78 days, 2790.90±115.85 lits., 380.07 7.52 days and 90.53±7.54 days. The overall values of these traits in the buffalo were 643.51±5.08 days, 1155.80±13.93 lits., 391.67±3.37 days and 242.84±4.34 days respectively.

Shrivastava and Singh (2000) studied the factors influencing efficiency of milk production in Friesian x Zebu crossbred cows in unorganized herds. The overall mean MY/CI and MY/LL were 7.11±0.03 and 9.09±0.03 Kg. respectively. The effect of management, location of the herd, herd-size and parity were observed to be statistically significant on both the traits. The effect of season of calving did not have any significant influence on the traits under investigation.

Singh *et al.* (2000) studied the factors affecting lactation performance in Jersey and Friesian crossbred cows. The overall mean, irrespective of the genetic groups of the cows, for calving interval, lactation yield, lactation length and peak yield were 434.77±2.74 days, 2748.20±18.93 Kg., 338.78±1.76 days and 13.92±0.07 Kg. respectively. When taken genetic-group wise, the corresponding values for Jersey crossbreds were 405.94±8.17 days, 2355.42±56.29 Kg., 322.50±5.23 days and 13.27±0.30 Kg. and for HF crossbreds the estimates were 429.47±40.53 days, 3021.73±40.53 Kg., 337.73±3.77 days and 15.23±0.21 Kg. respectively. The effect of the breed of sire was significant on lactation yield, lactation length and peak yield while did not have significant influence on calving interval. The effect of parity was statistically significant on all the traits under study, but the season of calving did not influence the traits significantly.

Thakur *et al.* (2000) recorded the average 300 days milk yield, daily milk yield per day of lactation length of calving interval in Jersey crossbred cows ranging from 1652.2±129.4 kg. – 2044.55±55.5 kg., 5.81±0.60 kg. – 7.25±0.26 kg. and 4.28±0.40 kg. – 5.43±0.17 kg. respectively. The corresponding overall least squares means were reported to be 1850.1±31.8 kg., 6.61±0.15 kg. and 4.76±0.50 kg. respectively.

Dutt and Bhusan (2001) studied the peak yield and its association with production and reproduction traits in crossbreds. The mean peak yield in Friesian and Jersey half-breeds were found to be 11.09±0.22 and 8.89±0.35 Kg. respectively. The effect of season of calving on peak yield was not significant.

Srivastava *et al.* (2001) reported that the average daily milk yield in crossbred cows maintained at Faizabad varied from 7.47±0.17 to 9.62±0.38 kg. The duration of shower provided to the cows in summer gave better results.

Singh (2002) analyzed the first lactation performance record of Murrah buffalo in U.P. The overall means for lactation milk yield, MY/LL and lactation length were 1400.05±19.25 Kg., 3.776±0.047 Kg. and 378.59±4.8 days respectively.

Hemalatha *et al.* (2003) made an attempt to work out economics of milk production of different breeds of bovines in Ahmadnagar district of Maharastra and reported that the average profit per animal was maximum in Jersey crossbred cows as compared to HF crossbreds. Even buffalo were found to be more profitable. Among economic indicators, the average lactation length was the longest (320 days) in HF crossbreds followed by Jersey crossbreds (298 days), graded buffaloes (278 days) and non-descript cows (240 days). The average dry period was recorded to be 90, 93, 180 and 135 days in HF crossbreds, Jersey crossbreds, non-descript cows and graded buffaloes respectively. The average inter-calving period was maximum in non-descript cows (420 days) followed by buffaloes (413 days), HF crossbreds (410 days) and Jersey crossbreds (381 days). The average daily milk in HF, Jersey and non descript cows as well as buffalo was recorded to be 13.0, 11.0, 3.0 and 6.5 lits. respectively.

Yadav *et al.* (2003 [a]) collected and analysed the data on first three lactation milk yields of Murrah buffalo by least squares analysis and reported the average lactation milk yield pooled over the three lactations to be 1646.09±36.02 kg.

Yadav *et al.* (2003 [b]) reported the average calving interval in Murrah buffalo to be 477.08±13.73 days with coefficient of variation as 35.10 %. Season of calving had significant effect on calving interval. They also estimated least squares mean for dry period as 174.06±9.5 days, the coefficient of variation being 65.8 %. The season effect contributed significantly ($P \leq 0.01$) to the variation in dry period.

B. ECONOMICS OF MILK PRODUCTION:

Singh *et al.* (1986) reported that in Friesian x Zebu cows in around Ranchi, the cost of milk production was influenced significantly due to variation in genetic constitution of the animal, size of the herd in which they were maintained and lactation order. The location of the herd (zone) and season of calving did not have significant influence on the cost of milk production. They recommended that under the farmers' managemental conditions dairy units of 6-8 Friesian half-breds, preferably in 2nd - 4th lactations would be optimum for cheap milk production in the plateau region of Chotanagpur.

Grover *et al.* (1992) worked out the cost of maintenance of milch cattle on different farm size groups and found that the green fodder, dry roughages and concentrate taken together as feed cost accounted for 73.00 and 68.42 percent of the total expenditure of the average annual net maintenance cost of cows and buffaloes respectively. Average milk yield per cow did not show any definite relationship with the farm size. Crossbreeding, suitable feeding programmes with the local resources and the comfortable agro-climatic conditions of the area were the factors responsible to make dairying as an economical enterprise.

Rajendran and Prabaharan (1993) conducted a study of milk production in desi and crossbred cows as well as buffaloes maintained by different categories of households viz., landless labourers, marginal farmers, small farmers, and large farmers in Dharampuri district of Tamilnadu. The contribution of fixed and variable cost items to the maintenance cost incurred per animal per lactation in the animals of different genetic groups ranged from 44.19 – 55.81 and 44.19 – 55.91 percent respectively. The interest on working capital, depreciations on buildings as well as machinery and equipments, labour cost, insurance cost and electricity cost constituted the fixed cost whereas, feeding cost, medicine and veterinary charges as well as miscellaneous cost constituted the variable cost.

Ram *et al.* (1993) made an economic analysis of milk production in rural households in Sugarcane tract of Western Uttar Pradesh and found that feeds and fodder were the major component of cost of production accounting for 64.4 percent of the total cost, followed by labour (14.9%), fixed cost (13.585) and miscellaneous recurring expenditures (7.32%). Dairying was found to be a remunerative preposition for weaker section of population with a vast scope of development as a potential source of income and employment for the rural poor in the study area.

Ahir and singh (1994) studied the cost of maintenance and return from the milch animal in South Gujrat. They reported that among the various variable cost items contributing to the gross cost of maintenance of crossbred and local cows as well as buffalo, the contribution of cost of feeds and fodder was the highest (54.75, 59.19 and 63.90 percent) followed by hired and imputed value of family labour (8.10, 13.94 and 12.93 percent) and veterinary and miscellaneous charges (2.20, 2.20 and 1.74 percent) respectively. Interest on working capital, managerial cost, interest on fixed capital and depreciation contributed 11.37, 8.27, 7.95 and 5.71 percent in crossbred; 7.79, 7.54, 5.18 and 4.16 percent in local cows and 6.08, 7.72, 4.55

and 3.08 percent in buffalo accordingly. The costs of production per litre of milk were Rs. 4.92, 4.38 and 6.09 in crossbred and local cows as well as buffalo respectively. Results also revealed that crossbred cows were relatively the most profitable as it gave a net profit of 17.0 percent over the investment.

Jahagir *et al.* (1994) analysed the economics of milk production in Bangladesh and found that variable and fixed cost items contributed 61.31 and 38.69 percent respectively to the total cost of milk production of crossbred cows. Among the fixed cost items capital cost contributed the highest (3.57%) followed by interest of operating capital (3.68%), housing cost (1.90%) and cost of dairy equipments (0.54%). Cost of feeds and fodder was found to be highest (41.71%) among the variable cost items followed by labour cost (14.85%).

Kalara *et al.* (1994) analysed comparative economics of milk production in rural and urban areas of Haryana and reported that in urban area the fixed and variable costs in maintaining crossbred cows were 7.99 and 92.01 percent respectively. Among the variable cost items the cost of feeds and fodder accounted for 67.70 percent followed by labour cost (15.50%), miscellaneous expenditure (4.65%) and cost of annual repair (1.86%). They concluded that crossbred cows had an edge in terms of returns over buffalo owing to its high milk yield. Crossbred cows as well as buffaloes yielded more profit in rural than in urban areas. However, the level of profit was not in accordance with the cost of feeds and fodders and profit was relatively lower in rural area. Lower milk yield and interference of middle men in rural areas were attributed to such results.

Shah and Sharma (1994 [a]) conducted a comparative study on economic performance of milch animals of different genetic groups in typical rural conditions of Bulandshahar district of Uttar Pradesh. The district was divided into two areas, the one covered by Dugdh Utpadak Sahkari Sangh (DUSS) and the other not covered by DUSS (NDUSS). The study revealed that the net income derived from different groups of bovines was much higher in DUSS area than in NDUSS area. On an average the cost of feeding accounted for nearly 60 percent for all the breeds in both the sample pockets. The expenditure on human labour were 18.73, 20.75, 21.79 and 19.94 percent for Murrah buffalo, local buffalo, local cow and crossbred cows respectively in covered under DUSS while the corresponding values for the animals under the group NDUSS were 19.49, 20.96, 21.52 and 17.99 percent.

Sharma and Singh (1994) worked out the cost and return from different breeds/grades of milch animals maintained by different categories of farmers of Himachal Pradesh. They found that the average operational costs comprising of feed cost, human labour and miscellaneous expenditure in crossbred and local cows as well as graded buffaloes were 84.59, 83.35 was 84.74 percent of the total maintenance cost respectively. The fixed cost, comprising of depreciation on assets and interest on fixed capital, accounted for only 15.41, 15.65 and 15.26 percent accordingly. Among the operational cost components, feed cost contributed 64.15, 61.33 and 66.14 percent while human labour contributed 19.03, 20.81 and 17.11 percent respectively in crossbred cows, local cows and graded buffalo. The contribution of the miscellaneous cost varied from 1.41 to 2.21 percent. Variation in the different cost items due to variation in categories of farmers was non-significant. The findings also indicated that crossbred farming was relatively more profitable as compared to buffaloes and local cows.

Kalara *et al.* (1995) worked out the economics of milk production in rural areas of Haryana. Among the variable cost items feed and fodder contributed the maximum (58.08, 56.22 and 63.64 percent) followed by labour cost (18.11, 19.45 and 16.95 percent) in buffalo, crossbreds and local cows respectively. The contribution of fixed cost was 17.95, 15.55 and 12.87 percent respectively in buffaloes, crossbreds and local cows. The corresponding costs of per litre milk production were Rs. 4.95, 3.53 and 6.91 for buffalo, crossbred and local cows.

Rao and Singh (1995) computed various cost components (variable and fixed) of cost of production of milk along with return for different categories of buffalo farms in Guntur district of Andhra Pradesh. They found that in the case of beneficiaries of Operation Flood Programme, among the variable cost items, feeds and fodders contributed 51.26 percent to the gross cost of milk production. It was followed by labour cost (30.25%) and miscellaneous expenditure (2.40%). The fixed cost comprised of interest on fixed capital and depreciation on fixed assets, their contribution to the gross cost of production being 7.69 and 8.40 percent respectively. The corresponding values for non-beneficiaries households were 51.10, 26.64, 2.04, 10.81 and 9.41

percent respectively. The cost of per kg. milk production in beneficiary and non-beneficiary households varied from Rs. 2.58 – 3.08 and Rs. 3.37 – 4.86 respectively.

Sangu (1995) analysed the economics of milk production in different types of milch animals in villages and towns in Western U.P. They found that variable cost, comprising of feed cost, veterinary charges and miscellaneous cost, in crossbred and local cows as well as buffaloes were 68.99, 75.42 and 70.34 percent for villages and 67.88, 74.04 and 68.99 percent for towns respectively. Fed cost alone accounted for 66.83, 73.51 and 68.64 percent in villages and 65.81, 72.01 and 64.45 percent for towns respectively in the animals of different genetic-groups. The contribution of fixed cost, comprising of interest on capital, depreciation on building, machinery, electric and water installation, labour and electric charges, were 31.01, 24.58 and 29.66 percent for villages and 32.12, 25.96 and 33.85 percent for towns respectively. The production cost per Kg. of milk was Rs. 4.12 and 4.48 for buffaloes in villages and towns respectively. The corresponding values for desi and crossbred cows were Rs. 3.89 and 3.48 for villages and Rs. 4.10 and 3.88 for towns respectively.

Shiyani and Singh (1995) worked out the economics of milk production for members and non-members of dairy co-operatives in Saurashtra region of Gujrat. Results revealed that on an average the cost of feeds and fodder varied from 70.63 – 71.24 percent in buffaloes and 64.98 – 65.94 percent in local cows. It was followed by labour cost ranging from 17.00 – 20.66 and 19.90 – 24.60 percent in buffalo and cows respectively. The cost of per litre milk production varied from Rs. 5.56 – 6.47 in buffalo. The corresponding range for local cows was Rs. 4.12 – 4.63. The milk yield of cows as well as buffalo was maximum during winter season. The average cost of per litre of buffalo milk production was minimum during summer season while the production cost for cow milk was the lowest in the winter season for both the categories of milk producers.

Baruah *et al.* (1996) studied the economics of milk production in Assam. Among the variable cost items, the contribution of feed cost, labour cost, veterinary charges and miscellaneous expenses to the gross cost of milk production were estimated to be 70.59, 14.98, 0.57 and 1.23 percent respectively. Among fixed costs, the interest on fixed capital, depreciation on building/shed, depreciation on equipments and depreciation on animals contributed 7.14, 0.13, 0.15 and 5.21 percent respectively. The average cost of milk production, irrespective of the size of the herd, was estimated to be Rs. 8.28 per litre. Jersey graded cows maintained in the herd of 4-6 cows performed better from the economic point of view in comparison to the cows in the herds of <4, 7-9, 10-12 and >12 cows.

Kumar and Balishter (1996) undertook an economic study of milk production in crossbred cows and Murrah buffaloes in Firozabad district of Uttar Pradesh. They reported the cost of production of milk in crossbred cows and buffalo to be Rs. 3.53 and Rs. 4.45 per litre respectively. Among variable cost items, feeding, labour and miscellaneous expenses contributed 54.70, 21.26 and 2.09 percent. in crossbreds whereas, the respective contributions of those cost items in Murrah buffaloes were 57.30, 19.89 and 1.61 percent. Among fixed cost components, the contribution of depreciation on fixed assets and interest on fixed capital were 8.96 and 12.98 percent respectively for crossbred cows and 12.50 and 21.20 percent for Murrah buffalo respectively.

Badal and Dhaka (1998) made an attempt to work out the cost of milk production of different breeds of bovines in Gopalganj district of Bihar. Among the various components of cost of milk production, feed cost contributed maximum followed by labour cost, interest on fixed assets, depreciation on animal and veterinary & miscellaneous expenditure; the range of contributions of those cost components in buffalo being 36.56-55.26, 16.33-44.30, 9.78-13.73, 8.08-11.64 and 1.18-3.04 percent respectively under different household categories. The corresponding values for crossbred cows ranged from 42.75-56.84, 13.62-35.68, 12.08-15.89, 8.53-11.10 and 0.96-2.55 whereas for local cows the estimates ranged from 37.08-52.26, 17.24-28.28, 9.80-14.77, 8.17-12.53 and 1.17-3.20 percent respectively. The overall net cost of milk production (Rs. Per litre) was reckoned to be the minimum (Rs. 5.67) in crossbred cows followed by buffalo (Rs. 5.88) and the maximum in local cows (Rs. 7.10).

Chandra and Agarwal (2000) worked out the costs and returns from milk production of crossbred cows and buffaloes in Farrukhabad district of Uttar Pradesh. There findings revealed that in the case of crossbred cows and buffaloes, out of the variable cost items, feeds and fodder accounted for 69.8 and 68.2 percent of the gross cost of maintenance, followed by labour cost (21.5 and 21.9 percent) and miscellaneous expenditure (1.0 and 0.8 percent) respectively. Among the fixed cost items, depreciation on fixed assets were 2.8 and 5.7 percent and interest on fixed capital accounted for 4.9 and 3.4 percent respectively in cow and buffalo. The value of dung reduced the gross cost of milk by Rs. 0.46 / litre in crossbred cows and Rs. 0.43 / litre in buffalo. The net cost of production of milk in crossbred cows and buffaloes were Rs. 6.83 and 7.58 respectively. Results also indicated that the net cost of production per litre of milk was higher in buffaloes as compared to crossbred cows for small, medium and large farmers, while it was just reverse in the case of landless laborers.

Hemalatha *et al.* (2003) made an attempt to work out economics of milk production of different breeds of bovines in Ahmadnagar district of Maharastra and reported that the average profit per animal was maximum in Jersey crossbred cows as compared to HF crossbreds. Even buffalo were found to be more profitable. Among the various components of cost of milk production, feed cost contributed maximum followed by labour cost, depreciation on animal, miscellaneous cost, veterinary cost and supervision cost, the range of contribution in the cases of animals of different genetic groups being 60.84-68.88, 13.85-22.25, 8.25-13.50,1.62-2.11,0.72-2.00 and 1.07-1.86 percent respectively. Finally, the net cost of milk production (Rs. Per litre) was reckoned to be the minimum (Rs. 4.03) in HF crossbreds followed by Jersey crossbreds (Rs. 4.51), graded buffaloes (Rs. 7.43) and the maximum in non-descript cows (Rs. 8.10). Dairy farming was recommended to be a suitable venture to harvest constant and regular income from sale of milk unlike in crop production.

Bardhan *et al.* (2004) carried out a study in Udham Singh Nagar district of Uttranchal to analyze the cost and returns involved in milk production from indigenous cattle in different seasons for different categories of farmers. The results showed that milk production from indigenous cattle in the study area was a highly unprofitable business. Net returns over total cost on an average basis were found to be negative for Winter, Summer and Rainy seasons. Among the overall estimates of different cost components, feed cost was the highest (57.32%) followed by labour charge (19.50 %), Depreciations (8.42 %), interest on fixed capital (6.24 %), working capitals (3.12 %) and Veterinary charges (2.25 %). The major constraints contributing to unprofitable milk production were high cost of feeds and fodder and non-remunerative price of milk paid to the producers.

C. CONSTRAINTS IN LIVESTOCK FARMING:

Bhoite and Shinde (1987) studied the constraints perceived by the farmers in adoption of scientific animal husbandry technology and found that the major constraints in respect of animal breeding was non-availability of crossbred cattle in local market following the high breeding charges, inadequate knowledge of A. I., costly treatment of repeat breeders and unavailability of timely A. I. facilities. The main constraints in feeding of animals were the high cost of feed and fodders. Inadequate knowledge of scientific animal management (65.66%), shortage of capital (90.0%) and low price of milk (99.0%) were the serious constraints to successful dairy farming. In respect of animal health, unavailability of space for isolating sick animals (76.7%), inadequate knowledge to identify contagious and infectious diseases (71.0%) and non-availability of veterinary aid at the door step (46.0%) were the major constraints.

Singh and Thomas (1992) reported that type and level of constraints in dairy farming differ from farmer to farmer and place to place. Non-availability of Veterinary aid in emergency at door step, the problem of longer distance of stockman centers and Veterinary hospitals, no market value of male crossbred calves and lack of finance were the common constraints in rearing high producing cows.

Rajendran and Prabaharan (1993) reported that in Dharampuri district of Tamilnadu, the important problems encountered in the management of crossbred cows were higher incidence of repeat breeding, high capital investment, high frequency of illness of animals, costly feeds and high cost on treatment of animals in order.

Raju *et al.* (1993) reported that lack of knowledge of approved dairy practices, non-remunerative price for milk, non-availability of Veterinary services, green fodders, labour etc. were the major constraints perceived by dairy farmers in crossbred rearing.

Bhaskar *et al.* (1994) reported that in and around Banglore, Friesian crossbreds were the animals of the choice. High cost of feed stuffs was the major problem in rearing high yielding crossbred cows.

Velmurugan (1998) concluded that in Pondicherry, the land and credit constraints acted powerfully and inexonerably on dairy households resulting in a problem in maintaining different land size-classes with number of milch stock.

Yedukondalu *et al.* (2000) carried out a study on dairy development and the constraints perceived by dairy farmers in randomly selected two Mandals in Medak district of Andhra Pradesh. Majority of the farmers reported that non-remunerative price for milk, lack of transport facilities for inputs and outputs, non-availability of good dairy animals, high cost of concentrates, non-availability of green fodders, high cost of crossbred animals, non-availability of Veterinary services, distant location of A. I. centers, non-availability of good breeding bulls, no knowledge of correct time of insemination, lack of credit facilities, high cost of Veterinary medicines and lack of proper housing for animals were the major problems in profitable dairy farming.

Sawarkar *et al.* (2001) recorded that in Wardha district of Vidarbha, the major constraints in adoption of A. I. for breeding dairy animals were non-availability of door-to-door service of A. I. and difficulty to take animals in heat to A. I. center in time. Moreover, 20.55% respondents were of opinion that A. I. practice is against religion. Findings suggested that more Veterinary extension efforts are required for changing the attitude of large number of dairy owners, who are still following the age-old natural insemination practices.

Mishra and Pal (2003) made a comprehensive study on constraints in dairy farming in West Bengal and reported that among the various constraints perceived by the respondents', inadequacy of technical knowledge (40.3%), poor organizational support (28.6%) and lack of financial resources (20.1%) were the major constraints for the dairy sector. Among the technical constraints, repeat breeding problem (14.6%), low conception rate through A. I. (9.6%), calf mortality (7.0%), lack of knowledge of heat detection (5.0%) and inadequate knowledge of animal management (4.1%) were the main. High cost of Veterinary services (13.8%), lack of credit facilities (4.1%) and non availability of green fodder (2.2%) constituted the economic constraints. Among the organizational constraints, distant location of A. I. centre (11.0%), lack of extension workers for motivation (5.2%), paucity of trained stockmen (5.2%), non availability of stockmen on A. I. centre (5.2%) and non availability of A. I. facility (5.2%) were the major constraints.. Besides that some social constraints (11.0%) were also perceived by the farmers which included low level of literacy (4.4%), lack of support from elders (4.4%) and social dogma (2.2%).

3. MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Source of Data:

Milch animals maintained in private dairy units, located in a radius of about 15 Km. in and around Darbhanga (Bihar), were the experimental animals for this investigation.

3.2 Geography and Climetological description of the Location:

Darbhanga, the historical city of Mithilanchal, is located in Northern part of Bihar at 26.10° North (latitude) and 85.57° East (longitude) at an altitude of about 60 meters from the Mean Sea Level. The climate of this zone is Hot - Humid. The climatological details of the area have been summarized in table-3.1.

3.3 Primary Survey: In a primary survey, the private dairy units popularly known as KHATALS, located in a radius of about 15 Km. in and around Darbhanga and consisting of three or more HF / Jersey crossbred cows, desi cows and buffaloes either alone or in combination, were enumerated through a "door to door survey" method. In this investigation Khatals were characterized as small dairy units in private sector, where cows and/or buffaloes are managed for milk production with the sole objective of "profitable production". In most of the khatals, the animals are managed under sub-optimal conditions of housing and sanitation, but are supplied with high quality concentrate mixture even more than requirement of the animals in order to challenge them to produce milk to their maximum. The whole area was divided into three distinct zones on the basis of some geographical boundaries. The zones were delineated as follows:

Zone I - **North-West, Darbhanga** (Hariharpur, Zale, Singwara, Biraul, Rampura, Madhopur, Sonki, Bihari, Ganj, Chipalia, Tarsarai etc.)

Zone II - **Central, Darbhanga** (Laxmisagar, Chunabhatti, Donar, Subhankarpur, Bela, Mirzapur, Urdu, Siwazi Nagar, Senapath, Laheriasarai, Kadirabad etc.)

Zone III - **South-West, Darbhanga** (Baheri, Bhigo, Ojhaul, Panchauv, Makhanpur, Chandanpatti, Taralahi, Dilahi, Banauli, Bisanpur etc.)

Altogether 115 dairy units, consisting of three or more milch animals, were enumerated in the area specified for this study. The number of desi cow, Jersey as well as HF crossbred cows and buffalo, maintained in the khatals so enumerated, were 345, 188, 171 and 436 respectively. Zone-wise distributions of milch animals of different genetic groups in the enumerated dairy units of different sizes are presented in table - 3.2 and 3.3.

Table-3.1 - The Climatological details of the study area.

Month	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)
	Max. (Avg.)	Min. (Avg.)	Morning (Avg.)	Afternoon (Avg.)	Avg.
January	21.20	4.10	88.50	48.00	3.75
February	24.95	10.15	86.50	44.50	0.50
March	35.75	14.25	79.50	36.50	0.50
April	35.80	20.45	73.50	37.00	15.00
May	34.35	24.55	82.00	58.00	123.75
June	34.50	26.30	88.00	79.00	194.65
July	33.45	27.45	87.50	77.50	226.25
August	33.50	25.60	89.50	73.00	166.50
September	31.70	25.70	90.50	74.50	347.50
October	32.15	24.15	85.00	59.50	136.25
November	29.30	17.10	91.50	51.00	0
December	23.15	10.30	91.00	55.00	0
Overall	**33.48**	**19.57**	**86.04**	**56.96**	**101.22**

Based on the records of last 10 years of Deptt. Of Climatology, RAU, Pusa (samastipur).

Table – 3.2

Zone – wise distribution of enumerated dairy units of different sizes in the study area.

Zones	Herd Size (No. of milch animals)				
	(3 - 6)	(7 - 10)	(11-14)	(15 & above)	Total
North-East	16	10	8	6	40
South-West	13	12	7	6	38
Central	11	9	8	9	37
Total	40	31	23	21	115

Table – 3.3

Zone – wise distribution of milch animals of different genetic groups in enumerated dairy units.

Zones	Genetic Group				
	Desi cow	J X B	HF X B	Buffalo	Total
North East	117	51	43	158	369
South West	128	56	58	147	389
Central	100	81	70	131	382
Total	345	188	171	436	1140

3.4 A brief note on general managerial practices in dairy units (Khatals):

The managerial practices in all the khatals were not quite uniform. In most of the cases animals were stall fed and individual feeding was in practice. Concentrates were fed on the basis of body size, level of milk production and other physiological status of the animals like dry and in gestation. Except a few, home made concentrate mixtures were fed in almost all the units.

Chaffed paddy straw, Wheat bhusha and Hay constituted the common items of dry fodder. Green Maize, Jowar, Barseem, Lucern, Oat, Barley and uncultivated grasses were the main source of green fodder. Linseed and/or Mustard cake along with cereals (Wheat, Maize, and Barley etc.), Pulses chunies, and Wheat bran were the chief ingredients of concentrate mixture. Vitamins, Minerals, Molasses and Common salt were also added to balance the ration of the animals in most of the units.

On an average an adult Crossbred Cow or Buffalo was provided daily with 4–5 Kg. of dry fodder, 1-2 Kg. of concentrate mixture and available amount of greens, as basal ration. A production ration @ 1.0 Kg. concentrate mixture for 2.5-3.0 Kg. of milk produced by an animal was supplied daily to cows and buffaloes, in addition to their basic ration. In some of the units, a "Let down" ration @ 0.5 Kg. of concentrate was also provided to the animals at the time of milking, especially to heavy yielder, producing more than 10.0 Kg. of milk per day. Maintenance ration was continued during dry and early gestation periods. An additional supply of 1.0 Kg. of concentrate mixture was made to a cow daily during the last two month of gestation. For a desi cow, the quantum of concentrate in basal ration was almost half of the quantum supplied to the crossbred cow or buffalo. However, the rate of supply of production ration to a desi cow was almost the same to that for crossbred cows and buffaloes and the animals were supplied with fodder *ad libitum*.

Artificial insemination was in common practice to breed the animals. Prophylactic and curative measures against various diseases were usually taken to keep the animal in sound physique. However, the complete scientific schedule in this regard was not strictly followed in majority of the units.

Housing pattern in the khatals was not in accordance with the scientific norms. Animals were housed in Kachcha, Half and Three - fourth Puccka and even Puccka houses. In this study, the types of houses provided to the animals in different units were classified as follows:-

Type A - Full kachcha house.

Type B - Half puccka house (only walls puccka without plaster).

Type C - Three - fourth puccka house (walls, floor and feeding troughs puccka).

Type D - Full puccka house (roof of CA / CI sheets).

The sale of raw fluid milk was the main pattern of disposal of milk and fixed households, hotels, sweet and tea shops near the khatals were the main consumers.

3.5 Respondent units:

The dairy units, whose owners were positive in providing relevant information, were called "Respondent units" and such units were sorted out for further approaches. Out of 115 enumerated units, 98 units possessing altogether 735 animals of different genetic groups were finally sorted out as Respondent units. Zone–wise distribution of Respondent unit of different sizes and the animals of different genetic groups therein, have been presented in table 3.4 and 3.5 respectively.

Table – 3.4

Zone – wise distribution of Respondent units of different sizes in the study area.

Zones	Herd Size (No. of milch animals)				
	(3 - 6)	(7 - 10)	(11-14)	(15 & above)	Total
North-East	15	7	5	6	33
South-West	17	9	4	4	34
Central	14	8	5	4	31
Total	46	24	14	14	98

Table – 3.5

Zone – wise distribution of milch animals of different genetic groups in the Respondent units in the study area.

Zones	Genetic Group				
	Desi cow	J X B	HF X B	Buffalo	Total
North-East	70	38	33	98	239
South-West	74	40	36	101	251
Central	67	52	45	81	245
Total	211	130	114	280	735

3.5.1 Sampling of Respondent Units: With an objective to have better control through close observation on each of the experimental units for accurate data recording, 50 percent of the Respondent units were randomly selected. As such, 49 Respondent units having

652animals were finally selected for further studies, utilizing the procedure of "Stratified random sampling with proportional allocation" (Snedecor and Cochran, 1967). Zone – wise distribution of selected Respondent units of different sizes as well as that of the animals of different genetic groups along with the number of animals discarded due to specific reasons have been depicted in tables 3.6 and 3.8 respectively. Herd-size-wise distribution of milch animals of different genetic-groups, finally selected for this study, has been shown in table-3.7.

Table – 3.6

Zone – wise distribution of selected Respondent units of different sizes.

Zones	Herd Size (No. of milch animals)				
	(3 - 6)	(7 - 10)	(11-14)	(15 & above)	Total
North-East	8	4	2	2	16
South-West	8	4	3	2	17
Central	7	4	3	2	16
Total	23	12	8	6	49

Table – 3.7

Herd–size wise distribution of milch animals of different genetic groups finally selected for this study.

Herds size	Genetic Group				
	Desi cow	J XB	HF XB	Buffalo	Total
(3 – 6)	33	10	9	39	91
(7 – 10)	29	18	23	32	102
(11 – 14)	17	13	16	52	98
(15 & above)	17	23	16	38	94
Total	96	64	64	161	385

Table – 3.8

Zone – wise distribution of animals of different genetic groups in selected Respondent units.

Particulars/ Genetic group	Zones			Total
	North-East	South-West	Central	
	Animals Included in this study			
Desi cow	32	31	33	96
J XB	14	19	31	64
HF XB	12	22	30	64
Buffalo	64	62	35	161
Sub Total (A)	122	134	129	385
	Animals Discarded*			
Desi cow	22	35	27	84
J XB	21	14	11	46
HF XB	10	9	10	29
Buffalo	32	35	41	108
Sub Total (B)	85	93	89	267
	Total (A+B)			
Desi cow				
J XB	54	66	60	180
HF XB	35	33	42	110
Buffalo	22	31	40	93
	96	97	76	269
Grand Total	**207**	**227**	**218**	**652**

- *Animals were discarded either due to their non-identified genetic makeup, were and/or did not complete one calving interval during the study period.*

3.6 Information recorded: The performance records of milch animals under the defined different genetic groups and in very first month of lactation were only utilized in this study. The following details were promptly recorded / derived:

3.6.1 Information on the unit:

a) Zonal location.

b) Herd – size.

c) Herd–constitution.

d) Farming system.

3.6.2 Information on the animals:

(i) General:

a) Genetic group.

b) Season of calving.

c) Lactation order.

(ii) Measures of Production efficiency:

a) Lactation milk yield (kg.).

b) Lactation length (days).

c) Peak yield (kg.).

d) Days to attain peak yield (days).

e) Milk yield per day of lactation length (kg.).

f) Milk yield per day of calving interval (kg.).

g) Milk production efficiency per kg. body weight (MPEK).

h) Milk production efficiency per kg. body weight at calving per day of lactation length (MPEKD).

(iii) Measures of Reproduction efficiency:

a) Dry period (days).

b) Calving interval.

(iv) Measures of Economic efficiency:

a) Cost of milk production.

Schedules and questionnaires were developed and suppiied to the finally selected Respondent units, to record the relevant information in the light of the objectives of this study. The Respondent units were approached frequently to collect and monitor the data recording. The information gathered through personal interviews was also incorporated. Milk recording was done weekly up to attainment of peak-milk yield and after then the recording was done fortnightly.

The **Average daily yield** was obtained by averaging the bi-weekly records during the lactation. The **Lactation yield** was obtained by multiplying the average daily yield with number of days the animal remained in milk. The rest of directly observed economic traits like **Lactation length, Peak-yield, Days to attain peak-yield, Dry period** (this period taken subsequent to calving) and **Calving interval** were recorded in the schedules supplied to the units.

The values for derived traits like **Milk yield per day of lactation length, Milk yield per day of calving interval, MPEK** and **MPEKD** were obtained utilizing the standard statistical formulae. The MPEK was estimated in terms of ratio of "lactation yield (kg.) and body weight of the animal at calving". Whereas, MPEKD was reckoned as the ratio of MPEK and lactation length (days) of an animal. It is worth mentioning that to obtain the body weight of an animal there was no weighing machine in the field. Rather, the body weights of animals were reckoned by utilizing the following formula based on their body measurement:

Weight of cattle (in pound) = $(L \times G^2) / 300$

Weight of buffalo (in pound) = $[(25.16 \times G) - 960.232]$

L = length of animal in inch.

G = Heart girth of the animal in inch.

The "Net cost of maintenance of an animal for each kg. of milk she produced per day of an inter-calving period" was taken as the measure of **Cost of milk production** for that animal. Statistically, it was the "ratio of average daily maintenance cost of an animal during an inter-calving period and average daily milk she produced during that inter-calving period", i.e.

$$\text{Cost per kg. of milk for an animal} = \frac{\text{Average maintenance cost (Rs.) of an animal during an inter-calving period (days).}}{\text{Value of average daily milk yield (Rs.) produced by that animal during the inter calving period (days).}}$$

The different components of expenditure on maintenance of milch animals were broadly categorized into:

I. Fixed cost items.
II. Variable cost items.
III. Miscellaneous cost items.

I. Fixed cost items:

(i) Depreciation on animal:

It was worked out by straight line method based on the market value of the milch animals during the period of study. A general prediction formula to estimate approximate market value of a lactating cow and buffalo in and around Darbhanga, could be derived on the basis of the purchase cost of 92 milch animals (50 cows and 42 buffaloes) based on their milk yield and lactation order at the time of purchase. It has been presented as follows:

Lactation No.	Rate of calculating price (Rs.)	
	Cows	Buffaloes
1st	Milk yield (Kg.) X 1500 = 00	Milk yield (Kg.) X 1800 = 00
2nd	Milk yield (Kg.) X 1400 = 00	Milk yield (Kg.) X 1700 = 00
3rd	Milk yield (Kg.) X 1100 = 00	Milk yield (Kg.) X 1500 = 00
4th	Milk yield (Kg.) X 900 = 00	Milk yield (Kg.) X 1200 = 00
5th	Milk yield (Kg.) X 600 = 00	Milk yield (Kg.) X 1000 = 00

Animal beyond fifth lactation were excluded from this study. A sum of Rs. 500 and Rs. 800 was added respectively to the cost of a cow having crossbred female calf of Jersey or Friesian origin. The corresponding value for a female buffalo calf was Rs. 500.00. The productive life of a milch animal was taken as of five lactations and depreciation was calculated @ 12 percent of the estimated cost per calving interval under the assumption that 40 percent of the animal's cost would be refundable even after completion of its fifth lactation as "salvage value". Per day depreciation value for a cow was calculated as the "Ratio of 12 percent of the estimated cost of the animal and number of days in the inter-calving period."

(ii) Depreciation on buildings/ sheds:

As mentioned earlier, the animals in khatals were managed in sub-optimal conditions of housing and sanitation. Animals were provided with variable types of houses in different dairy units. For calculation of the cost of housing and depreciation on buildings/sheds, the houses provided to milch animals in different khatals were grouped into four types:-

Type A - Full kachcha house.

Type B - Half puccka house (only walls puccka without plaster).

Type C - Three - fourth puccka house (walls, floor and feeding troughs puccka).

Type D - Full puccka house (roof of CA / CI sheets).

On the basis of enquiries made to khatal owner and information collected, classified and analysed, the following approximate rates could be derived to estimate the cost of different types of houses built up and utilized to run khatals in and around Darbhanga:-

Type of housing	Rate to build up per sft. Covered area (Rs.)	Cost of troughs etc. (Rs.)	Total cost of housing / animal (Rs.)
Type (A)	30 = 00	100 = 00	1300 = 00
Type (B)	50 = 00	200 = 00	2200 = 00
Type (C)	90 = 00	500 = 00	4100 = 00
Type (D)	120 = 00	500 = 00	5300 = 00

The basic assumptions behind fixation of housing cost were to provide 40 sft. covered area to each milch animal and the construction cost of troughs etc. varied according to the type of its construction. The total life of (A) and (D) type houses were accounted to be 10 and 40 years respectively, while for (B) and (C) types it was 25 years. Depreciation on housing was calculated as the ratio of "cost of housing per animal and the estimated life of that house in days". Depreciation per kg. of milk produced by an animal was calculated as:

$$\text{Depreciation per Kg. of milk produced by an animal} = \frac{\text{Housing cost for an animal}}{\text{Estimated life of that house (in days) X Av. Daily milk produced by that animal for the calving interval.}}$$

(iii) Depreciation on Farm Utensils, Machinery, Equipments and other assets except Animals and Housing: To estimate this depreciation value, the total cost of utensils, equipments, machinery and other assets of daily use, like chaff cutter, electric motor, canes, buckets, chains, milk pots, cycles etc. with each and every selected Respondent units, was estimated. The depreciation was calculated @ 10 percent of the total cost per annum. The depreciation per Kg. of milk produced at the khatal was reckoned as the ratio of "10 percent of the total cost of utensils, equipments, machinery etc. at a khatal and 365 X Average milk yield (Kg.) / day of calving interval for that khatal. This was done under the assumption that utensils, equipments, machineries etc. at a khatal were equally used for every animal at that khatal irrespective of its level of milk production. As such this cost item has been taken as fixed for every animal in Respondent units.

(iv) Interest on Fixed capital:

In this study, fixed capital comprised of all the assets of a Respondent unit including cost of animals, housing, utensils, equipments and machineries etc. and the interest on the fixed capital was worked out @ 12 percent per annum, the rate fixed by government financial instructions for the year 1998-99 for such type of loans for short duration.

II. Variable cost items:

(i) Cost of Feeds and Fodders:

Particulars of feedings were recorded for individual animal. Where individual records of average fodder fed was not available and there were no considerable differences in feeding schedules of different animals in a khatal, the daily record of total fodder, both dry and green, supplied to the animals under study was taken. Average quantity of fodder fed per animal was obtained by dividing the total quantity of fodder supplied by the number of animals fed. The prevailing market rates, including transportation cost, were taken as the purchase price for various green and dry fodders. Similarly the rates at which concentrates ration or its ingredients were purchased from the market, together with its transportation cost, were taken into account for calculating the expenditure on concentrate. For house grown feeds and fodders the prevailing market rates were considered. The seasonal variation in the market rates of different feeds and fodders were also taken into prompt consideration while calculating feeding cost. Accordingly, average daily expenditure on feeds and fodders was worked out for each animal under the investigation.

(ii) Labour Cost:

The aggregate of paid (hired) and unpaid (family) labour was taken as the total labour cost of milk production. For working out labour cost, the actual time spent on different operations concerned to milch animals was recorded for each unit and apportioned suitably for each animal. For family labour, the actual time spent daily on looking after the animals and other farm operations by each of the family members, including women, were recorded and apportioned for each animal. The cost of family labour was also calculated at the rate of the wage paid to the hired labour i.e. @ Rs. 60.00 per day (8 hrs.).

(iii) Cost of A. I. and Veterinary Aids:

This cost item comprised of costs of medicines, vaccines, semen and other sanitary items along with the remuneration paid to veterinarians, inseminators and other technical persons, whose services were utilized for taking prophylactic and/or curative measures to keep the animal under sound physical and sexual physique. It is worth mentioning here that majority of respondent units could not provide individual records of expenditure on this cost item. As such on the line of proposition of Tripathi *et al.* (1978), Veterinary and A.I. costs were taken as fixed @ Rs. 560/- per animal per calving interval. These estimates were based on the individual records of 20 respondent units of different sizes distributed in the three zones of the area of experimentation and was generalized for all the units under study.

III. Miscellaneous cost items: Revenue of the land, electric and water tariff, cost of repair of buildings / utensils / machineries etc. as well as unforeseen minor contingent expenditures comprised the miscellaneous cost item. In this study it was kept fixed @ 500.00 /

animal / calving interval. Finally, the cost on account of this component of expenditure was apportioned for each Kg. of milk produced by an animal as:

$$\text{Miscellaneous cost / Kg. milk} = \frac{500.00}{\text{Inter calving period (days) of an animal X Average milk yield per day of calving interval of that animal.}}$$

Gross cost of maintenance:

The gross cost of maintenance of an animal was reckoned by adding the expenditures on all cost components, viz. depreciation on animal, buildings / sheds, farm utensils, machineries, equipments and other assets; interest on fixed capital; cost of feeds and fodders; labour cost; cost of A. I. and Veterinary aids as well as miscellaneous expenditures.

Income:

Other than milk, dung as well as empty bags were the only source of income to the khatals. It was observed in general practice that the empty bags of jute were used to cover the animals as well as windows, doors etc. in winter to protect them from cold. The plastic bags were generally utilized for making ropes to tie the animals. However, it was in general practice to sale the animal dung or FYM time to time at reasonable price. It is pertinent to mention here that it could not be possible to have précised record of income from individual animal on account of the dung or FYM produced at the khatals. However, under the assumption that an adult cow excretes on an average 20 Kg. of wet dung daily (Reddy *et al.* 1972) and the current market rate of wet dung in and around Darbhanga being an average Rs. 10.00 per quintal, it was kept as a fixed income @ Rs. 2.00 per animal per day.

Net cost of maintenance:

It was reckoned by deducting income from dung from the gross cost of maintenance. The net cost of maintenance per kg. of milk produced per day of calving interval by particular animal was termed as "the cost of per kg. milk production" for that cow.

3.7 Classification of Data:

To study the effects of the different genetic and non-genetic factors on the economic traits under study, the data were classified on the basis of location (zones) and size (herd-size) of the unit; genetic group, season of calving and lactation order of the animals as well as herd-constitution and farming system adopted by the farmers. The various factors were sub classified as followed:

3.7.1 Zones:

(i) Zone – I

(ii) Zone – II

(iii) Zone – III

(As detailed in Para- 3.3).

3.7.2 Herd-Size:

The dairy units were grouped into the following four categories on the basis of number of milch animals (desi cows, crossbred cows and buffaloes) they possessed:

(i) Units having 3-7 milch animals,

(ii) Units having 7-10 milch animals,

(iii) Units having 11-14 milch animals,

(iv) Units having ≥15 milch animals.

3.7.3 Genetic Group of the Animals:

The milch animals included in this investigation pertained to the following four Genetic-groups.

(i) Desi Cows.

(ii) Jersey Crossbred Cows.

(iii) Friesian Crossbred Cows.

(iv) Graded Buffaloes.

HF and Jersey crossbred cows were identified on the basis of phenotypic appearance of the animals, irrespective of the level of exotic inheritance they possessed.

3.7.4 Season of Calving:

The year was further classified into following three seasons on the basis of change in climate:-

(i) Hot – Dry (Mar. - June).

(ii) Hot – Humid (July – Oct.).

(iii) Cold (Nov. – Feb.).

3.7.5 Lactation order:

Performance records of the animals in 1st to 5th lactations were coded in the sequence of 1, 2, 3, 4 and 5 accordingly.

3.7.6 Herd Constitutions:

On the basis of the constitution of the herd i.e. the types of milch animals maintained at the khatals, the units were grouped into the following three types:

(i) Units having only cows.

(ii) Units having only buffaloes.

(iii) Units having cows and buffaloes both.

3.7.7 Farming system:

The enumerated dairy units were also classified according to the farming system adopted by the farmers as detailed below:

(i) Only Animal Husbandry (20 units).

(ii) Mixed farming (29 units).

3.8 Statistical method:

3.8.1 Stratified random sampling with proportional allocation:

Assuming that the population of size N is divided in to K Strata (zones) of sizes N_1, N_2, N_3, ...N_k such that,

$$\sum_{i=1}^{K} N_i = N$$

Let sample of sizes n_1, n_2, n_3,.......................n_k be drawn from these strata respectively so that,

$$\sum_{i=1}^{K} n_i = N$$

Let $n_i \alpha N_i$

Or $n_i = C N_i$ ------------------(I)

Where,

C is the constant of proportionality.

After taking summation on both the sides, we get.

$$\sum_{i=1}^{K} n_i = C \sum_{i=1}^{K} n_i$$

Or, n = CN

Hence, n / N = C (constant)

After substituting the value of C in the equation (I), we get:

$$n_i = \frac{(n) N_i}{(N)} \qquad (i = 1, 2, 3, \ldots\ldots\ldots\ldots, K)$$

let y_{ij} be the value of j^{th} unit in the i^{th} strata of population (i = 1, 2, 3, ..., K and j = 1, 2, 3, ... N_i and y_{ij} be the corresponding sample observation. (i = 1, 2, 3, ...K and j = 1, 2, 3, ... n_i), then population mean $\overline{Y}$ given by:

$$\overline{Y}_{ij} = 1/N \cdot \sum_{i=1}^{K} \sum_{i=1}^{N_i} \bar{y}_{ij}$$

$$= 1/N \sum_{i=1}^{K} N_i \; \bar{y}_i$$

Where,

$\overline{Y}_i = 1/N_i \sum_{j=1}^{N_i} \bar{y}_{ij}$, which is the mean of the i^{th} strata of the population.

The population variance

$$V(\bar{y}) = \sum_{i=1}^{N_i} \frac{(N_i)^2}{N} (1/n_i - 1/N_i)\, s_i^2$$

$$= \sum_{i=1}^{N_i} w_i^2 (1/n_i - 1/N_i)\, s_i^2$$

Where, $w_i = ni/N$ and $s_i^2 = 1/(Ni - 1) \sum_{j=1}^{N_i} (y_{ij} - \bar{y}_i)^2$

Similarly, the sample mean can be defined as:

$$\bar{y} = 1/n_i \sum_{j=1}^{n_i} \bar{y}_i$$

Where, $y_I = 1/K \sum_{i=1}^{K} y_{ij}$ i.e. the sample mean of the i^{th} strata and

$$V(\bar{y}) = \sum_{i=1}^{N_i} w_i^2 (1/n_i - 1/N_i)\, s_i^2$$

Since, $[E(S^2) = S^2]$

$$s_i^2 = 1/n_i - 1 \sum_{j=1}^{n_i} (Y_{ij} - y_i)^2$$

3.8.2 Least square analysis:

To quantify the variation in different efficiency traits due to genetic and various non-genetic factors, the data was subjected to Least Square Analysis (Harvey, 1966) for which the following mathematical model was utilized:

$$Y_{ijklmnop} = \mu + G_i + Z_j + F_k + HS_l + HC_m + S_n + P_o + e_{ijklmnop}$$

Where,

$Y_{ijklmnop}$ = The value of p^{th} individual under i^{th} genetic group, j^{th} zone, k^{th} farming system, l^{th} herd size, m^{th} herd constitution, n^{th} season of calving and o^{th} parity.

μ = The population mean.

G_i = The effect of i^{th} genetic group (i = 1, 2, 3, 4)

Z_j = The effect of j^{th} location of herd (j = 1, 2, 3)

F_k = The effect of k^{th} farming system (k = 1, 2)

HS_l = The effect of l^{th} herd size (l = 1, 2, 3, 4)

HC_m = The effect of m^{th} herd constitution (m = 1, 2, 3)

S_n = The effect of n^{th} season of calving (n = 1, 2, 3)

P_o = The effect of o^{th} parity (o = 1, 2, 3, 4, 5)

$e_{ijklmnop}$ = The random error associated with individual which is randomly and independently distributed with mean zero and variance σ.

3.8.3 Duncan's multiple range test (DMRT):

The Duncan's Multiple Range (DMR) Test (Kramer, 1957) was utilized for pair wise comparison of the Least Square Means at 5 and 1 percent level of probability. Relevant phenotypic correlation among the economic traits was estimated utilizing standard statistical procedure (Snedecor and Cochran, 1967).

3.9 Constraints in dairy farming:

To conduct studies on the constraints in the adoption and management of milch animals, the respondents were requested to give the important technological and managemental problems, as they perceived. Garett's ranking technique was used to rank the problems. The orders of merit, thus given by the respondents, were converted into ranks by using the following formula (Garett & Woodworth, 1969):

$$\text{Percent position} = \frac{100\,(R_{ij} - 05)}{N_j}$$

Where,

R_{ij} = Rank given for i^{th} constraints by the j^{th} individual.

N_j = Number of factors ranked by j^{th} individual.

The percent position of each rank, thus obtained, was converted into scores by referring Garett's ranking table. Then for each factor the scores of individual respondents were added. The mean scores for all the factors were arranged in descending order and ranked.

4. RESULTS AND DISCUSSION

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4.1 MEASURES OF PRODUCTION:

In the present investigation, altogather eight economic traits i.e., Lactation length, Lactation milk yield, Peak milk yield, Days to attain peak yield, Milk production efficiency in terms of yield per kg. body weight at calving (MPEK), Milk production efficiency per kg. body weight per day of calving interval (MPEKD), Milk yield per day of lactation length and Milk yield per day of calving interval were taken as the measures of production. Out of the aforesaid eight traits, the former four were directly observed and recorded, while the later four were derived. To estimate the different parameters of these traits in the light of objectives of this study, the data were subjected to different statistical treatments including Least squares analysis, utilizing relevant mathematical models and the results are presented in tables-4.1 to 4.18 accordingly.

4.1.1 Lactation Length: Lactation period is one of the important factors affecting economics of dairy enterprises. Either too long or too short lactation period is not desirable from economic as well as cow's health points of view. The ideal lactation length has been regarded as 305 days in cattle and buffaloes. The overall Least Squares Mean for lactation length in dairy animals of the different genetic groups viz., local and crossbred cows as well as graded buffaloes, included in this study, was estimated to be 320.62 ± 1.13 days (Table-4.2).

4.1.1.1 Factor affecting Lactation length:

Least square analysis of variance (Table-4.1) revealed that genetic group and order of lactation had highly significant ($P \leq 0.01$) influence on lactation length. The effects of zone, herd-size, herd-constitution, season of calving and farming system were statistically not significant.

4.1.1.1.1 Zone: As evident from table-4.2, the average lactation length was longest (322.28 ± 1.46 days) in the animals in khatals located in Central zone of the study area followed by those in South-West (320.55 ± 1.38 days) and North-East (319.05 ± 1.41 days) zones. However, the contribution of zone-effect to the total variation in lactation length was only 0.419% and the animals in different zones were not significantly different among themselves with respect to their lactation length (Table-4.1). Singh *et al.* (1986 [b]) also recorded the effect of location of the herd on lactation length in crossbred cows to be non-significant. It may be attributed to the fact that the experimental area was limited in a radius of 15 km. only, which was divided into three zones in and around Darbhanga and as such there was not much variation in agro-climatic condition of the different zones.

Table – 4.1

Least square analysis of variance showing effects of genetic and non-genetic factors on lactation length of milch animals in and around Darbhanga (Bihar).

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	273.93	0.419
Herd-size	3	213.61	0.490
Herd-constitution	2	359.08	0.549
Genetic group	3	26911.38 **	61.704
Season of calving	2	204.75	0.313
Lactation order	4	633.80 **	1.938
Farming system	1	18.78	0.014
Residual	367	123.27	34.573

** $P \leq 0.01$

4.1.1.1.2 Herd-size: The contribution of the herd-size to the total variation in lactation length was 0.490% and the average lactation length of the animals in the herds of different sizes were statistically not significant (Table-4.1). However, results of this study (Table-4. 2) revealed that the animals managed in herd of 11 – 14 milch animals had longest average lactation length (324.48 ± 2.04 days) followed by those in herd of 7 – 10 animals (320.56 ± 1.43 days), 15 & above animals (319.55 ± 1.87 days) and 3 – 6 animals (317.91 ± 1.83 days). Singh *et al.* (1986[b]) and Shrivastava *et al.* (1998) recorded the effect of herd-size on lactation length in crossbred cows to be significant. Such variation may be attributed to the variation in genetic constitution of the experimental animals, agro-ecological conditions of the study area and the class-interval while classifying the herds based on the number of animals therein.

4.1.1.1.3 Herd-constitution: Herd constitution did not show significant influence on lactation length (Table-4.1). The contribution of the herd-constitution to the total variation in lactation length was 0.549%. However, the average lactation length was the longest (325.23 ± 2.32 days) for the milch animals maintained in the khatals having only graded buffaloes followed by those in the khatals having cow and buffalo both (318.30 ± 1.62 days) and it was the shortest (317.84 ± 1.38 days) for the animals in the units having only cows (Table-4.2).

4.1.1.1.4 Genetic group: Genetic-group had highly significant ($P \leq 0.01$) influence on lactation length and its contribution to the total variation in lactation length was 61.704% (Table-4.1). As evident from table-4.2, the HF crossbreds had the longest average lactation length (334.64 ± 1.99 days) which did not differ significantly from Jersey crossbreds (333.43 ± 2.02 days) but was significantly different from the average lactation length for desi cows and graded buffaloes. The average lactation length in graded buffaloes (321.14 ± 1.82 days) was significantly higher than the shortest lactation length for desi cows (293.29 ± 1.71 days). Singh *et al.* (1986 [b]), Singh (1995) reported the effect of genetic-group on lactation length to be statistically non-significant but their findings were based only on HF crossbred cows having different levels of Friesian inheritance. The desi cows and buffaloes, which were not included in their study, have also been included in this study.

The average lactation length in HF crossbred cows, estimated in this investigation, was close to the findings of Shah and Sharma (1994 [b]) and Singh *et al.* (2000), but higher than the estimates reported by Singh *et al.* (1986 [b]), Shrivastava *et al.* (1998) and Hemalatha *et al.* (2003). Whereas, the average lactation length in HF crossbred cows recorded by Rao *et al.* (2000) was higher than the estimate of this investigation. Singh *et al.* (1993) and Singh *et al.* (2000) reported the average lactation length in Jersey crossbred cows to be higher than the estimate of this study. Whereas, the findings of Deshmukh *et al.* (1995), Tkakur *et al.* (2000), Rao *et al.* (2000) and Hemalatha *et al.* (2003) were slightly lower than the estimate of average lactation length for Jersey crossbred cows in this study.

The estimates of Dev Raj and Gupta (1994) and Hemalatha *et al.* (2003) for average lactation length in desi cows and buffaloes were lower than the estimates of this study, while Shah and Sharma (1994 [a]) and Rao *et al.* (2000) recorded higher values for lactation length in desi cows and buffaloes. The estimate of lactation length in buffalo reckoned in this study was in agreement with the estimate of Verma and Kherde (1995).

In this study the estimates of average lactation length in crossbred cows and buffalo were longer than the standard lactation period. The probable reason was that indeed the crossbred cows continued to yield 3-4 lits. of milk even in their late gestation and the khatal owners did not practice force drying of their animals even beyond eight month of gestation to meet their sole objective of more and more milk, although it has adverse effect on the milk yield of the animals in subsequent lactation.

4.1.1.1.5 Season of calving: Season of calving did not influence lactation length significantly (Table-4.1), Its contribution to the total variation therein was 0.313%. However, the average lactation length was the longest in the animals calved during March – June (321.53 ± 1.66 days) followed by those during November – February (321.27 ± 1.28 days) and July – October (319.07 ± 1.45 days). Singh *et al.* (1993), Deshmukh *et al.* (1995), Rao *et al.* (1995), Shrivastava *et al.* (1998) and Singh *et al.* (2000) also reported the influence on season of calving on lactation length in cows and buffaloes to be non-significant.

4.1.1.1.6 Parity: Results (Table-4.1) revealed that order of lactation had significant influence ($P \leq 0.01$) on lactation length, its contribution to the total variation on lactation length being 1.938%.There was increase, although statistically not significant, in average lactation length from first (319.24 ± 1.33 days) to fourth (325.48 ±3.80 days) lactation followed by a significant decrease in fifth (314.70 ± 1.84 days) lactation. DMRT revealed that the average Lactation length was longest in fourth order of lactation which did not differ significantly from 1st, 2nd and 3rd lactation lengths, but differ significantly from 5th one. It was more or less similar to the trend recorded by Singh *et al.* (1986 [b]), Shrivastava *et al.* (1998) and Singh *et al.* (2000) in crossbred cattle. In females having normal estrus cycle, the lactation length, besides other factors, depends upon service period. The optimal reproductive functioning in cows and buffaloes is attained after first lactation and it is maintained up to 4th and/or 5th order of lactation. As such, the lactation length might not vary much up to 4-5 lactations, as recorded in this study.

Table – 4.2

Least squares mean of Lactation length and Lactation milk yield for the animals of different genetic groups.

	Lactation length (days)	Lactation milk yield (Kg.)
	Mean ± S. E.	**Mean ± S. E.**
Overall mean (μ) →	320.62 ± 1.13	1575.51 ± 11.79
Factors ↓		
Zone		
North-East	319.05 ± 1.41	1592.86 ± 14.46
Central	322.28 ± 1.46	1565.13 ± 15.18
South- West	320.55 ± 1.38	1568.54 ± 14.33
Herd-size		
(3-6) animals	317.91 ± 1.83	1556.95 [b] ± 21.24
(7-10) animals	320.56 ± 1.43	1588.11 [a] ± 14.94
(11-14) animals	324.48 ± 2.04	1607.20 [a] ± 19.04
(15 & above) animals	319.55 ± 1.87	1549.79 [b] ± 19.51
Herd-constitution		
Only cows	317.84 ± 1.38	1585.03 ± 14.42
Only buffaloes	325.23 ± 2.32	1563.95 ± 24.17
Both cows & buffaloes	318.80 ± 1.62	1577.55 ± 16.90
Genetic group		
Desi cow	293.29 [a] ± 1.71	734.45 [a] ± 17.85
HF crossbred	334.64 [b] ± 1.99	2160.16 [b] ± 20.69
Jersey crossbred	333.43 [b] ± 2.02	2037.54 [c] ± 21.03
Graded buffalo	321.14 [c] ± 1.82	1369.88 [d] ± 18.91
Season of calving		
Mar. – June	321.53 ± 1.66	1547.48 [a] ± 17.27
July – Oct.	319.07 ± 1.45	1558.56 [a] ± 15.09
Nov. – Feb.	321.27 ± 1.28	1620.49 [b] ± 13.31
Parities		
1st	319.24 [a] ± 1.33	1483.09 [ab] ± 39.61
2nd	320.80 [a] ±1.41	1561.40 [a] ± 14.68
3rd	322.90 [a] ± 1.16	1712.27 [c] ± 12.00
4th	325.48 [a] ±3.80	1625.94 [d] ± 13.88
5th	314.70 [b] ± 1.84	1494.85 [b] ± 19.17
Farming system		
Only animal husbandry	321.08 ± 1.43	1580.65 ± 14.91
Mixed farming	320.17 ± 1.79	1570.36 ± 18.67

 # Values superscripted by similar letter were not significantly different from each other.

4.1.1.1.7 Farming system: The farming system did not have significant influence on lactation length of different milch animals. Its contribution to the total variation was only 0.014 % (Table-4.1). There was not much difference between the average lactation length of the animals managed in the units exclusively involved in dairying (321.08 ± 1.43 days) and those maintained in the units integrated with agriculture farming (320.17 ± 1.79 days).

4.1.2 Lactation Milk Yield:

Milk yielded by a milch animal during normal lactation period was taken as lactation milk yield. The overall Least Squares Mean for lactation milk yield in dairy animals of the different genetic groups viz., local and crossbred cows as well as buffaloes, included in the study, was estimated to be 1575.51 ± 11.79 Kg (Table-4.2). Efficient milk production is the ultimate aim of dairy farming. Quantity of milk produced per unit time and input by a milch animal is an indicator of its economic worth. This necessitates a relative determination of the magnitude as well as direction of variation in milk yield in milch animals of different genetic constitutions.

4.1.2.1 Factor affecting Lactation Milk Yield:

Least squares analysis of variance (Table-4.3) revealed that variation in size of the herd ($P \leq 0.05$), genetic constitution of the animals, seasons of their calving and order of lactation had significant ($P \leq 0.01$) influence on lactation milk yield. The effects of zone, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting lactation milk yield are presented in Table – 4.2.

4.1.2.1.1 Zone: Zone effect contributed 0.050% to the total variation in lactation milk yield (Table-4.3). The least squares mean for lactation milk yield was the highest (1592.86 ± 14.46 kg.) for the animals of khatals located in North-East zone followed by those in South-West (1568.54 ± 14.33 kg.) and Central (1565.13 ± 15.18 kg.) zones. However, the animals in different zones did not differ significantly among themselves with respect to their lactation milk yield (Table-4.3). Non-significant effect, recorded in this study, might be due to more or less similar agro-climatic condition as well as managemental practices prevalent in the different zones, delineated within a radius of 15 kms. In and around Darbhanga city.

Table – 4.3

Least square analysis of variance showing effects of genetic and non-genetic factors on lactation Milk Yield of milch animals in and around Darbhanga (Bihar).

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	24146.09	0.050
Herd-size	3	36235.77*	0.112
Herd-constitution	2	3158.96	0.006
Genetic group	3	29839260.00**	92.004
Season of calving	2	19088.80**	0.392
Lactation order	4	581804.30**	2.392
Farming system	1	2418.28	0.002
Residual	367	13366.20	5.042

* $P \leq 0.05$, ** $P \leq 0.01$

4.1.2.1.2 Herd-size: Herd-size contributed significantly ($P \leq 0.05$) to the total variation in lactation milk yield (Table-4.3), the magnitude of contribution being 0.112%. As evident from Table-4.2, the animals managed in a herd of 11 – 14 animals had the highest average lactation milk yield (1607.20 ± 19.04 kg.) followed by those in herd of 7 – 10 (1588.11 ± 14.94 kg.), 3 – 6 (1556.95 ± 21.24 kg.) and 15 & more (1549.79 ± 19.51 kg) animals. Shrivastava *et al.* (1998) also reported the effect of herd size on lactation milk yield to be significant. It could be visualized in the study that the animal maintained in the herd of 11-14 animals had the highest lactation milk yield which did not differ significantly from the lactation yield of the animal maintained in the group of 7-10 animals. The lactation milk yield for the animals in either smaller (3-6 animals) or bigger (15 and above) herds were significantly lower than the lactation yield of the animal in herd of 7-10 and 11-14 animals (Table-4.2). It was indicative of the fact that the managemental technology, available in private dairy units in around Darbhanga, was able to sustain 7-14 milch animals in a group for higher lactation milk yield.

4.1.2.1.3 Herd-constitution: Herd constitution did not show significant influence on lactation milk yield (Table-4.3). The contribution of the herd-constitution to the total variation in lactation milk yield was 0.006 %. However, the average lactation milk yield was the highest (1585.03 ± 14.42 kg.) for the milch animals maintained in the khatals having only cows, followed by those in the khatals having cows and buffaloes both (1577.55 ± 16.90 kg.) and it was the lowest (1563.95 ± 24.17 kg.) for the animals in the units having only buffaloes (Table-4.2).

4.1.2.1.4 Genetic group: Genetic-group had highly significant ($P \leq 0.01$) influence on lactation yield and its contribution to the total variation on lactation milk yield was 92.004 % (Table-4.3). As evident from table-4.2, the HF crossbreds had the highest average lactation milk yield (2160.16 ± 20.69 kg.) followed by Jersey crossbreds (2037.54 ± 21.03 kg.), graded buffaloes (1369.88 ± 18.91 kg.) and Desi cows (734.45 ± 17.85 kg.). The animals of different genetic constitution differ significantly among themselves with respect to their lactation milk yield. Singh (1995), Singh *et al.* (1986 [b]), Singh *et al.* (2000) and also found the effect of genetic-group on lactation yield to be statistically significant. Shah and Sharma (1994 [a]) and Rao *et al.* (2000) also recorded similar trend for variation in lactation milk yield in HF crossbreds, Jersey crossbreds, buffalo and desi cow.

Least squares mean for lactation yield in the milch animals of different genetic constitution reckoned in this study, were in accordance with the expectations and the findings indicated that for relatively higher milk production in the agro-socio-echo-system prevalent in and around Darbhanga (Bihar), the order of the animals preferred to be kept was HF crossbred cow, Jersey crossbred cow, graded buffalo and desi cow.

4.1.2.1.5 Season of Calving: Season of calving had highly significant ($P \leq 0.01$) influence on lactation milk yield (Table-4.3). From the table 4.2 it is evident that the average lactation milk yield was significantly higher in the animals calved during November – February (1620.49 ± 13.31 kg.) as compared to those calved during March – June (1547.48 ± 17.27 kg.) and July – October (1558.56 ± 15.09 kg.). The later two average values did not differ significantly from each other. The contribution of season-effect to the total variation in lactation milk yield was 0.392 %. Patel and Tripathi (1994) also found the effect of season of calving on lactation milk yield to be significant while Singh *et al.* (1993), Deshmukh *et al.* (1995), Rao *et al.* (1995), Shrivastava *et al.* (1998) and Singh *et al.* (2000) found the influence of season of calving effect on lactation milk yield to be not significant.

Significant effect of season of calving on lactation milk yield, recorded in this study may be attributed to the availability of quality green fodder in different seasons. Significantly higher lactation yield in animals calved during Nov. – Feb. might be due to availability of quality leguminous green fodder like Brseem and winter Maize in abundant quantity during first 3-4 months of their lactation.

4.1.2.1.6 Parity: Results revealed that parity had significant ($P \leq 0.01$) influence on lactation milk yield. Its contribution to the total variation in lactation milk yield was 2.392 % (Table-4.3). From the table-4.2 it is evident that there was linear increase in average lactation milk yield from first to third order of lactation and then after it decreased gradually up to fifth one. The animals in third lactation had significantly higher (1712.27 ± 12.00 kg.) average lactation milk yield followed by those in fourth (1625.94 ± 13.88 kg.), second (1561.40 ± 14.68), fifth (1494.85 ± 19.17 kg) and first (1483.09 ± 39.61 kg.) lactation. Singh *et al.* (1986 [b]), Deshmukh *et al.* (1995), Shrivastava *et al.* (1998) and Singh *et al.* (2000) also found the effect of order of lactation on lactation milk yield to be significant. It was indicative of the fact that the lactation maturity in cattle and buffalo was attained in 3rd lactation. It could be explained as there would have been an increase in number of functional genes responsible for milk yield with advancement in lactation sequence and their expression could reach maximum around 3rd lactation. the another probable reason for increase in milk yield with lactation sequence could be ascribed to the increased functional activities of the secretary tissues of mammary glands during later lactations, being maximum at the age conceding with the 3rd parity. Probably thereafter the effect of senescence was set in gradually reducing the productivity in subsequent lactations.

4.1.2.1.7 Farming system: As evident from table-4.2, the animals managed in the units involved in the dairying alone had higher (1580.65 ± 14.91 kg.) average lactation milk yield in comparison to those maintained in the units integrated with agriculture farming (1570.36 ± 18.67 kg.). However, the farming system did not have any significant influence on lactation milk yield (Table-4.3) and its contribution to the total variation was only 0.002 %.

4.1.3 Peak Yield: Peak milk yield is a directly observed economic trait of very high practical significance in dairy farming and it is as one of the important economic indicators in determining worth of milch animals. The overall Least Squares Mean for peak milk yield in dairy animals of the different genetic groups viz., local and crossbred cows as well as buffaloes, included in the study, was estimated to be 9.85 ± 0.09 Kg (Table-4.5).

4.1.3.1 Factor affecting Peak Yield: Least squares analysis of variance (table-4.4) revealed that variation in genetic constitution of the animals, seasons of their calving and order of lactation had significant ($P \leq 0.01$) influence on peak milk yield. The effects of zone, herd-size, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting peak milk yield are presented in Table – 4.5.

4.1.3.1.1 Zone: Zone effect contributed 0.148 % to the total variation in peak milk yield (Table-4.4). The least squares mean for peak milk yield was the highest (10.04 ± 0.11 kg.) for the animals of khatals located in North-East zone followed by those in South-West (9.83 ± 0.11 kg.) and Central (9.68 ± 0.12 kg.) zones. However, the animals in different zones did not differ significantly among themselves with respect to their average peak yield (Table-4.5).Singh (1984) observed the effect of zone on peak yield to be significant in Friesian x Zebu crossbred cows in and around Ranchi which was contrary to the findings of this study. Such variation may be attributed to variation in genetic-group of the experimental animals as well as agro-climatic conditions of the study area.

4.1.3.1.2 Herd-size: The contribution of the herd-size to the total variation in peak milk yield was 0.187 % and the animals in herds of different sizes were statistically not significant in respect to their peak milk yield (Table-4.4). However, results of this study (Table-4. 5) revealed that the animals managed in a herd of 11 – 14 milch animals had the highest average peak milk yield (9.99 ± 0.14 kg.) followed by those in herd of 7 – 10 animals (9.88 ± 0.11 kg.), 15 & above animals (9.67 ± 0.15 kg.) and 3 – 6 animals (9.60 ± 0.16 kg.). Singh (1984) also reported the effect of herd size on peak milk yield in Friesian x Zebu crossbred cows in and around Ranchi to be not significant. However, Shrivastava *et al.* (1998) found this effect to be significant in the crossbred cows of same origin maintained in the same study area. Such variation may be due to variation in sample size, sizes of the herds, and genetic constitutions of the experimental animal and/or agro-climatic conditions of the experimental area.

Table – 4.4

Least square analysis of variance showing effects of genetic and non-genetic factors on Peak Yield of milch animals in and around Darbhanga.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	2.21	0.148
Herd-size	3	1.86	0.187
Herd-constitution	2	1.90	0.127
Genetic group	3	827.01**	82.950
Season of calving	2	18.84**	1.260
Lactation order	4	44.89**	6.003
Farming system	1	0.01	0.000
Residual	367	0.76	9.325

** P ≤ 0.01

4.1.3.1.3 Herd-constitution: Herd constitution did not show significant influence on the peak milk yield (Table-4.4). The contribution of the herd-constitution to the total variation in peak milk yield was 0.127 %. However, the average peak yield was the highest (10.10 ± 0.11 kg.) for the milch animals maintained in the khatals having only cows, followed by those in the khatals having cow and buffalo both (9.85 ± 0.13 kg.) and it was the shortest (9.60 ± 0.18 kg.) for the animals in the units having only graded buffaloes (Table-4.5).

4.1.3.1.4 Genetic-group: Genetic-group had highly significant (P≤0.01) influence on peak yield and its contribution to the total variation therein was 82.950 % (Table-4.4). As evident from table-4.5, the HF crossbreds had the highest average peak milk yield (12.30 ± 0.16 kg.), followed by Jersey crossbreds (11.89 ± 0.16 kg.), graded buffaloes (7.72 ± 0.14 kg.) and desi cows (4.99 ± 0.14 kg.). The animals of different genetic constitutions differ significantly among

Table – 4.5

Least squares mean of Peak yield and days to attain Peak yield for the animals of different genetic groups.

	Peak yield (Kg.)	Days to attain Peak yield (Kg.)
	Mean ± S. E.	**Mean ± S. E.**
Overall mean (μ) →	9.85 ± 0.09	40.11 ± 0.30
Factors ↓		
Zone		
North-East	10.04 ± 0.11	40.01 ± 0.37
Central	9.68 ± 0.12	40.23 ± 0.38
South- West	9.83 ± 0.11	40.08 ± 0.36
Herd-size		
(3-6) animals	9.60 ± 0.16	40.21 ± 0.54
(7-10) animals	9.88 ± 0.11	40.42 ± 0.38
(11-14) animals	9.99 ± 0.14	39.72 ± 0.48
(15 & above) animals	9.67 ± 0.15	39.57 ± 0.49
Herd-constitution		
Only cows	10.10 ± 0.11	39.74 ± 0.36
Only buffaloes	9.60 ± 0.18	41.31 ± 0.61
Both cows & buffaloes	9.85 ± 0.13	41.27 ± 0.43
Genetic group		
Desi cow	$4.99^{a} \pm 0.14$	$35.90^{a} \pm 0.45$
HF crossbred	$12.30^{b} \pm 0.16$	$43.02^{b} \pm 0.52$
Jersey crossbred	$11.89^{c} \pm 0.16$	$42.51^{b} \pm 0.53$
Graded buffalo	$7.72^{d} \pm 0.14$	$39.00^{c} \pm 0.48$
Season of calving		
Mar. – June	$9.67^{a} \pm 0.13$	$40.66^{a} \pm 0.34$
July – Oct.	$9.60^{a} \pm 0.11$	$40.25^{ab} \pm 0.38$
Nov. – Feb.	$10.28^{b} \pm 0.10$	$39.41^{b} \pm 0.44$
Parities		
1^{st}	$8.87^{a} \pm 0.30$	$38.20^{a} \pm 1.00$
2^{nd}	$9.75^{b} \pm 0.11$	$40.54^{b} \pm 0.37$
3^{rd}	$11.07^{c} \pm 0.09$	$42.71^{c} \pm 0.31$
4^{th}	$10.36^{d} \pm 0.11$	$40.89^{b} \pm 0.35$
5^{th}	$9.20^{a} \pm 0.15$	$38.20^{a} \pm 0.48$
Farming system		
Only animal husbandry	9.84 ± 0.11	40.64 ± 0.38
Mixed farming	9.80 ± 0.14	39.58 ± 0.47

 # Values superscripted by similar letter were not significantly different from each other.

themselves with respect to their peak yield. The trend recorded in this study was in accordance with the expectation because Friesian crossbred cows is the highest milk producer in the world and its crosses must prove superiority over Jersey crossbred cows. Most of the buffaloes included in this study were graded with Murrah, the best milk producer among the buffalo breeds. As such the buffalo occupied third position in respect to peak yield among the milch animal of different genetic-groups included in this study. The desi cows were mostly non-descript having the lowest potency to produce milk among the animals of different genetic-grades. The findings were in corroboration with the findings of Singh (1993), Shrivastava *et al.* (1998), Rao *et al.* (2000), Singh *et al.* (2000) and Dutt and Bhushan (2001) and could plausibly explained as in the case of lactation milk yield (Para- 4.1.2.1.4) in this study. The results of this study resubstantiated the dogma that peak yield was an indicator of lactation milk yield.

4.1.3.1.5 Season of Calving: Season of calving had highly significant ($P \leq 0.01$) influence on peak milk yield (Table-4.4) and its contribution to the total variation therein was 1.260 %. From the table-4.5, it is evident that the average peak milk yield was significantly higher in the animals calved during November – February (10.28 ± 0.10 kg.). It was the lowest when animal calved during July – October (9.60 ± 0.11 kg.) which did not differ significantly from the animals calved during March – June (9.67 ± 0.13 kg.). The animal calved in the months from November to February got cold climate and could attain peak yield in the months from December – April. November to April was also favorable for availability of leguminous fodders like Barseem, Lucern and Maize etc. Thus, congenial climatic conditions just after calving together with availability of good quality fodders may be attributed to the trend in peak yield recorded in this investigation.

4.1.3.1.6 Parity: Results revealed that parity had significant ($P \leq 0.01$) influence on peak milk yield; its contribution to the total variation being 6.003 % (Table-4.4). From the table-4.5, it is evident that there was gradual increase in the average peak milk yield from first to third order of lactation and after then it decreased up to fifth one. The animals in third lactation (11.07 ± 0.09 kg.) had significantly higher peak yield followed by those in fourth (10.36 ± 0.11 kg.), second (9.75 ± 0.11) and fifth (9.20 ± 0.15 kg) lactation. The shortest peak yield was recorded in first (8.87 ± 0.30 kg.) lactation which did not differ significantly with that in fifth one. The trend of variation in peak yield was similar to the trend of variation in lactation milk yield in this study and the explanation for the former trait (Para-4.1.2.1.6) would also stand valid for the later i.e. peak milk yield. Singh (1984), Deshmukh *et al.* (1995), Singh (1995), Shrivastava *et al.* (1998) and Singh *et al.* (2000) also reported parity-effect to be significant on peak milk yield with more or less similar trend.

4.1.3.1.7 Farming System: As evident from table-4.5, the animals managed in the units involved in the dairying alone had peak milk yield to be 9.84 ± 0.11 kg., which was almost same to the average peak milk yield for the animals managed in the units integrated with Crop production (9.80 ± 0.14 kg.). The farming system did not have any significant influence on peak milk yield (Table-4.4).

4.1.4 Days to attain Peak Yield: A milch animal is supposed to be economical if she attains peak yield shortly after calving and has higher persistency of peak milk yield. The overall Least Squares Mean for days to attain peak yield in dairy animals of the different genetic groups viz., local and crossbred cows as well as buffaloes, included in this study, was estimated to be 40.11 ± 0.30 days. (Table-4.5).

4.1.4.1 Factor affecting Days to attain Peak Yield:

Least square analysis of variance (Table-4.6) revealed that genetic group, order of lactation and season of calving had significant influence on days to attain peak yield. The effect of zone, herd size, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting days to attain peak yield are presented in Table – 4.5.

4.1.4.1.1 Zone: As evident from table-4.5, there was not much variation in average days to attain peak yield for animals in different zones. The average days to attain peak yield was 40.23 ± 0.38 days in the animals in khatals located in Central zone of the study area followed by those in South-West (40.08 ± 0.36 days) and North-East (40.01 ± 0.37 days) zones. However, the contribution of zone-effect to the total variation in days to attain peak yield was only 0.039

% and the animals in different zones were not significantly different among themselves with respect to their days to attain peak yield (Table-4.6).

Table – 4.6
Least square analysis of variance showing effects of genetic and non-genetic factors on Days to Attain Peak Yield of milch animals in and around Darbhanga.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	1.26	0.039
Herd size	3	20.83	0.975
Herd constitution	2	22.86	0.714
Genetic group	3	753.90**	35.297
Season of calving	2	33.31*	1.040
Lactation order	4	207.71**	12.967
Farming system	1	25.54	0.399
Residual	367	8.48	48.569

* $P \leq 0.05$, ** $P \leq 0.01$

4.1.4.1.2 Herd-size: The contribution of the herd-size to the total variation in days to attain peak yield was only 0.975 % and the animals in the herd of different sizes were statistically not significantly different in this regard (Table-4.6). However, results (Table-4. 5) revealed that the animals managed in a herd of 7 – 10 milch animals took more days to attain peak yield (40.42 ± 0.38 days) followed by those in herd of 3 – 6 milch animals (40.21 ± 0.54 days), 11 – 14 milch animals (39.72 ± 0.48 days) and 15 & above milch animals (39.57 ± 0.49 days).

4.1.4.1.3 Herd-constitution: Herd constitution did not show significant influence on the days to attain peak yield (Table-4.6). The contribution of the herd-constitution to the total variation in days to attain peak yield was 0.714 %. However, result revealed (Table-4.5) the milch animals maintained in the khatals having only graded buffaloes attained peak yield a bit later (41.31 ± 0.61 days) as compared to those in the khatals having cow and buffalo both (41.27 ± 0.43 days) and only cows (39.74 ± 0.36 days). In other words, it could be noted that on an average cows attained peak yield at the earliest after calving in comparison to buffaloes, although the variation was not significant.

4.1.4.1.4 Genetic group: Genetic-group had highly significant ($P \leq 0.01$) influence and its contribution to the total variation on the days to attain peak yield was 35.297 % (Table-4.6). As evident from table-4.5, the desi cows attained peak milk yield at the earliest (35.90 ± 0.45 days) followed by graded buffaloes (39.00 ± 0.48 days), Jersey crossbreds (42.51 ± 0.53 days) and HF crossbreds (43.02 ± 0.52 days). The trend for the days to attaining peak milk yield by the animals of different genetic-group included in this study followed the trend similar for their lactation length i.e. the animals attaining peak yield earlier had shorter lactation length and the genetic causes behind such association between these two traits needs to be investigated thoroughly.

4.1.4.1.5 Season of calving: Season of calving had significant ($P \leq 0.05$) influence on the days to attain peak yield (Table-4.6), its contribution to the total variation in this trait was 1.040 %. The average days to attain peak yield was the longest for the animals calved during March – June (40.66 ± 0.34) followed by those calved during July – October (40.25 ± 0.38) and November – February (39.41 ± 0.44). The shortest period in attaining peak milk yield for the milch animals calved during winter may be attributed to availability of good quality fodder as well as congenial environmental condition just after calving. Tailor *et al.* (1998) observed the influence of season of calving on days to attain peak yield in buffaloes to be significant. However, Raheja (1982) and Singh *et al.* (1993) recorded this effect to be not significant in Friesian and Jersey crossbred cows respectively.

4.1.4.1.6 Parity: Results revealed that parity had significant ($P \leq 0.01$) influence on days to attain peak yield. Its contribution to the total variation on days to attain peak yield was 12.967 % (Table-4.6). From the table-4.5, it is evident that there was significant increase in average days to attain peak yield from first to third order of lactation then it decreased gradually. The third lactation (42.71 ± 0.31 days) had significantly longest days to attain peak yield followed by fourth (40.89 ± 0.35 days) and second (40.54 ± 0.37 days). The lowest average days to attain peak yield was recorded in fifth parity (38.20 ± 0.48 days) which did not differ significantly with the first (38.20 ± 1.00 days) one. Variation in the days to attain peak yield followed the trend similar to that recorded for lactation milk yield (Para- 4.1.2.1.6) and could be explained as such.

4.1.4.1.7 Farming System: As evident from table-4.5, the animals managed in the units involved in the dairying alone had higher (40.64 ± 0.38 days) average days to attain peak yield in comparison to those maintained in the units integrated with agriculture farming (39.58 ± 0.47 days). The farming system did not have any influence on the days to attain peak yield and its contribution to the total variation therein was 0.399 % (Table-4.6).

4.2 MEASURES OF MILK PRODUCTION EFFICIENCY:

In order to evolve highly productive, input-responsive and efficient milk producing stock, selection on the basis of their relative efficiency of milk production seems to be much more advantageous as it includes selection for general adaptability, inherent capacity to produce and resource utilization efficiency. In this study, out of several derived measures of milk producing efficiency, only four viz.; Milk yield per day of lactation length (MY/LL), Milk yield per day of calving interval (MY/CI), Milk yield per day of body weight at calving (MPEK) and MPEK per day of lactation length (MPEKD) were included as efficiency traits.

4.2.1 Milk Yield per day of Lactation Length (MY / LL): In this study average daily milk yield was taken as one of the measures of production efficiency. It was derived as "the ratio of total milk yield (Kg.) during a lactation and total days in milk during that lactation (MY / LL)". Abnormal lactation length i.e. less than 200 days and more than 350 days were ignored. The overall Least Squares Mean for milk yield per day of lactation length in milch animals of the different genetic-group viz. local and crossbred cows as well as buffaloes was estimated to be 4.87 ± 0.04 Kg (Table - 4.8).

4.2.1.1 Factor affecting milk yield per day of lactation length (MY/LL): Least square analysis of variance (Table-4.7) revealed that variation in size of the herd, genetic constitution of the animals, seasons of their calving and order of lactation had significant influence on milk yield per day of lactation length. The effects of zone, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting milk yield per day of lactation length are presented in Table – 4.8.

Table – 4.7

Least square analysis of variance showing effects of genetic and non-genetic factors MY / LL of milch animals in and around Darbhanga.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	3.81	0.101
Herd size	3	4.99*	0.132
Herd constitution	2	2.16	0.057
Genetic group	3	2278.52**	90.528
Season of calving	2	11.59**	0.307
Lactation order	4	44.57**	2.361
Farming system	1	0.04	0.001
Residual	367	1.34	6.513

** $P \leq 0.01$

4.2.1.1.1 Zone: Zone effect contributed 0.101 % to the total variation in the MY/LL (Table-4.7). The least squares mean for the MY/LL was the highest (4.94 ± 0.05 kg.) for the animals in the khatals located in North-East zone followed by those in South-West (4.84 ± 0.05 kg.) and Central (4.82 ± 0.05 kg.) zones. However, the animals in different zones did not differ significantly among themselves with respect to their average MY/LL, which was in agreement with the findings of Priya Raj (2002) in crossbred cows. It is worth mentioning that no study has been conducted taking the milch animals of all the genetic-groups similar to this study, particularly in Hot-humid climate of North Bihar. However, Shrivastava and Singh (2000) undertook a study in plateau of Chotanagpur taking different grades of HF crossbred as experimental animals and they reported zone effect to be significant on MY/LL.

4.2.1.1.2 Herd Size: Herd-size contributed significantly ($P \leq 0.05$) to the total variation in the MY/LL (Table-4.7), the magnitude of contribution being 0.132 %. As evident from Table-4.8, animals managed in a herd of 11 – 14 had the highest average MY/LL (5.00 ± 0.06 kg.) followed by herd of 7 - 10 animals (4.89 ± 0.05 kg.), 15 & above animals (4.84 ± 0.07 kg.) and 3 – 6 animals (4.74 ± 0.07 kg.). The influence of herd-size on MY/LL followed more or less the similar trend for lactation milk yield. Herd-size had significant influence on lactation milk yield but its effect on lactation length was recorded to be not significant in this study. As such, the trend recorded for MY/LL was according to expectations, because it was derived as the ratio of lactation milk yield and lactation length. Shrivastava and Singh (2000) also recorded the size of the herd to be a factor effecting MY/LL significantly. However, the observation of Priya Raj (2002) for crossbred cattle in and around Darbhanga was contrary to the findings of this study.

4.2.1.1.3 Herd Constitution: Herd constitution did not show any significant influence on the MY/LL (Table-4.7). The contribution of this non-genetic factor to the total variation on the MY/LL was only 0.057 %. However, the average MY/LL was the highest (4.95 ± 0.05 kg.) for the milch animals maintained in the khatals having only cows followed by those in the khatals having cow and buffalo both (4.89 ± 0.05 kg.) and it was the lowest (4.77 ± 0.08 kg.) for the animals in the units having only graded buffaloes (Table-4.8).

4.2.1.1.4 Genetic Group: Genetic-group had highly significant ($P \leq 0.01$) influence on MY/LL and its contribution to the total variation therein was 90.528 % (Table-4.7). As evident from table-4.8, the HF crossbreds had the highest average MY/LL (6.47 ± 0.07 kg.) followed by Jersey crossbreds (6.16 ± 0.07 kg.), graded buffaloes (4.32 ± 0.06 kg.) and Desi cows (2.54 ± 0.06 kg.). The animals of different genetic constitutions differ significantly among themselves with respect to this efficiency trait. Results substantiated the genetic dogma that Friesian would be the most suitable exotic breed for higher milk yield in combination with local cows in the agro-climatic region of North-Bihar. It was in agreement with the findings of Singh (1984), Singh *et al.* (1993), Shrivastava and Singh (2000) and Singh *et al.* (2000) who also recorded the effect of genetic-group on average daily milk yield in crossbred cattle to be significant. The trend in variation of this efficiency trait was similar to that for variation in lactation yield (Para- 4.1.2.1.4) which was one of the components in its derivation.

4.2.1.1.5 Season of Calving: The season of calving contributed highly significantly ($P \leq 0.01$) to the total variation in MY/LL, the magnitude of contribution being 0.307 % (Table-4.7). Result revealed (table-4.8) that the average MY/LL was significantly higher in the animals calved during November–February (4.98 ± 0.04 kg.). It was the lowest for the animals calved during March–June (4.80 ± 0.05 kg.) which did not differ significantly from the average value for the animals calved during July–October (4.83 ± 0.05 kg.). Singh *et al.* (1989), Dev Raj and Gupta (1994) and Patel and Tripathi (1994) also recorded the effect of season of calving on MY/LL to be significant. Whereas, findings reported by Singh *et al.* (1993), Shrivastava and Singh (2000) and Priya Raj (2002) did not corroborate with the findings of this study. Variation in this efficiency trait due to season-effect followed the trend more or less similar to that of lactation milk yield (Para- 4.1.2.1.5) and could be explained as such.

4.2.1.1.6 Parity: Results revealed that parity had significant (P≤0.01) influence on the MY/LL. Its contribution to the total variation in this efficiency trait was 2.361 % (Table-4.7). There was gradual increase in the average MY/LL from first to third order of lactation then it decreased up to fifth. The animals in third lactation (5.24 ± 0.04 kg.) had significantly higher average MY/LL followed by those in fourth (5.06 ± 0.04 kg.). The lowest average MY/LL was recorded in first parity (4.56 ± 0.13 kg.) which did not differ significantly from second (4.80 ± 0.05 kg.) and fifth (4.70 ± 0.06 kg.) parities. The trend was almost the same as recorded for lactation yield in different parities (Para-4.1.2.1.6) and could be explained as such. Singh *et al.* (1989), Shrivastava and Singh (2000) and Priya Raj (2002) also recorded the effect of parity on this efficiency trait to be significant.

4.2.1.1.7 Farming System: The farming system did not have any significant influence on the milk yield per day of lactation length (Table-4.7) and its contribution to the total variation was only 0.001 %. The average values for the animals under the two farming systems were almost the same (Table-4.8).

4.2.2 Milk Yield per day of Calving Interval (MY/CI): Average daily milk yielded by a cow during its one calving interval was taken as another criterion to compare their milk production efficiency. It was "the ratio of total lactation milk yield and corresponding inter-calving period". The overall Least Squares Mean for MY/CI in milch animals of the different genetic-group, viz. local and crossbred cows as well as buffaloes, was estimated to be 3.55 ± 0.03 Kg. (Table - 4.8).

Table – 4.8

Least squares mean of Milk yield per day of Lactation length (MY/LL) and Milk yield per day of calving interval (MY/CI) for the animals of different genetic groups.

	MY / LL (Kg.) Mean ± S. E.	MY / CI (Kg.) Mean ± S. E.
Overall mean (μ) →	4.87 ± 0.04	3.55 ± 0.03
Factors ↓		
Zone		
North-East	4.94 ± 0.05	3.57 ± 0.04
Central	4.82 ± 0.05	3.54 ± 0.04
South- West	4.84 ± 0.05	3.54 ± 0.04
Herd-size		
(3-6) animals	$4.74^{a} \pm 0.07$	$3.43^{a} \pm 0.06$
(7-10) animals	$4.89^{bc} \pm 0.05$	$3.57^{bc} \pm 0.04$
(11-14) animals	$5.00^{c} \pm 0.06$	$3.65^{c} \pm 0.05$
(15 & above) animals	$4.84^{ab} \pm 0.07$	$3.54^{ab} \pm 0.05$
Herd-constitution		
Only cows	4.95 ± 0.05	3.65 ± 0.04
Only buffaloes	4.77 ± 0.08	3.51 ± 0.06
Both cows & buffaloes	4.89 ± 0.05	3.54 ± 0.04
Genetic group		
Desi cow	$2.54^{a} \pm 0.06$	$1.71^{a} \pm 0.05$
HF crossbred	$6.47^{b} \pm 0.07$	$4.79^{b} \pm 0.05$
Jersey crossbred	$6.16^{c} \pm 0.07$	$4.58^{c} \pm 0.05$
Graded buffalo	4.32 ± 0.06	3.10 ± 0.05
Season of calving		
Mar. – June	$4.80^{a} \pm 0.05$	$3.52^{a} \pm 0.04$
July – Oct.	$4.83^{a} \pm 0.05$	$3.51^{a} \pm 0.04$
Nov. – Feb.	$4.98^{b} \pm 0.04$	$3.62^{b} \pm 0.03$
Parities		
1st	$4.56^{a} \pm 0.13$	$3.29^{a} \pm 0.10$
2nd	$4.80^{a} \pm 0.05$	$3.40^{a} \pm 0.04$
3rd	$5.24^{b} \pm 0.04$	$3.84^{b} \pm 0.03$
4th	$5.06^{c} \pm 0.04$	$3.70^{c} \pm 0.04$
5th	$4.70^{a} \pm 0.06$	$3.38^{a} \pm 0.05$
Farming system		
Only animal husbandry	4.86 ± 0.05	3.51 ± 0.04
Mixed farming	4.88 ± 0.06	3.59 ± 0.05

Values superscripted by similar letter were not significantly different from each other.

4.2.2.1 Factor affecting milk yield per day of calving interval (MY/CI): Least square analysis of variance (Table-4.9) revealed that variation in size of the herd (P≤0.05), genetic constitution of the animals, seasons of their calving and order of lactation had significant (P≤0.01) influence on MY/CI . The effects of zone, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting MY/CI are presented in Table – 4.8.

Table – 4.9

Least square analysis of variance showing effects of genetic and non-genetic factors on MY/CI of animals of different genetic groups in and study area.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	0.45	0.019
Herd size	3	2.97*	0.189
Herd constitution	2	2.51	0.107
Genetic group	3	1417.19**	90.167
Season of calving	2	5.53**	0.235
Lactation order	4	26.48**	2.246
Farming system	1	1.53	0.032
Residual	367	0.90	7.005

* P ≤ 0.05, ** P ≤ 0.01

4.2.2.1.1 Zone: Zone effect contributed 0.019 % of the total variation in the MY/CI (Table-4.9). The least squares mean for the average MY/CI was relatively more (3.57 ± 0.04 kg.) for the animals of khatals located in North-East zone followed by those in South-West (3.54 ± 0.04 kg.) and Central (3.54 ± 0.04 kg.) zones (Table-4.8). However, the animals in different zones did not differ significantly among themselves with respect to their MY/CI. The results were quite logical because in this study, the zone-effect did not contributed significantly to the variation in lactation milk yield (Para- 4.1.2.1.1) as well as inter calving period (Para- 4.3.2.1.1) which were the component traits used for derivation of MY/CI.

4.2.2.1.2 Herd Size: Herd-size contributed significantly (P≤0.05) to the total variation in the MY/CI (Table-4.9), the magnitude of contribution being 0.189 %. As evident from Table-4.8, animals managed in a herd of 11 – 14 milch animals had the highest average MY/CI (3.65 ± 0.05 kg.) followed by herd of 7 - 10 (3.57 ± 0.04 kg.), 15 & above (3.54 ± 0.05 kg.) and 3 – 6 animals (3.43 ± 0.06 kg.). Variation in this efficiency trait was similar to that in lactation yield, which was one of the components on its derivation.

4.2.2.1.3 Herd Constitution: Herd constitution did not show any significant influence on the MY/CI (Table-4.9), the magnitude of contribution of this effect to the total variation in the trait being 0.107 %. However, the average MY/CI was the highest (3.65 ± 0.04 kg.) for the milch animals maintained in the khatals having only cows followed by those in the khatals having cow and buffalo both (3.54 ± 0.04 kg.) and it was the shortest (3.51 ± 0.06 kg.) for the animals in the units having only graded buffaloes (Table-4.8). Such variation may be due to variation in lactation milk yield of the milch animals of different genetic-group in more or less similar fashion (Para- 4.1.2.1.3).

4.2.2.1.4 Genetic Group: Genetic-group had highly significant (P≤0.01) influence on MY/CI its contribution to the total variation therein was 90.167 % (Table-4.9). As evident from table-4.8, the HF crossbreds had the highest MY/CI (4.79 ± 0.05 kg.) followed by Jersey crossbreds (4.58 ± 0.05 kg.), graded buffaloes (3.10 ± 0.05 kg.) and Desi cows (1.71 ± 0.05 kg.). The animals of different genetic constitution differ significantly among themselves with respect to their MY/CI. The trend of variation in MY/CI in milch animals of different genetic-groups was similar to that in their lactation milk yield (Table-4.2) which was one of the component in its derivation.

4.2.2.1.5 Season of Calving: Season of calving had highly significant (P≤0.01) influence on the MY/CI (Table-4.9). Its contribution to the total variation therein was 0.235 %. From the table-4.8, it is evident that the least squares mean for MY/CI was significantly higher for the animals calved during November–February (3.62 ± 0.03 kg.). It was the lowest for animals calved during July–October (4.83 ± 0.05 kg.) which did not differ significantly for the milch animals calved during March–June (4.80 ± 0.05 kg.). Such variation in MY/CI could plausibly be explained, as in this study, season of calving did not have any significant influence on calving-interval, one of the component used for derivation of MY/CI (Table-4.14). Further the season-effect contributed significantly to the variation in lactation milk yield, another component trait in derivation of MY/CI (Table-4.3). The trend in variation in MY/CI due to season-effect was similar to the trend in variation in lactation milk yield (Table-4.2) due to this effect, which was quite natural because the estimate of MY/CI was dependent on estimates of lactation milk yield.

4.2.2.1.6 Parity: Results revealed that parity had significant ($P \leq 0.01$) influence on the MY/CI. Its contribution to the total variation therein was 2.246 % (Table-4.9). There was gradual increase in average MY/CI from first to third order of lactation and then after it decreased up to fifth order of lactation. The animals in third lactation (3.84 ± 0.03 kg.) had significantly higher average MY/CI followed by those in fourth (3.70 ± 0.04 kg.). The lowest average MY/CI yield was recorded in first parity (3.29 ± 0.10 kg.) which did not differ significantly with second (3.40 ± 0.04 kg.) and fifth (3.38 ± 0.05 kg.) order of lactation. The trend of variation in MY/CI due to parity-effect also followed the trend of variation in lactation milk yield, recorded in this study (Table-4.2).

4.2.2.1.7 Farming System: The farming system did not have any significant influence on the MY/CI (Table-4.9), its contribution to the total variation in the trait being only 0.032 %. However, as evident from table-4.8, the animals managed in the units integrated with agriculture farming had slightly higher (3.59 ± 0.05 kg.) average MY/CI in comparison to those maintained in the units involved in the dairying alone (3.51 ± 0.04 kg.).

4.2.3 Milk production efficiency per kg body weight (MPEK) and MPEK per day of lactation length (MPEKD): Lactation yield per kg. body weight at calving (MPEK) and Lactation yield per kg. body weight at calving per day of lactation length (MPEKD), taken as milk producing efficiency of the desi cows, crossbred cows as well as graded buffaloes have been dealt together in this para. The overall Least Squares Mean for MPEK and MPEKD in milch animals of the different genetic-group viz. local and crossbred cows as well as buffaloes were estimated to be 4.32 ± 0.03 kg. and 0.0175 ± 0.0001 kg. respectively (Table - 4.11).

4.2.3.1 Factor affecting MPEK and MPEKD: Least squares analysis of variance (Table-4.10) revealed that variation in genetic constitution of the animals, seasons of their calving and order of lactation had significant ($P \leq 0.01$) influence on MPEK and MPEKD. The effects of zone, herd-size, herd constitution and farming system were statistically not significant. Least squares means for different levels of the factors affecting MPEK and MPFKD are presented in Table – 4.11.

Table – 4.10

Least square analysis of variance showing effects of genetic and non-genetic factors on MPEK and MPEKD of animals of different genetic groups in and study area.

		MPEK		MPEKD	
Source of variation	**d.f.**	**M. S. S.**	**R^2 (%)**	**M. S. S.**	**R^2 (%)**
Zone	2	30.30	0.211	0.023	0.225
Herd size	3	27.98	0.292	0.033	0.323
Herd constitution	2	28.23	0.196	0.038	0.372
Genetic group	3	7370.53**	76.877	4.357**	64.033
Season of calving	2	126.78**	0.882	0.129**	1.264
Lactation order	4	494.06**	6.871	0.356**	6.976
Farming system	1	1.10	0.004	0.004	0.020
Residual	367	11.495	14.667	0.0149	26.787

** $P \leq 0.01$

4.2.3.1.1 Zone: Zone-effect contributed 0.211 % to the total variation in MPEK (Table-4.10). The corresponding value for MPEKD was 0.225 %. The least squares mean for MPEK and MPEKD were the highest (4.35 ± 0.04 kg. and 0.0175 ± 0.0002 kg.) for the animals in khatals located in North-East and South-West zone, followed by for those in Central (9.68 ± 0.12 kg. and 0.0173 ± 0.0002 kg.) zones. However, the animals in different zones did not differ significantly among themselves with respect to these efficiency traits.

Table – 4.11

Least square means MPEK and MPEKD under genetic and non-genetic factors in animals of different genetic groups in and study area.

	MPEK (kg.)	MPEKD (kg.)
	Mean ± S. E.	Mean ± S. E.
Overall mean (μ) →	4.32 ± 0.03	0.0175± 0.0001
Factors ↓		
Zone		
North-East	4.35 ± 0.04	0.0175 ± 0.0002
Central	4.26 ± 0.04	0.0173 ± 0.0002
South- West	4.35 ± 0.04	0.0175 ± 0.0002
Herd-size		
(3-6) animals	4.21 ± 0.06	0.0171 ± 0.0002
(7-10) animals	4.33 ± 0.04	0.0175 ± 0.0002
(11-14) animals	4.44 ± 0.06	0.0179 ± 0.0002
(15 & above) animals	4.32 ± 0.06	0.0174 ± 0.0002
Herd-constitution		
Only cows	4.23 ± 0.04	0.0172 ± 0.0002
Only buffaloes	4.36 ± 0.07	0.0175 ± 0.0003
Both cows & buffaloes	4.37 ± 0.05	0.0177 ± 0.0002
Genetic group		
Desi cow	3.06^{a} ± 0.05	0.0146^{a} ± 0.0002
HF crossbred	5.36^{b} ± 0.06	0.0203^{b} ± 0.0002
Jersey crossbred	5.02^{c} ± 0.06	0.0191^{c} ± 0.0002
Graded buffalo	3.85^{d} ± 0.06	0.0160^{d} ± 0.0002
Season of calving		
Mar. – June	4.28^{a} ± 0.05	0.0174^{a} ± 0.0002
July – Oct.	4.25^{a} ± 0.04	0.0172^{a} ± 0.0002
Nov. – Feb.	4.43^{b} ± 0.04	0.0179^{b} ± 0.0001
Parities		
1st	4.18^{a} ± 0.12	0.0170^{a} ± 0.0004
2nd	4.37^{a} ± 0.04	0.0177^{a} ± 0.0002
3rd	4.68^{b} ± 0.04	0.0185^{b} ± 0.0001
4th	4.43^{a} ± 0.04	0.0178^{a} ± 0.0001
5th	3.94^{c} ± 0.06	0.0165^{c} ± 0.0002
Farming system		
Only animal husbandry	4.31 ± 0.04	0.0174 ± 0.0002
Mixed farming	4.32 ± 0.05	0.0176 ± 0.0002

 # Values superscripted by similar letter were not significantly different from each other.

4.2.3.1.2 Herd-size: The contribution of the herd-size to the total variation in MPEK and MPEKD were 0.292 and 0.323 % respectively and the animals in herd of different sizes did not differ significantly in these regard (Table-4.10). However, results of this study (Table-4.11) revealed that the animals managed in a herd of 11 – 14 milch animals had relatively higher mean MPEK and MPEKD (4.44 ± 0.06 kg. and 0.0179 ± 0.0002 kg.) followed by those in herd of 7 – 10 animals (4.33 ± 0.04 kg. and 0.0175 ± 0.0002 kg.), 15 & above animals (4.32 ± 0.06 kg. and 0.0174 ± 0.0002 kg.) and 3 – 6 animals (4.21 ± 0.06 kg. and 0.0171 ± 0.0002 kg.) respectively.

4.2.3.1.3 Herd-constitution: Herd constitution did not show significant influence on MPEK and MPEKD (Table-4.10). The contributions of this effect to the total variation in MPEK and MPEKD were 0.196 and 0.372 % respectively. However, results (Table-4.11) revealed that the mean MPEK and MPEKD values were the highest (4.37 ± 0.05 kg. and 0.0177 ± 0.0002 kg.) for the milch animals maintained in the khatals having cow and buffalo both followed by for those in the khatals having only graded buffaloes (4.36 ± 0.07 kg. and 0.0175 ± 0.0003 kg.) and cows (4.23 ± 0.04 kg. and 0.0172 ± 0.0002 kg.).

4.2.3.1.4 Genetic group: Genetic-group contributed significantly ($P \leq 0.01$) to the variations in MPEK and MPEKD, the magnitude of contribution being 76.877 and 64.033 % respectively (Table-4.10). The contributions of genetic grade to the variation in MPEK and MPEKD were the highest among all the factors included in the mathematical model for analysis of variance in MPEK and MPEKD (Table-4.10). Sharma (1978), Singh *et al.* (1987) and Khanna *et al.* (1980) also reported that genetic grade had significant effect on MPEK and MPEKD, of course, in crossbred cows.

Least squares means for MPEK and MPEKD (Table-4.11) were the highest for HF crossbreds (5.36 ± 0.06 kg. and 0.0203 ± 0.0002 kg.) followed by those for Jersey crossbreds (5.02 ± 0.06 kg. and 0.0191 ± 0.0002 kg.), graded buffaloes (3.85 ± 0.06 kg. and 0.0160 ± 0.0002 kg.) and desi cows (3.06 ± 0.05 kg. and 0.0146 ± 0.0002 kg.). DMRT revealed that for the animals of different genetic-groups were significantly different among each other. The results of this study indicated that in and Darbhanga (Bihar), the Friesian crossbred cows were the most efficient milk producer followed by Jersey crossbreds, graded buffaloes and desi cows. The results were in accordance with the expectations because MPEK and MPEKD were derived on the basis of lactation milk yield, body weight at calving and lactation length of the animal of different genetic-group. In case of buffaloes the average MPEK and MPEKD values were lower than crossbred cows because of lower average lactation milk yield and more or less equal body weight. Whereas, the reason for lower milk production efficiency of desi cow was due to relatively the lowest lactation milk yield among the experimental animals under different genetic-groups.

4.2.3.1.5 Season of Calving: Season of calving had highly significant ($P \leq 0.01$) influence on the MPEK and MPEKD. Its contribution to the total variation in MPEK and MPEKD were 0.882 and 1.264 % respectively (Table-4.10). From the table-4.11, it is evident that the mean MPEK and MPEKD were significantly higher for the animal calved during November–February (4.43 ± 0.04 kg. and 0.0179 ± 0.0001 kg.) followed by those calved during March–June (4.28 ± 0.05 kg. and 0.0174 ± 0.0002 kg.) and July–October (4.25 ± 0.04 kg. and 0.0172 ± 0.0002 kg.). The least squares means for later two season of calving did not differ significantly from each other. Singh *et al.* (1987) reported the effect of season of calving on MPEK and MPEKD, of course in Zebu x Friesian crossbred grades, to be not significant which was contrary to the findings of this study.

4.2.3.1.6 Parity: Results revealed that parity had significant ($P \leq 0.01$) influence on MPEK and MPEKD. Its contribution to the total variation in MPEK and MPEKD were 6.871 and 6.976 % respectively (Table-4.10). There was gradual increase in average MPEK and MPEKD from first to third order of lactation and then after there was a declining trend up to fifth order of lactation. Least squares means for both the efficiency traits were significantly higher in third (4.68 ± 0.04 kg. and 0.0185 ± 0.0001 kg.) lactation as compared to those for first (4.18 ± 0.12 kg. and 0.0170 ± 0.0004 kg.), second (4.37 ± 0.04 kg. and 0.0177 ± 0.0002 kg.) and fourth (4.43 ± 0.04 kg. and 0.0178 ± 0.0001 kg.) order of lactation, which did not differ significantly among each other. The least squares means for fifth (3.94 ± 0.06 kg. and 0.0165 ± 0.0002 kg.) order of lactation was the lowest and significantly different from the means for all other lactations. The results followed the trend similar to the trends recorded for the lactation milk yield in this study (Para-4.1.2.1.6) which was logical because the lactation yield was one of the components in deriving this efficiency trait.

4.2.3.1.7 Farming System: The farming system did not have any significant influence on the MPEK and MPEKD (Table-4.10). Its contribution to the total variation in MPEK and MPEKD were 0.004 and 0.020 % respectively. The average value for the animals under the two farming systems was almost the same (Table-4.11).

4.3 MEASURES OF REPRODUCTION:

4.3.1 Dry Period: Longer dry period in cows is one of the major factors resulting in uneconomical milk production in India. There is inverse relationship between length of dry period and reproduction efficiency of milch animals. Ideal dry period has been suggested as 60-70 days, both in cows and buffaloes. The overall Least Squares Mean for dry period in dairy animals of the different genetic groups viz., local and crossbred cows as well as buffaloes, included in the study, was estimated to be 125.03 ± 2.02 days (Table-4.13) which was higher than the optimum range desirable for profitable milk production. The probable reason behind it could be the taking out milk by the private khatal owners from the animals in late gestation and not subjecting particularly crossbred animals to force drying 60-70 Days earlier to the expected date of their subsequent calving.

4.3.1.1 Factor affecting Dry Period: Least squares analysis of variance (table-4.12) revealed that genetic group had significant influence ($P \leq 0.01$) on dry period. The effect of zone, herd size, herd constitution, season of calving, order of lactation and farming system were statistically non-significant. Least squares means for different levels of the factors affecting dry period are presented in Table – 4.13.

4.3.1.1.1Zone: The animals in different zones did not differ significantly among themselves with respect to their dry period and the zone-effect contributed only 0.520 % to the total variation in the trait (Table-4.12). However, the least squares mean for average dry period was the longest (126.99 ± 2.51 days) for the animals of khatals located in North-East zone followed by those in South-West (125.14 ± 2.45 days) and Central (122.95 ± 2.60 days) zones. Shrivastava *et al.* (1998), Rao *et al.* (2000) and Priya Raj (2002) also recorded this effect to be not significant in cattle and buffaloes under private sector.

Table – 4.12

Least square analysis of variance showing effects of genetic and non-genetic factors on Dry Period of animals of different genetic groups in and around the study area.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	429.59	0.520
Herd-size	3	49.86	0.091
Herd-constitution	2	670.36	0.812
Genetic group	3	4452.48**	8.089
Season of calving	2	188.56*	0.228
Lactation order	4	1067.51	2.586
Farming system	1	878.09	0.532
Residual	367	392.10	87.142

** $P \leq 0.01$

4.3.1.1.2 Herd size: The contribution of the herd-size to the total variation in dry period was 0.091 % and the animals in herd of different sizes did not differ significantly (Table-4.12) among themselves. However, the results of this study (Table-4. 13) revealed that the animals managed in a herd of 3 – 6 milch animals had the longest average dry period (126.95 ± 3.64 days) followed by those in herd of 7 – 10 animals (124.64 ± 2.56 days). 15 & above animals (124.31 ± 3.34 days) and 11 – 14 animals (124.21 ± 3.26 days). Priya Raj (2002) also recorded the effect of the sizes of herd on this trait to be not significant. But contrary to the findings of this study, Shrivastava *et al.* (1996) and Rao *et al.* (2000) recorded this effect to be significant. Variation in management of the herds included in different studies might be responsible for such variations in dry period.

4.3.1.1.3 Herd Constitution: Herd constitution did not show any significant influence on dry period (Table-4.12). The contribution of the herd-constitution to the total variation therein was 0.812 %. However, the average dry period was the longest (130.22 ± 4.14 days) for the milch animals maintained in the khatals having graded buffaloes only followed by those in the khatals having cow and buffalo both (124.37 ± 2.89 days) and it was the shortest (120.49 ± 2.47 days) for the animals in the dairy units having only cows (Table-4.13).

4.3.1.1.4 Genetic Group: Genetic-group had highly significant ($P \leq 0.01$) influence and its contribution to the total variation on dry period was 8.089 % (Table-4.12). As evident from table-4.13, the desi cows had the longest average dry period (134.82 ± 3.06 days) which did not differ significantly from the average dry period of graded buffaloes (128.96 ± 3.24 days). The shortest mean dry period was recorded in Jersey crossbreds (117.81 ± 3.60 days) which did not differ significantly from the average dry period for HF crossbred (118.52 ± 3.54 days) cows. Although dry period is supposed to be influenced mainly by non-genetic causes but in the present study crossbred cows, desi cows and buffaloes constituted the genetic-groups. More genetic divergence between crossbred cattle, buffalo and desi cows might have resulted into expression of genetic effect on dry period to be significant in this investigation. The findings of this study were contrary to the findings of Singh *et al.* (1993) and Priya Raj (2002) but their findings were based on studies in crossbred cows only. However, Shrivastava *et al.* (1996) and Rao *et al.* (2000) reported the effect of genetic-constitution of the experimental animals on dry period to be significant.

4.3.1.1.5 Season of Calving: Season of calving did not have significant influence on dry period (Table-4.12), its contribution to the total variation in dry period being 0.228 %. However the results revealed that the mean dry period was the longest in animals calved during November – February (126.35 ± 2.28 days), followed by those calved during July – October (125.34 ± 2.58) and March – June (123.39 ± 2.96 days). Deshmukh *et al.* (1995), Shrivastava *et al.* (1996), Rao *et al.* (2000) and Priya Raj (2002) also recorded similar results.

4.3.1.1.6 Parity: The effect of order of lactation on dry period was recorded to be significant and its contribution to the total variation therein was 2.586 % (Table-4. 12). The mean dry period was the longest in the second calvers (133.85 ± 2.78 days) followed by first (127.40 ± 3.28 days), fifth (122.04 ± 2.07 days), fourth (121.60 ± 5.38 days) and third (120.25 ± 2.51 days) calvers (Table-4.13). No definite trend in variation in dry period due to parity could be established in this study. However, the findings of Shrivastava *et al.* (1996), Rao *et al.* (2000) and Priya Raj (2002) were in agreement with the result of this study.

4.3.1.1.7 Farming System: The farming system did not have any significant influence on dry period (Table-4.12) and its contribution to the total variation therein was 0.532 %. As evident from table-4.13, the animals managed in the units involved in the dairy farming alone had higher (128.13 ± 2.55 days) average dry period in comparison to those maintained in the units integrated with agriculture farming (121.93 ± 3.20 days).

4.3.2 Calving Interval: Calving interval is the indicator of sound reproductive status of milch animals. A period of 12-13 months has been recommended as an ideal calving interval in cows and buffaloes. The overall Least Squares mean for calving interval in dairy animals of the different genetic groups viz., local and crossbred cows as well as buffaloes, included in this study, was estimated to be 445.56 ± 2.33 days (Table-4.13), which was slightly higher than the average value desirable for profitable milk production but close to the estimates reported by Jahagir*et al.* (1994), Shah and Sharma (1994 [a]), Rao *et al.* (2000) and Singh *et al.* (2000). The higher estimates of calving interval in comparison to the estimates of Reddy *et al.* (1972), Reddy *et al.* (1980), Becerril *et al.* (1981), Singh (1984), Shrivastava *et al.* (1996) and Priya Raj (2002) may be attributed to greater genetic divergence among the experimental animals included in this study as compared to those in investigation of other workers.

4.3.2.1 Factor affecting Calving Interval: Least squares analysis of variance (table-4.14) revealed that genetic group and order of lactation had significant ($P \leq 0.01$) influence on calving interval. The effect of zone, herd size, herd constitution, season of calving and farming system were statistically not significant. Least squares means for different levels of the factors affecting calving interval are presented in Table – 4.13.

Table – 4.13

Least square means Dry Period and Calving Interval under genetic and non-genetic factors in animals of different genetic groups in and study area.

	Dry Period	Calving Interval
	Mean ± S. E.	**Mean ± S. E.**
Overall mean (μ) →	125.03 ± 2.02	445.56 ± 2.33
Factors ↓		
Zone		
North-East	126.99 ± 2.51	446.68 ± 2.89
Central	122.95 ± 2.60	444.18 ± 3.00
South- West	125.14 ± 2.45	445.82 ± 2.83
Herd-size		
(3-6) animals	126.95 ± 3.64	449.93 ± 4.19
(7-10) animals	124.64 ± 2.56	444.44 ± 2.95
(11-14) animals	124.21 ± 3.26	443.51 ± 3.76
(15 & above) animals	124.31 ± 3.34	444.42 ± 3.85
Herd-constitution		
Only cows	120.49 ± 2.47	438.53 ± 2.85
Only buffaloes	130.22 ± 4.14	444.29 ± 4.77
Both cows & buffaloes	124.37 ± 2.89	443.87 ± 3.34
Genetic group		
Desi cow	$134.82^{a} \pm 3.06$	$427.08^{a} \pm 3.52$
HF crossbred	$118.52^{b} \pm 3.54$	$453.45^{b} \pm 4.08$
Jersey crossbred	$117.81^{b} \pm 3.60$	$451.85^{b} \pm 4.15$
Graded buffalo	$128.96^{a} \pm 3.24$	$449.87^{b} \pm 3.73$
Season of calving		
Mar. – June	123.39 ± 2.96	445.22 ± 3.41
July – Oct.	125.34 ± 2.58	443.73 ± 2.98
Nov. – Feb.	126.35 ± 2.28	447.73 ± 2.63
Parities		
1^{st}	$127.40^{a} \pm 3.28$	$441.51^{a} \pm 7.82$
2^{nd}	$133.85^{b} \pm 2.78$	$459.50^{b} \pm 2.90$
3^{rd}	$120.25^{a} \pm 2.51$	$443.47^{a} \pm 2.39$
4^{th}	$121.60^{a} \pm 5.38$	$442.24^{a} \pm 2.74$
5^{th}	$122.04^{a} \pm 2.07$	$441.08^{a} \pm 3.78$
Farming system		
Only animal husbandry	128.13 ± 2.55	448.06 ± 2.94
Mixed farming	121.93 ± 3.20	443.06 ± 3.69

Values superscripted by similar letter were not significantly different from each other.

4.3.2.1.1 Zone: Zone effect contributed 0.145 % to the total variation in calving interval (Table-4.14) which was statistically not significant. The least squares mean for calving interval was the longest (446.68 ± 2.89 days) for the animals of khatals located in North-East zone followed by those in South-West (445.82 ± 2.83 days) and Central (444.18 ± 3.00 days) zones. However, the animals in different zones did not differ significantly among themselves with respect to their calving interval. The results were in agreement with the findings of Shrivastava *et al.* (1996) and Priya Raj (2002) but contrary to the findings of Singh *et al.* (1986 [b]). However, the aforesaid reports pertained to crossbred cows only.

Table – 4.14

Least square analysis of variance showing effects of genetic and non-genetic factors on Calving interval of animals of different genetic groups in and around the study area.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	171.82	0.145
Herd-size	3	287.45	0.365
Herd-constitution	2	1437.47	1.217
Genetic group	3	11102.72**	14.095
Season of calving	2	590.47	0.500
Lactation order	4	1524.93**	2.581
Farming system	1	571.01	0.242
Residual	367	520.63	80.855

** $P \leq 0.01$

4.3.2.1.2 Herd size: The contribution of the herd-size to the total variation in calving interval was 0.365 % and the average calving interval for animals in the herd of different sizes were statistically not significant (Table-4.14). However, results of this study (Table-4. 13) revealed that the animals managed in a herd of 3 – 6 milch animals had the longest mean calving interval (449.93 ± 4.19 days) followed by those in herd of 7 – 10 animals (444.44 ± 2.95 days), 15 & above animals (444.42 ± 3.85 days) and 11 – 14 animals (443.51 ± 3.76 days). Shrivastava *et al.* (1996), Singh *et al.* (1986 [b]) and Priya Raj (2002) reported the effect of herd-size on calving interval to be significant. It was contrary to the findings of this study and may be attributed to variation in the size of the herd as well as genetic constitution of the experimental animals in different studies.

4.3.2.1.3 Herd Constitution: Herd constitution did not show significant influence on calving interval (Table-4.14), its contribution to the total variation therein was 1.217 %. However, the mean calving interval was the longest (444.29 ± 4.77 days) for the milch animals maintained in the khatals having only graded buffaloes followed by those in the khatals having cow and buffalo both (443.87 ± 3.34 days) and it was the shortest (438.53 ± 2.85 days) for the animals in the units having only cows (Table-4.14). The trend of variation in calving interval with variation in herd constitution was same to the trend recorded in lactation length and dry period for the same effect. As lactation length and dry period are the component traits of the calving interval, the results were in accordance with the expectation.

4.3.2.1.4 Genetic Group: Genetic-group had highly significant ($P \leq 0.01$) influence and its contribution to the total variation in calving interval was 14.095 % (Table-4.14). As evident from table-4.13, HF crossbreds had longest average calving interval (453.45 ± 4.08 days) followed by Jersey crossbreds (451.85 ± 4.15 days) and graded buffaloes (449.87 ± 3.73 days) but they did not vary significantly among each other in this regard. The calving interval was the shortest in desi cows (427.08 ± 3.52 days) which differ significantly from the animals under all other genetic groups. In spite of relatively longer dry period in desi cows, the calving interval was the shortest only due to relatively shorter lactation length in the animals of this genetic-group. Shrivastava *et al.* (1996), Rao *et al.* (2000), Singh *et al.* (2000) and Praia Raja (2002) also reported the effect of genetic-group on calving interval to be statistically significant in the case of crossbred cows and buffaloes in private dairy units.

4.3.2.1.5 Season of Calving: Season of calving had statistically not significant influence in variation in inter-calving period (Table-4.14), Its contribution to the total variation therein was 0.500 %.From the table-4.13 it is evident that the average calving interval was the longest when animal calved during November – February (126.35 ± 2.28 days) followed by those calved during March – June (123.39 ± 2.96 days) and July – October (125.34 ± 2.58). The results were according to the expectations because lactation period and dry period when added, gave the estimate of the inter-calving period and variation in both the traits, as recorded in this study, due to season-effect were statistically not significant (Table-4.1 and 4.12).

4.3.2.1.6 Parity: Results revealed that parity had significant (P≤0.01) influence on the calving interval. Its contribution to the total variation on calving interval was 2.581 % (Table-4.14). It was agreement with the findings of Shrivastava *et al.* (1996), Rao *et al.* (2000) and Priya Raj (2002). From the table-4.13, it is evident that the second calving interval (459.50 ± 2.90) was significantly longer than third (443.47 ± 2.39), fourth (442.24 ± 2.74), first (441.51 ± 7.82) and fifth (441.08 ± 3.78) which did not differ significantly among each other. Significantly longer dry period (Table-4.13) corresponding to second parity may plausibly be attributed to longest calving interval in the corresponding parity. The trend of variation in calving interval due to parity difference was similar to that for dry period under the influence of same factor (Table-4.13).

4.2.2.1.7 Farming System: As evident from table-4.13, the animals managed in the units involved in the dairying alone had higher (448.06 ± 2.94 days) mean calving interval in comparison to those maintained in the units integrated with agriculture farming (443.06 ± 3.69 days). However, the farming system did not have any significant influence on calving interval (Table-4.14) and its contribution to the total variation was only 0.242 %.

4.4 ECONOMICS OF MILK PRODUCTION:

The data on different cost components and their relative contributions to the gross cost of per Kg. milk produced by the animals of different genetic grades in the khatals, in and around Darbhanga, were promptly recorded and compiled. The data were subjected to Least squares analysis of variance (Harvey, 1966) to quantify the effect of genetic and various non-genetic factors on the cost of milk production. The results have been summarized in tables – 4.15, 4.16 and 4.17.

4.4.1 Cost Components:

The overall Least squares mean for Net cost of milk production was estimated to be 921.92 ± 1.76 paise per Kg. (Table-4.17). Average Gross and Net cost of milk production, along with the relative contributions of different cost components to the Gross cost of per Kg. milk produced by the animals of four different genetic groups, are shown in table–4.15.

Among the different cost items, the cost of feeds and fodder was found to be the maximum, contributing 66.64, 63.71, 66.03 and 60.25 percent to the Gross cost of milk production in Desi, HF crossbred, Jersey crossbred cows as well as graded Buffaloes respectively. The overall contribution of feeding cost was estimated to be 63.96 percent (Table-4.15).

Human labour was the second major cost component accounting for 14.31, 14.16, 14.35 and 18.43 percent to the Gross cost of production in Desi cows, HF crossbreds, Jersey crossbreds and graded Buffaloes respectively. The corresponding overall average value was estimated to be 15.61 percent (Table – 4.15).

The contribution of interest on fixed capital to the Gross cost of milk production in Desi, HF crossbred and Jersey crossbred cows as well as graded Buffaloes were reckoned to be 10.21, 9.94, 9.08 and 9.40 percent respectively (Table – 4.15). The overall estimate for average contribution of interest on fixed capital to the Gross cost of production was estimated to be 9.97 percent.

In this study depreciation on fixed assets, like depreciation on animal, housing, equipments and machineries, was taken together as one cost item. The overall contribution of average depreciation, irrespective of genetic-group of the milch animals, was estimated to be 5.41 percent. Among the milch animals of different genetic-groups, depreciation contributed 4.12, 6.21, 5.15 and 4.38 percent to the Gross cost of production in Desi, HF crossbred, Jersey crossbred cows as well as graded Buffaloes respectively (Table – 4.15).

Miscellaneous recurring expenditure contributed 2.70, 3.19, 2.35 and 2.84 percent to the Gross cost of production for Desi, HF crossbred, Jersey crossbred cows and Buffaloes respectively. The corresponding overall average value was 2.61 percent (Table – 4.15).

Table - 4.15

Average of different cost components and their relative contributions to the gross cost of milk production in animals of different genetic groups in the area of investigation.

Cost items	Mean ± S.E. (Paise per Kg. of milk)				
	Desi cows	Jersey crossbred	HF crossbreds	buffaloes	overall
Feed cost	710.92 ± 6.32 (66.64)	609.45 ± 5.67 (66.03)	585.81 ± 5.13 (63.71)	555.44 ± 6.12 (60.25)	610.59 ± 5.78 (63.96)
Labour cost	152.66 ± 3.36 (14.31)	132.45 ± 3.12 (14.35)	130.21 ± 3.07 (14.16)	169.91 ± 3.67 (18.43)	149.02 ± 3.28 (15.61)
Depreciation	43.95 ± 0.40 (4.12)	47.53 ± 0.52 (5.15)	57.10 ± 0.61 (6.21)	40.38 ± 0.39 (4.38)	51.65 ± 0.42 (5.41)
Veterinary & A.I. cost	21.55 ± 0.28 (2.02)	28.06 ± 0.42 (3.04)	29.79 ± 0.40 (3.24)	43.33 ± 0.36 (4.70)	23.29 ± 0.33 (2.44)
Interest on fixed capital	108.92 ± 3.24 (10.21)	83.81 ± 2.98 (9.08)	87.26 ± 3.47 (9.49)	86.66 ± 4.12 (9.40)	95.18 ± 3.60 (9.97)
Miscellaneous cost	28.80 ± 1.31 (2.70)	21.69 ± 1.27 (2.35)	29.33 ± 1.41 (3.19)	26.18 ± 1.39 (2.84)	24.92 ± 1.39 (2.61)
Gross cost of production (A)	1066.80 ± 1.79 (100.00)	922.99 ± 1.54 (100.00)	919.50 ± 1.91 (100.00)	921.90 ± 1.68 (100.00)	954.65 ± 1.77 (100.00)
Income from dung (B)	31.37 (2.94)	31.04 (3.36)	36.89 (4.01)	38.18 (4.14)	32.73 (3.43)
Net cost of milk production (A- B)	1035.43 ± 2.66	891.95 ± 3.09	882.61 ± 3.14	883.72 ± 2.82	921.92 ± 1.76

Veterinary and A. I. cost contributed the least to the Gross cost of milk production, the magnitude of contribution in Desi, HF crossbred, Jersey crossbred cows as well as graded Buffaloes being 2.02, 3.24, 3.04 and 4.70 percent respectively. The overall contribution of this cost item to the Gross cost of milk production was recorded to be 2.44 percent (Table – 4.15).

The dung was taken as the only source of income to the khatals, other than milk. The income from dung was estimated and deducted from Gross cost of milk production in order to get the estimate of Net cost of per kg. milk production. In this study, the income from dung was recorded to reduce the Gross cost of milk production by 2.94, 4.01, 3.36 and 4.14 percent in Desi, HF crossbred, Jersey crossbred as well as graded Buffaloes respectively, the overall average reduction in Gross cost of production being by 3.42 percent (Table – 4.15).

The estimates for contributions of different cost items in this study were almost in agreement with the findings of Kalra *et al.* (1995), Kumar and Balishter (1996), Badal and Dhaka (1998) and Priya Raj (2002), but lower than the report of Chandra and Agarwal (2000). It would be worthless to compare the estimates of contributions of different cost components to the total variation in Gross cost of milk production, obtained in this investigation, with the corresponding estimates reported by other workers in different parts of the country because of the following reasons:

(I) The reports reviewed and referred pertained to the studies made in different agro-ecological regions of the country and were not contemporary to this study.

(II) Different degrees of sampling errors associated with different reports due to variable sample size in different studies.

(III) Variable managemental practices in different dairy units and availability of different feeds and fodder in different ecological regions.

(IV) Periodical change in degree of demand of milk from place to place influencing price of milk and

(V) Variation in the genetic constitution of the animals included in different studies.

Indeed, the above noted factors are the prime determinants of the cost of milk production in dairy cattle. However, the trends in contributions of fixed as well as variable cost items, recorded in this study, were in agreement with the reports of Ram *et al.* (1993), Shah and Sharma (1994 [a]), Dev Raj and Gupta (1994), Kalra *et al.* (1994), Shiyani *et al.* (1995), Sangu (1995), Kumar and Balishter (1996), Badal and Dhaka (1998), Chandra and Agarwal (2000) and Priya Raj (2002) with minor variations in the values of contributions for the different cost items. All the aforesaid workers conducted their studies on Cattle and Buffaloes under private sector managed under farmer's managemental conditions.

4.4.1.1 Factors (other than cost components) affecting Net Cost of Milk Production: Least square analysis of variance (table-4.16) revealed that effects of zone, herd-size, herd-constitution, genetic group, season of calving, farming system and parity had significant influence on Net cost of milk production.

Table – 4.16

Least square analysis of variance showing effects of genetic and non-genetic factors on Cost of Milk Production of animals of different genetic groups in and around the study area.

Source of variation	d.f.	M. S. S.	R^2 (%)
Zone	2	40386.12**	4.713
Herd-size	3	92361.55**	16.169
Herd-constitution	2	12264.11**	1.560
Genetic group	3	395622.50**	69.259
Season of calving	2	71.14**	1.490
Lactation order	4	926.73*	0.216
Farming system	1	3801.49**	0.222
Residual	367	297.50	6.371

* $P \leq 0.05$, ** $P \leq 0.01$

4.4.1.1.1 Zone: Variation in the location of the herd had significant influence on Net cost of milk production and it contributed 4.713 % to the total variation therein (Table-4.16). The least squares mean for Net cost of milk production was significantly higher in the animals of khatals

Table – 4.17

Least square means Cost of Milk Production under genetic and non-genetic factors in animals of different genetic groups in and study area.

	Cost of Milk Production
	Mean ± S. E.
Overall mean (μ) →	921.92 ± 1.76
Factors ↓	
Zone	
North-East	911.06 [a] ± 2.19
Central	943.70 [b] ± 2.27
South- West	911.01 [a] ± 2.14
Herd size	
(3-6) animals	989.46 [a] ± 3.17
(7-10) animals	942.73 [b] ± 2.23
(11-14) animals	861.61 [c] ± 2.84
(15 & above) animals	893.89 [d] ± 2.91
Herd constitution	
Only cows	920.91 [a] ± 2.15
Only buffaloes	937.70 [b] ± 3.61
Both cows & buffaloes	907.16 [c] ± 2.52
Genetic group	
Desi cow	1035.43 [a] ± 2.66
HF crossbred	882.61 [b] ± 3.14
Jersey crossbred	891.95 [b] ± 3.09
Buffalo	883.72 [b] ± 2.82
Season of calving	
Mar. – June	922.52 [a] ± 2.58
July – Oct.	932.26 [b] ± 1.98
Nov. – Feb.	921.99 [a] ± 2.51
Parities	
1st	925.68 [a] ± 5.91
2nd	923.44 [a] ± 2.19
3rd	912.45 [b] ± 1.81
4th	921.98 [a] ± 2.07
5th	924.07 [a] ± 2.86
Farming system	
Only animal husbandry	928.37 [a] ± 2.23
Mixed farming	915.47 [b] ± 2.79

Values superscripted by similar letter were not significantly different from each other.

located in Central zone (943.70 ± 2.27 paise) followed by North-East (911.06 ± 2.19 paise) and South-West (911.01 ± 2.14 paise) zones. The animals of North-East and South-West zones did not differ significantly among themselves with respect to the Net cost of milk production. Costly feeds and fodder as well as hired labours in centre of the town as compared to its periphery / sub-urban area may be attributed to the higher cost of milk production in central zone of Darbhanga.

4.4.1.1.2 Herd-size: The contribution of the herd-size to the total variation in Net cost of milk production was 16.434 % and the average costs of milk production in the herds of different sizes were statistically significant ($P \leq 0.01$). Results of this study (Table-4.17) revealed that the Net cost of milk production was highest (989.46 ± 3.17 paise) for a herd of 3-6 animals followed by that for the herd of 7 – 10 animals (942.73 ± 2.23 paise), 15 & above animals (861.61 ± 2.84 paise) and 11 - 14 animals (893.89 ± 2.91 paise). The Least Squares mean for Net cost of milk production in the herd of different sizes were significantly different among each other. The herd-size of 11-14 milch animals was found to be optimum for relatively cheaper milk production. It can plausibly be explained as the MY/CI was maximum for the animals maintained in the herds of 11-14 animals (Table-4.8) and as such the cost of production was also the least in the animals managed in that size of herd. Besides that, the variation in expenditures of different cost items per kg. of milk production in the herd of different sizes might have resulted herd-size effect to be significant, but it was not under the preview of this study. Singh (1984), Singh *et al.* (1986 [b]) and Priya Raj (2002) also reported the effect of herd-size on cost of production to be significant in crossbred cows.

4.4.1.1.3 Herd Constitution: Herd constitution had highly significant ($P \leq 0.01$) influence on Net cost of milk production (Table-4.16). The contribution of this effect to the total variation on Net cost of milk production was 1.560 %. It is evident from the table-4.17 that the average Net cost of milk production was significantly higher in khatals having only cows (937.70 ± 3.61 paise) followed by those having only graded buffaloes (920.91 ± 2.15 paise) and both cows and buffaloes both (907.16 ± 2.52 paise). Average cost of production in the herds of different constitutions differed significantly among themselves. Higher cost of milk production in khatals having only cows, in spite of high average MY/CI (Table-4.8) may be attributed to considerably higher cost of maintenance of desi cows. The magnitude of maintenance cost of desi cows might be higher enough to overcome the lowest maintenance cost for crossbred cows and making the cost of per kg. of milk production higher in the units maintaining only cows. Here cow meant both desi and crossbred. Buffaloes had relatively lower cost of maintenance, but the lowest average MY/CI was probably the factor responsible for higher cost of milk production. The findings of this study revealed that for cheaper milk production in private sector in and around Darbhanga, both cows and buffaloes should be maintained together.

4.4.1.1.4 Genetic Group: The genetic constitution of the milch animals had highly significant ($P \leq 0.01$) influence on the Net cost of milk production, its contribution to the total variation therein being 69.259 % (Table-4.16). Duncan's Multiple Range (DMR) Test revealed that HF crossbred had the lowest average Net cost of milk production (882.61 ± 3.14 paise) which did not differ significantly from production cost for Jersey crossbreds (891.95 ± 3.09 paise) and buffalo (883.72 ± 2.82 paise). The average Net cost of production was the highest in desi cows which differ significantly from the milk production cost for milch animals of all other genetic-groups (Table-4.17).

The lower cost of production in crossbred cows may be attributed to relatively their higher milk yield, whereas in buffaloes, relatively higher price of per kg. of milk as compared to that of crossbred cows might be the reason of lower cost of production at par with the crossbred cows. Lower milk yield in desi cows resulted into higher cost of their maintenance per kg. of milk they produced i.e. the cost of milk production. on the basis of the findings, it could further be recommended that a herd consisting of both crossbred cows and buffaloes would be ideal for economic milk production in and around Darbhanga.

4.4.1.1.5 Season of Calving: Season of calving had significant influence on the Net cost of milk production (Table-4.16), its contribution to the total variation therein was 1.490 %. The average Net cost of milk production was the lowest for the animals calved during November – February (921.99 ± 2.51 paise) followed by for those calved during March – June (922.52 ± 2.58 paise) and July – October (932.26 ± 1.98 paise). However, the animals calved during

November – February and March – June did not differ significantly among each other in respect to the cost of milk production. Variation in Net cost of production due to the effect of season of calving of milch animals followed the trend similar to the trend recorded for average MY/CI under seasonal influence (Table-4.8). MY/CI was the sole determinant of cost of milk production and as such the results were quite logical and could be explained as such (Para-4.2.2.1.5). In addition, variation in cost of pertinent input commodities, including feeds and fodder, was also a factor responsible for significant season effect on cost of milk production. Singh (1984) and Priya Raj (2002) recorded the season effect on cost of milk production to be not significant in crossbred cattle. Such variation in results may be due to variation in experimental area as well as agro-eco-socio conditions prevalent therein and variable genetic constitution of the experimental animals in different studies.

4.4.1.1.6 Parity: Lactation order had significant ($P \leq 0.05$) influence on the Net cost of milk production and contributed 0.216 % to the total variation therein (Table-4.16). Singh (1984) and Priya Raj (2002) who made comprehensive study on this aspect in crossbred cows also reported parity-effect to be significant on cost of milk production in private sector. Least squares means for different lactations revealed that there was decrease in Net cost of milk production from first to third order of lactation and then after it increased up to fifth lactation. The third order of lactation (912.45 ± 1.81 paise) had significantly the least Net cost of milk production followed by fourth (921.98 ± 2.07 paise), second (923.44 ± 2.19 paise), fifth (924.07 ± 2.86 paise) and first (925.68 ± 5.91 paise) order of lactation. However, the variation in per kg. production cost of milk in 1st, 2nd, 4th and 5th lactations were statistically not significant. The trend of variation in the cost of milk production for the cows in different lactations was inversely proportional to the average daily milk yield (MY/CI), which was quite natural, and as per the expectations, because the average milk production per day of calving interval was the prime determinant of the cost of per kg. milk production.

4.4.1.1.7 Farming System: The farming system had highly significant influence on Net cost of milk production (Table-4.16) and its contribution to the total variation was 0.222 %. As evident from table-4.17, the animals managed in the units involved in the dairying alone had significantly higher (928.37 ± 2.23 paise) Net cost of milk production as compared to those maintained in the units integrated with agriculture farming (915.47 ± 2.79 paise). Findings of this study revealed that dairy husbandry integrated with Agriculture farming in more suitable for economic milk production. It can plausibly be explained as the Agricultural by-products would be available for feeding livestock relatively at lower cost, if home grown, as compared to those purchased from market and it would reduce the cost of feeding milch animals and thus, the Net cost of milk production.

4.5 Constraints perceived by khatal owners in rearing cows and buffaloes: The khatal owners in the study area were interviewed to enlist the constraints pertaining to breeding, feeding, management and disease control of their animals in order of priority. The type of constraints and their priorities differed from unit to unit with zone, herd size, and farming system. The most common constraints, as perceived and reported by the khatal-owners, were identified and ranked on the basis of frequency of farmers expressing the same. The results have been presented in table-4.18.

"**High cost of crossbred cows**", in and around Darbhanga, the first major constraint perceived by the khatal owners, was linked with the "**Non-availability of good dairy animals in the locality**", the 6th constraint in list. Indeed, as compared to the other leading milk producing states of the country, the number of high producing crossbred cows and buffaloes are lesser in Bihar and that is why, in the local cattle market the population of potent animals is very thin. Resultantly, khatal owners had to bring high producing crossbred cows and buffaloes from outside the state, mostly from Haryana and Punjab, making the animals costly.

"**High incidences of repeat breeding**" among milch animals in and around Darbhanga, as reported by 83.0 % of the khatal owners, may be attributed to deficiency of greens in their feed. Although animals were supplied with concentrate mixture, fortified with "minerals and vitamins", but probably all the essential minerals, particularly trace elements, required necessarily to maintain the sexual health of crossbred cows in general and rhythm of ovulatory oestrus cycle in particular, were either not made available or were not of assimilative quality. Mineral mixtures, in general, were not supplied in optimum quantity in the ration of desi cows. "**High cost and sale of spurious/duplicate defective medicines**", the constraint having rank fifth (reported by 68.0 % owners), might be the probable cause of making the treatment of repeat breeders ineffective and thus, uneconomical. The drug control system needs to be made more effective to overcome such constraints, perceived and reported by the private dairy owners of Darbhanga.

"**Poor result of A. I.**" (constraint having seventh rank) might be due to managemental lapses in timely detection of heat and insemination in time with quality semen by trained personnel.

Table-4.18

Constraints perceived by the khatal owners in and around Darbhanga in rearing cows and buffaloes.

SL.No.	Constraints	Percentage	Rank
1.	High cost of crossbred cows.	86.4	I
2.	Cases of repeat breeding are high and their treatment is not economical.	83.0	II
3.	High cost of feeds and feed supplements.	76.8	III
4.	Non-availability of green fodder throughout the year.	73.6	IV
5.	Costly and spurious veterinary medicines and service.	68.0	V
6.	Non-availability of good dairy animals in the locality.	67.4	VI
7.	Poor results of A. I.	49.1	VII
8.	Lack of proper housing and high cost of land.	45.2	VIII
9.	Lack of finance/credit facilities.	43.0	IX
10	No or less value of crossbred male calves.	38.7	X
11.	Non-remunerative price of milk.	37.1	XI

The **cost of land** in and around Darbhanga had gone very high and it was beyond the approach of khatal owners to have sufficient land to build up byre for dairy animals providing prescribed surface area according to the scientific norms. It is worth mentioning that in the village near by Darbhanga also, where sufficient land area is available, farmers preferred to raise profit oriented commercial crops at the cost of fodder crops. Utilization of land for fodder cultivation was also not remunerative due to high cost of land. Resultantly, to achieve the sole objective of "profitable production", the animals in the khatals were managed under sub-optimal conditions of housing and sanitation and animals were not supplied with required amount of green fodder throughout the year. To overcome the deficiency of green fodder and maintain the production level, high yielding stocks were fed with more quantity of protein rich concentrate fortified with over dose of feed supplements. This feeding practice, together with relatively higher cost of dry fodders due to its total procurement and transportation from distant villages, may be attributed to the third constraint reported by 76.8 % owners of Darbhanga.

"Lack of financial/credit facilities" was reported by 43.0 % of the khatal owners in the area under investigation as a constraint ranked ninth. It could plausibly be explained as there were several financial agencies, but there were certain terms and conditions of financing an enterprise, including mortgage of assets of value more than the amount to be credited. Most of the khatal owners did not have such assets, except their animals which are also not insured.

"Less or no value of crossbred male calves" perceived by 38.7 % of the khatal owners as a constraint ranked tenth in the study area, might be due to the fact that there was common practice of selling crossbred males before the age of castration. Farmers were of opinion that the crossbred males were unfit to be used as bullocks for farm operations, since they were unable to withstand the tropical climate. This false notion led the farmers to dispose off the males at a very early age i.e. even before castration at non-remunerative price.

"Non-remunerative price of milk" was perceived as a constraint by 49.1 % khatal owners in and around Darbhanga. In central zone, consisting of city area of Darbhanga, the bulk consumers of milk were hotels and sweet houses, where the price of milk was paid to the producers on the basis of total solid in the milk including fat. However, the household consumers of fluid milk were paying considerate price of milk and as such the "Non-remunerative price of milk" was reported to be as a constraint being last in priority order. Due to spacio temporal entity of the constraints varying from place to place, time to time and farmer to farmer, the findings of this investigation were not quite comparable with the similar studies conducted elsewhere. However, Gill (1985), Bhoite and Sinde (1987), Sharma (1988), Dube *et al.* (1989), Gupta and De (1989), Singh and Thomas (1992), Rajendran and Prabaharan (1993), Raju *et al.* (1993), Bhaskar *et al.* (1994), Singh and Prasad (1998), Reddy (1999), Yadukondalu *et al.* (2000), Sawarkar *et al.* (2000), Priya Raj (2002), Mishra and Pal (2003) and Bardhan (2004) have made similar studies in different agro-climatic and spacio-economic-echo systems of the country and identified the different constraints recorded in this study, also perceived by the farmers in their study areas. However, the priority order (ranks) of the different constraints varied in different studies made in different parts of country.

5. SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

5.1 SUMMARY:

This investigation pertains to a genetic analysis of milk production efficiency of cattle and buffalo in and around Darbhanga through estimation of phenotypic parameters of some economic indicators including cost of milk production as well as determination of magnitude of variation in different measures of production, reproduction and economic efficiency due to genetic and non-genetic causes. The various constraints perceived by the farmers in rearing high yielding cows and buffaloes in the area of investigation were also recorded and ranked, and finally a suitable package of dairy practices for economic milk production in the study area was also suggested.

This study was conducted on altogather 385 milch animals out of which 96, 64, 64 and 161 belonged respectively to desi cows, Jersey crossbred cows, HF crossbred cows and graded buffaloes. The experimental animals were maintained in 49 responding dairy units in private sectors (khatals) located in and around Darbhanga, Bihar. The entire study area was divided into three zones viz. North-East, Central and South-West Darbhanga. The khatals were grouped into four groups on the basis of number of milch animals they possessed and delineated as herds of sizes 3-6, 7-10, 11-14 and 15 and above. To study the effect of diversity in genetic constitution of the animal in a group, the herds were classified into three types i.e. units having only cows, only buffaloes, and cows and buffaloes both. To study the influence of season of calving on different economic traits, the year was divided into three seasons viz. Hot-dry (March-June), Hot-humid (July- October) and Cold (November-February). Performance record of milch animals in first to fifth lactation and calved twice during the period of this study were only included. On the basis of the farming system adopted by the farmers, the units were classified into two types i.e. exclusively doing animal husbandry and doing animal husbandry integrated with crop-production.

Lactation length, lactation milk yield, peak yield, days to attain peak yield, milk yield per day of lactation length, milk yield per day of calving interval, milk production efficiency per kg. body-weight at calving (MPEK) and MPEK per day of lactation length (MPEKD) were the economic traits taken as the measures of production efficiency whereas dry period and calving interval were included as measures of reproduction. The cost of milk production reckoned in terms of "Net cost of milk produced by an animal for per day of her calving interval" was taken as measure of economic efficiency for the animals of different genetic-groups.

Stratified random sampling with proportional allocation was adopted for selection of respondent units for detailed studies in this investigation. The data on various economic indicators were analysed according to Least squares analysis of variance procedures utilizing appropriate mathematical model. DMRT was utilized for pair-wise comparisons of the Least squares means.

The results of Least squares analysis revealed that the location of herd in and around Darbhanga did not have significant influence on the economic traits included in this study except the cost of milk production which was significantly ($P \leq 0.01$) influenced by the zone-effect.

The size of the herd had significant ($P \leq 0.01$) influence on lactation milk yield, milk yield per day of lactation length, milk yield per day of calving interval and cost of production in the animals of all the four genetic-groups included in this study. Variation in herd-size did not have any significant influence on rest of the economic traits under reference. The constitution of the herd did not have any significant influence on the economic indicators except the cost of milk production whereas, the variation in genetic constitution of the animals influenced all the economic indicators highly significantly ($P \leq 0.01$).

Season of calving did not have any significant influence on lactation length and calving interval. Its influence was significant at 5% level of probability on days to attain peak yield and dry period, whereas the variation in season of calving among the animals of different genetic-groups had significant ($P \leq 0.01$) influence on lactation yield, peak yield, milk yield per day of lactation length, milk yield per day of calving interval, MPEK, MPEKD and cost of milk production.

Parity-effect did not have any significant effect on dry period. However, variation in lactation order had significant ($P \leq 0.05$) effect on cost of milk production, whereas its effect on rest of economic indicators included in this study was significant at 1% level of probability.

The farming system influenced the cost of milk production highly significantly ($P \leq 0.01$). However, its effect on rest of the economic traits was statistically not significant.

In econometric study the Net cost of milk production in the animals of different genetic-groups varied between 882.61 ± 3.14 and 035.43 ± 2.66 paise per kg., the corresponding overall value being 921.92 ± 1.76 paise. It was the lowest for HF crossbred cows and highest for desi cows. The different items of expenditure on maintenance of the milch animals were categorized broadly into fixed and variable costs. The fixed cost consisted of depreciation on animals, buildings/sheds as well as farm utensils including machineries, equipments and other assets besides the interest on fixed capital invested for animals, housing, equipments and machineries etc. The cost of feeds and fodder, labour cost, cost of A.I. and Veterinary aids and miscellaneous items constituted the variable cost in this study. Genetic-group wise as well as overall contribution of different cost items to the Gross cost of milk production was reckoned and the income from dung for each kg. of milk produced in milch animals was deducted from the Gross cost of production to obtain the estimate of the Net cost of milk production.

Altogather 11 considerable constraints were reported to be perceived by the farmers in maintaining high yielding stock and thus profitable milk production, in and around Darbhanga, Bihar. The high cost of crossbred cows was reported to be the major most constraints followed by high incidence of repeat breeding and its costly treatment, high cost of feed and feed supplement, non-availability of green fodder round the year, costly Veterinary services and spurious medicines, non-availability of good dairy animals locally, poor results of A.I., lack of proper housing due to high cost of land, lack of credit facility, little value of crossbred male calves and non-remunerative price of milk.

RECOMMENDATIONS:

On the basis of findings of this investigation it is recommended that for profitable milk production in private sector in and around Darbhanga, Bihar, a herd of 7-10 milch animals consisting of both HF and Jersey crossbred cows together with buffaloes would be the optimum. The cost of milk production would be the lowest in the animals in third lactation and maintained in a unit integrated with agricultural farming. It seemed to be desirable to regulate the oestrous cycle of the milch animals in such a way that majority of them calve between July and October every year.

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