CHAPTER VI

SUMMARY AND CONCLUSIONS
The present investigation was undertaken to study the genetic architecture of growth and production traits of 689 S (Sahiwal), 639 BSxS (Brown Swiss x Sahiwal) and 3802 HFxSxSUxMF (a population of crosses where HF and SW sires were used) cattle collected from 7 farms in Northern India were used. The crosses of HFxSxSUxMF were classified into seven genetic groups (1/8 to 7/8) with the fraction of 12.5 per cent Frisian inheritance and BSxS crosses in five genetic groups (6/8, 4/8, 3/8, 2/8 and F2-F3). The data were spread over a period of 15 years (1961-75). The entire period was divided into 5 periods each of 3 years duration. Year was divided into 4 seasons based on climate. Parity of birth was considered in four groups (I, II, III-IV, >V). Ten body weights (weight at birth, 2, 4, 6, 9, 12, 15, 18 months, at first fertile service and at first calving), seven growth rates (g/day) worked out from body weights upto 18 months' age and 11 production traits (age at first calving, first lactation yield, and its components - initial, ascending, peak, descending — milking average in kg, first 170-305 days lactation yield in kg, first lactation length in days, 170-305 days lactation length and first dry period in days) were considered in this study.
Farms, genetic groups within crosses, parity, seasons and period of birth were considered as factors of importance for 17 traits of growth. For production traits, farm, genetic groups, season and period of calving were considered. Least square technique was used to derive the population mean, the constants and to study the influence of these factors affecting the growth and production.

The female calves of BSxSw inheritance were significantly heavier at birth (29.31±0.22 kg) than HFxSw-SwxHF (28.45±0.07) and purebred Sw (21.03±0.13 kg). Among Sw and its crosses with BS and HF, 6/8 BSxSw had the highest birth weight (27.31±0.19 kg). The body weights at various ages were in general higher for HFxSw crosses followed by BSxSw and Sw respectively. However, the weights at first calving were almost similar (331.85±2.18 kg of Sahiwal, 347.40±4.88 of BSxSw and 350.67±4.99 kg of HFxSw-SwxHF) in these three breed groups with significant variation in their respective ages. The growth rate (g/day) was maximum between 4-8 months and lowest in 18-24 months age interval in all breed groups. The maximum and minimum growth rate values were 481.8±7.1, 330.3±14.8 (Sw), 331.0±20.7, 314.6±22.5 (BSxSw) and 341.6±4.8, 343.0±4.8 (HFxSw-SwxHF) g per day.

The average age at first calving was 38.7±2.7 months (Sw), 30.4±0.6 months (BSxSw) and 36.4±0.3 months (HFxSw-SwxHF). Among Sw and its various genetic groups with BS and HF crosses,
half-bred (4/8) of BSxSw had the lowest age at first calving (23.8 months) followed by 3/8 (28.9 months), 3/4 (31.2 months), F2-F3 (32.7 months). For HFxSw crosses, the 4/8 to 6/8 level of HF inheritance had the lower age 35.4 and 35.8 months respectively.

Average first lactation yield was highest in BSxSw crosses (3288.99±133.20 kg) followed by HFxSw-SwxHF (2498.34±39.8 kg) and Sw (2022.11±38.07 kg). Similar trend was noted for first 170-305 days yield. For first lactation components based on an average of two days yield, defined as initial, ascending, peak, descending yield and milking average, the highest values were observed for BSxSw crosses, followed by HFxSw-SwxHF and Sw respectively. The average first lactation length and dry period were respectively 322.0±4.5, 134.7±4.9 days (Sw), 336.4±10.1, 74.4±6.0 days (BSxSw) and 309.5±2.9, 124.6±3.7 days (HFxSw-SwxHF).

Among genetic groups of BSxSw high yielder were noted 3/8 (4008.2 kg) followed by half-bred (3496.2 kg) while for HFxSw-SwxHF 6/8 (2808.8 kg) followed by 4/8 (2799.4 kg) and 5/8 (2735.4 kg). The relative performance of different genetic groups of BSxSw and HFxSw-SwxHF revealed the superiority of 3/8 to 4/8 (BSxSw) and 4/8 to 5/8 (HFxSw-SwxHF) over other grades in their respective genetic groups and Sahiwal cattle.

The affect due to farms was significant for all body weight and growth rate traits in Sw and HFxSw-SwxHF except for weight at birth, 12-15 and 15-18 months growth rate (Sw). The affect due to level of exotic inheritance was significant for all growth traits in BSxSw and HFxSw-SwxHF except weight at
2 months, weight at first fertile service and at first calving; growth rates from birth to 2 months, 4 to 6 months in BSxSw and 12 to 15 and 15 to 18 months in HFxSw-SwxHF crosses.

Significant effect due to parity of birth was observed for weight at 9 months age, weight at first fertile service in Sw; weight at birth, 4, 6 months, at first fertile service, 2-4 months and 12-15 months growth rate in BSxSw and non-significant for other growth traits. The effect due to parity of birth was non-significant for all growth traits in HFxSw-SwxHF. The effect due to season of birth was observed significant for weight at 9 and 12 months age; growth rate from 6-9, 9-12, 12-15 and 15-18 months age intervals while it was significant for all traits in BSxSw and HFxSw-SwxHF except weight at 2, 10 months, at first fertile service, birth to 2 months' growth in BSxSw and for weight at 15 months, first fertile service and weight at first calving in HFxSw-SwxHF crosses. The effect due to period of birth was significant for all growth traits in Sw, BSxSw and HFxSw-SwxHF crosses except 4-6, 6-9, 9-12 and 12-15 months growth rate in Sw, weight at birth, at first calving, 6-9, 12-15 and 15-18 months growth rate in BSxSw and 6-9 months growth rate in HFxSw-SwxHF crosses.

The effect due to farms was significant for all production traits in Sw and HFxSw-SwxHF crosses except age at first calving, ascending, peak and descending yield in Sw cattle. The effect due to genetic groups within crosses was significant for all production traits except first lactation length (BSxSw)
and first dry period in BSxSw and HFxSw-SwxHF. The effect due to season of calving was significant for age at first calving (Su), descending yield (Sw and BSxSw) while it was found significant for all production traits in HFxSw-SwxHF except first lactation yield. The effect due to periods of calving was significant for age at first calving, first lactation, initial, ascending and peak yield in Sw, age at first calving, first 170-305 days lactation length and first dry period in BSxSw and significant for all production traits in HFxSw-SwxHF crosses.

The $h^2$ estimate for body weight ranged between $0.29 \pm 0.17$ (weight at 9 months age) to $0.59 \pm 0.19$ (weight at 2 months age) in Sw, $0.17 \pm 0.20$ (weight at first calving) to $0.57 \pm 0.21$ (weight at 15 months) in BSxSw, $0.12 \pm 0.04$ (weight at first fertile service) to $0.34 \pm 0.09$ (weight at 18 months age) in Holstein sire group and $0.11 \pm 0.11$ (weight at first calving) to $0.60 \pm 0.16$ (weight at 2 months age) in Sw sire group. The $h^2$ estimated from growth rate (g/day) traits was found low except for growth rate from birth to 2 months age where the $h^2$ values were $0.62 \pm 0.19$ (Sw), $0.25 \pm 0.14$ (BSxSw), $0.15 \pm 0.05$ (HFxSw) and $0.44 \pm 0.13$ (SwxHF). The $h^2$ values for age at first calving were $0.75 \pm 0.21$ (Sw), $0.48 \pm 0.22$ (BSxSw), $0.45 \pm 0.12$ (HFxSw), $0.84 \pm 0.19$ (SwxHF). For first lactation yield $h^2$ values were $0.24 \pm 0.14$ (Sw), $0.12 \pm 0.17$ (BSxSw), $0.19 \pm 0.07$ (HFxSw), $0.06 \pm 0.08$ (SwxHF). Low to moderate $h^2$ values were observed for all components of first lactation yield in four breed groups. The values for lactation period and first dry period were close to zero or low. The $h^2$ estimates of 1st, 2nd and 3rd (305 days and below) lactation yield were respectively
The phenotypic correlations (four breed groups) among body weights and among production traits were in general moderate to high while between any two adjacent traits it was invariably high. The phenotypic correlations among growth traits were low to moderate whereas correlations of growth rate and body weights with production traits were mostly low.

Simple linear, multiple and quadratic functions using different combination of traits were used for the prediction of first lactation yield. The quadratic equations accounted for better estimate ($R^2$) than simple linear and multiple equations for predicting first lactation yield based on 4 body weight traits viz. weight at birth, 6 months, 12 months and at first calving. The maximum growth rate (4-6 months) explained low variation in first lactation yield in four breed groups ($R^2 = 0.58$ to $5.01$ per cent). The $R^2$ values using different combination of traits revealed that first lactation length alone explained larger variation for first lactation yield. The $R^2$ values were $55.10, 56.78, 34.63$ and $40.61$ per cent in $S_u, BSxSw, HFxSw, SuwHF$ respectively.

First lactation yield was also predicted using lactation components. Multiple and quadratic equations were found equally effective. Among lactation components peak yield and descending yield explained the maximum variation in four breed groups. The $R^2$ values using these traits ranged between
Genetic correlations of age at first calving with body weights at different ages and growth traits were either low or negative in the four breed groups. The $r_g$ of first lactation yield with body weights were also either low or negative except those with body weights at later ages. The correlation of age at first calving with production traits ranged between 0.36 to 0.76 in Sw. Similar trends were noted in BSxSw, HFxSw and SwxHF crosses where the estimates were either negative or ranged between low to moderate. The $r_g$ of first lactation yield with lactation components were high (>0.60) in all the four breed groups.

For each breed group, four selection indexes were constructed using different combination of economic traits viz. body weight at 6 months, 12 months and at first calving; age at first calving, peak yield and milking average. Expected genetic gain for traits included in these indexes indicated that index IV had the highest efficiency with $R_{IM}$ values in percentage as 93.89, 90.85, 78.50 and 93.36 respectively for Sw, BSxSw, HFxSw and SwxHF breed groups. The next in order were index I, II and III (Sw), I, III and II (BSxSw and SwxHF), III, I and II (HFxSw). These estimates of indexes were also compared with the results that are likely to be obtained by direct application of individual or mass selection on each trait. Index IV would reduce the age at first calving in next generation by 1.01, 0.62, 0.15 and 0.13 months, peak yield would increase and decrease respectively at the rate of 0.76, -0.46, -0.02 and 0.35 kg.
milking average 0.39, 0.56, -0.04 and 0.16 kg in $S_w, BSxS_w,$ $HFxS_w$ and $SwxHF$ breed groups respectively. The efficiency of selection indexes were increased by combining age at first calving, peak yield and milking average.

Genetic architecture inherent in growth and production records of famous dairy animals in Northern India revealed that Friesian genes had superiority in growth rate (g/day) and on body weights at chronological ages while Brown Swiss genes in production performance based on first lactation yield and its components. Brown Swiss genes place though studied at one farm only showed an edge over Holstein-Friesian inheritance for age at first calving and first lactation yield. The methodology employed and results achieved at farms in Northern India indicate that exotic inheritance could be generated around 50 per cent for getting optimum results (3/8 to 4/8 in $BSxS_w$ and 4/8 to 5/8 in $HFxS_w$) under present feeding and management technology. This will leave an ample scope of forward/backward blood level engineering in the hands of future geneticists till more valid conclusions are available.