CHAPTER VI

SUMMARY AND CONCLUSION

The genus *Coffea* is an economically important member of the family Rubiaceae and comprises of about 100 species. Of these, only two species namely, *C. arabica* popularly known as arabica and *C. canephora* called as robusta are commercially cultivated for the stimulating beverage ‘Coffee’. Arabica coffee possess superior quality characteristics but is susceptible to several diseases and insect pests. In contrary, robusta coffee is well known for its robust bush, high production potential and greater immunity towards major diseases and pests, but possess inferior bean quality parameters compared to Arabica both in terms of size and liquor quality. Exploitation of the desirable traits of both the species through introgressive breeding has been the main focus of plant improvement programmes being pursued across coffee growing countries. Therefore, the major objectives of coffee breeding are for high yield potential, resistance to the diseases and pests, wide adaptability and superior quality.

In line with the above envisaged objectives, a hybridization programme was undertaken at Coffee Research Sub Station, Chettalli, Kodagu District of Karnataka during the year 1997-98 using dwarf and tall cultivars. The F₁ hybrids were established in field plots for evaluation of vegetative, yield and quality characteristics. The present studies, pertains to the field performance of 15 F₁ hybrid progenies selected based on the availability of desired population size. The selected progenies included a group of five crosses involving Dwarf x Tall, Tall x Dwarf and Tall x Tall combinations and the parameters of evaluation were morphological traits, reproductive characters, post-harvest quality standards. Simultaneously, estimates of genetic components and correlation of characters were also studied. Based on the data generated, a new model was developed for quantification of transmission of parental traits.
as reflected by the paternal and maternal characters inherited to the offspring. In addition to the above, an attempt was made for molecular genetic analysis of inter-specific hybrids of tetraploid arabica cv. ‘Cauvery’ and a diploid robusta cv. (CxR) using Sequence Related Amplified Polymorphism (SRAP) markers.

The results indicated superior growth characteristics in progenies raised from Tall x Tall crosses as compared to the Dwarf x Tall and Tall x Dwarf cross combinations. As regards to yield, Sln.6 x Sln.9 progeny recorded maximum fruit yield of \(3.01\) kg plant\(^{-1}\), the average of three years. In general, the percentage of ‘A’ grade beans was high that ranged from 74 to 80 in the progenies recovered from the crosses involving Sln.5B as maternal parent and other arabica varieties like S.795, Sln.9 and ‘Cauvery’ as pollinators. Interestingly, the progeny of the cross Sln.6 x Sln.9, recorded 79 percent of ‘A’ grade beans. The cup quality parameters were also found to be superior in the progenies where Sln.5B was used as maternal parent.

On considering the average yield of three years of the F\(_1\) progenies developed from different groups of cross combinations, Tall x Dwarf combinations group recorded the maximum yield of \(2.38\) kg plant\(^{-1}\) followed by \(2.36\) kg plant\(^{-1}\) in Tall x Tall crosses and \(1.90\) kg plant\(^{-1}\) in Dwarf x Tall combinations group. Among the five progenies of Dwarf x Tall group, Cauvery x Sln.9 recorded highest average yield of \(2.50\) kg plant\(^{-1}\) with \(172.98\) gm fruit weight and \(163.93\) ml fruit volume. The lowest yield of \(1.52\) kg plant\(^{-1}\) was recorded in Cauvery x (C x R) progeny in spite of highest numbers of fruits (13.94) per cluster that might be because of the lowest fruit weight and volume. The progeny yields of Cauvery x Tafarikela was almost on par (\(1.53\) kg plant\(^{-1}\)) with Cauvery x (C x R) crosses. Similarly, the differences in realized yields of the progenies, Cauvery x S.881 and Cauvery x Devamachy are not
significant. The number of fruits cluster\(^1\) was significantly higher in the progeny of Cauvery x (CxR), among the Dwarf x Tall crosses. The progeny of Cauvery x Tafarikela exhibited highest fruit weight in all the three seasons with an average value of 185.65 gm 100 fruits\(^1\) but the differences among different progenies is not statistically significant. Similarly, 100 fruit volume was also higher in this progeny (P≥0.05). The lowest 100 fruit weight and volume was recorded in Cauvery x (CxR) progeny. As far as fruit floats are concerned, Cauvery x Tafarikela hybrid progeny showed the highest mean fruit floats of 11.23 percent.

Further, the variation in the fruit floats was considerably high (42.17 percent) with maximum percentage of floats among the progenies of Tall x Dwarf crosses. The F\(_1\) progeny of Sln.9 x Cauvery produced the highest crop of 2.91 kg ripe fruits plant\(^1\) while, Tafarikela x S.4179 yielded 1.97 kg plant\(^1\) which was lowest among the progenies. But, the differences in all the five progenies from Tall x Dwarf crosses were not noteworthy. Sln.5B x Cauvery progeny recorded the highest number of fruits per cluster (13.21) along with the highest 100 fruit weight and volume of 196.31gm and 181.19 ml respectively. Sln.6 x Cauvery and Sln.5B x Cauvery crosses produced comparatively lower percentage of fruit floats among all the crosses.

The seasonal variation in production of fruit floats was in the range of 39.66 to 56.09 percent. This indicated that the disturbances in fruit set and subsequent growth leading to high percentage of fruit floats, were highly influenced by the environmental factors than the genetical ones. The significant variation for fruit floats was observed in all the three seasons. Subsequently, the parameters like 100 fruit weight and volume and yield characters exhibited the seasonal variation in the three cropping periods. In the third set of
cross combination with Tall x Tall cultivars, the characters such as 100 fruit weight and volume as well as percent fruit floats indicated the significant differences among the progenies. The Sln.6 x Sln.9 progeny recorded the highest yield of 3.01 kg ripe of fruits plant\(^{-1}\) with the seasonal variation of 14.22 percent to 17.99 percent for number of fruits per cluster and low for 100 fruit weight and volume. High variation was noticed for fruit float character which was in the range of 21.72 percent to 104.43 percent. Sln.9 x Sln.11 hybrid population recorded the highest fruit floats among the F\(_1\) hybrids. This trend of fruit abnormality indicated the involvement of genetic factors controlling this trait.

Among the F\(_1\) generation of Dwarf x Tall, the hybrids of Cauvery x (C x R) exhibited significantly highest number of fruits cluster\(^{-1}\). The fruit weight and volume as well as percent fruit floats were maximum in Cauvery x Tafarikela progeny. Cauvery x Sln.9 progeny recorded the highest crop of 2.50 kg ripe fruits plant\(^{-1}\) among the Dwarf x Tall crosses. The seasonal variation was considerably high for fruit floats and yield characters in this group.

Among the Tall x Dwarf crosses, Sln.5B x Cauvery produced more number of fruits cluster\(^{-1}\) and 100 fruit weight and volume. The percentage of fruit floats was significantly higher in Tafarikela x S.4179 progeny. The yield of 2.91 kg ripe fruits plant\(^{-1}\) was found to be the highest in Sln.9 x Cauvery hybrid progenies but without significant difference. In this group of crosses too, the coefficient of variation was to the higher side for fruit floats and yield. Comparatively, less fruit weight and volume were seen in the progenies wherever, S.881 (Rume Sudan wild arabica) was used as a male as well as female parent with Cauvery cultivar.

The combination of Tall x Tall crosses indicated no significant variation in the three years mean number of fruits cluster\(^{-1}\). As far as 100 fruit weight and volume is concerned, Sln.6 x Sln.9 progeny expressed significantly higher fruit weight and volume as well as fruit
yield of 3.01 kg plant\textsuperscript{-1}. The percentage of fruit floats was significantly higher in Sln.9 x Sln.11 progeny. There were not much genetic and environmental variations for the parameters like number of fruits cluster\textsuperscript{-1}, 100 fruit weight and volume except for fruit floats and yield parameters.

The study on leaf rust incidence in F\textsubscript{1} progenies conferred that genotype as well as environment played a greater role in manifestation of susceptibility and resistance to the disease. Observations from the present study established that the genes governing the leaf rust resistance were highly influenced by the environmental conditions leading to the manifestation of disease and its build up levels.

Mean of two seasons of cup quality scores indicated that among the F\textsubscript{1} progenies, the progeny of the cross Cauvery x (CxR) recorded the highest score for the quality parameters and rated as speciality coffee. Cauvery x Tafarikela scored the second position in this group showing relatively low values for all the cup characteristics and slightly higher acidity than the Cauvery x (CxR) hybrids. Among the Tall x Dwarf crosses, Sln.5B x Cauvery progeny exhibited superior performance for all the quality parameters. The performance of Tafarikela x S.4179 was very similar to the Sln 5B x Cauvery progeny with slightly low acidity and flavour.

Out of five progenies of Tall x Tall crosses, four expressed almost equal performance for quality profiles with minimal differences in the numerical scores. The remaining progenies of all the three cross combinations indicated the consistency with negligible quantum of seasonal variation in some of the parameters.

The present study indicated the significant correlation of morphological characters with quality characteristics which may be useful in developing indicators for identification of
superior genotype. In tall cultivars, the characters such as bush span, stem girth and primary thickness seemed to have strong correlation. Phenotypic expression of any given character is primarily regulated by the gene combinations. Further, there are several other genes responsible for inheritance of other quantitative traits that appeared to be independent genes and their assortment may be self regulatory. Likewise, the genes governing the cup quality characters were found to have close association with the morphological traits like stem girth, primary thickness, inter-nodal length, leaf length and breadth, fruit weight and bean weight. Correlation between the morphological traits and quality components was observed to have clear distinction among the progenies depending on cross combination. In some of the crosses, characters were closely associated and in some other, they are distantly associated. This variation among the crosses might be due to variability in the population.

Investigation on morphological proportion demonstrated that among the parent cultivars, the magnitude of variability for the morphological characters was highly significant (P≥0.01) for all the characters recorded whereas, in the F₁ progenies either of Dwarf x Tall or Tall x Dwarf crosses, the plants had similarity for the bush spread, primary thickness and leaf length. In both the groups of crosses with dwarf parent used, either as a male or female, the dwarf characters exhibited dominance over tall ones. The other characters like; stem girth, intermodal length of primaries, leaf breadth, fruit length and breadth expressed significant differences (P≥0.05 and P≥0.01) with the range of 42.00 to 86.00 percent heritability among the F₁ populations.

All the fifteen progenies derived from various cross combinations of Dwarf x Tall, Tall x dwarf and Tall x Tall cultivars exhibited low level of GCV of 6.94 percent and PCV of
10.92 percent. The heritability was 46.45 percent and GA 11.20 percent. This proved that medium level of genetic variability for morphological traits in the F1 progenies.

The trend in transmission of genetic traits from parents to the offspring was not uniform as reflected in the progenies of the various crosses of dwarf and tall cultivars. The magnitude of genetic expression differed from parent to parent and based on their genetic constitution. Application of morphological proportions for detection of traits inherited from the parents to the offspring indicated a higher degree of heritability for the characters such as stem girth, primary intermodal length, leaf breadth, fruit length and fruit breadth. The study revealed that the cultivars used in breeding the F1 generations of Dwarf x Tall and Tall x Dwarf crosses had more variations for these traits rather than the other morphological characters.

The ‘Caturra’ gene had almost equal effect through male as well as female parent on stem girth character, while tall parents showed slightly lower influence on expression of this trait. This trend of inheritance indicated a case of co-dominance. Like bush spread, the parameter of primary thickness was also greatly influenced by the ‘Ct’ gene. The ‘Ct’ gene transmitted through the female parent exhibited stronger influence on primary’s intermodal length than transmitted by the male parent.

The results revealed the dependent characters in coffee follow the assortment of characters along with closely related characters and expressed the varying degree of expression, therefore, the frequency of the occurrence of such phenotypic traits did not considerably match with the expected frequency of the same traits at high probability level or it matched at low level. Further, the genetic behaviour of independent traits exhibited the genetic segregation in accordance with the Mendel’s law of independent assortment and fit in to the dihybrid ratio of 9:3:3:1 with high level of hypothetical confidence (P≥0.50 up to 0.95).
Genetic analysis of dihybrid cross combination with $\chi^2$ (chi square) test revealed that the characters such as leaf length, leaf breadth and primary length expressed notable deviation from expected frequencies of dihybrid ratio of 9:3:3:1. Although $\chi^2$ (chi square) test showed the acceptance of the hypothesis but it was at lower probability ($P_{\leq 0.50}$).

The study also revealed that the morphological characters such as leaf length and breadth and shoot length of primary or secondary are very sensitive to seasonal variation or environmental conditions. The genes controlling these traits were observed to be influenced by the environmental conditions in spite of their dominance in genetic behavior. Change in the morphology of such characters are easily perceptible than the characters not frequently influenced by the environment.

The present study revealed that the F$_1$ hybrids derived from Cauvery x Sln.9 in Dwarf x Tall group and Sln.9 x Cauvery and S.881 x Cauvery among Tall x Dwarf group can be exploited for commercial cultivation after stabilization of the characters of economic importance or by way of clonal propagation. Since, these hybrids exhibited higher degree of tolerance to the coffee leaf rust (CLR) due to introgression of horizontal resistance from S.881 and Tafarikela from Ethiopian origin. These hybrids recorded high yields besides good bean and liquor quality. Among the progenies of Tall x Tall group, Sln.5B x S.795 and Sln.6 x Sln.9 indicated comparatively better yields, bean grades and cup quality characteristics, in spite of low level of resistance to coffee leaf rust. However, the exploitation of these hybrids is recommended only after proper stabilization of the desirable traits.

Coffee being a perennial plant, it takes at least 5-7 years for attaining reproductive maturity for evaluation, identification of suitable DNA markers for both vegetative and reproductive characters would be of much use at early stage of plant growth. In
the present study, SRAP marker approach was found highly efficient and reproducible not only for identification and authentication of hybrid status and analysis of alien genome introgression in coffee.

Thus, the present study has potential implications with respect to the identification of promising F₁ hybrids for commercial exploitation. Furthermore, there exists a vast scope for exercising selection in the progenies to follow the true breeding strategy towards deriving the new lines commercial for commercial cultivation.