Chapter 6

6.1 Summary and Conclusion

Mango is the national fruit of India and referred as ‘King of fruits’. It is one of the delicious and commercially important fruits. Indian mangoes have attracted world market because of its better look, attractive fragrance, delicious taste, colour shade, sugar-acid blend, shelf life, good table as well as processing qualities. Mango is rightly referred as ‘super fruit’ due to its phytochemical and nutrient contents. Mangoes are periodic and short-lived fruits. Hence the fruits cannot be stored for a much longer time. Mango twigs and leaves are used in several religious and cultural rituals like wedding, public celebrations and religious ceremony. Mango plant leaves are used in decorations and preparation of garlands. India is known to be the home of more than 1500 mango varieties, among which very few are cultivated on commercial basis. Maharashtra, Karnataka, Tamil Nadu, Bihar, Gujarat, West Bengal, Andhra Pradesh, Uttar Pradesh, Kerala and Orissa are some states where mango is cultivated on large scale. Mango varieties like Alphonso, Neelum, Bangalora, Rumani, Bangangpali, Kaepad, Peter, Sendhura, Jahangir, Mulgoa, Himayuddin, Mallika, Amrapali, Salem, Sindhu, Dashehari, Langra, Fajil and Totapuri are grown on commercial bases. India is the topmost mango producing country in the world. Alphonso variety is well known for its flavor, colour, texture and taste. On the other hand, spongy tissue, alternate bearing, low resistance towards pests and less productivity as some of the major drawbacks of this famous variety.

Mango can be cultivated right from sea level up to an altitude of 1400m. However, above 500m altitude, the fruit production decreases due to unfavorable climatic conditions. In Konkan region, mango is cultivated in all types of soils except in water logging and saline soil. Mango cultivations are found on large scale in coastal areas of Konkan. Devgad, Vengurla, and Malvan are major mango producing tehsils of Sindhudurg district. Besides, neighbouring Ratanagiri district is also well known for its mango production. Alphonso mango cultivations away from coastal area are less profitable as the climatic conditions and soil profile do not support mango crop. Availability of good productive land is a major limiting factor for people coming forward for Alphonso plantation. However, a dense plantation does not prove beneficial for mango and invites probably higher pest populations on mango crop. There is limited cultivable land available for Alphonso cultivation in Devgad.

Mango cultivations require minimum rainfall between 20cm to 250cm. Adequate quantity of rainfall from June to September is essential for growth and development of plant. Then after in October, plants start flowering and rainfall during this period adversely affects
fruit setting. Rain washes off the pollen grains from flowers affecting fruit setting and decrease fruit production. Also the cloudy atmosphere after rainfall promotes attack of pests and diseases. Incidence of sunlight on mango trees is vital for fruit production. Mist and dew readily get evaporated due to sunlight. Sunlight naturally arrests pest infestation and diseases outbreak. Availability of sunlight directly influences the photosynthesis mechanism and growth of plants. Flowering of mango is an important physiological event that starts fruit production. It is a very complex mechanism. This process is actually the result of different phenomena happening simultaneously in the plant. These phenomena include maturity of branches, availability of food, fertilizers, hormonal secretion and favourable climatic conditions.

Various insect pests attack mango plants from flower initiation phase to fruit harvesting stage. A large group of population in Devgad Tehsil is engaged in mango production and related activities such as distribution, processing, nursery growing, transporting and marketing. Mango production and related activities are providing direct and indirect employment opportunities for work force here. Mango crop helps the natives to earn their livelihood. In Devgad Tehsil, average mango production in a year is about 24,000 ton. Alike other crops, mango crop is also prone to insect pests. But the level of destruction of crop is determined by intesnsity of infestation, nature of damage and kinds of insect pest. Pests attack leaves, stem, fruits, inflorescence, branches and tender shoots of mango trees. Incidences of insect pests on mango crop are major hurdle in fruit production. Among the insectpests, mango hoppers and thrips are the most destructive pests on mango crop. Pest control and orchard management are crucial problems faced by the farmers in mango production.

Insect pest problem on Alphonso mango in Devgad is not a new one. Farmers here are struggling with pests from decades. But initially, pest incidences were certainly low, also very few pests were found to be infesting mango crop. Now-a-days the pest infestation scenario has been completely changed. Therefore, it has become necessary to survey the mango cultivations to evaluate the status of major and minor pests of the mango crop. The conventional pest control methods are insufficient and incompetent in managing present pest situations. Advances in pest management practices along with knowledge of pests can be effective in accelerating the mango production at present.

Cultivation of Alphonso mango variety is done on large scale in Devgad Tehsil. This variety suffers a serious loss due to incidence of various pests and diseases. Among these limiting factors, insect pest infestation is a major constraint in mango production. Thus, it is
essential to focus on this issue in order to protect the crop and increase mango production. Hence, to know the present pest status in Devgad tehsil, the work on insect pest distribution and their mode of attack was badly required; which has been attempted in the present studies. Effective management of the insect pests on mango requires a better understanding of the seasonal dynamics of the pest species present in a locality. These practices help to ensure the control measures that are specifically targeted at the pest population status and the stage of plant to achieve an effective control. The present work will certainly add to present day strategies in insect pest management and fruit production technology of mango crop in the prescribed study area as well as in other parts of the country.

Various methods were implemented to carry out present work. In present studies, work was carried out actually in the field i.e. in mango cultivations and laboratory. Informal interviews were implemented in research to gain information from villagers, farmers, labours, mango dealers, commission agents, contractors, transporters, consumers, etc. Similar discussions were done with pesticide dealers, fertilizers dealers and women engaged in selling mangoes in local markets. Formal interviews were also the integral part of the research work. Formal interviews were conducted with Government staff of Mango Research Center at Girye, Mango Co-operative Society of Devgad, Panchyat Samithi of Devgad and various Grampanchayat members. Personal visits and observations were essential part of the study work. Private walks in study areas assisted to become familiar with the locations of study area and to observe the mango cultivations. Secondary data was essential for the studies concerned with the details of study area, history, location, topography, climate, population, agricultural production, fruit production and other related data. That was collected from published and unpublished documents of government reports, local newspapers, articles, magazines, various research papers, Taluka Agricultural Offices, reference books, text books as well as the personal records available with some cultivators in the selected areas and some suppliers of pesticides and fertilizers. Numbers of methods were applied to carry out the field study during study period. Mango trees from selected sites were closely observed and observations were noted. For proposed study, infested plants were purposely selected and kept under observation. The plants and branches were tagged to continue the observations in further study. All plants were acutely observed and visited at regular interval. At preliminary levels, external examination of plants was done to record the readings. In case of severe infestations, symptoms were easily visible at a glance. But in low or just initiating infestations, acute observations were necessary. Methods like external examinations for insect pest,
external examinations of trees for evidence of damage, removing bark for collection of specimen and photography were applied in present work.

Many insect pests simultaneously attack mango trees, but each pest has its separate ecological niche. Each one has their own unique micro-habitat. Even though number of insect pests live on single tree, they have different ecological niche and they can survive only in there. They are well adapted to their niche environment and flourish within. These ecological niches support the life cycle stages of the pest, without which pests cannot complete their life cycle. There are several ecological niches of insect pests on a tree such as inflorescence, fruits, foliage, shoots, stems, bark surface and bark interior. These niches are utilized by insect pests for food and shelter and meanwhile these plant parts get damaged. Insect pest activities like boring, sucking, dew, prickling and secretions damage the plant parts.

Insect pests at different stages were collected from the fruits, leaves, mango seeds, twigs, flowers in the mango cultivations. Thorough observations were done and noted by studying them in detail. Photographs essential for research were taken in fields as well as laboratory. Present study was carried in Devgad Tehsil to evaluate insect pests infesting mango crop. From Devgad tehsil, five distant sites were selected for present study owing to their mango plantations in the region. First of all, Devgad itself was selected as it is one of the prominent regions in mango production. It is situated on coastal region and surrounded by Arabian Sea. The coastal area is interrupted with creeks and mangrove vegetation. Second site selected for study was Wada. This site was selected as large area is under mango cultivation. This site is 12 km away from Devgad town. This region is hilly and away from coastal region. Third site selected for study was Kunkeshwar that is 17 km away from Devgad. Kunkeshwar is located along the coastal area, but the mango cultivations are located in the interior parts of the village. Fourth location selected for present was Talebazar. It is 14 km away from Devgad. Area is composed by basalt plateau. Mango cultivations are generally located on plain area. Fifth location selected for study was Waghutan. It is 35 km away from Devgad. This region is surrounded by creeks and mangrove vegetation. Mango cultivations are on hilly and plain areas.

Present investigations on different insect pests on Alphonso mango cultivations in Devgad tehsil were carried out in field as well as under laboratory conditions during the years 2014-15 to 2016-17. Different insect pests were recorded by actual spot visits to the mango cultivations weekly in villages selected for the present studies namely Devgad, Wada, Kunkeshwar, Talebazar and Waghutan. Prescribed studies on the topic have revealed the
presence fourteen species of insect pests belonging to eight orders. During studies insect pests like mango hopper, fruit fly, thrips, fruit borer, mango mealy bug, stone weevil, shoot borer, stem borer, leaf webber, mango scales, leaf miner, aphids, ants and termites were reported. Various stages of the pests were observed on the mango cultivations in the tehsil. Life cycle of each insect pest infesting mango crop was studied in detail. Each life stage of insect pest was reviewed and observations were noted. Images of each stage of pest were taken for study.

Insect pest infestation is a major constrain in mango production in Devgad Tehsil. Due to pest infestations, mango production has become a crucial job. There are fourteen insect pests attacking mango crop right from nursery stage to maturity. To gain good yield, farmers have to protect mango crop at each reproductive stage from pest attacks. Protection of inflorescence and tender leaves from insect pest like mango hopper, thrips, mango mealy bug, aphids, shoot borer, leaf miner, leaf webber, ants and mango scales should be done as a part of first step of prevention. Further it needs to be done after fruit setting to secure the fruits from pest like fruit fly, fruit borer and stone weevil. As infestation of stem borer and termites is noted throughout the year, regular monitoring of mango trees as well as orchards management is essential for crop protection. Thus for producing good quality mangoes and to increase the fruit production, farmers should principally focus on pest control measures and orchard management practices. Farmers need to adopt integrated pest management practices to suppress pest population. Insect pest infestation on mango crop has gained importance in recent years. The overall pest problem is so severe that it poses significant threats to mango industry. As compared to last decade, pest infestation level has increased in many folds.

Studies revealed that pest problem on Alphonso mango in Devgad is not a new one. Farmers are struggling with it from decades. But there is huge difference between past and present pest infestation scenario. One of the reasons is the susceptibility of Alphonso mango variety to pest attacks. During the survey, farmers had mentioned that in 1980s, only 2-3 sprays were taken throught out the season to suppress pest population on mango crop. Mango hopper was the major pest in that period too. Pesticides like Endosulphan and Carbaryl were mainly used by farmers. Later on the use of endosulphan was banned by Government due to its adverse effects on environment and human being. Actually according to farmers which were interviewed during the studies, endosulphan was a better chemical for the pest control. It was legally banned as its occurrence was detected in ground water tables in the state of Kerala. It was due to overuse of that chemical in Kerala which was never the case in Devgad due to less per cent of overall infestations. It was further interesting to note that endosulphan
reached to underground water tables in Kerala as the water tables are very close to crust of
the land. It is not the case in other regions like Devgad and other parts of Sindhudurg as the
underground water table here is very deep under the crust; even below average 60-70 feet.
Hence percolation of the chemicals like endosulphan was least possible due to its optimum
use by the farmers.

In earlier 1980s, the pest infestation levels were low and easy to control. Then since
1995, the number of sprays gradually increased up to 6-7. After 2007, the conditions became
worst due to considerable increase in the population of pests, rise in percent of their
infestation, gradual rise in their resistance for the pesticides as well as changing climatic
parameters. Obviously, farmers were committed to spray the pesticides for at least 10-12
times in a mango season depending on the climatic conditions. As pest incidences on mango
crop has been found to be increasing in many folds in terms of population, concentration of
pesticides used earlier remained no more effective in controlling the same. No detrimental
effect of sprays was observed on insect pests. Subsequently farmers started to increase the
concentration of pesticides during its application.

Pest infestation pattern is different at each location owing to their geographical
location and climate. The pest infestation varies every year due to climatic changes. Different
infestation patterns are observed at same location due to varying pest management practices.
The climatic conditions during mango cropping season that is from October to April have
significant impact on insect pests. Every year, there are climatic uncertainties like post
monsoon rainfall, temperate fluctuations, storms, etc. These factors affect mango production
and even impact insect pest infestation pattern. The climatic uncertainties either support pest
population or it may arrest the pest attack. The effect of climatic conditions on each insect
pest is different. This phenomenon can be well explained with the following example.
Rainfall in December and January decreases the population of mealy bug, as the rain washes
the mealy bug nymphs crawling up on tree. Thus, nymphs die and cannot invade the mango
tree to complete further life cycle. Rainfall cannot completely suppress the mealy bug
population but considerable number is checked. The mealy bug batches coming out during
rainfall are washes whereas; the former and later batches survive and infest mango trees in
their further life cycle. It was observed that mealy bug population was less in the years when
there was rainfall in November and December. On other hand exactly opposite observations
were noted in case of fruit fly. Rainfall in December and January supports fruit fly
population. Rainfall in this period increase humidity in the region this conditions favours the
fruit fly infestation. Consequently the attack of fruit fly increased in successive period.
During studies, it was observed that geographical features of a location and the climatic conditions of particular year govern the pest infestation pattern on mango crop. However, it was noted that every year there are more or less changes in insect pest infestation pattern. In case of some pests, there are drastic changes in their populations. Farmers mentioned that a decade before attack of thrips was low and thrips was termed as minor pest. But today it is the most destructive pest on mango crop. One important observation noted during studies is that infestation of fruit fly is increasing gradually. In near future it may emerge as major pest on mango crop. Similar observations were mentioned by farmers in case of fruit borer. That attack of fruit borer may increase on large scale in near future because incidence of fruit borer is gradually increasing. Attack of fruit borer causes premature fruit drop, which ultimately affects the yield. Pest scenario will keep on changing in proportion to climatic conditions and pest management practices adopted by farmers. Studies revealed that mango hopper and thrips are the most dominant insect pest on mango crop. Mango hopper and thrips are the major insect pests on mango crop, while others are also responsible for damaging the crop but the levels of infestation are low. Mango hopper and thrips contribute to maximum yield loss every year.

Among the three species of mango hopper, *Idioscopus niveosparsus* (Lethierry) was the most dominant species recorded on mango crop. While the other two species namely *Amritodus atkinsoni* (Lethierry) and *Idioscopus clypealis* (Lethierry) were rarely recorded. Mango hopper was recorded as major and destructive pest on mango crop. It was present in all mango cultivations which were included in the study. Infestation of hopper is severe and major threat to mango crop. Infestation of fruit fly *Bactrocera dorsalis* (Hendal) was mainly observed in mango cultivations located in coastal area. Fruit fly damaged harvestable fruits. Overall, infestation of fruit fly is medium on mango crop. Attack of thrips *Scirtothrips dorsalis* (Hood) is severe on mango crop. Farmers find it quite difficult to control the attacks of thrips. Thrips was recorded at all location and termed as major pest on mango cultivations. Attack of fruit borer *Noorda albizonalis* (Hampson) is low to medium, but it was observed that infestation is gradually gaining momentum. In near future, it may emerge as a major pest on mango crop. Infestation of mango mealy bug *Drosicha mangiferae* (Green) is low to medium on mango crop. However, attack of stone weevil *Sternochetus mangiferae* (Fabricius) was found to be very low. Very few stones were found to be infested by this pest. Attack of shoot borer *Clumetia transversa* (Walker) was medium on mango crop. Though over all attack is low, it is mainly responsible for damaging young shoots. Infestation of stem borer *Batocera rufomaculata* (de Geer) is remarkable on mango crop. As it is the only insect
pest on that can completely kill the mango trees in case of severe infestation. Furthermore, infestation of stem borer is increasing at alarming rate. Attack of leaf webber Orthaga exuvinae (Hampson) was low and mostly confined to neglected and old mango cultivation. Attack of mango scales Aspidotus destructor (Newst) is low to medium. But distribution of pest was noted in all locations. Attack leaf miner Acrocercocops syngramma (Meyrick) was also low on mango crop. Attack of mango scales Aspidotus destructor (Newst) is low to medium. But distribution of pest was noted in all locations. Attack leaf miner Acrocercocops syngramma (Meyrick) was also low on mango crop. Occurrence of ants Oecophylla smaragdina (Fabricius) was very less and mainly confined to neglected and unmanaged mango cultivations. Attack of termites Odontotermes obesus (Rambur) was very less. Very few mango plants were noted with termite infestation. It was observed sucking pest like mango hopper, thrips and mealy bugs are more harmful to mango crop.

Studies revealed that farmers’ knowledge about pest management was so less that ultimately attributed to high yield loss. Farmers fail to exercise plant protection measures like acute monitoring, regular pruning, application of pesticides, weeding, manure application and mulching. Farmers are induced to use the chemical pesticides mainly due to fear of low production, insufficient knowledge about pest life cycle and its biological control. Farmers were not much interested in updating their knowledge related insect pest management, pest life cycle or other plant protection measures except use of pesticide. Besides, the marketing strategies adopted by pesticide industries such as demonstration and seminar attract farmers towards the pesticides. No attention is paid on pesticides available in market that are being toxic to high toxic. In some cases, it was observed that farmers were unable to identify insect pest by their names. They described pests by related symptoms or plant parts under attack. Farmers’ knowledge especially about insect pest was found to be very low. Some farmers who are producing mangoes from two decades or even more than that were unaware of pest life cycle. In fact, they were found to have some misbelives about the life stages of insect pest. These misunderstandings lead to inappropriate pest management practices. Such observations were recorded in case of pests like stem borer and thrips. Stem borer was initially a minor pest and its infestation was very less and mainly confined to old and ignored mango trees. Thus very few farmers had knowledge about its management. In later period, due to unawareness and negligence, attack of thrips and stem borer has increased immensely. However mango hopper and thrips were mentioned as the most destructive pest by farmers.

Farmers admitted that they use paclobutrazol to induce flowering and overcome problem of irregular fruit bearing in Alphonso mango. Application of paclobutrazol increases number of hermaphrodite flowers which finally helps to increase mango production. Also the
dose of paclobutrazol applied to mango trees are gradually increasing. But it was observed that application of paclobutrazol was not supplemented by addition of fertilizers that is essential for growth and development of trees. This made plants weak and suppressed the productivity in future. During this research, it was observed that many farmers exercise biased methods of pest management. They use duplicate pesticides owing to their low prices. On other hand, farmers do not follow the doses that are prescribed by pesticide companies. They just either increase or decrease the prescribed concentration of pesticides while applying them for better results. Even some of the farmers mix two different pesticides together and applied on mango trees. These practices are found to be very common now a day. Farmers mention that prescribed concentrations are ineffective in controlling the pest attacks.

Farmers admitted that one of the major problems faced by them other than insect pests was the attack of monkeys and langurs in the mango orchards. The problem is serious in Talebazar, Kunkeshwar and Wada whereas low in Devgad and Waghotan. Monkeys are responsible for considerable fruit loss. Their jumping and other activities vibrate the trees which lead to fruit drop and damage mango trees. If monkeys invade mango cultivations after March when harvestable fruits are present on mango trees and their attack leads to heavy loss. Farmers find it quite difficult to cope up with this problem. They mentioned that insect pests can be controlled by applying pesticides but the attack of the monkeys is beyond their control.

Farmers are unable to plan their pest management strategies according to changing climatic conditions. Farmers lack the knowledge of correlation of pest incidence with corresponding climate. They are unable to predict the pest infestation pattern according to the daily climatic changes. By observing daily environmental changes, they are unable to guess the increase or decrease in any pest attack. Hence they fail to control the pest attack before it flourish and attack mango crop severely.

During study period at each location, high infestation level was noted every year. It was observed that the infestation level is high irrespective to the geographical features and climatic condition. The climatic conditions are varied every year but attack of these two pests is high. This depicts that these pests are almost adapted to all climatic conditions and can survive in all odds. Climatic uncertainties like post- monsoon rainfall, increase or decrease in temperature, decrease in humidity etc. have no significant impact on the population of mango hopper and thrips.
Due to increase in pest populations, many pesticides are available in market to check the pest attacks. But it was observed that farmers had failed in proper application and utilization of pesticides to check pest outbreak. Farmers use same pesticides continuously to arrest pest population on the crop. This practice ultimately had made pesticides ineffective in controlling the pest attack. Simultaneously other malpractices exercised by farmers are equally responsible for the present condition. Implementation of improper or random concentrations of pesticides and ignoring the standard range or concentrations that were suggested by the manufacturers, were some the malpractices noted during study period. Moreover, they mix two or more pesticides in wrong proportion for spray. Some farmers use less concentration of pesticides than mentioned.

Indiscriminate use of pesticides has adversely affected the natural predators of different pests in the area. Along with pests, pesticides also eliminate the non-target species such as natural enemies of pests, other insects and pollinating agents. During pesticide application period from October to March, death of various butterflies was observed. The natural enemies help in control of pest populations by their predation. Pesticides have created imbalance in pray and predators relationship. Furthermore previously minor pest like thrips, mealy bug, fruit borer and stem borer have emerged as major pests in last few years. These pests are severely infesting the mango cultivations and should be managed at earliest before they pose any major threat to mango industry further.

Along with application of pesticides, farmers need to understand all these aspects related with flowering phenology and pest attacks. All these aspects are correlated with each other. Farmers should also have thorough knowledge of pest life cycle and its nature of damage. Application of paclobutrazol not only promotes reproductive growth of plant but also supports pest incidences indirectly. Thus, addition of paclobutrazol and fertilizer should be done in essential quantity that will be beneficial to mango tree. Trees should be supplemented with bio-fertilizers to increase production. It was observed that farmers have very few knowledge about the biological control of the insect pest. They lack the information about the natural enemies of pest like predator, parasite and insect pathogens. Very few farmers had knowledge about the natural enemies of insect pests on mango crop.

During studies, it was observed that very few farmers thoroughly study the present insect pest and climatic scenario to exercise the plant protection measures. Few educated farmers referred books, journals, periodicals, pest control information booklets published by various agencies to determine the pest control plan. They were also found to focus on other factors that are equally responsible for hampering mango production. They mentioned that
only insect pest attack is not responsible for lower the mango crop yield. Those farmers had also studied the climatic changes and flowering pattern at initial stage of flowering flush. Considering all these environmental and plant physiological aspects, they define further strategies. Such observations were noted in case of large scale farmers who were completely economically dependent on the mango crop. They cited that along with insect pest other factors responsible should not be sidetracked. In pest management practices priority is only given for arresting insect pest attack. In case of failure in flowering flush, intensive fruit drop, leaves drop, or other major issues that is likely to affect the mango crop are generally ignored by farmers. Only few of them seek expertise guidance to control the situation.

Pest infestation is a major limiting factor in mango production. In certain cases it was observed that there was complete crop failure due to attack of insect pest on mango crop. Presently, 12-13 sprays are taken on mango crop right from flower initiation to fruit maturity stage. Insect pests have developed resistance to pesticides. Thus, there is urgent need to switch the plant protection measures. Use of biopesticides, plant products and natural enemies are the solutions to control the current situation. In present decade, more emphasis is laid on use of pesticides rather than regulation of insect pests through implementation of other control measures. Plant protection measures are not only confined to pest control but also fruit quality and yield management.

Marketing of mangoes in Devgad is mainly controlled by intermediaries like wholesalers and commission agents. Mangoes produced in Devgad are sold in local market, exported and sold to local canning dealer. Very few farmers sold their produce directly to the consumers. Marketing of mango is a critical task as there are no storage facilities coupled by poor road infrastructure.

Irrespective to pesticides, there are several other methods that are implemented to control pest attack. Some of the methods are namely use of sterile male technique to control attack of fruit fly. Along with pest attacks, diseases infestation is also a threat mango crop. Diseases such as pink diseases, branch drying, shoot blight, black banded, phanerogamic parasites, gummosis, red rust, anthracnose, powdery mildew, phoma blight, blossom blight, black sooty mould and stem end rot were reported on mango crop. However, damaged caused by diseases is comparatively less than that of pest infestation. Besides these, there are other factors too that contribute to lower the mango production. These factors are characteristics of the alphonso mango variety, characteristics of mango orchard, socio-economic characteristics of farmers and climate uncertainties.
All these adversities eventually are responsible for drastic fall in mango production of Devgad Tehsil. A decade before mango productivity of Devgad was 5 tons per hectare which is now dropped to 2.12 tons per ha. Expenditures done on mango crop are rising due to increase in spending on orchard management, crop protection and labour wedges. In spite of all these spending there is no guarantee of good crop. Expenditures are either equal or more than returns. Thus net profit earn by farmers is very less. Changes in pest scenario, climate uncertainties and increasing expenses are major constrain in mango production. Furthermore, irregular bearing is a major drawback of Alphonso mango variety. It leads to uncertainty in fruit production. Irregular bearing in Alphonso mango variety is mainly due to its genetic characters and climatic conditions. Monoculture of Alphonso mango variety has marginalized nonpopular mango varieties. Forest areas are being cleared for plantation of Alphonso mango variety.

The excessive use of pesticides on mango crop is responsible for development of resistance among the insect pests, decline in number of natural predators and increase in problems of minor pests. Companies always promote pesticides on basis of their curing effects but their adverse impacts are always overlooked. Plant protection measures play significant role in mango industry as pest attack is the vital reason to hamper mango production. But the incidence of an insect pest cannot be completely controlled just by application of pesticides as pest prevalence is highly influenced by the climatic conditions. Studies had revealed that mango crop is encountered by several harmful insect pests that attains peak in February to April while subsides in May with variations in agro-climatic conditions. Other threat to mango crop is repeated flowering. It provides continuous ecological niche for insect pests to feed and breed. Thus it favours pest population and several generations of pest occur in a cop season. Mango hopper and thrips are mainly benefited by this phenomenon. They continuously get inflorescence on mango tree for infestation. Thus mango tree is continuously subjected to pest infestation. In case of Alphonso mango variety repeated flowering is a common phenomenon.

Paclobutrazol (Cultar) application is regular practice to promote the flowering phase in mango plant. Almost all the Alphonso mango plants are applied cultar to over the problem the alternate bearing. Thus flowering phase in Alphonso mango variety begin early as compared to other varieties that included non-commercial and native mango varieties. There is no synchronization in flowering phase of mango verities. Thus Alphonso mango plants fail to receive pollen grains from other mango plant. Consequently cross pollination do not take
place. On other hand self-pollination of Alphonso variety is poor. All these factors effect fertilization of perfect flowers and fruit setting.
6.2 Recommendations:

1. **Thorough knowledge of mango tree, insect pest and climatic factors influencing mango production:**

   Principally farmers should have thorough knowledge of mango tree, insect pest and climatic factors influencing mango production. Basically farmers should have complete knowledge insect pest life cycle, nature of damage, period of occurrence and control measures. Farmers should be able to predict the infestation pest infestation according to the daily climatic changes. By observing present environmental conditions, they shall be able to guess level of insect pest attack. Weather forecasting methods need to be applied to control pest attack.

2. **Reduce the use of chemical pesticides:**

   Farmers should seriously study the adverse effects of pesticides used on mango crop to control pest and minimize its use. Presently numbers of pesticides are used for plant protection.

3. **Integrated pest management practices:**

   Farmers usually rely of chemical pastiches to control pest attack. However, farmers should switch to integrated pest management practice that is combination of various reliable techniques. Study in detail about natural enemies of insect pests attacking mango crop should be done in order to check the insect pest naturally.

4. **Implementation of new techniques in mango industry:**

   New technique like rejuvenation of old orchards and canopy management should be implemented. Rejuvenation must be applied for old mango plants that are large size. Similarly canopy management should be adopted.

5. **Orchard sanitation:**

   Orchard sanitation plays important role in plant protection measures. Thus, good orchard sanitation practices need to be adopted by farmers.

6. **Marketing of mangoes:**

   Farmers should individually involve in marketing of mangoes rather the relying on agents to sell their produce. They should individually communicate with customer so that they can gain good returns.

7. **Attend trainings, seminar and awareness programs:**

   Government, agricultural institutes, non- government organizations etc. organize various trainings, seminar and awareness programs for farmers to exchange idea related to mango crop. Farmers should attend such programs to seek recent knowledge related to mango crop.
6.3 Future Scope:

Further research can be done on several aspects related to mango industry. The mango insect pests like hopper, thrips are said to developed resistance against the pesticides but there is no strong evidence to prove it. Thus further study may be done to decode the mutations in these pests. Presently researchers have been successful only in identifying the pheromone of fruit fly. Similarly research should be carried to decrypt sex pheromones and juvenile pheromones of insect pests damaging mango crop. That can be used against pest as a part of biological control.

At present farmers mechanically trace the local of stem borer to remove the grubs. This process requires close examination of each and every plant accomplished by skill labours which is not possible for every farmer. Thus new technique should be developed to control attack of stem borer. To control all insect pests infesting mango from nursery stage to maturity it is essential to develop an integrated pest management technique. This should include all means of control measures like chemical, biological and mechanical.

Physiological and genetic study of native mango varieties is essential. There are several local varieties which are not yet studies. These varieties have different vernacular names at different locations. It is important to bring uniformity in their nomenclature. Thus genetic study is necessary of each mango variety. This will help to identify the mango varieties, study the diversity and conserve the mango species.

Models of integrated pest management practices on mango should be developed and demonstrated. Training programs should be organized to educate farmers, youth and labours regarding innovation in mango crop protection. On other hand to predict incidence of insect pest on mango crop monitoring and weather forecasting should be implanted.

Research should be carried out on use of various plant products and essential oils that can be used to against insect pests. Similarly, studies should be carried on natural enemies of insect pests like predators, pathogens, insects, fungus, microbes, bacteria and genetic disturbance.

Studies should be done on weather based forecasting of insect pest population on mango crop. Similar research should be done on effects of temperature fluctuations or sudden changes in environment on insect pest. Continuous research should be done on the development of new pest resistance mango varieties.
6.4 Limitations of research work:

There were several limitations to carry out the present study work. It was not possible to reach each location from selected site due to time consent, distance, geographical barriers as well as the unresponsive mentality of the cultivators. Distance was a major constrain in the research work as the selected location were far from each other. Actual study of insect pests was only possible from October to May that is infesting period of pest, rest of the period research work was not possible. From June to September it was not possible to conduct field visits due to heavy rainfall. Some mango cultivations were in the interior pats of the villages while some of them were on hill slopes. It was difficult to reach such mango cultivation. More time was required to reach the location rather than the actual field work. At times it was difficult to observe each and every mango tree from selected cultivation as sample size was high. Also it was difficult to trace the pest infestation and collect the specimen due height of tree.

Collection of specimen was a crucial job as emergence of each pest on mango crop was independent and governed by the climatic factors. Also collection of different life stages of pest was quite difficult as they were confined to their ecological niche.

Every farmer has adopted different plant protection methods. Each farmer has his own pest management strategy. Therefore, there were variations in pest infestation pattern at same location. Study of natural enemies of insect pests attacking mango crop was not possible as their population was very low and hardly any farmers had knowledge about it. During studies it was observed that insect pests are developing resistance to the pesticides applied to them. But actual gene level study was possible due to lack of resources and equipped laboratory. Genetic study of successive generations can reveal the information regarding development of resistance. Mere observations cannot be considered valid for the research.

Indiscriminate use of pesticides leads to soil and water pollution. But analysis of soil and water samples was not possible due to unavailability of laboratories in vicinity. Similarly fruits cannot be tasted to find the pesticide residue in pulp. As no research centers are available in Sindhudug district to carry out technical research work. No previous work is carried out on present studies; therefore limited literature was available on the topic.

Table 6.1 Mango crop protection schedule:
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Time of Spray</th>
<th>Recommended Insecticides</th>
<th>Quantity of pesticides per 10 lit.</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First Spray at Vegetative Flush Stage</td>
<td>Cypermethrin 25% Or Fenvelrate 5% Or Deltamethrin 2.5% Or Profenophos 40% + Cypermethrin 4% Or Chlorpyriphos 50% + Cypermethrin 4%</td>
<td>3 ml 5 ml 9 ml 15 ml 10 ml</td>
<td>Spray on complete tree to control the hopper population</td>
</tr>
<tr>
<td>2</td>
<td>Second Spray at bud burst Stage</td>
<td>Quinalphos 25% Or Carbaryl 50% Or Profenophos 40%</td>
<td>20 ml 20 gm 10 ml</td>
<td>To control powdery mildew and anthracnose mix 20 gm Sulphur 80% or 10 gm Carbendazim 50% or 5 ml hexaconazole 5% or 10 gm Thiophenate methyl 70 % or 20 gm</td>
</tr>
<tr>
<td>3</td>
<td>Third Spray 15 days after 2nd Spray</td>
<td>Imidachloprid 17.8% Or Clothianidin 50%</td>
<td>3 ml 1.2 gm</td>
<td>Propineb 70% in 10 lit solution</td>
</tr>
<tr>
<td>4</td>
<td>Fourth Spray 15 days after 3rd Spray</td>
<td>Thiamethoxam 25% Or Triazophos 40%</td>
<td>1 gm 10 ml</td>
<td>Propineb 70% in 10 lit solution</td>
</tr>
<tr>
<td>5</td>
<td>Fifth Spray 15 days after 4th Spray</td>
<td>Fenthoate 50% Or Diamethoate 30% Or Deltamethrin 1% + Triazophos 35% Or Lambda Cyholothrin 5%</td>
<td>20 ml 10 ml 10 ml 6 ml</td>
<td>To control powdery mildew mix 5ml hexaconazole 5% or 10gm Cerbendazim 50% or 20gm Sulphur 80%in 10 lit Solution during 3rd, 4th and 5th spray</td>
</tr>
<tr>
<td>6</td>
<td>Sixth Spray 15 days after 5th spray if necessary</td>
<td>Insecticide recommended for 5th spray but not used for 5th spray</td>
<td></td>
<td>Spray if necessary</td>
</tr>
</tbody>
</table>