1.1 Introduction:

1.1.1 History and importance of mango:

Mango is national fruit of India and referred as ‘King of fruits’ (Rosalin 2014). 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 and good table as well as processing qualities. Along with this, mango also possesses medicinal and nutritive values. A ripe mango is used for desert. Along with this, mango fruits are also exploited for jam, squash, beverages, sweets, baby food, toffee and a common ingredient in soft drinks, ice creams, shakes and syrups. While the sour unripe mango fruits are used for preparing pickles, syrups and chutneys. Mango is rightly referred as ‘super fruit’ due to its phytochemical and nutrient contents. Mangoes are periodic and short-lived fruits, these fruits cannot be stored for long time (Durrani et al. 2012). Mango fruit is a rich source of vitamins and dietary minerals. Similarly the mango seeds contain carbohydrates and proteins. It has significant demand from many countries in world. Approximately mango is produced half of the rest tropical fruit produced universally.

The chemical composition of mango peel resembles citrus fruits; they are rich source of dietary fibers (Sarwar et al. 2014). Mango seed stone comprises of 65% starch, 2.9% reducing sugar, 5.7% proteins, 0.8% pectin, 9.3% fat and 1.1% tannins. Thus mango seed kernel flour is suitable for human consumed besides being used as animal feed (Sonthalia 2015). The shape and size of ripe fruit is variable and depends upon the mango variety. The colour may be yellow, orange or green. Generally fruit colour indicates its maturity and presence of defect. The unpeeled ripe mango gives off a distinct smell. Seed is single, flat, oblong and located at the center. Seed can be hairy or fibrous at surface depending on the variety. The seed coat encompasses an embryo of about 1 cm thick, 4-7 cm long and 3-4 cm wide (Fowomola 2010).

Mango being one of the ancient fruits in India is associated with Indian heritage and culture. Mango twig 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. Leaves and twigs of mango plant have special importance in religious functions, they are recognized as sacred and are integral part of each holy function. Along with this, mango themes and paisleys are
popular embroidery styles in India and used in decorating Kashmiri shawls, Kanchipuram sarees etc. (Gopalkrishnan 2013). A large group of population in India is engaged in mango production, processing, transportation and marketing. Mango production and related activities are generating employment opportunities and helping to earn the considerable amount of foreign capital (Yadav 2016). Mango farming is a crucial means of livelihood and generates employment for rural unskilled masses in many states of India like Maharashtra, Karnataka and Gujarat. A large workforce depends on mango crop for their source of income. Though mango crop is seasonal it employs large masses in that period. Men are generally involved in tasks that require more muscular energy like harvesting fruits and transportation. While women participation is mostly in orchard sanitation techniques, weeding and sell of mangoes in local market.

Mango plant has its origin in India subcontinent and Southeast Asia (Fowomola2010). Mango has originated from one of the Eastern country. However, historically mango is said to be the native of Indo-Burma region. It has been said that cultivation of mango began in India nearly before 4000-6000 years ago. As it is one of the ancient fruits, its references are found in holy books like Ramayana and Mahabharata. Coral Clusius was the first botanist to refer mango as Mangas and Amba in 1605 (Chattopadhyay 2010). Later on in 1658, Bontius for first time gave the name Mangifera and was referred as Arbor Mangifera, which means a tree producing mango. Subsequently in 1753 Linnaeus changed to its present name that is Mangifera indica Linn.

Mango is established in India a long term before. Alexzender had noted some of the selected mango verities from India. Similarly some Buddhist voyagers have also cited the Indian mango during their journey. In 16th century Portuguese spread the mango crop from India to other parts of the world. During this period, mango reached Philippines and Persian Gulf. Thereafter it extended to Yemen in second half of the 17th century. In the course of 18th century mango was transported from Goa to South Africa and later it was taken to Brazil. In middle of 18th century mango crop was taken to West Indies, Hawaii in 1809, Egypt in 1825, California in 1860 and Florida in 1869 (Chattopadhyay 2010).

India is known to be home of more than 1500 mango varieties but few of them are cultivated on commercial bases. Maharashtra, Karnataka, Tamil Nadu, Bihar, Gujarat, West Bengal, Andhra Pradesh, Uttar Pradesh, Kerala and Orissa are some states were mango is cultivated on large scale in India. Mango varieties like Alphonso, Neelum, Bangalora, Ruman, Bangangpali, Kaepad, Peter, Sendhura, Jahangir, Mulgoa, Himayuddin, Mallika, Amrapali, Salem, Sindhu, Dashehari, Langra, Fajil and Totapuri are grown for commercial
benefits. India is the top most mango producing country in the world. But most of the mangoes are consumed domestically. Among the cultivated mango varieties, there exist a wide diversity in fruit shape, size, skin, colour, flavour, aroma and taste. Along with this, variations are also observed in leaf colour, apex, foliage density lamina and venation. Each variety has its own unique signature quality. About 1200 mango varieties exist in country (Chowdhury 2015).

Alphonso variety is well known for its flavor, colour, texture and taste. On other hand, spongy tissue, alternate bearing, low resistance towards pest and less productivity as some of the major drawbacks of this famous variety (Salvi et al. 2013). Spongy tissue is a kind of ripening disorder. It is referred as a soft center. Apart from this, Alphonso variety bears fruits that have thin skin due to which they are susceptible to pest attack.

India is leading a country in mango production in the world. Similarly India leads in area under mango cultivation. India produces about 10.99 million tons of mangoes per year. Total area under mango cultivation in country is about 1.23 million hectares (Bhattacharyya 2014). The average mango yield of world is 25t/ha. While that of India is as low as 6t/ha. As compared to world productivity, mango productivity in India is very low. But the national productivity of India is 5.5 t/ha. Uttar Pradesh tops the list in India with maximum productivity of 12 t/ha (Gopalkrishnan 2013). In Konkan region mango is an economically important fruit crop. Mango cultivations provide both employment and income to farmers.

Mango tree grows up to 35-40 feet in height. The crown radius is about 25-30m. The mango leaves are evergreen and simple. The leaf arrangement is alternate. Length of leaf is 15-30 cm and breath is up to 6-16 cm. At early stage, leaves are orange-pink and turn green at maturity (Fowomola 2010). Mango belongs to family Anacrdiceae and class Dicotyledonye. Genus of Mangifera includes 69 species (Yadav 2016). The varieties of mango are mainly classified into three categories as early, mid-season and late based on the availability of the mature fruits.

**Mango Mangifera indica (Linn) developmental stages**
Fig. 1.1 Mango inflorescence

Fig. 1.2 Pea size mangoes
1.1.2 Soil profile and climate suitable for mango cultivation:
Mango can be cultivated from sea level up to 1400m altitude. However above 500m altitude, the fruit production decreases due to unfavorable climatic conditions. Mango crop can be grown on alluvial and lateritic soil. Soil with good drainage and aeration is more suitable for mango cultivation. Water holding capacity of soil should be less to avoid the water logging conditions. Poor water drainage affects the plant progression. Plants become weak and prone to various pest and diseases. Hence mango cultivations are avoided in wetlands or water logged areas. Clay and black soil is incompatible for mango cultivation. As mango is a deep rooted tree, it requires groundwater table at minimum 2m depth.

In Konkan region, mango is cultivated in all types of soil except in rocky, water logging and saline soil. Obviously flowering and fruit setting in all areas is quite different. Mango cultivations in all types of soil do not prove much beneficial. Alphonso mango cultivations are proved to be advantageous on mountain slope near sea shore. On the other hand, mango cultivations on plain and valley region are less productive. The mountain sloping towards the sea shore, which is in west direction, is the best site for mango cultivation. Due to slope, water does not percolate in soil and plant do not get sufficient amount of water. Thus water stress is developed within plant. This stress actually triggers the reproductive stage in mango tree. Along with this, winds blowing near sea boost the flowering stage. All these factors are essential to initiate the flowering flush. In Devgad Tehsil, the soil is lateritic in nature and area is plain. Being plain region, winds blowing from sea spread uniformly throughout the mango cultivations. However lateritic and rocky soil types in Devgad do not let water to percolation within soil, thus creating water stress in mango plants.

Mango cultivations are found on large scale in coastal areas on Konkan. Devgad, Vengurla, Rajapur, Malvan and Ratnagiri are major mango producing Tehsils in Sindhudurg district. Alphonso mango cultivations away from coastal area are less profitable as the climatic conditions and soil profile do not support mango crop. In such areas, cultivation of mango varieties like Kesar and Goamankur are found to be more suitable. Along with orchards, mango tree plantations are also observed near the houses, roadsides and residential complexes. These mango trees also produce good quality fruits depending on their nurture.

Availability of good productive land is a major limiting factor for people coming forward for Alphonso plantation. However dense plantation does not prove beneficial for mango, but invites probably higher pest population on mango crop. There is limited cultivable waste land available for Alphonso cultivation in Devgad. Whatever suitable land
is available for cultivation is owned by many family members leading to many relevant disputes. The land available near Sahyadri foot hills is not suitable for mango plantation due to low yield and late fruit setting. So the availability of land for new plantation is a major constraint. All these limitations force the new comers to go for hard rock plantations. Moreover the quality of Alphonso mangoes grown on lateritic rock is also good.

Although mango plants can be grown from 0°C to 48°C; it is not a temperature which can support for flowering and fruit setting. The optimum temperature range for better mango production is between 10°C to 42°C. During flowering period, temperature should be not less than 15°C. If temperature drops below 2°C, reproductive and vegetative organs of plant are likely to be damaged. But during fruit setting, temperature needs to be up to 20°C. Mango productivity is highly influenced by the climatic changes. October heat followed by rainy season creates abiotic stress conditions. Climatic changes and unseasonal rains delay the flowering phenology. Undesirable climatic conditions initiate vegetative flush instead of flowering flush. Delayed rains and lack of cold temperature hamper the flowering flush within a season which finally affects the fruit setting. October heat and cold in November as well as December are the factors essential to create the abiotic stress to initiate the flowering flush. Within 80-90 days the vegetative flush gets mature (Salvi et al. 2013). Particularly Alphonso variety is very sensitive towards temperature extremes. Sudden rise in temperature may develop black spots on fruits and also can cause fruit drop.

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 plant starts flowering and rainfall during this period adversely affect the fruit setting. Rain washes off the pollen grains from flowers affecting the fruit setting and decrease the fruit production. Also the cloudy atmosphere after the rainfall promotes the attack of pest and diseases. Moreover water stress is essential before flowering phase. Therefore prolonged rainy season pushes the flowering period further.

Mango cultivations do not prove profitable in the region of gusty wind. As it not only damages the fruits but also breaks the branches of mango tree. But in case of Konkan region, wind blowing from the sea promotes the flowering in mango plant. Also the wind washes off the dew and mist present in mountain region including mango cultivations. It accelerates fruit setting and ultimately promotes the mango production. In case of mango plant maximum pollination is done by the insects while in small quantity, wind is involved.

Incidence of sunlight on mango tree is vital for fruit production. Mist and dew readily get evaporated due to sunlight. Sunlight naturally arrests the pest infestation and diseases
outbreak. Availability of sunlight directly influences the photosynthesis mechanism and growth of plants. In accessibility of plenty sunlight, fruits grow well and can be harvested early. Such fruits have attractive colour and good market value.

Generally farmers need to have preliminary information about the climate and topography of the location prior to the mango plantation. A high land with porous soil with good drainage is most suitable for mango plantation. While planting, canopy size of the full grown tree should be taken into account and accordingly space in between plants should be ascertained. In Devgad tehsil, mango cultulations are also observed on Laterite rock due to unavailability of suitable land. Mango plantations away from the sea are less productive, thus hard rock plantation is the better option. Alphonso mango cultivation grows well in laterite rock and is known for its unique flavor and texture.

1.1.3 Propagation of mango:

Initially mango was mainly propagated by seed. With advances in the technology of propagation, now it is propagated by different vegetative methods. Generally grafting methods such as inarching, veneer grafting, soft wood grafting and stone grafting are practiced to produce mango saplings. Chattopadhyay (2006) reported that viability of mango stone (seed) is inversely proportional to duration of storage. For grafting, freshly extracted healthy stone of mature ripe fruits are sown in beds. During rainy season seedlings are lifted with along with soil ball. Then a strip of bark about 6.0-7.5 is removed from the seedling. A similar size strip is removed from the scion shoot selected for grafting. Scion and root stock must be of the same thickness. Also the selected scion needs to be healthy along with well-developed foliage. Then the exposed surfaces of seedlings and scion are fitted together carefully without leaving gap in between. It takes about 1.5-2 months for successful union of scion and stock.

1.1.4 Flowering phenology of mango:

Flowering of mango is an important physiological event that starts the fruit production. Flowering mechanism in mango is a complex process. This process is actually the result of different phenomenon happening simultaneously in plant. These phenomena include maturity of branches, availability of food, fertilizers, hormonal secretion and favourable climatic conditions. When these conditions are well synchronized, flowering stage is initiated. Besides this, cold weather, water and wind stress are essential to accelerate the emergence of flowering flush. Successive phases of flowering are fruiting, fruit growth, maturity and ripening. Flowering stage occurs in the month of November and December. However it is also prominently influenced by the local environmental factors. Generally
mango tree starts bearing flowers and fruits after 4-5 year. Mango flowers are small, sessile, aromatic and yellowish green in colour. Mostly flowers blooms in morning. The inflorescence in mango is of racemose type. Development of flowers requires macro and micro elements but the development of hermaphrodite flowers requires more nutrient supply as compared to male flowers (Kumar et al. 2014). The inflorescence may be either terminal or axillary based on the position of the pinacles on the branches. Inflorescence can be divided into two main categories like pure inflorescence and mixed inflorescence. Former one consists of only floral buds and later one is mixture of leaves and floral structure. In Devgad, flowers are initiated in month of November-December. In mango, mainly two types of flowers are observed, male flowers and hermaphrodite flowers. Male flowers consist of male parts with viable pollen grains. While hermaphrodite flowers are also known as perfect flowers and possess both male and female parts that are androecium and gynoecium. (Chattopadhyay 2006) mentioned that average percentage of perfect flowers in Alphonso variety is 6-11%. However fruit setting is a varietal character that is prominently influenced by the abiotic stresses during flowering phase, flower sex ratio and presence of pollinating agents.

1.1.5 Irrigation:

Flower imitation and fruit retention are mainly influenced by method of irrigation; thereby directly influencing the final fruit production. It is necessary to irrigate the young plants once a week except in monsoon season. Immediately after the monsoon, it is essential to weed the area around the plants and a circular ring should be made around the base of the plant for irrigation. Each plant should be irrigated in such a manner that the excess water should not reach other plants in vicinity. Flow of irrigated water can promote the transmission of pest or diseases form one plant to other. New grafts require 20 liters of water once in a week during winter and twice in summer. Devgad region is mainly composed of laterite zone where scare water resources are available during post monsoon period. Under such conditions, it is essential to irrigate a mango tree for initial 2 to 3 years. Drip irrigation method has been found to be more beneficial for plant and is economical for the farmers. Mango plant should not be irrigated prior to flowering stage as water stress is essential to initiate flowering flush. But after flowering stage, when mango fruits attain pea size, the plant must be irrigated. It reduces the fruit drop and enhances the growth and development of fruit.

1.1.6 Manuring:

Use of manure supports healthy and fast growth of the plant. However common suggestions are not possible in case of manuring as application, it depends on soil profile,
plant stage, etc. The organic manure applied before planning takes care of the plant up to one year. However, many farmers expect faster initial growth, in that case application of fertilizer is a better choice. But continuous application of fertilizer leads excessive and undesirable growth of plants. Generally the land under mango cultivation and soil richness should be considered before manuring. To overcome the major constraints in mango production like alternate bearing, low fruit setting and retention, fertilizer application is essential. The best period for manuring young plants is before monsoon. The method of fertilizer application is influenced by antiquity of mango plants. For young plants, basin method is preferred while for older plants furrow method is more suitable. In case of high density plantation addition of fertilizer is essential.

1.1.7 Fertilizer application:

Period of fertilizer application depends on the plantation method and geographical location of the mango orchard. Generally fertilizers are applied before commencement of monsoon or two months before flowering period. There are different periods for manuring of mango plants based on their geographical location and climatic conditions.

1. January – February:
Mangoes in the North region usually start blooming in this period due to cold climatic conditions. Application of fertilizer in this period supports flowering and fruiting stage in later period.

2. June- July:
Application of fertilizer in this period promotes vegetative growth of plants. But major share of applied fertilizer gets washed off due to heavy rainfall.

3. September- October:
These months are preferred to apply fertilizer then June- July in the areas of heavy rainfall. The applied fertilizer remains intact the tree. This is the most preferred period to apply fertilizer in India as the intensity of rainfall gradually decreases.

It is advisable to give fertilizers to plants in the month of September- October that is after completion of monsoon. Because plants are more benefited as loss of fertilizer is minimal due to less rainfall, this also prevents growth of weeds in orchards. As the washed off fertilizer accelerates weed population in mango orchard. Ultimately, maximum nutrients will be available for plants.

1.1.8 Methods used for fertilizer application:

Age of plant is the important factor while application of fertilizer. Thus methods of fertilizer application reply upon the age of mango tree. In case of young trees, basin method
is implemented, whereas for older trees furrow technique is suitable. For young plants, trench should be well dug around the tree before application of fertilizer. The trenches should be up to 15cm deep and 30cm away from the main trunk. In case of older tree furrow method is implemented. In this method, minimum quantity of applied fertilizers escapes from the tree basin. Trees are able to utilize maximum quantity of fertilizer. Adoption of this technique helps to prevent weed growth.

Manure consists of mainly compost or farm yard manure, oil cakes, super phosphate, potash and wood ash. Every year fertilizer application is necessary for growth and development of mango tree. However quantity of fertilizer depends on the age of tree. Dose of fertilizer varies with the age of mango plant. At initial stages of plant fertilizer application is less, then after with progression of in plant growth fertilizer dose increases.

1.1.9 Prunning:

Prunning is one of the most important operations in mango orchard management. It includes cutting of damaged branches, removal of overcrowded branches, maintaining the shape and size of plants. All tress should be pruned regularly for it proper growth and development of plant. There are four types of prunning techniques namely prunning of high density plantation, hard prunning, centre opening and light prunning. Climatic conditions of Konkan region are hot and humid; therefore there is repeated development of vegetative flush on mango trees. For better fruit production mango tree require proper ventilation and sunlight exposure. In case of high density plantation branches of neighboring tree interlock with each other. Such conditions are not favourable for development of inflorescences and fruit setting. In Konkan region there are many old mango trees. These trees are very tall and difficult to manage. Fruit production of such trees is less more over they are attacked by several insect pest and diseases. In case of mango trees more than 60-70 years hard prunning in beneficial. It consists of rejuvenation of mango plants. Prunning can be done every 3-4 years. Prunning should be done in month of October.

Prunning has significant impact on mango production. It helps to eliminate dried, damaged and infested branches. It also maintains the appropriate crown of tree, which facilitates in application of pesticides and fruit harvesting. Furthermore prunning improves ventilation and penetration of sunlight. Thus naturally controls attack of pest and diseases on mango tree. Prunning of trees promote development of new vegetative flush and improve fruit setting.

1.1.10 Manuring bearing mango tree:
Manuring bearing mango tree is essential for fruit setting, fruit retention and fruit quality. Thus nutrient requirement of a bearing plant is more to support progression of vegetative and reproductive development. Bearing plant should be applied with farmyard manure, bone meal, wood ash, nitrogen, phosphorous, potassium and oil cakes in appropriate quantity. Also foliar application of urea solution should be done before beginning of vegetative plant growth. Similarly micro nutrients essential for plant growth can be supplied through foliage.

1.1.11 Foliar fertilizer:

Foliar fertilizers are also used to supply nutrients to mango tree. Sprays of essential concentration are taken on the mango tree. Essential micro elements are applied through foliar application. The plants readily absorb the nutrients through the leaves. Foliar application technique is one of the popular methods of fertilizer application.

1.1.12 Mango plantation planning:

General information about the climatic conditions of location to be selected for plantationis essential prior to mango cultivation. Mango is a tropical plant, thus there is limited scope to select the site for mango cultivation. Plantations are strictly limited to tropic level only. However there are various environmental factors influencing mango crop.

Mango cultivations are generally suggested in area where there are existing mango plantations. It proves beneficial in understanding the suitability of geographical location to mango crop. Secondarily it also helps in gaining information about their experiences, techniques applied, pest and diseases infestation pattern, market avenues and availability of labour force.

Mango cultivation should be done on high land possessing porous soil. The selected site should have good ventilation and sunlight exposure. However, locations receiving high rainfall and hail storm should not be selected for plantation. High rainfall and storms during flowering phase or fruiting stage damage the crop. Rainfalls during flowering phase wash-down the pollen grains and hamper pollination and fruit setting. On other hand rainfall storms during fruit developmental period leads to fruit drop, thus such locations are not suitable for plantation of mango trees. Furthermore high humidity favours the attack of fungus of inflorescences, incidence of pest and diseases and effects fruit growth and development.

During the time of plantation, the canopy size of mango variety selected must be considered and accordingly the spacing between plants should be determined. According to the mango variety and type of plantation, either traditional method or high density plantation
should be selected and the distance between the plants should be ascertained. Generally plantation is done in row and spacing in plants is 5-10 meter. In case of dwarf mango variety and high density plantation the spacing in plant is 3-5 meter. On other hand in case of tall variety and conventional plantation technique distance in plants is about 10-12 m. Various new techniques are adopted in mango plantation to accommodate more number of plants in given areas in order to increase per unit area production.

1.1.13 Plantation technique:

Before selection of site for mango plantation in lateritic rock it is essential to assure the availability of clean and good quality water supply. After monsoon, irrigation is necessary to for plants minimum up to five years. After filling of the pits, good quality genuine Alphonso grafts having vigorous growth, free from diseases and pests should be selected and planted on the mound. While planting if the graft is in polybag, polybags should be removed without disturbing the root ball. If the grafts are of 2-3 years age and if they are in a tin pot should be cut gently from top to bottom from one side and the grafts may be removed along with the root ball and plant it in the pit. While planting care should be taken to keep the graft joint above the soil surface. Otherwise the joint gets contaminated with wet soil and may cause diseases. Normally the planting should be done during onset of monsoon for better survival.

1.1.14 High density plantation:

Generally Alphonso mango grafts are recommended to plant with spacing 10m x 10m that accommodates about 100 plants per hectare under normal soil conditions. However, when planting is done in lateritic rock the plant growth is restricted. In case of hard rock plantation, the plant spread is between 25 to 40m² area, even if the planting is done with 10m x 10m spacing. Considering the higher investment for hard rock plantation it is better to prefer high density plantation with 5m x 5m spacing and square system of planting. This can accommodate about 400 plants per hectare. Further orchard management practices like application of fertilizer, paclobutrazol, pruning, regular plant protection measures, orchard sanitation, etc. should be adopted. In case of hard rock plantation the cost of production is very high. If number of plants per unit is less. Such orchards are not much profitable for at least 10-15 years. Initial 15 years production of high density plantation (5 x 5 m) per tree is equal to traditional plantation technique (10 x 10 m). So as to overcome this problem it is advisable to go for high density plantation with 5m x 5m spacing. This will accommodate four times more number of plants per unit area and thus gain four times more returns from the
same unit area during the initial fifteen years. But the initial coast is higher for such plantation. However returns will be four times more than the conventional planting.

In high density plantation mango trees are maintain to certain high and tree crown is pruned regularly. This helps in harvesting of fruits and monitoring of plants to note observation. In case of high density plantation spacing of 5 x 5 m essential due to climatic conditions. In hot and humid conditions plant growth is fast, thus plant grow tall and spread in all directions. Hence in case of high density plantation regular pruning is unavoidable. After pruning the mango plants application of paclobutrazol is must to increase the production. Otherwise there will be only vegetative growth of the plant. Generally after 15 years in high density planation braches of mango plants start interlocking each other. Therefore after 15 years, each year trimming of plants is necessary. After harvesting season, trees should be pruned immediately. Generally it should be done by end of April. Branches bearing fruits should be avoided. If pruning is done every year 20-25 cm of braches should be cut, where as if it is done in alternate years 30-40cm should be cut. Bordeaux mixture should be applied after completion of cutting process. Following are advantages of high density plantation. Following are the advantages of high density plantation.

1. More production in less area.
2. Plant size is small, thus it becomes easy for pruning and thinning of branches.
3. Pesticide application becomes easy due to limited size of tree. Thus pests and disease infesting on mango tree can be controlled.
4. Due to limited plant size, each and every fruit can be observed acutely and maintained.
5. In high density plantation fruits can be harvested by hand along with stalk intact. These fruits have good value in market as they are with no injury. In case of large size trees, fruits are harvested with help of tools. During harvesting fruits may separate from stalks.
6. Fruit maturity cannot be identified while harvesting fruits from tall trees. Thus sometimes immature fruits are harvested.

1.1.15 Spongy tissue incidence in mango:

Spongy tissue is another major drawback of Alphonso mango, it is a ripening disorder often described as soft center, white corky tissue or internal break down of tissue in mango. Spongy tissue is a non-edible sour patch developed in the mesocarp of the mango. Spongy tissue cannot be noticed from outer appearance. It can be only detected after cutting the ripen mango. Such ripen mangoes are unfit for human consumption. Alphonso mango variety is most susceptible to this disorder. Alphonso cultivar is a thin skin fruit mango variety which is
very sensitive to the heat. Changing climatic conditions, particularly temperature extremes are mainly responsible for the damage.

1.1.16 Fruit setting in mango:

A mango tree does not bear fruit every year. Fruit bearing may not be observed exactly in alternate year also. So irregular bearing is more appropriate term for mango tree. Irregular bearing doesn’t mean that tree will not bear fruits. There is no guarantee of a tree in particular year. There are two major factors responsible for irregular bearing such as genetic makeup of plant and climatic conditions. To overcome irregular bearing, doses of the lacking plant hormones can be adjusted by external application of plant growth hormones.

To overcome loss due to irregular bearing, plant growth regulators are used by farmers to promote reproductive growth of plant. The growth retardant paclobutrazol is mostly preferred by the farmers to beat the problem of alternate bearing. Multi-locational trials are made at the tree base for its application. This practice is very common in Devgad tehsil.

1.1.17 Harvesting and marketing of mangoes:

Earlier, mangoes were harvested by the month of April and then the actual mango cropping season started. But nowadays, mangoes hit market by the month of February and March. For induction of flower and fruit setting, most of the farmers in Devgad cultivating Alphonso mango have started using paclobutrazol. This has brought a big revolution in mango industry in recent years by accelerating fruit production. It has not only rejuvenated old orchards but has also optimized mango productivity. However, early initiation of flowering flush in mango has also resulted in early arrival of insect pests like hopper, thrips, mealy bug and other sucking pests on foliage and newly emerged panicles.

Maturity is a particular stage at which fruit completes its growth and development. Mango farmers have fair idea regarding maturity indices of fruit. Fruit maturity is indicated by external appearance of fruits like waxy glow, appearance of few dots on fruit and comparative size of fruits. At maturity stage, changes in fruit shape like fullness of cheeks, building of shoulders and reduction in curvature between shoulders and lower side of fruit are noticed. Maturity indices also include transformation of dark green fruit skin to pale green and shoulders turn reddish.

Harvesting mangoes at perfect stage is a crucial job. Delay in harvesting will ripen fruits on tree and early harvesting will lead to immature produce. It is often observed that farmers harvest mangoes before they attain optimum maturity for getting higher prices in the beginning of season that is in January-February. Harvesting prior to maturity develops white
patches on fruit. It also hampers the shelf life and quality of fruit by lowering total soluble solid, acid ratio, poor taste and flavor. Such immature mangoes doesn’t ripe but decay. Thus famers need to harvest mangoes at accurate maturity stage to enhance quality, shelf life and marketing value. The stage at which the fruit should be harvested has an important bearing on ripening and fruit quality. Unless the fruits are harvested at correct stage, when they attain full size and the characteristic taste or flavor will not develop. Harvesting season varies with the soil, climatic conditions and maturity of fruits. In India, mango harvesting season varies from south to north. In southern part of India that is Kerala and Tamil Nadu, mango harvesting starts in the month of February and gets over in the month of May while in northern parts like Uttar Pradesh, Bihar, Punjab and Haryana it starts from the month of May-June and extends up to August end. In the Konkan region mango harvesting season is from March to June, while rest of Maharashtra it is from May to July end.

In Konkan region due to warm and humid climate, the developing fruits suffer from fungal diseases and black spots appear on the fruits. This phenomenon is now common in case of late harvested fruits. There are various criteria recommended for judging mango maturity.

1. Number of days that is 105 to 130 days from flowering to maturity.
2. Slight reddish colour develops on the shoulders and outward bulging of the shoulders.
3. When one or two ripe fruit fall from tree naturally.
4. Change in fruit colour from dark green to light green or development of characteristic colour depending upon the respective variety.
5. In case of Kesar variety, oil glands on the fruit skin distinctly become clear.
6. Fruits should be harvested at 85% maturity stage especially in case of Alphonso variety to prevent spongy tissue disorder.
7. Specific gravity of Alphonso mangoes ranges between1.01 to 1.02.
8. In case of Payari variety prominent beak development on the lower side of fruit is noted.
9. In Alphonso variety beak disappears, the fruit will have depression at the stalk fruit joint.

Harvesting of fruits should be done with stalk intact with it. Such harvested fruits show better quality during ripening with more shelf life. Individual fruits should be harvested with 4-5 cm long fruit stalk intact. Harvested fruits should be directly exposed to sunlight; they should be placed in shade. Harvesting should be done in cooler part of the day preferably in morning or late in evening.

Mangoes, on commercial basis, are mostly harvested at mature stage. The harvesting operation is done manually with help of a fruit picker depending upon the height of the
plants. Hand picking of fruits is not possible in case of heighted plants. Harvesting operation is a labour intensive and likely to cause mechanical injury to fruits. Generally fruits with intact stalk are harvested from trees.

**1.1.18 Grading:**

Grading implies sorting of fruits into different quality groups. It is the most important step in successful marketing. Graded fruits create good will in market and directly help in branding of the quality mark throughout the country. Fruits of same tree may sometimes show variation in quality grades after harvest. In many mango producing areas, Alphonso, Totapuri and Dashehari mango fruits are graded on the basis of size.

After harvesting mango, grading and sorting of fruits is done by visual inspection. Immature, damaged, ripen, infested and mechanically injured fruits are separated. Slightly damaged fruits and fruits with latex on the surface are not removed from the marketable produce but sold at a lower price in local market. Marketable fruits are again graded according to size and marketed likewise. Smaller and larger fruits are marketed separately. Graded standards are generally based on the physical characteristics, such as size, weight and colour. Fruits should be uniform in colour, size, shape, free from pest and diseases infestation. Also free from any mechanical injuries, etc. The harvested fruits are generally sorted into three to four grades according to size. This practice of sorting the mangoes in different grades is common in Gujarat, Maharashtra and Karnataka for Alphonso mangoes. Now a day’s mechanical grading systems are also available. Grading is generally done in three categories viz. more than 350g, 300-350g, 250-300g, 225g-250g and less than 225g.

**1.1.19 Grading for export quality:**

Grading is very essential step for the export. Mangoes with infestation, damaged, diseased, bruised are discarded and spotless clean mangoes are selected. In case of Alphonso variety the maturity of fruits should be 85%. However, in order to separate immature fruits all fruits should be dipped in water. The fruits that float on water are immature and should be rejected from export. The remaining fruits should be placed in 2.5% salt water. Now the floating fruits should be selected for the export and those settled at bottom should be rejected on account of presence of spongy tissue.

**1.1.20 Post-harvest treatment:**

The post-harvest treatment like hot water dip, fungicidal dip, precooling, waxing, etc. are practiced to increase the shelf life of fruits. Alphonso mangoes are pre cooled at 13-15° temperature before storage. Mature green Alphonso mangoes are dipped in 500ppm Carbendazim solution for five minutes, it reduces the post-harvest decay.
1.1.21 Packing:

Proper packing is an essential pre requisite for maintaining good appearance and quality of the produce. Packing provides protection against mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. Initially mangoes were packed in tin boxes, wooden boxes and bamboo baskets. Now wooden boxes and corrugated fiberboard boxes are commercially used for mango packing. Packing of mango in wooden boxes with capacity of 48-72 fruits is still a common practice in Konkan region. Wooden boxes of 4-7 dozen capacity possess good stacking strength. However they are heavy in weight which adds to more freight cost. On other hand wooden boxes are not eco-friendly, they consume three times more wood than corrugated fiberboard boxes for manufacturing similar size box. But the corrugated fiberboard boxes should be well ventilated. These boxes are light weight that reduces freight cost, cause less damage to fruits, easy to handle and print. They improve the product image as they appear neat and tidy. These boxes can be prepared from cheaper wood, bamboo, plant cellulose waste and various types of agricultural residue as well as by recycling the cardboard or paper. Care should be taken that at least 2-4 holes should be kept on all sides except on top and bottom. About 6% of the area should be kept for aeration, it prevents fruit rot and support ripening process. Such packages are costly but give but give better return. Corrugated fiberboard boxes are also used for exporting mangoes. For exporting mangoes it should be borne in mind that foreign customers would like to have elegant, attractive and properly labeled container, in additional to the good quality of the fruits. Wrapping of individual fruits in tissue paper is also practiced to reduce spoilage during transportation. The cushioning used may be either of shredded paper or any other material, which should be clean, hygienic and appealing.

1.1.22 Ripening:

Usually the harvested mangoes ripen in about 7-8 days under tropical conditions. In Konkan the fruits are kept in single layers in paddy straw. This is usually done in closed but well ventilated room. Fruits ripe uniformly at 23° to 27° C. Wax coating on mango slower the ripening condition and increase the shelf life of fruit. Artificial methods are also implemented to ripen fruits, it includes use of chemicals or exposure to gases like acetylene and ethylene. Ethrel treatment at desired concentration accelerates the ripening process with uniform colour development. Now a day’s ripening chamber concept is developing rapidly in case of mangoes. The fruits are ripened in ripening chamber with controlled temperature, humidity and ethylene concentration.
1.1.23 Storage:

The main objective of the fruit storage is to extend the period of availability by arresting transpiration, ripening and undesirable biochemical changes and diseases infections. Various techniques and methods are practiced to increase the storage life of fruits. These methods are refrigeration, cold storage, ice bank cooler, controlled and modified atmosphere storage, cool chamber etc. Mango is climacteric fruit and unless the fruits are stored properly one can’t be sure of the storage is absolutely essential during the period of glut. Further the processing unit cannot utilize the entire produce at a time. Mango can be stored at low temperature. Its storage life can be extended upto 3 weeks at the temperature 12° to 14° C with 85-95 per cent relative humidity. But for ripening, these fruits should be exposed to the temperature of 15.0° to 27° C. Also the fungicidal dip treatment helps in extending the storage life. Wax coated fruits wrapped in tissue paper or packed in perforated plastic bags also show better results in extending storage life.

1.1.24 Transportation:

Transport of fruit with minimum damages is very important in successful marketing of perishables. Generally, mode of transport depends upon distance of market and availability of means. The fruits are generally transported either as head loads, loose in carts, motor, trunks, rails or air shipment. Transporting mangoes as head load or cart is only adopted where the orchards are near market or when transport is not possible. For distant market truck or rail transport is used, while for export market either air or waterways are used. In India, the road transport is 3-4 times expensive than the rail. Further, rail shipment is 8-10 times more efficient in the use of energy than road transport for the movement of the same tonnage. Yet in India, road transport is preferred for shipment of fresh fruits, simply because of the faster movement of the perishables and advantages of door to door service. Long distance transport involves much time and there is a risk of deterioration of fresh produce due to various causes. Thus road truck or rail wagons should be well equipped with ventilation system to reduce the excessive heat generated during transport. Refrigerated transport has to be adopted to save spoilage over long distance and to tide over seasonal bulk harvest.

Transportation of mangoes to local market is done by head loads in small quantity as mango fruits are hard enough to sustain the damage. The marketable produce is well packed in boxes with dry grass or paddy straw that cushion the produce and prevent it from mechanical injury. But in case of distant markets, care is taken while choosing suitable vehicle as delay in transit may cause ripening of fruits. It may ultimately spoil the produce by ripening, softening and cracking. The orthodox road transport system generally used in
transporting mangoes is poor in that sense; but is still widely under use. During journey, mangoes encounter numerous road discontinuities like bumps and accidents, railway crossings and poor road infrastructure. In spite of all these drawbacks, road transport is preferred for its cheapness, easy mobility and quick transport from the place of production to that of the delivery. But it may affect the fruit quality to some extent. Most of the damages are latent and could be noticed only after ripening. Improper loading as well as unloading and over loading contribute considerable proportion of damage. Transport damages are directly correlated with the transport distance.

1.1.25 Marketing:

In Konkan region the usual practice is to auction the orchard to contractors at the flowering stage or fruiting stage. Sometimes orchards are auctioned to contractors for 2-5 years also. The contractors are often financed by the commission agents or they themselves send their produce to leading commission agents through forwarding agents. Also quite often, the original contractor passes the orchards to subcontractors and makes some money in between. These chains of middlemen eat away most of the legitimate profits of the growers as well as the consumers. Also the orchards are not well maintained by the contractors. Consequently such plantations become less remunerative and unproductive in due course of time. Another evil of contract system is immature harvesting of fruits. About 70 per cent marketing of mangoes is handled by middleman. The prevailing system, centered on the contractors is disastrous to the farmers as well as the consumers.

1.1.26 Marketing channels:

Mangoes produced in Devgad are marketed in various ways. There are mainly four channels through which mangoes are marketed are given below.
1. Producer to consumer (Local market)
3. Producer- Pre harvest contractor- Wholesaler Commissions Agent- Retailer-Consumer.

Maximum produce is sold through commission agents, that is through second number channel mentioned above. Commission agents from Mumbai, Pune, Sangli, Kolhapur, etc. purchase mangoes from farmers and sell further. Very few farmers are in directly contact with the consumer, they solely rely on the agents to sell their produce. Some farmers auction their mango orchards to contractors for harvesting and marketing the produce. That is the third number of channel motioned above. This is generally practiced by the famers who do
not have labour force to carry out the orchard activities. Also some owners are out of station so they cannot look after the orchards, thus they prefer to auction the orchard. The auction terms of mango orchards are varied. Earlier terms where up to five years or more than that. But today the mango orchards are auctioned after the flowering stage of the mango plants. This is to reduce the risk involved in mango production. Very few farmers are sale their produce in local market, as the returns are low and market avenues are limited. While some use cooperative societies to market their produce.

Mango is a highly perishable fruit. Hence requires adequate transport and storage facilities. Due to unavailability of these facilities, significant share of mango is wasted every year (Karthick et al. (2013)). If proper care is taken right from the harvesting stage to final marketing to the consumers, considerable losses can be prevented. Eventually better quality fruits can reach consumers which will help the farmers to get fair prices. Mango ripens fast during summer due to heat, then after over ripe fruits become unsuitable for marketing. Mango fruits are trade at international level also. (Akoto et al. 2011). Not even 5% of produced mangoes are processed and exported. Mainly mango pulp is exported. However there is a potential scope to increase the export. Mangoes are exported to about fifty different countries in world from India. Among which, UAE, Saudi Arabia, Qatar, Malaysia, Singapore, UK, Kuwait, Bahrain, and Bangladesh contribute nearly 97% of total mango export from India (Rosalin et al 2014). Alphonso mangoes from Devgad tehsil, mostly in unripen form, are marketed in bulk to nearby state and metros like Mumbai, Pune, Satara, Sangli, etc. However, most of the village women are engaged in selling mangoes at local markets. Mangoes to be sold in local market are ripened by farmers and those to be marketed at distant markets ripe after reaching the destination. Fruits are placed in layers of paddy straw or dry wild grass. Then they are packed in suitable corrugated fiberboard, wooden boxes or trunks that are suitable for transportation. Farmers do not store the harvested mangoes for a longer time. Farmers hardly held the mangoes for a day or two when they are unripen or market them immediately due lack of storage facilities in Devgad and concerned study area. Farmers have to sell their produce at the earliest even though the market value is down. It is never beneficial to store mangoes and wait for good market price.

At initial stage, farmers have to take care of the mango tree by applying appropriate fertilizers and irrigation. Then after protect the inflorescence from pest attack and encourage fruit development. Further post harvesting care and marketing of mangoes to gain optimum price, mango farming is a crucial task. Year round hard work, care and investment is essential
in mango production. Farmers have to tackle numerous problems at each stage in mango production.

1.1.27 Mango varieties:

About 1300 mango species are reported from India. All these varieties have diverse taste, colour, aroma, fruit size shape and other characters. There are also variations in plant characters like size of tree, flowering period and fruit setting. Among these species nearly 25-30 varieties are grown on commercial basis, while others are not considered as economically important varieties. There are mainly two types of mango varieties, naturally occurring varieties and other are hybrid varieties. Natural or native varieties are unpopular varieties; they are not cultivated for commercial purpose. These varieties have low productivity, alternate bearing is other draw back and fruit setting is late. Due to these characters native varieties are not preferred commercially. There are several native mango varieties like Rayval, Ghagri, Khobri, Pavshya, Kalya, Payari, Totapuri, Neelum etc. These native varieties are given different names at different locations. Few native mango varieties plants are present in villages and orchards. Cultivation of these varieties will not be profitable, thus hybrid were developed by individuals and institutes by economical point of view. These varieties were developed by breeding selected varieties to overcome the drawbacks such as alternate bearing, late bearing, small fruit size, low yield, etc. The developed verities were Alphonso, Ratna, Kesar, Sindhu, Amrapali, Goamankur, etc.

1.1.28 Growth of Loranthus on mango trees:

Loranthus are commonly observed parasitic plants on mango tree in Konkan region. These plants are semi parasites on the tree trunks and branches. Their leaves possess chlorophyll and synthesize carbohydrates. This parasite attacks the aerial part of host trees. It is devoid of true root system of its own and hence becomes dependent on host plant for supply of water and mineral nutrients. Loranthus develop haustoria which penetrate into host tissue and intimately associate with vascular elements of the plant.

*Dendrophthae falcate* is most common species of loranthus in India, which has strong branches. Flowers are long and tubular in shape usually greenish white or red in colour and emerge in clusters. Fruits are fleshy, gummy containing solitary seeds, sweet in taste and therefore early consumed by birds and animals. The birds are attracted by its brilliant coloured fruits. When seeds are deposited on other trees at the junction of branches, they germinate and give rise to haustoria thus establishing as new parasite. Dropping of birds also contain the seeds of loranthus.
In early stages of attack, the damage to the plant may not be appreciable but as the parasite grown on tree, the effects become apparent. The attacked branches weakend due of the interference in flow of sap. The leaves of infected plants become smaller in size and may show unhealthy green colour. The fruit quality and production is hampered.

Cutting of the infected braches is the commonly used method for control of loranthus. It is important that branches should be cut sufficiently behind the loranthus that is about 0.5m so that all of the haustorim of the parasite is eradicated. For the easy removal of loranthus, amarloranthus cutter is useful. After removal of loranthus, Butachlore (0.03%) or Fluchoralin (0.03%) or Glycel (0.5%) should be sprayed on the cut portion. If loranthus are of big size and large branches should be cut, then cut portion of the branches must apply with Bordeaux mixture or coal tar may be smeared.

1.1.29 Disease on mango crop:

Mango crop is attacked by various diseases throughout the season. Similarly infestation of various diseases is also responsible for considerable yield loss and low productivity. Disease attacks fruits, braches and inflorescence of mango tree and damage them. Diseases are also one of the important constrain in mango production. Diseases infestation too spread on large scale and damage mango cultivations. Causal agents of each diseases and period of infection is different.

1.1.29 Pest and pesticide:

Pests belong to class insecta. Some of the insects that are harmful to crops and human beings, they are termed as pest. Occurrence of pest or increase in pest population can cause serious threat to human beings and environment. Incidence of pests influences the production and profit margin of crops. Body of insect mainly divided into head, thorax and abdomen regions. Further based on their characteristics they are further classified into various phyla. Pests are further classified on basis of their occurrence and infestation pattern.

1. Regular pest-
These pests occur frequently on the crops and damage them.
Example-Stem borer on rice crop.

2. Occasional pest-
Infestation of these pests is infrequent; incidence may be once in many years. But the sudden attack of pest is severe and damages the crop.
Example- Case worm on rice

3. Seasonal pest-
These pests attack the crop in particular season only. They attack crops on large scale during their cropping seasons and damage them.

Example- mango hopper, thrips attack on mango crop

4. Persistence pest-
These pest attack crop throughout the year and are quite difficult to control.
Example-Thrips on chilly crop.

5. Sporadic pest
Attack of these pests is confined to certain location and period.
Example-Slug caterpillar on coconut tree.

1.1.31 Pesticides:

Pesticides are the chemicals used to suppress the pest population attacking the crop. Pesticides have detrimental effect on pest and protect the crop from being damaged. Pesticides are grouped into two categories namely system and contact.

1. Contact pesticides:
2. System pesticides:

1. Contact pesticides:
These pesticides are harmful or toxic to pest when they directly come in contact with it. These pesticides are lethal to pest when they are absorbed by pest body. These pesticides leave residue after application on crop. They are generally sprayed in form of aerosols. These pesticides are detrimental to non-target species too. This is a major drawback of the contact pesticides.

2. System pesticides:
System pesticides are absorbed by plants and translocate in plant body. Translocation of pesticides in plant body in mainly carried by plant vascular system. Absorbed pesticides move in plant part such as root, inflorescences, stem, leave and shoots. Pests invading leaves, inflorescences, shoots and stem for sucking sap encounter with the toxins present in the plant body and ultimately kill the pest.

1.1.32 Integrated insect pest management of mango:

Large populations of insect pests are damaging mango crop thus there should be modification in pest management process. Integrated insect pest management merely does not mean application of a particular type of controlling agent or a procedure. It is best combination of different controlling agents in well-organized manners, which will effectively control pest attack without harming any other component of ecosystem.

Supplementary objectives of integrated pest management are as-
i. Do not harm any natural component of ecosystem, but includes use of natural enemies.
ii. Maximum use of natural components to control pest attack.
iii. Fusion of two or more techniques in integrated manner.
iv. Application of scientific methods as per need.

Most important part of integrated insect pest management is monitoring the crops and effects of environmental factors on pest population. It also includes acute observation and sampling of insect pests and their natural enemies. Implementation of integrated insect pest management can prove effective in controlling insect pest incidence on mango crop below economic injury level. Plant protection measure is one of the most important factors in agriculture. Plant protection pattern are divided into five different phases.

1. **Subsistence phase:**
Crops are cultivated in traditional way without implementing any plant protection measure. The crop yield completely depends upon the environmental factors and pest infestation is checked by natural enemies.

2. **Exploitation phase:**
Plant protection measures are adopted by farmers to increase yield, implement new varieties and gain good returns. Farmers use various chemical pesticides to suppress insect pest attack and increase yield.

3. **Crises phase:**
Growth in crop yield is not sustainable due to application of synthetic pesticides. After exploitation phase, gradually multiple issues related crop arise. Major issues problems like hike in concentration and dosage of pesticides, development of resistance in insect pest due to use of similar pesticides repeatedly and increase in pest population. All these factors lead to increase in usage of pesticides and raise the cost of production.

4. **Disaster phase:**
Application of chemical pesticides becomes infective and expensive. Production is less and expenditure is more on crop protection. It leads to economical imbalance. Furthermore the soil becomes infertile due to excessive use of chemicals.

5. **Integrated control phase:**
This phase is implementing combinations of different techniques in organized way. It includes evaluation of basic ideas, ecology, details of crop and insect life cycle. Then after practicing plant protection measures to control pest attack on crop.
In Sindhudurg district Alphonso mango is commercial cultivated in Tehsils like Devgad, Vengurla, Malvan, Kudal and Sawantwadi of Sindhudurg district. But there is considerable difference in the flavor of mangoes grown in each tehsil. Soil profile and climatic conditions highly influence the mango quality. However major cultivations are concentrated in Devgad and Vengurla followed by Sawantwadi and Malvan. Devgad is leading Tehsil in mango production as large area is under mango cultivation as compared to other Tehsils. Mango is a main commercial crop of Devgad Tehsil. Alphonso mango cultivations from all tehsils are attacked by similar insect pests. Also the pest status is almost similar everywhere. Insect pest infestation on mango cultivations in Devgad, Vengurla, Sawantwadi, and Malvan are similar and principally responsible for reducing mango production.

Along with Alphonso mango, cashew nut is also grown for commercial benefit in Sindhudurg district. Cashew nut cultivations are rarely found in Devgad but is major crop of Vengurla and Sawantwadi. This crop is also severely infested by insect pests. But the insect pests infesting cashew and mango crop are completely different. There is no common insect pest on both the crops.

To tackle various insect pests, new insecticides and molecules are consistently entering in the market. These pesticides are highly effective in controlling the pest populations as compared to conventional pest control methods. A relative study has been attempted in the present research project with the help of survey of the prescribed study area to estimate the overall pest diversity on mango crop, their local geographical distribution and relevant occurrence as well as different methods of pest management with some new attitudes and approaches to improvise the ultimate crop status.

Various insect pests attack mango plant from initiation phase to harvesting stage. A large group of population in Devgad Tehsil is engaged in mango production, 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 tons.

Alike other crop, mango crop is also prone to insect pest. But the level of destruction of crop is determined by level of infestation, nature of damage and kinds insect pest. Pests attack plant parts like leaves, stem, fruits, inflorescence, branches and tender shoots of mango
trees. Mango crop is damaged by leaf eating insect pest like mango hoppers, thrips at the nursery, termites at early and defoliators, sapsuckers, shoot borer, gall formers, stem borers, fruit borers, stone weevil and fruit flies perpetually at the later stages. Incidence of insect pests on mango crop is major barrier in fruit production.

Insect pest problem on Alphonso mango in Devgad is not a new one. Farmers here are struggling with pest from decades. But initially pest incidence was certainly low, also very few pests were found to be infesting mango crop was. Now-a-days the pest infestation scenario has 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 regarding pest can be effective in accelerating the mango production than at present.

In Indian market large numbers of mango varieties are sold, but Alphonso mango attracts the consumers towards it due to its unique characters. Cultivation of Alphonso mango variety is done of large scale in Devgad Tehsil. This variety suffers a serious loss due to incidences 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 mango 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. During the mango season, attack of insect pests is serious problem in Devgad tehsil. Therefore the work on studies of diversity of insect pests and their geographical distribution among the mango cultivations was prescribed. 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 current day strategies in insect pest management and fruit production technologies of mango crop in the prescribed study area as well as in other parts of the country.
1.2 Problem on Hand

Mango *Mangifera indica* (Linn) is the king of fruits having a premier status among the commercial fruits grown in India. Large group of population in India is engaged in cultivation, marketing, transportation and processing. Mango related operations help to generate employment at rural as well as urban. Thus mango is one of the important fruit crops of India. In Devgad Tehsil Alphonso mango crop is grown on commercial basis.

Regarding the cultivation practices, monoculture of the species *Mangifera indica* Alphonso variety is observed all over the Tehsil on large scale. Besides Alphonso wild varieties like payari, rayval, kesar, totapuri and kobari are also cultivated in Tehsil. Alphonso variety is preferred for its high productivity, aroma and unique flavor. Other hand, Alphonso mangoes have high market value than any other mango variety. Cultivation of Alphonso mango earns good returns therefore farmers are replacing wild mango varieties with Alphonso mango. Such practices have marginalized native mango varieties. As the land under mango cultivation is increasing day by day, the problems related to the crop protection are becoming critical.

As compared to the natural or wild mango varieties, Alphonso mango is the most susceptible towards pests, diseases, climate changes and relevant damage. Fruits too are sensitive towards temperature extremes. Alphonso mango cultivations are infested by number of insect pest. Insect pest infestation is principally responsible for crop damage on large scale. Thus it is important to record and evaluate insect pests on mango crop. In the proposed research work, specifically insect pests will be focused that attack mango cultivations right from flowering stage to harvestable fruit. There are several insect pests on mango crop; they infest plant parts such leaves, inflorescence, fruits, shoots and stem. Pest infestation begins in October with vegetative and reproductive development of plant. Pest attack on mango cultivation degrades fruit quality and lower the crop productivity. Thus it is very essential to evaluate pest problem thoroughly to decrease the damage caused by the pest. Low productivity is a serious threat to mango industry. In Devgad Tehsil land under mango cultivation is increasing every year, but there is no correspondingly hike in mango production. Along with pest infestation there are other factors that are responsible for lowering mango production. It is essential to evaluate all these adverse factors hampering mango crop.

Majority of farmers use pesticides to control pest attack. Such practices have developed resistance among the insect pest. Various pesticides that are being used for a
decade are no more effective in suppressing pest attack. This is forcing farmers to increase the concentration and doses of pesticides. The excessive use of pesticide leaves behind the trace of toxicant in fruits. For this reason mangoes are rejected by foreign countries. Similarly trade of Alphonso mangoes from was banned in few countries due to presence of insect pests on fruits such as fruit fly. The indiscriminate use of pesticides has resulted in serious environmental problems. On other hand these expenditures on pest management increase production cost.

Farmers do not exercise integrated pest management practices that include physical, biological and chemical pest management practices. They completely rely on pesticides to rid of insect pest as its application is easy. Pest management practices adopted by farmers are insufficient in arresting pest attack. Monoculture of single mango variety that is Alphonso which is susceptible to pest attack coupled by inappropriate pest management practices, all these factors are particularly responsible for multiplying insect pest infestation severely in Devgad Tehsil. Moreover, farmers do not have sufficient knowledge about pest attack and pesticides to be used. They are unaware about the pest life cycle and their nature of damage. They are afraid of implementing new techniques that may improve crop productivity. They are also unacquainted about orchard sanitation, tree pruning, soil treatment, etc. Thus pest management practices exercised by the farmers are insufficient to check the pest outbreak. Farmers mainly focus on insect pest management to protect crop from damage. But the fail to highlight on other factors influencing mango crop. Many of them are completely unaware of these factors. Hence it is essential to evaluate every factor directly or indirectly influencing mango crop. Farmers don not have thorough knowledge of every aspect related to mango crop. They are unable to plan their pest management practices due to lack of knowledge.

In the proposed research work, focus will be given on the occurrence and identification of pest infestation in selected Alphonso Mango cultivations in Devgad Tehsil of District Sindhudurg. Insect pest infestation is principally responsible to lower the mango production as well as hampers the trade of fresh mangoes. It is essential to create awareness among the farmers regarding complete life cycle of each pest along with its nature of damage. Similarly studies should be done on, at which stage of pest it will be feasible to control it. It is necessary to develop some integrated pest management practices to suppress pest attack on mango crop. Use of pesticides should be lowered and farmers should be educated about insect pests infesting mango crop. That will help to produce quality mangoes those will be accepted by the foreign countries.

Table 1.1: Production of mango crop in 2016
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Location</th>
<th>Area in hectare</th>
<th>Per year mango production in tons</th>
<th>Mango productivity in tons per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>World</td>
<td>4946314</td>
<td>37124740</td>
<td>7.51</td>
</tr>
<tr>
<td>2.</td>
<td>India</td>
<td>2312300</td>
<td>15026690</td>
<td>6.50</td>
</tr>
<tr>
<td>3.</td>
<td>Maharashtra</td>
<td>474500</td>
<td>597000</td>
<td>1.26</td>
</tr>
<tr>
<td>4.</td>
<td>Sindhudurg</td>
<td>22400</td>
<td>67200</td>
<td>3.00</td>
</tr>
<tr>
<td>5.</td>
<td>Devgad</td>
<td>12190</td>
<td>2590</td>
<td>2.12</td>
</tr>
</tbody>
</table>

Table 1.1 represents the criticality of the mango productivity in Devgad tehsil. Devgad tehsil has very less productivity. Actual reasons responsible for low productivity of mango crop are evaluated in present study. Mango is economically important crop of Devgad Tehsil where large area is under mango cultivation. Low productivity is leading to low returns, farmer are facing economic crises due to increase in production cost. A decades before mango crop productivity in Devgad was up to 5 to 6 tons per hectare. Presently mango productivity of mango crop in Devgad is 2.12 tons per hectare. If same such situation continues future of mango crop in Devgad Tehsil in critical. Many farmers and labour are engaged in mango production and related businesses. Low productivity is major constrain in mango industry. Farmers and labours have are losing their source of income. On other hand the cost of production is compensated by increasing the cost of mangoes in market. Thus mangoes exported from Devgad are costlier then mangoes coming from other states.

### 1.3 Research Objectives

Following are the research objectives are set for proposed study to record and evaluate insect pest diversity on Alphonso mango cultivations in Devgad.

1. To study the insect pest diversity on Alphonso cultivations in Devgad Tehsil.
2. To study the seasonal variations in them.
3. To visit the selected Alphonso Mango cultivations at regular time intervals and to observe the mode of pests attack.
4. To study the nature of damage of each pest.
4. To study the detail about insect pest namely mango hopper, mango mealy bug, fruit fly, fruit borer, thrips, termites, aphids, stone weevil, shoot borer, leaf miner, stem borer, leaf webber, ants and mango scales.
5. To develop recommendations for safe pest management and application of relevant techniques.

1.4 Scope of research work

The proposed study will be significant with reference to following aspects:
1. The work which has been proposed here has not yet been done in the given study area with reference to the given objectives. Hence the work will produce baseline data for reference to the followers in the field.
2. The outcome of the proposed work will surely help to evaluate the distribution of insect pest within the Tehsil.
3. The study will evaluate insect pests and their life cycle infesting mango crop. This will help to generate data of insect pests’ diversity in Devgad Tehsil.
4. The results of the proposed work will also come to the help of the local farmers to improve insect pest management practices and mango production.
5. The study also focuses various other issues related to mango cultivation and limiting mango productivity.
6. Farmers will get knowledge about alternate pest management practices rather than only depending upon pesticides to arrest pest infestation.
7. Farmers will also get sufficient information about new techniques to be implemented in orchard management practices to increase mango production.
8. Farmers will get knowledge about appropriate use of pesticides and define concentrations during application.
1.5 Organization

Research work of present study included filed survey and laboratory work. Several filed visits of selected sites were conducted at regular interval in mango cultivations for proposed study. During field visit various observations related to insect pests and damage caused by them were noted. Also insect pest specimen, leaves, fruits, barks, flowers and seeds were collected from the sites and brought to laboratory for further investigation. In laboratory plant parts like fruits, barks, flowers and seeds were dissected and observed under microscope to note acute observations.

The said research work was carried in laboratory of Shri Sadashiv Hari Kelkar College of Arts, Commerce and Science, Devgad. College is located in Neerabai Parkar Vidhyanagari, AT Post Devgad, Tal-Devgad, District Sindhudurg, Pin Code- 416613.

Shri Sadashiv Hari Kelkar College of Arts, Commerce and Science was established in 1974 by Shikshan Vikas Mandal. The college is affiliated to Mumbai University and first college in Devgad Tehsil. NAAC Re-Accredited Devgad College with B Grade higher education institute. This college is one of the leading institutes in educating students from rural region. About 1500 students are admitted in college for academic progression. There are also hostel facilities within campus for girls and boys. College has special provisions to promote economic backward students. College provides various courses under disciplines of science, arts and commerce. Recently college has started professional courses like Computer Science, Information Technology, Management and Banking Insurance so that students from rural region can gain knowledge in various fields. Initially there were only under graduate courses in the college, but later on post graduate courses were started by the college. This was one of the milestone achievements of the college in education field. Post graduate courses like Environmental Science, Chemistry, Physics, Rural Development and Commerce. These post graduate courses attract students from different districts and states. Along with the graduate and post graduate courses college also run Community college for students. Through community college two courses are run for students namely horticulture and food processing.

College has well equipped laboratories that support the experimental work, curriculum and research. There are also comport laboratories with internet facilities for students. College has a playground and gymnasium to develop sportsmanship in students. College infrastructure is good and well maintained. The garden and green belt in the college,
adds to the beauty of the campus. The campus is endowed with butterfly garden and various rare endemic plants. Biogas plant is also set in college to manage the solid waste generated in college mess and canteen. College has roof rain water harvesting practice that helps to recharge ground water level. College runs various programs for the well fare of the students and society. Many awareness programs and workshops are organized by college for betterment of society.

Students are the integral part of the institute. Various activities are organized in college for student development. Number of guest lectures, workshops, seminars etc. is organized especially for student in college. The Oxford Connection is special programs structured by college through which alumina of Oxford University, visit college and interact with college students. Campus interviews are arranged for final year students by college for placement. Various institutes like banks, IT companies, and pharmaceutical companies conduct interviews in college. Soft skill development program is especially run for final year students of commerce, management, computer sciences and banking insurance to develop their languages and soft skills. This proves beneficial for students while seeking jobs after completion of their degree courses. Considering the importance of competitive exam college conduct Pre- IAS coaching for students and guide them in preparation of exams. Similarly students those who are interested in making their career in army are trained through a ‘Call me a Cadet’ scheme. Selected students are sent for training in army training institutes. Every year college organizes Devgad Youth Festival to provide platform for students to promote their participation in extracurricular activities. Students actively participate in this three days program.

College pays special attention for academic development of slow learners and improves students’ performance in examination. Remedialcoaching is arranged for each subject along with regular lectures. This practice has proved beneficial in improving students’ performance in academics and ultimately increased college result. Along with there are various other activities that are conducted in college for betterment of students and college.
1.6 Hypothesis

Till date, it is been found that no work has been done on the zoogeographical distribution of insect pests in on Alphonso Mango cultivations in Devgad region. Similarly, no efforts have yet taken to carry out the complete studies on the insect pests infesting mangoes. Hence this work will certainly be a primary database for the future steps taken in the direction. Mango cultivations in Devgad are being infested by various insect pests. Hence, the proposed research work will be beneficial to the farmers of Devgad in understanding pest ecology. Depending on the ultimate findings and conclusion, the extent of applicability of work can be decided at local level. The study is intended to evaluate the infestation status of different insect pests attacking mango crop in Devgad Tehsil. Besides, the relevant occurrence of insect pest in selected mango cultivations depending on the seasonal fluctuations will also help to understand the probable levels of infestation throughout the season. It is also proposed to understand and describe the prevalence of the insect species with respect to zoogeographical situation and status of the selected cultivation area. Depending on eco-geographical status, it is hypothecated that all species of insect pest are not prevalent in all parts of Devgad Tehsil and even the effectiveness of their damage to crop is not also similar in all parts of the Tehsil.

Alphonso mango variety is susceptible to temperature extremes as well as pests and diseases. These are the major limiting factors in fruit production and productivity. Insect pest are principally responsible for low yield because of inability of farmers to control the same regards. Due to lack knowledge farmers are unable to control pest incidence on mango crop. Farmers fail to adopt integrated pest management practices. That is particularly responsible for lowering mango productivity. Farmers should appropriately plant protection measures to overcome all limiting factors to increase production as well as productivity of mango crop.

Other contributors limiting mango production are non-availability of pest resistance variety, unawareness about different insect pest that attack mango crop and pesticides to be used to check pest incidence. There is lack of knowledge about crop insurance scheme like Pradhan Mantri Pik Vima Yojana and its usefulness. Furthermore, inadequate finance to meet the coast of mango production, unavailability of land for new plantation, lack of irrigation facilities, low market price for produce, unavailability of labour force and climate change are some of the problems faced by farmers in mango industry. Unavailability of land for mango cultivation and lack irrigation facilities are major factors limiting new plantation. Thus it is hard to expand area under mango cultivation. Whereas development of mango plantation up
to 4-5 years is suppressed due to unavailability of sufficient water supply. This affects mango productivity.

In mango industry generally there is imbalance in demand and supply chain. Mango gain good returns from February to March due to more demand and less supply. But by end of April supply exceeds demand in market which leads to decline in price of mango. On other hand natural calamities like rainfall and temperature extremes lead to drop in mango production. Hence the price of produce increases due to low yield. The fluctuation in price creates havoc among the farmers. Absence of large number organized markets, inadequate transport facilities at reasonable cost, increased dependence on internal demand, lack of storage facilities are some of problems faced by mango farmers in Devgad.

The problems faced by farmers in marketing the fruits are very critical. They have to cultivate, harvest, transport and even market their produce. There are several problems in these stages of mango crop. The problems may be related to irrigation, fertilizer application, pest management, inadequate finance, human resource, preservation, returns, transportation and other related aspects.

Pest problem in Devgad Tehsil is not a new only. It was recorded decades before, but the infestation level and insect diversity was less as compared to present pest scenario. Mango crop was attacked by pest like mango hopper, mealy bug and thrips that too at low level. In year 1981-82 only 2-3 sprays were taken by farmers to suppress pest population attacking mango crop. By 1995-96 sprays increased to 4-5 in mango cropping season. Then after by 2009-10 there tremendous increase in pest population as the area under mango cultivation was increasing. Thus number of sprays was also increased to arrest the pest incidence. Meanwhile there was remarkable increase in the pest infestation level. Minor pest like stem borer, fruit borer, fruit fly, shoot borer, scales and leaf miner have emerged as major pest. Earlier infestation level of these pests was negligible. By 2013 pest infestation has reached peak and significantly threatened the mango crop. Use of pesticides is adding to coast of production, subsequently increasing the mango price at market. Thus Devgad Alphonso mangoes are costlier than those coming from other states.

Present condition of mango crop is critical. Pesticides are ineffective to control the pest, thus higher doses are used to arrest the pest population. Pests are developing resistance against the pesticides. Thus frequent pesticides sprays are needed to protect mango crop. Indiscriminate use of pesticides is leaving its negative impact on non-target species like birds, butterflies, honey bees and pollinators. Also the impact is observed on the flora like
herbaceous plants as considerable amount of pesticide drop on ground while spraying. Similarly the pesticides are polluting the soil and water in vicinity. Small scale farmers are unable to finance the cost of pesticides sprays. Therefore their cultivations are left untreated that harbors several insect pests within them. Such cultivation are spread the infestation in adjacent cultivations. Pest infestation level is found to increase rapidly as their host plant mango trees are available on large scale.

Pest incidence is principally responsible for low productivity and fruit quality. Insect pests are major constraint in foreign exchange. Devgad Alphonso mangoes are rejected by foreign countries as mangoes were found to be infested by fruit fly and presence of pesticides residues in mango above permissible limit.

The invasion of popular horticultural variety that is Alphonso mango had marginalized the local unpopular varieties like Payari, Totapuri, Rayval, etc. Monoculture of single mango variety that is Alphonso is observed throughout the Devgad Tehsil. There are certain issues related to the mango production, pest infestation, orchard management and exclusive use of chemical fertilizer that are to be addressed at the length.