The bael is an indigenous fruit and has been known from prehistoric time. It is known as Indian Quince, Bengal Quince, stone apple, Holy fruit, Sriphal and bael. It grows throughout the India as well as Sri Lanka, Pakistan, Bangladesh, Burma, Thailand and most of the South East Asian countries. In India, the bael fruit is evidenced by its different names which have been given to it in different parts of the country, viz. Bela, bael, vilva in Bengali, Bel in Assamese and Marathi, Bil in Gujrati, Sriphal, bilwa, Malura, balva and bilva phalam in Sanskrit; Vilva-phzham in Tamil; Maluramu, bilva pandu in Telgu; Kuvalap pazham in Malayalam and Belpatri in Kannad.

HISTORICAL BACKGROUND:

Bael is known to mankind since long time for its therapeutic values. The leaves of bael fruit tree are dedicated to Lord Shiva, whose worship cannot be completed without it (Bailey 1919). Its importance is mentioned in ancient religious book like 'Yajurveda' and early Buddhist and Jain literature. (Om Prakash, 1961). Bael fruit is also mentioned in 'Brihat Samhita' and Upavan Vinoba, Sanskrit literature.
MEDICINAL PROPERTIES:

Its medicinal properties have been mentioned in 'Charaka Sanhita' (Aiyer 1956). Watt (1889) reported that unripe fruit is regarded as astringent, digestive and stomachic, and is prescribed in diarrhoea and dysentry with debility of the mucous membrane.

It has been often found most effective in chronic cases of dysentry where all other medicines have failed. The ripe fruit is sweet, aromatic and cooling. It is pleasantly laxative and a good simple cure for dyspepsia and is useful in febrile infections. The dried ripe pulp is mildly astringent and may be used in dysentry. A useful popular preparation, made in India, is the Bel preserve (Morabba) which may be taken at the breakfast table in convalescence from chronic dysentry or diarrhea. The root (and sometimes the stem) bark is made into a decoction which is used in the treatment of intermittent fever. It constitutes an ingredient in the 'Dasamul' (a preparation from the roots). It is given in hypochondriasis and palpitation of the heart. The leaves are made into poultice, used in the treatment of ophthalmia. The fresh juice is bitter and pungent, and diluted with water is praised as remedy in feverishness. The astringent rind of the ripe fruit
is employed in dyeing and tanning. It is also sometimes used medicinally.

Marmelosin \( (C_{13}H_{12}O_{3}) \) is most-probably the therapeutically active component of the bael fruit. It was isolated as a colourless crystalline substance with a faint smell reminding that of bael. It crystallises in fine silky needles from petroleum ether and in large cubical crystals from alcohol. It is insoluble in water, but on boiling with water for a long time, it melts to an oily liquid which on cooling again solidifies the somewhat greasy crystals, the substance being partially decomposed by the process.

In ordinary saturated steam, it is volatile only in traces, imparting to the condensed water its characteristic smell, but in super heated steam \( (200^\circ C - 210^\circ C) \) it volatilises with partial decomposition into anhydromarmelosin. When carefully heated by itself in a drytube, it melts, partially carbonises, the then superintendent of the Govt. Archipelago Garden Lahore, India (now in Pakistan) wrote to David Fairchild on Dec. 3, 1908, as follows:

"All India medicinal authorities agree that the bael fruit has a most salutory influence on the digestive system. The ripe fruit is mildly laxative and is a good simple remedy for dispepsia. The unripe fruit is a specific of the highest value for dysentery, so mild
that it can be given to children without danger".

Watt (1889) reported that the fruit delicious to the taste and exquisitely fragrant, is not only nutritious, but possesses a laxative and aperient quality, confirmed by experiences, which renders it particularly serviceable in habitual costiveness.

Chopra (1933) stated that the root bark is used in the form of a decoction as a remedy in hypochondriasis, melancholia, intermittent fever and palpitation of the heart.

Kirtikar and Basu (1935) reported that the bael fruit is prescribed for hepatitis and tuberculosis in Columbia.

According to Nadkarni (1976), the bael fruit is very valuable in habitual constipation, chronic dysentry and dyspepsia.

It is one of the ingredients in the 'Dasamul' or ten roots used in Ayurveda. Unripe or half ripe fruit, owing to the presence of tannins or mucilaginous substances which act as demulscent, cut in slices and sun dried or roasted and made into a confiture (conservé) or a powder, is prescribed in chronic diarrhoea and dysentry with debility of the mucous membrane intestinal conditions especially useful in chronic diarrhoea and dysentry of children.
when there is no fever. Dried pulp of the fresh ripe fruit is made into a pleasant orange coloured morning sherbat by mixing with sugar or cream, or with curds, two ounces of the pulp in three ounces of water or syrup, by straining all these through a piece of muslin to remove seeds and mucilage. The sharbat has mild astringent properties, is laxative and is a good simple cure for dyspepsia. Bael fruit is eaten during convalescence after diarrhoea. Bael marmalade or aromatised confection is useful at the breakfast during convalescence from chronic dysentery or diarrhoea; for daily use as preventive during cholera epidemics. It is also given to prevent the growth of piles. Decoction of the root, root bark and sometimes, the stem bark is useful in intermittent fever; also in hypochondriasis, melancholia, and palpitation of the heart. Leaves are made into a poultice and applied to inflamed parts. Fresh juice of the leaves is given with the addition of black pepper in anasarca with constiveness and jaundice and when diluted with water or honey it is a highly praised remedy in feverishness.

Mishra et al. (1990) observed that the essential oils of fresh leaves of 19 species collected in Varanasi were tested at 5000 ppm against the storage fungus A. flavus. The per cent inhibition shown was 100% for Amomum subulatum, Alpinia galanga
and lippia alba, 57% for curcuma langam, 66.66% for Artimisia vulgaris, 60% for Elettaria cardamomum and 54% for Salvia plebeia. Further investigations of A. subulatum oil showed that the minimum concentration for complete inhibition was 3000 ppm. The oil possessed a broad range of fungitoxicity in test with 20 plant pathogenic species and proved more efficacious than several standard fungicides. It has no significant adverse effect on seed germination in test with Oryza sativa.

**CULTURAL ASPECT:**

Bael can be grown up to an altitude of 1219 m. and is able to restore injury by temperature as low as -7°C. It is very hard fruit tree and thrives practically in every types of soil and unfavourable conditions, adopting itself well in swampy, alkaline or story soils and grows wild in sub-Himalayan forests (Watt, 1889).

According to Davis (1930), in its wild and semi-wild state, the bael fruit tree grows freely in Bahraich forest of northern India even on poor clay soils when other trees fail.

Bailey (1950), reported that it grows luxuriantly in the soil having pH range from 5 to 8. The bael tree can withstand the maximum temperature up to 116°F (46.6°C) and tolerate considerable degree of cold as low as 20°F (-6.66°C).
The bael is commonly grown from seeds but it can also be propagated by root cuttings, layers and budding in the month of June (Singh 1954; Hayes 1960; Singh 1963; Singh 1969; Moti et al. 1976; and Singh et al. 1976).

The bael fruit tree starts fruiting in about five year time. The fruit takes about a year to ripen and ripe fruits may be obtained in India from February to July, peak season being April-May. Ripening of bael fruit is relatively early in eastern India and late in northern India and also in Western India. It produces about 200 to 250 kg of fruits per tree and the number of fruits per tree varies from 200-400 Roy and Singh (1972).

Under Delhi conditions, Roy and Singh (1972) found that during ripening, complete defoliation of tree takes place in April. New leaves and shoots appear by the end of April. The flower buds appear almost simultaneously i.e. in May and flower start opening from middle of May and fruit setting takes place in about third week of May to first week of June. A huge number of flower buds appear in each terminal branch but ultimately the bearing of fruits is restricted to few in number.

Fruit drop is a problem in bael fruit for which remedy has yet not been found. Application of different growth regulators, namely 2, 4-D, gibberellic acid, 2,
4, 5-T etc. in different concentration could not prevent fruit drop (Pramanick and Bose, 1974).

Roy and Singh (1979) reported that the bael tree is very hardy and can be grown under adverse agro-climatic conditions, unlike other delicate fruit trees. Most tropical and sub-tropical fruits have a limited storage life, but bael fruit has a good post harvest storage life even at room temperature because of its hard outer shell, and it can withstand transport and marketing hazards to a considerable extent.

Hossain et al. (1993) reported that a protocol for organogenesis from nucellar explants excised from fertilized ovules of immature fruits was developed. Adventitious buds were initiated on MS medium containing various combinations of benzyladenine (BA), NAA, IAA and gibberellic acids. Medium containing 4.4 μM BA and 2.7 μM NAA produced the greatest number of adventitious buds per explant. Shoots were elongated by transferring explants with shoot buds to medium with a low concentration of BA (0.44 μM). Rooting of in vitro-regenerated shoots was obtained in half strength MS medium with 4.9 μM IBA. This is the first report of plant regeneration from nucellar explants of A. marmelos.

Varghese et al. (1993) found that callus of A.
marmelos on MS medium supplemented with different concentration of kinetin, 2, 4-D and NAA. Meristemoids developed in the callus when subcultured on medium supplemented with 1 mg kinetin +5 mg NAA/Litre in the presence of BA, alone or in combination with NAA, these calluses showed shoot development. Multiple shoot induction from nodal explant was achieved in MS medium augmented with different concentration of BA, kinetin and NAA. The shoot buds that developed from nodal explants were most numerous in medium supplemented with kinetin and NAA. Rhizogenesis of shoots was achieved in the presence of IAA.

Hossain et al. (1994) reported that cotyledons from A. marmelos seedlings of various ages were cultured on MS medium supplemented with different combinations of growth regulators. The optimum seedling age was 10 days for shoot induction response and benzyladenine (BA) was superior to kinetin, isopentenyladenine or zeatin. The optimum cytokinin (BA) concentration for bud induction was 2 mg/litre. The addition of 0.2 mg IAA/litre improved shoot regeneration efficiency. The proximal part of the cotyledon had the highest regeneration potential. Adventitious shoots were elongated on MS medium containing 0.5 mg kinetin and 0.1 mg gibberellic acid/litre. Approximately 25% of regenerated shoot were induced to differentiate roots on half-strength MS medium with 0.5 mg IBA/litre. The rooted plantlets were
successfully transplanted into soil.

Hossain et al. (1994) reported that slow growing calluses were induced from nucellar explant excised from 90-120 days old developing fruits collected from a 40 year old tree on MS medium containing 40 g sucrose, 400 mg casein hydrolysate, 5 mg NAA and 1 Mg kinetin/litre. Regeneration of shoots from 3 months old callus was achieved using the basal medium with 1-5 mg benzyladenine and 0.1 mg NAA/litre. Addition of 1 mg gibberellic acid/litre favoured shoot growth. Callus derived shoots produced roots and developed into plantlets when transferred to half-strength MS medium supplemented with 0.5 mg IBA and 0.5 mg NAA/litre. Plantlets that were subsequently acclimated outside were obtained in approximately 5 months.

Islam et al. (1994) reported a protocol for excising and culturing cotyledon explants from seeds of different ages was developed for the purpose of mass propagation. Cotyledon explants formed callus and shoot buds on supplemented MS agar medium. The highest frequency of explants forming adventitious buds and the maximum number of shoots per explant were obtained with cotyledons 110-150 days old. Benzyladenine with IAA or Gibberellic acid gave better results than benzyladenine alone shoots were elongated by transferring explants with shoot bud to the same basal medium with 1 mg
Fruits of *A. marmelos* are used in traditional medium in India. The effect of pre sowing seed treatments on longevity, germination and seedling growth of *A. marmelos* cv. Mirzapuri were investigated. Seeds were extracted from ripe fruits, derived and stored for 1 month in sealed polythene bags. The highest percentage germination after storage for 1 and 15 months (97.11 and 91.14% respectively) was observed following treatment with nutrients + GA (GA 100 ppm + Microshakti 1% + K$_2$HPO$_4$ 1000 ppm), compared with control. The nutrients + GA treatment also promoted seedling growth (leaf number, height, root length and seedling FW). High percentage germination values were also observed following treatment with K$_2$HPO$_4$ (1%) KNO$_3$ (0.5%) or GA (200 ppm). The number of days required for germination to commence and the number of days required to complete germination were reduced by the GA (200 ppm) and the nutrient + GA treatments (Hove et al. 1995).

Hazarika et al. (1996) reported that in vitro grown shoots of *A. marmelos* were cultured in MS medium supplemented with BAP (Benzyladenine 0, 0.25, 0.50, 0.75, 1.0, 1.25 or 1.5 mg/litre). Observations were recorded 4 and 8 weeks after culture initiation. The highest shoot number and weight were observed after 8 weeks of culture on a medium supplemented with BAP at 0.5 mg/litre. Shoots were rooted on half-strength MS
medium supplemented with IBA at 0.5 mg/litre and successfully transferred to soil. Intact seedlings of A. marmelos were tested for their ability to produce adventitious shoots by direct culture of mature seeds on MS medium supplemented with 0-5 mg BA/litre; BA at 1-2 mg/litre was optimal. Addition of 0.1 mg IAA/litre further increased shoot proliferation efficiency. Shoot buds originated from regions adjacent to the bases of cotyledons and cotyledonary axil and roots. In many cases adventitious shoots were produced from their enlarged apical region of roots. Shoots were rooted on MS medium supplemented with IBA. Rooted plantlets were successfully established in soil.

A. marmelos is an important Ayurvedic medicinal tree species. Cotyledonary node explants, excised from 15 days old seedlings of bael (A. marmelos) were placed on Murashige and Skoog (MS) medium supplemented with BAP (benzyladenine), IBA, IAA or NAA. BAP induced the best production of multiple shoots and subsequent plant regeneration. The highest number of shoots (75.2/explant) was observed on MS medium supplemented with BAP at 3 mg/litre. The number of shoots was further enhanced by (i) using nodal explant of in-vitro regenerated shoots as micro cuttings and (ii) repeated subculture of the original explants on the same medium after excising the shoots. More than 12376 shoots were obtained from a single explant within 5 months. Regenerated shoots produced roots in 30% of cultures when transferred to a
medium containing IBA at 4 mg/litre. Plant lets were transferred to soil, acclimatized and transplanted to the field (Arumugam et al. 1996).

An aqueous extract of neem seed kernel at 0.5% was tested for the control of Papilio demoleus, a pest of the medicinal tree Aegle marmelos in Karnataka, India. Spraying seedlings twice with an interval of 8 days was effective in providing protection against the pest. Although low mortality (23.3%) was reported, the extract had strong antifeedant and repellent effects and was effective as a moulting inhibition (Ranjeet Singh et al. 1996).

Ray et al. (1996) found that growth regulators and etiolation treatment were significantly effective in inducing roots in ringed system cuttings of A. marmelos. An invigoration treatment (the production of water shoots following removal of long branches) accompanied by growth regulator and etiolation, treatments significantly increased root quality on cuttings. The highest rooting rates of 75-80% were achieved using 5000 ppm IBA, etiolation and investigation.

**VARIETAL PERFORMANCE:**

Bael is found growing near to temple, corner of the orchards and backyard of the house in scattered
form. There is no standard name of cultivar of bael. They are generally named after the names of the locality where they are most easily available. A brief account of the work done yet on this fruit is given below.

Singh (1961) described six U.P. varieties of bael fruit. 'Mirzapuri' was considered to be the best followed by 'Daroga jee', 'ojha', 'Rampuri' and Khamaria.

Teaotia et al. (1963) also listed five varieties from Uttar Pradesh and found that 'Kaghji Gonda' was the best, producing large fruits (1412.82 g) with a thin rind (0.15 cm) and soft yellow pulp of excellent flavour. The keeping quality of this variety was also excellent.

Jauhari et al. (1969) presented the morphological and physico-chemical data on seven varieties of bael fruit from U.P. Further, Jauhari and Singh (1971) reported that the important bael fruit growing areas of Bihar and Uttar Pradesh and found that among the varieties studied 'Kaghji Etawah', 'Sewan Large', 'Mirzapuri' and 'Dooria Large' were excellent in taste and other qualities.

Mazumdar (1975) studied five types of ripe bael (Aegle marmelos Correa) fruits which differed in size and shape and growing in district of 24 Parganas of West Bengal. Those were subjected to physico-chemical tests. In general, considering the higher level of the different fruit constituents analysed, spherical
flattened fruits categorised as type 'A' could be graded as superior to the other types.

Mathura Rai et al. (1992) found that twenty four genotypes, including 3 wild types, having a wide range of variation in morphological and quantitative traits were identified from collections made in the eastern part of Uttar Pradesh and adjoining parts of Bihar. Based on an organoleptic test, six genotypes were identified as promising, having medium to large fruits, thin and papery rind, and soft deep yellow, highly flavoured, sweet pulp with few seeds.

Maikhuri et al. (1994) reported that the Garhwal, Himalaya, U.P. is an important source of wild fruit species. These wild fruit trees grows abundantly across an altitudinal gradient of Himalaya and the majority of them bear fruits during summer. Fruits are eaten raw by the local inhabitants of the region and whilst they are a rich source of protein, carbohydrate, fat and other elements, compared with cultivated fruits, they have not yet been considered as a source of alternative food products. About 13 potentially exploitable species of wild fruits and one semi domesticated species having high potential for exploitation were selected for study; six (Aegle marmelos, Berberis asiatica, Hippophae rhammoides, Myrica nagi, Rubus ellipticus and prunus armeniaca) were
examined in detail for their economic potential. Among the wild fruits Hippophae rhamnoides was found to be economically efficient, followed by Aegle marmelos, Rubus ellipbicus and Myrica nagi (M. rufra), respectively. Prunus armeniaca, a semi domesticated and less utilized fruit of higher Himalaya, provided better economic return on an annual basis. The authors have recently made an attempt to utilize these wild fruits as a source of income, particularly for poor rural inhabitants and unemployed youths of the region, through making a variety of edible products such as Jam, Jelly, Juice, Squash, Sauce etc. The enterprise was demonstrated to the people to encourage them to adopt it in the form of a small village level cottage industry. The present paper discusses the distribution, botany phenology, yield ethnobotany and the uses of these species and the cost benefit analysis of food products prepared from them.

**BOTANICAL ASPECTS**

The fruit consists of hard shell, pulp and seed sacs ranging from 13 to 25 filled with a muscilagenous gummy substance and arranged in a circle with numerous seeds. The pulp is soft, yellow or orange coloured with very fragrant scent and pleasant flavour. The seeds are surrounded with a very tenacious, slimy transparent mucus which becomes hard when dry (Webber and Batchelor 1948 and Hume, 1957).
Teo et al. (1963) reported that bael is a medium size tree with trifoliolate deciduous leaves and the branches have usually long straight thorns. The bisexual flowers which are greenish-white in colour, borne in cluster. The globose fruits are smooth, usually greyish-green turning yellowish when ripe, unlike citrus fruits of the same family.

Fruit usually globose, pericarp nearly smooth, greyish-yellow, about 1/8 inch thick, hard, filled with softer tissue becoming very hard and orange-red when dry; cells as in ovary. Seeds numerous, some what compressed, ranged in closely packed tiers in the cells and surrounded by a tenacious, stamy transparent mucus which becomes hard when dry; testa white, covered with wooly hairs immersed in the mucus, embryo with large cotyledons, and a short superior radicles; no endosperms. Aegle marmelos has dimorphic twigs: (a) normal twigs with internodes 3 to 5 cm long with one well developed leaf at each node, often with one or two thorns alongside; (b) foliage spurs produced on primary branches of the previous year's growth, usually very short, 1 to 3 cm long, with numerous very short internodes, each node bearing a leaf but no thorns. The numerous leaves crowded on the foliage spur vary greatly in size, the largest being nearly as large as the normal leaves on rapidly growing long-internoded branches but having decidedly longer petioles. The
smaller leaves borne near the base of the foliage spur are often much dwarfed, sometimes being only one-fifth or one-tenth as long as normal leaves. These crowded leaves of all sizes often hide almost completely the branches which bear them.

A tree reaching a height of 30 to 40 feet (9 to 12 m) when cultivated, with a short thick trunk and narrow oval head. In the wild state, smaller and more irregular shape with short, strong, sharp and thorny branches are found. Thorns are three or more cm long in the axils of leaves. The bark is bluish-grey soft with irregular colouring on the younger branches. Leaves alternate, compound, with one or two pairs of shortly stalked opposite leaflets and a larger long petiolate terminal one, leaflets 1-2 inches long, ovate or oval ovate, abrupt or tapering at the base, somewhat attenuated towards the blunt apex, very shallow serrato-crenate, smooth, thin, midrib prominent beneath. Flowers 3/4 inch wide, sweet-scented, stalked, solitary or terminal cymes. Calyx shallow, with five short, broad teeth pubescent outside. Petals 5 (rarely 4), oblong-oval, blunt, thick pale greenish white, dotted with glands, imbricate, spreading stamens numerous, some times coherent in bundles, hypogynous with short filaments as long as the linear anthers. Ovary superior oblong-ovoid, slightly tapering into the thick short style which is again some what thickened upward. Stigma
capitate, axis of ovary wide, cells numerous, 8-20 small, arranged in a circle, with numerous ovules in each cell (Swingle and Race 1967).

The bacl fruit group has 4 genera – Aegle, Afraegele, Aeglopsis and Balsamocitrus. The genus 'Aegle' to sub tribe Balsamocitrinae, Tribe-citreae, sub-family-Auran tiodeae and Family-Rutaceae. The genera of this group represent the typical hard shelled citroid fruit tree. The generic name 'Aegle' is of Greek origin and species 'Marmelos' is of Portugese origin (Singh and Roy 1984).

**PHYSICAL CHARACTERS**

A variety is known good with its chemical composition, nutritive status and medicinal value, fruit weight, size and volume, ratio of edible and non edible parts, number and weight of seeds, colour and aroma of the pulp and yield per plant.

Constant increase in weight of fruit has been seen during the period of growth and development. This increase is due to increase in the number of cells because of the mitotic activity of cells in the fruit, as has been reported in case of valencia oranges (Nitsch, 1953 and Bain, 1958). Further increase in weight is affected due to increase in size of these cells. The rate of increase in weight during the period of growth and development of fruit is not uniform and
depends upon many internal and external factors. Different stages of the development of the fruits depending on their size and weight have been marked in mangoes, valencia oranges and apple by many research workers (Bain and Robertson, 1951; Bain, 1958; Singh 1960; Denne, 1960; Blanpied and wilde, 1968). Budar-Ud-Din (1950) studied the physical properties of bael gum.

Kaul et al. (1967) found a linear increase in weight, of as usual, was due to an increase in the size of fruit.

Jauhari et al. (1969) reported after research on, seven varieties of bael fruit from Uttar Pradesh adn found that weight of fruit, number of seeds and thickness of rind varied from 1283 g to 2818 g, 74-207 and 0.16 to 0.28 respectively.

Fruit size also vary with variety and locality (Gardner et al. 1952, Hayes, 1957; 1960 and Winkler, 1965), Teaotia et al. (1963), Jauhari et al. (1969) and Jauhari and Singh (1971).

Garge et al. (1977) observed the physical and chemical composition of Aegle marmelos on five different dates. Fruit harvested at the middle stage of maturity, extending from late October to late December, was most suitable for preserve making, with preserves made in late October having the flavour. For fresh consumption,
the optimum harvest time was from mid March to mid May.

Roy (1978) reported the physical characters of the different cultivars bael fruit procured from Calcutta, Varanasi, Agra and Delhi. They were of different shape and size. From the limited number of 24 cultivars of 4 centres, variability met with in fruit characters was clearly discernible. The range of variability was larger in fruit size, while in shape, some odd types like that of near cylindrical and pear shape have also been observed. In general, larger fruits had lesser peel percentage than smaller fruits. Among the cultivars studied, Agra recorded highest percentage of edible portion (77.26%) by weight with thin and low peel (0.18 cm and 20.54%, respectively), low fibre content (1.39%) and very low seed percentage (0.81). This cultivar of Calcutta and Varanasi compared favourably.

Roy and Singh (1980) reported that bael followed a single sigmoid curve during development. The growth rate of fruit has three distinct phases; the initial slow phase or one month, i.e. upto June, followed by a rapid increase upto September and then more or less a stationary phase until the fruits are harvested. The rate of respiration in bael fruit at the early stage of development was very fast. With growth, the respiration rate declined. No dimacteric rise in respiration was noted as long as the fruit was attached
to the plant. However, an upsurge in respiration was not noted after harvest, which coincides with the optimum ripening condition of fruit. This characterises the bael fruit as climateric in nature.

Singh (1986) observed that there was only one flush of growth in a year in bael when both vegetative and reproductive shoots emerged simultaneously in the second fortnight of May after leaf fall. The bud burst started from top terminal buds and subsequently covered the entire tree in 7 to 9 days. Four distinct type of growths were formed on one year old shoot, followed in descending order by 2, 3, 4 and even more years old branches. The highest number of mature fruits developed on horizontally divided upper portion of the tree followed by middle and lower portions. The maximum development of fruit was observed upto beginning of October, which gradually sowed down till December and remained constant upto first fortnight of April. The bael produced a regular and mostly uniform crop once a year.

**COLOUR :**

Colour of the fruit plays a vital role in the quality of almost all the varieties. Fruit colour is controlled by a number of factors but sunlight and atmospheric temperature appear to be most important contributary factors. A temperature around 76° F was
reported to have inhibitory action against pigment formation (Uota 1952). Fruit size and age of the tree also affect the colour significantly (Ting et al. 1958). The variation in day and night temperature was observed to be responsible for the uniform colour development in oranges.

Erickson (1960) found in a study that colour development of Valencia oranges, during two months exposure (20°C) by day and 5°C by night, fruit became uniformly orange coloured. Relatively lower temperature is reported to favour bright fruit colour in Valencia oranges (Young and Erickson 1961). Shading of grapes from natural light intensity at the rapid stage of growth, improved the colour of berries (Naito et al. 1965). The bael fruit remain deep green in the initial stage and it is difficult to locate them in bushy leaves. The colour gradually fades away with the advancement of maturity and become yellowish at ripening (Roy and Singh 1972).

Khanna et al. (1996) reported that natural vegetable dyes have gained importance all over the world after a lapse of more than a century due to their eco-friendly nature. India can play a vital role in this field on account of its varied climate and rich flora. Forest and domestic waste can also serve as a potential source of natural dyes. This communication deals with some forest/domestic waste, including fruit.
rind of A. marmelos, Anar (Punica granatum) Sharifa/Sitaphal (Anona squamosa) florets of safflower (Carthamus tinctorious) and Marigold (Tagets erecta); dried bark of Eucalyptus; fruit pulp and seed and Amaltas and the upper dry scales of onion.

CHEMICAL AND BIOCHEMICAL CHARACTERS:

Baslas and Deshpande (1949) extracted essential oil from the leaves of Aegle marmelos. Its chief component is found to be $\alpha$-d-phellandrene which forms about 56 per cent of the oil. Further two more components namely, p-cymene (17%) and cumin aldehyde (5%), have been found in the essential oil from the leaves of Aegle marmelos. The essential oil from the twigs and the fruits of this plant have also been examined. The former contains cineol (40-45%) and $\alpha$-d-phellandrene (34.5%) and the latter contains $\alpha$-d-phellandrene only (Baslas and Deshpande 1951).

Jayaweera (1952) reported the need for growing A. marmelos in ceylen as a drug plant. Chatterjee and Bose (1952) isolated an alkaloid, Rutacin ($C_{14}H_{13}O_{4}N$) and a sterol, Aegelin ($C_{16}H_{18}O_{4}$) from the leaves of A. marmelos Correa. The physical and chemical properties of rutacin is as skimmianine ($C_{14}H_{13}O_{4}N$).

Bhatia (1953) Dasgupta and Chakravarti (1958) reported the presence of d-$\alpha$-phellandrenine the essential oil of bael fruit.
According to Chatterjee and Choudhary (1955), young bark of the tree gives a coumarin, namely marmin ($\text{C}_{19}\text{H}_{26}\text{O}_5$).

Chatterjee and Roy (1957) found aegelenine ($\text{C}_{14}\text{H}_{10}\text{O}_2\text{N}_2$), an alkaloid in the leaves of bael fruit.

Shaha and Chatterjee (1957) reported coumarins, like alloimperatorin, imperatorin and $\beta$-sistosterol in fruits of bael.

Chakravarti and Dasgupta (1956, 1958) isolated a tree sterol viz. $\gamma$-sistosterol ($\text{C}_{29}\text{H}_{50}$O) from the leaves of A. marmelos.

Parikh et al. (1958) hydrolysed the bael fruit mucilage and recorded the presence of three reducing sugars, viz. galactose, arabinose, and rhamnose.

Chatterjee and Roy (1959) isolated and identified three compounds from the heart wood of Aegle marmelos, viz. marmesin ($\text{C}_{14}\text{H}_{14}\text{O}_4$), $\beta$-sistosterol ($\text{C}_{29}\text{H}_{50}$O) and dietammine ($\text{C}_{12}\text{H}_9\text{NO}_2$).

Haksar and Kendurkar (1961) reported that bael fruit yielded 2% of dried water soluble gum. The gum was used to prepare adhesives, water proofing and emulsion coating. Variation in sugars content was also recorded and the range was 12.50 to 17.90 per cent for total sugars. The non-reducing sugars were found to be more in content to the reducing sugars in all the cultivars tested. The variation recorded in ascorbic
acid content from 7.68 to 18.20 mg per 100 gms of edible portion. The acidity varied from 0.31 to 0.40 per cent, Sharma and Sharma (1981) isolated a new naturally occurring alkaloid from the ripe fruit of A. mormelos and characterised as O-methyl fordinal. Alloimperatorin methyl ether, hitherto unknown in the Aegle genus, and O-isopentenylhal fordinol, earlier detected in the leaves were also obtained.

According to Gopalan et al. (1971), bael fruit contain 61.5 g water, 1.8 g protein, 0.39 fat, 1.7 g minerals 31.8 g carbohydrates, 5.5 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niacin and 8 mg vitamin C per 100 g of edible portion. No other fruit has such high content of riboflavin.

Jauhari and Singh (1971) surveyed the varieties of bael fruit in the important fruit growing areas of Bihar and Uttar Pradesh. The total soluble solids, total sugars, and Vitamin C varied from 32.0 to 36.0 per cent, 15.15 to 16.89 per cent and 19.4 to 22.2 mg per 100 g of edible portion, respectively.

Roy et al. (1972) observed that bael fruit attains its maximum weight in December but does not become fully ripe on the tree until April. Fruit harvested in January and again a five minute dip in ethephon as ethrel at 240, 480, 960 or 1440 ppm did ripen when held at 30°C. Untreated fruit also ripened at this temperature, but not so rapidly. The sugars
content of the fruit was highest in the 480 and 960 ppm treatments.

Shoeb et al. (1973) isolated psoralen, xanthotoxin, O-methylscopoletin, scopoletin, tembamide and skimmin from the roots of A. marmelos.

Roy and Singh (1978) reported the chemical composition and organoleptic quality of bael fruit of different cultivars obtained from Calcutta, Vasranasi, Agra and Delhi. Among the cultivars studied, variation in total soluble solids was not much, but generally, smaller fruits had higher total soluble solids.

Chakraborty et al. (1978) reported that marmeloide, a tyrosinase accelerating and tryptophane pyrolase inhibiting furocoumarin were isolated from ripe fruits.

Chatterjee and Bhattacharya, (1959 and Patra et al., 1979) reported compounds like ciuroptius, marmin, umbelliferone, lupeol, skimminiane and β-sitosterol have also been found in the bark of Aegle marmelos.

Pandey et al. (1986) studied the biochemical changes in A. marmelos fruit. Fruits of the cultivars Deshi and Mirzapuri were sampled at monthly intervals between August and May. An increasing trend in both reducing and non reducing sugars was observed. Fruit-pulp contained very low acid level which did not
vary much with fruit development. The ascorbic acid content increased with fruit maturity. A sharp increase in pectin, tanin and marmelosin content in the pulp was recorded until January and later a gradual decline was noticed.

Bhardwaj et al. (1995) observed that changes in fatty acids, phospholipids and galactolipids content during cellular and organ differentiation in Aegle marmelos are described. Decrease in phosphatidylinositol content and presence of 3 trans hexadecenoic acid in phosphabidylglycerol are related to greening and shoot bud differentiation. The galactolipids levels, the monogalactosyl diglyceride/digalactosyldiglyceride ratio and the linolemic acid level (mainly in monogalactosyl diglyceride) increase with the degree of differentiation, indicating the possible biogenesis of functional chloroplasts.

PROCESSING AND STORAGE:

Roy and Verma (1950) mentioned the process of manufacturing bael squash and bael jam. Agnihotri (1950) published the method for preparing and preserving syrup from ripe bael fruits. However, an early reports of Singh & Dutta (1941) stated that although the fruit was rich in pectin, it did not form jelly due to excess of gummy principles.
Verma and Ahmed (1958) reported that bael fruit powder would also be manufactured successfully.

Extraction of pulp from the ripe bale fruit is the main hindrance to processing. This is mainly due to mucilageneous texture and tendency of the pulp to develop off flavour and colour. The bael fruit pulp was successfully extracted by addition of water equal to the pulp (with seed and fibre) adjusting the pH to 4.3 with citric acid (titratable acidity 0.5%) and heating at 80°C for one minute. The application of heat not only inactivated the enzyme but also helped in dissolving the mucilage uniformly to provide a homogeneous pulp (Roy and Singh 1979a).

Roy and Singh (1979c) reported about storage studies of bael fruit product. During storage, there was reduction in non-reducing sugars and increase in reducing and total sugars in bael products. Addition of SO₂ not only improved the initial quality of bael fruit slab, toffee and powder but also prevented non enzymatic browning reaction during storage of all the bael fruit products. The optimum relative humidity for the storages of bael fruit slab, toffee and powder was found to be 63, 58 and 5 per cent respectively. Practically no change in organoleptic quality was noticed in frozen pulp after six months and in case of other products stored at 37°C, the organoleptic quality remained much above the acceptable point.
The post-harvest storage life of ripe bael fruit can be enhanced from 2 weeks at the ambient temperature of 27°C - 32°C to 12 weeks at cool storage temperature of 9°C (RH 85 to 90%). At low temperature (below 9°C), spoilage is mainly due to chilling injury, i.e. appearance of brown spots on the fruit surface while at high temperature (about 14°C) storage spoilage is mainly in total sugars and greater accumulation of reducing sugars are observed (Roy and Singh 1979d).

Ripe fruits of bael can be made available 2-3 months ahead of schedule by giving a treatment of 1000 to 1500 ppm of ethrel and keeping the fruits at 30°C after harvesting them in January. It takes 18-24 days for the fruits to be artificially ripened. The composition of bael fruit, whether ripened artificially or naturally, does not vary much. Only accumulation of sugars is slightly less in artificially ripened fruits as compared to naturally ripened ones (Roy & Singh 1981).

Although it is very important from medicinal and other points of view, yet no much work has been done on bael. Taking the above view, bael has been selected for the study under the proposed research programme.