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ANATOMY OF WOOD (TIMBER) OF *MANGIFERA INDICA* L. FROM BALRAMPUR DISTRICT IN THE TERAI REGION OF UTTAR PRADESH, INDIA AND ITS ORIGIN AND DIVERSIFICATION

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ABSTRACT

The present study is undertaken to understand the anatomy of different variety of *Mangifera indica* L. *i.e.* Dashehri, Langra, Safeda, Chaunsa and Bombay mango. *M. indica* L. is one of the most common timber resources for Indian peoples utilizing mainly in house construction, furniture and fuel. Its Wood is moderately hard, light colored, contains tannin cells and resin canal; clearly demarcated sapwood and heartwood by growth ring of parenchymatous cells. It is generally characterized by medium to large, thin-walled, numerous, diffuse porous, solitary or in radial multiples of 2-3 vessels with simple perforation plates. Axial parenchyma is usually paratracheal, Rays thin walled, 1-3 seriate, heterogeneous, composed of both upright and procumbent cells, Fibers slightly thick walled and sepate containing simple pits. The anatomical characters of each variety of mangos have been studied in detail and analysed them in order to distinguish each others. The biogeography of *Mangifera indica* L. is also illustrated along with the history, origin and earliest occurrence of this commercially important species. This study suggests that the centre of origin of the genus *Mangifera* Linn. was from north-east India from where it spread into neighboring area.

Key words : Wood, *Mangifera indica* Linn., Timber resources, Anatomy, Origin, Diversity, Balrampur, U. P.

Introduction

The family Anacardiaceae (Cashew family) comprises about 83 genera with about 860 species and has pantropical distribution, grows mainly in the tropical regions of both the hemispheres. *Mangifera* L. is one of the most significant genera producing commercially important an edible fruit, *i.e.* known as Mamgo (Aam). The genus *Mangifera* L. presently consists of about 40 species distributed in south-east Asia and Indo-Malayan region (Willis, 1973). Out of them only four species are found in India (Santapau and Henry 1973). The species of *Mangifera* Linn. are mostly trees**,** characterized by simple, alternate leaves actinomorphic, hermaphrodite, hypogenous flowers, free sepals, petals and stamens and drupe type of fruits. *Mangifera indica* Linn. is one of well famous woody trees of the tropics, which can attain a height of more than 40 m with large canopy. They grow well on a well-drained alluvial or lateritic and producing commercial timbers used by about 60 percent of local villagers to fulfil their day to day needs. This is an essential resource in the life of human beings and is used by them for various purposes *i.e.* house construction, furniture, and agricultural and musical instruments and packing cases etc. A good amount of work has been carried out on wood anatomy of different genera and species of both monocot and dicot families. Some of the study on the different aspect of wood anatomy and physical properties of tree and shrubs has also been done in India (Gamble, 1972; Pearson and Brown, 1932; Metcalfe and Chalk, 1950; Pande, 2012; Gautum, 2010). Several scientist have study and described the anatomy of both angiospermous and gymnospermous fossil woods from different geological strata exposed in India and abroad (Awasthi,

1970; Chitaley and Patil, 1972; Mehotra, 1987, Navale, 1963; Prakash, 1966; Prasad, 1993; Shukla *et al*., 2023). In most of the cases the fossil woods are identified with their modern equivalents on the basis of anatomical characters and build up palaeoflora of the regions. Keeping in view the importance of wood anatomy, we have started to study the anatomy of commercial wood yielding plants (tree and shrub) of District Balrampur and nearby area in order to aware the peoples about the characters, identification and uses of timber yielding plants around them. The present communication deals with the anatomy of five varieties of *Mangifera indica* Linn. collected from a Mango field (27.433068°N: 82.169544°) of Dr. J. S. Chauhan, near Neel Kothi, Balrampur (U.P.).

Materials and Methods

Study area

Balrampur is a districts of the Uttar Pradesh and is a part of Devipatan division in the terai of Awadh regions. It occupies an area of about 3719sq km. lying all along Indo- Nepal border. It is surrounded by district Siddharth Nagar and Gonda in the east-west and south sides respectively and Nepal in the northern side containing Siwalik Hills of the Himalaya foot hills (Fig. 1).

It has an average elevation of 106m. There are two main rivers, Rapti in the north and Ghaghara River in the south running in this area. They flow from north-west to south-east and are joined by numerous tributaries. They only overflow their banks in rainy season. Many of these contain water for a part of the year only. But the only one which can be considered as a water stream is that know as the Burhi Rapti, which emerges near Mathura in in the north-western part of the area and flow across the district in a direction roughly parallel to that of the Rapti. Kuwana River flows with slow speed. The well known forests, Suhelwa Wild life forest is situated in the north of Balrampur district between the altitudes of 120m and 200m above the mean sea level and covering the adjoining districts of Balrampur, Shrawasti and Gonda. The most common woody plant in the forest area is *Shorea robusta* Roth. of the family Dipterocarpaceae. The other common trees found in the forest area of Balrampur are *Tectona grandis* Linn. f. (Lamiaceae), *Adina cordifolia* (Roxb.) Brandis (Rubiaceae), *Mangifera indica* Linn. (Anacardiaceae), *Ehretia laevis* Rottler ex G. Don. (Boraginaceae), *Gmelina arbroea* Roxb.ex Sm. (Lamiaceae), *Ficus* spp. (Moraceae), *Schleichera oleosa* (Laur.) Oken (Sapindaceae) and *Dalbergia sissoo* Roxb. (Fabaceae).

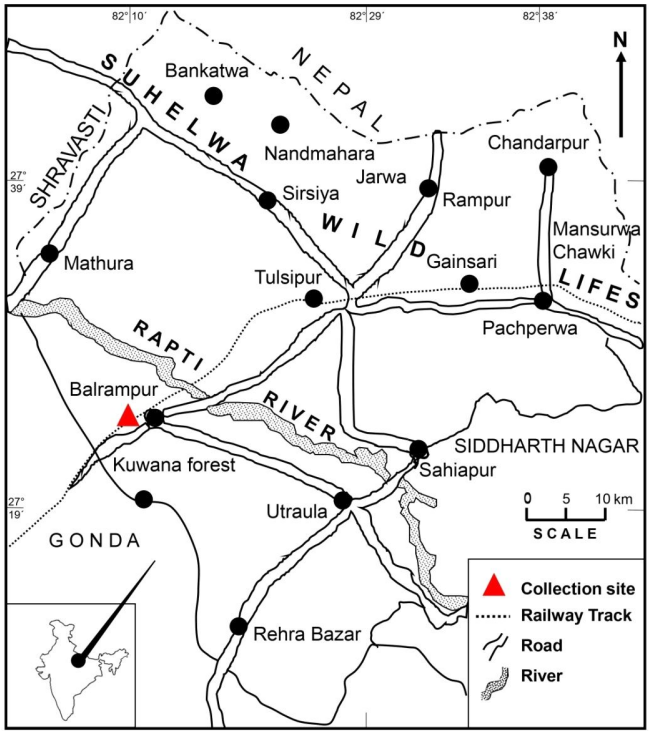

Fig. 1 : Map of district Balrampur showing the location of collection site of different varieties of *Mangifera indica* for present study.

Climate of the study area is mainly divided into four seasons; the cold season from about the middle of November to February is followed by the summer season from March to the middle of June. The south-west monsoon season is from the middle of June to September. October and first half of November constitutes the post-monsoon or transition season. May is generally the hottest month with the mean daily maximum temperature at around 39°C and the mean daily minimum temperature is around 24°C with grater humidity.

Methodology

The material (woods) for present study have been taken from the trunk of all the five varieties (Dashehri, Langra, Safeda, Chaunsa and Bombay mango) of *Mangifera indica* Linn. growing in the Mango field of Dr. J. S. Chauhan, near Neel Kothi in Balrampur district of Uttar Pradesh. The height of each tree is measured with the help of measuring tape from base as ground level to the apex of the tree and expressed in a meter which is up to 30 meters. The trunk girth was measured as average of 2.25m. The wood sample for its anatomical study has been taken from the trunk above about 1m from the earth surface with the help of a carpenter. The wood sample is boiled with water by mixing a little amount of Glycerine until it become soft. The wood has been cut into thin slices along transverse (TS), tangential longitudinal (TLS) and radial longitudinal (RLS) with the help of Microtome available at the Botany Department,

M.L.K. Post Graduate College, Balrampur and then prepared their slides by using different grades of ethyl alcohol for dehydration and safranin for staining. Canadabalsum has been used for as a mounting substance for making permanent slides. The thin section will be examined critically under high power microscope and described their anatomical features in detail. Their photography has been carried out with the help of microscopic camera attached to the high power microscope. All the prepared slides were kept at Department of Botany, M. L. K. College, Balrampur, U. P.

Results and Discussion

A critical study of the wood slides prepared from the woods of all the above mentioned five varieties of *Mangifera indica* Linn. has been carried out. The anatomical characters exhibited by each variety are observed and described separately in details according to terminology given by International Association of Wood Anatomist (IAWA) committee (1989).

Description of Wood anatomy of different varieties *M. indica* L.

Dashehri : ***Wood*** diffuse porous; ***Growth ring*** distinct as demarcated by marginal parenchyma in concentric ring ***Vessels*** are medium to large, thin-walled, numerous, diffuse porous, solitary or in radial multiples of 2-6, ***Tyloses*** are conspicuous and scanty, vessels with simple perforation plates, intervessel pits are simple bordered with lenticular apperture. ***Xylem parenchyma*** is both paratracheal and apotracheal, paratracheal parenchyma are found around the vessels and apotracheal parenchyma in the form of growth ring as well as irregular bands of 2-4 cells thick, parenchyma cells are circular to oval and thin walled. ***Xylem rays*** thin walled, 1-3 seriate, usually 1-2 seriate, heterogeneous, medium sized , upto 20 cells in height and composed of both upright and procumbent cells. ***Fibers*** slightly thick walled and sepate containing simple pits (Fig. 2A-E).

Langra : ***Growth ring*** well demarcated by thin band of parenchyma and size of the vessels as well as dense fibres. ***Wood*** diffuse-porous. ***Vessels*** diffuse porous, solitary as well as in radial multiples of commonly short 2–4 vessels or up to 7. Average tangential vessel diameter 130-2900 µm. Average number of vessels/mm² 3-6. Perforation plates simple. Intervessel pits alternate, bordered, 18-12 µm in diameter. ***Tyloses*** in vessels present abundantly, thin walled. ***Vasicentric tracheids*** absent. Fibres are moderate in thickness having, simple to minutely bordered pits and septate. ***Parenchyma*** both apotracheal and paratracheal; Apotracheal parenchyma

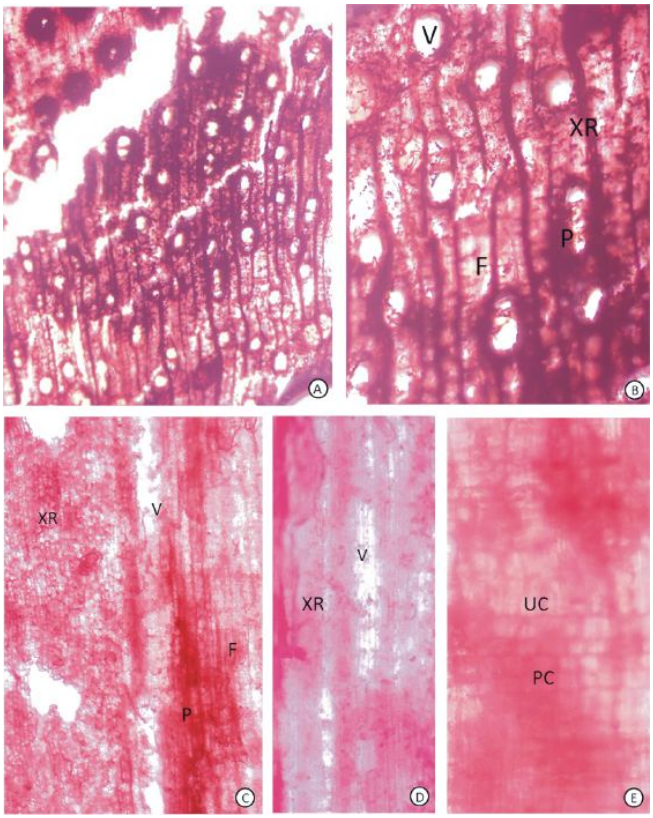

Fig. 2 : Wood of *Mangifera indica* variety Dushehri. **A.** T.S. of wood showing nature and distribution of vessels, xylem rays, parenchyma and growth ring demarcated by thin band of parenchyma and difference of vessels size, **B.** Transverse section enlarged to show the nature of vessels and parenchyma cells, **C, D.** T.L.S. of wood showing 1-3 seriate mostly 1-2 seriate xylem rays, **E.** R.L.S. of wood showing heterogeneous xylem rays composed of both upright and procumbent cell, V-vessels, XR- Xylem rays, P-Parenchyma, F- Fibres, UC –Upright cells, PC – Procumbent cells.

banded. Fine, up to 3-7 cells wide. Paratracheal parenchyma aliform, or confluent, aliform parenchyma sometimes extended in the form of short band. ***Rays***. 6–8 per mm, 1–3 cells wide and 18-27 cells in height, heterogeneous, composed of two type of cells. Upright and procumbent; upright cells are square and restricted to marginal rows. Number of marginal rows of upright or square cells is usually 1-5. ***Sheath cells*** absent. ***Storied structure*** absent (Fig. 3 A-E).

Safeda : ***Wood*** is moderately hard, light colored, diffuse porous; contains tannin cells and resin canal; clearly demarcated sapwood and heartwood by growth ring of parenchymatous cells. ***Vessels*** are medium to large, thin-walled, numerous, diffuse porous, solitary or in radial multiples of 2-4. ***Tyloses*** are inconspicuous and scanty, vessels with simple perforation plates. ***Xylem parenchyma*** is usually paratracheal, apotracheal

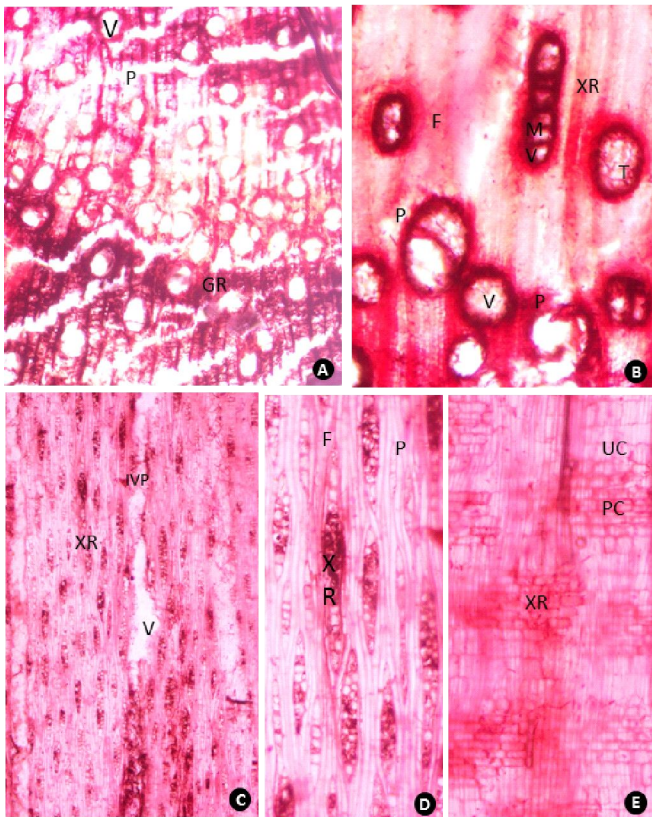

Fig. 3 : Wood of *Mangifera indica* variety Langra. **A.** T.S. of wood showing nature and distribution of vessels, xylem rays, parenchyma and growth ring demarcated by thin band of parenchyma and difference of vessels size and dense fibres, **B**. Transverse section enlarged to show the nature of vessels and parenchyma cells and tyloses , **C.** T.L.S. of wood showing 1-3 seriate xylem rays, **D.** T.L.S. of wood showing uniseriate, biseriate and triseriate rays and septate fibres, **E.** R.L.S. of wood showing heterogeneous xylem rays composed of both upright and procumbent cell, **6**.Intervessels pits. V-vessels, XR- Xylem rays, P- Parenchyma, F- Fibres, UC –Upright cells, PC – Procumbent cells. VP- vascular pits.

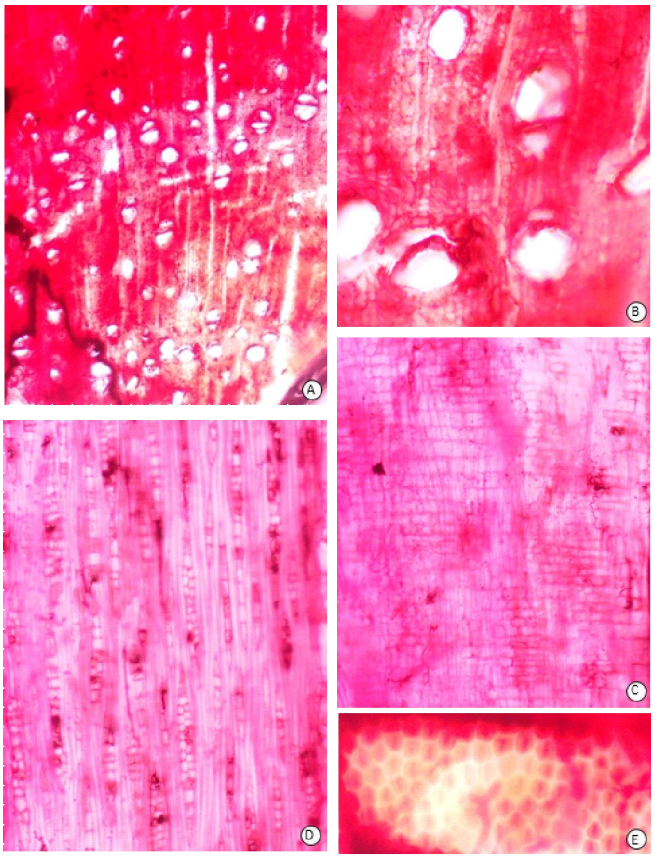

Fig. 4 : Wood of *Mangifera indica* variety safeda. **A.** T.S. of of wood showing nature and distribution of vessels, xylem rays, parenchyma and growth ring demarcated by thin band of parenchyma and difference of vessels size, **B.** Transverse section enlarged tio show the nature of vessels and parenchyma cells, **C.** T.L.S. of wood showing 1-3 mostly 1-2 seriate xylem rays, **D.** R.L.S. of wood showing heterogeneous xylem rays composed of both upright and procumbent cell, **E.** Intervessels pits.

parenchyma in the form of growth ring as well as irregular bands. ***Xylem rays*** thin walled, 1-3 seriate, heterogeneous and composed of both upright and procumbent cells, large in size. ***Fibers*** slightly thick walled and septate containing simple pits (Fig. 4.A-E).

Chaunsa : ***Growth ring*** present demarcated by thin band of parenchyma and size of the vessels. Vessels. ***Wood*** diffuse-porous. ***Vessels*** arranged in no specific pattern, in multiples, commonly short 2–4 vessels in radial rows. Average tangential vessel diameter 120-270 µm. Average number of vessels/mm² 3-8. Perforation plates simple. Intervessel pits alternate, bordered, 18-12 µm in diameter. Vessel-ray pits not distinct. ***Tyloses*** / tannin in vessels present, thin walled. V***asicentric tracheids*** sporadic to absent. Fibres are moderate in thickness having, simple to minutely bordered and septate. ***Parenchyma*** both apotracheal and paratracheal; Apotracheal parenchyma banded. fine, up to 3-6 cells wide. Paratracheal parenchyma aliform, or confluent. Aliform parenchyma sometimes extended in the form of short band, *Xylem* ***Rays***. 7–10 per mm 1–3 cells usually 1-2 cells wide. Heterogeneous, composed of two type of cells, Upright and procumbent, upright cells are square and restricted to marginal rows. Number of marginal rows of upright or square cells is usually 1-3. ***Fibers*** slightly thick and seemingly sepate. ***Sheath cells*** absent. ***Storied structure*** absent (Fig. 5 A-F).

Bombay mango : ***Growth ring*** not distinct. ***Wood*** diffuse-porous. ***Vessels*** diffuse porous, solitary as well as in radial multiples of commonly short 2–4. Average tangential vessel diameter 120-290 µm. Average number

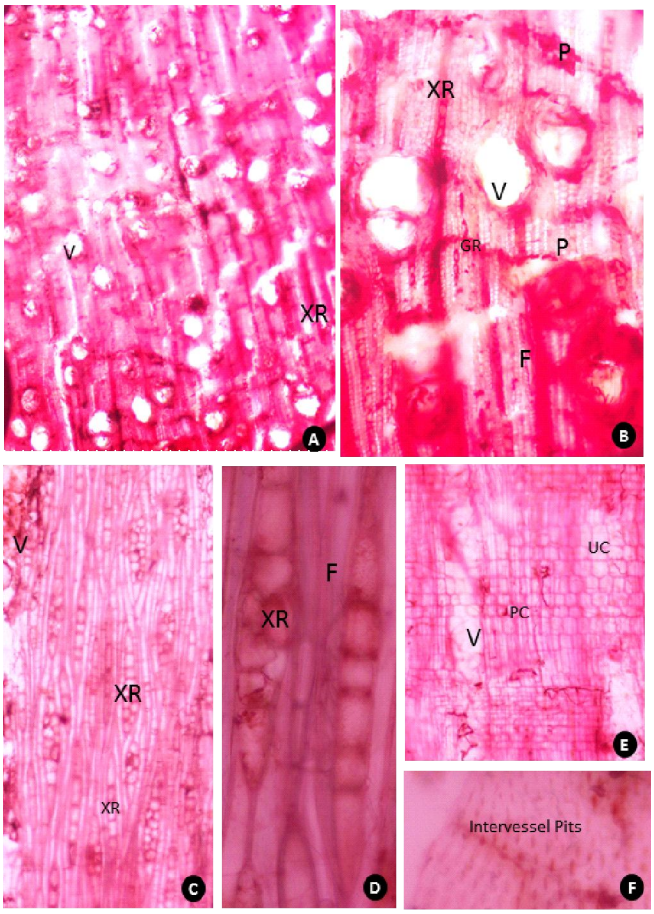

Fig. 5 : Wood of *Mangifera indica* variety Chaunsa. **A.** T.S. of wood showing nature and distribution of vessels, xylem rays, parenchyma and growth ring demarcated by thin band of parenchyma and difference of vessels size, **B.** Transverse section enlarged to show the nature of vessels and parenchyma cells, **C.** T.L.S. of wood showing 1-3 seriate mostly 1-2 seriate xylem rays, **D.** T.L.S. of wood showing uniseriate and biseriate rays cells and septate fibres, **E.** R.L.S. of wood showing heterogeneous xylem rays composed of both upright and procumbent cell, **F.** Intervessels pits. V-vessels, XR- Xylem rays, P-Parenchyma, F- Fibres, UC –Upright cells, PC – Procumbent cells.

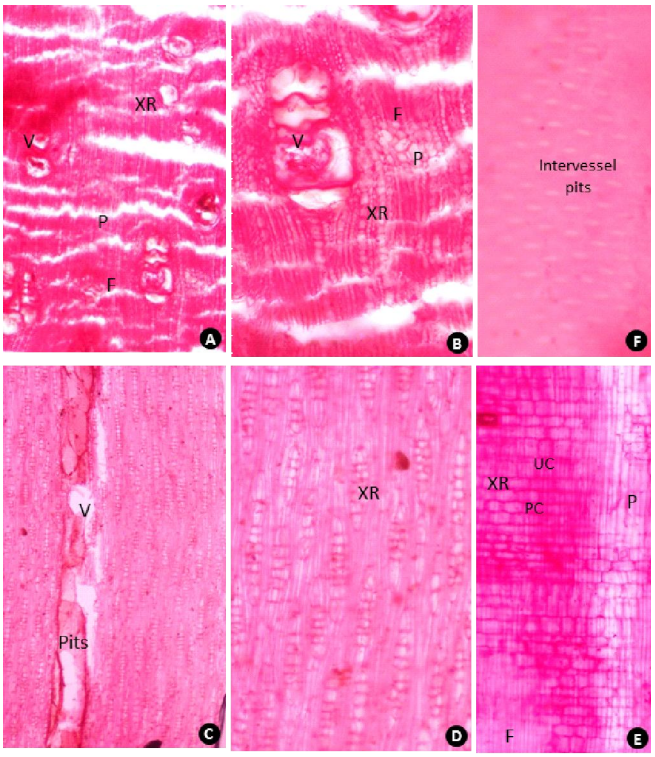

Fig. 6 : Wood of *Mangifera indica* variety Bombay Mango. **A.** T.S. of wood showing nature and distribution of vessels, xylem rays, parenchyma and growth ring demarcated by thin band of parenchyma and difference of vessels size and dense fibres, **B.** Transverse section enlarged to show the nature of vessels and parenchyma cells and tyloses, **C.** T.L.S. of wood showing 1-2 seriate xylem rays, **D.** T.L.S. of wood magnified to show the nature of xylem rays and septate fibres, **E.** R.L.S. of wood showing heterogeneous xylem rays composed of both upright and procumbent cell, **F.** Intervessels pits. V-vessels, XR- Xylem rays, P-Parenchyma, F- Fibres, UC – Upright cells, PC – Procumbent cells.

of vessels/mm² 3-5. Perforation plates simple. Intervessel pits alternate, bordered, 12-16 µm in diameter with lenticular apertures. ***Tyloses*** in vessels present abundantly ***Vasicentric tracheids*** absent. ***Parenchyma*** both apotracheal and paratracheal; Apotracheal parenchyma abundant banded up to 3-7 cells wide. Paratracheal parenchyma aliform, or confluent. Aliform parenchyma sometimes extended in the form of short band. parenchyma cells are oval to circular in shape medium size. ***Rays*** comparatively fine, 8–12 per mm, mostly 1-2 cells wide and 12-20 cells in height, heterogeneous, composed of two type of cells. Upright and procumbent; upright cells are square and restricted to marginal rows. Number of marginal rows of upright or square cells is usually 1-4, uniseriate rays are frequent however triseriate rays are rare. ***Fibres*** are moderate in thickness having, simple to minutely bordered pits and septate (Fig. 6 A-F).

The mango originated in the Himalayas foothills of the southern Asia (eastern India, Burma and the Andaman Islands) bordering the Bay of Bengal, dating back to 4000 BC, where it still grows wild in the hills of Assam and adjacent areas. The earliest mention of mango tree is found in ancient Sanskrit scriptures dating back to ~ 4000 BC.

Historical records and palaeobotanical evidences provide ample proof about its origin in the Indo-Burma-Malay region. It moved to China by the 7th Century; to East Africa around the 10th Century AD; to the

Philippines in the beginning of the 15th Century. It spread from South and Southeast Asia over the tropical and subtropical areas of the world from the end of the 15th Century onward. It reached Africa during the 16th Century; Brazil in the 1700s; Mexico early in the 19th Century; Jamaica in 1782; Hawaii in 1809 and America during the second half of the 19th Century (Yadav and Singh, 2017). Afterward it began popping up all over the world. Mango is now cultivated throughout the tropical and subtropical world for commercial fruit production, as a garden tree, and as a shade tree for stock. In the Pacific region, all mangos were introduced from other parts of the world. Mango is an Indian fruit that originated thousands of years ago in India. It is also known as an ancient sacred fruit and has spread gradually worldwide.

On the basis of presence of maximum number of allied species growing in Malaysia, some workers are lead to believe that Malaysian region is the original home of mango. But, Mukherjee (1949) concluded that occurrence of wild form of *Mangifera indica* and its allied species originated in Indo-Burma region.

According to de Candolle (1883), it is impossible to doubt that the mango is a native of the south of Asia or of the Malay Archipelago. Several investigations have been carried out on more scientific lines on the origin of the cultivated plants. Vavilov (1926) worked on the genetic variation in some crop plants of the world. According to him the location of the centres of those variations is the most outstanding and he suggested the 'Indo-Burma' region as the centre of origin of the mango. This problem has been further investigated and conclusions have been derived by an analysis of the phytogeographical data phylogenetic taxonomy of all the species included within the genus *Mangifera*. The genus of mango was described by Linnaeus (1754) in Genera Plantarum. The genus *Mangifera* of the family Anacardiaceae and the order Sapindales is restricted to the tropical Asia. The highest concentration of the species is found in the western part of Malaysia (Malay Peninsula, Sumatra, Java and Borneo). The primary centre of origin of the genus *Mangifera* is considered in the region of Myanmar (Burma)-SiamIndochina or Malaya Archipelago and the secondary centre in the Sunda Island (Java, Sumatra, Borneo), the Philippines and Celebes- Banda-Timor group (Mukherjee, 1985). *Mangifera gebede*, a wetland species, is widely distributed from Burma (Myanmar) through Malaysia to New Guinea. Out of the two groups of other species occurring in Malaysia, one group is adapted to monsoon climate of Myanmar, India, Thailand, Indonesia and the Lesser Sunda Islands of Indonesia and the larger part of the ever wet tropical rain forest, stretching from India including Andaman Island, eastward as far as Micronesia. From Malaysia, *Mangifera* species moved eastward with one species to the Pacific area, and westward with nine species to India including Andaman Islands and 3 species to Sri Lanka. *Mangifera merrillii* and *M. monandra* are endemic to the Philippines. *Mangifera altissima* perhaps occurs in the Celebes (Kostermans and Bompard, 1993).

The genus *Mangifera* consists of 69 species of tree restricted in their native range to tropical Asia (Bompard and Schnell, 1997). Wild members of this genus occur in India, Sri Lanka, Bangladesh, Myanmar, Sikkim, Thailand, Cambodia, Vietnam, Laos, southern China, Malaysia, Singapore, Indonesia, Brunei, the Philippines, Papua New Guinea and the Solomon Islands and Micronesia. The greatest diversity, with approximately 28 species, occurs in western Malaysia, especially in peninsular Malaysia, Borneo, and Sumatra, a region considered to be the center of diversity of this genus (Lemmens *et al*., 1995; Bompard and Schnell, 1997). Fifteen species were described in the flora of Malaya (Kochummen, 1989) and about 16 species occur in Thailand (Chayamarit, 1994).

The occurrence of two leaf fossil species eg. *Mangifera palaeoindica* and *M. paleocaloneura* (Swang Chote *et al*., 2009) in the Oligocene sediments of Thailand and two allied species of *Mangifera indica* i.e. *M. sylvatica* Roxb. and *M. laurina* Bl. Further suggests that it could be an area of evolution and diversification of *Mangifera indica* Linn. Fossil leaves and wood showing affinities with *Mangifera* have been found mostly from Tertiary deposits in South and Southeast Asia (Matsuo, 1967; Lakhanpal and Awasthi, 1984; Awasthi and Prasad, 1990; Prasad, 1994 Awasthi and Mehrotra, 1995; Mehrotra *et al*., 1998). The earliest fossil species thought to be related to *Mangifera* is *Eomangiferophyllum damalgiriense* Mehrotra *et al*. (1998) from the Upper Paleocene of north-eastern India. Thus, it may be concluded that the genus *Mangifera* originated elsewhere during early Cretaceous like most of the other angiospermous taxa and diversified from there in India before Paleocene and flourished luxuriantly in the most part of the regions.

Fossil wood of *Mangifera* is also known from the Middle Miocene of Assam (Prakash and Tripathi, 1970; Prakash *et al*., 1994), Middle to Upper Miocene of West Bengal (Roy and Ghosh, 1981), Upper Miocene-Pliocene of Arunachal Pradesh (Lakhanpal *et al*., 1981) and Pondicherry (Awasthi, 1966), Pliocene of Rajasthan (Guleria, 1984) and Neogene of Sumatra and Borneo

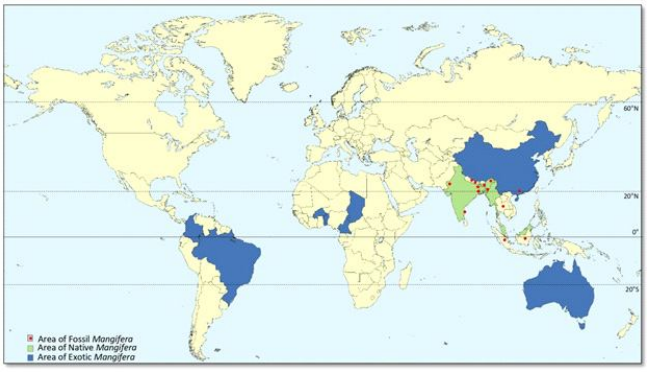

Fig. 7 : Map showing occurrence of the genus *Mangifera* in the past and present in India and abroad.

(Kramer, 1974). This suggests that the genus *Mangifera* Linn. was also distributed widely in the geological past (Fig. 7).

The species of the genus *Mangifera* Linn. mostly restricted to tropical Asia. The highest diversity occurs in Malaysia, particularly in peninsular Malaya, Borneo and Sumatra representing heart of the distribution range of the genus. The natural occurrence of all the *Mangifera* species extends as far north as 27° latitude and as Far East as the Caroline Islands. Wild mango trees occur in India, Sri Lanka, Bangladesh, Myanmar, Sikkim, Thailand, Kampuchea, Vietnam, Laos, southern China, Malaysia, Singapore, Indonesia, Brunei, the Philippines, Papua New Guinea and the Solomon and Caroline Islands. Maximum species diversity exists in western Malaysia with about 28 species found in this region. *Mangifera* species are mostly distributed below 300 m but can occur at 600-1900 m above the sea level. The species is found as scattered individuals in tropical lowland rain forests on well-drained soils. Most of the species (about 44) are found on well drained soils, about 9 species in flooded area and some species occur in swamp forests.

Conclusion

The present study revealed the wood anatomy of different variety of *Mangifera indica* Linn. *i.e.* Dashehri, Langra, Safeda, Chaunsa and Bombay mango, which have been taken from the trunk of all the above five varieties of *Mangifera indica* Linn. growing in the Mango field near Neel Kothi in Balrampur district of Uttar Pradesh.

The anatomical characters exhibited by each variety are observed and described separately in details according to terminology given by International Association of Wood anatomist (IAWA).

Wood is demarcated into sapwood and heartwood by growth ring of parenchymatous cells. It is generally characterized by medium to large, thin-walled, numerous, diffuse porous, solitary or in radial multiples of 2-3 vessels with simple perforation plates. Axial parenchyma is usually paratracheal, Rays thin walled, 1-3 seriate, heterogeneous, composed of both upright and procumbent cells, Fibers slightly thick walled and sepate containing simple pits.

Vessel size in all the five varieties is almost similar. Vessels in Langra mango is are in multiples of up to 7, while in other it is up to 4 only. Frequncy of vessel in the Bombay mango is comparatively lower and in Dashehari it is higher. The xylem rays are mostly unicellular in Safeda while in Langra and Dashehari the xylem rays are mostly 2-3 seriate and in Chaunsa, 1-2 seriate xylem rays are common. The xylem rays are heterogeneous in all the varieties, but the heterogeneity is more pronounced in Langra variety. The frequency of the xylem rays in Langra and Safeda is higher than other varieties.

The genus *Mangifera* Linn. consists of 69 species mostly restricted to tropical Asia. The highest diversity occurs in Malaysia, particularly in peninsular Malaya, Borneo and Sumatra representing heart of the distribution range of the genus. Maximum species diversity exists in western Malaysia with about 28 species.

The historical records and palaeobotanical evidences provide ample proof about its origin in the Indo-Burma-Malay region.

The fossil records suggests that the genus *Mangifera* Linn. originated elsewhere during early Cretaceous like most of the other angiospermous taxa and diversified from there in India before Paleocene and flourished luxuriantly in the most part of the regions.

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