SUMMARY AND CONCLUSION
SUMMARY

➤ The cambium in Moringa, Erythrina and Peltophorum is characterized by storied arrangement while Kigelia exhibits nonstoried cambium.

➤ A seasonal variation in arrangement of cambial cells was noticed in Moringa and Peltophorum. The former showed disturbance of double storied pattern due to radial fusion of rays whereas latter showed transition from storied to semi-storied nature because of high rate of s-type division followed by active tip growth from one end.

➤ In all the species, additive divisions in the CZ are paralleled by transformative divisions of FCC into RI resulting in maintenance of FI: RI ratio.

➤ Among the evergreen trees, Moringa undergoes CA throughout the year and the rate of cambial cell division is paralleled by rate of DX. On the other hand, Peltophorum showed cambial dormancy for two months period.

➤ CA and xylem differentiation in deciduous tree Erythrina occur for seven months (February to August) and cambium remains dormant in rest of the months.

➤ In brevideciduous species Kigelia africana, cambial activity occurs only for short period of 2-3 months of monsoon period. However, distinct variation was observed by cambial seasonality between different years. In 2009, cambium was active for two months (July-August), 2011 for three months (August to October), whereas, in 2012, cambium remains dormant throughout the year.
Among phenological changes, flowering and fruiting have significant effect on cambial reactivation in Erythrina, while cambium in Peltophorum and Kigelia enter dormancy irrespective of phenological changes.

Analysis of impact of climatic factors on cambial activity revealed that in Erythrina, temperature plays a role in reactivation of cambium. The peak cambial cell division and DX in Kigelia, Erythrina and Moringa is closely related to rainfall and relative humidity. Peltophorum, on the other hand showed peak cambial activity in December suggesting soil water availability rather than humidity. The year wise variation in cambial seasonality in Kigelia found to be associated with frequency and continuity of rainfall following CA.

Study on lignification revealed that during secondary growth (xylogenesis), lignification occurs first in vessels and its associated parenchyma cells with deposition of more guaiacyl lignin monomers followed by fibers with more syringyl lignin units. Rays are the last xylem element to undergo lignification and they are characterized by the deposition of more guaiacyl lignin units in their wall.

In all the four species studied, an increase in FIs was observed during active cambial growth. In Erythrina, the seasonal variation in fiber length is paralleled by variation in length of FI. In Kigelia, Moringa and Peltophorum, fibers in DX during active period are shorter and appeared elongated after maturation (during enlargement) suggesting more duration for completion of elongation growth. Statistical analysis revealed that in the species having storied cambium, a positive correlation exist between vessel elements length and FIs. Vessel density
found to be increased during peak CA in monsoon in Erythrina and Moringa.

Statistical analysis of cell size variation and climatic factor revealed that the cell development of xylem is greatly influenced by rainfall and rarely by temperature.

The comparison of variation in seasonal starch accumulation with phenological changes and cambial activity showed that it related to both vegetative and reproductive growth. Depletion of starch reserve in xylem were noticed during the sprouting of new leaves, flowering and fruiting in Kigelia and Erythrina in March to June and April-May respectively. Tissue level variation pattern suggest during period of cambial growth, living xylem fiber forms the major starch reserve in Moringa and Peltophorum whereas fluctuation in Kigelia and Erythrina, axial and ray parenchyma showed seasonal variation in starch accumulation.

The starch accumulation pattern in the xylem elements of Erythrina and Moringa showed affinity towards gravity. All the elements containing starch sedimented towards gravity because of mass and do not act as a statoliths.

Ultrastructural studied revealed the major anatomical features of cambium and xylem elements. Based on the cambial structure and wood ultrastructural features observed, Erythrina considered being the phylogenetically more advanced tree species. The major advanced characters include storied cambium, occurrence of aggregated RI, alternate arrangement of pits with vesture and arrangements of pits in grooves.
CONCLUSION

The present study reveals the cambial structure, seasonality of cambium, wood formation, cell size variation, lignification and seasonal starch variation in xylem in relation to phenology and climatic factors in four tropical tree species of Gujarat. Although all the species are exposed to similar climatic conditions, the seasonality of cambium is specific to each species. Cambium remains active throughout the year in Moringa while in Peltophorum and Erythrina CA lasts for ten and seven months respectively. While in Kigelia CA continues for two months in 2009 and three months in 2011 and remains dormant throughout the year in 2012. CA in all the plants is sensitive to water availability. Peak CA and rate of DX in Moringa and Erythrina depend on average rainfall during monsoon period, while in Kigelia, CA depends on consistency of daily rainfall. Irregularity in daily rainfall affects the CA in Kigelia during 2012. Cambial cell division during winter in Peltophorum reveals sensitivity of cambium to soil water availability and minimum temperature. In Erythrina, rise in temperature favored reactivation of cambium. CA reaches higher in Moringa in the presence of more number of active shoots and mature leaves, while Peltophorum shows more CA in winter when tree have less flowers and more number of mature leaves. On the other hand, Kigelia shows three to four flushes in a single year where time gap between leaf shedding and sprouting of new leaves is not more than ten days but CA in main trunk is not influenced by these flushes. In Erythrina, dormant cambium reactivates with the start flowering followed by sprouting of new leaves indicating the role of auxins in cambial cell division. All the selected species have developed new leaves during dry season before the arrival of the first rain indicating that substantial subsoil water storage in old, deeply weathered soil permit leaf flushing during the late dry season. Statistical analysis of cell
size variation and climatic factor reveals that the cell development of xylem is greatly influenced by rainfall and rarely by temperature. FIs and vessel elements length showed positive correlation in the species having storied cambium. In Erythrina, FCC derivatives in the expansion zone of DX showed frequent anticlinal divisions and give rise to fibers indicating cell type specialization may occur not only in the xylem derivatives close to cambium but also in those away from CZ. All the plants show similar pattern of lignification in DX where vessels are the first element to develop lignified walls and ray cells are the last element to become lignified. Fiber cell walls show more syringyl lignin while all other xylem elements are characterized by relatively more guaiacyl lignin units. Seasonal starch accumulation is influenced by vegetative and reproductive growth as well as active cambial cell division and xylem differentiation. Sedimentation of starch grains towards gravity is first time observed in the xylem elements of Moringa and Erythrina. Starch grains are settled at the lower tangential wall of straight growing trunk while they settled on the lower radial wall of horizontally growing branches. The reverse orientations of samples do not change the position of starch grain from their original position. Therefore it is concluded that starch grains do not act as statoliths. Starch present in fibers of Moringa and Peltophorum serve as major site of storage. Storied arrangement of xylem fibers in Moringa is an unique and rare feature not common in many plants. The intrusively grown cell ends of fibers show variability in their length by showing relatively more elongation towards gravity. Finally, the starch grains in the macerated xylem elements could be successfully retained by adopting modified method which permits the visualization of starch in xylem elements with more clarity and reliability.