ABSTRACT
The present investigation considered growth, development and senescence aspects of seven varieties of Corchorus capsularis (Maniksari, 7447, D-154, 919, 9687, Japred and M2) and seven varieties of Corchorus olitorius (3690, 4360, 632, Dhaleswari, 620, Sudan and IRI). The data revealed remarkable differences in their vegetative and reproductive growth responses as well as patterns of senescence behaviour and from their natural senescence patterns three distinct types could be sorted out in each of the two species, viz. early leaf-shedding variety (E), late leaf-shedding variety (L) and Average early-late leaf shedding variety (AEL). In addition, growth, development and leaf abscission behaviour of three varieties (viz. Krishna, Andrew Sea-Island and Egyptian Cotton) of annual cotton (Gossypium hirsutum) have been analysed considering the fact that all past studies in these areas related to perennial cottons. Detailed analysis of leaf abscission process, along with its physiological and biochemical regulations during different developmental stages of the plants have clearly revealed an intimate involvement of growth and developmental physiology in the control of abscission process. Besides specific and varietal influences on the mechanism of its control have also been established.
Growth and developmental studies have clearly shown that the maximum accumulation of dry matter is accompanied by the augmentation of extension growth and leaf-formation. A developmental correlation between higher vegetative growth remaining associated with maximum time required for the commencement of reproductive stage has also been established. A close agreement between the maximum occurrence of vegetative growth with the overall senescence time in Jute plants has been shown. Late varieties of both the species of Jute reveal maximum vegetative growth and overall senescence time as compared to early and average early-late varieties. Of the three varieties of annual cottons, the variety Krishna shows a more desirable growth and yield performances. A clear correlation between dry matter formation and yield of lint in all the three varieties has been established. The germination study in cotton has revealed the occurrence of maximum dormancy immediately after harvest of seeds and with the advancement of storage periods, germinatibility of seeds initially increases and later decreases in the environments of prevailing temperature.

Retention times of debladed petioles are maximum during vegetative stage and also in the late varieties. In all the abscission studies, perioles of advanced age
shows consistently an earlier tendency of abscission as compared to the petioles that are younger. Furthermore, in cotton plants where aging has been deferred, the retention times of the debladed petioles are longer.

The chemical regulation of abscission process of debladed petioles in different categories of studies has interestingly revealed a changing sensitivity of the process in different varieties of Jute and annual Cotton plants towards various regulatory treatments. It has been also confirmed that endogenous mechanisms determining the earliness and lateness of any variety remained intimately related to age and developmental growth of the plants which characteristically regulate the abscission process through a well-defined sensitivity towards internal biochemical factors.

The abscission process is inhibited by NAA in Jute plants and magnitudes of NAA effects appear weaker in older petioles. NAA inhibition is comparatively higher in vegetative stage as compared to the reproductive stage. The variations of abscission responses can clearly shown to be a function of age. It has also been observed that aged tissue contains a lesser amount of IAA-like compound and it is likely that decreasing sensitivity of older petioles can also be a reflection
of lesser presence of endogenous IAA-like compound in tissues remote to the abscission zones of the two species of Jute.

The study has reported the patterns of involvement of auxin inhibitable stage-I and auxin promotive stage-II of abscission process in the petioles of early, late and average early-late varieties of Jute and also in the context of their increasing age and progress of developmental growth. The stepwise analysis further confirms the declining nature of its control with increasing age. In petioles of varying ages of Jute, the extent of auxin-induced abscission-inhibition, followed at different time intervals is also a clear indicative of fading of auxin effects with age. It will be also clear that contrary to the requirement of shorter durations of induction periods in older petioles to overcome the auxin inhibitable stage-I of abscission, the younger petioles need a much longer periods showing that the regulation of auxin inhibitable stage-I of abscission is a function of age.

Of the three phenoxy compounds applied to the debladed petioles of different varieties of Jute, 2,4-D having high auxin activity produces maximum inhibition; whereas 4-Cl inhibits the process in a decreasing fashion. PAA
however promotes abscission and of the three stages of debladed petioles (A, B and C), the younger petioles reveal higher degree of sensitivity towards treatments of phenoxy compounds possessing auxin like properties; thus indicating a more stronger control of abscission by auxin in younger petioles. Of the two developmental stages, maximum inhibitions are noted during vegetative stage and promotions during reproductive stage thereby, revealing a more critical role of developmental growth of plants in determining the sensitivity of abscission process. It is interesting to note that while PAA, applied for a continuous period promotes abscission, treatments for restricted durations are inhibitory in nature. The translocation pattern and the action of PAA in abscission zones of Jute petioles are not exactly known, but it may be possible that quantitative requirement of this particular phenoxy compound is very critical at the outcome of some indirect effects due to endogenous ethylene.

The present study has clearly established an interspecific variation in auxin-sensitivity vis-a-vis manifestation of leaf abscission process in Jute. The study has confirmed the existence of intervarietal differences;
late variety of *C. capsularis* showing maximum inhibition by auxin and phenoxy compounds. In *C. olitorius*, the intervarietal differences of the process are rather different. In many experiments, AEL (of *C. olitorius*) proves to be more sensitive towards inhibitory and promotive effects of different treatments in place of late and/or early varieties of the species. Thus while there remains an uniformity in responsiveness of the process in different varieties of *C. capsularis*, it is not the case with *C. olitorius*. Could such a phenomenon of behavioural differences between the two species be utilized in interpreting *C. capsularis* to be a more stable one than *C. olitorius*? Only genetical studies, taking leaf-fall behaviour as a 'marker character' would be able to throw light on such an intriguing problem. Even deviations in the set patterns of biochemical changes in distal/proximal zones of abscission have been observed in early/late/AEL varieties of this species, the AEL behaving as 'early' type in this responsiveness towards different treatments.

The results of our experiments relating to effects of NAA in the abscission process *vis-a-vis* petiolar lengths of different varieties of annual cotton are interesting because NAA treatments clearly induce abscission promotion and the ranges of promotion are
comparable in different varieties during different stages of reproductive development. The promotion of abscission due to application of NAA to 1 cm length petiole at '0' hrs of deblading can attract some speculative arguments. It is also interesting to note that manipulative treatment (debudding) increases the extent of promotion in all the varieties indicating that debudding treatments enhance the sensitiveness of abscising petioles towards promotive effects of NAA. Contrastingely, the effects of NAA on 0.5 cm length petioles at '0' hours show inhibition. The lack of inhibitory effects of NAA on longer petioles might suggest that auxin transport to the abscission zone is a slow process in cotton tissues, and during the process of transport, abscising petioles actually pass into stage-II of abscission process causing NAA to manifest its promotive effects. The present investigation, therefore, points out to the necessity of considering the length of abscising petioles in characterizing the stage-I and stage-II of abscission in the annual cottons.

Promotive effects of ethrel on the abscission process of Jute and Cotton, more pronouncedly during stage-II of abscission process (of Jute plants), have been established. The older petioles are found to be more sensitive towards abscission promotion effects of ethrel in *C. capsularis*; whereas in *C. olitorius*, younger petioles show the higher
responsiveness. The extent of ethrel-induced promotion gradually increases with the progress of developmental growth and normally reproductive stage appears to be more sensitive to ethrel treatments. A distinct varietal difference has also been observed and in Cotton, the variety Krishna shows maximum promotion due to ethrel during later periods of reproductive development. Other two varieties of Cotton, however, show maximum promotion during early stage of reproduction (flowering stage) and manipulative treatments lessen the extent of abscission promotion.

Amino acid treatments promote abscission in all the varieties of Jute and Cotton. It has been noted that the abscission process of younger petioles are more sensitive to amino acid treatments and the sensitivity decreases with the increase of age of petioles. The changing pattern of abscission regulation due to amino acid application also varies from species to species and also from variety to variety. Late-shedding varieties of Jute reveal higher promotion of abscission as compared to early-shedding varieties. Of the three varieties of cotton, Krishna exhibits maximum promotive effects during later stages of reproductive development as compared to other varieties, which reveal maximum promotive effects during early stage of reproductive development.
In the present investigation, analysis of different biochemical parameters like different nitrogenous fractions, chlorophyll contents, dry matter accumulation and also the IAA-like compound of laminar tissues of younger and older leaves of Jute and Cotton plants with progress of developmental stages have been made and these biochemical substances are shown to take part in a well-defined way in the regulation of abscission process. A definite relation is revealed between the pattern of petiolar abscission and the levels of these biochemical parameters in laminar tissues. In Jute, a high level of soluble nitrogen content remains associated with lesser total nitrogen, IAA-like compound and chlorophyll during reproductive stage of all the varieties, and these features remained linked with the faster rate of petiolar abscission during that period. The late varieties of both the species on the other hand, reveal higher rates of formation of total nitrogen, IAA and dry weight; remaining matched with slower abscission rates of the debladed petioles as compared to the early/AEL varieties. In manipulated cotton plants it is interesting to note that there occurs an increased formation of dry matter, chlorophyll and total nitrogen in laminar tissues upto the period corresponding to flowering stage; in contrast to normal plants, where the increase takes place upto pre-flowering stage. A
direct relationship between the levels of endogenous IAA contents and natural tendency of leaf abscission during different developmental stages of annual cotton plants has also been established. IAA level has remained high during initial growth period when the rate of leaf-abscission is lesser (and also longer time taken for petiolar abscission). Again, leaf abscission is maximum during post-fruiting stage which is concomitantly linked with the lower contents of IAA and other biochemical parameters during the said developmental stage.

Estimations of certain biochemical parameters in the tissues that are proximal and distal to the abscission zones have yielded clues regarding the mechanism of cellular separation during abscission process. The higher tendency of natural leaf-fall and lesser time required for leaf abscission in early varieties are found to be associated with higher rates of distal decrease and proximal increase of total nitrogen and total phosphorus as compared to the late varieties of both the species of Jute which exhibit lesser rates of such mobilizations. It has also been observed that rates of distal decrease and proximal increase of two metabolites are pronounced during reproductive stages of the plants and also in the older petioles. Interspecific and intervarietal variations of the abscission process have also their reflections in their patterns of guided distal/proximal
mobilization of such metabolites. Again, in annual cotton plants, where the abscission phenomenon can be deferred by debudding treatments, lesser rates of distal decrease and proximal increase of the metabolites have been noted. The study also shows that the AEL variety of *C. olitorius* under certain conditions of forced petiolar abscission has its concomitant reflections in the mode of mobilization patterns at its abscission site. And as a result, the rates of decrease/increase of TN and TP from distal/proximal tissues are shown to be higher in this variety as compared to early variety. It is interesting to note however, that the total quantities of the components are initially high in the distal/proximal regions of abscising zones of AEL varieties. The abscission behaviour of petioles of this variety when forced by deblading operations, has been shown to be varying in patterns under conditions of different regulating treatments and the explanations of such a situation might have to be traced into the nature of unstability of the species (and also the variety). Such an assumption may find comfort in the fact that the said AEL variety has initially its biochemical make up of the distal/proximal tissues comparable to medium early-late variety; which after the removal of the lamina, has undergone mobilization, in accordance to the set patterns of an
early variety. The use of abscission patterns, including its intricate mode of biochemical control, in interpreting the agronomic nature of a variety, as has been done in the present study, is novel as well as interesting.

The study of radioactive phosphorus incorporation through the apical meristem clearly reveals that incorporation of $^{32}$P remains higher in the late varieties of Jute species and also in younger leaves. Higher incorporation of $^{32}$P has been noted during vegetative stage as compared to the reproductive ones. Decline of radioactivity has occurred with advancement of time and the rates of loss of radioactivity have increased with the increases of age of leaves. Such a behaviour can also be correlated with the early senescence as well as faster rates of petiolar abscission.

Whatever might be the outcome of different studies on abscission conducted from time to time, one should not undermine the facts that the manifestation of process depends very much on a particular species and even on varieties of a species; on systems of growth and developmental regulation; on age and other internal inherent factors; on physical and biological conditioning of tissues at the site and adjoining to the sites and as will be somewhat indicative in the present study, on genetic
stability of a particular species. Thus, study on abscission physiology during early fifties has made impressions that the phenomenon to be a rather simple one, mainly centering the activity of endogenous auxin. But due to its subjection to more analytical investigations in later years, its complex nature gradually has become evident.

However, from the results of the present investigations, it can be stated that leaf abscission in Jute and Cotton plants remains intimately compatible with their inherent nature of agronomic types; early and late varieties have reflections in their detailed mechanisms of control of the phenomenon. Further its quantitative nature; its mode of physiological control; its differential attitude and adaptiveness; its biochemical manifestations (both at the site and the remote) are mostly in readiness to suitably adjust according to the characteristics of a particular species and even of a variety. Sensitiveness of the process differed in types and even in same types that are manipulatively different (like cotton in this study). Results also reveal a shifting nature of sensitivity of the abscission process in relation to age, developmental maturity and metabolic
status; which in turn, remains controlled by phenotypic and genotypic differentiation of a particular species. Can not it be expected that results of this study, with somewhat a newer approach, will open up further areas of investigation of abscission in future?