SUMMARY OF RESULTS

Populus deltoides -a fast growing exotic is being planted as monoculture plantations, shelterbelts/windbreaks, or as a tree component of alley cropping systems. This practice is being followed in order to gain maximum out of a given land unit in minimum time through increased productivity. The intensity of plantations during the last decade has increased so much that least significance is attached to the edapho-climatic suitability and the ecosystem sustainability. The situation took the shape in the absence of any study on the impact of this tree as monoculture plantation or in agroforestry systems. The study was, therefore, conducted to assess the impact of *P. deltoides* plantations on natural as well as agro-ecosystems. The results obtained during the investigation have been summarised hereunder:

A comparative study on the performance and consequences of monocultures of different tree species as well as a mix-culture thereof revealed the presence of low diversity under *P. deltoides* compared to other monoculture or even the mix-culture plantations. The number and types of individual species were reduced appreciably followed by Importance Value Index (IVI). The biomass of the species was assessed to be the least under *P. deltoides* plantations. The low diversity levels were further confirmed by the values of Species Diversity Index, Shannon-Weiner Index, Index of Richness and Evenness Index. The values of all these indices were calculated to be low under *P. deltoides* compared to mix-culture and other monocultures showing thereby the presence of an unstable community under it. More or less homogenous nature of vegetation as estimated through the index of similarity under *P. deltoides* further confirms the unstable community structure under *P. deltoides*.

Soil seems to play an important role in imparting *P. deltoides* a phytotoxic nature. The germination and relative growth rate of several agricultural crops in comparison to an open area control was seen to be reduced. In order to minimize

the role of soil for causing toxicity, the soil medium was replaced by the top soil collected from a vegetation free area nearly 100m away from the plantation (control). The seed germination as well as relative growth rate (RGR) of the crops grown in replaced soil was seen to be reduced greatly. It suggests the continuous influx of phytochemicals/inhibitory substances to the soil from tree.

The study was extended to the agroecosystems wherever *P. deltoides* was planted as shelterbelt/windbreaks. It showed reduction in the growth and yield of wheat (*Triticum aestivum*). The effect varied with distance from the shelterbelt. Closer the distance, more the effect. However, the reduced growth, yield, and density etc. was noticed upto 12m from the shelterbelt. The reduction in growth and yield of wheat in fields sheltered by *Dalbergia sissoo*, however, was observed to be relatively less. Compared to unsheltered fields, the grain yields of wheat were less by nearly 57 and 21% in fields sheltered by *P. deltoides* and *D. sissoo*, respectively.

The different parts of *P. deltoides* exhibited phytotoxicity to varying degree, through water leachable allelochemicals. Leaves among other parts, *viz.*, root, stem, bark or buds caused maximum reduction in seed germination and further growth of *Phaseolus aureus*. Roots and stem contributed little as compared to other parts. The allelochemicals leachable in water existed in their glycosidic bonds and comprised secondary metabolites. The existence of allelochemicals/aglycones in glycosidic form facilitiates their movement within and outside the plant and also prevents intra-plant toxicity. The aglycones separated from glycosidic bonds through acid hydrolysis were found to be maximum in leaves compared to other parts of the tree.

The phytotoxicity of water leachable allelochemicals from leaves was assessed on twenty eight crop seeds. The results reveal the different susceptibility of crops depending on seed type. The role of seed characters in imparting seeds susceptibility/resistance was found to be significant. The ratio of the seed coat thickness and the seed volume (S_t/S_v) was found to be an important biological function in determining the susceptibility/resistance of seeds. Employing a mathematical function, the critical/threshold level of the ratio of the seed coat thickness and seed volume (S_t/S_v) were calculated separately for seed germination, seed vigour and seedling length. These values were calculated to be 1.0833, 1.2057 and 0.1600, respectively, for germination, seed vigour and seedling length. It is proposed that seeds with ratio of (S_t/S_v) more than the respective thresholds would

show more resistance or *vice-versa*. The mathematical equation derived to calculate threshold levels of S_t/S_v was

$$Y = Y' (1 - e^{-x/x_t})$$

where, Y is the respective parameter (germination or seed vigour or seedling length) with Y' being its maximum limit,
x represent the S_t/S_v
x_t is the threshold value of x.

On the basis of this study, the seeds of *Cyamopsis tetragonoloba* exhibited maximum resistance to the aqueous leachates of *P. deltoides* whereas, seeds of *Brassica napus* var. Purple Top, *Phaseolus aureus* var. SML-32, *P. mungo* var. PV-191 and *Vigna unguiculata* var. HFC-42/1 totally failed to germinate showing appreciable susceptibility.

Phytotoxins were also extracted in their partially purified forms employing a system of polar and non-polar solvents. Chemicals extracted in non-polar solvents exhibited more toxicity towards *P. aureus* compared to polar solvent extracts. Lipids which are extractable in non-polar solvents caused maximum toxicity, partially owing to their larger sizes which may cause physical injury to the target plant. Based on their extraction in different solvents, the allelochemicals may be of variety of chemical nature ranging from non-polar to those of varying polarity. The chemicals of *P. deltoides* also exhibited acidic, basic or neutral nature with acidic fraction causing maximum phytotoxicity followed by neutral or basic fraction.

The speculation that allelochemicals might be entering soil system through fallen leaves was made evident through bioefficacy studies of leaf litter and decomposed leaves which from a thick cover on the ground after their fall especially in winter. Both leaf litter as well as decomposed leaves either placed as surface mulch or mixed in the soil caused reduction in growth of the test crops. The toxicity was more when leaf litter/decomposed leaves were mixed in the soil, compared to when placed as surface mulch. On the other hand, addition of peat moss (to maintain the equivalent soil texture, aeration, humidity as that of litter/decomposed leaves) to soil instead of litter or decomposed leaves enhanced the growth of test crops. It was, therefore, concluded that decomposed leaves/litter contained phytochemicals which may escape to soil through leachation, and microbial degradation. Escape of

phytochemicals to soil was evidenced through the presence of organic chemicals in soil inhabited by *P. deltoides*. Appreciable amount of organic chemicals was found in soil of *P. deltoides* compared to the negligible amount in the open area of control. These chemicals of the soil also exhibited phytotoxicity towards the test plant- *P. aureus*. Not only germination, but growth parameters were also reduced. The phytotoxicity due to soil chemicals was also exhibited through impairment of photosynthesis, respiration, protein metabolism and hydrological status of mature plants. The organic chemicals present in soil were identified to be different phenolic acids like gallic acid, chlorogenic acid, p-hydroxybenzoic acid, vanillic acid, syringic acid, p-coumaric acid, ferulic acid, succinic acid, p-anisic acid, and protocatechuic acid besides some remaining unidentified. Most of these were also identified from leaves confirming that leaves may be the source of phenolic acids present in soil. Salicin-a phenyl glucoside was also identified from leaves. However, this could not be detected in soil probably due to very low amounts. Salicin was used to study its impact on respiratory activity of *P. aureus* embryos. The per cent respiratory activity of embryos was significantly enhanced at 0.03 to 0.05M concentration, whereas at lower concentrations it was more or less same as that of control. It is, therefore, concluded that owing to stress of salicin, the respiration of embryos is enhanced to meet the greater energy demands. However, at very high concentration, this capacity of embryos is lost as was evidenced through the results of 0.06M concentration of salicin. The response was concentration as well as time (period of exposure) dependent, the product of which formed an important biological function and had critical/threshold limits depicting the levels upto which system can resist stress. The following function was applied to study the impact

$$X = \frac{25{,}000\ Y^3}{e^{Y/0.256} - 1}$$

where, X represents respiratory activity,
Y is product of concentration and period of exposure (i.e. c.p.),
25,000 is the value of the dimensional constant, and
0.256 is the threshold value of Y (c.p) at which respiratory activity would be maximum.

It is proposed that response to *P. aureus* towards salicin could be assessed from the above mathematical function without subjecting the seeds to experimentation.

The fractions of *P. deltoides* in partially purified forms also affected the metabolism of *P. aureus* plants at macromolecular and enzymatic levels. The amount of macromolecules, *viz.*, protein, carbohydrates (both structural and nutritional) and RNA, in general, was reduced in treated plants compared to control whereas, specific activities of enzymes were enhanced. The decrease in macromolecular contents was attributed to reduced synthesis as well as increased hydrolysis.