CHEMOTAXONOMY

MBOT6 - Unit-III

M.Sc. Sem-II

(2018-20)

Background:

Chemotaxonomy or chemosystematics or biochemical systematics deals with the classification of plants on the basis of their chemical constituents which are deeply concerned with the molecular characteristics. The method of chemical taxonomy is simple in principle and is based on the investigations of the distribution of chemical compounds or groups of biosynthetically related compounds in series of related plants. Different plants sometimes contain substances which although belong to different chemical compounds appear to be biosynthetically analogous. Such plants may contain similar enzyme systems, and the compounds produced by such enzymes are indicative of the relationships that exist between the plants. However, the chemotaxonomic studies include the investigation of the patterns of the compounds existing in plants. Climatic conditions have a major influence on the distribution of plants containing certain substances, e.g., fats, volatile oils, alkaloids, flavonoids, etc.

The presence of such chemicals in different groups of plants has great taxonomic significance (Stuessy, 2008). Taxonomic studies for various plant taxa by using different parameters have been successfully carried out.

Application of Chemotaxonomy

(i) Occurrence and distribution of the various types of chemical substances present in plants prove to be of taxonomic significance.

(ii) Phytochemical characters of taxonomic significance have been classified

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into three types. These include:

(a) Primary constituents

- Macromolecular compounds directly taking part in metabolism include proteins, nucleic acids, chlorophyll and polysaccharides.

- All chemical materials synthesized by an organism reflect the information in DNA, RNA and proteins. These molecules are called Semantides. Semantides thus contain useful information of taxonomic and phylogenetic significance.

(b) Secondary constituents

- They include compounds lacking nitrogen which are not directly involved in plant metabolism.

- Simple phenolic compounds like caffeic, benzoic and nicotinic acids and polyphenolic compounds like flavinoids, terpenes, coumarines, alkaloids and pigments have widely been studied with respect to plant systematics.

(c) Miscellaneous substances

- On the basis of their molecular weight, Jones and Luchsinger (1987) divided the natural chemical plant products of taxonomic value into two major groups:

- Micro-molecules — They are low molecular weight compounds, e.g., amino acids, alkaloids, fatty acids, terpenoids, flavonoids, etc.
- Macromolecules — They include

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high molecular weight compounds like proteins, DNA, RNA, complex polysaccharides, etc.

Some taxonomically important chemical compounds and their systematic value are as hereunder:

PROTEINS: Among the various semantides, proteins serve as the most important tool in chemotaxonomy.

- They show little qualitative variation with changing environmental factors.
- They are universally distributed and are relatively simple to extract and handle and present in appreciable amounts.
- Variation in protein structure between plants effectively provides information about the cellular genome.
- Protein banding patterns help in the identification of critical taxa, their relationship and taxonomic status.
- Comparison of proteins from homologous organ of the same age help in taxonomic interpretations.
- Variation in protein complements at the level of species and genera and even between the same plants in different populations provide evidences upon which taxonomic systems may be founded, tested or demolished.
- Phylogenetic affinities have been demonstrated on the basis of protein electrophoresis in Trichinae (Johnson and Hall, 1965). Close relationships have also been established between Vicia and Lathyrus based on these features.

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- Interspecific variations among eight species of Cassia have been evaluated on the basis of seed protein and pollen protein patterns.

- Comparison of amino acid sequences of homologous proteins from different taxa has also provided clues for evolutionary and systematic interpretations.

- Phylogeny of various taxa of Malvaceae, Ranunculaceae, Magnoliaceae, Polygonaceae, Myrtaceae and Leguminosae Solanaceae have also been elucidated.

NUCLEIC ACIDS:

(i) Recent advances in DNA technology have created a wealth of new opportunities for taxonomy.

(ii) Relative homology of DNA or RNA of various plants is useful in a taxonomic study and as a possible screening method for inter-fertility of species.

(iii) RNA of each ribosomal subunit contains some sequence information relevant to divergence in the distant past, as well as more evolving sequences carrying informations relevant to separations almost to the present.

(iv) Unfortunately so far there have been few comparative studies of codon usage between higher taxa, it might throw some light on the phylogeny at a range of levels.

(v) Both mt DNA and cp DNA are inherited through maternal line. Thus comparison of nuclear genome with cp DNA offers a potentially powerful tool for revealing past hybridization events or introgression.

AMINO ACIDS:

(i) Specific non-protein amino acids present in different groups of plants are of taxonomic significance.

- Acetyl ornithine has been identified as the main non-protein amino acid

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in Fumarioideae under Fumariaceae.

- 60% species under Liotoideae of Leguminosae contain canavanine, and this is considered as an advanced character as it is unknown in the primitive tribes.

- Azetidine-2-carboxylic acid is extremely restricted in its distribution being present in Agavaceae, Amaryllidaceae and Liliaceae.

- Lathyrus spp. could be grouped under seven infra-generic groups on the basis of the association of amino acids within the seeds. Each group is characterized by a different amino acid or group of amino acids.

FLAVONOIDS:

(i) Of the various secondary metabolites, flavonoids have been the most widely exploited phytochemical constituent in chemotaxonomic studies. They are phenolic glycosides consisting of two benzene rings linked together through a heterocyclic pyrane ring.

(ii) They are found in leaves, flowers and fruits.

(iii) The use of flavonoids in evaluating contemporary classificatory systems has been mainly based on their distribution patterns, i.e., presence or absence. Phytochemical taxonomists have considered them as evolutionary markers due to many positive correlations that they display.

(iv) Flavonoid systematics of the genus Peridendia (Umbelliferae) has extensively been studied and 16 species have been differentiated on the basis of flavonoids.

ALKALOIDS: (i) About 5000 alkaloids have been recorded from angiosperms.

(ii) Distribution of alkaloids has proved useful in the taxonomy of Fabaceae, Fumariaceae, Papaveraceae, etc.

TERPENOIDS: (i) They are biogenic group of volatile compounds and have been used extensively in the taxonomy of mints, umbellifers, citrus plants and gymnosperms.

(ii) A number of phytochemical constituents are also of taxonomic significance.

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