Chapter 1

INTRODUCTION

1. INTRODUCTION

The effect of one plant on another did not receive serious attention of plant scientists till the early part of the twentieth century. The term 'allelopathy' was coined to describe the effect of the one plant on neighbouring plants. The word Allelopathy has been derived from two Greek words *Allelon* meaning 'each other' and *Pathos* meaning 'to suffer' i.e. the injurious effects of one plant upon another However, Molisch (1937) coined this term which refers to all biochemical interactions (stimulatory and inhibitory) among plants, including micro-organisms. It represents the plant – against plant an aspect of the broader field of chemical ecology. Some authors have used the term in a more restricted sense to describe only the harmful effects of one higher plant upon another. Rice (1984) reported many cases of allelopathy which either directly or indirectly involved microbes. Allelochemicals which inhibited the growth of some species at certain concentrations may stimulate the growth of same or different species at lower concentrations.

The term allelopathy generally refers to the detrimental effects of higher plants of one species (the donor) on the germination, growth or development of another species (the recipient). In the crop fields, at any given time there are at least more than one plant species growing together. These species may be weeds, while in sole cropping there may be crops and weeds mixed. In crop mixtures or intercropping systems, the major plant species are crops with which some weeds may also be present. When the two plant species grow together they interact with each other either inhibiting or stimulating their growth or yield through direct or indirect allelopathic interactions. Allelopathy is generally associated with interactions between living plants and have been observed in agricultural lands from centuries Generally inhibitory effects are considered to be the principal effects of chemicals (allelochemicals) released by the plants on the neighbouring plants.

Crops exert allelopathic effects on other crops and weeds They may inhibit (+ve effect) or stimulate (-ve allelopathic effect) the germination and growth of weeds in agro-ecosystems. The commonality of weed species within a crop ecosystem throughout a wide geographical area indicate that crops biochemically promote certain weeds and inhibit others.

One crop may inhibit or stimulate the germination, growth and yield of associated crop growing with it (Crop mixture or intercropping) or of following crop (monoculture or crop rotations) through release of leachates or washing from germinating seeds or from decomposing crop residues. Germinating seeds of barley inhibited seed germination of white mustard (*Sinapis arvensis*), while the seed leachate of wheat, oat, maize, vetch and prosomillet helped increasing seed germination (Prutenskaya 1972). Seed and root leachates of barley inhibited seed germination and seedling growth of wheat and tobacco but leachates of living plants were more inhibitory than dead ones (Overland 1966). The ascorbic acid in the root extracts of *Raphanus* stimulated the seedling growth of pearl millet (Sharma and Singhvi 1981). Many phytotoxic compounds from crop residues or their extracts are released which inhibit the growth of other plants. Collison and Conn (1925) concluded that two mechanisms are associated with phytotoxicity of plant residues, (a) toxic compounds which act quickly and are usually inactivated through their adsorption by colloidal matter in the soil, and (b) stimulation of microbial population which immobilizes much of nitrogen making it unavailable to the plants. This review is confined to the first mechanism i e. inhibitory /stimulatory effects of compounds released from crop residues.

Allelochemicals refer mostly to the secondary metabolites produced by plants and are byproduct of primary metabolic processes (Levin 1976). They have an allelopathic effect on the growth and development of the same plant or neighbouring plants. The term allelochemicals include, (a) plant

biochemicals that exert their physiological / toxicological action on plants (allelopathy, autotoxicity or phytotoxicity). (b) plant biochemicals that exert their physiological/ toxicological action on micro-organism (allelopathy or phytotoxicity) and (c) microbial biochemicals that exert their physiological/ toxicological action on plants (allelopathy and phytotoxicity). Secondary compounds are metabolically active in plants and micro-organisms, their biosynthesis and biodegradation play an important role in the ecology and physiology of the organism in which they occur (Waller and Nowacki 1978, Waller and Dermer 1981).

Allelochemicals are reported to selectively inhibit the growth of soil micro-organisms or other plants. They play a role in chemical warfare between plants (allelopathic interactions) and include natural herbicides, phytoalexins (microbial inhibitors) and inhibitors of seed germination. Although many allelochemicals are strictly defence substances, others are offensive compounds that act directly in weed aggressiveness, competition and the regulation of plant density. Allelochemicals most often impart plant resistance to insects, nematodes and pathogens, besides following their release into environment some may regulate the distribution and vigour of plants. Most often plants come in contact with the allelochemicals in soil and their effect on crop plants may be modified by soil moisture, soil temperature and other soil factors (Patrick and Koch 1958, Patrick *et al.* 1964, Wang *et al.* 1967b, McCalla and Norstadt 1974, Bhowmik and Doll 1983 a,b; Einhellig and Eckrich 1984). Some of the allelochemicals such as terpenoids and polyacetylenes may function in a volatile state, but most of the current research in agroecosystems involves water soluble compounds.

The existence of allelochemicals in higher plants and micro-organisms, have been documented by several researchers. These are produced in above or below ground plant parts or in both to cause allelopathic effects in a wide

range of plant communities. Plant parts known to contain allelochemicals (Rice 1974) are –

i) **Roots and rhizomes** – In general, they contain fewer and less potent or smaller amounts of allelochemicals than leaves, but some times it may be the reverse also.

ii) **Stems** – They contain allelochemicals and are some times the principal sources of toxicity.

iii) **Leaves** – They are the most important sources of allelochemicals. Specific inhibitors in leaves have been demonstrated by many workers.

iv) **Flowers / inflorescence and Pollen** – Although studies on flowers or inflorescence are limited, there is growing evidence that the pollen of corn and *Parthenium* have allelopathic properties.

v) **Fruits** - Many fruits are known to contain toxins and have been proved to be inhibitory to microbial growth and seed germination.

vi) **Seeds** – Seeds of many plant families or species have been found to inhibit seed germination and microbial growth

1.2. Modes of release of allelochemicals

Since a major requisite of allelopathy is that organic substances which are be transferred from a donor plant to a recipient plant, therefore, mode of transfer may play a great role in its toxicity and persistence

The donor plant which releases these chemicals, generally stores them in the plant cells in a bound form, such as water-soluble glycosides, polymers including tannins, lignins and salts. It has been suggested that upon cleavage by plant enzyme or environmental stress, the toxic chemicals are released into the environment from special glands on the stems or leaves (Putnam and Duke 1978, Fisher 1979, Einhellig 1985a).

There are evidences that the terpenoids such as α-pinene, β-pinene, cineole and camphor are released to the environment through volatilization, and are noticeable under drought conditions. The water-borne phenolics and alkaloids are then moved out by rainfall through leaching. Next, phytotoxic aglycones such as phenolics are produced during the decomposition of plant residues in soil. Finally, many secondary metabolites such as scopoletin and hydroquinones may be released to the surrounding soil through root exudates Release through leachates and exudates requires water solubility and a broad range of allelochemicals are involved Whatever may be the mode of formation, it is generally assumed that these chemicals are not toxic to the donor plants. Once the chemicals from the donor plants are released into the environment, they may be either degraded or transformed into other forms. The resultant stages of these chemicals may also be toxic to the host plant Grodzinsky (1982) reported that the pool of allelochemicals in soil is replenished by the volatization, leachates, root exudates and decomposition of crop residues etc. and at the same time, it is exhausted through absorption by plants, decomposition by micro-organisms and carried away by wind and water etc. In higher plants allelochemicals are released from plants through – (a) volatilization, (b) leaf or stem leachates, (c) root exudates and (d) decomposition of plant residues. (Rice 1984, Putnam 1985).

Leaching - Leaching is the removal of substances from plants by the action of aqueous solvents such as rain, dew, mist and fog (Tukey Jr.1970), although earlier workers such as Bonner (1960) have used the term excretion for this

phenomenon. All plants seen to be leachable, although the degree depends on type of tissue, stage of maturity and type, amount and duration of precipitation (Tukey Jr. 1970) A large diversity of allelopathic compounds are leached, both organic and inorganic such as phenolic acids, terpenoids and alkaloids (Borner, 1960, Tukey and Mecklenburg 1964, Tukey Jr 1970) The leaching of mineral nutrients, carbohydrates and phytohormones, may be beneficial for growth of associated species. Under field conditions, the occurrence of the allelopathic phenomenon depends on the amount of rainfall during late spring or early summer, presumably at a critical stage for crop growth and development. Leached material may fall to the soil beneath, from where they can be absorbed directly through roots by either (a) the same plant from which they were leached or (b) adjacent plants of the same or different species. Besides, leached materials may also be intercepted before they reach the soil by stems, branches and foliage of the same or adjacent plants

Leaf and Root extract – The aqueous extract of leaf and root contains many allelochemicals. These allelochemicals are dissolved or precipitated in water and seeds and plants are treated. The extract also contains some phenolic acid and alkaloids and these types of allelochemicals exhibit a significant inhibitory effect to the germination and growth of the treated plants or seeds. Inhibitory activity was found mainly in the ethanol and water extracts.

Under the premise enunciated it was considered pertinent to examine more closely the allelopathic effects of weeds on the germination and growth of seedlings emerged from the treated seeds. For this purpose four common species of weeds viz *Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Mikania micrantha* H B K and *Cannabis sativa* L., were selected to find their effects on three rabi crops viz. *Raphanus sativa, Trigonella foenumgraecum* and *Brassica rugosa.* The findings are expected to help the agriculturists in a big way exploiting allelopathy for eliminating detrimental effects and utilizing the beneficial ones for boosting up crop production.