Allelopathy and its Role in Agriculture

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The inhibitory effects (Allelopathy) of crop plants on other plants have been reported as far back as 300 B.C. by Theophrastus and later Pliny recognized the existence of interference among the plants and noted its significance in agriculture (Rice, 1984). Unfortunately, research in allelopathy did not receive the attention it deserved. Only a few historical reports are found prior to the beginning of the twentieth century. However, involvement of plant- produced chemicals in plant- plant interaction was first suggested by the Swiss scientist M.A-R de Candolle in 1842. This was later emphasized by Hoy and Stickey in 1881, who observed the effect of black walnut(*Juglans nigra*) on surrounding vegetation. Schreiner and Reed (1907) reported that the root of wheat, oats, and certain other crop plants exude chemicals inhibitory to their own seedlings. Breazeale (1924) indicated the ill-effects of crop following sorghum , were not due to excess nutrient uptake by sorghum. He proposed that some toxic materials were possibly responsible for such effects. Years later in 1937, Molisch coined the term allelopathy to include both harmful and beneficial interactions between all types of plants and interactions involving micro organisms. This broad definition of allelopathy is appropriate because considerable research has indicated the involvement of micro organisms and lower plants in production of phytotoxins. This definition was later adopted by Rice (1984), and is accepted at the present time. Allelopathy is an important mechanism of plant interference mediated by the addition of plant-produced phytotoxins to the plant environment. Under appropriate environment, generally the rhizosphere, in sufficient quantities to affect neighbouring plants. The other main mechanism of plant interference is a subtractive process and is caused by competition for required sources such as as light, space, nutrients, water and CO_2 These interference mechanisms are difficult to separate in the field, but both have been well documented in studies performed under controlled conditions
During the past 40 years, the potential impacts of allelopathy on agriculture have been described (Rice,1984). Much research have been concerned on the detrimental effects of living plants or their residues upon growth of higher plants and crop yields. Replanting problems, autotoxicity, toxicity of mulch stubble, problems with crop rotations and direct interference by certain plants or weed species have been attributed to allelochemicals. Plants influence each others growth by means of exudates (Rice,1984), leachates from residues incorporated in the growing medium (Buchholtz,1971; Fisher *et al,* 1978; Bhowmik and Doll, 1980; Bhowmik and Doll, 1983) or residues in natural, undisturbed condition (Schreiber and Williams, 1967).in addition to inhibiting effect , on growth and development, nutrient uptake also be affected. Allelopathic compounds or phytotoxins , escape into the environment by volatilization, exudation from roots, and by decay of plant material . It appears that all plant parts contain allelopathic substances. Due to increased interest in various agricultural systems where plant interactions are critical, knowledge of allelopathy has become a necessity. Allelopathy and its role in agro-ecosystems has been evaluated with respect to effects of :
crops on weed suppression,
crops residues on succeeding crops,
weed residues on crop yields,
weed residues on weed interactions and ,
weed seeds on crop growth.
incorporation of crop residue in soil
allelopathic agents on nutrient uptake by crop plants
allelochemicals released from crop residues

Chemicals with allelopathic potential are present in virtually all plants and in most tissues, including leaves, stems, flowers, roots, rhizomes, buds and seeds. Under selected environmental conditions, the active form may be released which can in turn, cause the allelopathic effects Many of the compounds do appear to be broad- spectrum inhibitors.

Crops on weed suppression: Allelopathic interaction between crops and certain weeds has been shown to be beneficial to the crops and inhibitory to other competing weeds(Altieri and Doll, 1978). and Nuttonson (1958) have reported that rye exudate reduced the germination of wild oats *(Avena fatua* L). Dzyubenko and Petrenko (1971) found that root secretions of corn (*Zea mays* L) inhibited the growth of common lambsquarters*(Chenopodium album* L) and *Amaranthus retroflexus.*
Neustruyeva and Dobretsova (1972) reported that wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), peas (*Allium sativum* L.) and buckwheat suppressed growth, accumulation of above ground biomass and leaf surface of common lambsquarters. Oats had a marked effect, which peaked at flowering time. They concluded that oat exerts an allelopathic effect in addition to its competitive role. Similarly, Hilton (1979) reported sunflower leachate reduced total weed cover by 33%. Lazauska and Balinevichiute (1972) tested excretions from seeds of hairy vetch(a common winter cover crop) against seed germination and seedling growth of thirteen species of weeds. They found that seed germination and particularly seedling growth were markedly inhibited in many tests.
Reported that germinating seeds of millet, wheat, oats, vetch, maize and buckwheat stimulated germination of crunchweed (*Brassica kaber* L.) seeds, whereas germinating barley seeds inhibited germination of crunchweed seeds. She found that the compounds which stimulated or inhibited the germination of crunchweed seeds were produced during germination. Prutenskaya (1974) demonstrated that wheat, rye, and barley strongly inhibited the weedy *Brassica kaber,* whereas millet (*Panicum miliaceum* L.) stimulated the weed. screened 526 accessions of cucumber (*Cucumis sativa* L) and 12 accessions of eight related *Cucumis* species from 41 countries for allelopathic activity against a forb, *Brassica hirta*, and a grass *Panicum miliaceum*, One accession inhibited indicator plant growth by 87% and 25 inhibited growth by 50% or more. The work of Overland (1966) and Peters (1968) indicates that several other crop plants are allelopathic to various species of weeds.
Sorghum (*Sorghum bicolor* L.) residues reduced the populations of common purslane (*Portulaca oleracea* L.) by 70% and smooth crabgrass (*Digitaria ischaemum* L.) by 98%. Residues of barley, oats, wheat, rye and sorghum were very effective in reducing weed populations in several vegetable crops (Putnam and Defrank,1983) found that the addition to sunflower residues to the soil reduced the seed germination of *Amaranthus retroflexus* and the percentage of inhibition

increased with increased concentration of total phenolics in that sunflower residues.

Cheema *et al.* (1988) evaluated under laboratory and pot experiments the allelopathic potential of wheat straw aqueous extract (0. 25, 50, 75 and 100 % w/v) on germination and growth responses of field bindweed (*Convolvolus arvensis* L.) and crowfoot grass (*Dactyloctenium aegyptium* L.). Wheat straw aqueous extract significantly inhibited the germination and growth of both weeds at all extract concentrations. rl field studies, sweet potato (*Ipomoe batatas* L.) greatly reduced yellow nutsedge Cyperus esculentus L.) growth when the two species were grown together using standard cultural practices.

AlSaadawi *et al.* (1986) screened root exudates of 100 cultivars of sorghum for their ability to inhibit seed germination and seedling growth of redroot pigweed (*Amaranthus retroflexus* L). Exudates of some of the test cultivars were found to inhibit significantly seed germination and/or seedling growth of *A. retroflexus* and most of the inhibitory activity was found in neutral and acetone fractions of root exudates. Testing of aqueous extracts and decaying residues of four selected sorghum cultivars (two toxic and two nontoxic) revealed that all four cultivars significantly reduced *A. retroflexus* growth and nitrification processes with greater inhibition achieved by the toxic cultivars.

Einhellig and Souza (1992) found that root exudates of sorghum reduced the growth of all weed seedlings tested: *Abutilon theophrasti, Datura stramonium, Amaranthus retroflexus, Setaria viridis, Digitaria sanguinalic, and Echinochloa crusgalli.* They further stated that root exudates of sorghum bicolor consist primarily of a dihydroquinone that is quickly oxidized to a p-benzoquinone named sorgoleone. Abdul-Rehman and Habib (1989) investigated in greenhouse and laboratory experiments, the possible allelopathic potential of alfalfa and its decomposed residue on bladygras (*Imperata cylindrica* L. Beauv.), a noxious weed in Iraq. Results have indicated that decomposed alfalfa roots and their associated soil produced a 51-56% reduction in bladygrass seed germination. Root and shoot lengths of bladygrass seedlings reduced by an average of 88%. Decayed and undecayed mixtures of alfalfa roots and soil at a ratio of 0.05:1 (w/w) inhibited bladygrass seedlings reproduced from rhizomes by 30 and 42% . It was found that root exudates of alfalfa seedlings caused significant reduction in shoot and root dry weights 6 bladygrass seedlings when alfalfa and bladygrass were grown together in nutrient culture. Caffeic, chlorogenic, isochlorogenic, p-coumaric, p-OH-benzoic and ferulic acids were detected in alfalfa root exudates and residues. The highest amount of these compounds was found in alfalfa root residues after six months of decomposition in soil.

Crop residues on other crop plants: The inhibitory effect of certain plants on crop yield was suggested in the early 1800's and the toxic effect of walnut (*Juglan nigra* L.) species on a variety of plants was well- known before 1900. Schreiner and his associates (1907) tested water extracts of the soil from wheat, oat, corn and cowpea fields on the growth of wheat They found that these crops exude materials into the growing medium inhibiting the growth of crop plants. McCalla and Duley (1948) reported that stubble mulch reduces the stand and growth of corn under some conditions. They found that soaking corn seeds in an aqueous extract of sweet clover (*Melilotus indica* L.) for 24 hours reduced germination and growth of tops and roots. Alfalfa extracts had less depressing effects and wheat straw extracts either stimulated growth or had no effect.

Guenzi and McCalla (1962 showed that the water extracts of a number of crop residuess inhibited the germination and growth of sorghum, corn, and wheat in a laboratory experiment. They further reported that all residues contained

water soluble substances that depressed the growth. Martin and Rademacher (1960) incorporated fresh rape (*Brassica napus* L.) roots in soil and planted wheat seeds in this soil and similar soil without the rape roots. Growth of the wheat seedling was inhibited at first, but after 4 days ,it was stimulated.

Residues of wheat, oat, corn, and sorghum contained water soluble materials that were toxic to growth of other wheat, corn, sorghum and other crops. Wheat as well as other crops were shown to contain a number of phenolic acids and the five most dominant ones were: ferulic , p-coumaric , syringic, vanillic, and p- hyderoxybenzoic acids. Oleswzek and Jurzysta (1987) reported that wheat seed germination and seedling growth were suppressed by water and alcohal extracts of alfalfa roots. Madicagenic and glycosides were found to be the inhibitors.

Cheema *et al.* (1988) reported that wheat straw aqueous extract caused 15-20% inhibition of germination of cotton. But stimulated shoot and root growth and dry matter production. Extracts of decomposing field residues of barley, rye, broadbean (*Vicia faba*) wheat, vetch and sudangrass (*Sorghum sudanense*)were found to be toxic to lettuce seedlings.

Chou and Lin (1976) studied the effects of decomposing rice residues in soil on the growth of rice plants. They found that aqueous extracts of decomposing rice residues in soil inhibited radical growth of rice seedlings and growth of rice plants. Maximum toxicity occurred in the first month of decomposition and declined thereafter. Some toxicity persisted for four months. Five inhibitory phenolic acid were identified from decaying rice residues.

Aqueous leaf extracts of cultivated sunflower alter the water balance and inhibit the growth of grain sorghum. The allelochemicals are present in root ,stem, and leaf tissues and seed hulls. The expression of allelopathic effects by sunflower is subject to environmental modifications, including the nutrient status of the plants. Irons and Burnside (1982) reported that when a 2% (w/w) mature sunflower leaves mixed with the soil reduced emergence , growth of soybean sorghum and sunflower. The root exudates of sunflower inhibited sunflower emergence , height , fresh weight, and dry weight. Aqueous extracts from fresh and dried roots and root exudates of the Chinese cabbage inhibited growth of mustard. Extracts from dried roots were more inhibitory than those from fresh (Akram and Hussain,1987). Decaying sweet potato plant residues incorporated into the soil caused significant inhibition of growth of sweet potato vine cutting and cowpea plants (Walker *et al.* 1989). Yang and Futsuhara (1991) found that when soybean (*Glycine max L.*) callus was cultured with rice (*Oryza sativa* L.) callus in the same cultured bottle, the allelopathic effect was so intense that the growth rates of the soybean calli were reduced by more than 100- fold under many experimental conditions. Further studies showed that the inhibitory effect was from volatile compounds which were produced by rice callus.

Lovett and Jessop (1982) and studied a range of twelve crop plants (four cereals, five legumes, and three oil seeds) and found that all produced chemicals which significantly reduced the early growth of wheat under controlled and field conditions . Hikam *et al.* (1991) found that maize dry matter accumulation reduced and tissue N concentration was increased in intercrop culture with winged bean (*Phosphocarpus tetragonolobus* L.)These results indicated that N stress did not cause the decreased growth of maize when grown with winged bean on maize be occurred.

The phenomenon of autotoxicity that is phytochemical inhibition of one species on the germination, growth and development of the same species has been widely studied. Specially so in alfalfa , where extracts from fresh material, from decomposing material or from material left as stubble

have been studied (Hall and Henderlog,1989).

This phenomenon has also been studied in other crops like rice (Chou and Lin,1976) wheat (Nielson etal, 1960)., corn and oat (Nielson *et al.*,1960); cotton and many other crops (Schreiner and Reed, 1907; Kimber,1973; Ellis and McSay, 1991; Hedge and Miller,1990). From these studies it is clear that nutrient deficiency of pathogenic infection can not account for the effect observed. The authors are unanimous that the effect is due to autotoxic compounds.

Some authors have shown that alfalfa residues contain water soluble substances toxic to other plants and that alfalfa roots are richer in these chemicals than the tops Kher *et al.*, 1983; Kimber, 1973; Lawrence and Kilcher, 1962. The origin of these may be either directly from the plants , usually as secondary compounds, or arise indirectly from the plants during the decomposition of the residues (Patrick,1971; Rice 1974) . These secondary compounds are either byproducts of metabolism or waste products stored in the vacuoles to prevent deleterious effects on the producing plant (Rice, 1974). Compounds implicated as likely Phytotoxic agents are phenolic acids,terpenoids, flavonoids,alkaloids, cyanogenic glycosides, quinones, and amino acid derivatives (Rice ,1974).

Weed residues on crops: A weed may be defined as any plant growing where it is not wanted. King has provided a history of the term "weed". A crop plant is any plant grown for its value to man at a given time. Thus , both weeds and crops are plants. Plants, in general , have similar growth and propagation characteristics. They require essentially the same environment to support these characteristics. Weeds as suggested by Young and Evans (1976), are opportunistic genotypes naturally selected in disturbed agricultural ecosystems. Weeds have been a constant companion of crop plants in crop lands since man replaced native vegetation with more nutritious , productive and economical plants. Weeds cause annual loss of about 10% in agricultural production si estimated at more than $18.2 billion , with about $ 12 billion of this amount attributed to the production losses caused by weeds. Another $3.6 billion is spent on chemical weed control, and $ 2.6 billion is spent on cultural , ecological and biological weed – control methods (Shaw,1982).

Weeds generally compete with crop species for light, space, water and nutrients (Retta *et al.*, 1991), but in many cases, have a selective advantage due to allelopathic activity. The occurrence and distribution of weeds in fields is influenced by a number of environmental and management factors. Some of these include soil chemical and physical properties such as pH, fertility, water holding capacity, crop, tillage and weed control .

It is commonly assumed that reduction in crop yield from weeds are the direct result of competition , of allelopathy , or of the two acting together. Competition between crops and weeds is generally for the growth factors available in the space occupied by these plants. In the process of competition, weeds frequently absorb nutrients (N, P, and K)much more than the crop plant. Shade crop plants affecting the process of photosynthesis. Various allelochemicals (volatile terpenoids, phenyl propanoids, quionones, coumarins, flavonoids, tannins, and other phenolics and cyanogenic glucosides, steroids and alkaloids) contained in weeds generally enter into the crops environment by exudation , leaching or decomposition (Rice, 1974).

Competition occurs between two or more plants when the supply of one or more factors essential to growth and development falls below the combined demands. The more aggressive species usually dominates an intermixed community of weed and crop plants. Aggressiveness is favoured by greater root elongation and branching, resulting in a root system that absorbs water, nutrients and oxygen from the soil at the expense of adjacent plants. Aggressiveness is also

favoured by taller plant species that grow more quickly than adjacent plants or by plants that climb their neighbours as vines, producing foliar canopies that shade slower or shorter plants in the community. Reduction in crop yield has been used as an indicator of weed-crop competition. Burnside (1979) reviewed the weed- crop competition in soybeans, the following key factors in crop yield reduction were identified: weed-crop emergence ; competition duration; weed life cycle and growth habit; density of weed and crop plants; crop species and cultivars; crop life cycle and growth habit; crop planting date; depth of planting and row spacing and climatic, edaphic and other biotic factors.

Weed crop competition in the first six weeks or so after planting tends to have the greatest adverse effect on the crop yields. Soybeans kept weed free for the first four weeks after planting showed little loss in yield from competition with later emerging weeds, where as season long weed competition reduced yields by 50 to 75 %, depending on weed species involved and severity of weed infestation (Burnside,1979).Weeds that emerge after soybeans are well established are less competitive because established soybean plant compete well with weeds.

Different weed species vary in their competitiveness with crop plants. Soybean yields were reduced 7,8 and 23% by competition from prickly sida *(Sida spinosa* L.), venice mallow (*Hibiscus trionum* L.), and velvetleaf (*Abutilon theophrasti* Medic.), respectively, emerging with or during the first 10 days after soybean emergence. Soybean yields were not affected by weed species that emerged 20 or more days after soybeans.

Le Tourneau *et al*, (1956) found that water extracts from 23 common weed and crop species inhibited germination and growth of wheat seedlings. Water extracts of corn and sorghum residues inhibited germination and growth of wheat (Guenzi and McCalla, 1962). The phytotoxic effects of 14 aqueous root extracts upon germination and seedling growth of 15 plant species has been reported (Lawrence and Kilcher, 1962). Root exudates of wild oats (*Avena fatua*) reduced growth of wheat tops. The effect is often attributed to water soluble phytotoxins either leached from the residue or produced during microbial decay (Kimber, 1973).

Kossanel *et al*. (1977) found that root exudates of common lambsquarters in culture solutions retarted growth of radicles of corn. Water solutions in which common lambsquarters previously grew and water extracts of its roots also inhibited growth of corn roots. Bhowmik and Doll (1979) found that water extracts of residues of common lambsquarters inhibited root and shoot growth of corn and hypocotyl growth of soybeans. Residues of common lambsquarters incorporated in three different soils reduced the height growth and fresh weights of shoots of both corn and soybeans.

Reported that water extracts of dried residues of common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retrofluxes* L.), fall panicum (*Panicum dichotomiflorum*), giant foxtail (*Setaria faberi Herrn*), green faxtail (*Setaria viridis* L Beauv.)and yellow foxtail (*Setaria glauca* L. Beauv.) inhibited radicle elongation in corn , where as only common lambsquarters extracts reduced coleoptile growth also. Soybean yield reductions ranging from 14 to 19% occurred with common lambsquarters.

Bhatia *et al*. (1982) studied the effects of common lambaquarters on wheat and found stimulating effect on the growth of wheat. Souto *et al*. (1990) have also reported similar effects with wheat crop. Datta and Ghosh (1982) studied the effets of nettleleaf goosefoot (*Chenopodium murale* L.) on mustard (*Brassica juncea*) and found phytoxicity effect of the growth of mustard. An oily residue having carboxyl and hydroxyl functions and a solid residue containing oxalic acid were probably involved in the phytotoxicity of this weed. Root exudates of *Phalaris minor*

and *Chenopodium murale* decreased shoot and ear length and dry matter production of wheat. Bhowmic and Doll (1984) used the residues of common lambsquarters (Chenopodium album L.), redroot pigweed (*Amaranthus retroflexus* L.), common ragweed (*Ambrosia artemisifolia* L.), valvetleleaf (*Abutilon theophrastic* Medic.) and yellow foxtail (*Setaria glauca* L Beauv.) to evaluate their allelopathic effects on soybean and corn. All the weeds reduce the growth of both the crops. Pope et al. (1984) reported that root exudates of portulaca olerecea significantly reduced soybean height. Dharmaraj et al. (1988) reported that root and shoot leachetes of *amaranthus viridis* and *portulaca oleracea* caused greatest reduction in sorghum seed germination.

Purple nutsedge (*Cyperus rotundus* L.) was listed by Holm (1969) as one of the ten worst weeds of the world. Interference by purple nutsedge adversely affects the crop yields tested water extracts of tubers of purple nutsedge on seed germination and seedling growth of 1000 species of crops. Inhibition and seed germination varied from 0 to about 65 % compared to water controls. Seedling growth was also inhibited in all species with a maximum of about 85 % studied the effects of purple nutsedge on sorghum and soybeans. They found that incorporation of tubers in soil caused pronounced growth inhibition of both crops. Saleem and Fawusi (1983) found in greenhouse and laboratory experiments that aqueous extracts of the purple nutsedge completely inhibited root development and reduced growth of aerial parts of rice crop. Elmore (1985) reported that *Cyperus rotundus* allelopathically caused the crop losses of cotton, maize, soybean, sorghum, groundnut and tobacco. Lopes et al. (1987) studied the effects of aqueous extracts of shoots and roots of Cyprus on germination and seedling growth of rice. About 95 % germination of rice seeds was obtained in all cases. Alam et al. (1990) demonstrated that aqueous extract of fresh leaves at 0.0.5, 1.0, 1.5 and 2.0 % (w/w) of purple nutsedge significantly reduced the percent germination, shoot and root lengths of wheat crop. At the highest level of 2 % extract, the shoot growth was reduced by 33 % and root by 40 %.The reductions in shoot and root growth may possibly be due to release of water- soluble compounds affecting the growth.

Interference by yellow nutsedge (Cypreus esculentus L.) markedly reduced crop yield . Tames et al. (1973) found that the tuber of yellow nutsedge contained compounds that inhibited the growth of oat coleoptile and the germination of seeds of seven crop species studied. They identified several phenolic compounds such as ferulic, vanillic, syringic and p coumaric acids in the residues. Drost and Doll (1980) observed that the foliage residues of yellow nutsedge were very inhibitory to root and shoot growth of corn and soybeans. Root, shoot, leaf and flower extracts of *Phalaris minor* mixes with soil were studied for their effect, on rice seedling growth. All *Pharis minor* plant parts decreased rice root dry weight compared with the control (Bansal and Singh, 1986). Seed germination, root and top growth of barley were inhibited when growing in soil that had previously contained Bermuda grass (*Cynodon dactylon* L.) residues. Field experiments conducted over 2-3 years demonstrated that bermuda grass inhibited the growth of newly planted peach (*Prunis persico*) trees. Meissner et al.(1989) have reported that growth pattern of young carrot , cucmber , lettuce maize, squash, onion, radish, sunflower and tomato plants were affected when grown in cynodon dactylon infested soil.

Vegetative propagules of cynodon dactylon and convolvulus arvensis reduced the growth of plu, apple and vine plantlets. Aliotta et al. (1990) used the chloroform extracts of scarlet pimpernel (*Anagallis arvenensis*) on germination of radish and lettuce seeds. They found that although germination was not affected , but root growth and dry weight of both radish and lettuce were markedly inhibited . The phytotoxic constituent

isolated from chloroformic extract was a triterpenoid. Kil and Lee (1987) reported that aqueous extracts of young green tops of (*Chrysynthamum moriflorum*) significantly inhibited the germination and seedling growth of six flowering plants: *Callistephus chinensis*, *Cosmos bipinnata*, *Tagetes electa*, *petunia hybrida*, *celosia cristata*, *Salvia splendens* and *Portulaca grandiflora*. Allelochemicals related to this phenomenon were salicylic, ferulic , vanillic, gallic and caffeic acids.

The allelopathic effects of other weeds growing in agricultural fields such as, Barnyard grass (*Echinochola crussgalli;* Bhowmik and Doll,1979; Abdallah, et al., 1990); Quackgrass (*Agropyron repens*-ohman and Gabor and Veatch, 1981), Canada thistle (*Cirsium arvense*- Hodgson, 1958; Crabgrass (*Digitaria sanguinalis*-Parenti and rice, 1969), Milk thistle (*Silybum marianum*- Chaghtai et al.,.1988), Johnson grass (*Sorghum halepense*, Weil and Mcfadlen, 1991) , walnut (*Juglan regia*- Hussain et al., 1991), curley dock (Rumex crispus- Moreno and Francisco- 1991), *Euphorbia prostrate*, Parthenium (*Parthenium hysterophorus*, Singh and Sangeeta, 1991., Italian ryegrass (*Lolium multiflorum*), slender amaranth (*Amaranthus viridis*), common purslane (*Portulaca oleracea*- Pope et al, 1985), asparagus (*Asparagus officinalis*) Littleseed canary grass *(Phalaris minor*-Bansal and Singh,1986), leafy spurge (*Euphorbia esula*-Hogan and manners,1991), Lantana (*Lantana camara*) have also been shown to affect the germination and seedling growth of various crop plants.

Many weeds common in the agricultural fields in Pakistan have been reported to exhibit allelopathic effects on the growth of various crop plants. Weeds like Italian ryegrass (*Lolium multiflorum*), *Diachanthium annulatum* , *Euphorbia granulata* (Hussain 1980), Datura innoxia (Hussain et al,1979), buffelgrass *(Cenchrus ciliaris*- Husain and Anjum1980), Columbus grass *(Sorghum almum*- Qureshi and Husain, 1980), *Citrullis colocynthis*, Sstachys parviflora (Hussain et al., 1986), Bermuda grass *(Cynodon dactylon*- Hussain and Khan 1988), *Ficus bengalensis*, Purple nutsedge (*Cyperus rotundus*) bladygrass (*Imperata cylindrica*- Hussain and Abidi, 1991) have been reported to reduce the germination, seedling growth and shoot and root dry weight of various crop plants under laboratory and field conditions.

Weed on weed growth: Several workers have shown that allelopathic phenomenon occurs in weed-weed interaction (Rose et al., 1984), affecting growth of each other. AlSaadawi and Rice (1982) reported that prostrate knotweed (*Polygonum aviculare*), rapidly enchroches into Bermuda grass lawns and the grass dies and at the edges of the knotweed patches turns yellow. Soil collected under knotweed markedly inhibited seed germination and seedling growth of Bermuda grass. Eleven allelochemicals inhibitory to growth of Burmuda grass were isolated from soil under prostrate knotweed . Four phenolics and seven long chain fatty acids were identified (Alasaadawi and Rice 1982a). Inhibitors from *P. aviculare* also inhibit germination of common lambsquarters (Alasaadawi and Rice 1982b).

Shoot residues of Chenopodium album reduced Cyperus esculantus shoot numbers and tubers. Aqueous extracts of Cyperus esculantus inhibited the germination of Chenopodium album, Amaranthus retroflexus and Echinochloa crussgalli. Similarly , Chenopodium album , Amaranthus viridis , Abutilon theophrasti and Setaria faberi reduced Cyperus esculantus (Simkins,1983).

The allelopathic effect of shoot residue of (*Parthenum hysterophorus* L.) was found on the growth of wheat (*Triticum aestivum* L.) and velvetleaf (*Abutilon theophrasti* Medic.) . Parthenium shoot contained water soluble materials that were toxic to root growth of velvetleaf. At 4% (w/v) concentration ,root growth of wheat and velvetleaf were reduced by 60 and 75% respectively. At 1 and 2% (w/v) , the inflorescence and

leave caused more root inhibition than stem extract.
The phytotoxity of plant leachates was found from four subtropical grasses . *Brachiaria mutica* ,*Digitaria decumbens*, *Imperate cylindrica* and *Penicum repens.* The aqueous leachates of each grass was used to water the growth of four grasses in pots. The leachates exhibited variable inhibition of grass growth as compared to the tap water control. h laboratory bioassays , the leachates showed a significant phytotoxic effect on the radicle growth of ryegrass. They further pointed out that the leachates of four grasses posses phytotoxic compounds that may play a significant role in grass dominance in the field. Weidenhamer and Romeo (1989) have reported that germination and growth of bahiagrass *(Paspalum notatum*) were reduced significantly in *Polygonella myriophylla* (a perennial shrub) soil compared to adjacent bare zone soil. The average germination of bahiagrass was 71% in *Polygonella* soil and 81% in bare zone soil, and average shoot dry weight was 48% in *polygonella* soil and 81% in bare zone soil.

AlSaadawi, *et al* .(1990) demonstrated that aqueous extract, decaying residues and root exudates of *Euphorbia prostrata* were inhibitory to Bermuda grass and Prostrate knotweed . They suggested that the presence of inhibitory compounds in the extract from this weed were responsible for growth reduction of Bermuda grass. Chou and Lee (1991) reported that the aqueous extract of *Miscanthus transmorrinensis* showed significant phytotoxic effects on seed germination and radicle growth of ryegrass (*Lolium perenne* L.)

Weed and crop seeds on crop growth: The seeds of many plant species , including wheat and rice often fail to germinate promptly after being exposed to stress conditions. Phytotoxic substances have been found in weed and crop seeds germination and seedling growth may be partially inhibited or delayed often resulting in poor stands. Mckee *et al.* (1971) did not fine any effect of crownvetch seed leachates on the germination and seedling growth of 48 different crops.
Germination of lettuce seeds as well as their roots and hypocotyl elongation were inhibited when the seeds were sown in petri-dishes together with a few seeds of Heracleum maximum (*Heracleum lanciniatum* Horn). The *H. lanciniatum* seeds inhibited the germination of Salix pentendra seeds and to some extent the germination of radish . Milk thistle (*Silybum marianum*) seed did not inhibit the germination of wheat seed . The application of seed extract of common lambsquarters inhibited the seed growth of wheat, red clover and lucerne (Stefureac and Fratilescu-Sesan, 1979).
Reported that aqueous extract of valvetleaf seeds severely inhibited germination of turnip seeds. Aqueous extracts from seeds of harmal inhibited the germination of mustered and Persian clover (Hussain and Nasrin, 1985). Similarly , pericarp extract of mesquite was found to be inhibitory to germination of radish seeds (Geol, *et al.*1989). Weed seed extract from ten species affected the germination of tomato (Reth and Hurle, 1986). They further reported that the effect was not due to phenolics.
Water extracts from weed seeds inhibited or retarted the germination of sugarbeet and many other seeds, Svinarev and Borannikov (1956) reported that solution in which rough rice had germinated inhibited the germination of other seeds. They also observed that an organic substances excreted from rough rice seed reduced the germination of *Echinochola crussgalli*. The compounds identified at present in rice hull extracts are vanillic acid , ferulic acid, p-coumaric acid and indole acetic acid. The seed of oats were found to be inhibitory to the seeds of several other plants .

Incorporation of wild plants , crop and weed residues in soil:
The crop residues and farmyard manure are as practice added to soil to improve the soil humus content, water holding capacity, conservation of moisture, water infiltration rate aeration and porosity, and improved productivity (Khind *et al.*, 1987; Capriel *et al.*, 1992). Incorporation of organic residues has been residues has been shown to act as a source of slow release nitrogen . It provides carbon as energy source to N fixing bacteria, enhances seed germination root, growth, yield, nutrient uptake and chlorophyll synthesis.
Interest in using crop residues has increased in the face of high cost of chemical fertilizers and the growing concern for maintaining long term soil productivity and sustainability. Large amounts of residues from high yielding cultivars are being incorporated in soils. The ultimate advantage of any organic matter to create a favourable environment in the soil. Usually the greater amount of Soil organic in the soil , the better are the physical properties of the soil (Magdoff and Amadon,1980). Rice straw addition which is an important source of organic matter in rice growing areas in combination with farmyard manure increased wheat grain yield. The yield and N uptake were best with tons rice straw and 100 kg N/ha resulting in wheat grain yield of 1.43 t/ha over the control (Baghat and Verma,1991).
Some wild plants such as mesquite (*Prosopis glandulosa* L.) *Withnia somnifera* L.) and country mallow (*Abutilon indicum* L.) which are common in the southern part of Pakistan have been shown to posses very high antibiotic activities (Naqvi *et al.*, 1987). In their laboratory studies , such residues have been shown to have active inhibitory effects on the nitrification of nitrogen fertilizers.

Effect of allelopathic agents on nutrient uptake by crop plants:
Nutrient uptake is of basic importance in the growth and development of plants, and evidence is accumulating that many types of allelopathic agents effect the rate of nutrient uptake. Both increases and decreases in the nutrient uptake have been reported for plants subjected to a variety of allelopathic conditions. Cases of mineral imbalance in receiving plants have been created by leachates from plant residues, root exudates , and allelopathic residues (Bhowmik and Doll, 1984)
Measured the uptake of phosphorus (p32) by bean plants growing alone or in association with other bean plants, pigweed or green foxtail. They found that one associated bean reduced the p32 uptake by the test bean plant as much as by four associated bean plants. The weed species caused less reduction in phosphorus uptake than did the associated bean plants, even though these particular weed species were found to absorb large quantities of the major elements. In fact pigweed absorbed 7 times as much phosphorus as the bean plant and still had less effect on absorption of P^{32} by the test bean plant. These facts indicate that competition for limited phosphorus did not cause the reduced phosphorus uptake by bean plants. Consequently the authors concluded that an allelopathic interrelationship was involved.
Buchholtz (1971) observed that corn plants growing in areas infested with quack grass, appeared to be suffering from s server deficiency of mineral element, particularly nitrogen and potassium. As the area was heavily fertilized to meet more than the requirement of both corn and quack grass it was concluded that it was not the competition for nutrients but the allelopathic effects.
Olmsted and Rice (1970) found that the total uptake of K and Ca by pigweed seedlings from a culture solution was significantly reduced by both chlorogenic and tannic acids. Results from several studies illustrate that over a short time interval, phenolic acids in the external root medium can alter uptake of mineral ions. Glass (1973, 1974) found that absorption of P and K by excised barley roots was inhibited to some degree by each of the twelve benzoic and cinnamic acid derivatives that were tested. Exposure to most of these compounds also caused depolarization of the plasmalemma

and a generalized increase in membrane permeability . Harper and Balke (1980) showed that salicylic and ferulic acids inhibition of K uptake by oat roots was greater in a medium with a low pH. There is little evidence concerning the longer-term action of specific allelochemicals on the mineral nutrition of intact plants and it is not known whether effects on the uptake or distribution of minerals are a cause of growth alterations.

K olesnichenko and Aleikina (1976) reported that absorption of minerals from soil was lower in oak roots (*Quercus robur*) growing close to roots of ask *(Fraxinus excelsior)* than in oak roots growing near other oak roots. Newman and Miller (1977) applied root exudates of *Anthoxanthum oderatum, Loloum perenne, Plantago lanceolata* and *Trifolium* to pots containing each of the same four species (one species in each pot). They reported that whereas others inhibited uptake. Allelopathic compounds may influence phosphorus uptake in soybeans. Enhanced K uptake of other nutrients (Newman and Miller, 1977). Enhanced K uptake by sugar maple (*Acer saccharum* Marsh.) seedlings caused by goldenrod (*Solidago canadensis* L.) and aster *(Aster nova-angliae* L.) mulches, was reported by Fisher *et al.* (1978).

In an experiment, Bhowmik and Doll (1982) reported that barnyard grass, yellow foxtail and sorghum reduces N concentration in corn. Corn grown under common lambsquarters and redroot pigweed residues had higher concentration of K than corn grown in control plots with no residue. Similarly, residues of lambsquarters, redroot pigweed and barnyard grass increased K concentration in soybean. Phosphorus concentration was unaffected by residues of common lambsquarter, redroot pigweed, velvetleaf, barnyard grass, giant foxtail and yellow foxtail in its uptake by corn and soybean. The inhibition or stimulation of N, P and K uptake by corn and soybean, redroot pigweed, common pigweed, velvetleaf and yellow foxtail was not consistent and dependent on the residues, source, residue placement or soil texture (Bhowmik and Doll, 1984). Walker *et al.* (1989) found that the uptake of Ca, Mg and S was impaired by sweet potato plant residues was incorporated in to the soil.

Allelochemicals produced by crop weed residues: The diversity of allelochemicals produced by plants is vast, and chemical range in structure from simple hydrocarbons to complex polycyclic aromatics. All plants produced similar compounds such as sugars, amino acids and organic acids. However, plants differ extensively in the kinds of compounds that they produce from these primary metabolites. However, plants differ extensively in the kinds of compound that they produce from their primary metabolites. Secondary metabolites are sporadic occurrence and thus do not appear to play a role in the basic metabolism of organism. However, most of the identified allelopathic chemicals are secondary metabolites. Various investigators have suggested that secondary metabolites are involved in defense mechanism for insect and disease. There appear to be five major categories of secondary metabolites; phenyl propanes, acetogenins, terpenoids, steroids and alkolides. (Rice,1984; Bradow and Connick,1990; Weidenhamer *et al.,* 1993). Much time and efforts has been spent on identifying novel secondary products isolated from higher plants in attempts to develop pharmaceuticals and products with medicinal values. Many of these novel compounds may also exhibit herbicidal activity and consequently interest exist in utilizing material products for synthetic herbicidal templates (Rice, 1984).

Some specific effects of compounds implicated in allelochemicals interactions include inhibition of cell division (Coumarin, many alkaloids); modification of cell wall construction; phytohormones and their balance; membrane permeability and function , modification of active transport; inhibition of specific enzymes (e.g indoleacetic acid oxidase);

germination of pollen, spores and seeds; mineral uptake; stomatal movement; pigment synthesis; photosynthesis; respiration (many flavonoids) protein synthesis (many phenolics and alkaloids; leghemoglobin biosynthesis and N_2 fixation , inhibition of nitrifying bacteria , and micorrhizal fungi; plant water relations; modifications of DNA and RNA; complexation of nutrients; prevention or promotion of haustorium formation in parasites; and changes in frequency of other organisms, for example, pathogens (Rice,1984, 1992; Rizvi and Rizvi ,1992; Wink and Twardowski,1992).

Incorporating allelopathy into agricultural management may reduce the use of herbicides, cause less pollution and diminish autotoxic hazards. Authentic inhibitors isolated from plants, plant extracts, dried plant material and living plants have all been subjects for examination, but attempts to compare their effects in soils are rather limited. However , some positive parallel effects are known, for example extracts of various seeds were found to inhibit germination both in the laboratory and in soils. Another approach is the use of crops which specifically reduced weeds. Traditional interplanting of squash *(Cucurbita pepo)* in corn or bean fields by Mexicans as well as in young orchards in the Middle East is aimed at suppressing weeds by 'living mulch'. Selection for allelopathically –active genotypes among accessions has been attempted in *Cucumis* and Oats *(Avena sativa* L.) and although proved successful, improvement was only marginal. A past work was by has shown that cereal grains, such as sorghum (*Sorghum bicolor*), rye (*Secale cereale* L.) ,wheat(*Triticum aestivum* L),barley (*Hordeum vulgare* L.) and oats *(Avena sativa* L.), when desiccated by freezing or with contact herbicides 30-40 days after planting, provide excellent cover for weed suppression (Putnam and Defrank, 1983).

Further examination of plants with allelopathic potential or with autotoxic effects, and of their allelochemicals or of those produced by associated microorganisms could provide new strategies for maintaining and increasing agricultural production in the future.

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