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ALLELOPATHY – A SUSTAINABLE ALTERNATIVE AND ECO-FRIENDLY TOOL FOR PLANT DISEASE MANAGEMENT

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ABSTRACT

Allelopathy is a normal and eco-friendly phenomenon that involves inhibitory or promotional effects of released phyto-toxins "Allelochemicals" by the crop plants. Allelopathy is considered as both beneficial and deleterious biochemical interaction through the production of chemical compounds that escape in to the environment and subsequently influence the growth and development of neighbouring plants.This phenomenon can be utilized efficiently for the pest free crop production.Use of agrochemical can be minimized by exploiting the allelopathy as an alternative tool for disease pest management in crop production. The continuous use of agrochemical is not only increasing the number of disease resistant bio-types but also polluting the environment, deteriorating the quality of food with negative impact on human and animal health. The ability to understand the physiological basis for allelopathy in a plant species may allow an agronomist to work closely with the molecular biologist or plant breeder to selectively enhance the trait responsible for disease suppression. Several researchers have described Allelochemicals as natural pesticides to manage biotic stresses be it disease, weeds even in insect pests. Considerable efforts have been made in the near past in designing alternative strategies for diseases management. Evidence of Allelochemicals activity in field situations is difficult to obtain, but it is evident that some rotation crops are significantly better at reducing diseases than others. Rotations with non-host plants may simply deny the pathogen population an adequate food source for reproduction, whereas allelopathic crops kill pathogens by the production of toxic compounds. The possibility exists to exploit allelochemicals for disease control, and there have been many attempts to use this approach either by crop rotation, intercropping, crop residues, leaf water extracts etc. Allelopathy offers great potential for diseases management in field crops. This presentation is an attempt to review the role of allelopathy and its practical utility asefficient alternative disease management tool along with future thrust to improve and widened our understanding in this regard.

Keywords: Allelopathy, Allelochemicals, Crop rotation, Disease management, Intercropping.

Allelopathy occurs when plant or its cultivars release some specific chemicals, which affect other species in its vicinity, usually their detriment. It is a natural phenomenon and has been observed for over 200 years and the phenomenon reports as early as 300 BC document that many crop plants inhibited the growth of other plants. The word allelopathy is derived from two Greek words: '*allelon*', meaning 'of each other', and '*pathos*', meaning 'to suffer'. This ancient concept was known to classical researchers in the Greek and Roman era. Harmful effects of crop plants on other plants were observed by Theophrastus and by Pliny II, while De Candolle considered allelopathy to be soil sickness. The term '*allelopathy*' was first used by Austrian plant physiologist (Molisch, 1937), who defined it as the chemical interaction among plants and microorganisms.Allelopathy is a mechanism whereby secondary metabolites synthesised by fungi, viruses, microorganisms and plants influence biological and agricultural systems, which may be either stimulatory or inhibitory (Rice1979, Bhowmik and Indrajeet 2004). Allelopathy is the influence of one plant on the growth of another one, including microorganisms, by the release of chemical compounds into the environment (Rice, 1979 and 1984). These chemicals are usually secondary plant metabolites or byproducts of the principal metabolic pathways in plants (Rice 1984,Puttam 1983 and Einhellig, 1995b). They are non-nutritional and can be synthesised in any plant part, i.e. leaves, stems, roots, bark, seeds, etc. Under favourable environmental conditions, allelochemicals are released into the environment through the processes of volatilization, root exudation, decomposition and/or leaching, thereby affecting the growth of adjacent plants (Rice, 1979, Bais*et al.* 2004a andEinhellig, 1995a).Nonetheless, not all Allelochemicals are involved in vital physiological events within the plant system (Rice, 1979, Bhowmik and Indrajeet 2004). Allelopathy involves the synthesis of plant bioactive compounds, known as allelochemicals, capable of acting as natural disease controller and can resolve problems such as resistance development in races of pathogens, health defects and soil and environmental pollution caused by the indiscriminate use of synthetic agrochemicals(Rice, 1979, Bhowmik and Indrajeet 2004, Bais *et al.* 2004a and Einhellig, 1995b). Allelopathic crops, when used as cover crops, intercrops, or grown in rotational sequences, can combat disease pathogens and additionally build up fertility and organic matter status of soil, thereby reducing soil erosion, and improve farm yields. Thus, allelopathy may be exploited profitably in many ways.Allelopathy is the any process involving secondary metabolites that influence the growth and development of agricultural and biological systems (excluding animals), including positive and negative effects (Willy 1979, Gomez *et al.*, 2003, Bhowmik and Indrajeet 2004 and Torres *et al.* 1996). Allelopathy also refers to the beneficial or harmful effects of one plant on another plant, by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems. Micro-organisms such as fungi, bacteria, viruses, and nematodes are an integral part of agro ecosystem (Gomez *et al.*2003 and Hengnauer, 1988). Some of them are harmful plant pathogens, where as others are neutral or beneficial in their effects on plant growth. Control of disease-causing organisms is an essential component in every crop production system. The objective of allelopathy for disease management is very important for increasing crop production. (Molisch, 193, Rice1979 and Einhellig, 1995b).This is very useful way to control diseases in various types of crops in a definite way (Bhowmik and Indrajeet 2004). It is depend on the chemical constitution of allelochemicals. Plants or organisms that release these compounds are called"donor species", while those that are influenced in their growth and development are called "target or recipient species" (Rice, 1979 ,Einhellig, 1995b Hengnauer, 1988, Bais*et al.*, 2004a). Allelopathy includes plant-plant, plant-microorganisms, plant-virus, and plant-soil-plant chemical interactions (Akobundu, 1987 and Fuerst and Putnam, 1983).Although allelopathy has already contributed to some solution of naturally practical disease problems in agriculture but it are still now a new concept (Hedin*et al.*, 1978 and Grayer and Harborne, 1994). The main objectives of this review paper to focus the role of allelopathy in disease management, the effects of crops and microorganisms.

Allelopathy and Allelochemicals:

Allelopathy is a normal phenomenon and it includes both harmful and beneficial biochemical linteractions between all types of plants including other microorganism(Rice, 1979 and Einhellig, 1995a). After the publication of classical work in the form of book "allelopathy" by Rice (1984).The phenomenon got a new attention in science community, who later reinforced this definition of allelopathy. The effects of one plant to another plant may be either both stimulatory and inhibitory that depends on the concentration of their leased compounds. For example chemicals, at lower concentration that inhibit the growth of some species where at higher concentration that may be stimulate the growth of other different species. In this phenomenon on the allelochemicals (active compound or its precursor) is released from living or dead tissues of a donor plant (crop) and the allelo chemical(s) is /are received by the targetplant.

Various plant organs such as plant tissues, including leaves, flowers, fruits, stems, roots, rhizomes, seeds and pollen are the main sources of allelochemicals of donor plants are in stressed or competing with neighbouring plants, which released through crop - environmental ecological process (Van Loo 1994, Weir *et al.*,2004 , Smirnoff and Hutchinson 1965).Different groups of plants and crops have wide known allelopathic interactions (Bais *et al.* 2004b and Einhellig, 1995a). Plant releases chemicals that show allelopathic potentiality are called Allelochemicals (Duke *et al.*,1998). It covers a wide range of chemicals used by plants or organisms. Allelochemicals are largely classified as secondary plant metabolites which are generally considered as *alkaloids, phenoloics, flavinoids, terpenoids* and *glucosinolates*) which do not play a role in plant primary metabolic process,but these are essential for their survival (Rice, 1984 and Duke*etal.*, 1998) and also play a role in the general defence against herbivores and plant pathogen (Hedin *et al.*,1978,Grayer and Harborne, 1994 and Einhellig, 1995b). Secondary metabolites, including *terpenes, phenolics* and nitrogen (N) and sulphur (S) containing compounds, defend plants against a variety of herbivores and pathogenic microorganisms as well as various kinds of abiotic stresses (Akobundu, 1987,Fuerst and Putnam, 1983).Plant or organisms respond to different stimuli through synthesis of secondary metabolites ; allelochemicals. Allelochemicals are the single or mixture of chemicals of plants which can naturally suppressed diseases, and are termed as natural fungicides *bactericides* and *viricides*.(Smith 1976, Grayer and Harborne, 1994 and Einhellig, 1995a).

Allelochemicals or natural compounds have more benefits over synthetic compounds as they have novel structure and short half-life, therefore considered safe from the environmental toxicity point of view (Duke *et al.*, 1998).The glucosinolates of the root tissues are of particular importance to the disease break strength of canola within the cereal rotation, as only these tissues release significant quantities of isothiocyanate into the soil. The roots of *B. juncea*produce significant quantities of both 2-PE and 2-propenyl glucosinolate has strong anti-pathogen properties. Defense metabolites can be divided in to constitutive substances, also called prohibitins or phytoanticipins and induced metabolites formed in response to an infection involving *de novo* enzyme synthesis, known as phytoalexins(Van et *al.*, 1994; Grayer and Harborne, 1994).N containing (Alkaloids) secondary metabolites found in approximately 20% of the species of vascular plants (Hegnauer*et al.*, 1988), most frequently in the herbaceous dicot and relatively a few in monocots and gymnosperms. Generally, most of them, including the pyrrolizidine alkaloids (PAs) are toxic to some degree and appear to serve primarily in defense against microbial infection and herbivoral attack (Grayer and Harborne, 1994, Potter *et al.*, 1998and Weir *et al.*, 2004).

It is well known that crops cultivated in rotation produce higher yield than those of grown in monoculture. Organic farmers also must know about the soil borne pathogens that build up when a soil is sown with the same crop or family of crops every year. Generally, crops in the same family should not follow one another in the field. For instance, cantaloupes should not follow cucumbers. A *cucumber-melon-squash* rotation obviously invites disease problems. At a minimum, crops from a particular family should be separated by *at least* two years of crops from other families. For example, a rotation of families might include Brassicaceae (cole crops), followed by Asteraceae(lettuce, cut flowers), followed by Solanaceae(tomatoes, potatoes, peppers, egg plants), followed by Curbitaceae (squashes, cucumbers, melons), because of their requirements and disease pest management. (Duke *et al.* 1998 and Hedin *et al.*, 1978 and Hegnauer, 1988) further emphasised that when a plant is challenged by chemicals from another plant (or a herbicide, for example) a defence response is engendered in the receiver plant.

Mode of action of Allelochemicals:

Several allelochemicals are synthesized by the plants during their growth and developmental period. Plant releases allelochemicals or its precursors at their early developments stage of even plants are most stressed and competing with neighbouring plants, for light, nutrients and water (Weir *et al.,* 2004 and Smirnoff and Hutchinson 1965).Moreover crops and microorganisms that possessing allelopathic activity to major diseases could reduce the loss in crop yields due to disease causing agents and hence reduces fungicide, bactericide and viricide application and its costs, ultimately helping to protect our environment (Everts, 2002, Pare *et al.*, 1993 and Huang and Chou,2005). These phytochemicals have low or no toxicity to animals and beneficial insects, possess an array of activity with varying and diverse site of action and have a comparatively high degradation rate. Hence allelopathy is directly or indirectly involved in disease management during crop production (Hengnauer, 1988, Bais *et al.*, 2004a and Einhellig, 1995b). Allelochemicals may influence vital physiological processes such as respiration, photosynthesis, cell division and elongation, membrane fluidity, protein biosynthesis and activity of many enzymes, and may also affect tissue water status. Allelochemicals are usually more effective in mixtures than singly to influence targets (Rice, 1984,Akobundu, 1987,Fuerst and Putnam, 1983and Everts, 2002).

Allelopathy*vis-a-vis* Disease Management - Over view:

Plant disease causes harmful effects on many crops including cereals, oilseeds, etc., and especially vegetables. A number of soil-borne diseases cause substantial losses to crop production by disturbing the crop stand and lowering product quality. Although cultural practices such as burning infected plant debris and using resistant cultivars have long been used, diseases still cause abundant losses in crop yields. Plant - allelopathy mechanism can be applicable as a component of integrated disease management program. Chemical disease control for most diseases is either unavailable or ineffective. Plant pathogens can be suppressed using allelopathic crops in different ways. Intercropping is a promising allelopathic approach to biological control for soil-borne disease management (Hazara, 2001 and Gomez-Rodrigucza *et al.,* 2003).Root exudation releases allelochemicals into the rhizosphere, effectively influencing interactions with neighbouring plants and microbes (Bertin *et al.* 2003; Walker *et al.* 2003; Weir *et al.* 2004; Batish *et al.* 2007; Broeckling *et al.* 2008). Canola (*Brassica napus*) tissues containing high levels of the *glucosinolate 2-phenylethyl* (2-PE) has been shown to be toxic against a great range of cereal pathogens, including plant parasitic nematodes (Potter *et al.*, 1998). Intercropping creates a microclimate, which is helpful for reducing disease intensity. Sugi(*Cryptomeria japonica* (L. f.) bark has inhibitory effects against diseases causing root infections in tomato (*Lycopersicon esculentum* L.). Root exudates from Chinese chive (*Allium tuberosum* L.) inhibit multiplication of bacterial wilt (*Pseudomonas solanacearum* Smith). When intercropped with tomato, Chinese chive suppressed bacterial wilt while having no negative effect on the tomato. Certain volatile allelochemicals are exuded from aerial parts of marigold (*Tageteserecta* L.). When intercropped with tomato, marigold suppressed tomato early blight disease caused by *Alternaria solani* by more than 90%.Bacterial wilt of tomato (*P. solanacearum*) has been well controlled by intercropping tomato with cowpea. Cover crops are grown to control disease pathogens, includes sunhemp (*Crotalaria juncea* L.), yellow sweet clover (*Melilotus officinalis* (L.), sorghum, cowpea, alfalfa (*Medicago sativa* L.), velvet

Table 1. Allelopathic suppression of pathogens, nematodes and diseases

Allelopathic source	Application mode/ rate	Pathogen/ disease suppression
Barley (*Hordeum vulgare* L.) – potato	Grown in rotation	55.1% reduction in inoculum intensity of *Rhizoctonia solani* (JG Kühn)
Turnip (*Brassica rapa* L.) + potato	Grown in rotation	56.2% reduction in inoculum intensity of *Rhizoctonia solani* (JG Kühn)
Indian mustard (*Brassica juncea* L.) – potato	Grown in rotation	45.5% reduction in inoculum intensity of *Rhizoctonia solani* (JG Kühn)
Rice (*Oryza sativa* L.)	Root exudates (1.5 mL)	37% reduction in germination of *Fusarium oxysporum* f. sp. *niveum* spores
Rice	Root exudates (20 mL)	71.28% reduction in spore reproduction of *Fusarium oxysporum* f. sp. *niveum*

Table 2. Allelochemicals showing defence against pathogens

Crop name	Allelochemicals	Protected crop	Defence against pathogen
Potato	α-tomatine (Solanum lycopersicon)	Tomato	*Cladosporium fulvum* *Fusarium oxysporum*
L. pimpinellifolium		Tomato	*Pseudomonas solanacearum* *Alternaria solani*.
Potato	solanine, chaconine and solanidine		
[illegible]	Alkaloid		*Mycosphaerella blight*
Cow pea	Phenolic, alkaloid	Groundnut	*Cercospora* (Leaf spot)
Sorghum	Hydrocyanic acid		*Helminthosporium turcicum* and *Fusarium moniliforme*
Watermelon and Rice	Phenolic acids, sugars and free amino acids	Watermelon	*Fusarium oxysporum f. sp. niveum*
Lettuce	Phenolics	Cucumber	*Fusarium oxysporum f. sp. radicis-cucumerinum*

bean, red clover and ryegrass (*Lolium perenne* L.)(Huang *et al.* 1992 and Huang and Chau 2005).Allelopathic properties of cover crops can break disease cycles and reduce populations of bacterial and fungal diseases (Everts, 2002), and parasitic nematodes (Potter *et al.* 1998, Vargas-Ayala *et al.* 2000). Species in the brasicaceae family, such as mustards, have been widely shown to suppress fungal disease populations through the release of naturally occurring toxic chemicals during the degradation of glucosinolade compounds in their plant cell tissues (Lazzeri and Manici 2001). Crop rotation is important in managing soil-borne fungal pathogens in many crops of economic importance.It is the sequential sowing of various crops in a particular field over a definite time period. In crop rotation, allelopathic crops use allelochemicals exuded by roots and released by decomposition of preceding crop residues to suppress disease pathogens.A suitably designed crop rotation can increase yield by around 20%. Crop rotation leads to numerous benefits over monocultures. Special attention should be paid to disease management when designing the rotation. Factors such as different root systems and plant architechure, differences in sowing and harvesting times, allelopathy, varying soil and crop management techniques and diverse cultural practices may be responsible for disease suppression and other benefits in a rotation. Plant-released allelochemicals through root exudation and litter decomposition in rotational sequence suppress diseases. Crop rotation is also helpful in neutralizing potential auto toxic effects associated with Allelochemicals(Willey, 1979, Hazra, 2001 and walker *et al.*, 2003).

Water-soluble secondary metabolites or allelochemicals present in the plant tissues are extracted in water to use them for disease management. Water extracts can be used as a medium for the expression of allelochemical activity to depress the growth of other organisms. Several researchers have suggested the use of allelochemicals extracted in water for disease suppression in the laboratory and also application under field conditions. Huang *et al.*, 2005 evaluated the potential of wheat, barley, oat, rye, canola, sweet clover and lentil (*Lens culinaris* L.) water extracts (1, 2 or 4% w/v) in suppressing the lesion development of *Sclerotinia sclerotiorum* (Lib.), the germination of ascospores and the carpogenic germination of s*clerotia* on detached bean leaves. Application of 1% extract of canola, 2% extracts of barley, canola, oat and lentil and 4% extracts of all seven crops substantially reduced sclerotia germination compared with the water control. However, 1, 2 and 4% extracts of barley and 1 and 4% extracts of oat suppressed ascospore germination, while these concentrations of sweet clover, wheat, canola, lentil and rye extracts promoted ascospore germination. Inoculation of detached bean leaves with ascospores of *S. sclerotiorum* mixed with 4% crop extracts of barley, oat or sweet clover significantly reduced the lesion severity index compared with leaves inoculated with water + *S. sclerotiorum.* Inoculation with 4% wheat extract significantly increased the lesion severity index. Fukuta *et al.* evaluated the comparative *in vitro* antibacterial, fungicidal, antioxidant and herbicidal activities of momilactone A and B. Momilactone B had higher antifungal, antibacterial and herbicidal action than momilactone A, although its antioxidant property was less than that of momilactone A. An indicative list (Table 1) is given below in respect to allelopathic suppression of pathogens, nematodes and diseases in different filed crops grown sole or in rotation.

There are several studies of nematicidal chemicals in crude plant homogenates, leachates, and decomposing residues. The seed meal Ethiopian mustard (*Brassica carinata* L.) in the form of a commercial product at 2.5 t ha^{-1} was effective in reducing root-knot nematode (*Meloidogyne chitwoodi*) incidence in potato (*Solanum tuberosum* L.) and increasing yield of potato.*Brassica* spp. produces volatile sulfur compounds (*glucosinolates*) in the soil microenvironment, which are converted to isothiocyanates through biofumigation to suppress soil organisms. These compounds can reduce fungal pathogens and nematodes in the soil. Two allelochemicals from rice, 5, 7, 40-trihydroxy-30, 50-dimethoxy flavone (a flavone) and 3-isopropyl-5-acetoxy cyclohexene-2-one-1 (a cyclohexenone), inhibited two fungal pathogens (*Rhizoctonia solani* Kühn and *Pyricularia oryzae* (Cavara) by suppressing the germination of spores, and were suggested to be a part of the defence mechanism of rice against diseases. Plant allelochemicals may also mediate interactions between herbivores and their pathogens. Allelochemicals may directly inhibit pathogens which attack herbivores or may act indirectly by altering herbivore susceptibility (Steinhaus 1960, Smith, 1976). Critically tested particularly as it applies to the effects of allelochemicals within host tissues on parasitoids, pathogens and insect predators of insect herbivores. Current way on plant-disease interactionas well as the application of the theory has virtually ignored the potential importance of natural enemies. If plant allelochemicals are found to have important roles in the survival and effectiveness of natural enemies, this will force modifications in current theories concerning both the distribution of allelochemicals among plant species and within plant individuals, and their role in plant defense. Differences in the quantity and/or quality of allelochemicals in time or space, can create a pattern of defense.Smirnoff and Hutchison (1965) evaluated 74 plant species for their ability to inhibit growth of *Bacillusthuringiensis.* Myrcene, (3-caryophyllene and a-pinene (terpenoids) as well as gossypol, catechin and cotton tannins (phenolics) have shown high suppressant activity (in vitro) against *B. thuringiensis.* Cotton plant allelochemicals like gossypol, tannins, a-caryophyllene and gallic acid suppressed growth of five bacteria species, isolated from the gut of *Anthonomous grandis*, the boll weevil and against *B . thuringiensis.* Roots may also exude toxic allelochemicals. Rangaswami and Balasubramanian(1963) showed that sorghum root exudate (hydrocyanic acid) delayed germination of spores of *Helminthosporium turcicum* and *Fusarium moniliforme.* The majority of antifungal allelochemicals are glycosides, e.g., cyanogenic and phenolic glycosides. Various other types of antifungal allelochemicals also have been reported among the saponins, unsaturated lactones and mustard oils. *Pythium ultimum* Trow, is a predominant pathogen of sugarbeet (*Beta vulgaris* L.), field pea (*Pisum sativum* L.), safflower (*Carthamus tinctorius* L.) and canola (*Brassica napus* L. and *B. rapa* L.) in southern Alberta (Huang, *et al.*, 1992) whereas *P. ultimum* and *P. irregulare* are the predominant species for damping-off of field pea in northern Alberta (Hwang and Chang, 1989).Judicious use of allelopathy in cropping systems may be an effective, economical and natural method of disease management, and a substitute for heavy use of agrochemicals (Rice 1984, Puttam 1983 and Bhowmik and Indrajeet 2004). Allelochemicals usually have a mode of action different from synthetic agrochemocal, being more easily and rapidly degradable owing to a shorter half-life, with comparatively fewer halogen substituents and no unnatural ring structures (Rice, 1979 ,Bhowmik and Indrajeet 2004 , Puttam 1983 and Hengnauer, 1988).

Contribution of Allelopathy in Environment safety:

Negative effects of disease controlling chemicals use, such as environmental contamination, development of disease resistant races, and human health problems, make it to find necessary to diversify or develop other alternatives of disease management (Rice, 1979, Bhowmik & Indrajeet, 2004 and Hengnauer, 1988). This use may be reduced by exploiting allelopathy as an alternate pest management tool in sustainable intensive crop production. (Rice, 1979, Bais *et al.*, 2004a, Einhellig, 1995b, Bhowmik and Indrajeet 2004 and Hengnauer, 1988).Potentiality of crop allelopathy greatly influenced by the quality (composition) and quantity (concentration) of allelochemicals ,which released from crops into soil and these chemicals, were degraded by several soil factors including biotic and abiotic (Steinhaus 1960, Smith,1976 and Hwang and Chang, 1989).Transport, transformation, retention in rhizosphere ,leaching and residual effects of allelochemicals is influenced by soil texture, temperature and different chemicals. Several authors have hypothesized that allelopathy may be part of an intricate network of biochemical signalling in nature, comprising not only interactions between plants but also plants and other organisms. Therefore, allelopathy may be regulated in complex fashion by pathogen-induced plant defences and related signalling, and vice versa. Therefore, minimum use of synthetic chemicals along with sufficient labour be an alternative way to minimize environmental loss; thus will increase the interest of researcher to conduct research on allelopathy through screening, breeding approaches (Broecklin *et al.*, 2008 and Huang, *et al.*, 1992).

Future Thrust:

There are some problems in crop allelopathy and some of the impossible to be solved. Selectivity and limited activity are the limitation of natural chemicals. In addition, it may also toxic on on-target organism. It is stated that there are some reasons behind the short comings allelopathy research in crop field to natural disease management. Many allelochemicals are extremely expensive to synthesize, some allelochemicals have short half-life and some are toxic and carcinogenic to mammalian (Huang, *et al.*, 1992 and Duke *et al.*, 1998).Therefore, in view of the importance of allelochemicals ,it is necessary together knowledge regarding allelopathy.Various areas of allelopathy have already been identified althoughthere are lots of a research has still yet not been started (Batish *et al.*, 2007, Irving *et al.*, 1945 and Joens *et al.*, 1981.) There is a sufficient scope to do research on donor and receiver plants. Many approaches such as phenotypic characters, biotechnology, physiology, anatomy, plant source-sink relationship, nutrient availability, deficiency, ecology, environmental factor, soil physical and chemical charters and chemical analysis of the released Allelochemicals can be used for analysing and characterizing different chemicals which are derived from natural sources. Many plants, in particular rice, sunflower, sorghum, wheat, etc., and microorganisms have strong allelopathic potential, which may be used for managing diseases effectively. Nonetheless, special care is required in this regard to avoid any detrimental impact of the allelopathic phenomenon on agricultural systems. Thus we can say that to concern on this review the properties of allelochemicals of many crops are a better way to control diseases. It is non-toxic to our soil fertility and productivity by the means most advantageous to our sustainable agriculture.

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