“Allelopathy can be defined as an important mechanism of plant interference mediated by the addition of plant produced secondary products to the soil rhizosphere” (Weston 2005). These products are typically exuded into the soil profile and impact the growth of plants that are growing near the allelopathic species. Allelopathic species produce these compounds to reduce populations of other plant species that are directly competing for similar resources such as nutrients, sunlight, or water. Allelopathic compounds can show selectivity towards different plant species and can alter the composition of plant populations. Allelochemicals can be released in the soil by decomposition, root exudation, and volatilization of compounds by the allelopathic species. Allelopathy could be potentially used for weed control by producing and releasing allelochemicals from leaves, flowers, seeds, stems, and roots of living or decomposing plant materials (Weston, 1996).

Allelopathic species can also suppress weed or crop growth by direct competition for limited resources, thus cover crops are normally killed off before crop establishment to avoid competition with the crop. Recently agricultural research has looked at weed control using allelopathic crop residues. There is also interest in developing cultivars that produce higher amounts of these toxic compounds that suppress weed growth. Allelopathic cover crops would provide other benefits besides weed control in minimum or no tillage practices such as erosion prevention, moisture conservation (mulch), and improving soil productivity (Akemo et al., 2000).
Using a living allelopathic crop that is incorporated into crop rotations, and also using it as mulch have looked at allelopathic weed suppression. Studies have shown that when compared to other leguminous cover crops such as peas or hairy vetch, rye provides much better weed suppression which suggests that it is caused by a chemical interaction and is not solely due to direct competition. Allelopathic species weed suppression could provide us with another possible approach to integrated weed management especially in organic farming or minor use crops. Although, allelopathic species provide weed suppression, replacing herbicide use with allelopathic species is not a viable option for complete weed control in large-scale operations. If allelopathic species could be incorporated in certain cropping systems to provide weed suppression, this could reduce dependency on synthetic herbicides that are potentially hazardous to our environment.

**Historical Background of Allelopathy**

The earliest recorded observations of weed and crop allelopathy were by Theophrastus (300 BC) and Pliny II (1 AD). The term allelopathy was first introduced by Molisch (1937), which refers to chemical interactions among plants, including those mediated by microorganisms. Rice (1974) defined ‘allelopathy as any direct or indirect effect by one plant, including microorganism, on another through the production of chemical compounds that escape into the environment and subsequently influence the growth and development of neighbouring plants’. The complete review on allelopathy by Rice (1979) describes almost all aspects related to it. The use of the term “allelopathy “may therefore be somewhat controversial.
Chemicals found to inhibit the growth of a species at a certain concentrations may help stimulate the growth of the same species or another at a lower concentration (Rice, 1984; Putnam and Tang, 1986). Aldrich (1984) describes two types of allelopathy:

- **True type:** - The release into the environment of compounds that are toxic in the form in which they are produced.

- **Functional Type:** - The release into the environment of a substance that is toxic as the result of transformation by microorganisms.

The word allelopathy (root words: allelon and pathos) is derived from the Greek *allelon, ‘of each other’, and pathos, ‘to suffer’*; hence it means: the injurious effect of one upon another (Rizvi *et al.*, 1992). These compounds then come in contact with neighbouring plants, which can then stimulate, or more typically negatively impact the growth of these neighbouring plants. Although these compounds are not restricted to plant-plant interactions, they can also interact with other organisms. Lovett looked at allelopathy as the complex of subtle communications between plants and also between plants and other organisms (Einhellig, 1995). Allelopathic species can indirectly affect their growth rate by manipulating microbes in their surrounding rhizosphere, and altering the plant-microbe interaction. Biorational alternatives are gaining increased attention for weed control because of concerns related to pesticide usage and dwindling numbers of labeled products, particularly for minor use crops (Weston, 1996). In certain cropping situations allelopathy may have the potential to be integrated into a weed management plan in order to reduce the use of synthetic herbicides, as well as provide other
added benefits from the allelopathic crop. Allelopathic crops can be incorporated into weed
management plans as crop rotations, living mulches, or as residue cover crop.

---

**Review and Literature**

Genetic engineering could be a useful tool in order to create cultivars that produce greater
amounts of allelopathic compounds for weed suppression in agriculture. Pliny stated the nature
of some plants though not actually deadly is injurious owing to its blend of scents or of juice
(Albert, 2005). This statement shows that Pliny hypothesized how plants were releasing
chemicals that resulted in this interference. Although allelopathy does not always cause negative
effects to neighbouring plants, throughout history it was probably easier to observe negative
plant responses. De Candolle in the 1800’s was one of the first to perform research on toxic root
exudates from allelopathic species (Weston, 2005). Examples of allelopathy have shown up
throughout agricultural history, mainly by farmers that have observed the abnormal negative
impacts on crops that are grown with other certain species. The Romans described allelopathy as
a process resulting in the “Sickening” of the soil. (Weston 2005).

Willis (1985) suggested that six criteria be met, and even when maximally relaxed to just three,
proving allelopathy is rarely, if ever accomplished (Blum et al., 1999):

- Pattern of inhibition of one species by another.
- Putative aggressor must produce a toxin.
- Known mode of release of this toxin.
- Toxin transport or accumulation in the environment.
• Afflicted plants have means of uptake of toxin.

• Observed pattern of inhibition cannot be solely explained by physical competition or other biotic factors.

Review and Literature

Proof of Allelopathy

Many field studies implicate allelopathy, but isolation and identification of the chemical agents require a rigorous laboratory effort. It is extremely difficult to prove that any deleterious effect is due to allelopathy rather than to competition for essential products. Numerous studies have provided evidence, but seldom have a specific protocol be followed to achieve convincing proof (Putnam and Tang, 1986). These authors pointed out that shortcomings of the discipline make it hard to differentiate between allelopathy and competition. These shortcomings include:

✓ A general lack of nomenclature to adequately describe the plant responses that occur in this manner.

✓ A dearth of techniques to separate allelopathic interactions from competition.

✓ A failure to prove the existence of direct compared with indirect influences via other organisms /micro environmental modification.

✓ A considerable body of information has accumulated implicating allelopathy as an important form of plant interference.
According to Willis (1985), Putnam and Tang (1986) and Cheng (1992) the methodology dictates certain points for allelopathic research to be established to suggest that is operative. A pattern of inhibition one species by another must be shown using suitable controls, describing the symptoms and quantitative growth reductions; The putative aggressor plant must produce a toxin; There must be a mode of toxin release from the target plan;

**Review and Literature**

Mode of toxin transport or accumulation in the environment must be evident; The afflicted plants must have some means of toxin uptake, be exposed to the chemical in sufficient quantities and time to cause damage, and to notice similar symptoms. The observed pattern of inhibition should not be solely by physical factors or other biotic factors, especially competition. It is important to stress that the above points do not prove that allelopathy is operative, only that it offers the most reasonable explanation for the observed pattern. According to Cheng (1992), once the chemical enters the environment, a number of interacting processes will take place. These processes have identified as:

- **Retention:** - The related movement of the chemical from one location to another, through soil, water.

- **Transformation:** - The change in form or structure of the chemical, leading to partial change or total decomposition of the molecule;

- **Transport:** - Defines how the chemicals move in the environment.

Cheng (1992) also pointed out that these processes are influenced by the nature of the chemical, the organisms present, the properties of the soil, and environment conditions. The fate of the
chemicals depends on the kinetics and interactions of individual processes with time, at a particular site under a particular condition.

**Allelochemicals**

According to Putnam and Tang (1986) all alleged cases of allelopathy that have been studied appear to involve a complex of chemicals. No single phytotoxin was solely responsible for or produced as a result of interference by a neighbouring plant, Rizvi et al. (1992) pointed out that the subject not only deals with the gross biochemical interactions and their effects on the physiological processes but also with the mechanism of action of allelochemicals at specific sites of action at the molecular level.

Few studies on allelopathy, concentrate on the mechanism and processes, involved in the production of allelochemicals. Putnam and Tang (1986) and Einhellig (1987), raised question whether alleged biochemical agents were in sufficient concentrations and with enough persistence in the environment to affect a neighbouring or succeeding plant. These chemicals could be transformed during the course of extraction. According to Cheng (1992), allelopathic symptoms may not be manifested at the time or site of where plants damage has actually occurred. Allelopathy also may be one of several attributes, which enable a plant to establish in a new ecosystem (Callaway and Ascjempig, 2000; Callaway and Ridenour, 2004).
From the emanation of allelochemicals, plants can regulate the soil microbial community in their immediate vicinity, affect herbivory, encourage beneficial symbiosis, change the chemical and physical properties of the surrounding environment, and directly inhibit the growth of competing plant species (Pedrol et al., 2006). Allelopathic compounds play important roles in the determination of plant diversity, dominance, succession, and climax of natural vegetation and in the plant productivity of agro ecosystems.

Review and Literature

Sources of allelochemicals

According to Aldrich (1984), allelochemicals must be concentrated in the leaves, stem or roots than in the fruit or flowers. If it is concentrated in these organs it is likely that it could be available in time to interference with neighbouring plants. Rodosevich and Holt (1984) stated that the primary effect of allelopathy seems to result from an association with plant litter in or on the soil. Rice (1984) and Putnam (1985) reported that allelochemicals are present in virtually all plant tissue, i.e. leaves, fruit, stems, and roots. Leaves may be the most consistent source, while roots are considered to contain fewer and less potent toxins. According to them, there are four ways in which the chemicals are released: -

a) Volatilization: -
Release into the atmosphere It is only significant under arid or semi-arid conditions. The compounds may be absorbed in vapour by surrounding plants, be absorbed from condensate in dew or may reach the soil and be taken up by the roots (Muller, 1966). Kanchan (1975) reported that Parthenium hysterophorus also released the allelochemicals through volatiles. The genera, which release volatiles, are Artemisia, Salvia, Parthenium and Eucalyptus (Rice, 1984).

b) Leaching: -

Rainfall, dew or irrigation may pats of plants that are subsequently deposited on other plants; on the soil leaching also may occur through plant residues. Their solubility will affect their mobility in soil water.

Review and Literature

c) Root exudation: -

From plant roots into the soil environment. Whether these compounds are actively exuded, leaked or arise from the cells sloughing off the roots is not clearly understood at this time.

d) Decomposition of plant residues: -

It is difficult to determine whether toxic substance are contained in residues and simply released upon decomposition, or produced instead by microorganisms utilizing the residues.

Natural products identified as allelopathic agents

Alleged allelochemicals represent a myriad of chemicals compounds from simple hydrocarbons and aliphatic acid to complex polycyclic structures. More than 10,000 secondary metabolites in
plants are known to play an important role in allelopathy, which includes positive and negative effects (Bell and Koepepe, 1972; Rice, 1984; Waller, 1987; Lieble et al., 1992; Inderjit and Dakshini, 1995; Olofsdotter et al., 1995; Inderjit, 1996; Inderjit and Keating, 1999; Olofsdotter, 1998, 2001; Inderjit et al., 2000; Chung et al., 2003; Inderjit and Duke, 2003; Vasilakoglou et al., 2005, 2006; Dhima et al., 2006 a, b; Vaitor et al., 2006; Machado, 2007).

The secondary products could be classified in the following categories but it is possible to enumerate each and every chemical identified as an allelochemical Whittaker and Feeney (1971), Rice (1984), Putnam and Tang (1986) divided allelochemicals into various major chemical groups: -

**Review and Literature**

- Simple water-soluble organic acids.
- Simple unsaturated lactones.
- Long-chain fatty acids and polyacetylenes.
- Napthoquinone, anthroquinones and complex quinines.
- Simple phenols.
- Benzoic acid and derivatives.
- Cinnamic acid and derivatives.
- Flavonoids.
- Tannins.
Review and Literature

**Mechanisms of action of allelopathic Compounds**

Allelopathy involves the release of secondary metabolites that are termed allelochemicals. These compounds are biosynthetically produced but are not needed for the plants primary growth. Although, these compounds can affect plant growth indirectly by modifying the competition from other organisms including plants. “Many secondary metabolites found in plants have a role in defense against herbivores, pests and pathogens. The role of secondary metabolites in defense may involve deterrence/anti-feedant activity, toxicity or acting as precursors to physical defenses” (Inderjit and Keating, 1999).

The amount of different allelopathic compounds produced by plants is enormous. Like synthetic herbicides, these allelochemicals can show species selectivity and can be applied to neighbouring
plants by several mechanisms. Root exudation produces allelopathic compounds that are actively secreted directly into the soil rhizosphere by living root systems. The allelochemicals then move through the soil by diffusion and come into contact neighbouring plants. This creates a radius effect, where proximity to the allelopathic species results in greater concentrations of the allelochemical, which in turn typically decreases the growth of neighbouring plants. Compounds can also be leached off the roots and leaves into the soil profile by sufficient water application. Allelochemicals can also be given off though the air as volatile compounds, which can come into contact with neighbouring plants and cause different biological and physiological alterations.

“The diversity of allelochemicals produced by plants is vast, and the chemicals can range in structure from simple hydrocarbons to complex polycyclic aromatics”

Review and Literature

(Weaton, 1996). This variation in sizes and structures of the allelochemicals produced for allelopathy allow for these compounds to have varying modes of action or attack strategies, which dictates what type of physiological impact they will have on neighbouring plant species. How allelopathic compounds interact in the soil depends on the turnover rate of allelochemicals and how they interact with the clay, organic matter and other soil properties (Weaton, 2005).

Soil properties impact the movement of allelochemicals in the rhizosphere, which can alter their impact to neighbouring plants. These naturally produced secondary compounds can have chemical structures as complex as synthetic herbicides, they can also have the same wide range of selectivity and control for weeds. Knowing what species produce what type of allelopathic compounds is needed in order evaluate what pest species they will control. “Because all plant species produce a variety of organic compounds that may be released into the environment as
exudates, leachates, or volatiles, allelopathy may be a widespread phenomenon” (Lau, 2008). With the wide range of secondary metabolites that plants produce, as well as the variety of release mechanisms used to distribute these compounds, these combinations lead to numerous defense or attack strategies that allelopathic species can use.

Using tobacco Inderjit et al. (2009) showed the first report demonstrating that the natural release of a volatile chemical inhibits the growth of neighbouring siblings. Last, allelopathic crop residues can be used as mulch or a cover crop, which can release allelochemicals from their decaying plant tissues. These compounds are released from decaying plant matter and end up in the soil rhizosphere where they move by diffusion. With these few mechanisms presented above you can see the great variations that exist for dispersing allelopathic chemicals in different species. Having knowledge of these release mechanisms is crucial if we are to effectively utilize allelopathic compounds for weed control in agriculture. Along with having a variety of chemical release mechanisms, the number of different compounds that allelopathy can include is enormous.

The mode of action of a chemical can broadly be divided into a direct and an indirect action (Rizvi et al., 1992). Effects through the alternation of soil properties, nutritional status and an altered population or activity of microorganisms and nematodes represent the indirect action. The indirect action involves the biochemical on various important processes of plant growth and metabolism. Processes influenced by allelochemicals -

Review and Literature
- **Mineral uptake**: Allelochemicals can alter the rate at which ions are absorbed by plants. A reduction in both macro –and micronutrients are uncounted in the presence of phenolic acids (Rice, 1974).

- **Cytology and ultrastructure**: A variety of allelochemicals have been shown to inhibit mitosis in plant roots (Rice, 1974).

- **Phytohormones and balance**: The plant growth hormones indole acetic acid (IAA) and gibberellins. IAA is present in both active and inactive forms, and is inactivated by IAA-oxidase. IAA-oxidase is inhibited by various allelochemicals (Rice, 1974) other inhibitors block GA- induced extension growth.

- **Membranes and membrane permeability**: Many biological compounds exert their action through change in permeability of membranes. Exudation of compounds from roots on root slices have been used as an index of permeability because plant membranes are difficult to study (Harper and Balke, 1981).

- **Photosynthesis**: Photosynthetic inhibitors may be electron inhibitors or uncouples, energy-transfer inhibitors electron acceptors or a combination of the above (Einhellig and Rasmussen, 1979; Patterson, 1981).

- **Respiration**: Allelochemicals can stimulate or inhibit respiration both of which can be harmful to the energy producing process (Rice, 1974).
• **Protein synthesis**: - Studies utilizing radio labeled C14 sugars or amino acids and traced incorporation of the label into protein, found that allelochemicals inhibit protein synthesis (Rice, 1974)

• **Specific enzyme activity**: - Rice (1984) reported on a number of allelochemicals that inhibit the function of enzymes in the plant.

• Through conducting tissue (Rice, 1974).

• Maintaining Water relations (Rice, 1974).

• Through Genetic material (Aldrich, 1984; Rice, 1984).

Under natural conditions the action of allelochemicals seems to revolve round a fine tuned regulatory process in which many such compounds may act together on one or more of the above processes (Muller, 1966; Rizvi et al., 1992). Factors affecting production of allelochemicals according to the environmental conditions to which they are exposed. Stress has a marked effect on the production of allelochemicals. Allelopathy is strongly

_________________________

**Review and Literature**

coupled with other stresses of the crop environment, including insects and diseases, temperature extremes, nutrient and moisture variables, radiation and herbicides. These stress conditions often enhance allelochemicals production, thus increasing the potential for allelopathic interference (Einhellig, 1996).

According to Aldrich (1984) and Rice (1984), a variety of environmental conditions influence the variety of chemical produced:
- **Light stress:** - Some allelochemicals are influenced by the amount, intensity and duration of light. The greatest quantities are produced during exposure to ultraviolet and long day photoperiods. Thus, under story plants filter out the

- **Minerals stress:** - More allelochemicals are produced under conditions of mineral deficiency.

- **Drought stress:** - Under these conditions more allelochemicals are produced.

- **Temperature stress:** - In cooler temperatures, greater quantities are produce.
  
The location within the plant and effect in specific allelochemicals seems to be variable.

There are also numerous other factors influencing the production of allelochemicals. The type and age of plant tissue during extraction is important since compounds are not uniformly distributed in plants. Production differs between species as well as within species.

---

**Review and Literature**

**Aldrich (1984)** stated that environmental conditions that restrict growth tend to increase the production of allelochemicals. One could postulate that allelopathy may frequently be an accentuation of competition although not part of competition. It stress from competition increases the quantities of allelochemicals produced, it is conceivable that allelochemicals will inhibit the growth of some species and not others, there by reducing the ability of the affected species to complete. The allelopathy plant and those affected by them are part of the ecosystems. If one factor changes, changes will occur in one more factors. For example, light can be expected to interact with temperature and indirectly with soil moisture and other factors. Much of
evidence indicates that several chemicals are released together and may exert toxicities in an additive or synergistic manner. Sometimes the allelopathic effect will be obvious and asserting, but in the majority of cases the effects are stable and thus more difficult to access.

**Problems Studying Allelopathy**

When monitoring the influence of allelopathic compounds on other plants it is difficult to separate the impact caused from competition versus the impact due to allelopathic interactions. This predicament was known as early as 1983 when Fuerst and Putnam proposed that “proof of competitive interference includes:

(1) Identification of the symptoms of interference;

(2) Demonstration that the presence of the agent is correlated with reduced utilization of resources by the suspect;

(3) Demonstration of which resource(s) depleted by the agent are limiting resources; and

(4) Simulation of that interference (in the absence of the agent) by reduction of the supply of resources to levels that occur during interference

(5) Isolation, assay, characterization, and synthesis of the toxin;

(6) Simulation of the interference by supplying the toxin as it is supplied in nature; and
Quantification of the release, movement, and uptake of the toxin.

It would be desirable but not essential to show that the selectivity of the toxin to various species corresponds to the range of species affected by the allelopathic agent” (Fuerst and Putnam, 1983). From these lists of proofs for competition versus allelopathic interference you can see the problem with separating out these effects when conducting allelopathic research. “Allelopathy can play an important role in structuring plant communities, but allelopathic effects are often difficult to detect because many methods used to test for allelopathy can be confounded by experimental artifacts” (Lau et al., 2008). Lau and others describe how in allelopathic studies the use of activated carbon for neutralizing allelochemicals can actually affect nutrient availability and therefore impact plant growth. Finding proper techniques that can separate out chemical interference versus competition is the main dilemma when studying and evaluating the impact of allelopathic species.

Techniques and Methodology in Allelopathic Research

Kohli et al., (1993) developed a mathematical model to predict tissue response to parthenin, an allelochemicals produced by Parthenium weed. Thijs et al., (1994) developed an elegant experimental design to separate competition and allelopathic interactions. They grew a target plant with varying densities of neighbouring plants in a pot. They then applied a toxin, atrazine to the pots and harvested the plants after a month. Interestingly they found that target plants with increasing neighbour densities actually increased growth. Finally, great progress has been identified. Flux rates of allelochemical production in the field can now be studied by using ion exchange resins to extract nutrient from soil (Weidenhammer, 1996). Perhaps
unsurprisingly, there have be coincident changes in the flora of intensively managed arable farmland (Marshall, 2001; Marshall et al., 2001).

In association with the advances in agriculture, there is also evidence with farmland have shown marked reduction in range and population size over the past 30 years. Weeds are an important constraint on yield in most crops across the world. The global pesticide market was valued at $29 billion in 2000 (CPA, 2002) divided approximately between herbicides 48%, insecticides 27%, fungicides 19% and other products 6%. Improved crop management techniques including herbicides, have resulted in good control of weeds and have facilitated different cropping patterns and steadily increasing crop yields.

It is clear that some broad changes have occurred over the past 75 years in the arable plant communities. Allelopathy also plays an eminent role in the intra-specific and inter-specific competition and may determine the type of inter-specific association. Allelopathic potential has been reported for a number of weed species (Einhellig and Rasmussen, 1979; Shaukat et al., 1985; Ahmed and Wardle, 1994; Seigler, 1996; Burhan and Shaukat, 1999; Rebaz et al., 2001; Shaukat and Siddiqui, 2002; Kong et al., 2002 a, b; Tajuddin et al., 2002; Marshall et al., 2003; Shaukat et al., 2003; Golisz et al., 2008; Sharma et al., 2009).

______________________________
**Review and Literature**

A preliminary study has been made on systems engineering-based method for the evaluation of allelopathic potential in crops and its application by Sheng-peng and Yong-qing (2007).
Weeds Allelopathy and Agricultural Uses

Weeds are always considered as unwanted plants (Harlan and deWet, 1965). They compete with agricultural crops for nutrient, light and moisture and harbour many diseases and insects. There are many weed species that are allelopathic in nature. It is a viable weed management strategy but needs to be extensively studied under laboratory as well as in the field conditions. It is a natural and environment friendly technique, which may prove an effective strategy for weed management and thereby increase crop yields. In ancient Indian literatures, it is mentioned that every plant on this earth is useful for human beings, crops and animals. Weeds are one of the major problems in crop production around the world, and we are trending toward controlling these weeds with herbicides, which comes with increased environmental impact.

Cultural practices and chemicals control the weeds in wheat crop. Cultural practices are weather dependent, while chemicals are not environmentally safe (Kassasion, 1971) and may affect the nutritive value of some crops (Saghir and Bhatti, 1970). Putnam and Duke (1974) first explored the possibility of utilizing allelopathic crops to dominate or inhibit weed growth in agricultural sites. The effect of weeds on crops, crops on weeds and crops on crops, has invariably been emphasized (Klein and Miller, 1980). Weeds are enemies to the crop plants and have harmful effects on agricultural crops due to several factors such as competition for space, light and nutrients. The production of allelochemicals in crop plants and their release into the soil could influence the germination and growth of plant species (Rice, 1984).
According to Aldrich (1984), weeds interfere with crops in two ways:

- **Inhibiting germination and seedling establishment.**

- **Inhibiting growth of the crop.**

Back in 1982-84, Bhowmik and Doll saw that “the residue remains at the soil surface where it may modify the environment both physically and chemically during seed germination and plant growth”.

Organic chemicals released as leaf leachates, affect the crop plants. Weeds species are considered as rich source of secondary metabolites (Allelochemicals) and these chemicals improve a certain kind of environmental system on other plants growing in their vicinity and the phenomenon known as allelopathy (Nandal et al., 1994). At this point they even had the idea of incorporating allelopathic potential into crops as well as using them as rotational crops, cover crops, or intercropping them for weed control in agriculture. If we could find a way successfully integrate allelopathy into agriculture we could reduce our herbicide use as well as gaining other benefits from an allelopathic crop. “One common way that allelopathy may be utilized in weed management systems is through the manipulation of allelopathic cover crop residues in annual and perennial cropping systems” (Weston, 1996).

---

**Review and Literature**

Narwal (1994), the negative allelopathic effects on crops is used to develop green growth promoters. Most plants exhibit Allelopathic effects on seed germination, growth and development of other plants by releasing allelochemicals into the soil, either as exudates from
living organs or by decomposition of plant residues (Peters and Zam, 1981; Bansal, 1988; Smith and Martin, 1994; Narwal, 1999; Ahn and Chung, 2000; Sasikumar et al., 2001; Singh et al., 2003 a, b; Tawaha and Turk, 2003; Nouguchi and Ino, 2005; Singh et al., 2005 a, b; Sampietro and Vattuone, 2006; Bogatek et al., 2006; Batish et al., 2001, 2002a, b, 2006, 2007; Machado, 2007; Meksawat and Pornprom, 2010).

Multiple physiological effects have commonly been observed from treatments with many allelochemicals. The effects include decrease in plant height, absorption of water and mineral nutrients, ion uptake, leaf water potential, shoot turgor pressure, and osmotic potential, dry matter production, leaf area expansion, photosynthesis, chlorophyll accumulation, protein synthesis, reduction in stomatal aperture etc., in different plants (Einhellig and Kaun, 1971; Datta and Roy, 1973, 1975; Patterson, 1981; Bhowmik and Doll, 1982, 1984; Einhellig et al., 1970, 1985; Gerald et al., 1992; Inderjit, 2001; Singh and Thaper, 2002; Inderjit and Duke, 2003; Verma and Rao, 2006; Sisodia and Siddiqui, 2009; Chou, 2010).

Results obtained so far clearly demonstrate that some of the findings on allelopathic control of weeds, elimination of deleterious allelopathic effects of crops on crops, or exploitation of beneficial interactions in a rotation or mixed cropping system have an effect on seed germination, seedling growth and a direct bearing on crop production (Stoller, et al., 1979; Rizvi, et al., 1992; Qasem, 1993, 1995, 2001; Mehboob et al., 2000; Ebana et al., 2001;)

**Review and Literature**

Gniazdowska and Bogatek, 2005; Hegab et al., 2008; Kamal and Bano, 2008).
The only need is to identify of its uses. We can consider the weeds are useful plants. Many studies conducted at Department of Agronomy, Indira Gandhi Agricultural University, Raipur (India) have clearly revealed that stimulatory allelopathic effects of weeds on crops can be utilized successfully for higher production (Oudhia, 1996 and Lal and Oudhia, 1999). Weeds compete for light, nutrients, moisture and space with the crop and thus cause severe losses to yield. Losses in wheat due to range 17-25% (Shad, 1987) and in monetary terms it may be as high as Rs.28 billions (Hassan and Marwat, 2001). These effects are selective, depending upon the concentrations and residue type, either inhibitory or stimulatory to the growth of companion or subsequent crops or weeds (Kimber, 1973; Hall et al., 1982; Bhowmik and Doll, 1984; Einhellig et al., 1985; Purvis et al., 1985; Cheema, 1988; Khan and Vaishya, 1992; Naseem, 1997; Naseem et al., 2003; Cheema et al., 2004; Jalili et al., 2007).

Sorghum is known to exude Sorgoleone an allelochemical from its living root system, which helps it out compete neighbouring weed species (Bertin, 2007). One mechanism explaining the success of invasive weeds may be the production and release of allelopathic compounds by the invader that due to a lack of co-evolutionary history, have effects on plant neighbours in the introduced range (Abhilasha et al, 2008).

In ancient Indian literatures, it is mentioned that every plant on this earth is useful for human beings, crops and animals. Allelopathy may be used as a tool in weed management by applying the residues of allelopathic weeds or crop plants as mulches, growing them in

Review and Literature
successions and leaving their residues in the field (Altieri and Doll, 1978; Drost and Doll, 1980; Putnam and DeFrank, 1979). Allelopathy is a novel approach to keep the environment safe and to develop sustainable agriculture (Yongqing, 2005). Among the various alternatives, use of natural plant products, offers a new approach for the management of noxious weeds and pests in a sustainable manner.

Many Compositae (Asteraceae) plants have allelopathic potentials and the activities and types and amounts (Chon and Nelson, 2010; Ilori et al., 2010). Differential effects of aqueous extracts of many members of Asteraceae have been studied by many workers (Stachon and Zindel, 1980; Schon and Einhellig, 1982; Eze and Gill, 1992; Inderjit and Dakshini, 1995; Ratwat et al., 2002; Chon et al., 2003; Bogatek et al., 2006; Mulatu et al., 2006; Batish et al., 2007; Ilori et al., 2007; Javed and Asghari, 2008; Javaid et al., 2009).

*Parthenium hysterophorus* L., a somewhat unattractive and an aggressive weed member of the Compositae (Asteraceae) native to Southern North America, Central America, The West Indies and Central South America (Picman and Picman, 1984), within the last hundred years, has found its way to Africa, Australia to Asia. It has changed native habitat in Australian grasslands, open woodlands, riverbanks and floodplains (McFadyen, 1992; Chippendale and Panetta, 1994). It is considered as one of the noxious weeds of Australia (Haseler, 1976; Persons and Cuthbertson, 1992; Stephen and Sowerby, 1996; Adkins et al., 1997). It is commonly known as carrot weed, white top, chatak chandani Congress grass, star weed, etc.

---

**Review and Literature**
As an exotic weed, it accidentally introduced in India in 1955, through the imported food grains (Rao, 1956) but the earliest record of this species goes back to 1814 by William Roxburgh, ‘the father of Indian Botany’ (Paul, 2010). Since 1956, the weed has spread like wildfire throughout India. \textit{P. hysterophorus} due to its invasive capacity destroyed its natural ecosystems In national wildlife parks southern of India its invasiveness have been observed (Evans, 1997).

\textit{Parthenium} is an aggressive weed and therefore poses a serious threat to the environment and biodiversity owing to its high invasion and allelopathic effect, which has the capacity to rapidly replace the native vegetation (Pandey \textit{et al.}, 1993). Many efforts are being made to control the growth or to eradicate this weed by different researches (Jayachandra, 1971; Rajulu \textit{et al.}, 1976; Francis, 1978; Rajendrudu and Rama Das, 1981; Singh, 1983; Syamasundar and Mahadevappa, 1986; Jayanth, 1986; McClay, 1987; Joshi, 1991, 2006; Mahadevappa, 1997; Evans, 1997; Dhileepan and McFadyen, 2001; Goyal and Brahma, 2001; Tamado and Milberg, 2002, 2004).

The aqueous foliar extracts of some trees and other herbs were used to check the germination and seedling growth of Parthenium (Dhawan and Dhawan, 1995; Sankaran \textit{et al.}, 1996; Sharma, 2003). The allelopathic effects of Amaranthus viridis to suppress the growth of \textit{Parthenium hysterophorus} have been studied (Athanassova, 1996; Thapar and Singh, 2003). Seed germination of Parthenium was inhibited by leaf leachates of \textit{Azadirachta indica} and latex of \textit{Calotropis procera} (Goyal and Singh, 2003). The survey conducted in India by Wahab (2005) has shown that species like \textit{Cassia sericea}, \textit{Cassia tora}, \textit{Cassia auriculata}, \textit{Croton bonplandianum}, \textit{Amaranthus spinosus}, \textit{Tephrosia}
*purpurea, Hyptis suaveolens, Sida spinosa* and *Mirabilis jalapa* could suppresses Parthenium in natural habitats.

The effects of Parthenium on different plants can be discussed under the following heads:

- Regulation of growth with Parthenium extracts
- Regulation of productivity with Parthenium extracts
- Biochemical regulation with Parthenium extracts
- Response of crops to Parthenium compost
- Biocontrol value
- Green manure value
- Soil amendment value
- Biocidal value
- Human Sensitivity

**Regulation of growth with Parthenium extract**

Further, Rice (1974) observed that many species of weeds produce toxins that are inhibitory to other weeds and often to themselves. Pandey et al. (1993) reported that Parthenium suppress the associated species, through the release of allelochemicals from
Review and Literature

decomposing biomass and root exudates. Parthenium competes directly with pasture species, reducing pasture vigour and seed set leading to habitat and ecosystem change (Evans 1997; O’Donnell and Adkins 2005; Shabbir and Bajwa 2006). Based on a study conducted in the rangelands of Northern Himalayas (India), Kohli et al. (2004) found that invasion by Parthenium, significantly decreased species richness in the invaded areas. Parthenium have allelopathic effect on neighbouring flora by which it is capable to replace most of the associated herbaceous species (Yadav and Chauhan, 1998; Sinha and Deo, 1999; Bhowmik et al., 2007). With the increasing concentration of Parthenium extracts the seed germination and growth of Eragrostis decreased significantly (Tefera, 2002). In similar ways, studies in Australia and India have also demonstrated that Parthenium adversely affects the composition and diversity of species thereby resulting displacement and imbalance in natural and agricultural system (McFadyen, 1992; Chippendale and Panetta, 1994; Sakai et al., 2001; Grice, 2006). It has been reported that the forage production of Indian croplands and grasslands was reduced by 40% and 90%, respectively due to the invasion of this weed (Khosla and Sobti, 1981).

Negative allelopathic effects of Parthenium on cultivated plants (e.g. Brassica campestris, B. oleracea and B. rapa, Glycine max, Lolium multiflorum, Oryza sativa, Phaseolus vulgaris, Raphanus sativus, Cicer arietinum, Triticum aestivum, Vigna 26 radiata and Zea mays) have been well documented (Hussain and Abidi, 1991; Kil & Yun, 1992; Bajwa et al., 1998; Yadav and Chauhan, 1998; Sinha and Deo, 1999; Oudhia, 2000 a, b; Batish et al., 2002 a, b, c, 2005; Singh et al., 2003 a, b; Singh et al., 2005 a, b; Paudel, 2007; Maharajan et al., 2007). In agriculture, the inhibitory effect of weed species on
germination and growth of crops has been attributed to phytotoxic chemicals released from the leaf litter and roots. In this context, a study was undertaken to elucidate the effects of few common weed species on germination behaviour, root and shoot growth of some of the paddy crops (Krishna et al., 2007). Plant extracts have exhibited inhibitory effect on germination of BPT -5204, while they have not influenced the germination of coarse varieties (9926 and Abhilash).

Srivastava et al. (1985) reported that that aqueous extracts of leaves and inflorescences inhibited the germination and seedling growth of barley, wheat and peas. Kohli et al. (1985) suggested that two allelochemicals acting synergistically were responsible for the significant decrease in seed germination and subsequent growth of cabbage, when placed in leaf and inflorescence leachates from Parthenium weed. Patil and Hedge (1988) isolated and purified parthenin from leaves P. hysterophorus and demonstrated that this compound significantly decreased the germination of wheat seeds and adversely affected seedling growth. Nath (1988) studied the effect of Parthenium extract on germination and seedling growth of crops.

The inhibitory effects of Parthenium., on germination of many crops have been reported (Narwal, 1994). Effect of Parthenium (Mehta et al., 1995); okra, chilli peppers and clover (Dhawan and Dhawan, 1995), have demonstrated that the germination and yields of traditional Indian pulse crops (guar, black and green gram) were reduced when these were grown in soils previously infested by Parthenium weed. An experiment conducted on allelopathic effect of Parthenium leaf extract on sunflower and sorghum revealed that the germination percentage, shoot and root length, dry weight and vigour index decreased with an increase in the concentration of Parthenium leaf extract from one to 10% (Murthy et
Similar results showed with allelopathic effects on germination and seedling vigour of Kodo (Oudhia and Tripathi, 1998).

Swaminathan et al., (1989) in their studies also observed the positive effect of leaf extracts on radical growth. The allelopathic effects have been shown with foliar leachates of *P. hysterophorus* on a diverse range of agricultural and tree crops: cowpea, sunflower, *Casuarina, Acacia, Eucalyptus* and *Leucaena* (Swaminathan et al., 1990); rice, wheat, black gram and chickpeas (Singh and Sangeeta, 1991); green gram and wheat (Agarwal and Anand, 1992); barley and *Cassia tora* (Singh and Rizvi, 1992), mung beans and guar (Kohli and Rani, 1992); various species of Indian forage crops, pulses and oil seeds (Aggarwal and Kohli, 1992); sorghum (Ayala et al., 1994); maize, ragi (*Eleusine oracana*) and soybeans (Bhatt et al., 1994); sunflower, french beans and cotton (Madhu et al., 1995). The Parthenium inhibit the germination and growth of plants including pasture grasses, cereals, vegetables, and other plant species (Navie et al., 1996; Evans, 1997). Similarly, The effects of different parts of Parthenium extract itself enhanced the nutrients, elevated photosynthesis, biomass and yield in several agricultural crops (Ramaswami, 1997; Khalid, 2000; Park et al., 2003).

In different studies, it was noticed that species varied considerably in their sensitivity to aqueous extracts of Parthenium for both root growth and germination (Belz et al., 2007; Rashid et al., 2008). In India the weed was found to invade the agriculture lands of sugarcane, vegetable crops field and even rice fields (Singh et al. 2004). The presence of Parthenium was reduced pasture production by excluding beneficial forage plants, resulting in a monoculture (Anonymous 2004). Tismina (2007) reported that *Trifolium repens*,

**Review and Literature**
Review and Literature

*Imperata sp.*, *Chrysopogon aciculatus*, *Sporobolus sp.* and *Dactyloctenium 24 aegypticum* were affected by Parthenium invasion, but she reported increase in species richness by Parthenium invasion. *Euphorbia hirta* was reported in good proportion in high Parthenium invaded site than the other sites (Ayele, 2007). Wegari (2008) declared that *Chrysopogon aucheri* and *Cynodon dactylon* could out-compete the growth of Parthenium.

In pot experiment, shoot growth in terms of shoot length and biomass production was markedly suppressed by aqueous extract of Parthenium in different test species (Hsu *et al.*, 1989; Lawerence *et al.*, 1991). Hussain and Abidi (1991) have also reported similar reduction in root growth of *Dicanthium annulatum*, *Chrysopogon montanus* and *Medicago polymorpha* by the *Imperata cylindrica*. The reduced root and shoot growth under the allelopathic resulted in declined capitulum’s diameter and biomass sunflower test. These observations are also supported by the findings of Afzal *et al.* (2000), who reported that root growth of *Vigna radiata* and *Phaseolus vulgaris*, both in terms of length and biomass production, was significantly reduced by aqueous shoot extract of *Imperata cylindrica*, at all the growth stages.

Kanchan and Jayachandra (1979) reported that the air dried plants of *P. hysterophorus* L. such as the dry leaves mixed to the soil inhibit nodulation and growth in legumes (ragi bean and cowpea), branching in tomato up to 30% but have stimulatory effect on bajra (*Pennisetum typhodieum*) Rich C.V.H.B.I. Tamado (2001) found out that 90% of the interviewed farmers rank *Parthenium* weed as the most serious problem both in rangeland and crop lands. *Parthenium* exerts strong allelopathic effect and reduces the growth and reproductively of
associated crops. It does these by releasing phytotoxins from its decomposing biomass and root exudates in soil. Bioassay, pot culture and field studies have revealed that all plant parts (shoot, root, inflorescence and seed) are toxic to plants (Yaduraju et al., 2005). The reduced shoot growth under the allelopathic stress may also be attributed to reduced root growth. Root length as well as root fresh and dry weight of test species was significantly suppressed by aqueous shoot extract of P. hysterophorus.

Pandey (1994) reported that the relative effects plant residue on growth of Salvinia and paddy seedlings. The leaf growth responses of Parthenium treated plant in relation to number; thickness and weight, etc. were also altered with alternation in doses. Pandey et al. (1993) have reported the treatment drastically reduced the number of healthy leaves of Eichhornia crassipes.

**Regulation of productivity with Parthenium extracts**

Parthenium extracts can reduce up to 40% in yield (Swaminathan et al., 1990). Kohli and Batish (1994) have demonstrated that the germination and yields of traditional Indian pulse crops (guar, black, and green gram) were reduced, when these were grown in soils previously covered by Parthenium. The competitive ability of Parthenium weed was studied by, Channappagoudar et al. (1990), in irrigated sorghum in India. They found that the presence of Parthenium reduced grain yields from 6.47 to 4.25 tons/ hectare and decreased grain weight by almost 30%. Cryptic factor, which can influence crop yields, is thus even more difficult to quantify than direct competition and much of evidence, such as reduction of grain filling in

Review and Literature

Artificial dusting of pollen on the stigmatic surface of vegetables crops inhibits fruit development in brinjal, tomato and chilies (Paprica). There was a 40% reduction in grain filling in maize by 100-150 clusters of the pollen. Parthenium hysterophorus, which is present in Kenya, Uganda, Tanzania, South Africa, Mozambique, and Swaziland is currently considered to be the most important weed both in croplands and grazing areas by 90% of farmers in the lowlands of Ethiopia (Tamado and Milberg, 2000). Sorghum yields being reduced by 97% in experimental fields with high densities of Parthenium (Tamado et al., 2002). The impact of Parthenium has also been well documented in Australia and India (Evans, 1997) where studies have revealed that Parthenium is allelopathic and that infestations reduce crop yields and that the weed displaces palatable species in natural and improved pasture (Channappagoudar et al., 1990).

Regulation of biochemical with Parthenium extract

In relation to the reduction of chlorophyll contents in the leaves, Kumari et al. (1985) showed that chlorophyll content was markedly reduced, when leaf leachates were sprayed directly sprayed on crop plants. The reduction in chlorophyll content was also observed by Suresh and Rai (1987) in tree plants and Jayakumar et al. (1990) in groundnut and corn, under allelochemicals. Above 0.50% (w/v) dry leaf powder treatment caused reduction of chlorophyll
contents in the leaves. *Pandey et al.* (1993) reported that the allelopathic effect of Parthenium leaf residue on water hyacinth was studied. *Pandey* (1994) stated total chlorophyll and carotenoid pigments in the leaves of the paddy seedlings grown in the medium were comparable to the amounts in the leaves of seedlings grown in distilled water. This demonstrated beneficial effects of the treatments. *Batish et al.* (2002) suggested that

---

**Review and Literature**

with 500 µm parthenin treatment chlorophyll content was reduced by nearly 70% in *Amaranthus viridis*, whereas nearly 80% reduction was observed for *Chenopodium murale* (P< 0.01).

*Singh et al.* (2002) reported that the content of photosynthetic pigment, chlorophyll was appreciably reduced in the leaves of test plants spray treated with parthenin at 200µm concentration. However, this inhibitory effect declined with the passage of time and 10 days after treatment, only at 25% reduction in chlorophyll content was observed, compared to 76% on the first day after spray. Likewise, the cellular respiration measured through 2, 3, 5-triphenyl-tetrazolium chloride was found to be less in the treated leaves and inhibitory responses also declined with time. The aqueous extracts of different parts of Parthenium significantly reduced the chlorophyll content in mustard plants (*Thakur and Siddiqui, 2003*). They observed that even 10% of Leaf extract of Parthenium was inhibitory for chlorophyll content in mustard. The reduction in chlorophyll also reported in target species by *Einhellig and Rasmussen, (1979)*; *Daizy and Kohli, (1991)*; *Baziramakenga et al., (1994)*; *Dayan et al., (1999)*; *Romgani et al., (2000)*; *Singh et al., (2002)*.

In relation to sugar content it has been stated that Parthenin (Sesquiterpene lactone) altered this physiological change by reducing the sugar content in *Ageratum conyzoides* (*Singh et al., 2002*).
Pandey et al. (1993) have obtained those macromolecules: protein, lipid and nucleic acid resulting in root dysfunction and other inhibitory activities in the root. Picman (1986) pointed out that parthenin, like other sesquiterpenes, may bind to sulfhydryl bonds of amino acids and proteins and cause irreversible alkylation of key enzymes, thereby impairing general metabolism and causing growth inhibition.

---

**Review and Literature**

**Effect of Parthenium Compost on Crop**

It is reported that increasing availability of nitrogen, phosphorus, potassium and sulphur in soil when integrated application composted Parthenium (Gupta et al., 1986). Ramaswami (1997), Tamil Nadu Agricultural University, Coimbatore stated that field experiments were conducted with rice followed by soybean and maize followed by cowpea using the composts prepared out of different organic wastes. All the organic waste composts including Parthenium enhanced organic status of the soil indicating beneficial effect of incorporation of wastes. The highest increase was to the extent of 22.6 and 20.8 percent over NPK alone due to application of composted Parthenium at flowering and harvest stages, respectively. Among the treatments, Parthenium compost recorded higher available soil N at post harvest stage. This could be attributed to the higher N content of Parthenium compost than other composts from organic wastes. All the organic waste composts recorded higher grain yield of rice as main crops over NPK alone. Similarly, all the organic waste composts recorded the highest yield of 1917 Kg per ha and 1285 kg per ha, respectively, as compared to other organic waste composts and application of NPK alone. This residual effect of Parthenium can be exploited for beneficial use.
Kishor et al., (2010) reported that the application of 100% N through composted Parthenium resulted in significant reduction in plant height, tillers and root volume of plant and ultimately grain and straw yield of wheat. Oudhia et al. (1997 a, b) studied the integrated use of 50% recommended dose of N through each of urea and composted Parthenium along with *Azotobacter chroococcum*, which was beneficial to target higher yield of wheat. Inoculation of *Azotobacter chroococcum* produced 33-130 % more volume of roots as compared to its corresponding uninoculated treatment indicating synergistic effect of composted Parthenium on activity of organophilic *A. chroococcum*. Clearly showed that integrated use of Parthenium compost and *Azotobacter* increased nitrogen phosphorus, potassium and sulphur acquisition in wheat than urea and Parthenium compost. The maximum uptake N (0.67 g pot-1), P (0.16 g pot-1), K (0.68 g pot-1) and S (0.22 g pot-1) were recorded with treatments T7, where 50% N through each of urea and composted Parthenium were applied with *Azotobacter*.

**Biocontrol value**

The weed population in rice field was influenced by the incorporation of composted organic wastes. Sudhakar (1984) reported the reduction in weed population with *Parthenium*, in rice fields. Among the treatments, the composted coir pith and *Parthenium* recorded lower weed population. The application of organic waste composts reduced the weed count from 30.5 to 39.8 percent over NPK at 60 DAT (Days After Treatment). This could be attributed to the role of allelopathic compounds such as phenol present in this two-plant debris even after composting.
Son (1995). Among different comports, coir pith and Parthenium compost recorded lower weed population in maize. The beneficial effect of organic wastes in reducing the incidence of pests such as stem borer and leaf roller was observed due to the application of organic comports. Generally, under incorporation of organic wastes, the reduction in pest incidence was to the extent of 43.4 to 50 percent at 60 DAT as compared to NPK alone, Son (1995). Incidence of leaf roller in rice crop was the highest with urea application.

________________________________________________

Review and Literature

Soil Amendment Value

Any organic waste application aids in moisture conservation, which is utilized for better root penetration and crop growth. In general, incorporation of organic wastes enhanced the moisture content of the soil to the tune of 45.5 to 77.4% as compared to application of NPK alone to maize crop (Son, 1995). This enhancement could be attributed to the higher water holding capacity of the soil due to the influence of organic waste application. The moisture in soil due to application of Parthenium compost was 14.5 and 16.5% at 0-15 and 15-30 cm depths as compared to 10.7 and 11.6% at 0-15 and 15-30 cm depths of soil due to application of NPK alone. This may be due to building up of organic carbon status in soil. This behaviour can be well utilized for moisture conservation practices. Parthenium is causing change in vegetation that ultimately results in changing soil characteristics (Daubenmire, 1974; Qureshi et al., 2006).
Green manure value

For the main crop of rice, the effect of Parthenium green leaf manure on plant height was comparatively less as compared to other green manures like leucaena and sunnhemp. Whereas, in the ratoon rice crop, Parthenium green leaf manure was superior in influencing the plant height (Sudhakar, 1984). Similarly in the main crop, Parthenium green leaf manure produced less number of filled grains while it produced the highest number of filled grains in the ratoon crop. Among the green leaf manures tried, the residual effect for dry matter production was the highest with Parthenium.

Biocidal value

The latest thinking includes, allelopathy to both harmful and beneficial interactions between the plants (Rizvi et al., 1992). Allelochemicals, which inhibited the growth of some species at certain concentration may stimulate, the growth of same or different species at lower concentration (Narwal, 1994; Narwal et al., 2003). Positive allelopathic effects of many weed on other can be exploited to develop ecofriendly cheap and effective “green herbicides containing green allelochemicals” are an integral part of eco or organic farming (Oudhia and Tripathi, 1999; Macias et al., 2001; Batish et al. 1997, 2002; Javaid and Anjum, 2006; Batish et al., 2007). Use of natural compounds as herbicides or as chemical basis for the development of new herbicides offers several advantages:
• The wide array of phytotoxic compounds produced by plant provides many complex chemical structures that are unlikely to be discovered in the traditional synthetic strategies used by pesticide companies.

• Degradation of natural compounds in the environment proceeds faster than that of synthetic compound and thus, reduces the environment pollution.

Parthenium hysterophorus extracts significantly inhibited the seed germination of weed, *Eragrostis tef* (Tefera, 2002) due to released of phytotoxins from Parthenium leaves (Stephen and Sowerby, 1996). Seed germination of *Lepidium pinnatifidum*, weed was more prone to higher concentration of Parthenium extracts where there was no germination at Parthenium concentration of 30 g L$^{-1}$. Species-specific differences in the sensitivity to aqueous extracts of fresh or dry leaf material of Parthenium, were reported by Mersie and Singh (1987). Marwat et al., (2008) reported that pre-emergence application of Parthenium extracts was more effective compared to post-emergence application. These results suggested that higher concentration of Parthenium retard the growth of plants which might be due to inhibition of cell division as allelopathic chemicals have been found to inhibit gibberellin and indole acetic acid function (Tomaszewski and Thimann, 1966). Parthenin is among other inhibitors relevant for residue allelopathy as simulated under laboratory conditions by delaying germination and reducing plant growth (Belz et al., 2007).

The application of organic waste composts reduced the weed count from 30.5 to 39.8% over NPK at 60 DAT. Among the different composts, coir pith and Parthenium compost recorded
lower weed population in maize. The beneficial effect of organic wastes in reducing the incidence of pests such as stem borer and leaf roller was observed due to the application of organic waste composts. Generally under incorporation of organic wastes, the reduction in pest incidence was to the extent of 43.4 to 50% at 60 DAT as compared to NPK alone (Son, 1995). Incidence of leaf roller in rice crop was the highest with urea application, whereas it was the lowest with Parthenium as green leaf manure application (Sudhakar, 1984). Parthenium is used as an additive with cattle manure in biogas production (Gunaseelan, 1987). Sharma and Bhutani (1988) studied the amoebicidal activity of parthenin from Parthenium. It is used as potential source of herbicide, fungicide and nematicide (Hasan and Jain, 1984; Bano et al., 1986; Ramaswami, 1997; Duke et al., 2000, 2005; Bajwa et al., 2003; Sharma, 2003; Marwat et al., 2008). It has been observed to also have pesticidal and nematicidal properties (Datta and Saxena, 2001).

Review and Literature

Sesquiterpene lactones are one of the very important groups of natural plant products known for their biological activities, including allelopathic properties (Macias et al., 2001). Little has been done to explore their herbicidal potential, although there have been some studies (Batish et al. 1997, 2002; Macias et al., 2001). Among sesquiterpene lactones, parthenin is a natural component of Parthenium hysterophorus known for its phytotoxicity towards other plants including aquatic species (Megharaj et al., 1987; Pandey 1996; Batish et al., 1997, 2002) Recently, it has been observed to also possess pesticidal and nematicidal properties (Datta and Saxena 2001).


**Human sensitivity**

Studies have shown also that those who came into contact with Parthenium weed can develop allergic eczematous contact dermatitis. It also causes mental depression (Oudhia and Tripathi, 1998). Parthenium weed is also known to have caused human health problem like asthma, bronchitis, dermatitis, and hay fever (Srirama et al., 1991; Hosmani, 1995; Kololgi et al., 1997). The mild dermatitis can be treated with topical corticosteroids. However, moderate to severe dermatitis, 15 particularly airborne contact dermatitis require systematic corticosteroids and other immuno-suppressive drugs (Verma et al., 2001). Another widespread allergic reaction of Parthenium is allergic rhinitis, or hay fever. This is caused by the presence of its pollen grains in the air (Rao et al., 1985).

For instance, Mangla et al. (1981) have reported that in areas that were infested with the weed, almost 44% of the pollen load in the atmosphere during the months of June to September was derived from Parthenium. The inhalation of the pollen of the weed can cause allergic trinities and speeds up the development of bronchitis or asthma if the pollen enters the respiratory tracts during mouth breathing (Evans, 1997). The weed of Parthenium is the causative agent of many other reactive toxic classes of compounds known as sesquiterpene lactones (Towers, 1981). There has been an epidemic cause of Parthenium weed dermatitis in India and several USA (Subba Rao et al., 1976; Towers, 1981). In Australia, many individuals were affected by dermatitis though human population density in the Parthenium affected area
(McFadyen, 1992). Other reports revealed that respiratory problems usually start with high fever and then gradually progress to asthma and allergic bronchitis after 3-5 years are increasing. McFadyen (1992) indicates that about 15% of individuals regularly exposed to Parthenium plant would develop the dermatitis and another 7-15% develop respiratory problem. Affected individuals have no alternative except leaving the area. In Ethiopia, it was reported that individuals who remove Parthenium with hands in infested crops suffer from dermal allergy, fever, and asthma (Taye, 2002). The survey undertaken in Central Queensland demonstrated that individuals sensitized to Parthenium were found to have a greater economic outlay to treat the effects of allergy symptoms than none sensitized residents in the same area. Seventy seven percent of individuals sensitive to Parthenium weed spent up to $40 per month for medication to help treat their allergy symptoms considerably more than those who are non-sensitized in the study (Goldsworthy, 2005).

Parthenium has high sensitizing potential. As much as, 56% of occupationally exposed persons were found sensitive to this weed, although not manifesting apparent dermatitis (Mahajan et al., 2004). Direct or indirect contact sensitization is also possible in view of the widespread growth of the weed (Paulsen, 1992). Sensitization occurs more frequently during the weed’s growing season, when there is little dust and detritus of plants left (Guin, 1989). Mahajan et al., (2004) reported that a Parthenium patch-test-positive patient showing widespread dermatitis of non-airborne contact dermatitis improved when moved to a Parthenium-free area.
Some weeds, which were earlier susceptible, are now herbicide resistant (Ahmad, 1996). The *P. hysterophorus* become a widespread weed in the zone of U.P. Presently the weed is a major problem in the agriculture filed. The species start their growth before rainy season and cover whole area of agriculture field, which suppressed the growth of other herbaceous vegetation also. Before Kharif crop *P. hysterophorus* remain covered with their peak growth in agricultural land. People through ploughing in agriculture uproot *P. hysterophorus* collect and burned in the agriculture filed. The large-scale burned ash of *P. hysterophorus* remained with the sown crop in the agriculture filed.

**Nodulation**

Nitrogen is an essential constituent of all living organisms. There exists a virtually unlimited (3.9 X 10^{15} metric tonnes and only 2.0% of the total N on earth) source of nitrogen in the atmosphere. It constitutes about 78% of the total gaseous atmosphere. Nitrogen status in the atmosphere is as a result of a number of functions like nitrogen fixation, microbial decomposition, nitrification and dentrifications. Biologically nitrogen fixation is not a characteristic of all plants, but is almost haphazardly distributed through a broad spectrum of microorganisms, belonging to prokaryotes (Bacteria and related groups).

**Review and Literature**

Legumes are dependent for their nitrogen availability on their ability to fix nitrogen symbiotically. The total amount of nitrogen fixed by legumes has been estimated to 14-35 metric tonnes/year. The nitrogen fixation by legumes was proved more than 100 years ago (Hellriegel and Wilfarth, 1998). This capability to fix nitrogen is because of their ability to associate with
nitrogen fixing organisms in the form of root nodules structures. In 1888, Beijerinck first isolated the nodules bacteria. In 1932, Fred, Baldwin and McCoy published their monograph. Who collected, reviewed and analysis the existing information on legume-symbiosis. Leguminous root nodules, a type of abnormal but highly organized growth, are often considered an organ suigeneris (Libbenga and Bogers, 1974).

Nodulation usually occurs in the field after the unfolding of the first leaf and nodule life is limited. The morphogenesis of root nodules is accomplished through a series of processes as follows-

i. Infection of the host root cell by Rhizobium.

ii. Development of infection thread into cortex tissue of the host.

iii. Proliferation of cortex tissue to form a nodule.

iv. Deposition of Rhizobia into the host cell and the formation of membrane envelope.

v. Differentiation of Rhizobia to the bacteriods state.

Nitrogen fixing soil bacteria, collectively known as Rhizobia, can establish a symbiotic partnership with legumes, which leads to the development of a new plant organ called a root nodule (Heidstra and Bisseling 1996; Downie and Walker 1999).

Review and Literature

The molecular dialogue between the correct species governs the initiation of a nodule or bio-var of Rhizobia audits appropriate plant host (Long 1996). Nodulation is an ecologically and economically important plant phenomenon, in which the symbiosis is between plants from the
family Fabaceae and *Rhizobium* results in the development of nitrogen fixing nodules on the roots of the host plant. In this organ, the bacteria differentiate into bacteroids, fix nitrogen for the plant host and in return are provided carbon by the host plant (*Crespi and Galvez, 2000; Hirsch et al., 2001*).

Formation of the nodules requires cross talk between plant and bacterial partner and this determines the host specificity. Plants secrete iso-flavonoids that induce the biosynthesis of bacterial lipochito-oligosaccharide which are called No factors (*Heidstra and Bisseling, 1996; Kistner and Parniske, 2002*). This rhizobial nodulation signal i.e. Nod factor, initiates a cascade of events leading to the development of the nodule primordium followed by entry of bacteria into the nodule primordium via root hair cells (*Gage and Margolin, 2000*). Once the bacteria inhabit nodules (*Long, 1996*), the bacteria and the plant cooperate in fixation and assimilation of atmospheric nitrogen.

Nodules are of two different types: **Indeterminate nodulating plants** such as *Pisum sativum, Medicago sativa* and *Vicia* are characterized by the presence of a permanent meristem. In these plants the initiation of nodule primordial occurs in the inner cortex of the root. The mature indeterminate nodules contain a meristem, a bacterial invasion zone and bacterial differentiating zone, nitrogen fixing zone and a senescing zone surrounded by layers of cortical cells. On the other hand, nodule primordials of the **determinate nodule forming plants** (*Glycine max, Phaseolus spp Lotus sps*) are initiated in the outer cortex of the root. This type of nodule primordial does not remain active for long period of time and the nodules only show a temporal differentiation pattern (*Crespi and Galvez, 2000*).
The products of symbiotic N$_2$ fixation (amides in temperate legumes and ureides in tropical legumes) are exported from the nodules to the rest of the plant, where they are incorporated into essential macromolecules such as amino acids and proteins that drive plant growth, development and in the case of agriculture crop yields. Root nodules not only make a crucial contribution to the N-economy of leguminous crops, but also enhance the N-content of the soil, and thus they have a key role in environment-friendly agriculture practices. Legume-Rhizobia symbioses are beneficial to both partners. In exchange for exported N-compounds, the symbiotic bacteria (such as *Rhizobium, Bradyrhizobium, Sinorhizobium, Mesorhizobium* and related genera) are supplied with energy and C skeletons in the form of dicarboxylic acids (*Lodwig et al.*, 2003).

The bacteria and plant cells also probably exchange amino acid; for example, the plant supplies the bacteria with glutamate and so enable them firstly to limit ammonium assimilation and secondly to produce aspartate and alanine to be returned to the plant. This would also allow ammonium to the plant for assimilation and would favours mutual benefit from the exchange processes (*Lodwig et al.*, 2003).

The establishment of the symbiosis requires extensive recognition and signaling by both partners (*Long*, 2001). Symbiosis is initiated by release of lipochito-oligosaccharide molecules called ‘Nod’ factors by the bacterium through the expression of Nod genes in response to plant-derived flavonoid, stachydrine and aldonic acid molecules in the soil (*Hirsch*, 1992; *Stougaard*, 2000).

---

**Review and Literature**

If penetration occurs via rhizobial attachment to the root hairs then invasion of the cortical tissue via a structure called the ‘infection thread’ as accompanied by initiation of meristematic activity in the root cortical and pericycle cells. The Nod factors modify the plant hormone balance in
such a way as to stimulate mitosis and to allow development of the symbiosome that houses the bacteria within the plant (Ferguson and Mathesius, 2003). This involves the release of the bacteria into individual cortical cells by endocytosis, a process that results in the enclosure of the bacteria with in a plant member called the ‘peribacteroid’ or ‘symbiosome’ membrane. This membrane effectively isolates the bacteria from the host cell cytoplasm. The ‘peribacteroid’ membrane thus fulfils essential structural and metabolic roles, separating the bacteria from the plant cell cytoplasm and controlling exchange of metabolites and signals. Moreover, the plant provides a unique microaerobic low-oxygen environment for the bacteria within the symbiosome that control the expression of the bacteria N-fixation genes as well as cytochromes that work best in these condition (Long, 2001).

Leguminous plants nodulated by the same nodule bacteria constitute a group. Rhizobia are isolated from nodules on a plant in the group usually produced nodules on other plants in the same group. These plant groups called as "cross inoculated" group. Fred et al. (1932) observed this instance between Soybean and Cowpea, Kleczkowska et al. (1944) in between Clover and Pea and Lange (1966) in between cowpea-soybean-lupine group.

The symbiotic association between Rhizobium and legume is a result of interaction between prokaryotic organism with eukaryotes in a way, so as to influence and coordinate the expression of both prokaryotic and eukaryotic genes. The host genome plays an important role in development of the nodules in nitrogen fixation (Hirsch, 1992; Ferguson

Review and Literature
Plant also determines the size, shape, distribution and morphology of the nodules including intracellular organization of the infected host cell (Kidby and Goodchild, 1966; Corby, 1971; Dart, 1977). The leguminous trees and shrubs have large woody perennial nodules; the nodules of fast-growing annual species are relatively short-lived compared with the parent roots. The N-fixing capacity of the nodules peaks early in the life of the nodules; begins to decline when the nodule is only 3-5 weeks old. Whereas, leaf senescence and cell death related to the development of vascular tissues have been intensively studied (Buchanan-Wollaston et al., 2003). The factors that limit the lifespan of the Rhizobia-plant symbiosis have received relatively little attention. Over the last 10-year, more than 30 reviews have been published on the Rhizobia-legume interaction. These able texts have considered many key aspects of nodule biology from structure to recognition and signaling emphasizing the interaction occurring at the early stage of the nodulation process.

To date, only one review has exclusively conserved the complex and poorly understood process of nodule senescence (Swaraj and Bishnoi, 1996). Moreover, the general dearth of literature on this topic is surprising given its importance to agriculture. Nodule senescence is genetically controlled, and while legume breeding programmes have yielded varieties with early or delayed senescence, the lack of research may reflect the absence of useful mutants with early and delayed senescence phenotypes with which to tackle the problem. Although a long number of nodulation mutants are now available, no late senescing phenotypes have been described. It is widely accepted that functional genomic approaches are powerful tools that rapidly accelerate investigations of developmental
Review and Literature

processes in specialized tissues such as inoculated roots, nodules and mycorrhiza (Gamas et al., 1996; Journet et al., 2002).

Little data base information specific to nodule senescence exists, but The Institute for Genomics Research (TIGR) Medicago truncatula Gene Index: Expressed Sequence Tags (ESTs) from senescent nodules supplied by Carroll Vance (MtGI-GVSN) library is recommended to the reader in this regard. The Medicago truncatula Expressed Sequence Tag (EST) database contains over 140,000 expressed sequences of which <3000 come from the GVSN library of senescent nodules (Fedorova et al., 2002). Of particular note within the GVSN database are: (1) the Cys- cluster proteins and (2) the tentative consensus (TC) sequences similar to the nodule-specific protein nms-22. These sequences suggest firstly that Cys-cluster protein are induced before N-fixation commences and extend throughout nodules senescence, and secondly that the nMs-22-like protein are specifically expressed during nodules senescence (Fedorova et al., 2002).

Transcript profiling has also been used to identify genes that are expressed in nodules and roots form 7-wk-old. Lotus japonicus plants (Fang, 2001; Colebatch et al., 2002; 2004), with the aim of identifying genes that are essential for symbiotic N-fixation, in particular the nodulins genes that are expressed only in developing or mature nodules. Nodulins are classed as early or late, based on when the gene transcripts are first detected (Verma et al., 1992). Early nodulins genes are largely involved with nodule development and are activated in roots within hours or days of inoculation with Rhizobia. Late nodulins genes are activated around the time that N-fixation commences and include enzymes of C and N metabolism as well as structural components. The breakdown of root nodules symbiosis
occurs not only due to ageing of the tissues but also due to incompatibility between host and the Rhizobia. Sooner or later, the infected cells degenerate and become greenish brown.

Bacteriods show the symptoms of deterioration a few days earlier of the nodule cease to function (Bergersen, 1971; 1973; Heichel et al., 1979). Visible structural changes occur during the senescence process in nodules, for example the colour of the N-fixing tissues of the nodule changes from red (due to presence of functional leghaemoglobin) to green (indicating and alteration of the protein) by Swaraj and Bishnoi (1996) and Swaraj et al. (1993). Moreover, because hormones regulate the nodule plant development programme from seed dormancy to flower senescence, it is logical to consider that ABA, auxins, cytokinins, ethylene and gibberallic acid can also affect nodules senescence (Ferguson and Mathesius, 2003).

About the Problem- Nematodes on Crops

Plant parasitic nematodes are unique and in their ubiquitousness and persistence as soil borne pathogens. Rarely any crop is free from the attack of these tiny and microscopic pathogens. They are present everywhere, in fields, glass house, orchards, home gardens, and yet their presence is generally not felt till the concerned individual is baffled by the continuous decline of crop inspite of best agronomic practices. Among the best-known plant parasitic nematodes are the root knot nematodes, belonging to the genus Meloidogyne prevalent all over the world. These produce conspicuous galls on the roots and the infestation can be easily recognized in the fields.
The wide distribution of these nematodes through tropics, sub-tropics and temperate regions and their occurrence in cultivated fields and green house as well as make them as one of the most common agricultural pests. The **root knot nematodes** (RKN) *Meloidogyne* sp. was discovered on cucumber in a greenhouse for the first time in England (*Berkeley, 1855*). Later on it was recorded in Holland (*Beijerinck, 1888*). It has a broad host range including vegetables, field crops and trees.

According to *Mehrotra* (1983) RKN is the most important and dominant group of plant parasitic nematodes found almost in all vegetable growing areas and enormous losses are caused due to the nematodes. About 2000 plants are susceptible to infection by root knot nematodes and they cause approximately 5 % of global crop loss (*Hartman and Sasser, 1985; Sasser and Carter, 1985*). *Trifolium* spp. and *Vicia* spp. are typically excellent hosts for *M. incognita* (*Malek and Jenkins, 1964; Minton et al., 1965; Quesenberry et al., 1986; Mercer and Miller, 1997*).

*Meloidogyne* occurs in 23 of 43 crops listed as having plant-parasitic nematodes of major importance, ranging from field crops, through pasture and grasses to horticultural, ornamental and vegetable crops (*Stirling et al., 1992*). If RKN become established in deep-rooted perennial crops, control is difficult and options are limited. Vegetable crops grown in warm climates can experience severe losses from root-knot nematodes, and are often routinely treated with a chemical nematicide. Root knot nematode damage results in poor growth, a decline in quantity and yield of the crop and reduced resistance to other stresses (e.g. Drought, other diseases). A high level of RKN damage can lead to total crop loss. Nematode- damaged roots do not use water and fertilizers as effectively, leading to additional losses for the grower.
M. incognita is the most prominent and widely distributed. The optimum temperature of RKN has 25 °C to 30 °C and it prefers lighttextured, sandy soil with pH 4.0 to 8.0. Plant diseases caused by parasitic nematodes are widespread (Tsay, 1997). The most destructive species is M. incognita, which causes serious problems on a number of economically important agricultural crops including grape (Vitis vinifera), papaya (Carica papaya), guava (Psidium guajava), tomato (Lycopersicon esculentum), tobacco (Nicotiana tabacum), and watermelon (Citrullus vulgaris). M. incognita also increases the severity of bacterial wilt disease in solanaceous plants caused by Ralstonia solanacearum (Yen et al., 1997).

Although RKN produce visible symptoms of disease on plant and might have existed since time immemorial, RKN is economically important plant parasitic nematode (Ferraz and Brown, 2002). They exist in soil in areas with hot climates or short winters. RKN larvae infect plant roots, causing the development of root-knot galls that drain the plant’s photosynthates and nutrients. Infection of young plants may be lethal, while infection of mature plants causes decreased yield. All the vegetables are highly damaged by RKN under green house condition in temperate region (Sikora and Fernandez, 2005). Substantial reproduction of Meloidogyne incognita on winter cover crops may lead to damaging populations in a subsequent cotton (Gossypium hirsutum) crop (Timper et al., 2006).

**Plant Symptoms of root-knot injury**

Root knot is very distinctive because of the galls or swellings produced on roots and underground portions of stems. These deformations can often completely ruin crops for sale. Plants, if infected when young, will be stunned, more susceptible to drought stress,
and show symptoms of nutrient deficiency. Large and small roots may be affected with swellings varying from round sphere-like galls to elongated spindles formed from large numbers of individual galls growing together. Root knot galls involve the entire root in the affected zone. They do not take the form of easily detached galls like those produced by nitrogen-fixing bacteria on the roots of legumes. Root knot galls should not be confused with the fungal disease, club root, on cruciferous crops. In most instances, root knot is characterized by smaller swellings, and more uniformly distributed infection on the lateral feeding roots than is typically seen with clubroot. When the galls formed by the root knot nematode are broken open, shiny white bodies about the size of a pinhead, the enlarged female nematodes, are usually found. Also, glistening white to yellow egg masses is present on the root surface. The galls formed by clubroot do not possess this characteristic and are usually pinkish or brick colored. Phenoxy-type herbicides such as 2,4 D can cause swellings on stems of cruciferous crops that superficially look like root knot galls. Herbicide damage on these crops will not affect the roots, however, on young potato tubers the outer surface appears rough and warty because of the enlarged females underneath the skin. Plants are swollen or knotted roots (root galls) or a stubby root system. Root galls vary in size and shape depending on the type of plant, nematode population levels, and species of root knot nematode present in the soil.

Nematodes feeding on roots lead to poor plant growth (Hussey, 1989). Some graminaceous and leguminous cover crops are hosts of Meloidogyne incognita race 3 (Johnson and Motsinger, 1989; Windham and Pederson, 1992; Ibrahim et al., 1993; Mercer and Miller, 1997), one of the most widespread and damaging pathogens of cotton (Blasingame and Patel, 2001). The RKN and Rhizobia (beneficial, symbiotic bacteria)
Review and Literature

exploit a common strategy or have same pathway. Plant pathogenic nematodes are obligate biotrophs that infect a wide range of economically important plant (Williamson and Hussey, 1996). These round worms are endoparasites while other group of nematode is sedentary endoparasites. The latter includes cyst nematode (Heterodera and Globodera species) and RKN (Meloidogyne sps.). The infection of plants by this group can be visualized as stunted growth, wilting and susceptibility to various other pathogens (Williamson and Hussy, 1996, Back et al., 2002). RKN has potential host range of more than 3000 species (Abad et al., 2003). M. incognita causes the majority of the damage to crop plants, which inhibit both tropical and temperate climates. The damage to the root system caused by these pathogens result in comprised nutrient and water uptake giving rise to weak plant with poor yield.

Adegbite et al., (2006) studied the cowpea varieties ten weeks after planting from randomly selected plants for root-galls and nodules and that root galling varied significantly. Olabiyi (2008) studied in the green house, tomato seedling, cv. DT 69/257, grown in a steam – sterilized soil were inoculated with graded inocula of 5,000; 10,000, 15,000; 20,000 and 25,000 eggs of root knot nematodes, M. incognita. At inocula levels of 15,000; 20,000 and 25,000 eggs of M. incognita, number of leaf per plant, plant height, fruit yield and root galls were significantly reduced. Bharadwaj and Sharma (2007) stated that root knot nematodes are major limiting factors affecting plant growth and yield.

Nematicides

Nematodes are also intrinsically more difficult to kill than insects; for example, the non-fumigant nematicides alter the behaviour of nematodes, preventing them from entering host
roots, but they may eventually recover from the treatment and invade the host plant; and the limited resources allocated to nematicide discovery by agrochemical companies because the total markets are small compared to those for other pesticides (Hague, 2009). In the early days of nematicidal development it was noticeable that there were few trained nematologists, most of the evaluations being done by zoologists/entomologists.

**Herbal nematicides**

Current management of *M. incognita* primarily relies on pesticide and nematicide application (Tsay, 1999). The majority of the chemical nematicides are highly toxic to humans and some are also harmful for the environment when improperly used (Sikora and Fernandez, 2005). The synthetic pesticides for controlling nematodes are neither economically nor environmentally safe, thus alternatives to nematicides are desirable. Chemicals produced by plants are a potential source of new chemistry for development of new nematicidal compounds. Nematicidal phytochemicals are generally safe for the environment and humans (Chitwood, 2002). Chinese herbal remedies may be a source of new nematicidal compounds (Ferris and Zheng, 1999; Zasada et al., 2002). The use of plant extracts as an alternative to synthetic nematicides.

In recent years, chemicals are being replaced gradually by bioagents due to increasing awareness about their affectivity against *M. incognita* (Siddiqui and Alam, 1987 a, b). There has been growing interest in the inhibitory effect of some plant extract to control Nematode growth (Alam et al., 1988; Dhanger et al., 1996; Ali et al., 2001).
If we go back to the history, Terthienyl and related compounds were isolated from *Tagetes* spp. and have been shown to be nematicidal at low concentrations in vitro (Uhlenbroek and Bijloo, 1958, 1959). Nematicides of plant origin also include isothiocyanate, glucosides, alkaloids, phenolics, and fatty acids (Gomers, 1973). Polyacetylenes are another chemical group from the Asteraceae with nematicidal activity. For example, nematicidal dithioacetylenes have been isolated from *Milleria quinqueflora, Iva xanthiifolia, Ambrosia artemisifolia, Ambrosia trifida, Schkuhria pinnata*, and *Eriophyllym caespitosum* (Gomers and voor in 't Holt, 1976) and polyacetylenes have been isolated from flowers of *Carthamus tinctorius* and roots of *Cirsium japonicum* (Kogiso et al., 1976; Kawazu et al., 1980). Today thousands of plants, possessing insecticidal properties are known (Grainge and Ahmed, 1988). A wide variety of plant species representing 57 families have been shown to contain nematicidal compound (Sukul, 1992). Various plants have been shown to be effective in controlling nematodes on agricultural crops when grown in rotation, inter-planted with susceptible crops, or used as a soil amendment (Hackney and Dickerson, 1975; Halbrendt, 1996; Wang et al., 2002).

Rangaswamy and Reddy (1993) studied the effect of leaf extracts of trap croz viz. marigold (*Tagetes patula L.*) and mustard (*Brassica juncea L.*) at different concentration on the growth of tomato and development of root knot nematodes, *M. incognita* was studied under glasshouse condition. The leaf extract of marigold had no adverse effect on the growth of tomato, but increased shoot height, root and shoot weight.

growth was increased along with significant reduction in root-knot infestation in pot experiments when seed was treated with botanicals extracts. In field experiment, application of neem cake @ 5t/ha decreased root-knot infestation significantly and increased okra yield. Land management, cultural practices, resistant hosts, biocontrol agents, physical factors and use of chemicals had proved effective in management of *Meloidogyne spp.* causing root-knot diseases in cultivated plants. **Sharma and Trivedi (2002)** reported fresh leaves extracts of *Datura stramonium, Calotropis procera, Verbesena enceloides, Parthenium hysterophorus, Morus alba, Phyllanthus amarus, Eichhorneacrssipes, Ricinus communis, Jatropha curcas, Azdirachta indica, Tinospora cordifolia, Clerodendron multilflorum, Catharanthus roseus and Adhatoda vasica* were tested against root – knot nematodes, *Meloidogyne incognita* and wilt fungus, *Fusarium oxysporum f.sp.cumini* infesting cumin. Many nematicidal phytochemicals from a great variety of chemical structures have been isolated from numerous plant families (**Gommers and Barker, 1988; Chitwood, 2002**).

A majority of these nematicidal phytochemicals isolated have been from the plant family Asteraceae (**Gommers and Barker, 1988**). The results of different experiments show that about 60% of the species of Asteraceae tested were either highly resistant or moderately resistant to *M. incognita*. Only 7 of the 35 resistant species were previously reported to be resistant to *M. incognita* or to contain substances toxic to this nematode. These seven were *Ageratum houstinianum, Gerbera jamesonii, Tagetes patula, T. erecta, Zinnia elegans, Calendula officinalis, Helianthus annuus, and Xanthium strumarium* (**McSorley and Frederick, 1994; Tsay et al., 2004**).
Among these plants, marigold (*Tagetes* spp.) is the most commonly studied (McSorley and Frederick, 1994; Halbrendt, 1996). Thiarubrine C isolated from the roots of *Rudbeckia hirta* has been shown to have nematicidal activity against *M. incognita* and *Pratylenchus penetrans* (Sánchez de Viala et al., 1998). Elecampane (*Inula viscosa*, syn. *Cupularia viscosa*, *Ditrichia viscosa*) (Asteraceae), a widespread plant in Mediterranean countries, has been found to have nematicidal activity in the shoot (Oka, 2001; Oka et al., 2000, 2001). Sesquiterpenic acids (costic acid and isocostic acid) from *I. viscosa* leaf extracts were found to be the nematicidal phytochemicals (Oka et al., 2001; 2006). A mixture of these compounds was toxic to *M. javanica* at concentrations as low as 50 mg/kg in soil.

From the preliminary data, *Gaillardia pulchella* (blanket flower) showed consistent resistance to *M. incognita* (Tsay et al., 2004). Olabiyi et al., (2008) observed the effect of leaf extract of some weeds on root knot nematode, *Meloidogyne incognita* and also on the chemical compounds in the leaf extracts of some weeds. In the field planted with tomato seedlings, aqueous extracts from the marigold, nitta and basil plant were applied to root knot inoculated soil at four levels of 25,000; 500,000; 750,000; 1,000,000 ppm concentrations, 10ml per tomato stand. The entire aqueous plant root extracts applied in the trails reduced root knot nematodes population in the soil with corresponding increase in plant height; plant leaf and fruit yield over the control. Significant reduction of root galls from the treated plots indicted effective root knot nematode control by the aqueous root extracts (Olabiyi, 2008).

Numerous secondary metabolites released by the plants are inhibitory to plant-associated microorganisms, especially the beneficial microbes (Rice 1984; AlSaadawi and Rice,
1982; AlSaadawi et al., 1985). Bano et al., (1986) studied the allelopathic effect of leaf extract of Araucaria cokkie, Biota orientalis, Calotropis procera, Verbasina enceliodes, Cartharathus reosus and Eicchoria crassipes for egg inhibition of Meloidogyne app. The allelochemicals like, phenolic acids, terpenes, terpenoids, glycosides, alkaloids and flavonoids, released from various plant parts eventually penetrate the soil and not only hinder the normal growth of the neighbouring plants but may also affect development and reproduction of many plant-parasitic nematodes (Whittaker and Feeny, 1971; Addabbo, 1995; Blum, 1996; Inderjit et al., 1999a, b; Shaukat et al., 2002; Taba et al., 2008).

Khan et al., (2008) evaluated Azadirachta indica (neem), Withania somnifera (ashwagandha), Tagetes erectus (marigold) and Eucalyptus citridora (eucalyptus), against nematodes associated with papaya (Carica papaya) and to assess their influence on papaya growth and yield. While fresh shoot weight of papaya seedlings in pots was significantly increased by the plant extracts, in general, the fresh root weight remained unaltered compared to controls. The number of Meloidogyne incognita juveniles, root-knot index and the number of egg masses per root were remarkably reduced by all treatments.

Using allelopathic crops for weed suppression in agricultural crops has been shown to work in the greenhouse and in field trials, but incorporating these species in large scale farming operations in order to replace weed suppression supplied by synthetic herbicide use is just not practical or cost efficient in its current state. Although not really feasible on large-scale operations, allelopathy would be a good fit for weed control in organic farming or minor use crops. Allelopathy has potential for weed control in certain cropping systems, but is still far from replacing synthetic herbicide use for weed control in production agriculture.
Review and Literature

This situation demands that efforts should be made to develop an alternative technology for weed control. Allelopathy could be an appropriate potential technology for this purpose. This study was initiated to survey species of Asteraceae plant (Parthenium) for their susceptibility to *M. incognita* and to evaluate their effect on this nematode. However, formulating this plant extract is essential for commercial use of the nematicidal extracts. Cowpea production is beset by an array of pests RKN and other diseases that can cause serious devastation, thus leading to reduced yield and low profitability (*Blade et al., 1997*). Keeping in view, the studies were conducted to use the potentials of Parthenium extracts having nematicidal compound to control RKN in cowpea.