HortFlora Research Spectrum, 1(2): 97-102 (2012) Online Copy ISSN : 2250-2823

ALLELOPATHY: IT'S INTERFACE IN TREE-CROP ASSOCIATION

Anil Kumar Singh[1], Pravesh Kumar, Nidhi Rathore, Triyugi Nath[2] and Renu Singh

Department of Agronomy, (RGSC) Institute of Agricultural Sciences, BHU, Barkachha, Mirzapur (UP).

[1] ICAR Research Complex for Eastern Region, Patna (Bihar)

[2]Department of Soil Science and Agricultural Chemistry (SSAC), IAS, BHU, Varanasi

ABSTRACT: Combination between tree and crops interacts dynamically and provides multi-faceted aspects of improvement such as increased productivity, enrichment of soil with organic matter and nitrogen, transport of nutrients from lower to the upper layer of soil, conservation of environment, improved microclimate and allelopathy is one amongst them when it comes to combine the both components for sustainable land use and to increase food production. Because these components co-exist simultaneously, their allelopathic compatibility may be decisive to determine the selection of successful tree-crop combination. Mostly trees have negative allelopathic effects on crops, therefore, it is essential to explore that what type of tree-crop interaction will have no or positive allelopathic effects on the companion crops may be combined for beneficial results. As trees remain a part of the agroforestry system for a longer period, and most of them produce a large amount of leaves and litter, their allelochemicals may play an important role in an overall improvement. If the due emphasis is given, allelopathy could play a major role in enhancing the production and productivity in agroforestry systems by having the better understanding about tree-crop combination.

Keywords: *Allelopathy, tree-crop association, allelochemicals, interference.*

The term allelopathy was coined by Molish (16) to include both harmful and beneficial biochemical interaction between all types of plants including micro-organisms. Rice (28) reinforced this definition in first monograph on allelopathy. Allelopathy is an important mechanism of plant interference and is mediated through the addition of chemicals to the plant environment. Muller (18) suggested the term interference of one plant (including micro-organism) on another. However, compared to forest tree species, the agroforestry tree species have been investigated for alleloapthic influences. Although, agroforestry system has a potential to increase yield, it has compete with food crops (Paulino *et al.,* 24). The overall effect of tree on understorey vegetation depends on the balance between their positive (facilitation) and negative (competition) effects (Callaway and Walker, 6). Rafiqul-Hoque *et al.* (27) have shown that certain trees contain higher levels of bioactive chemicals, suggesting a large inhibitory potential (Barnes *et al.,* 3). Allelopathic interaction involves the production and release of chemical substances which can inhibit the growth and the develpoment of the understorey vegetation. Cannell *et al.* (7) argued that agroforestry may increase productivity because trees can capture resource which are underused by crops. Ovalle and Avendano (21) reported that trees increase understorey herbaceous productivity. Allelopathy arises from the releasse of chemicals by one plant species that affect other species in its vicinity, usually to their detriment.

The most formidable problem in managing simultaneous agroforestry in drylands is how to retain the positive effects of tree canopies and roots on soil physical and chemical properties while reducing the negative effects of below-ground competition for limited resources (Ong and Leakey, 20; Schroth, 30).

1. COMPETITION AND ALLELOPATHY

Competition means effect on others in terms of harmfulness, but allelopathic effect may be beneficial or harmful. Allelopathic substances are imprtant factors in competition between crops and trees (Paulino *et al.,* 24). Allelopathic effects are closely associated with competition and it is

Received : 16.3.2012 *Accepted : 10.4.2012*

difficult to eliminate allelopathy from competition studies. Muller (17) has seperated "competition" from "Allelopathy", the former was based on use of resources (nutrients, water and light) which are the limiting factors, whereas the latter involve the production of toxic substances (allelochemicals). Puri and Bangawa (25) have found that neem tree has no adverse effect on the yield of wheat (*Triticum aestivum*) if grown 5 m apart from the main stem. Some studies suggest a direct role of neem allelochemicals in this effect on crop plants. Allelopathy can be defined as chemical interactions between and among both plants and microorganisms *via* releases of biologically active chemical compounds into the environment. The allelopathic potential of certain trees and crop species can influence the growth and distribution of associated trees species and the yield of desired plants. For a tree to be biologically efficient and ecologically effective, it must interfere with other surrounding species. This interference has two primary components: competition and allelopathy. Competition is the control or removal from the common environment of essential resources needed for life. Allelopathy is the addition of materials to the common environment which changes life functions. Allelopathy is the biochemical modification of the environment to enhance tree survival and reproduction Interference is the proper name for individual ecological interactions. The word "competition" is mis-used/over-used to describe species interactions. Rarely is allelopathy isolated or eliminated in competition studies, and so, the combined term "interference" is most accurate to use. Allelopathy is a defensive component of tree interference. The component plant species in agroforestry system depends on the same reserve of growth resources such as light, water and nutrients and hence there will be influence of one component of a system on the performance of the other components as well as system as a whole. These are referred to as tree-crop interactions. These interactions may be positive or negative (Basavaraju and Gururaju, 4). The balance between these positive and negative effects determines the overall effects of the interactions in a given agroforestry combination.

2. ALLELOPATHY IN TREE-CROP INTERACTION

2.1 Effect of Trees on Crops

Trees and crops have been grown together since ancient times. In any system, the trees and the crops may compete for light, water, and nutrients or have complementary needs. When the interactions between the trees and crops are managed well, agroforestry systems, traditional or modern, can outperform sole cropping systems. In most of the cases allelopathic effect are selective and vary with different tree crops (Melkania, 15; Stowe, 31). In general leaves are most potent source of allelochemicals, however, the toxic metabolites are also distributed in all other plants parts in various concentrations. The allelopathic effect may be so striking that competition for resources does not explain why, in plant communities, many species appear to regulate through the production and release one another through the production and release of chemicals attractants, stimulators or inhibitors (Putnam and Tang, 26). Several species are known to have allelopathic effects on other crops, *e.g.,* maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.) as reported by Rice (28). Rafiqul-Hoque *et al.* (27) have shown that certain trees contain higher levels of bioactive chemicals, suggesting a large inhibitory potential (Barnes *et al.* 3). Agroforestry have both tree and crop components. So the situation will be very complex. In case of legumes allelopathic effect of leachates and extracts of *Pinus roxburghii* in Kumaon Himalaya has been recorded. Mimosine toxicity of *Leucaena leucocephala* was observed on green gram *i.e.* inhibitory effect on germination. Various types of trees shows different type of positive and negative effect on crops. A possible allelopathic effect of *Acacia* trees has also been recognized. Other authors have shown a large inhibitory potential in the genus of *Acacia* (Rafiqul-Hoque *et al.,* 27). Autotoxicity is also responsible for the

Table 1. Allelpathic effect of different tree species on agri-horticultural crops.

Tree species	Plant part/soil allelochemicals	Affected crop	Effect
Leucaena leucocepahala	Mimosine	Green gram, Rice	Inhibitory effect on germination and growth
	Mimosine	Rice, rye, lettuce	Inhibitory effect on germination and growth
	Leaf extract	Wheat, maize, pea, mustard	Inhibitory effect on germination
	Soil	Rice	No effect on germination
	Leaf extract	Rice	Inhibitory effect on germination
	Leaf extract	Rice	Stimulatory effect on germination
Acacia tortilis	Leaf ,stem, and soil extract	Pearl millet, sesame, cluster bean, Wheat	Inhibitory effect on germination, growth and yield
Walnut	Field study	Potato, tomato, Alfalfa	Inhibitory effect on growth
	Field study	Potato,maize, turnip	Inhibitory effect on growth
Bamboo	Leaf extract	Groundnut	Inhibitory effect on growth, chlorophyll and protein content
Eucalyptus citridora	Leaf, stem and root extract	Okra, wheat, cowpea, maize	Inhibitory effect on growth
Eucalyptus tereticornis	Leaf, stem and root extract	Sorghum, cowpea, sunflower	Inhibitory effect on germination and growth
Pinus radiata	Leaf extract	Ryegrass, white clover	Inhibitory effect on ryegrass and stimulatory effect on white clover
Pinus roxburghii	Leaf and root leachates, decaying litter, field soil	Black gram, green gram, horse gram, soybean	Both inhibitory and stimulatory effect

inhibition of seed germination and/or delay of seedling growth exhibited by some annuals including corn, *Zea mays* (Martin *et al.,* 13) and wheat, *Triticum aestivum* (Jessop and Stewart, 11). Allelochemicals in soil and their effect on crop plants may be modified by soil moisture, soil temperature and other soil factors (Patrick and Koch, 23). The effects of secondary substances released by these mechanisms can be long lasting (Patric, 22) or quite transitory (Kimber, 12) and can ultimately influence practices like fertility, seeding and crop rotations. The allelopathic effects are selective (Melkania, 14; Stowe, 31) and vary with different trees since these plants will vary in the amount of indigenous secondary metabolites and would release different amounts of the phytotoxins. Harborne (10) proved that higher plants (tree crops) release some phytotoxins into soil, which adversely affect the germination and yield of crops. Such type of tree crop interactions called phytochemical ecology/ecological biochemistry. These are given in Table 1.

2.2 Effect of Trees on Tree

Allelopathy is the chemical modification of a site to facilitate better tree growth, and control ecological volume and essential resources. The proportion of allelopathy within each species interference effect is highly variable depending upon the site, species, and individual. Some trees are rich sources of secondary metabolites (allelochemicals), which play a major role in regulating pattern of vegetation, these chemical

Table 2: Tree species with potential allelopathic activities.

Tree species	Allelochemicals
Leucaena leucocephala	Mimosine
Walnut	Juglone
Azadirachta indica	Azadirachtin
Eucalyptus spp.	1,4- and 1,8-cineole
Guava	Phenolics
Peach	Amygdalin
Mallus domestica	Phlorizin, Quercetin

Table 3: Crop species with potential allelopathic activities.

Crop species	Common name
Allium sativum	Garlic
Avena sativa	Oat
Brassica hirta	White mustard
Brassica juncea	Brown mustard
Cajanus cajan	Pigeon pea
Carthemus tinctorius	Safflower
Cucumis sativus	Cucumber
Glysine max	Soybean
Medicago sativa	Alfalfa
Oryza sativa	Rice
Hordeum vulgare	Barley

imposed a kind of environmental stress on other plants growing in their vicinity. The seedlings of one tree shows positive and negative influence on total volume of seedling of neighbouring tree. The influence of tree seedlings on growth of each started from first year and become powerful in the second year. In case of walnut, tree toxicity is found to other tree plant like, apple, berry. Auto toxicity, a type of intra-specific allelopathy, is a major reason why managed tree ecosystems fail to regenerate, causing replant problems. The allelopathic effects of Eucalyptus have been studied extensively (Del Bajwa and Nazi, 2; Moral and Muller, 8; El-Khawas and Shehata, 9; Sasikumar *et al.,* 29). Phenolic acids and volatile oils released from the leaves, bark and roots of certain Eucalyptus spp. have harmful effects on other plant species (Sasikumar *et al.,* 29). Most reports have focused on the allelopathic effects of litter extracts; those of living root exudates have been less well investigated (Bagavathy and Xavier, 1; Bernhard-Reversat, 5).

2.3 Effect of Crops on Crop

Effect of one crop including micro-organisms on other crop/same crop is called "crop allelopathy". It is well known that crops cultivated in rotation produce higher yield than those of grown in monoculture. It is reported that allelochemicals from alfalfa soil inhibit growth of barley, wheat, radish, and alfalfa. Narwal *et al.* (19) have reported alleloapthic effect on the germination and seedling growth of Indian colza, wheat, barley, lentil, chickpea, etc. and aqueous root extract of soyabean on rape and mustard. A high concentration of phenolic acid in paddy (*Oryza sativa* L.) soils of India and Japan has been reported which found inhibitory to root growth of rice plants. Thus auto toxic effect in oat, maize, rice, sorghum, and wheat have been established.

CONCLUSION

The allelopathic potential of trees and crop can influence the growth and distribution of associated tree species and the yield of desired plants, and allelopathy has been employed successfully in this context. When the trees and crops grown together they interact with each other either inhibiting or stimulating their growth or yield through direct or indirect allelopathic interaction. Thus, it plays an important role in an agroforestry system and it is clear that a better understanding of allelopathy can help in developing more sustainable agroforestry system.

REFERENCES

1. Bagavathy, S. and Xavier, G.S.A. (2007). Effects of aqueous extract of *Eucalyptus globulus* on germination and seedling growth of sorghum. *Allelopathy J.,* **20:** 395–401.
2. Bajwa, R. and Nazi, I. (2005). Allelopathic

effects of *Eucalyptus citriodora* on growth, nodulation and AM colonization of *Vigna radiata* (L.) *Wilczek. Allelopathy J.,* **15:** 237–246.

3. Barnes, R.D., Filer, D.L. and Milton, S.J. (1996). *Acacia karroo.* In: *Tropical Forestry Papers* No. 32. Oxford Forestry Institute, Oxford University.
4. Basavaraju, T.B. and Gururaja, R. (2000). Tree-crop interactions in agroforestry systems: A brief review. *Indian Forester,* **126** (11): 1155-116
5. Bernhard-Reversat, F. (1999). The leaching of *Eucalyptus hybrids* and *Acacia auriculiformis* leaf litter: laboratory experiments on early decomposition and ecological implications in congolese tree plantations. *Applied Soil Eco*., **12**: 251–261
6. Callaway, R.M. and Walker, L.R. (1997). Competition and facilitation: a synthetic approach to interactions in plant communities. *Ecology,* **78:** 1958-1965.
7. Cannell, M.G.R., Van Noordwijk, M. and Ong, C.K. (1996). The central agroforestry hypothesis: the trees must acquire resources that the crop would not otherwise acquire. *Agroforest. Syst*., **34:** 27-31.
8. Del Moral, R. and Muller, C. H. (1969). Fog drip: a mechanism of toxin transport from *Eucalyptus globulus*. *Bull. Torrey Bot. Club*, **96:** 467–475.
9. El-Khawas, S.A. and Shehata, M.M. (2005). The allelopathic potentialities of *Acacia nilotica* and *Eucalyptus rostrata* on Monocot (*Zea mays* L.) and Dicot (*Phaseolus vulgaris* L.) *Plant Biotech*. **4:** 23–34.
10. Harborne, J.B. (1977). *Introduction to Ecological Biochemistry.* Academic Press, New York.
11. Jessop, R.S. and Stewart, L.W. (1983). Effect of crop residues, soil type and temperature on emergence and early growth of wheat. *Plant and Soil,* **74:** 101-109.
12. Kimber, R.W.L. (1973). Phytotoxicities form plant residues. I. The influence of rotted wheat straw on seedling growth. *Aust. J. Agric. Res.*, **18:** 361-374.
13. Martin, V.L., McCoy, E.L. and Dick, W.A. (1990). Allelopathy of crop residues influences corn seed germination and early growth. *Agron. J.,* **82:** 555-560.
14. Melkania, N.P. (1983). Influence of certain selected tree species on ground flora, *Ph.D. Thesis,* Kumaun Unviersity, Nainital. 442 p.
15. Melkania, N.P. (1986). Allelopathy and its significance on production of agroforestry plants association. *Proceeding workshop of Agroforestry for Rural Needs*. Feb.22-26, 1986, New Delhi. ISTS, Solan, pp. 211-224.
16. Molisch, H. (1937). Der Einfluss einer Pflanz auf die andere–Allelopathige. Fischer, Jena, Germany.
17. Muller, C.H. (1966). The role of chemical inhibition (allelopathy) in vegetational composition. *Torrey Bot. Club***, 93:** 332-51.
18. Muller, C.H. (1969). Allelopathy as a factor in eceological process. *Vegetation,* **18**: 348-57.
19. Narwal, S.S., Singh I., Singh, A. and Gupta, K. (1989). Allelopathy effects of pearl millet extract on the seed germination and seedling growth of Indian Colza. *Indian J. Ecol.,* **16**: 84-87.
20. Ong, C.K., Black, C.R., Marshall, F.M. and Corelett, J.E. (1996). Principles of resource capture and utilization of light and water. In: Ong, C.K., Huxely, P. (Eds.), Tree–Crop Interactions. A Physiological approach. CAB International, Wallingford, UK, pp. 73–158.
21. Ovalle, C. and Avendano, J. (1987). Interactions de la strate ligneuse avec la strate herbacée dans les formations d'*Acacia caven (Mol.)* Hook. et Arn. au Chili. *Oecol. Plant*, **9**: 113-134.
22. Patric, A.Z. (1971). Phytotoxic substances associated with the decomposition in soil plant residues. *Soil Sci.*, **III :** 13-18.
23. Patrick, Z.A. and Koch, L.W. (1958). Inhibition of respiration, germination and growth by substances arising during the decomposition of certain plant residues in soil. *Canadian J. Bot.,* **36:** 621-647.

24. Paulino, V.T., Sanchez, M.J.F., Werner. J.C. and Consla, V. (1987). Allelopathic effects of *Eucalyptus* on forage growth, *Rev. Agric*. (Pirachiacaba), **62 :** 17-35.
25. Puri, S. and Bangawa, K. S. (1992). Effect of trees on the yield of irrigated wheat crop in semi-arid regions. *Agroforestry Syst.,* **20:** 229–241.
26. Putnam, A.R. and Tang, C.S. (1986). *The Science of Allelopathy.* Wiley, New York, p. 317.
27. Rafiqul-Hoque, A.T.M., Ahmed, R., Uddin, M.B. and Hossain, M.K. (2003). Allelopathic effect of different concentration of water extracts of *Acacia auriculiformis* leaf on some initial growth parameters of five common agricultural crops. *Pak. J. Agron.* **2:** 92-100.
28. Rice, E.L. (1984). *Allelopathy,* 2nd ed., Academic Press, Orlando, FL, pp. 67–68.
29. Sasikumar, K., Vijayalakshmi, C. and Parthiban, K.T. (2002). Allelopathic effects of eucalyptus on blackgram (*Phaseolus mungo* L.). *Allelopathy J.,* **9:** 205–214.
30. Schroth, G. (1995). The roots characteristics as criteria of species selection and systems design in agroforestry. *Agroforestry Syst.* **29:** 125-143.
31. Stowe, L.G. (1979). Allelopathy and its influence on the distribution of plants in an Illinois old field. *J. Ecology,* **67:** 1065-1085.