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Allelopathy: An Alternative to Synthetic Herbicides for Weed Management

(Review Article)

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Abstract

Allelopathy refers to inhibitory or detrimental effects of secondary metabolites produce by plants or micro-organisms that influences the growth and development of Agricultural and Biological systems. In field crops, allelopathy can be used following rotation, using cover crops, mulching and plant extracts for natural pest management. Some plants and trees are well known as allelopathic are Black Walnut (*Juglans nigra*), Tree of Heaven (*Ailanthus altissima*), Fragrant Sumac (*Rhus aromaticus*), Rice (*Oryza sativa*), Pea (*Pisum sativum*), sorghum etc. Allelopathy is a naturally occurring biochemical interaction among organisms that may be employed for managing weeds, insect pests and diseases in the immediate vicinity. It is a new approach to be used as an alternative (bio herbicides) to synthetic herbicides for the weed management. To ensure sustainable agricultural development, it is important to exploit cultivation systems that take advantage of the stimulatory/inhibitory influence of allelopathic plants to regulate plant growth and development and to avoid allelopathic autotoxicity. Allelochemicals can potentially be used as growth regulators, herbicides, insecticides, and antimicrobial crop protection products.

The main purpose of this review article is to know the research progress on the use of plant Allelopathy as a source of bio herbicides for the weed management.

Allelopathy refers to inhibitory or detrimental effects of secondary metabolites produce by plants or micro-organisms that influences the growth and development of Agricultural and Biological systems. Molish[31], coined the term "allelopathy" as an interaction among the plants and the microorganisms. Rice[36], defined allelopathy as the effects of one plant (including microorganisms) on another plant via the release of chemicals into

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the environments. In 1996, the International Allelopathy Society broadened its definition of allelopathy to refer to any process involving secondary metabolites produced by plants, microorganisms, viruses and fungi that influence the growth and development of agricultural and biological systems.

Several workers have shown that allelopathy plays an important part in weed and weed interaction[33,35,41,43], and weed crop interaction[12].

Allelopathy is a new approach to be used as an alternative to synthetic herbicides for the weed management as a source of bio herbicides. Several allelopathic plant species such as *Sorghum bicolor* (L.) Conard Moench.,[10,42], *Helianthus annuus* L.[3,29] and *Parthenium hysterophorus* L.[1,5,6,25] are inhibitory at high doses as well as stimulatory to weeds at low doses due to hormesis[4].

Many plants from different families of angiosperm have been studied for their allelopathic potential in which Fabaceae, Euphorbiaceae, Myrtaceae, Apocynaceae, Compositae and Rubiaceae show strong inhibition towards the recipient plants[23,26]. Similarly crop plants, such as soybean, sunflower, wheat, alfalfa, maize, sesame, rice, sorghum and many others, have demonstrated allelopathic impacts on certain weed species. Weeds are almost found in both the seasonal crops; winter and summer. It has been commonly observed that weeds come from the time the soil is prepared for sowing the seed, and reach maturity before the crop is mature and ready for harvest. In this way, they leave their plant residues in the field while the crop is growing and also affect the crop through their allelopathic releases. During the growing season they release allelochemicals through leaf leachates and root exudation and hinder germination as well as plant growth and development. It is well-known fact that majority of allelochemicals are products of secondary metabolism, with a few exceptions of primary metabolism. Allelochemicals thus released are produced as by-products during different physiological processes in plants[7,20]. These metabolites have basically four precursors: acetyl coenzyme A, shikimic acid, mevalonic acid and deoxy xylulose phosphate. Based on these precursors, secondary metabolites can be grouped into three main chemical classes: terpenoids, N- containing compounds and phenolic compounds. These are a less toxic, safer and are released by plants via volatilization, exudation, leaching, or residue decomposition. Action of these compounds is concentration dependent[18], as they inhibit the plant growth at high concentrations and promote‘ at low concentrations[32]. These allelochemicals may thus be used as natural pesticides at high concentration[19]. Inhibitory role of allelochemicals is well explored and has been directly and indirectly used for weed management. A lot of research work has been done to explore the inhibitory potential of different allelopathic crops and trees for weed management.

A number of important crops have recognized allelopathic activity that can be either greater or lesser depending on the cultivar, climatic conditions, soil fertility, water availability and competing weeds. The current worldwide demand for cheaper, more environmental- friendly weed management technologies has motivated a number of studies on the allelopathic interaction between crops and weeds[14]. Agricultural practices such as reseeding, overseeding, cover crops and crop rotation must take into account the allelopathic activity of the crops involved, at the risk of obtaining low yields[11,34]. Allelopathic plants may also be consider potential source of new molecules with herbicidal action for the chemical industry, the necessity of which is due to the emergence of resistant weeds to older synthetic molecules[8,17,28]. Another potential application is in the development of genetically modified crops that can be used as allelopathic plants[15,16,40].

The possible application of allelopathy in agriculture is the subject of much research which is focused on the effects of weeds on crops, crops on weeds, and crops on crops. Research furthers the possibility of using allelochemicals as growth regulators and natural herbicides, to promote sustainable agriculture. A number of such allelochemicals are commercially available or in the process of large-scale manufacture. Examples of crops and weeds with recognized allelopathic activity and their importance for weed management are discussed in this paper. Leptospermone is a signified thermochemical in lemon bottlebrush (*Callistemon citrinus*). Although it was found to be too weak as a commercial herbicide, a chemical analog of it, mesotrione (trade name Callisto), was found to be effective. It is sold to control broad leaf weeds in corn but also seems to be an effective control for crabgrass in lawns. Sheeja[37] reported the allelopathic interaction of the weeds *Chromolaena odorata* (*Eupatorium odoratum*) and *Lantana camara* on selected major crops. Allelopathic effects of some plants viz. *Phaseolus trilobus Ait., Prosopis spicigera* Linn., *Albizzia odoratissima* Benth. *and Tephrosia purpurea* Linn., they showed positive and negative allelopathic effects, which can be used as natural fertilizers and natural herbicides respectively. Studies concluded that out of four plants extracts P.S. and A.O. showed detrimental allelopathic effect (negative allelopathy). They can act as natural herbicides. Those chemicals responsible for natural herbicides can be isolated and refined for commercial use. Other two plants extract P.T and T.P. showed beneficial allelopathic effect (positive allelopathy) which can be used to increase the growth of any plant species more than their normal growth and can be used as natural herbicides[44]. The sunflower is an annual oleaginous plant native to the Americas that also has allelopathic activity against weeds[9]. Its use as a natural herbicide for some broadleaf weeds has been suggested[2]. In this species several substances with allelopathic properties such as phenolic compounds, diterpenes and triterpenes have been isolated and chemically characterized[30].

Modern techniques and equipment are available and an increasing number of bioactive molecules are isolated and identified every year from crops, weeds and forest trees. A number of chemical separation methods combined with spectroscopic techniques, such as multinuclear/ multidimensional nuclear magnetic resonance (NMR), have proven useful for isolating, quantifying and identifying known or new molecules with potential allelopathic activity[13]. Bioassays using target species with an isolated substance or mixture of substances at increasing concentrations are carried out to confirm their allelopathic activities. There is some consensus that a simple compound in a field situation may not be enough to affect the growth of the receiving plant and it is likely that different allelochemicals act additively or synergistically to inhibit growth[6,28,39].

If allelopathy can be properly integrated into sustainable agriculture, the heavy reliance on synthetic pesticides and other agrochemicals can be significantly reduced. Allelochemicals released from living plants and decomposition includes many toxins, which may suppress growth of useful bacteria, fungi, and micro-organisms, but they can also cause problems with minerals and nitrification in the soil.

References :

1. Adkins, S. W., and M. S. Sowerby, (1996). *Plant Protection Quarterly 11*(1): 20-23.
2. Anjum T, and R Bajwa (2007) *Field Crops Res. 100 :* 139–142.
3. Batish, D. R., P. Tung, H. P. Singh, and R.K. Kohli (2002). *Journal of Agronomy and Crop Science 188*(1): 19-24.
4. Belz, R. G. (2008). *Dose-Resp. 6*(1): 80-96.
5. Belz, R. G. (2016). *J. Chem. Eco. 42*(1): 71-83.
6. Belz, R.G., C.F. Reinhardt, L.C. Foxcroft and K. Hurle (2007). *Crop Prot. 26*(3): 237-245.
7. Bhadoria, P.B.S. (2011). *Amer. J. Exp. Agric. 1:* 7-20.
8. Bhowmik, P.C. and Inderjit (2003). *Crop Prot 22:* 661– 671.
9. Bogatek, R., G. Agnieszka, W. Zakrzewska and Krystyna oraz (2006). *Biol. Plant. 50 :* 156–158.
10. Cheema Z.A., A. Khaliq and M. Mubeen (2003) *Pak. J. Weed Sci. Res. 9:* 89–97.
11. Chon, S.U., J.A. Jennings and C.J. Nelson (2006). *Allelopathy J.18:* 57-80.
12. Colton, C. E. and F. A. Einhellig. (1980). *Amer. J. Bot., 67:* 1407-1413.
13. D'Abrosca B., M. DellaGreca, A. Fiorentino, P. Monoco, L. Previtera, A.M. Simonet and A. Zarrelli (2001). *Phytochemistry 58:* 1073-1081.
14. Dudai, N., M. Polijakoff., A.M. Mayer and E. Putievsky (1999). *J. Chem. Ecol. 25:* 1079–1089.
15. Duke, S.O. (2003) *Trends Biotechnol. 21:* 192–195.
16. Duke, S.O., B.E. Scheffler, F.E. Dayan, L.A. Weston and E. Ota (2001) *Weed Technol., 15:* 826–834.
17. Einhellig F.A. (1996) *Agron. J. 88*(6)*:* 886–893.
18. Einhelling, F.A., A.R. Putnam and C.S. Tang (1986). *The Science of Allelopathy* (Eds.)John Wiley & Sons, New York: pp. 171-188.
19. Farooq, M., A. Wahid, N. Kobayashi., D. Fujita and S.M.A. Basra (2009) *Agron Sustain Dev. 29:* 185-212.
20. Farooq, M., K. Jabran, Z.A. Cheema, A. Wahid and Siddique (2011). *Pest. Manag. Sci. 67:* 493–506.
21. Farooq, M., S.M.A. Basra., R. Tabassum and I. Afzal (2006) *Plant Produce Sci., 9:* 446-456.
22. Francisco, A. Macias (1996) International Allelopathy Society. Symposium; A science for the future: [1st Symposium of the International Allelopathy Society (IAS), Cádiz, Spain, September 1996].
23. Fujii, Y., S. Parvez, M. Parvez, O. Yoshio and Osamuiida (2003). *Weed Biol. Mang. 3:* 233-241.

24. Hari, O., S. Kumar and S.D. Dhian (2002). *Crop Protect. 21 :* 699-705.
25. Hassan, G., U.H.Rashid and I.A. Khan (2018). *PlantaDaninha, 36*(2): e018176372.
26. Ilori, O. J., O.O. Otusanya, A.A. Adelusi and R. O. Sanni (2010) *International Journal of Botany, 6*(2): 161-163.
27. Kong, C. H. and X Huaxu (2002). *J. Chem. Ecol. 28*(6): 1173-1182.
28. Kruse M., M. Strandberg and B. Strandberg (2000) Ecological effects of allelopathic plants-a Review. NERI Technical Report No. 315, *National Environmental Research Institute, Silkeborg,* Denmark.
29. Leather, G. R. (1987). *Plant and Soil*, *8 :* 17–23.
30. Macias, F.A., A. Oliveros-Bastidas, D. Marin, D. Castellano, A. M. Simonet, and J.M. Molinillo (2004). *J.Agric. Food Chem. 52:* 6402–6413.
31. Molísch H, (1937) *Der Einfluss einer Pfalnze auf die Andere-allelopathie*. Fischer, Jena, Germany.
32. Narwal, S.S. (1994). Allelopathy in Crop Production. Jodhpur, India: Scientific Publishers. pp. 288.
33. Newman, E.I. and A. D. Rovira (1975). *J. Ecol.*, *63:* 727–737.
34. Oueslati, O (2003). *Agric. Ecosyst. Environ. 96:* 161-163.
35. Rasmussen, J. A. and E. L. Rice (1971). *Amer. Midl. Nat., 86:* 309-326.
36. Rice, E.L. (1984). Allelopathy. 2nd Ed. Academic Press, Orlando, Florida, USA pp 67-68.
37. Sheeja B.D. (1993). M. Phil dissertation submitted to Manonmaniam Sundaranar University, Tirunelveli.
38. Stephen, D., F.R. Dayan., R. Joanne and Rimando (2002). *Weed Res. 40*(1): 99-111.
39. Tabaglio, V., C. Gavazzi, M. Schulz and A. Morocco (2008). *Agron Sustain Dev. 28:* 397–401.
40. Taiz, L. and E. Zeiger, (2006). Plant Physiology, 4th ed, USA: Sinauer Associates, Inc...
41. Tajuddin, Z., S.S. Shaukat and I.A. Siddiqui (2002). *Pak. J. Biol. Sci., 5:* 866-868.
42. Weston, L.A. and S.O. Duke (2003). *Crit. Rev. Plant Sci. 22:* 367–389.
43. Wilson, R.E and E. L. Rice (1968). *Bull. Torrey Bot. Club., 95:* 432-448.
44. Yadav, P. and, R. N. Yadava (2012). *Int. J. Science & Research (IJSR) 3:* 5 ISSN (Online): 2319-7064.