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Review Article

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"Allelopathy: An eco-friendly tool for the management of sustainable weed in the agriculture field."

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Abstract

Allelopathy is a phenomenon in which a plant or microorganism releases a natural product (allelochemicals) into the environment which can stimulate or inhibit the growth of other plant growing in vicinity. Most important allelochemicals found in allelopathic plants are- phenolic compounds, benzoxazinoids, alkaloids, terpenes, glucosinolates etc,. These allelochemicals enter into the environment from plants in a number of ways such as plant degradation, volatilization, leaching from plant leaves and root exudation.

Weeds are the largest threats in agricultural field which affects the productivity of beneficial crop and can weak the commercial market. According to Indian Council of Agriculture Research (ICAR), India loses agriculture production worth over $11 billion to weeds every year. Sustainable weed management is needed for declination of beneficial crop production. Thus, for handling this critical situation, allelopathy may be a unique and eco-friendly tool for the management of weed from the agricultural field. This review provides a recent update regarding the application of allelopathic plant which suppresses the weeds growing in agricultural field.

Introduction

The term allelopathy is the combination of two greek word, 'allelon' i.e. of each other and 'pathos' i.e. 'to suffer'. The term allelopathy was first coined by Prof. Hans. Molish (1937). Bahadur et al. (2015), defined as the allelopathy is any direct and indirect effect by one plant, including micro-organisms, on another by releasing of chemical compounds which escape into the environment to influence the growth and development of other plant growing in vicinity. The allelochamicals releases by the allelopathic plant may be deleterious or beneficial. These allelochemicals are mostly secondary metabolites which are produced by the different physiological processes in plants (Bhadoria, 2011). Allelochemicals visibly affects on the growth and development of plants include inhibited or retarded germination rate, seeds darkened and

swollen; reduced root or radicle and shoot or coleoptiles extension; swelling or necrosis of root tips; curling of the root axis; discoloration, lack of root hairs; increased number of seminal roots; reduced dry weight accumulation; and lowered reproductive capacity. Recent research shows that allelopathy has a significant role in sustainable agriculture, such as biological weed and pest control (Duke and Lydon, 1928).

Weed the unwanted or wild plant that grows on agriculture fields with the growth of cultivated plant (Rizvi et.al, 1981). Kohli et.al, (2004) reported that approximately 30,000 plant species identified as weed. Among these, about 80 are known to reduce crop yield. The main sustainable characteristics of weed are 1. Produce and abundance of seed, 2. Rapid seed growth, 3. Quick maturation, 4. dual mode of reproduction. Weeds compete especially with crop plant for the resources of nutrients, space, light and moisture. Due to this, the physiological activities and growth of crops are negatively affected in the presence of weeds (Rajcan and Swanton, 2001). Ultimately, it causes a great loss in their productivity. With the increasing of world population and limited available resources, weed management is a major challenging job. In ancient time, the methods used for eradication of sustainable weed from the agricultural field are: pulling by hand, cutting, and physically smothering weeds (Oerke et al., 1999; young et al., 2014). Hand weeding, mechanical weeding, and herbicide applications have been considered as the most relied methods for weed control (Griepentrog and Dedousis, 2010; Bergin, 2011; Rueda-Ayala et al., 2011; chauvel et al., 2012). These methods for weed control keep weed infestations low only. Decreasing availability and increasing cost of labour, and inconsistent weed control are the major challenges in hand weeding (Carballido et al., 2013; Gianessi, 2013). By using the herbicide, health effect, and environmental concerns becomes the major problems (Annett et al., 2014; Hoppin, 2014; Powels, 2008; starling et al., 2014). Need for new approaches in management, production and use of existing agricultural practices for sustainable agricultural production seems necessary. Suppressing of weed by the allelopathic phenomenon may be the important innovative method for weed control from the agricultural field (Jabran and Farooq, 2013; Zeng, 2014). Pickette et al., (2014) state that, plant hormones and defence mechanisms are manipulated to weed control in different agro-ecosystem.

This review article discusses the application of eco- friendly tool for the management of sustainable weed in agriculture field. We have also focused on allelochamicals their process of release and potential allelopathic crops in agro – ecosystem.

Allelochemicals:

Chemicals released from the weed termed as ‘allelochemicals’ or ‘allelochemics’, are mostly secondary metabolites, which produced by different physiological processes in plants (Bhadoria, 2011, Farooq et al., 2011a). They released from plants after being produced by the process of secondary metabolism (E.L. Rice, 1984). They do not play any role in primary metabolic process of the plant producing them. The higher concentrations of allelochemicals usually inhibit the growth of plants and soil microorganisms. However, they exhibited stimulatory effects on growth, development, flowering, fruiting and yield at lower concentrations (M.Mallik & R.D. William, 2005). These positive or negative effects of leachates, extracts and residues on recipient plants are based on the stimulatory or inhibitory action of allelochemicals.

Rice (1984); Putnam and Tang (1986) classified these allelochemicals into the following major groups:

1) Flavonoids,
2) Tannins
3) Organic acids and aldehydes
4) Toxic gases
5) Aromatic acids
6) Simple unsaturated lactones

7) Coumarins
8) Alkaloids
9) Terpinoids and steroids
10) Quinines
11) Thiocyanates
12) Purine and nucleiotides
13) Sulphides and glucosides
14) Benzoic acid and derivatives
15) Miscellaneous and unknown

Most of these allelochemic compound act through positive or negative impact on Cell division and cell elongation, Phytohormone induced growth, Membrane permeability, Mineral uptake**,** Stomatal opening and photosynthesis**.** Respiration**,** Protein synthesis and changes in lipid and organic acid metabolism**,** Inhibition and stimulation of specific enzymatic activities (E.L. Rice, 1984 and N.B Mandava, 1985).

Mode of Release of Allelochemicals:

Allelochemicals present in the plant may be release into the environment by the various methods:

Volatilization: by this mode allelopathic plants release the chemical compounds in the form of gas through the small openings in the leaves. The plants growing nearby absorb the toxic chemicals and die. Some oils plants rich in terpenoids and monoterpenoids, may be released continuously to the environment, this process enhanced in hot weather, observed in arid region. Parthenium and Eucalyptus genera release by volatilization.

Leaching: due to various environmental factores, removal of water soluble substance from plants, the leaves fall down on the ground. Some plants store protective chemicals in the leaves which fall down, they decompose and give off chemicals that protect the plant. This fall foliage leaves contains alleleochemicals which inhibit the mitosis in plant toots. Mostly plants leachable, although the degree depends on type of tissue, stage of maturity and type, amount and duration of precipitation. Such type of plants is Camelina weed, contained Benzylamine, adversely affected the growth of linseed plants.

Root exudates: Root exudates are the phenolic compounds (e.g. coumarins) released from intact plants roots into the atmosphere. In some cases it may provide plant with immunity against pytopathogens, sustain the life activity of microflora in the rhizosphere, sustain the life of mycorrhiza to improve mineral nutrition in the plants. But in case of wheat, barley, oat, carrot, and radish, shows inhibitory effect. Factors of root exudates are plant species and age, temperature, light, plant nutrition, microorganism activity around the roots and nature of medium supporting to the roots.

Decomposition: By the mode of decomposition, largest quantity of allelochemicals released which may be added to the rhizosphere. It depends up on the various important variables 1. Nature of plant residue 2. Soil type and 3. Condition of decomposition. .it is estimated that, up to 30% of plants dry matter entering the decay cycle was lignin, formed from alcohols and acids with the skeleton of phenylpropane, the inhibitory substances.

Potential of allelopathic plant:

Allelopathy plays a major role in influencing the productivity of agro ecosystem through its inhibitory or stimulatory interactions. The allelopathic interactions based on the synthesis and release of secondary metabolites by higher plants which initiate a wide array of biochemical reactions and induce several biological changes. Plants having allelopathic potential are listed below which can suppress the growth of sustainable weed from the agricultural field.

Sorghum: it is an important allelopathic crop. Extensive researches have been done on allelochemicals of sorghum, most among these are: hydrophobic p- benzoquinone, Phenolics and acyanogenic glycoside (Weston et al., 2013). Weston et al., (2012) noted that Sorgolene is the most imp allelochemicals of sorghum exuded by

its roots. so the root hair cells are responsible for the sorgolene. Thus, sorghum has a great potential of allelopathic compound which can be used for weed control in agricultural field. Weed may be removed from the field by planting cultivars, applying sorghum mulch and may be used as cover crops and intercrop or as crop rotation.

Rye: it has great allelopathic potential. Schulz et al. (2013) listed 16 allelochemicals found in rye plant such as ß- Phenyllactic acid, protocatechuic acid, DIBOA (glucoside), Vanillic acid, apignenin-glycosides, gallic acid, ferulic acid etc. another studies reported that, the allelopathic inhibition of other crops and weeds by rye (Bertholdsson et al., 2012; Didon et al., 2014; Macias et al., 2014). Thus, it can be used to inhibit the growth of weeds by using cover crop or mulch, rotational crop (Norsworthy et al., 2011; Tabaglio et. al., 2013).

Sunflower: sunflower (*Glycine max*.) is the most important allelopathic plant having the ability to suppress the weed in agricultural field. Alsaadawi et al. (2012) reported that, the allelopathic potential of eight sunflower cultivars against problem weed species in wheat. According to his evaluation, the sunflower cultivars in the study varied in their allelopathic potential and suppressed total weed density by 10-87% and total weed biomass by 34-81% and increased wheat grain yield and yield components over the non treated control. Further study shows that, 16 allelochemicals (phenolic acid) of higher concentration were found across the tested sunflower cultivars.

Brassica: It produces the allelopathic compound glucosinolate throughout the plant body, which varies in different parts of the plant in different concentration (Fahey et al., 2001). Recent literature shows that the allelopathic potential of brassica plants can be used to inhibit the weed by using the brassica plants as cover crops, intercropping brassica crops with the main crop, crop rotation or the use of brassica litter as mulch (Haramoto and Gallandt, 2005; Rice et. al., 2007; Bangarwa and Norsworthy, 2014).

Wheat: Norsworthy et al., (2011) investigated that, wheat cover crops helped to improve weed control (*E. indica*, *Amaranthus palmeri*, *Ipomoea lacunose* L.,) in glyphosphate-resistant cotton under conservation till system.

Berseem with legumes: investigation of Fernandez-Aparicio et al., (2010), noted that, *Orobanche* spp. is the notorious weed parasite which severely damage different crops. It can be suppressed by the exploiting of Berseem as intercropping with legumes.

Allelopathic cultivars for weed control:

The allelopathic potential of crop plants suppresses the weed sustained in agricultural field. Here some crops are summarizes which have the capacity to inhibit or suppress weed.

Table: 1 The allelopathic crops suppressed the weed in agricultural field.

Allelopathic cultivars	Weed sps. suppressed	Allelochemicals	Weed suppressed (%)	References
Rice				
Huagan-3	*E. crus-galli, Cyperus difformis* L.,	-	26-39	(Kong et al., 2011)
P1312777	*Cyperus iria* L., *Lindernia procumbens philcox, Eclipta prostrate* (L.,)Nees,	-	27-51	
Hinohikari	*Lactuca sativa* L.,	Momilactone B	75	(Kato-Noguchi et al.,2010)
BR17	*E. crus-galli, E. colona*	2,9-dihydroxy-4-megastigmen-3-one	42-45	(Salam et al., 2009)
Barley				
Athinaida	*Echinochloa crus-galli* (L.,), P. Beauv., *Setaria verticillata* (L.,)	-	83	(Dhima et al., 2006)
Alpha	*Papaver rhoeas* L., *Veronica hederifolia* L.,		53-58	Dhima et al., 2008)
Rye				
Wheeler	*Amaranthus retroflexus* L., *Eleusine indica* L., Gaertn.	DIBOA	5-95	(Reberg-Horton et al., 2005)
Sorghum				
Enkath	*Sorghum halepense* L., *Cyperus rotondus* L., *Echinocloa colona* L., (Link), *Convolvulus arvensis* L., *Portulaca oleraceae* L.	-	23-44	(Wu et al., 2003; Al –Bedairy et al., 2013)
Wheat				
Rohtas 90	*A. fatua*	-	42-83	(Mahmood et al., 2013)
22 Xiaoyan	*Descurainia sophia* (L.,) Webb ex	-	-	(Zuo et al., 2014)
Sunflower				
Sin- Altheeb	-	Phenolic compounds	74	(Alsaadawi et al., 2012)
Suncross-42	*Rumex dentatus* L., *Chenopodium album* L.,	-	57-67	(Anjum and Bajwa, 2008)

Conclusions

It is concluded from the above discussion due to rising human population, food demand becomes the major problem in world. The revolution of weed in agricultural field weakens the all process of agriculture. Weed play dangerous role in agricultural field which affect the commercial value. But, at the same time, the capability of crop cultivars plays an important role to suppress weeds from the agricultural field. Intercropping, cover crop allelopathy into natural and agricultural management system may reduce the use of herbicides, pesticides, insecticides and other environmental and soil pollution. To ensure continued productivity and potentially reduce synthetic herbicide requirements, Allelopathy is an eco-friendly tool through which, at minimum cost, productivity of important crop can be increased. It will be easily handled and beneficial for commercial purpose.

References

Annett, R., Habibi, H.R., Hontela, A., (2014). Impact of glyphosate and glyphosate based herbicides on the freshwater environment. J. Appl. Toxicol. **34**, 458-479.

Anjum, T.& Bajwa, R., (2008). Screening of sunflower varieties for their herbicidal potential against common weeds of wheat. J. Sustain. Agric. **32**, 213-229.

Alsaadawi, I.S., Sarbout, A.K., Al-Shamma, L.M., (2012). Differential allelopathic potential of sunflower (*Helianthus annuus* L.) genotypes on weeds and wheat (*Triticum aestivum* L.) crop. Arch. Agron. Soil Sci. **58**, 1139-1148.

Al-Bedairy, N.R., Alsaadawi, I.S., Shati, R.K., (2013). Combining effect of allelopathic *Sorghum bicolor* L. (Moench) cultivars with planting densities on companion weeds. Arch. Agron. Soil Sci. **59**, 955-961.

Bahadur S, Verma SK, Prasad SK, Madane AJ, Maurya SP, GAURAV et al., (2015). Eco-friendly weed management for sustainable crop production-A review. Journal Crop and Weed.; **11**(1), 181-189.

Bangarwa, S.K., Norsworthy, J.K., (2014). Brassicaceae cover-crop effects on weed management in plasticulture tomato. J. Crop Improv. **28**, 145-158.

Bertholdsson, N.O., Andersson, S.C., Merker, A., (2012). Allelopathic potential of Triticum spp., Secale spp. and Triticosecale spp. and use of chromosome substitutions and translocations to improve weed suppression ability in winter wheat. Plant Breed. **131**, 75-80.

Bergin, D., (2011). Weed Control Options for Coastal Sand Dunes: a Review. New Zealand Forest Research Institute LTD, pp. 5-13.

Bhadoria P.P.S., (2011). Allelopathy: a natural way towards weed management. Amer. J Exp. Agric. **1**, 7-20.

Carballido, J., Rodríguez-Lizana, A., Agüera, J., P_erez-Ruiz, M., (2013). Field sprayer for inter and intra-row weed control: performance and labor savings. Span. J. Agric. Res. **11**, 642-651.

Chauvel, B., Guillemin, J.-P., Gasquez, J., Gauvrit, C.,(2012). History of chemical weeding from 1944 to 2011 in France: changes and evolution of herbicide molecules. Crop Prot. **42**, 320-326.

Didon, U.M., Kolseth, A.-K., Widmark, D., Persson, P., (2014). Cover crop residues effects on germination and early growth of annual weeds. Weed Sci. **62**, 294-302.

Dhima, K., Vasilakoglou, I., Eleftherohorinos, I., Lithourgidis, A., (2006). Allelopathic potential of winter cereals and their cover crop mulch effect on grass weed suppression and corn development. Crop Sci. **46**, 345-352.

Dhima, K., Vasilakoglou, I., Lithourgidis, A., Mecolari, E., Keco, R., Agolli, X., Eleftherohorinos, I., (2008). Phytotoxicity of 10 winter barley varieties and their competitive ability against common poppy and ivy leaved speedwell. Exp. Agric. **44**, 385-397.

Duke, S.O., and J. Lydon, (1987). Herbicides from natural compounds. Weed Technology, **1**, p. 122-128.

Fahey, J.W., Zalcmann, A.T., Talalay, P., (2001). The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry **56**, 5-51.

Farooq M., Jabran K., Cheema Z. A., Wahid A. & Siddique K.H.M., (2011 a). The role of allelopathy in agricultural pest management. Pest management. Sci. **67**, 493- 506.

Fern_andez-Aparicio, M., Emeran, A.A., Rubiales, D., (2010). Inter-cropping with berseem clover (*Trifolium alexandrinum*) reduces infection by *Orobanche crenata* in legumes. Crop Prot. **29**, 867-871.

Gianessi, L.P., 2013. The increasing importance of herbicides in worldwide crop production. Pest Manag. Sci. **69,** 1099-1105.

Griepentrog, H.W., Dedousis, A.P., (2010). Mechanical Weed Control, Soil Engineering. Springer, pp. 171-179.

Haramoto, E.R., Gallandt, E.R., (2005). Brassica cover cropping: I. Effects on weed and crop establishment. Weed Sci. **53**, 695-701.

Hoppin, J.A., (2014). Pesticides and respiratory health: where do we go from here? Occup. Environ. Med. **71**, 80.

Jabran, K., Farooq, M., (2013). Implications of Potential Allelopathic Crops in Agricultural Systems, Allelopathy. Springer Berlin Heidelberg, pp. 349-385.

Kato-Noguchi, H., Ino, T., Kujime, H., (2010). The relation between growth inhibition and secretion level of momilactone B from rice root. J. Plant Interact. **5**, 87-90.

Kong, C.H., Chen, X.H., Hu, F., Zhang, S.Z., (2011). Breeding of commercially acceptable allelopathic rice cultivars in China. Pest Manag. Sci. **67**, 1100-1106.

Kholi, R.K., H.P. Singh, and D.R. Batish, (2004). Allelopathy in agro ecosystems. Food Products Press. New York, USA.

Mahmood, K., Khaliq, A., Cheema, Z.A., Arshad, M., (2013). Allelopathic activity of pakistani wheat genotypes against wild oat (*Avena fatua* L.). Pak. J. Agric. Sci. **50**, 169-176.

Macias, F.A., Oliveros-Bastidas, A., Marin Mateos, D., Chinchilla, N., Castellano, D., Gonzalez Molinillo, J.M., (2014). Evidence for an allelopathic interaction between rye and wild oats. J. Agric. Food Chem. **62** (39), 9450-9457.

Mandava N.B., (1985). Chemistry and biology of allelopathic agents. In: Chemistry of Allelopathy- Biochemical interactions Among plants. (Ed. A.C. Thomson). ACS Symposium series No. **268**, 33-54. American Chemical Society, New York.

Mallik M. A.B. & William R.D., (2005). Allelopathic growth stimulates of plants and microorganisms. Allelopathy J. **16** (2), 175-178.

Molisch H., (1937). Der. Enflusslinear pflanze auf die andere Allelopathic. Gustac Fischer, Jena, Germany.

Norsworthy, J.K., McClelland, M., Griffith, G., Bangarwa, S.K., Still, J., (2011). Evaluation of cereal and Brassicaceae cover crops in conservation-tillage, enhanced, glyphosate-resistant cotton. Weed Technol. **25**, 6-13.

Oerke, E.-C., Dehne, H.-W., Sctionbeck, F.,Weber, A., (1999). Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops. Elsevier, B.V. Amsterdam, The Netherlands

Pickett, J.A., Aradottír, G.I., Birkett, M.A., Bruce, T.J., Hooper, A.M., Midega, C.A., Jones, H.D., Matthes, M.C., Napier, J.A., Pittchar, J.O., 2014. Delivering sustainable crop protection systems via the seed: exploiting natural constitutive and inducible defence pathways. Philos. Trans. R. Soc. B Biol. Sci. **369**, 20120281.

Powles, S.B., (2008). Evolved glyphosate-resistant weeds around the world: lessons to be learnt. Pest Manag. Sci. **64**, 360-365.

Putnam A.R, Weston L.A. (ed. A. R. Putnam and C.-S. Tang), John Wiley & Sons, (1986), 43-56.

Rajcan, I., Swanton, C.J., (2001). Understanding maize -weed competition: resource competition, light quality and the whole plant. Field Crops Res. **71**, 139-150.

Reberg-Horton, S.C., Burton, J.D., Danehower, D.A., Ma, G., Monks, D.W., Murphy, J.P., Ranells, N.N., Williamson, J.D., Creamer, N.G., (2005). Changes over time in the allelochemical content of ten cultivars of rye (*Secale cereale* L.). J. Chem. Ecol. **31**, 179-193.

Rice, A., Johnson-Maynard, J., Thill, D., Morra, M., (2007). Vegetable crop emergence and weed control following amendment with different Brassicaceae seed meals. Renew. Agric. Food Syst. **22**, 204-212.

Rice E.L., (1984). Allelopathy (2nd Ed.). Academic Press, New York, London.

Rizvi, S.H.J., Mukerjee, D. and Mathur, S.N. (1981). Selective phytotoxicity of 1, 3, 7-trimethylaxanthine between *Phaseolus mungo* and some weeds. Agricultural Biological Chemistry, **45**, p. 1255-1256.

Rueda-Ayala, V., Rasmussen, J., Gerhards, R., Fournaise, N.E., (2011). The influence of post-emergence weed harrowing on selectivity, crop recovery and crop yield in different growth stages of winter wheat. Weed Res. **51**, 478-488.

Salam, M.A., Morokuma, M., Teruya, T., Suenaga, K., Kato-Noguchi, H., (2009). Isolation and identification of a potent allelopathic substance in Bangladesh rice. Plant Growth Regul. **58**, 137-140.

Schulz, M., Marocco, A., Tabaglio, V., Macias, F.A., Molinillo, J.M., (2013). Benzoxazinoids in rye allelopathy-from discovery to application in sustainable weed control and organic farming. J. Chem. Ecol. **39**, 154-174.

Starling, A.P., Umbach, D.M., Kamel, F., Long, S., Sandler, D.P., Hoppin, J.A., 2014. Pesticide use and incident diabetes among wives of farmers in the agricultural health study. Occup. Environ. Med. **71**, 629-635 oemed-2013-101659.

Tabaglio, V., Marocco, A., Schulz, M., (2013). Allelopathic cover crop of rye for integrated weed control in sustainable agroecosystems. Italian J. Agron. **8**, e5. http://dx.doi.org/10.4081/ija.2013.e5.

Weston, L.A., Ryan, P.R., Watt, M., (2012). Mechanisms for cellular transport and release of allelochemicals from plant roots into the rhizosphere. J. Exp. Bot. ers054.

Weston, L.A., Alsaadawi, I.S., Baerson, S.R., (2013). Sorghum allelopathyd from ecosystem to molecule. J. Chem. Ecol. **39**, 142-153.

Wu, H., Pratley, J., Ma, W., Haig, T., (2003). Quantitative trait loci and molecular markers associated with wheat allelopathy. Theor. Appl. Genet. **107**, 1477-1481.

Young, S.L., Pierce, F.J., Nowak, P., (2014). Introduction: Scope of the Problem- rising Costs and Demand for Environmental Safety for Weed Control, Automation: the Future of Weed Control in Cropping Systems. Springer, pp. 1-8.

Zuo, S., Li, X., Ma, Y., Yang, S., (2014). Soil microbes are linked to the allelopathic potential of different wheat genotypes. Plant Soil **378**, 49-58.

Zeng, R.S., (2014). Allelopathy-the solution is indirect. J. Chem. Ecol. **40**, 515-516.

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