REVIEW ARTICLE

ALLELOPATHIC SUPRESSION OF SOME BROAD LEAVED WEEDS

Vijayveer Singh* Abha Arora[2] and Adesh Kumar[3]

[1&2]S.D. College, Muzaffarnagar (U.P.)
[3]M.M.H. College, Ghaziabad (U.P.)

Received-26.11.2017, Revised-30.07.2018

Abstract: Allelopathy is environmentally safe tool for removal of hazardous weeds which interferes with crops in terms of nutrition, space, fertilizers. The weed plants affect the growth of crop plants through secreting certain allelochemical subsances. To solve this problem, a majority of research has been done to evaluate the properties and effects of allelochemicals extracted from plants or procured. In this review effect of allelochemicals on some selected broad leaved weeds like black nightshade (*Solanum nigrum* L.), goatweed (*Ageratum conyzoides* L.), indian mallow (*Abutilon indicum* (Linn.) Sweet, velvetleaf (*Abutilon theophrasti* Medik.), coffee senna (*Cassia occidentalis* L.), sicklepod (*Cassia obtusifolia* L.) have been discussed for their management.

Key words: Allelopathy, Allelochemicals, Crop, Weeds

INTRODUCTION

In 1937, Austrian botanist, Hans Molisch, described this phenomenon as allelopathy, which he determined to be the result of biochemical interactions between plants (Molisch 1937; Putnam and Duke 1978). When first described, allelopathy referred to both deleterious and beneficial interactions between species; since that time, however, allelopathy has been applied to only adverse plant interactions, rather than to both. Allelopathy involves the synthesis of bioactive compounds capable of growth regulation, weed infestation control and pest management that resolve the problem of health defects and environmental pollution caused by ruthless use of synthetic chemicals (Dayan *et al*., 2009; Macías *et al*., 2007). These weeds compete with cultivated crops and retard their growth by releasing the growth inhibiting chemicals. Allelopathy is economical and ecofriendly solution to control such weed infestation and found in different parts of the plants with varying concentration and composition ,and their pathways to release these compounds into the environment are species dependent (Gatti *et al*., 2004).

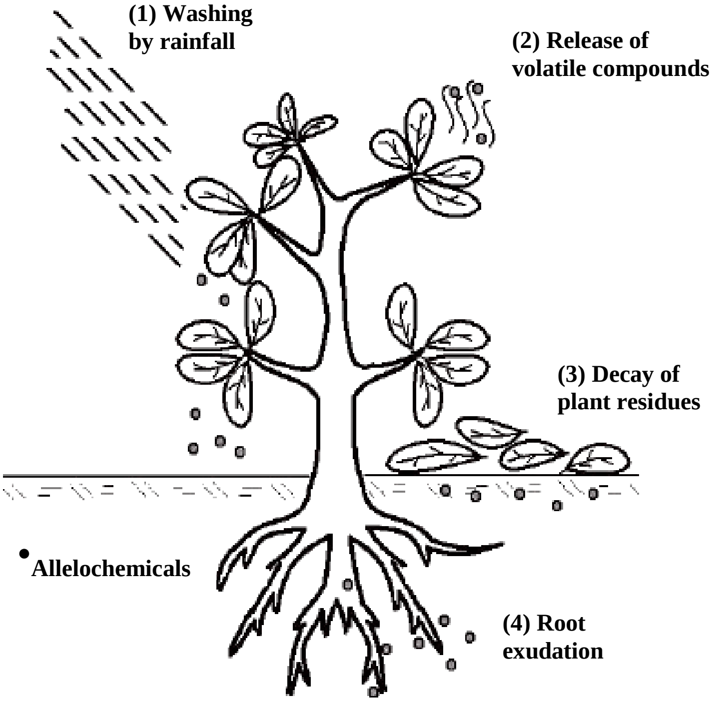

Figure 1: Pathways of releasing allelochemicals from different plant parts

Allelopathins are products of the secondary metabolism and are non-nutritional primary Metabolites (Weir *et al*., 2004; Iqbal and Fry, 2012). These compounds belong to numerous chemical groups including: triketones, terpenes, benzoquinones, coumarins, flavonoids, terpenoids,

*Corresponding Author

strigolactones, phenolic acids, tannins lignin, fatty acids and nonprotein aminoacids. A wide range of these biochemicals are synthesized during the shikimate pathway (Hussain and Reigosa, 2011) or, in the case of essential oils, from the isoprenoid pathway. Allelochemicals can be classified into 10 categories (Li *et al*., 2010) according to their different structures and properties:

1. Water-soluble organic acids, straight-chain alcohols, aliphatic aldehydes, and ketones
2. Simple lactones
3. Long-chain fatty acids and polyacetylenes
4. Quinines (benzoquinone, anthraquinone and complex quinines)
5. Phenolics
6. Cinnamic acid and its derivatives
7. Coumarins
8. Flavonoids
9. Tannins
10. Steroids and terpenoids (sesquiterpene, lactones, diterpenes, and triterpenoids).

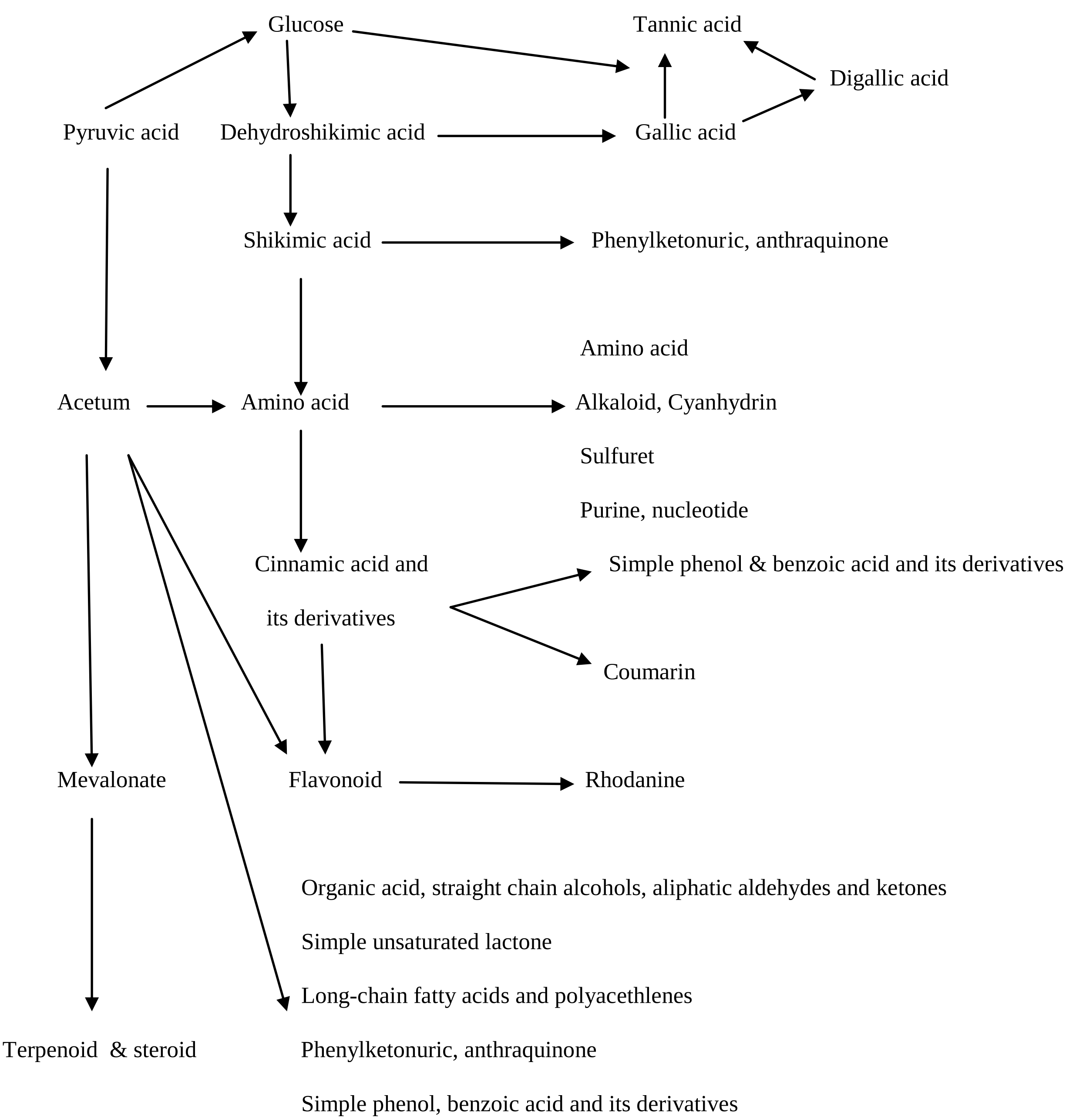

Figure 2: Major pathways leading to production of the various categories of allelochemicals (Source: Wang *et al*., 2006).

Based on the morphology of the plant, the weeds are also classified in to three categories. This is the most widely used classification by the weed scientists.

(a) Grasses: All the weeds come under the family Poaceae are called as grasses which are characteristically having long narrow spiny leaves. The examples are Sawa millet (*Echinochloa colona*), Indian doab (*Cynodon dactylon*) etc.

(b) Sedges: The weeds belonging to the family Cyperaceae come under this group. The leaves are mostly from the base having modified stem with or without tubers. The examples are Purple Nutsedge (*Cyperus rotundus*),Grasslike Fimbry (*Fimbrystylis miliacea*) etc.

(c) Broad leaved weeds: This is the major group of weeds as all other family weeds come under this except that is discussed earlier. All dicotyledon weeds are broad leaved weeds. The examples are Black Nightsade (*Solanum nigrum* L.), Goatweed (*Ageratum conyzoides* L.), Indian mallow (*Abutilon indicum* (Linn.) Sweet), Velvetleaf (*Abutilon theophrasti* Medik.), Coffee senna (*Cassia occidentalis* L.) and Sicklepod *Cassia obtusifolia* L.) etc.

Allelopathic suppression of black nightshade (*Solanum nigrum* L.)

Allelopathic effects of Eucalyptus species have been widely reported and considered as a natural way for sustainable weed management. Phytotoxic effects of various solvent extracts (aqueous, methanolic, ethyl a cetate, acetonic and benzene) and different concentrations of extracts (0, 1.25, 2.5, 5 and 10 gram per liter) of *E. globulus* leaves against Solanum nigrum weed indicated that with increasing of extract concentration germination percentage and rate, root and shoot lengths and fresh and dry weights significantly decreased. (Ataollah *et al*., 2014). Sadeghi *et al*. (2010) reported that sunflower extracts reduced *S. nigrum* hypocotyl length, hypocotyl weight, radicle weight, seed germination and radicle length by as much as 56, 64, 61, 77 and 81% respectively, when compared with a water control. Increasing the water extract concentrations from 5 to 25g per 100 ml of water of all sunflower parts significantly increased the inhibition of *S. nigrum* germination, seedling length and weight. Uremis *et al*. (2009) reported that shoot and root extracts of rapeseed cultivars inhibited seed germination, seedling and root growth of *S. nigrum* are investigated in proportion related to the concentration of extracts. Arouiee et al. (2010) reported that the allelopathic effects of leaf extracts of *Thymus vulgaris, Lavadula sp, Rosmarinus officinalis and Eucalyptus citriodora* at five levels (0, 10, 20, 30 and 100 %) on seed germination and some growth characteristics of *Solanum nigrum* was investigated. The internode length and plant height, node number and leaves total chlorophyll content decreased with increasing rate of extracts. When dried alfalfa residues were mixed into vermiculite, germination, length of shoot and root of *Solanum nigrum*, were significantly inhibited as the dried residue concentration increased. More than 10% concentration of the dired residue caused 80% germination and growth inhibition (Yu *et al*., 1995).

Allelopathins	**Source**	**References**	**Sensitive Weed**
Solvent extracts	*Eucalyptus globules*	Ataollah *et al*., 2014	Black nightshade (*Solanum nigrum*)
Water extracts	Sunflower	Sadeghi *et al*., 2010	″
Root and shoot extracts	Rapeseed	Uremis *et al*., 2009	″
Leaf extracts	*Thymus vulgaris, Lavadula sp, Rosmarinus officinalis and Eucalyptus citriodora*	Arouiee *et al*.,2010	″
Dried residue	Alfalfa	Yu *et al*., 1995	″

Allelopathic suppression of Goatweed (*Ageratum conyzoides* L.)

Allelopathic effects of the aqueous extract of the leaf and seed of *Leucaena leucocephala* were tested on goatweed (*Ageratum conyzoides*). Germination, shoot length, root length and fresh weight of goatweed were reduced in response to respective increasing concentrations of the seed and leaf extracts (Ishak and Sahid, 2014). Biswas *et al*. (2014) reported that *Brassica* crops were uprooted at 30 days after sowing (DAS) and incorporated to the soil @ 0.5 kg m^{-2} as per treatment. Wheat seeds were sown on December 04, 2007 using 20 cm line to line distance. *Ageratum conyzoides* was not found in the wheat field. Sharma *et al*. (2017) reported that aqueous leaf extracts of *Withania somnifera* in 100% w/v concentrations were sprayed on three month old seedlings of weeds at an interval of 5 d. All the aqueous extracts significantly suppressed shoot length, root length, fresh weight and dry weight of *Ageratum conyzoides.* Xuan *et al*. (2016) reported that the allelopathic potential of sweet potato varieties was determined to control invasive weed goatweed (*Ageratum conyzoides* L.) in crop fields. The phytotoxic potential of eugenol, a major component from the essential oil of clove [*Syzygium aromaticum* (L.) Merrill and Perry], was investigated against *Ageratum conyziodes* L. The effect of eugenol (50–1,000 μM) on the growth and development of seedlings after 7 days of treatment was studied in terms of percent germination, root and shoot length, total chlorophyll content and cellular respiration (Ahuja *et al*., 2015). A significant effect on weed emergence and early seedling growth was observed in a dose-response based laboratory bioassay in a sand culture. Emergence of *A. conyzoides* was completely inhibited at 100 μg/g sand content of citronellal. Seeds of *A. conyzoides* failed to emerge even at 50 μg/g content. Root length was inhibited more caused visible injury in the form of chlorosis and necrosis, leading to wilting and even death of *A. conyzoides* (Singh *et al*. (2006).

Allelopathins	Source	References	Sensitive Weed
Aqueous extracts of leaf and seed	*Leucaena leucocephala*	Ishak and Sahid, 2014	Goatweed (*Ageratum conyzoides* L.)
Soil incorporation in wheat field	*Brassica spp.*	Biswas *et al*., 2014	″
Aqueous leaf extracts	*Withania somnifera*	Sharma *et al*., 2017	″
Stem extracts	*Ipomoea batatas*	Xuan *et al*., 2016)	″
Eugenol	*Syzygium aromaticum*	Ahuja *et al*., 2015	″
Citronellal	Procured in pure form	Singh *et al*., 2006	″

Allelopathic suppression of Sicklepod (*Cassia obtusifolia* L.) and Coffee Senna (*Cassia occidentalis* L.)

The allelopathic potential of wild radish was evaluated in controlled environments by determining if an aqueous extract from oven-dried wild radish shoots suppressed germination and radicle growth of *Cassia obtusifolia* (Norsworthy, 2003). Raoof and Siddiqui (2012) reported the allelopathic effects of *Tinospora cordifolia* weed on seed germination and seedling growth of sicklepod. Leaf extracts of *Psidium guajava* were used to investigate allelopathic potential against seed germination and growth of *Cassia occidentalis*. (Kawawa *et al*., 2016). (Singh *et al*. (2006) reported that upon citronellal treatment, there was loss of chlorophyll pigment and reduction in cellular respiration indicating the impairment of photosynthetic and respiratory metabolism. Scanning electron microscopic studies in *C. occidentalis* leaves upon treatment of citronellal revealed disruption of cuticular wax, clogging of stomata and shrinkage of epidermal cells at many places. The phytotoxic potential of eugenol, a major component from the essential oil of clove [*Syzygium aromaticum* (L.) Merrill and Perry], was investigated against *Cassia occidentalis* The effect of eugenol (50–1,000 μM) on the growth and development of seedlings after 7 days of treatment was studied in terms of percent germination, root and shoot length, total chlorophyll content and cellular respiration (Ahuja *et al*., 2015). The effect of volatile oil from leaves of *Eucalyptus citriodora* against *Cassia occidentalis* was investigated. In a laboratory bioassay seed germination, chlorophyll content and cellular respiration *Cassia occidentalis* were significantly reduced in response to the different concentrations of the eucalypt oil (Batish *et al*., 2004). Again a similar study was undertaken to assess the allelopathic potential of citonellol, a volatile monoterpene found in *Eucalyptus citriodora, E. globulus, Ocimum basilicum, Zingiber officinale, Coriandrum sativum, Citrus limon* and several other aromatic plants, against *Cassia occidentalis*. Citonellol was found to appreciably inhibit the germination and seedling growth even at very low concentrations. Not only the growth, even the content of total chlorophyll and cellular respiration in *Cassia occidentalis* was reduced quite significantly, thereby indicating that citronellol has a negative effect on the photosynthetic efficiency and the energy metabolism of *Cassia occidentalis* (Vaid, 2016a). A similar study was also carried out by same researcher to assess the inhibitory potential of linalool, a volatile monoterpene found in many flowers and spice plants against coffee-weed, *Cassia occidentalis*. Linalool was found to have a significant inhibitory effect on the germination and early seedling growth of the test weed. The physiological parameters *viz.* the content of total chlorophyll and percent cellular respiration of the test weed were also reduced to varying degrees compared to control, indicating a negative effect of the test monoterpene on the photosynthetic efficiency and energy metabolism of *Cassia occidentalis* (Vaid, 2016b).

Allelopathins	Source	References	Sensitive Weeds
Aqueous extracts of shoot	Wild radish	Norsworthy, 2003	*Cassia obtusifolia* (Sicklepod)
Aqueous extracts of root	*Tinospora cordifolia*	Raoof and Siddiqui, 2012	″
Leaf extracts	*Psidium guajava*	Kawawa *et al*., 2016	*Cassia occidentalis* (Coffee senna)
Citronellal	Procured in pure form	Singh *et al*., 2006	″
Eugenol	*Syzygium aromaticum*	Ahuja *et al*., 2015	″
Eucalypt oil	*Eucalyptus citriodora*	Batish *et al*., 2004	″
Citronellol	Aromatic plants	Vaid, 2016a	″
Linalool	Spice plants	Vaid, 2016b	″

Allelopathic suppression of Indian Mallow [*Abutilon indicum* (Linn.) Sweet] and Velvetleaf (*Abutilon theophrasti* Medik.)

Seed germination and seedling growth of velvetleaf were inhibited by the wheat-straw extracts (Steinsiek *et al*., 1982). Benzyl isothiocyanate (BITC) was extracted from mature papaya (*Carica papaya* L.) seeds and applied to to etiolated velvetleaf seedlings at 4×10^{-4} M, 100% died in 2 days (Wolf *et al*., 1984). Liu *et al*. (2006) reported that the allelopathic effect of aqueous extract from the aerial part and root of *T. repens* under different concentrations on the germination rate, physiological and biochemical mechanism of germinating seeds of *Abutilon theophrasti* Medic. was studied. Citronellol and citral exhibited inhibiting germination of velvetleaf (Liu *et al*., 2006). Fanaei *et al*. (2013) reported that chlorophyll content of *Abutilon theophrast* decreased by using of extract different concentration of Sweet basil. Younesabadi *et al*. (2014) reported that the inhibitory effects of water extracts of *A. camelorum*, *A. annua*, *I. graveolens*, *X. strumarium*, *C. bonariensis* and *S. nigrum* on *A. theophrasti* growth and germination. Decaying leaves and inflorescences, and field soils collected beneath *Chenopodium ambrosioides* and *C. murale* were examined in terms of the inhibition of seed germination and seedling growth of *Abutilon indicum*. The respective plant-parts from the two species were chemically analysed and the presence of three terpenes (p-cymene, ascaridole and aritazone) from *C. ambrosioides* and an organic acid (oxalic acid) from *C. murale* were implicated in the allelopathic effect (Datta and Ghosh, 1987).

Allelopathins	Source	References	Sensitive Weeds
Straw extracts	Wheat	Steinsiek *et al*., 1982	Velvetleaf (*Abutilon theophrasti*)
Benzyl isothiocyanate (BITC)	Papaya (*Carica papaya* L.)	Wolf *et al*., 1984	″
Aqueous extracts of aerial part and root	*Trifolium repens*	Liu *et al*., 2006	″
Citronellol and Citral	Procured in pure form	Liu *et al*., 2006	″
Water extracts	Sweet basil	Fanaei *et al*., 2013	″
Water extracts	*A. camelorum*, *A. annua, I. graveolens, X. strumarium*, *C. bonariensis* and *S. nigrum*	Younesabadi *et al*., 2014	″

Decaying leaves and inflorescences	*Chenopodium ambrosioides* and *C. murale*	Datta and Ghosh, 1987	Indian mallow (*Abutilon indicum*)

REFERENCES

Ahuja, N., Batish, D. R., Singh, H. P. and Kohli, R. K. (2015). Herbicidal activity of eugenol towards some grassy and broad-leaved weeds. *Journal of Pest Science.* **88(1)**: 209-218.

Arouiee, A., Quasemi, S., Azizi, M. and Nematy, H. (2010). Allelopathic effects of some medicinal plants extracts on seed germination and growth of common weeds in mashhad area. *The 8th International Symposium on Biocontrol and Biotechnology Proceedings* pp139-147.

Ataollah, R., Dejam, M. and Khaleghi, S. S. (2014). Phytotoxic effects of *Eucalyptus globulus* leaf extrat on *Solanum nigrum. South west J Hortic Biol Environ*. **5(1)**: 43-53

Batish, D. R., Setia, N., Singh, H. P. and Kohli, R. K. (2004). Phytotoxicity of lemon-scented eucalypt oil and its potential use as a bioherbicide. *Crop Protection*. **23(12)**: 1209-1214.

Biswas, P. K., Morshed, M. M., Ullah, M. J. and Irin, I. J. (2014). Allelopathic effect of *Brassica* on weed control and yield of wheat. *Bangladesh Agron. J.* **17(1)**: 73-80.

Datta, S. C. and Ghosh, K. N. (1987). Allelopathy in two species of *Chenopodium* inhibition of germination and seedling growth of certain weeds. *Acta Societatis Botanicorum Poloniae*. **56(2)**: 257-270.

Dayan, F. E., Cantrell, C. L. and Duke, S. O. (2009). Natural products in crop protection. *Bioorganic & medicinal chemistry*. **17**: 4022-4034.

Fanaei, M., Aboutalebi, A. and Hasanzadeh, H. (2013). Allelopathic effects of Sweet basil (*Ocimum basilicum*) extract and essence on chlorophyll content of three weed species. *Intl. Res. J. Appl. Basic. Sci.* **4 (6)**: 1511-1513.

Gatti, A. B., Perez, S. C. J. G. D. and Lima, M. I. S. (2004). Atividade alelopática de extratos aquosos de Aristolochia esperanzae O. Kuntze na germinação e no crescimento de *Lactuca sativa* L. e *Raphanus sativus* L. *Acta Botanica Brasilica*.

Hussain, M. I. and Reigosa, M. J. (2011). Allelochemical stress inhibits growth, leaf water relations, PSII photochemistry, non-photochemical fluorescence quenching, and heat energy dissipation in three C3 perennial species. *Journal of Experimental Botany*. , **62(13)**: 4533-4545.

Iqbal, A, and Fry, S. C. (2012). Potent endogenous allelopathic compounds in *Lepidium sativum* seed exudate: effects on epidermal cell growth in *Amaranthus caudatus* seedlings. *Journal of Experimental Botany*. **63(7)**: 2595-2604.

Ishak, M. I. and Sahid, I. (2014). Allelopathic effects of the aqueous extract of the leaf and seed of *Leucaena leucocephala* on three selected weed species. *AIP Conf. Proc*. pp 659-664.

Kawawa, R. C. A., Muyekho F. N., Obiri, J. F. , Agevi, H. and Obiet, L. (2016). The allelopathic impact of *Psidium guajava* L., leaf extracts on the germination and growth of *Cassia occidentalis* L.,seeds. *Journal of Agriculture and Veterinary Science*. **9(7)**: 101-105.

Li, Z. H., Wang, Q., Ruan, X., Pan, C. D. and Jiang, D. A. (2010). Phenolics and Plant Allelopathy. *Molecules*. doi:10.3390/molecules15128933, **15(12)**: 8933-8952.

Liu, Y., Wang, Jin-xin., Hu, Y., Dong, Xiao-wen. and Zhang, M. (2006). Allelopathy of *Trifolium repens* L. on *Abutilon theophrasti* Medic.and *Echinochloa crusgalli* L. *Acta Phytophylacica Sinica*. **33(4)**.

Macías, F. A., Molinillo, J. M., Varela, R. M. and Galindo, J. C. (2007). Allelopathy—a natural alternative for weed control. *Pest Management Science*. **63**: 327-348.

Molisch, H. (1937). *Der Einfluss einer Pflanze auf die andere-Allelopathie.* Fischer, Jena.

Norsworthy, J. K. (2003). Allelopathic potential of wild radish (*Raphanus raphanistrum*). *Weed Technology*. **17(2)**: 307-313.

Putnam, A. R., and Duke, W. B. (1978). Allelopathy in agroecosystems. *Annual Review of Phytopathology*. **16**: 431-451.

Raoof, K. M. A. and Siddiqui, M. B. (2012). Allelopathic effect of aqueous extracts of different parts of *Tinospora cordifolia* (Willd.) Miers on some weed plants. *Journal of Agricultural Extension and Rural Development*. **4(6)**: 115-119.

Sadeghi, S., Rahnavard, A. and Ashrafi, Z. Y. (2010). Allelopathic effect of Helianthus annuus (sunflower) on Solanum nigrum (black nightsade) seed germination and growth in laboratory condition. *Journal of Horticultural Science & Ornamental Plants*. **2(1)**: 32-37.

Sharma, M., Kaur, R. and Puri, S. (2017). Bio-herbicidal efficiency of *Withania somnifera* against important himalayan weeds. *Int J Pharm Pharm Sci*. **9(3)**: 88-97.

Singh, H. P., Batish, D. R., Kaur, S. and Kohli, R. K. (2006). Phytotoxicity of the volatile monoterpene citronellal against some weeds. *Z. Naturforsch*. **61c**: 334-340.

Steinsiek, J. W., Oliver, L. R. and Collins, F. R. (1982). Allelopathic potential of wheat (*Triticum aestivum*) straw on selected weed species. *Weed Science*. **30**: 495-497.

Uremis, I., Arslan, M., Sangun, M. K., Uygur, V. and Isler, N. (2009). Allelopathic potential of rapeseed cultivars on germination and seedling growth of weeds. *Asian Journal of Chemistry*. **21(3)**: 2170-2184.

Vaid, S. (2016a). Phytotoxicity of citronellol against two weedy species. *Int.J Curr.Microbiol. App. Sci.* **5(1)**: 560-564.

Vaid, S. (2016b). Potential of linalool for inhibition of *Cassia occidentalis*. *Int.J.Curr.Res.Aca.Rev.* **4(1)**: 155-159.

Vaughn, S. F. and Spencer, G. F. (1993). Volatile monoterpenes as potential parent structures for new herbicides. *Weed Science*. **41**: 114-119.

Wang, Q., Ruan, X., Li, Z. H. and Pan, C. D. (2006). Autotoxicity of plants and research of coniferous forest autotoxicity. *Sci. Sil. Sin.***43**: 134-142.

Weir, T. L, Park, S-W. and Vivanco, J. M. (2004). Biochemical and physiological mechanisms mediated by allelochemicals. *Current Opinion in Plant Biology*. **7(4)**: 472-479.

Wolf, R. B., Spencer, G. F. and Kwolek, W. F. (1984). Inhibition of velvetleaf *(Abutilon theophrasti)* germination and growth by benzyl isothiocyanate, a natural toxicant. *Weed Science*. **32**: 612-615.

Xuan, T. D., Minh, T. N., Trung, K. H. and Khanh, T. D. (2016). Allelopathic potential of sweet potato varieties to control weeds: *Imperata cylindrica*, *Bidens pilosa* and *Ageratum conyzoides*. *Allelopathy Journal*. **38(1)**: 41-54.

Younesabadi, M., Habibian, L. and Savarinejad, A. R. (2014). Using of plant extracts in control of Abutilon theophrasti Medicus. *International Journal of Farming and Allied* Sciences. **3(5)**: 483-488.

Yu, C. Y., Jeon, I. S., Chung, I. M., Hur, J. H. and Kim, E. H. (1995). The allelopathic effect of Alfalfa residues on crops and weeds. *Korean Journal of Weed Science*. **15(2)**: 131-140.