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Chapter 11
Applied Allelopathy in Weed Management: An Update

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Abstract Allelopathic phenomenon perpetuating in nature is of considerable significance, which has gained even more importance these days. Field applications of allelopathy have attracted the attention of scientists as an alternate to weedicide use. In this chapter, allelopathy development and its application for weed management have been reviewed over the last two decades. Allelochemicals of potential herbicidal activity, developed bioherbicides from plants or microorganisms, plant species of allelopathic properties and the inflicted weeds, allelopathy forms, and methods of application have been documented. Some implications on allelopathic crops and their utilization in agricultural system, and positive and negative impact of allelopathy on cultivated crops and weeds have also been evaluated. Constraints associated with allelopathy application for weed management in the field, results obtained and conclusions drawn based on certain findings are discussed. Prospects of allelopathy as a possible strategy for weed management, for development of eco-friendly bioherbicides, and its importance for sustainable agriculture are also discussed. Some recent findings on molecular aspects of allelopathic species and the genetic basis of produced allelochemicals have been described.

Keywords Allelopathy · Field application · Weed management · Bioherbicides · Allelochemicals · Allelopathic crops · Weeds · Allelopathy formulations in the field

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11.1 Introduction

Allelopathy as a natural mechanism and new tool for pest management in the field has been more developed in the last 2–3 decades than its entire previous history (Willis 1996, 1997, 2004). A large number of publications is available; hundreds are yearly accumulating on different aspects of the subject, and published in a range of journals worldwide (Carral-Vilarifio 2002; Qasem 2007). A multidisciplinary allelopathy subject has been revealed in recent years and resulted in the discovery of a large number of allelochemicals that possess pesticidal properties and formulations of more are now being commercialized in world markets as alternatives to a number of synthetic pesticides. Many reference books were published, and several world congresses, national meetings, workshops, and symposia were held on the subject across the globe (Qasem 2010).

The last two decades have witnessed the birth of International Allelopathy Society (IAS) and the establishment of many new allelopathy societies/chapters worldwide. During the same period, many isolated and identified allelochemicals were biologically studied on plants and at the molecular level. These have been already tested against different agricultural pests and some proved potent, with no phytotoxicity (Rizvi 1994). These allelochemicals are known now to the industry and potentially considered as chemicals of the future pest control strategy with no adverse effects on environment.

Application of allelopathy under field conditions for pest management (including weeds) is another important development on the subject. New methods, techniques, and advance technologies are now employed for better pest control and for isolation of allelopathy from other mechanisms of plants interference in nature. However, significant achievement and the breakthrough in allelopathy research would be the development of genetically engineered allelopathic and self-defense crops that can avoid agricultural problems or pest hazards. This, however, remains the future task of researchers in this field of science by which allelopathy would be highly recognized.

The present chapter highlights recent developments on the role of allelopathy in weed management under field conditions, and its possible implementation or integration for more successful weed management programs. Crops or other plant species of allelopathic effects, inflicted weeds, and the treated crops have been reviewed. In addition, allelochemicals reported as potentially effective and important for herbicides industry have been tabulated. Updated research results, on applied allelopathy for weed management in different crops, would greatly help weed researchers as well as farmers in planning effective weed control programs for better crop production.

11.2 Bioherbicides of Plants/Microorganisms Origin and Allelopathic Chemicals of Potential use as Herbicides

Out of the 7,50,000 existing plant species only 5–15 % have been screened for biologically active compounds, and from the total 4,00,000 estimated secondary metabolites in plants, only 10,000 have been characterized. While almost all allelochemicals exist in plants in nontoxic, conjugated forms (Putnam 1988), chemicals of pesticide properties identified from 2,121 plant species belong to more than 30 plant families (Grainge and Ahmed 1988; Dhawan and Dhaliwal 1994). The main role of allelochemicals in plants is defensive, which is important and attractive for pesticide industry (Varma and Dubey 2006). However, allelochemicals are believed to affect plant germination, growth, densities and distribution, but only few were found active enough to be developed as commercial herbicides, including Callisto, Triketones, and Glufosinate (based on a natural product Bialaphos from phosphinothricin in plants), naphthalenediones (SeaKlean), and Neem (*Azadirachta indica*) that alone has more than 200 formulations in the world market. Natural products with herbicidal properties are believed to be less in number than for other pesticides (Pachlatko 1998), and generally less active than synthetic herbicides, although some are produced in relatively higher quantities (BIBOA and as much as 14 kg ha^{-1}). However, recent studies reported a large number of allelochemicals from microbes or plants of potential use as herbicides (Table 11.1), and have provided structural models for herbicides industry (Duke and Abbas 1995; Duke et al. 1996, 1997, 1998, 2000; Duke 2002; Belz 2007; Macias et al. 2007). Some work on the mode of action of these allelochemicals (Duke et al. 2005), and on their genetic basis has been reported.

11.3 Plants of Herbicidal Activities

Recommended allelopathic plant species for weed management in different crops and those for general weed control are shown in Table 11.2. A total of 111 species were reported to exert allelopathic effect under field conditions, used in 43 crops and in 11 uncultivated sites for general weed control. Target weeds were 78 species among which are many noxious species. The most frequently reported allelopathic species, inflicted weeds, and treated crops are summarized in Table 11.3.

Most literature is concentrated on certain allelopathic crops important for weed management including: cereals (*Avena* spp., *Digitaria sanguinalis, Festuca* spp., *Hordeum vulgare*, *Imperata cylindrica, Lolium* spp., *Oryza sativa*, *Sorghum* spp., *Triticum aestivum*, and *Zea mays*), certain legumes (*Glycine max, Medicago* spp., *Vicia* spp. including *Vicia villosa*, and *Trifolium* spp.), and certain crucifer species (Oleszek et al. 1994). Genetic variations among cultivars of different crop species

Table 11.1 Natural herbicides and allelochemicals of potential use as herbicides and their origin

Natural chemical/bioherbicide name	Origin	Reference
1,8-Cineole	Plants	Duke and Abbas (1995)
2,5-anhydro-D-glucitol	Microorganisms (*Fusarium solani*)	Duke (2002)
AAL-toxin	Microorganisms (*Alternaria alternata*)	Abbas et al. (1995); Duke and Abbas (1995)
Agrostemin	Plants (*Agrostemma githago*)	Chou (2010)
Alaphos	Microorganisms	Putnam (1983)
Alectrol	Plants (*Vigna unguiculata*)	Qasem (2006)
Anisomycin	Microorganisms (*Streptomyces griseolus*)	Prakash and Pahwa (1994)
Acetic acid (organically produced)	Plants	Duke and Dayan (2009)
Australifungin	Microorganisms (*Sporormiella australis*)	Abbas et al. (1998)
Benzanin (based on Benzoxazinones)	Plants	Prakash and Pahwa (1994), Villagrasa et al. (2009)
Bialaphos (degraded to phosphinothericin in plants)	Microorganisms (*Streptomyces hygroscopicus*, *Streptomyces vividochromogenes*)	Putnam (1983); Prakash and Pahwa (1994); Duke and Abbas (1995); Duke et al. (2000)
Botcinol A	Microorganisms (*Botrytis cinerea*)	Chaudhari et al. (1994)
Botcinolide	Microorganisms (*Botrytis cinerea*)	Chaudhari et al. (1994)
Callisto	Plants (*Callistemon citrinus*)	An and Pratley (2005)
Catechin	Macrophyte (*Myriophyllum spicatum*)	Macias et al. (2007)
Cinmethylin (Cineole analog)	Plants	Prakash and Pahwa (1994); Duke et al. (2000); Varma and Dubey (2006)
Coaristeromycin	Microorganisms (Actinomycetes)	Cutler (1999)
Coformycin	Microorganisms	Cutler (1999)
Colletotrichin	Fungi (*Colletotrichum* spp.)	Duke et al. (1992)
Corn gluten meal (MGM)	Plants (*Zea mays*)	Christians (1995)
Coumarins	Plants (*Helianthus annuus*)	Macias et al. (1994)
Cyanamide	Plants (*Vicia villosa*, *Vicia cracca*, *Robinia pseudoacacia*)	Fujii et al. (2008)

(continued)

Table 11.1 (continued)

Natural chemical/bioherbicide name	Origin	Reference
Cyanobacterin	Microorganisms	Sobokta (1997)
Cytochalasins	Microorganisms and Plants	Prakash and Pahwa (1994)
DIBOA	Plants (*Triticum aestivum*)	Macias et al. (2005)
Dihydro prehelminthosporal	Microorganisms (*Bipolaris* sp.)	Varma and Dubey (2006)
DIMBOA	Plants (Cereals)	Kluge et al. (1995)
Dihydro-5,6-dehydrokawain (DDK)	Plants	Khanh et al. (2007)
Dimethyl phosphorothioate	Plants	Khanh et al. (2007)
Diterpene lactones (e.g. Artemisinin, Chaparrinon)	Plants	Dayan et al. (1999a, b)
Essential oils (carvacrol, linalool)	Plants (*Zataria multiflora*)	Saharkhiz et al. (2010)
Flavonoids	Plants (*Helianthus annuus*)	Macias et al. (1994)
Fumonisins	Microorganisms (*Fusarium moniliforme*)	Abbas et al. (1995)
Gallic acid	Plants	Prakash and Pahwa (1994)
Glucosinolates	Plants (*Rorippa sylvestris* and *Rorippa indica*)	Yamane et al. (1992a, b)
Glyphosinate (Phosphinothricin based)	Microorganisms (*Streptomyces* spp.)	Duke and Abbas (1995); Duke (2002)
Gostantin	Microorganisms	Sobokta (1997)
Heliannuol	Plants (*Helianthus annuus*)	Macias et al. (1994)
Herbicidins	Microorganisms (*Streptomyces saganonensis* No. 4075)	Prakash and Pahwa (1994), Cutler (1999)
Herboxidiene	Microorganisms	Sobokta (1997)
Homoalanosine	Microorganisms	Sobokta (1997)
Hydantocidin	Microorganisms (*Streptomyces hygroscopicus* SANK 63584)	Sobokta (1997); Hoagland and Cutler (1998)
Hypericin	Plants	Duke et al. (1996); Tellez et al. (1999)
Isoxazole-4-carboxylic acid	Microorganisms	Sobokta (1997)
Kerlinic acid	Plants (*Salvia beerlii*)	Gonzalez-Ibarra et al. (2002)
Koninginins A,B,C	Microorganisms (*Trichoderma koningli*)	Cutler and Parker (1994)

(continued)

Table 11.1 (continued)

Natural chemical/bioherbicide name	Origin	Reference
Leptospermone	Plants (*Callistemon citrinus*)	Mitchell et al. (2001)
Lignas	Plants (*Helianthus annuus*)	Macias et al. (1994)
Maize gluten	Plants (*Zea mays*)	Duke and Dayan (2009)
Malinoformin	–	Prakash and Pahwa (1994)
Margosan-O	Plants (*Azadirachta indica*)	Dhawan and Dhaliwal (1994)
Myrigalone A (3-(1-oxo-3-phenylpropyl)-1,1,5-trimethylcyclo-hexane-2,4,6-trione)	Plants (*Myrica gale*)	Popovici et al. (2011)
Mesotrione (modified structure of leptospermone)	Plants (*Callistemon citrinus*)	Mitchell et al. (2001)
Methoxyphenone (anisomycin based)	Plants	Prakash and Pahwa (1994)
Momilactone B	Plants (*Oryza sativa*)	Kato-Noguchi (2011)
Monesin	Microorganisms (*Streptomyces cinnamonensis*)	Hoagland and Cutler (1998)
Monoterpenes (citronellol, citronellal, linalool)	Plants	Singh (2004)
Naphthalendiones (SeaKlean, Vitamin K)	–	Cutler and Cutler (2002)
Neem (*Melia azedarach*) products	Plants (*Melia azedarach*)	Chou (2010)
Nigericin	Microorganisms (*Streptomyces hygroscopicus*)	Hoagland and Cutler (1998)
Orobanchol	Plants (*Trifolium pretense*)	Cited by Qasem (2006)
Parasorbic acid	Plants (Mountain ash, *Sorbus Americana*)	Putnam (1983)
Patulin	Microorganisms (Fungi including *Penicillium urticae*)	Putnam (1983)
Pelargonic acid-based products	Plants (*Pelargonium* sp.)	Duke and Dayan (2009)
Phenanthrenoids	*Juncus effuses*	DellaGreca et al. (2002)
Phosalacine	Microorganisms	Sobokta (1997)
Phosphinothricin (PPT) (Glufosinate)	Microorganisms (*Streptomyces viridochromogenes*)	Hoagland and Cutler (1998)

(continued)

Table 11.1 (continued)

Natural chemical/bioherbicide name	Origin	Reference
Phytobabine-2	–	Orel (1994)
phytobaphum	–	Orel (1994)
Phytopacine	–	Orel (1994)
Phytosphingosine	Microorganisms (fungi) and Plants	Abbas et al. (1995)
Prehelminthosporal	Microorganisms (*Bipolaris* sp.)	Varma and Dubey (2006)
Prohydrojasmon	Plants	Zuo et al. (2010)
Pseudoonic derivatives	Microorganisms (*Pseudomonas fluorescence*)	Sobokta (1997)
Pyridazocidin	Microorganisms (*Streptomyces species*)	Hoagland and Cutler (1998)
Quassinoids	Plants (Simaroubaceae)	Lin et al. (1995)
Rotenone	Plants	Putnam (1983)
Salannin	Plants (*Azadirachta indica*)	Dhaliwal and Arora (1994)
Sesquiterpenes	Plants (*Helianthus annuus*)	Macias et al. (1994); Dayan et al. (1999a, b)
Sorgeolon	*Sorghum* spp.	Nimbal and Weston. (1996); Hoagland and Cutler (1998); Rimando et al. (1998); Duke et al. (2002)
Sphingoid		Abbas and Boyette (1993)
Strigol	*Sorghum* spp.	Rimando et al. (1998)
Tentoxin	Microorganisms	Duke and Abbas (1995); Sobokta (1997)
Trialphos	Microorganisms	Sobokta (1997)
TRIBOA	Plants (Cereals)	Kluge et al. (1995)
Triketones herbicides	Plants (*Callistemon citrinus*, *Callistemon* spp.)	Lee et al. (1997); Duke et al. (2000); Mitchell et al. (2001); Duke (2002)
Triterpenes	Plants (*Helianthus annuus*)	Macias et al. (1994)
Usnic acid	Lichen (*Usnea* sp.)	Duke et al. (2002)
Zea maysexistin	Microorganisms (*Pacecilomyces variokii*)	Duke and Abbas (1995); Hoagland and Cutler (1998); Duke et al. (2000)
Ziniol	–	Prakash and Pahwa (1994)

Table 11.2 Plant species of herbicidal activity, target weed species, form used and rate of application under field conditions

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Acer rubrum	–	*Desmodium toruoston*	Woodchips mulch	–	Rathinasabapathi et al. (2005)
Acorus tatarinowii	–	Algae	Mixed growth Leachates	Chlorophyll destruction	Kong (2005)
Ageratum conyzoides	Citrus orchards	Weeds	Cover crop Intercropping	–	Kong et al. (2004); Kong (2005)
Ailanthus altissima	*Phaseolus vulgaris*	Weeds	Extract 99 kg/ha	40 %	Heisey and Heisey (2003)
Alchemilla mollis	Roadside	Roadside weeds	Groundcover	Nearly complete	Weston et al. (2005)
Amaranthus spinosus	*Oryza sativa*	Weeds	Residue in the soil at 0.5 kg/m^2	Lowered weed infestation	Gaffar et al. (1998)
Apium graveolens	*Allium porrum*	Weeds including *Senecio vulgaris*	Intercropping	58 % in biomass 98 % seedling emergence	Baumann et al. (2000)
Artemisia annua (source of Artemisinin)	*Triticum aestivum*	*Amaranthus retroflexus* *Chenopodium album*	Extract	66 % weed emergence and 80 % biomass	Delabays and Mermillod (1999)
Avena sativa		*Picris echioides*	Extract, flavonoid, residue	Reduced weed number by 94 %	Bertoldi et al. (2009)
Asparagus officinalis	–	Weeds	Cover crop or Living mulch	–	Weston (1996)
Azadirachta indica A. Juss	–	*Desmodium toruoston*	Woodchips mulch	Suppression	Rathinasabapathi et al. (2005)
Bidens pilosa	*Oryza sativa*	*Commelina diffusa* *Jussiaea decurrens* *Rotala indica*	Shoot residue at 2 t ha^{-1}	80 % reduction in weed density and weed dry weight and increased yield by 20 %	Rathinasabapathi et al. (2005)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Brassica (accessions) *B. Juncea* *B. nigra*	–	*Avena ludoviciana* *Cirsium arvense* *Chenopodium album* *Melilotus album* *Phalaris minor* *Rumex retroflexus*	–	75–98 % 80 %	(Narwal et al. 2002a); Ercoli et al. (2005)
Brassica crops	–	Small seeded weeds	Green manure	Suppression	Al-Khatib and Boydston (1999)
Brassica juncea cv. Jyti and *Carum carvi*	Stored potato tubers	sprouting	Essential oils mixture	31 %	Hannukkala et al. (1996)
Brassica nigra	–	Weeds	Cover crop or living mulch	Suppression	Weston (1996); Gavazzi and Paris (2000)
Brassica rapa (L.) var. *rapa* spp. *oleifera*	–	Weeds	mulch	Strong suppression	Peterson et al. (1999)
Brassica spp.	–	Weeds	Cover green crop	Strong suppression	Peterson et al. (1999)
Brassica spp. (*juncea, carinata, napus*)	Accessions	Weeds	Accessions volatiles	45-77 % population	Yadava et al. (1994)
Cajanus cajan	–	*Cyperus rotundus*	Residue	Effective	Hiremath and Hunshal (1998)
Cajanus cajan line I-58	*Lycopersicon esculentum*	Weeds	Residue	Effective	Semidey and Medina (1996)
Canavalia ensiformis	–	*Amaranthus hypochondriacus* *Echinochloa crusgalli*	Dried leaves	Effective	Torres-Barragan et al. (1996)
Canavalia ensiformis	*Zea mays*	Weeds	Living cover crop Dead mulch	68 %	Caamal-Maldonado et al. (2001)
Cannvalia ensiformis	–	Weeds	Cover crop	Smothering	Fujii (2001)
Carum carv	Stored potato tubers	sprouting	Essential oil	92 %	Hannukkala et al. (1996)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Carvone (*Carum carvi*)	Potato sprout inhibitor	Potato sprout inhibitor and against rotting	Talent formulation	Effective	Varma and Dubey (2006)
Cassia spp. (*siamea*)	Sustainable agriculture	Weeds	Mulch	Biomass and Density	Kamara et al. (1997); Narwal et al. (2001)
Chromolaena odorata	*Morus rubra*	Weeds, *Lathyrus sativus*	Mulching 1.5-3 kg/m^2	High leaf yield	Premasthira et al. (2002)
Croton laciferus	*Oryza sativa*	*Echinochloa crus-galli* *Leptochloa chinensis*	Green manure 14 t/ha	40 and 60 % reduction in germination 30 and 50 % in biomass	Abeysekera et al. (2002)
Cucurbita pepo	*Zea mays*	Weeds *Amaranthus retroflexus* *Convolvulus arvensis*	Dense stand Intercropping	Suppression	Fujiyoshi (1998) Fujiyoshi et al. (2007)
Cynodon dactylon	–	*Cuscuta* spp.	Extract	Effective	Hiremath and Hunshal (1998)
Cyperus alternifolius	–	*Microcystis aeruginosa*	Fragments Extracts	Growth inhibition	Kusumoto et al. (2002)
Cyperus rotundus	*Oryza sativa*	Weeds	Residue in the soil at 0.5 kg/m^2	Lowered weed infestation	Gaffar et al. (1998)
Deguelia rufescens var. urucu		*Mimosa pudica*	Natural chemical (3,5-dimethoxy-4'-O-prenyl-trans-stilbene)		Lobo et al. (2010)
Digitaria sanguinalis	*Vitis vinifera*	*Amaranthus retroflexus*	Cover crop	25 %	Dharmaraj and Sheriff (1994)
Dolicos lablab	–	Weeds	Cover crop	Smothering	Fujii (2001)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Echinochloa colonum	*Oryza sativa*	Weeds	Residue in the soil at 0.75 kg/m^2	Lowered weed infestation	Gaffar et al. (1998)
Eichhornia crassipes	*Microcystis aeruginosa*	*Microcystis aeruginosa*	Fragments Extracts	Growth inhibition	Kusumoto et al. (2002)
Eichhornis crassipes	–	*Chlamydomonas reinhardii*	Root exudates	Effective	Wu and Yu (1996)
Eriogonum cinereum	–	Dicotyledonous weeds	Mulches	Effective	Gavazzi and Paris (2000)
Eucalyptus sp.	*Cicer arietinum*	Weeds	Leaf powder 50 kg/ha	70 % in population	Mukhopadhyay and Monda (1998)
Euphorbia prostrate	–	*Cynodon dactylon*		–	Hiremath and Hunshal (1998)
Fagopyrum esculentum	–	*Agropyron repens* *Capsella bursa pastoris* *Thlaspi arvense*	Suppression	94 %	Golisz et al. (2002) Golisz et al. (2008)
Festuca arundinaceae	–	Dicotyledonous weeds	Mulches	Effective	Gavazzi and Paris (2000)
Festuca arundinasae	–	Weeds	Cover crop or Living mulch	Strong suppression	Weston (1996)
Festuca spp. (*rubra, arundinoca*)	–	Dicotyledonous weeds and *Digitaria sanguinalis*	Mulches, cultivars root exudates	Strong suppression	Gavazzi and Paris (2000) Bertin and Weston (2002);
Gliricidia sepium	–	Weeds	Mulch	Biomass and Density	Kamara et al. (1997)
Glycine max	Sustainable agriculture	Weeds	–	–	Narwal et al. (2001)
Gossypium hirsutum and *Arachis hypogea*	*Capsicum annuum*	–	Intercropping	Weed density by 92.3 %	
Helianthus annuus	*Gossypium hirsutum*	*Cyperus rotundus*	Extract + low rate of glyphosate	Density reduction by 59–99 %	Narwal et al. (2001)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Helianthus annuus	*Helianthus annuus* varieties	*Parthenium hysterophorus* *Trianthema portulacastrum*	Root leachates	75–96 % 56–84 %	Dharmaraj and Sheriff (1994)
Helianthus annuus	*Triticum aestivum*	Weeds	Cover crop, Mulch	Significant reduction in population	Gawronski et al. (2002); Gawtonski (2004)
Helianthus annuus	–	*Trianthema portulacastrum*	Cover crop	94 % population 96 % biomass	Dharmaraj et al. (1994)
Helianthus annuus/ Legumes (*Pisum arvense, Pisum sativum, Vicia sativa*) mixture	*Triticum aestivum* organic farming	Weeds (mustard)	Mulch	Management	Bernat et al. (2004); Gawtonski (2004)
Heracleum laciniatum	Sustainable agriculture	Weeds	–	–	Narwal et al. (2001)
Hordeum vulgare	Catfish bonds	Cyanobacteria	Decomposed straw		Wills et al. (1999)
Hordeum vulgare and accessions	–	*Avena ludoviciana, Cirsium arvense, Chenopodium album* *Melilotus album* *Phalaris minor* *Rumex retroflexus* *Setaria glauca* *Sinapis arvensis* *Solanum ptycanthum* *Stellaria media*	Cover crop Accessions, Foliage leachates Residues Rotation	Suppression 70–100 %	Creamer et al. (1996); (Narwal et al. 2002b); Kremer and Ben-Hammouda (2009)
Hyptis suaveolens	*Ulex europaeus*	Weeds	Mulching 1.5–3 kg/m2	High leaf yield	Premasthira et al. (2002)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Imperata cylindrica	*Oryza sativa*	Weeds *Parthenium hysterophorus*	Residue in the soil at 1 kg/m^2 Extract 10 %	Lowered weed infestation	Gaffar et al. (1998); Anjum et al. (2005)
Imperata cylindrica.	*Medicago sativa.*	*Cuscuta campestris*	Extract Extract + gas oil + 10 % engine oil	High killing	Al-Juboory and Al-Mohamadi (2006)
Ipomoea patatis	–	*Cyperus esculentus*		Reduced tuber viability	Miles (1994)
Ipomoea tricolor	*Saccharum officinarum*	Weeds	Cover crop residue	–	Anaya and Jimenez-Osornio (1999)
Juniperus silisicola	–	*Desmodium toruoston*	Woodchips mulch	–	Rathinasabapathi et al. (2005)
Kasarwala mundara	–	–	Residue	98 %	Jung et al. (2004)
Lavendula angustifolia	Stored potato tubers	sprouting	Essential oils mixture	73 %	Hannukkala et al. (1996)
Leucaena leucocephala	*Vitis vinifera* Sustainable agriculture *Zea mays*	Weeds	Residue, Living cover crop Dead mulch	68 %	Anaya and Jimenez-Osornio (1999); Caamal-Maldonado et al. (2001); Narwal et al. (2001)
Linum usitatisimum	*Lathyrus sativa* *Lens culinaris* *Oryza sativa*	*Melilotus* spp. *Vicia* sp.	Relay crop Rotation	87 %	Das and Das (1998)
Lolium spp. (*perenne*)	Pasture *Lactuca sativa*	*Calystegia sepium* Dicotyledonous weeds	Dead and Living mulches	Suppression	Wu et al. (1996); Gavazzi and Paris (2000)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Lysilema latisiliquum	*Zea mays* *Vitis vinifera*	Weeds	Living cover crop Residue or dead mulch	68 %	Anaya and Jimenez-Osornio (1999); Caamal-Maldonado et al. (2001)
Magnolia grandiflora	–	*Desmodium toruoston*	Woodchips mulch		Rathinasabapathi et al. (2005)
Mangifera indica	*Rosa* spp.	Different weeds	Leaf mulch 15 kg/ 25 m^2	80 %	Challa and Ravindra (1998)
Medicago sativa	–	Weeds *Cyperus rotundus*	Cover crop or Living mulch, Root exudation Root layer	71–78 %	Suzuki and Yoshida (1996); Weston (1996)
Medicago sativa (cv. WL605)	*Lactuca sativa*, *Brassica oleracea* var. *italica*, and *Lycopersicon esculentum*	Weeds	Residue as a soil cover	–	Stirzaker and Bunn (1996)
Menthe piperita	Stored potato tubers	sprouting	Essential oil	96 %	Hannukkala et al. (1996)
Mucuna spp.(*daeringiana*, *deeringiana*, *deeringianum*, *pruiens*, *pruriens* (var.*ana* and *utilis*)	*Glycine max* Orchards Smothring and food resource Sustainable agriculture *Vitis vinifera* *Zea mays*	Weeds *Imperata cylindrica* *Portulaca oleracea*	Living cover crop Dead mulch Extract	68 % Suppression	Anaya and Jimenez-Osornio (1999); Kim et al. (1999a); Udensi et al. (1999); Caamal-Maldonado et al. (2001); Fujii (2001); Narwal et al. (2001)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Myrathecium verrucaria (with surfactant SilWet-L-77)	–	*Pueraria lobata*	Bioherbicide (Fungus)	90–100 %	Hoagland et al. (2005)
Nepeta x Faassennii	–	Roadside weeds	Groundcover	Nearly complete	Weston et al. (2005)
Oryza sativa and rice germplasm (PI 312777, XL8, 4593, Damagung)	Different Crops Germplasm *Hordeum vulgare* *Ipomoea patatis* *Triticum aestivum* *Zingiber officinale*	*Alopecurus aequalis* *Ammannia coccinea* *Bidens tripartite* *Cyperus difformis* *Cyperus iria* *Cyperus serotinus* *Dinebra retroflexa* *Echinochloa crusgalli* *Eleocharis kuroguwai* *Heteranthera limosa* *Leersia japonica* *Leptochloa fascicularis* *Monochoria vaginalis* *Persicaria hydropiper* *Phalais minor* *Portulacastrum* sp. *Trianthema portulacastrum* Weeds	Living and Dead mulch Cultivars Extract exposure Accessions (TONO BERA 439, CICA4, TANG GAN, PI 312777)	Weed suppression Suppressing cultivars 37–97 %	YongQing and QingHua (1995); Park (1996); Kim et al. (1999b); Olfosditter et al. (1999); Okuno et al. (1999); Fujihara and Yoshida (1999); Lovelace et al. (2001); Hassan et al. (2002); Gealy et al. (2003); Ahn et al. (2005); Inderjit and Kaushik (2005); Kong (2005); Hu et al. (2008).
Oryza longistaminata	*Oryza* spp.	*Echinochloa crusgalli*	Accessions suppression	62 % weed growth suppression	Zhang et al. (2008)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Pachyrhizus erosus	–	Weeds	Cover crop	Smothering	Fujii (2001)
Passiflora incarnata	*Oryza sativa*	Different weed species	Shoot residues at 1.5 t ha^{-1} at 2 days after transplanting	Reduction in weed density and dry weight by 75 %	Khanh et al. (2008)
Passiflora edulis	*Oryza sativa*	Different weed species	Shoot residues at 1–2 t ha^{-1} at 2 days after transplanting	Reduction in weed dry weight by 40–73 %	Khanh et al. (2008)
Pennisetum glaucum	*Oryza sativa/ Triticum aestivum* and Varieties	Weeds *Parthenium hysterophorus* *Trianthema portulacastrum*	Rotation	Smothering 31–63 %	(Narwal et al. 2004a)
Phragmites communis	*Medicago sativa*	*Cuscuta campestris* *Microcystis aeruginosa*	Different parts extract Extract + gas oil + 10 % engine oil	Growth inhibition High killing	Kong (2005); Al-Juboory and Al-Mohamadi (2006)
Pinus resinosa	*Panax quinquefolius*	Weeds	Bark mulch	Suppression	Reeleder et al. (2004)
Pinus strobes	*Panax quinquefolius*	*Parthenium hysterophorus*	Bark mulch	Suppression	Reeleder et al. (2004)
Pisum sativum and cultivars	*Lycopersicon esculentum* *Capsicum* sp.	Weeds *Amaranthus dubius* *Cyperus rotundus* *Echinochloa colona* *Trianthema portulacastrum*	*Galinsoga*, killed cover crop Plant stubble Soil incorporation	Reduced density	Semidey and Bosques-Vega (1999); Akemo and Bennet (2000)
Polygonum aviculare	–	*Cynodon dactylon*	–	–	Hiremath and Hunshal (1998)
Pseudomonas isolates	*Triticum aestivum*	*Bromus tectorum*	Metabolites	50 %	Mallik and Williams (2005)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Pseudomonas isolates	*Hordeum vulgare*	*Phleum pratense* *Trifolium pratense*	Metabolites	Suppression	Mallik and Williams (2005)
Quercus mechausii	–	*Desmodium toruoston*	Woodchips mulch	–	Rathinasabapathi et al. (2005)
Ranunculus bulbosus	*Glycine max*	Weeds	Residue		Gander (1998)
Secale cereale	*Brassica oleracea var. Capitata* *Different crops* *Glycine max* *Helianthus annuus* *Lycopersicon esculentum* *Nicotiana tabacum* *Solanum tuberosum* *Sorghum bicolor* *Zea mays*	*Amaranthus retroflexus* *Amaranthus* spp. Boadleaf weeds *Capsella bursa-pastoris* *Cassia abtusifolia* *Chenopodium album* *Echinochloa crus-galli* *Galinsoga parviflora* *Galinsoga quadriradiata* *Ipomoea* spp. *Portulaca oleracea* *Setaria glauca* *Sida spinosa* *Solanum plycanthum* *Urtica urens* *Xanthium strumarium*	Cover crop 189 kg seeds/ha Intercropping Rotation Residue mulch	Suppression 49–100 %	Creamer et al. (1996); Smeda and Weller (1996); Weston (1996); Worsham et al. (1999); Akemo and Bennet (2000); Borowy and Jelonkiewicz (2000); Gavazzi and Paris (2000); Nagabhushana et al. (2001); Samedani et al. (2002); Ercoli et al. (2005); Uchino et al. (2005)
Sinapis alba	*Pisum sativum*	Annual weeds *Setaria viridis*	Seed meal Killed plants cover Soil residue incorporation	Reduced germination	Jaakkola (2002); Weidenhamer et al. (2005)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Solidago sphacelata	–	Roadside weeds	Groundcover	Nearly complete	Weston et al. (2005)
Sorghum bicolor genotypes (Giza 115, Giza 15, Enkath, JS.263)	Deciduous trees *Glycine max* *Gossypium hirsutum* *Hordeum vulgare* Orchards *Oryza sativa* *Oryza sativa*/*Triticum aestivum* rotation *Triticum aestivum* *Zea mays*	*Alternanthera tenella* *Avena fatua* *Chenopodium album* *Cyperus rotundus* *Echinochloa crus-galli* *Ipomoea grandifolia* *Lolium temulentum* *Parthenium hysterophorus* *Phalaris minor* *Rumex dentatus* *Sinapis arvensis* *Trianthema portulacastrum* Weeds	Cover crop Extract Rotation, Residue 0.5–8.5 t/ha Sorgaab Smothr crop Companion crop Mixing crop Varieties	Density 67 % Smothering 13–80 %	Weston (1996); Sene et al. (1999); Cheema and Khaliq (2000); Gavazzi and Paris (2000); Narwal (2000); Cheema and Khaliq (2002); Correia et al. (2002); (Narwal et al. 2004b); Irshad and Cheema (2004); Alsaadawi et al. (2005); Cheema et al. (2005); Urbano et al. (2006); Alsaadawi and Dayan (2009)
Sorghum bicolor x *Sorghum sudanense*	Nurseries	Weeds	Mulch	–	Gavazzi and Paris (2000)
Sorghum bicolor	*Gossypium hirsutum*	*Cyperus rotundus*	Extract + low rate of glyphosate	Density reduction by 59–99 %	Iqbal and Cheema (2007)
Sorghum bicolor + *Helianthus annuus* + *Brassica campestris* + *Oryza sativa*	*Brassica napus*	*Trianthema portulacastrum*, *Cyperus rotundus*, *Chenopodium album*, *Coronopus didymus*	water extracts at 15 L ha^{-1} tank mixed	Density and growth reduction	Jabran et al. (2010)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Sorghum halepense	*Medicago sativa*	*Cuscuta campestris* Yunk.	Extract Extract + gas oil + 10 % engine oil	High killing	Al-Juboory and Al-Mohamadi (2006)
Sorghum hybrids	–	Dicotyledonous weeds	Mulches	–	Gavazzi and Paris (2000)
Sorghum sudanense	*Hordeum vulgare*	*Sinapis arvensis*	Cover crop	–	Urbano et al. (2006)
Stizolobium pruriens	–	*Amaranthus hypochondriacus* *Echinochloa crus-galli*	Dried leaves	–	Torres-Barragan et al. (1996)
Trichoderma virens/ *Secale cereale*	Vegetables	Weeds	Cover crop	Suppression	Heraux et al. (2005)
Trifolium incarnatum	Sustainable agriculture	Weeds *Solanum plycanthum*	Cover crop	Suppression	Creamer et al. (1996); Narwal et al. (2001)
Trifolium pretense	*Brassica juncea* *Linum usitatisimum* *Pisum sativum* *Zea mays*	Dicotyledonous weeds *Brassica kaber*	Green manure Residue mulch	Reduced density and competitiveness 88–91 %	Gavazzi and Paris (2000); Blackshaw et al. (2001); Conklin et al. (2002)
Trifolium subterranean	Sustainable agriculture	Weeds	–	–	Narwal et al. (2001)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Triticum aesivum and accessions	Fields and orchards No-till system Orchards *Oryza sativa* *Triticum aestivum* *Zea mays*	*Amaranthus retroflexus* *Ammania coccinea* *Avena ludoviciana* *Chenopodium album* *Cirsium arvense* *Cyperus esculentus* *Digitaria ciliaris* *Echinochloa crus-galli* *Heteranthera limosa* *Imperata cylindrica* *Ipomoea hederace.* *Melilotus album* *Phalaris minor* *Rumex retroflexus* *Sida spinosa* *Stellaria media* Weeds	accessions Cover crop Extract Rotation Straw mulch 6 t ha^{-1}	Excellent control Reduced infestation 87–96 % density 78–100 % 100 % control	YongQing and QingHua (1995); Pereira et al. (1996); Weston (1996); Jordan et al. (1999); Li-Xiang et al. (2000); Blum et al. (2002); Narwal et al. (2002c); Ni and Zhang (2005); Kong (2005); Li et al. (2005)
Ulex europaeus	–	Dicotyledonous weeds	Mulches	–	Gavazzi and Paris (2000)

(continued)

Table 11.2 (continued)

Donor species	Crop/application place	Receiver weed species	Form used and rate of application	Effect/ % control	Reference
Vicia villosa	Crops in general, *Glycine max* *Ipomoea patatis* *Lycopersicon esculentum* Orchards *Oryza sativa* *Solanum tuberosum* Sustainable agriculture Vegetables landscape and abandoned fields *Zea mays* *Zingiber officinale*	*Amaranthus retroflexus* *Chenopodium album* Dicotyledonous weeds *Digitaria ciliaria* *Portulaca oleracea* *Solanum plycanthum* Weeds	Cover crop Dry shoot cover 500 g m^{-2} Intercropping	24–52 % density 60–93 % biomass	Creamer et al. (1996); Fujihara and Yoshida (1999); Gavazzi and Paris (2000); Narwal et al. (2001); Araki and Hatano (2002); Samedani et al. (2002); Ercoli et al. (2005); Fujii and Heradata (2005); Fujii et al. (2008)
Zea mays	*Oryza sativa/ Triticum aestivum* rotation *Poa pratensis*	Weeds *Digitaria* sp. *Trifolium* sp. *Taraxacum* sp.	Rotation *Zea mays* gluten meal	Smothering 58–91 %	Christians (1995); Narwal (2000)

Table 11.3 Most commonly reported allelopathic crops and other plant species, targeted weeds controlled and most commonly cultivated crops in which allelopathy was used

Allelopathic plants	Target weed species	Cultivated crops
Brassica (accessions)	*Amaranthus* spp.	*Brassica* spp.
Cajanus cajan	*Avena ludoviciana*	*Glycine max*
Echinochloa colonum	*Chenopodium album*	*Helianthus annuus*
Festuca arundinaceae	*Cyperus* spp.	*Hordeum vulgare*
Helianthus annuus	*Echinochloa colona*	*Lactuca sativa*
Hordeum vulgare	*Phalaris minor*	*Lycopersicon esculentum*
Lolium spp.	*Portulaca oleracea*	*Medicago sativa*
Oryza sativa and accessions	*Trianthema portulacastrum*	Orchards
Secale cereale		*Oryza sativa* (most frequent)
Sorghum bicolor	Unidentified weeds	Stored potato tubers
Sorghum halepense		*Triticum aestivum* (most frequent)
Sorghum hybrids		*Vitis vinifera*
Sorghum sudanense		*Zea mays* (most frequent)
Trifolium incarnatum		
Triticum aesivum and accessions		
Vicia villosa		
Zea mays		

and their competitiveness with weeds have been documented (Putnam and Duke 1974; Dilday et al. 1991). Different lines of *Beta vulgaris, Cucumis sativus, H. vulgare*, *Lupinus* spp., *O. sativa*, *Pisum sativum*, and *T. aestivum*, were reported to inhibit different weed species, and differences among these lines were detected biologically and at the molecular level (Kong 2005; Wu 2005). Other occasionally reported less important species including some annual and perennial herbs.

Treated crops showed variable response with the methods of allelopathy application. However, many of the crops used (*Avena* spp., *H. vulgare*, *Secale cereale, Sorghum* spp., and *T. aestivum*) have long been reported best for suppression of several noxious weeds and resulted in up to 95 % weeds density reduction (Putnam 1983). Accessions of certain crops have experimentally proved variations among germplasm in nature of allelopathic chemicals and/or their concentrations under field conditions. In addition, allelopathic features of these species were not linked to any of their competitive properties.

On the other hand, plant growth activators such as ComCat® (Carla GmbH) obtained from seed extract of *Lychnis viscaria* has been commercialized in Germany (Belz 2007). Several chemicals were isolated and identified as stimulants of seed germination in certain parasitic species (Zwanenburg and Reizelman 2001). Main parts of these are the sesquiterpenes lactones (Butler 1995) and some are alectrol from *Vigna sinensis*, orobanchol from *Trifolium pratense* (Sugimoto 2000) and strigolactones and orobanchol from *sorghum* (Yokota et al. 1998; Yoneyama et al. 2001; Bouwmeester et al. 2006). Strigol was first isolated and identified from the root exudates of *Gossypium hirsutum* and later from *Z. mays*, all are also produced by *Striga* host plants (Hsiao et al. 1981; Wegmann 1998). Some sesquiterpene lactones were found to induce seed germination of *O. cumana* (Perez-de-Luque et al. 2001) and better than the synthetic germination “GR24” stimulant. Sesquiterpenes were also detected from *H. annuus* plants (De-Luque et al. 2000),

Table 11.4 Trap crops for different *Orobanche* or *Striga* species

Scientific name	Common name	References
Orobanche ramosa		
Arabidopsis thaliana	Thale cress	Goldwasser et al. (2000)
Brassica rapa	Turnip	Al-Menoufi and Adam (1996)
Capsicum spp.	Capsicums	Sand (1983)
Coriandrum sativum	Coriander	Al-Menoufi and Adam (1996)
Cucumis sativus	Cucumber	Labrada and Perez (1988)
Linum usitatissimum	Linseed	Eplee (1984); Khalaf (1992)
Lupinus termis	Lupinus	Al-Menoufi and Adam (1996)
Phaseolus aureus	Mung bean	Kleifeld (1996)
Phaseolus vulgaris	French bean	Labrada and Perez (1988)
Sorghum bicolor	Sweet sorghum	Labrada and Perez (1988)
Trigonella foenum graecum	Fenugreek	Al-Menoufi and Adam (1996)
Orobanche aegyptiaca		
Arabidopsis thaliana	Thale cress	Goldwasser et al. (2000)
Capsicum annuum	Sweet pepper	Hershenhorn et al. (1996)
Linum usitatissimum	Linseed	Kleifeld et al. (1994)
Vigna radiata	Green gram	Kleifeld et al. (1994)
Orobanche cernua		
Crotalaria juncea	Sunhemp	Dhanapal and Struik (1996); Dhanapal et al. (2001)
Phaseolus aureus	Greengram	Dhanapal et al. (2001)
Sorghum bicolor	Sweet sorghum	Dhanpal and Struik1996; Hershenhorn et al. (1996)
Vicia dasycarpa spp. *villosa*	Vetch	Linke et al. (1991)
Vigna radiata	Green gram	Dhanapal and Struik(1996)
Orobanche crenata		
Allium sativum	Garlic	Hassan (1998)
Astragalus boeticus	Vetch	Schnell et al. (1994)

(continued)

Table 11.4 (continued)

Scientific name	Common name	References
Brassica rapa	Turnip	Al-Menoufi and Adam (1996)
Capsicum annuum	Pepper	Al-Menoufi and Adam (1996); Dhanpal and Struik1996; Hershenhorn et al. (1996)
Coriandrum sativum	Coriander	Al-Menoufi and Adam (1996); Zemrag and Bajja (2001)
Crotalaria juncea	*Orobanche cernua*	Dhanpal and Struik1996; Hershenhorn et al. (1996)
Glycine max	Soybean	Schnell et al. (1994)
Hedysarum coronarium	Sulla	Schnell et al. (1994)
Hordeum vulgare	Barley	Linke et al. (1991)
Lablab purpureus	Hyacinth bean	Schnell et al. (1994)
Lathyrus ochrus	Ochrus vetch	Schnell et al. (1994)
Linum usitatissimum	Linseed	Khalaf (1992); Abou-Salama (1995)
Lupinus termis	Lupinus	Al-Menoufi and Adam (1996)
Phaseolus vulgaris	French bean	Schnell et al. (1994)
Pisum sativum	Pea	Hassan (1998)
Saccharum officinarum	Sugarcane	Abou-Salama (1995)
Sesamum indicum	Sesame	Al-Menoufi (1991)
Trifolium alexandrinum	Berseem	Schnell et al. (1994); Al-Menoufi and Adam (1996)
Trigonella foenum graecum	Fenugreek	Al-Menoufi and Adam (1996); Zemrag and Bajja (2001)
Vicia dasycarpa spp. *villosa*	Vetch	Linke et al. (1991)
Vicia narbonensis	Narbonne vetch	Schnell et al. (1994)
Vigna radiata	Green gram	Schnell et al. (1994)
Vigna unguiculata	Cowpea	Schnell et al. (1994)
Orobanche minor		
Allium sativum	Garlic	Hassan (1998)
Arabidopsis thaliana	Thale cress	Goldwasser et al. (2000)
Pisum sativum	Pea	Hassan (1998)

(continued)

Table 11.4 (continued)

Scientific name	Common name	References
Orobanche spp.		
Allium cepa/*Arachis hypogaea*	Onion/Groundnut	Chttapur et al. (2001)
Bidens pilosa	Hairy beggarticks	Mitich (1993)
Crotolaria juncea	Sun hemp	Chttapur et al. (2001)
Linum usitattisimum	Flax	Qasem (2006)
Nicotiana tabacum/*Capsicum annuum*	Tobacco/Pepper	Chttapur et al. (2001)
Phaseolus aureus	Mung Bean	Chttapur et al. (2001)
Phaseolus mungo	Black gram	Chttapur et al. (2001)
Sesamum indicum	Sesame	Chttapur et al. (2001)
Sorghum bicolor/*Zea mays*/*Oryza sativa*	Sweet sorghum/Maize/Rice	Chttapur et al. (2001)
Tridax procumbens		Mitich (1993)
Striga asiatica		
Arachis hypogaea	Peanut	Prabhakarasetty (1980)
Cajanus cajan	Pigeon pea	Prabhakarasetty (1980)
Crotalaria juncea	Sunhemp	Prabhakarasetty (1980)
Gossypium hirsutum	Cotton	Prabhakarasetty (1980)
Helianthus annuus	Sunflower	Prabhakarasetty (1980)
Medicago sativa	Lucerne	Prabhakarasetty (1980)
Panicum miliaceum	Broomcorn millet	Chttapur et al. (2001)
Phaseolus aureus	Green gram	Prabhakarasetty (1980)
Sesamum indicum	Sesame	Prabhakarasetty (1980)
Sorghum bicolor	Sweet sorghum	Chttapur et al. (2001)
Sorghum sudanense	Sudan grass	Chttapur et al. (2001)
Zea mays	Maize	Chttapur et al. (2001)
Striga hermonthica		

(continued)

Table 11.4 (continued)

Scientific name	Common name	References
Abelmoschus esculentus	Okra	Hudu and Gworgwor (1998)
Aeschynomene histrix	Porcupine jointvetch	Merkel et al. (2000)
Arachis hypogaea	Groundnut	Parker and Riches (1993); Chttapur et al. (2001)
Cajanus cajan	Pigeon pea	Parker and Riches (1993)
Cicer arientinum	Chickpea	Parker and Riches (1993)
Corchorus olitrius	Jute	Parker and Riches (1993)
Cyamopsis tetragonoloba	Cluster bean	Bebawi and Mutwali (1991)
Glycine max	Soybean	Jost (1997), Kureh et al. (2000), Schulz et al. (2003)
Glycine max	Groundnut	Chttapur et al. (2001)
Gossypium hirsutum	Cotton	Bebawi and Mutwali (1991); Jost (1997)
Gossypium spp.	Cotton	Chttapur et al. (2001)
Helianthus annuus	Sunflower	Bebawi and Mutwali (1991); Hudu and Gworgwor (1998)
Hibiscus cannabinus	Kenaf	Parker and Riches (1993)
Lablab purpureus	Hyacinth bean, Egyptian kidney bean	Bebawi and Mutwali (1991)
Menispermum dauricum	Koumorikazura	Ma et al. (1998)
Sesamum indicum	Sesame	Bebawi and Mutwali (1991); Hudu and Gworgwor (1998)
Vigna subterranea	Bambara groundnut	Hudu and Gworgwor (1998)
Vigna unguiculata	Cowpea	Schulz et al. (2003)
Striga gesneriodes		
Lablab purpureus	Hyacinth bean, Egyptian kidney bean	Berner and Williams (1998)
Sphenostylis stenocarpa	African yam bean	Berner and Williams (1998)
Vigna catjang	Indian cowpea	Chttapur et al. (2001)

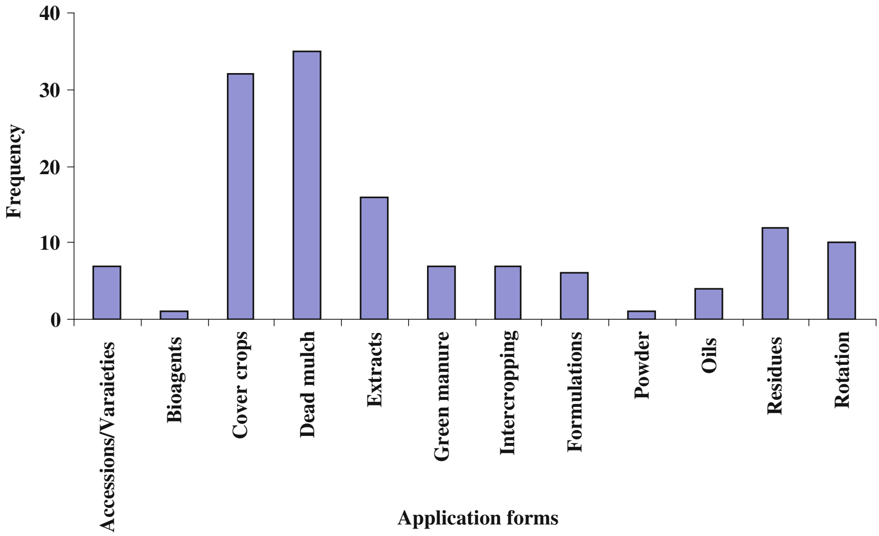

Fig. 11.1 Most common forms of allelopathic materials applied for weed control and their frequent uses (Qasem 2010)

Ambrosia artemisiifolia (Rugutt and Rugutt 1997), and *Pulicaria crispa* (Dendougui et al. 2000). Although amount, concentration, and environmental conditions are important factors determining the effectiveness of these chemicals under field condition, isolation, and identification of such allelochemicals would make possible large-scale production of these compounds or their synthetic analogs. However, an effective novel natural herbicide against parasitic weeds may be used in preplanting treatment in absence of host crop “suicidal germination”.

Allelochemicals are promising and effective natural tools for parasitic weed management either used as such or by incorporation of dead or living plants that releasing these into the surrounding environment as “catch” or “trap” species. Some of trap plant species reported for certain parasitic weeds are shown in Table 11.4. However, an early review study on plants possessing herbicidal activity was conducted by Rice (1983), while a more recent comprehensive review on allelopathy and parasitic weeds has been recently reported by Qasem (2006).

11.4 Methods of Allelopathy Application in the Field

Importance of allelopathy may be adjudged from its applicability to field conditions, and farmer’s responses toward this mechanism as a tool for pest management and sustainable agriculture. Since effectiveness of natural chemicals is mostly lower than of synthetic pesticides, farmers usually prefer a single active product rather than two (synthetic and/or natural). Natural products are necessary for organic farming. Hence to be attractive to farmers and for better commercialization for other systems, mixtures of synthetic, and natural products may be more suitable than any of them separately. This needs studies on chemicals compatibility and their weed or pest control spectrum. Pesticides of high activities, less persistence, reasonable rate of application, and wide spectrum of pest control are more acceptable. The marketing of natural products depends on farmer's trust and yield return. Successful natural product would benefit farmers worldwide, and help ecologist exploiting this biotechnology for higher yield and safe environment.

Methods for the application of allelopathy in weed control are many and variable. These include the use of crops accessions, varieties or cultivars, volatiles producing accessions, bark mulch, bioherbicides (fungus), cover crops or living mulch, dead mulch, dead woodchips mulch, decomposed straw, dense crop stand, dried leaves, dry shoot cover, extract, formulations, fragments, gluten meal, green manure, intercropping, killed plants cover, leachates, leaf powder, metabolites, oil or oils mixtures, plant stubble, relay crop, plant residue as a soil cover or soil incorporation, root layer, crop rotation, root exudates through rotation, and seed meal (Qasem 2010). However, most commonly used forms of allelopathy in weed management under field conditions and their frequency of use are shown in Fig. 11.1. Other less applied forms as dusting, foliage spray preparations (extracts or plant oils), or soil drenching are also reported.

11.5 Allelopathy Field Research, Problems and Prospects

Although a large number of publications is available on allelopathy application in the field, but most deal with a limited number of strong weed suppressant crops or those providing nutrients to the soil. However, reported data failed to separate the effect of allelopathy from that of competition (Qasem and Foy 2001). Intercropping and interpretation of results obtained on growth and yield, and the role of intercropped species in weed management, have neglected other positive effects of this system on intercropped species at which species complementing each other's needs for growth. Species interaction is additive in the absence of direct competition for growth factors, and thus better exploitation of resources and higher yields are possible than any of these grown separately. Intercropping system and yield obtained depend on species magnitude to share the same resource(s) or the differences in their requirements over growth factors. The possibility that one species facilitates other's growth in mixture through growth promoting substances in root exudates (Altieri and Liebman1988), or by symbiosis (Altieri and Liebman1988), are other factors to be considered. Higher weed smothering efficiency of *Capsicum annuum*, *G. hirsutum,* and *Phaseolus vulgaris* was found attributed to canopy coverage offered by *Arachis hypogea* and/or *P. vulgaris* as evident for higher light interception of intercrops (Shesshadri and Prabhakarasetty 2001).

Cover crops may affect weed growth through allelochemicals, competition or other mechanisms including stimulation of microbe's allelochemicals, physical barriers, shading effect of debris, and changes in soil physical properties (Lehman and Blum 1997). Cover crops are characterized by strong abilities to cover the soil surface and to effectively smother weeds (Qasem 2003). If these are legumes they could also elevate the soil nitrogen level. Legumes are less competitive than other crops (e.g. cereals and crucifers), their root systems with the associated bacterial nodules could modify the soil to be fluffier, enable better penetration of crop roots to deep soil layers, and thus effectively exploit water and nutrients (Qasem 2010). Soil mulching with living *V. villosa* has been reported to improve various soil physical properties including increase in water permeability and drainage, stabilization of soil temperature, and decrease of soil hardness (Fujihara and Yoshida 1999). In contrast, largest weed dry weight in mulched plots has been reported although mulch reduced number of weeds compared with the untreated control (Araki and Hatano 2002). Changes in physical environment reduce emergence of *Circium vulgare* seedlings in presence of leaf litter, although chemical effects were also possible (Dawson 1998). Kojima and Ohkubo (1999) reported good summer weed suppressions using *Cortalaria juncea*, *C. spectabilis*, *G. max*, *Mucuna prurience*, and *Panicum maximum* as green manure due to the quick growth and good ground cover of these species. Effect of allelopathy on crops and weeds is also implicated in the effect of cover crops or their residues. Bradow (1996) speculated that decomposed legume cover crop residue emit inhibitory chemicals to crop plants, while 2 % residue rate of *Sinapis alba* controlled weeds but decreased emergence of *P. sativum* by 90 %, and was highly phytotoxic to crop seedlings (Jaakkola 2002). The green manure of *S. alba* was more toxic to *Spinacia oleracea* and *P. sativum* than to weeds (Jaakkola 2005). Low density of *Cucurbita pepo* intercropped with *Z. mays* reduced weed biomass but high density was detrimental to both weeds and *Z. mays* (Fujiyoshi 1998). Stirzaker and Bunn (1996) showed that some or all benefits of soil mulch were eroded by phytotoxic leachates from residues of *S. cereale* and *Trifolium subterranean* as cover crops. However, allelochemicals are natural pesticides and may have their negative consequences on crop plants and environment.

In using allelopathy and cover crops for weed management, all of the above mentioned conditions should be considered. Most beneficial cover crops are legumes (Fujii and Heradata 2005), while the effect of these on crop plants needs to be compared with a weed-free crop of no cover crop. However, many of the allelopathic crops are used under field conditions as straw mulch, in which space between crop rows is mulch-covered or in some cases crop plants are grown in straw mulched soil. The most commonly used allelopathic straw mulches are those of *T. aestivum*, *H. vulgare* and *S. cereale*. *S. cereale* and *T. aestivum* have been reported to reduce emergence, height, and yield of *Z. mays* (Burgos and Ronald 1996). Water-soluble toxic substances of wheat straw mulch inhibited *Z. mays* growth, and the effect was more pronounced under wet conditions (YongQing 1994). Wheat residues were also reported to stimulate germination and growth of summer weeds and contrary to forage crops that smothered weeds up to 45 days in the next crop (Narwal 1996).

Beneficial impact of soil cover may be better observed in arid and semi-arid regions. Mulching prevents light from reaching small emerged seedlings and hence photosynthesis. The ability of emerged seedlings to establish depends on the thickness of straw mulch layer; therefore, it is difficult to separate the mechanical or physical effects of mulch from that of allelopathy. Residue of desiccated cover crops is influenced by different factors and generally at natural levels alone is not sufficient to provide full-season weed control, but requires integration with other management practices for optimum control (Teasdale 2002). Cover crops may antagonize the efficacy of some weed management practices such as preemergence herbicides and may increase the incidence of certain agricultural pests. Therefore, untreated weed-clean crop (control) is necessary to include for evaluation. Cover crops or residues may increase the incidence or population of certain agricultural pests, or their persistence; therefore, species of different families or their residues are always recommended in rotation. Increase in the incidence of *Pythium* spp. infection of wild mustard seedlings has been reported as a result of amended soil with *T. pratense* manure and compost (Conklin et al. 2002). Intercropping of *Cajanus cajan, G. max*, *G. hirsutum*, *Macrotyloma uniflorum*, or *V. radiata* with *sorghum* increased *Striga asiatica* infestation (Chttapur et al. 2001) and enabled establishment of stimulated parasite seeds on the true host sorghum (Prabhakarasetty 1980).

Inclusion of allelopathic cultivars or accessions for smothering or managing of weeds in the field should be carried out after full consideration of all competitive features of the used lines or cultivars. Low competitiveness and high smothering effect of a cultivar on weeds may indicate allelopathic character; otherwise, the effect may be due to competition, allelopathy, or both.

Direct application of aqueous crude extracts in the field has both positive and negative effects on weed control and crop plants. In most cases, extracts were found effective to certain limits against weeds or other agricultural pests, but negative effects such as partial weed control and serious crop injury have been also reported (Heisey and Heisey 2003). Extracts/herbicides mixtures may be more effective on weeds than the herbicide alone, and thus allow reduction in herbicide application rates. Since most plant extracts have low pH values with acidic nature they may act as surfactants, modify the leaf waxy layer of weed species (may be more in grasses), and enhance better herbicide penetration. The effect of herbicide/extract mixture may not be due to herbicidal activity of extracts rather than of a surfactant effect. However, some difficulties usually associated with allelopathy application for weed management, include (Qasem 2010):

- Techniques/methods used and difficulty in separating competition effects from those of allelopathy.
- Application at reasonable amounts of allelopathic materials (extensive rates applied in most cases)
- Absence of control treatments (untreated plots) in field studies in most cases.
- Problems associated with low stability and effectiveness of allelochemicals under field conditions.
- Time of allelopathy application, and interference or incompatibility with other agricultural or farm operations.

- Allelopathy impact (may be negative in certain cases) on the following crop plants.
- Effect of allelochemicals on treated crop plants.
- Yield economic wise of allelopathic crop accessions and how far they increase yield as a result of weed suppression through allelopathy mechanism.
- Integration of allelopathy with other methods of pest control or management.
- Imbalanced weed species and the need for integrated weed control program.
- Decision on whether the chemicals obtained are allelochemicals (naturally released) or phytotoxins (extracted)?
- Difficulty in explaining the promotory effects and whether these are due to nutrients or allelochemicals?
- Knowledge of whether the obtained effect is due to a single or mixture of allelochemicals that brought the ultimate effect on inflicted species.

11.6 Molecular Aspects and Genetic basis of Allelopathic Potential of Different Species

It is worth indicating that allelopathy research on *T. aestivum* has been rapidly progressed from the initial evaluation of allelopathic potential to the identification of allelochemicals and genetic markers associated with its allelopathy (Wu 2005). Correlation between allelopathic effect of *T. aestivum* genotype and their genes was detected and found increased as genome changed from 2n to 4n to 6n (Zuo et al. 2005). Further, novel selection methods of allelochemical fingerprinting were developed (Kong et al. 2002) and proved that concentrations of three types of glucosides produced by *Oryza sativa* plants were significantly different between allelopathic and non-alleloapthic accessions. Growth adaptation under water or nutrient stresses and allelopathic potential has been a subject of different studies (Fang et al. 2010; Zuo et al. 2010) and the link between these and the expression of genes associated with allelochemicals in different crop species have been thoroughly investigated (Wang et al. 2008, 2009; Fang et al. 2010). The responses of certain crops to exogenous treatment with inhibitory chemicals, the development of the defence mechanism in these crops, induction of allelochemicals against certain associated weed species and enhancement of certain enzyme production have been also implicated (Qiu et al. 2009; Fang et al. 2009). These results provide evidence for possible separation of allelopathy effect from that of competition under field conditions and on the role that allelopathy has in weed management.

11.7 Future Thrusts

Phytotoxic properties and ecotoxic features of allelochemicals from release to degradation, selectivity in relation to crop stages and concentrations, their joint actions with herbicides, and/or with their derivatives are important aspects to be considered. Studies on the biochemical signaling between interfering plants in nature and the resulting inducible allelopathic processes may merit future consideration. Future work should elucidate any biochemical communication among plants in nature and the importance of this phenomenon and its exploitation to imbalance crop/weed interaction in favor of crop production. New studies may be directed to screen for highly allelopathic germplasm of strong weed suppressive ability in collection crops, with the goal of transferring the allelopathic character into improved cultivars by either conventional breeding or other genetic transfer technique (Kim and Ho 1997). Choosing varieties with optimal production of allelochemicals and optimizing the time of sowing in relation to the formation of bioactive metabolites (Fomsgaard 2006) are another management practice that would greatly contribute to weed suppression.

The chemistry of allelochemicals (growth promoting or demoting) and development of more precise allelopathy techniques enable separation from other mechanisms of plant interference in nature, merit further search.

Research is needed on biological activity, mechanism and mode of action, gene expression, persistence, fate or dynamics of allelochemicals in soil, and on molecular biology of allelopathic plants (Macias et al. 2005; NI and Zhang 2005). Research efforts should be also directed to discovery of genes involved in the biosynthesis of potent allelochemicals and possible development of biopesticides (Baerson et al. 2005). Identification of genetic markers associated with crops allelopathy would enable researchers to locate allelopathic genes for transfer into modern varieties for weed suppression (Labrada 2002). Selection for allelopathic crops, using allelopathic companion plants or rotational crops, or by searching for natural product herbicides from both higher plants (cultivated or wild races) and microbes are another aspects of future allelopathy research line (Putnam 1988).

It seems appropriate for any researcher and/or farmer to consider the following measures or to address the below mentioned questions before setting an experiment or apply allelopathy tools for weed management.

- Determination of extract concentration, pH, volume, osmotic potential, mixtures compatibility, time of application in relation to weeds and crop plants, and their mechanism of action.
- Inclusion of control treatments at which crop plants treated only with extract and untreated weed-free crop, for comparison.
- Selectivity of allelochemical to crop plants grown from seeds or seedlings.
- Production and secretion of allelochemicals in response to stresses or certain agricultural practice(s).
- Role of microorganisms and availability on time and concentration to receiver plants.

- Effect of soil-residue compaction on seed germination and/or on seedlings emergence and growth.
- Type of allelochemicals uptake (passive or active) by different treated species.
- Selective uptake of allelochemicals in response to certain conditions.
- Effect of plant density on allelochemical/s accumulation in target weeds.
- How far the separation of allelopathy from other mechanisms of plant interference in the field is achieved?
- What are the other positive effects of intercropping on all interacting species?
- How far are the differences in species requirements for growth factors?
- What was the canopy coverage effect on crop plants and weeds?
- Consideration of other mechanisms, microbes' stimulation, physical barriers, shading, and changes in soil physical properties.
- Legume cover crops, physical smothering effects on weeds, and nitrogen supply to crop plants.
- The high demand of allelopathic cereal and crucifer species for water and nutrients and magnitude of soil depletion from these growth factors.
- Effect of soil mulch on moisture conservation, soil temperature, water permeability, drainage, and soil hardness.
- The correlation between weed suppressions effect and the rapid growth of ground cover crops.
- Physical effects of soil mulch versus phytotoxic leachates from residues of cover crops.
- Possible outcrossing of allelopathic traits to weedy relatives and possible production of chemotypes.

11.8 Conclusions

Allelopathy has been long considered as a branch of ecological sciences, and has rich history. Results of a huge number of publications on different aspects on the subject are promising and showed possible inclusion of this mechanism in weed management programs. However, exploitation of allelopathy under field conditions and the potential development of natural botanical- and/or mico-herbicides are still at their infancy. Literature indicated a high tendency toward recommending certain cover crops, crop residues, limited number of allelochemicals and herbicides based natural products, allelopathic crop cultivars, and intercropping system for weed management. In addition, crop rotation is regaining now as an agricultural practice for weed and soil weed seed-bank control.

The isolated allelochemicals from extracts, root exudates, or decomposed plant materials may be of great value for industry and for development and synthesis of safe and effective bio-herbicides or surfactants. Considering the difficulties and problems mentioned, allelopathy offers a great potential for weed management and a wide arry of research and may be regarded as a potentially future strategy for pest control in sustainable and organic farming agriculture. Some proofs and signs on allelopathy role for weed management may be drawn from,

- Gene studies and allelopathy characters of plant species.
- Differences between crops accessions in allelopathic activities and allelochemical contents.
- Effect of volatile materials of certain species inhibited weed growth in the field (e.g. cucumber)
- The poor competitive traits of certain weed species but their tendency to form colonies and ecological niche or to affect crop plants and *vice versa*.
- The poor receiver growth and performance in spite of the optimum condition available for its growth.

References

Abbas HK, Boyette CD (1993) Biological control of weeds using AAL_toxin. United States Patent Number 5,256,628, dated Oct 26, 1993

Abbas HK, Duke SO, Merrill AH, Wang E, Sheir WT (1998) Phytotoxicity of australifungin, AAL-toxins and fumonisin B1 to *Lemna pausicostata*. Phytochem 47:1509–1514

Abbas HK, Tanaka T, Duke SO, Boyette CD (1995) Susceptibility of various crops and weed species to AAL, a natural herbicide. Weed Technol 9:125–130

Abeysekera ASK, Sirisena DN, Wickrama UR (2002). Allelopathic activity of *Croton laciferus* (L.) Trimen, a commonly use green manure in paddy fields of Sri Lanka. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III World Congress on Allelopathy Challenge for the New Millennium, 26–30 Aug 2002, Tsukuba, Japan, p 83

Abou-Salama AM (1995) Utilization of crop rotation for the control of *Orobanche crenata* Forsk. Assiut J Agric Sci 26:245–252

Ahn JK, Hahn SJ, Kim JT, Khanh TD, Chung IM (2005) Evaluation of allelopathic potential among rice (*Oryza sativa* L.) germplasm for control of *Echinochloa crus-galli* P. Beauv in the field. Crop Prot 24:413–419

Akemo MC, Bennet RegnierEE (2000) Tomato growth in spring-sown cover crops. Hortsci 35:843–848

Al-Juboory BA, Al-Mohamadi AF (2006) Control of dodder (*Cuscuta campestris* Yunk.) grown on alfalfa by herbicides and some plant extracts. In: Kumari SG, Makkouk KM, Al-Chaabi S, El-Ahmed A (eds.), Abstacts, 9th Arab congress of plant protection, 19–23 Nov 2006, Damascus, Syria. Abstract W14, p E-127

Al-Khatib K, Boydston R (1999) Weed control with *Brassica* green manure crops. In: Narwal SS (ed) Allelopathy update, vol 2., Basic and Applied Aspects, Science Publishers, Enfield, pp 255–270

Al-Menoufi OA (1991) Crop rotation as a control measure of *Orobanche crenata* in *Vicia faba* fields. In: Wegmann K, Musselman LJ (eds.), progress in *Orobanche* research, proceedings, international workshop on orobanche research, obermarchtal, 1989. Eberhard-Karls-Universitat, Tubingen, pp 241–247

Al-Menoufi OA, Adam MA (1996) Biological and chemical inhibition of *Orobanche* seed germination. In: Moreno MT; Cubero JI; Berner D; Musselman LJ; Parker C (eds.). Advances in parasitic plant research, proceedings 6th parasitic weed symposium. Cordoba, 16–18 April 1996, Junta de Andalucia, Consejeria de Agricultura y Pesca, Cordoba, pp 418–423

Alsaadawi IS, Al-Ekelle MHS, Al-Hamzawi MK (2005) Allelopathic potential of *Sorghum bicolor* L. (Moench) genotypes against weeds. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of Fourth World Congress. On Allelopathy ''Establishing the 893 scientific base'', 21–26 August, 2005, Charles Sturt University, Wagga Wagga, NSW 894, pp 254–257

Alsaadawi IS, Dayan FE (2009) Potential and prospects of sorghum allelopathy in agroecosystems. Allelopathy J 24:255–270

Altieri MA, Liebman M (1988) Weed management in agroecosystems: ecological approaches. CRC Press Inc, Boca Raton

An M, Pratley J (2005) Searching native Australian plants for natural herbicides- a case study. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of Fourth World Congress on Allelopathy "Establishing the Scientific Base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW, p 581

Anaya AL, Jimenez-Osornio JJ (1999) Perspectives on the use of some allelopathic plants as bioregulators for weed control in agricultural management. In: Mallik AU (ed) Abstracts, II world congress on allelopathy critical analysis and future prospects. Lakehead University, Canada, p 51

Anjum T, Bajwa R, Javaid A (2005) Biological control of *Parthenium* I: effect of *Imperata cylindrical* L. on distribution, germination and seedling growth of *Parthenium heterophorus* L. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW pp 297–300

Araki H, Hatano Y (2002) Weed control effect of cover crop mulch in the soil with different weed density. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Tsukuba, p 116

Baerson SR, Cook D, Dayan FE, Rimando AM, Pan Z, Duke SO (2005) The use of functional genomics to advance allelopathic science-investigating sorgoleone biosynthesis as an example. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW pp 191–196

Baumann DT, Kropff MJ, Bastiaans L (2000) Intercropping leeks to suppress weeds. Weed Res 40:359–374

Bebawi FF, Mutwali EM (1991) Whitchweed management by sorghum-Sudan grass, seed size and stage of harvest. Agron J 83:781–786

Belz RG (2007) Allelopathy in crop/weed interactions: an update. Pest Manage Sci 63:308–326

Bernat W, Gawtonska H, Gawtonski SW (2004) Effectiveness of different mulches in weed management in organic winter wheat production. In: Oleszek W, Burda S, Bialy Z, Stepien W, Kapusta I, Stepien K (eds.), Abstracts, II European allelopathy symposium, allelopathy-from understanding to application, 3–5 June 2004 Institute of Soil Science and Plant Cultivation, Czartoryskich 8, 24–100 Pulawy, p118

Berner DK, Williams OA (1998) Germination stimulation of *Striga gesnerioides* seeds by hosts and nonhosts. Plant Dis 82:1242–1247

Bertin C, Weston LA (2002) Allelopathic ability and weed suppression of fine leaf fescue spp. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 August, Tsukuba, Japan, p 114

Bertoldi C, Leo M, Braca A, Ercoli L (2009) Bioassay-guided isolation of allelochemicals from *Avena sativa* L.: allelopathic potential of flavone C-glycosides. Chemoecol 19:169–176

Blackshaw E, Mayer JP, Doram RC, Boswell A (2001) Yellow sweet clover, green manure and its residues effectively suppress weeds during fallow. Weed Sci 49:406–413

Blum U, King LD, Brownie C (2002) Effects of wheat residues on dicotyledonous weed emergence in a simulated no-till system. Allelopathy J 9:159–176

Borowy A, Jelonkiewicz M (2000) Effect of rye (*Secale cereale* L.) as a cover crop on weeds and aphids occurring in cabbage crop. In: Oleszek W, (ed.), Abstract, biochemical responses in environmental interactions, 2000, Institute of Soil and Plant Cultivation, Pulawy, and Polish Phytochemical Society, Poland, pp 37–38

Bouwmeester HJ, Matsusova RS, Zhongkui B, Michael H, Rani K (2006) Making plants resistant to parasitic weeds as well as strigolactone-overproducing trap-crops by modulating carotenoid catabolism to strigolactones. PCT Int. 85 pp

Bradow JM (1996) Plant residue and ephemeral allelochemicals in agriculture. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996 Cadiz, Spain, p 71

Burgos NR, Ronald ET (1996) Weed control and sweet corn (*Zea mays* var. *rugosa*) response in a no-till system with cover crops. Weed Sci 44:355–361

Butler LG (1995) Chemical communication between the parasitic weed *Striga* and its crop host. A new dimension in allelochemistry. In: Inderjit, Dakshini KMM, Einhellig FA (eds.), Allelopathy, organisms, processes, and applications, pp 158–168

Caamal-Maldonado JA, Jimenez-Osorino JI, Barragan AT, Anaya AL (2001) The use of allelopathic legume cover and mulch species for weed control in cropping systems. Agron J 93:27–36

Carral-Vilarifio EV (2002) Trends in allelopathy research over six-year period analysis (1995–2000). In: Reigosa M J, Nuria P (eds.), Allelopathy, from molecules to ecosystems, Science Publisher, Inc. Enfield, USA, pp 299–1304

Challa P, Ravindra V (1998) Allelopathic potential of mango leaves for weed management in rose (*Rosa hybrida* cv. Happiness) basins. Source as per S. No.1 pp 147.9 Indian Institute of Horticultural Research hessaraghatta, Bangalore, India

Chaudhari VH, Diwakar MP, Mandokhot AM, Gondhalekar (1994) Allelopathic potential of neem products in management of yellow mosaic of horsgram *Macrotyloma uniflorum* (L.) Verdc. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash, J. (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 132

Cheema ZA, Khaliq A (2000) Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi arid region of Punjab. Agric Ecosys Environ 79:105–112

Cheema ZA, Khaliq A (2002) Use of sorghum water extract (sorgaab) for weed suppression in irrigated wheat and maize. In: Fujii Y, Hiradata S, Araya H. (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 August, 2002. Tsukuba, p 132

Cheema ZA, Khaliq A, Igbal N (2005) Use of allelopathy in field crops in Pakistan. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005 Charles Strut University, Wagga Wagga, NSW pp 550–553

Chou CH (2010) Role of allelopathy in sustainable agriculture: use of alleloachemicals as naturally occurring bio-agrochemicals. Allelopathy J 25:3–16

Christians N (1995) A natural herbicide from corn meal for weed free lawns. IPM Practitioner 17:5–8

Chttapur BM, Hunshal CS, Shenoy H (2001) Allelopathy in parasitic weed management, role of catch and trap crops. Alleloapathy J 8:147–160

Conklin AE, Erich MS, Liebman M, Lambert D, Gallandt ER, Halteman WA (2002) Effects of red clover (*Trifolium pratense*) green manure and compost soil amendments on wild mustard (*Brassica kaber*) growth and incidence of disease. Plant Soil 238:245–256

Correia NM, Souza IF, Klink UP (2002) Sorghum straw associated with imazamox for weed control in soybeans planted in succession under no-till system. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p183

Creamer NG, Bennett MA, Stinner BR, Cardina J, Regnier EE (1996) Mechanisms of weed suppression in cover crop-based production systems. Hortsci 31:410–413

Cutler HG (1999) Potentially useful natural product herbicides from microorganisms. In: Inderjit, Dakshini KMM, Foy CL (eds.), Principles and practices in plant ecology, allelochemical interactions, pp 497–516. CRC Press, Boca Raton

Cutler HG, Cutler SJ (2002) Natural product allelochemicals for controlling pests in ships' ballast water, a multibillion dollar market. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p 39

Cutler HG, Parker SR (1994) Allelochemicals from fungal-fermentation, some practical applications. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 64

Das NR, Das AK (1998) Allelopathic effects of rainfed linseed (*Linum usitattisimum*) on *Vicia* and *Melilotus* weeds in west Bengal. World Weeds 5:21–25

Dawson MP (1998) Effect of leaf litter on seedling emergence of bull thistle [*Circium vulgare* (Savi) Ten]. M.Sc. Dissertation. The University of Western Ontario, Canada pp 173

Dayan FE, Hernandez A, Allen SN, Moraes RM, Vroman JA, Avery MA, Duke SO (1999a) Comparative phytotoxicity of artemisinin and several sesuiterpene analogues. Phytochem 50:607–614

Dayan FE, Romagni JG, Tellez MR, Duke SO (1999b) Managing weeds with natural products. Pestic Outlook 10:185–188

De-Luque AP, Galindo JCG, Macias FA, Jorrin J (2000) Sunflower sesquiterpene lactone models induce *Orobanche cumana* seed germination. Phystochem 53:45–50

Delabays N, Mermillod G (1999) Assessment of the allelopathic properties of a selected strain of *Artemesia annua*. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical analysis and future prospects, Lakehead University, Canada, p 82

DellaGreca M, Fiorentino A, Isidori M, Monaco P, Previtera L, Zarrelli A (2002) Phenanthrenoides as potential antialgal substances. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p 110

Dendougui H, Benayache S, Benayache S, Connoly JD (2000) Sesquiterpene lactones from *Pulicaria crispa*. Fitoterapia 71:373–378

Dhaliwal GS, Arora R (1994) Botanical pesticides in insect pest management, Emerging trends and future strategies. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 65

Dhanapal GN, Mallory-Smith PC, Ter-Borg SJ (2001). Interactions between nodding broomrape and bidi tobacco in India. In: Fer A, Thalouarn P, Joel DM, Musselman LJ, Parker C, Verkleij JAC (eds.), Proceedings of the 7th international parasitic weed symposium. Nantes, France, p 42

Dhanapal GN, Struik PC (1996) Broomrape (*Orobanche cernua*) control before attachment to host through chemically or biologically manipulating and germination. Neth J Agric Sci 44:279–291

Dharmaraj G, Sheriff MM (1994) Allelopathic activity of sunflower (*Helianthus annuus* L.). In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept, 1994, New Delhi, p 38

Dharmaraj G, Sheriff MM, Nagarajan M, Kannaiyan S (1994) Allelopathic effects of sunflower (*Helianthus annuus* L.) on carpet weed (*Trianthema Portulacastrum* L.). In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 89

Dhawan AK, Dhaliwal GS (1994) Potential of neem in management of insect pests of agricultural crops. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p114

Dilday RH, Nastasi P, Lin J Smith RJJ (1991) Allelopathic activity in rice (*Oryza sativa* L.) against ducksalad (*Heteranthera limosa* (Sw.) Willd.)., in symposium proceedings "Sustainable

Agriculture for Great Plains",In: Hansen JD, Shaffer MJ, Ball DA, Cole CV (eds.), USDA, Agricultural Research Services, ARS-89, pp 193–201

Duke SO (2002) Chemicals from nature for weed management. Weed Sci 50:138–151

Duke SO, Abbas HK (1995) Natural products with potential use as herbicides. Am Chem Soc Symp Ser 582:348–362

Duke SO, Abbas HK, Amagasa T, Tanaka T (1996) Phytotoxins of microbial origin with potential for use as herbicides. In: Copping LC (ed.), Crop protection agents from nature, natural products and analogues. critical review on applied chemistry, vol. 35. Society for Chemical Industries, Cambridge, pp 82–113

Duke SO, Baerson SR, Pan Z, Kagan IA, Sanchez-Moreiras A, Reigosa MJ, Pedrol-Bonjoch N, Schulz M (2005) Genomic approaches to understanding allelochemical mode of action and defenses against allelochemicals. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW pp 107–113

Duke SO, Canel C, Remando AM, Tellez MR, Duke MV, Paul RN (2002) Current and potential exploitation of plant glandular trichome productivity. Adv Bot Res 31:121–151

Duke SO, Dayan FE (2009) Current and future herbicides for organic farming. Abstracts of papers, 238th National Meeting, Washington, 20 Aug 2009, p AGRO-006

Duke SO, Dayan FE, Gromagni JG, Rimando AM (2000) Natural products as sources of herbicides, current status and future trends. Weed Res 40:99–111

Duke SO, Dayan FE, Hernandez A, Duke MV, Abbas HK (1997) Natural products as leads for new herbicide modes of action. Brighton Crop Prot Conf Weeds 2:579–586

Duke SO, Dayan FE, Remando AM (1998) Natural products as tools for weed management. In: Proceedings Japanese Weed Science Society (Suppl.), 1–11

Duke SO, Gohbara M, Paul RN, Duke MV (1992) Colletotrichin causes rapid membrane damage in plant cells. J Phytopathol 134:289–305

Eplee RE (1984) *Orobanche ramosa* in the United States. In: Parker C, Musselman, L J et al., (eds.). Proceedings of the third international symposium on parasitic weeds. international center for agricultural research in the dry areas, Aleppo, pp 40–42

Ercoli L, Masoni A, Pampana S (2005) Weed suppression by winter cover crops. Allelopathy J 16:273–278

Fang CX, He HB, Wang QS, Qiu L, Wang HB, Zhuang YE, Xiong J, Lin WX (2010) Genomic analysis of allelopathic response to low nitrogen and barnyardgrass competition in rice (*Oryza sativa* L.). Plant Growth Regul 61:277–286

Fang CX, Xiong J, Qiu L, Wang HB, Song BQ, He HB, Lin RY, Lin WX (2009) Analysis of gene expressions associated with increased allelopathy in rice (*Oryza sativa* L.) induced by exogenous salicylic acid. Plant Growth Regul 57:163–172

Fomsgaard IS (2006) Chemical ecology in wheat plant-pest interactions. How the use of modern techniques and a multidisciplinary approach can throw light on a well-known phenomenon. J Agric Food Chem 54:987–990

Fujihara S, Yoshida M (1999) Allelopathy of hairy vetch, *Vicia villosa* Roth. and its application for crop production as mulching material. Bullet Shikoku National Agric Exp Stat 65:17–32

Fujii Y (2001) Alternative weed control by allelopathic cover crops. In: Proceedings, international symposium challenges today for weed management in 21st century. 17–18 Sept 2001, Tsukuba. Asia and Pacific Working Group for Improved Weed Management Newsletter, Oct 2001, p. 11. Weed Science Society of Japan

Fujii Y, Heradata S (2005) A critical survey of allelochemicals in action, the importance of total activity and the weed suppression equation. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW, pp 73–76

Fujii Y, Kamo T, Hiradate S, Hirai N (2008) Cyanamide in hairy vetch, tufted vetch, and black locust. Abstracts of papers, 236th ACS National Meeting, Philadelphia, 17–21 Aug 2008, AGRO-012

Fujiyoshi PT (1998) Mechanisms of weed suppression by squash (*Cucurbita* spp.) Intercropped in Corn (*Zea mays* L.). Ph.D. Dissertation.University of California Santa Cruz, p 89

Fujiyoshi PT, Gliessman SR, Langenheim JH (2007) Factors in the suppression of weeds by squash interplanted in corn. Weed Biol Manage 7:105–114

Gaffar MA, Reza MS, Rahman MM (1998) Allelopathic effect of several plant species in controlling weeds in direct seeded Aus' rice (BR-120). Bangladesh J Sci Ind Res 33:69–73

Gander JR (1998) Potential of allelopathic weeds for weed control in soybean. Ph.D. Dissertation. University of Arkansas, p 165

Gavazzi C, Paris P (2000) Allelopathy, do plants hate each other too? Informatore Agrario 56:53–55

Gawronski SW, Bernat W, Gawronska H (2002) Allelopathic potential of sunflower mulch in weed control. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002, Tsukuba, p 160

Gawtonski SW (2004) Allelopathic pre-crop mulch as a tool of weeds managements in winter organic farming. In: Oleszek W, Burda S, Bialy Z, Stepien W, Kapusta I, Stepien K (eds.) Abstracts, II european allelopathy symposium, allelopathy-from understanding to application, 3–5 June 2004 Institute of Soil Science and Plant Cultivation, Czartoryskich 8, 24–100 Pulawy, p 26

Gealy DR, Wailes EJ, Estorninos LE, Chavez RSC (2003) Rice cultivars different in suppression of barnyardgrass (*Echinochloa crus-galli*) and economics of reduced propanil rates. Weed Sci 51:601–609

Goldwasser Y, Plakhine D, Yoder JI (2000) *Arabidopsis thaliana* susceptibility to *Orobanche* spp. Weed Sci 48:342–346

Golisz A, Clarka D, Gawronski SW (2002) Allelopathic activity of buckwheat-*Fagopyrum esculentum* Moench. 2002. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p 161

Golisz A, Gawronska H, Gawronski SW (2008) Influence of buckwheat allelochemicals on crops and weeds. Allelopathy J 19:337–350

Gonzalez-Ibarra M, Aguilar-Martinez M, Lotina-Hennsen B, Trejo-Lopez C (2002) Effect of kerlinic acid on photosynthesis and growth. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p 129

Grainge M, Ahmed S (1988) Handbook of plants with pest-control properties. Wiley, New York

Hannukkala A, Laitinen P, Piirainen (1996) The potential of essential oils as sprouting inhibitors on potato. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 241

Hassan EA (1998) Broomrape species in Egypt, a recent survey in relatioa to geographical distribution. In: Maillet (ed.), 6th EWRS mediterranean symposium, 13–15 May 1998, Montpellier, p 155

Hassan SM, Draz AE, Sheble SM, Abou-Yousef MI, Bastawisi AO, Aidy IR (2002) Allelopathic activity of Egyptian rice varieties around most troublesome weeds in rice. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Tsukuba, p 74

Heisey RM, Heisey TK (2003) Herbicidal effects under field conditions of *Ailanthus altissima* extract, which contains ailanthone. Plant Soil 256:85–99

Heraux FMG, Hallen SG, Weller SC (2005) Combining *Trichoderma virens*-inoculated compost and a rye cover crop for weed control in vegetables. Biol Contr 34:21–26

Hershenhorn J, Goldwasser Y, Plakhine D, Herzlinger G, Golan S, Russo R, Kleifeld Y (1996) Role of pepper (*Capsicum annuum*) as a trap and catch crop for control of *Orobanche aegyptiaca* and *O. cernua*. Weed Sci 44:948–951

Hiremath SM, Hunshal CS (1998) Control of problem weeds through allelochemicals. Source as per S. No. 1 pp 155. Department of Agronomy, University of Agricultural Sciences, Dharwad-580 005, India

Hoagland RE, Boyette CD, Weaver MA, Abbas HK (2005) Research findings and strategies to reduce risks of the bioherbicide, *Myrothecium verrucaria*. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW, pp 114–121

Hoagland RE, Cutler SJ (1998) Plant and microbial compounds as herbicides. Southern Weed Science Research Unit, USDA-ARS, Stoneville, MS 38776 USA, p 97

Hsiao AI, Worsham AD, Moreland DE (1981) Regulation of witchweed (*Striga asiatica*) conditioning and germination by dl-strigol. Weed Sci 29:101–104

Hu F, Wang D, Chen XH, Ding GL (2008) Allelopathic potential of rice accessions against barnyard grass in paddy field. Allelopathy J 22:329–336

Hudu AI, Gworgwor NA (1998) Preliminary results on evaluation of trap crops for *Striga hermonthica* (Del.) Benth control in sorghum. Int Sorghum Millets Newslet 39:118–121

Inderjit, Kaushik S (2005) Allelopathic properties of rice straw. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 August, 2005, Charles Strut University, Wagga Wagga, NSW, p 549

Iqbal J, Cheema ZA (2007) Effect of allelopathic crops water extracts on glyphosate dose for weed control in cotton (*Gossypium hirsutum*). Allelopathy J 19:403–410

Irshad A, Cheema ZA (2004) Effect of sorghum extract on management of barnyard grass in rice crop. Allelopathy J 14:205–213

Jaakkola S (2002) Weed control with cruciferous plant material. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Tsukuba, p 81

Jaakkola S (2005) White mustard mulch is ineffective in weed control. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on Allelopathy "Establishing the scientific base", 21–26 August, 2005, Charles Strut University, Wagga Wagga, NSW pp 227–232

Jabran K, Cheema ZA, Farooq M, Hussain M (2010) Lower doses of pendimethalin mixed with allelopathic crop water extracts for weed management in canola (*Brassica napus*). Int J Agric Biol 12:335–340

Jordan DL, Bollich PK, Braverman MP, Sanders DE (1999) Influence of tillage and *Triticum aestivum* cover crop on herbicide efficacy in *Oryza sativa*. Weed Sci 47:332–337

Jost A (1997) Integrated cereal cropping in north Ghana with special attention for *Striga* problems. Integrierter Getreideanbau in Nord-Ghana unter besonderer Berucksichtigung der Striga-Problematik. 127., 10 pp (Abstracts)

Jung WS, Kim KH, Ahn JK, Hahn SJ, Chung IM (2004) Allelopathic potential of rice (*Oryza sativa* L.) residues against *Echinochloa crus-galli*. Crop Prot 23:211–218

Kamara AY, Jutzi SC, Akobundu IO, Chikoye D (1997) The effect of mulch from three multipurpose trees (MPTS) on weed composition and biomass in maize. Source as per S. No. 72. Vol 2, 635–654. (Institute of Crop Science, University of Kassel, Steinstrasse 19, 37213 Witzenhausen, Germany)

Kato-Noguchi H (2011) Barnyard grass-induced rice allelopathy and momilactone B. J Plant Physiol 168:1016–1020

Khalaf KA (1992) Evaluation of the biological activity of flax as a trap crop against *Orobanche* parasitizm of *Vicia faba*. Trop Agric 69:35–38

Khanh TD, Cong LC, Xuan Y, Uezato Y, Deba F, Toyama T, Tawata S (2009) Allelopathic plants: 20. hairy beggarticks (*Bidens pilosa* L.). Allelopathy J 24:243–254

Khanh TD, Elzaawely AA, Chung IM, Ahn JK, Tawata S, Xuan TD (2007) Role of allelochemicals for weed management in rice. Allelopathy J 19:85–96

Khanh TD, Xuan TD, Linh LH, Chung IM (2008) Allelopathic plants: 18. Passion fruit (*Passiflora* spp.). Allelopathy J 21:199–206

Kim KU, Ho PK (1997) Weed management using potential allelopathic crop. Korean J Weed Sci 17:80–93

Kim KU, Shin DH, Kim HY (1999a) Study on rice allelopathy. I. Evaluation of allelopathic potential in rice germplasm. Korean J Weed Sci 19:105–113

Kim KU, Shin DH, Kim HY, Lee IJ, Kim JH, Kim KW (1999b) Study on rice allelopathy. II. Factors affecting allelopathic potential of rice. Korean J Weed Sci 19:114–120

Kleifeld Y (1996) Role of pepper (*Capsicum annuum*) as a trap and catch crop for control of *Orobanche aegyptiaca* and *O. cernua*. Weed Sci 44:948–951

Kleifeld Y, Goldwasser Y, Herzlinger G, Joel DM, Golan S, Kahana D (1994) The effects of flax *Linum usitatissimum* (L.) and other crops as trap and catch crops for control of Egyptian broorape (*Orobanche aegyptiaca* Pers.). Weed Res 34:37–44

Kluge M, Hartenstien H, Hazard R, Tallec A (1995) First syntheses of natural products with the 2,7-Dihydroxy-2H-1, 4 benzoxazin-3 (4 h)-one skeleton. J Heterocycl Chem 32:395–402

Kojima K, Ohkubo Y (1999) Weed suppression of several green manure crops planted in upland field converted from rice paddy. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical Analysis and future prospects, Lakehead University, Canada, p 113

Kong C (2005) Allelopathy in China. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW pp 314–317

Kong CH, Hu F, Liang WJ, Wang P, Jiang Y (2004) Allelopathic potential of *Ageratum conyzoides* at various growth stages in different habitats. Allelopathy J 13:233–240

Kong CH, Xu XH, Hu F, Chen XH, Liang B, Tan ZW (2002) Using specific secondary metabolites as markers to evaluate allelopathic potentials of rice varieties and individual plants. Chinese Sci Bullet 47:839–843

Kremer RJ, Ben-Hammouda M (2009) Allelopathic plants. 19. Barley (*Hordeum vulgare* L.). Allelopathy J 24:225–242

Kureh I, Chiezey UF, Tarfa BD (2000) On-station verification of the use of soybean trap-crop for the control of *Striga* in maize. Afr Crop Sci J 8:295–300

Kusumoto K, Kuba T, Kusuda T (2002) Allelopathic effects of macrophyte on growth of *Microcystis aeruginosa*. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002, Tsukuba, p 111

Labrada R (2002) Allelopathic crops, another option in the context of irrigated weed management. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002, Tsukuba, p 80

Labrada R, Perez R (1988) Non-chemical control methods for *Orobanche ramosa* (in Spanish). Agrotecnica de Cuba 20:35–40

Lee CW, Kim YW, Koo BC (1997) Influence of light, osmotic potential, pH and rice straw mulching on growth of barley (*Hordeum vulgare* L.) and water foxtail [*Alopecurus aequalis* var. *amurensis* (Kom) Ohwi]. Korean J Weed Sci 17:310–313

Lehman ME, Blum U (1997) Cover crop debris effects on weed emergence as modified by environmental factors. Allelopathy J 4:69–88

Li X, Wang G, Li B, Blackshaw RE (2005) Allelopathic effects of winter wheat residues on germination and growth of crabgrass (*Digitaria ciliaris*) and corn yield. Allelopathy J 15:41–48

Lin LJ, Peiser B, Ying P, Mathias K, Karasina F, Wang Z, Itatani J, Green L, Hwang YS (1995) Identification of plant growth inhibitory principiles in *Alianthus altissima* and *Castela tortuosa*. J Agric Food Chem 43:1708–1711

Linke KH, Schnell H, Saxena MC (1991) Factors affecting the seed bank of *Orobanche crenata* in fields under lentil based cropping systems in northern Syria. In: Ransom JK, Musselman LJ, Worsham AD, Parker C (eds.), Proceedings of the 5th international symposium of parasitic weeds, 24–30 June 1991, Nairobi 321–327

Li-Xiang J, Lu DZ, Li-Yang H (2000) Study on allelopathic effect of wheat straw on emergence of crabgrass (*Digitaria ciliaris*). J Agric Uni 23:74–77

Lobo LT, da Silva GA, de Freitas MCC, Souza F, Antonio PS, da Silva MN, Arruda AC, Guilhon GMSP, Santos LS, Santos AS, Arruda MSP (2010) Stilbenes from Deguelia rufescens var. urucu (Ducke) A. M. G. azevedo leaves: effects on seed germination and plant growth. J Brazil Chem Soc 21:1838–1844

Lovelace ML, Talbert RE, Dilday RH, Scherder EF, Buchring NW (2001) Use of allelopathic rice with reduced herbicide rates for control of barnyardgrass (*Echinochloa crus-galli*). Research Series, Arkansas Agric Experl Stat 485:75–79

Ma Y, Babiker AGT, Sugimoto Y, Inanaga S (1998) Effect of medium composition on production of *Striga hermonthica* (Del.) Benth germination stimulant(s) by *Menispermum dauricum* (DC.) root cultures. J Agric Food Chem 46:1587–1592

Macias FA, Molinillo JMG, Varela RM, Galindo JCG (2007) Allelopathy: a natural alternative for weed control. Pest Manag Sci 63:327–348

Macias FA, Oliveros-Bastidas A, Marin D, Castellano D, Simonet AM, Molinillo JMG (2005) Degradation studies on benzoxazinoides. Soil degradation dynamics of (2R)-2-O-D-glucopyranosyl-4-hydroxy-(2H)-1, 4-benzoxazin-3(4H)-one (DIBOA-Glc) and its degradation products, phytotoxic allelochemicals from gramineae. J Agric Food Chem 53:554–561

Macias FA, Varela RM, Torres A, Molinillo JMG (1994) Potential of sunflower (*Helianthus annuus* L.) as source of natural herbicide models. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.) Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 76

Mallik MAB, Williams RD (2005) Allelopathic growth stimulation of plants and microorganisms. Allelopathy J 16:175–198

Merkel U, Peters M, Tarawali SA, Schultze-Kraft R, Berner DK (2000) Characterization of a collection of *Aeschynomene histrix* in subhumid Nigeria. J Agric Sci 134:293–304

Miles JE (1994) Possible allelopathic effect of sweet potato on purple nutsedge (*Cyperus rotundus* L.). In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 85

Mitchell G, Bartlett DW, Fraser TEM, Hawkes TR, Holt DC, Towson JK, Wichert RA (2001) Mesotrione, a new selective herbicide for use in maize. Pest Manag Sci 57:120–128

Mitich IW (1993) Orobanche-The broomrape. Weed Technol 7:532–535

Mukhopadhyay SK, Monda DC (1998) Possibility of production of plant herbicide from *Eucalyptus*. Source as per S. No. 1 pp 107. (Department of Agronomy, Institute of Agriculture, Visva-Bharti, Sriniketan, west Bengal, India)

Nagabhushana GG, Worsham AD, Yenish JP (2001) Allelopathic cover crops to reduce herbicide use in sustainable agricultural systems. Allelopathy J 8:133–146

Narwal SS (1996) Allelopathic strategies for weed control in sustainable agriculture. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 73

Narwal SS (2000) Weed management in rice-wheat rotation by allelopathy. Crit Rev Plant Sci 19:249

Narwal SS, Palaniraj R, Hardeep R, Sati SC, Rawat LS (2002b) Weed management potential of barley accessions for sustainable agriculture in North India. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30. Aug 2002 Tsukuba, p 145

Narwal SS, Palaniraj R, Kadian HS (2001) Allelopathic potential of legumes for weed management in sustainable agriculture. Indian J Pulses Res 14:90–106

Narwal SS, Palaniraj R, Sati SC, Dahiya DS (2004b) Field screening of sorghum varieties for allelopathic potential against *Parthenum hysterophorus* and *Trianthema portulacastrum*. In: Narwal SS, Barbara P (eds.), Abstracts, IV international conference allelopathy in sustainable terrestrial and aquatic

Narwal SS, Palaniraj R, Singh H, Sati SC, Rawat LS (2002c) Field screening for allelopathic potential of wheat accessions against major winter weed in North India. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Tsukuba, p 84

Narwal SS, Sati SC, Palaniraj-Singh HR, Rawat LS (2002a) Weed management potential of *Brassica* accessions on major winter weeds. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Japan, p 146

Narwal SS, Sati, Palaniraj R (2004a) Allelopathic weed suppression of pearl millet accessions against on *Parthenium hysterophorus* and *Trianthus portulacastrum*. In: Narwal SS, Barbara P (eds.), Abstracts, IV international conference allelopathy in sustainable terrestrial and aquatic ecosystems, 23–25 Aug 2004. International Allelopathy Foundation, 8/15 Haryana Agricultural University, Hisar 125 004, p 14

NI H, Zhang C (2005) Use of allelopathy for weed management in China: a review. Allelopathy J 15:3–12

Nimbal CI, Weston LA (1996) Mode of action of sorgoleone, a natural product isolated from *Sorghum bicolor*. In: Brown H, Cussans CW, Devine MD, Duke SO, Fernandez-Quintanilla C, Belweg A, Labrada RE, Lavdes M, Kudsk P, Strebig JC (eds.), Proceedings of the second international weed control congress, Copenhagen, Denmark, 25–28 June, pp 863–868

Okuno K, Ebana K, WG Yan, Dilday RH (1999) Rice allelopathy, Screening strategy and genetic variation. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical analysis and future prospects, Lakehead University, Canada, p 140

Oleszek W, Assard J, Johansson H (1994) Cruciferae as alternative plants for weed control in sustainable agriculture. In: Narwal SS, Tauro P., Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994 New Delhi, p 160

Olfosditter M, Navarez D, Rebulanan M, Streibig JC (1999) Weed suppressing rice cultivars-does allelopathy play a role? Weed Res 39:441–454

Orel LV (1994) Development of ecologically safe herbicides of plant origin. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 84

Pachlatko JP (1998) Natural products in crop protection. Chimia 52:29–47

Park KH (1996) A potential weed management by allelopathic rice germplasm in Korea. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996 Cadiz, p 269

Parker C, Riches CR (1993). Parasitic weeds of the world, biology and control. CAB International, Wallingford 350 P

Pereira MM, das Neves CH, Gaspar EM (1996) Potential allelopathic sterols and ketosteroids from wheat straw (*Triticum aestivum*). In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on 851 allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 155.

Perez-de-Luque A, Rubiales D, Galindo GC, Macias FA, Jorrin J (2001) Allelopathy and allelochemicals within the plant-parasitic weed interaction. Studies with the sunflower-*Orobanche cumana* system, In: Fer A, Thalouarn P, Joel DM, Musselman LJ, Parker C, Verkleij JAC (eds.), Proceedings of the 7th international parasitic weed symposium. Nantes pp 196–199

Peterson J, Belz R, Walker F, Hurle K (1999) Weed suppression by release of isothiocyanates from turnip mulch. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical analysis and future prospects, Lakehead University, Canada, p 148

Popovici J, Bertrand C, Jacquemoud D, Bellvert F, Fernandez MP, Comte GP, Florence (2011) An allelochemical from *Myrica gale* with strong phytotoxic activity against highly invasive *Fallopia* × *bohemica* taxa. Molecules 16:2323–2333

Prabhakarasetty TK (1980) Studies on the biology and control of *Striga asiatica* (L.) Kuntze. Ph.D Thesis. Bangalore, India, Department of Agronomy, University of Agricultural Science, pp 277

Prakash J, Pahwa SK (1994) Use of natural plant metabolites as herbicides. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994 New Delhi, p 75

Premasthira C, Chumcheun S, Taengpew P, Zungsontiporn S (2002) Weed control in mulberry by allelopathic plants. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 August, 2002. Tsukuba, p 86

Putnam AR (1983) Allelopathic chemicals, nature's herbicides in action. Special Report, April, 1983 C and EN. Michigan State University, USA

Putnam AR (1988) Allelochemicals from plants as herbicides. Weed Technol 2:510–518

Putnam AR, Duke WB (1974) Biological suppression of weeds: evidence for allelopathy in accessions of cucumber. Science 185:370–371

Qasem JR (2003) Weeds and their control. University of Jordan Publications, Amman 628 pp

Qasem JR (2006) Parasitic weeds and allelopathy, from the hypothesis to the proof. In: Reigosa MJ, Pedrol N, Gonzalez L (eds) Allelopathy, a physiological process with ecological implications. Springer, The Netherlands, pp 565–637

Qasem JR (2007) Allelopathy in plant protection: a review of the last two decades research acheivements under field conditions. In: Malik A, Iqbal Z (eds.), Abstracts, proceedings of international conference "Role of alleloapthy in sustainable agriculture", University of Arid Agriculture Rawalpindi, 22–24 March 2007 pp 25–26

Qasem JR (2010) Allelopathy importance, field application and potential role in pest management: a review. J Agric Sci Technol 4:104–120

Qasem JR, Foy CL (2001) Weed allelopathy, its ecological impact and future prospects. J Crop Prod 4:43–119

Qiu L, Xiong J, Wang HB, Fang CX, He HB, Li ZW, Lin WX (2009) The nitrogen nutrient efficiency and the expression analysis of the related genes in different allelopathic potential rice (*Oryza sativa* L.) varieties at seedling stage. Shengtai Xuebao 28:677–684

Rathinasabapathi B, Ferguson J, Gal M (2005) Evaluation of allelopathic potential of wood chips for weed suppression in horticultural production systems. Hortsci 40:711–713

Reeleder RD, Capell BB, Roy RC, Grohs R, Zilkey B (2004) Suppressive effect of bark mulch on weeds and fungal disease in ginseng (*Panax quinquefolius* L.). Allelopathy J 13:211–232

Rice EL (1983) Pest control with nature's chemicals, allelochemics and pheromones in gardening and agriculture. The University of Oklahoma Press, Oklahoma. Publishing Division of the University. Norman, Oklahoma

Rimando AM, Dayan FE, Czarnota MA, Weston LA, Duke SO (1998) A new photosystem II electron transfer inhibitor from *Sorghum bicolor* (L.). J Nat Prod 61:927–930

Rizvi SJH (1994) Allelochemicals in improving crop productivity. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 78

Rugutt JK, Rugutt KJ (1997) Stimulation of *Striga hermonthica* seed germination by11beta,13-dihydroparthenolide. J Agric Food Chem 45:4845–4849

Saharkhiz MJ, Smaeili S, Merikhi M (2010) Essential oil analysis and phytotoxic activity of two ecotypes of *Zataria multiflora* Boiss growing in Iran. Natural Prod Res 24:1598–1609

Samedani B, Rahimian H, Ranjbar M, Rivand M (2002). Utilization of cover crops for weed control in transplanted tomato. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002 Tsukuba, p 175

Sand PF (1983) *Orobanche ramosa* in Taxas. In: Meeting of weed science society of America, 1983. animal and plant health inspection servey, plant protection and quarantine, Hyattsville, Maryland, USA, Abstract no. 47

Schnell H, Linke KH, Sauerborn J (1994) Trap cropping and its effect on yield and *Orobanche crenata* Forsk. infestation on following pea (*Pisum sativum* L.) crops. Trop Sci 34:306–314

Schulz S, Hussaini MA, Kling JG, Berner DK, Ikie FO (2003) Evaluation of integrated *Striga hermonthica* control technologies under farmer management. Exp Agric 39:99–108

Semidey N, Bosques-Vega A (1999) Yield and weed suppression by pigeonpea cultivars in rotation with tomato and pepper. J Agric Uni Peurto Rico 83:55–64

Semidey N, Medina R (1996) Source of allelopathic chemicals in pigeon pea. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996 Cadiz, p 92

Sene M, Dore T, Gallet C (1999) Allelopathic potential increase with biomass accumulation in grain sorghum [*Sorghum bicolor* (L.) Moench]. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical analysis and future prospects, Lakehead University, Canada, p 163

Shesshadri T, Prabhakarasetty TK (2001) Weed smothering efficiency as influenced by intercropping in chilli. In: 1st biennial conference of ecofriendly weed management options for sustainable agriculture, 23–24 May 2001 University of Agricultural Sciences, Bangalore, p 174

Singh HP (2004) Possible exploitation of volatile monoterpenes as bioherbicides. In: Narwal SS, Barbara P (eds.), Abstracts, IV international conference allelopathy in sustainable terrestrial and aquatic ecosystems, 23–25 Aug 2004. International allelopathy foundation, 8/15 Haryana Agricultural University, Hisar, p 9

Smeda RJ, Weller SC (1996) Potential of rye for weed management in transplanted tomatoes. Weed Sci 44:596–602

Sobokta W (1997) Role of allelopathy in search for ecological crop protection agent. In: Oleszek W (ed.), Theoretical and practical aspects of allelopathy, proceedings 1st polish conference IUNG Pulawy, K (10), pp 21–34

Stirzaker RJN, Bunn DG (1996) Phytotoxicity of ryegrass and clover cover crops and a lucerne alley crop for no-till vegetable production. Biol Agric Hort 13:83–101

Sugimoto Y (2000) Germination stimulants for the seeds of root parasitic weeds. J Pestic Sci 25:438–440

Suzuki J, Yoshida T (1996) Rhizospheric allelopathy, a new weapon for an alternative agriculture. “Even the world’s worst weed such as purple nutsedge can submit to a suitable attack of plant rhizosphere”. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 93

Teasdale JR (2002) Weed management with cover crop mulches. In: Fujii Y, Hiradata S, Araya H (eds.), Abstracts, III world congress on allelopathy challenge for the new millennium, 26–30 Aug 2002. Tsukuba, p 115

Tellez MR, Canel C, Rimando AM, Duke SO (1999) Differential accumulation of isoprenoides glanded and glandless *Artemisia annua* L. Phytochem 52:1035–1040

Torres-Barragan A, Hernandez-Bautista BE, Caamal A, Anaya AL (1996). *Stizolobium pruriens* and *Canavalia ensiformis* as cover crops for pest control. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996 Cadiz, p 239

Uchino H, Iwama K, Terauchi T, Jitsuyama (2005) Weed control by cover crop under organic farming of maize, soybean and potato. In: Harper JDI, An M, Wu H, Kent JH (eds.), proceedings of fourth world congress on allelopathy “Establishing the scientific base”, 21–26 Aug 2005, Charles Strut University, Wagga Wagga, NSW pp 318–320

Udensi EU, Akobundu OI, Ayeni AO, Chikoye D (1999) Management of cogongrass (*Imperata cylidrica*) with velvetbean (*Mucuna pruriens* var. *utilis*) and herbicides. Weed Technol 13:201–208

Urbano B, Gonzalez-Andres F, Ballesteros A (2006) Allelopathic potential of cover crops to control weeds in barley. Allelopathy J 17:53–64

Varma J, Dubey NK (2006) Prospective of botanical and microbial products as pesticides of tomorrow. Efficient Technique-TSP. Available via http//www.ias.ac.in/currsci/jan25/articles22.htm

Villagrasa M, Eljarrat E, Barcelo D, Barcelo D (2009) Analysis of benzoxazinone derivatives in plant tissues and their degradation products in agricultural soils. Trends Analy Chem 28: 1103–1114

Wang H, He H, Qiu L, Shen L, Fang C, Lin R, Lin W (2009) Molecular physiological properties of enhanced weed-suppression ability of rice allelopathy induced by lower phosphorus supplies. Yingyong Yu Huanjing Shengwu Xuebao 15:289–294

Wang HB, He HB, Xiong J, Qiu L, Fang CX, Zeng CM, Yan LL, Wen-Xiong (2008) Effects of potassium stress on allelopathic potential of rice (*Oryza sativa* L.). Shengtai Xuebao 28:6219–62227

Wegmann K (1998) The Orobanche problem in tobacco. In: Current problems of *Orobanche* researches. In: Wegmann K, Musselman LJ, Joel DM (eds.), Proceedings of the 4th international orobanche workshop, 23–26 Sept 1998, Albena pp 21–24

Weidenhamer JD, Durkalski,J, Dick WA (2005) Evaluation of the allelopathic potential of mustard cover crops. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005 Charles Strut University, Wagga Wagga, NSW pp 559–561

Weston LA (1996) Utilization of allelopathy for weed management in agroecosystem. Agron J 88:860–866

Weston LA, Eom SH, Senesac AF (2005) Use of weed suppressive groundcover to suppress weed growth over time, allelopathy or competition? In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005 Charles Strut University, Wagga Wagga, NSW, p 458

Willis RJ (1996) The history of allelopathy 1. The first phase 1785–1845, The era of A.P. de Candolle. Allelopathy J 3:165–184

Willis RJ (1997). The history of allelopathy. 2. The second phase (1900–1920), the era of S.U. Pickering and the U.S.D.A. Bureau of soils. Allelopathy J 4:7–56

Willis RJ (2004) Justus Ludewig von Uslar and the First Book on Allelopathy. Springer, New York

Worsham AD, Nagabhushana GG, Wickliffe WB (1999) Management of allelopathy cover crops to enhance weed suppression. In: Mallik AU (ed.), Abstracts, II world congress on allelopathy, critical analysis and future prospects, Lakehead University, Canada, p 191

Wu H (2005). Molecular approaches in improving wheat allelopathy. In: Harper JDI, An M, Wu H, Kent JH (eds.), Proceedings of fourth world congress on allelopathy "Establishing the scientific base", 21–26 Aug 2005 Charles Strut University, Wagga Wagga, NSW pp 201–208

Wu H, Henk N, Gerard O (1996) The allelopathic effect of dead and living mulches from English ryegrass (*Lolium perenne* L.) on *Calystegia sepium* (L.) R.Br In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, first world congress on allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 251

Wu H, Yu SW (1996) Allelochemicals from root exudates and extracts of water hyacinth *Eichhornis crassipes*. In: Macias FA, Galindo JCG, Molinillo JMG, Gutler HC (eds.), Abstracts, First world congress on allelopathy, a science for the future, 16–20 Sept 1996. Cadiz, p 160

Yadava JS, Narwal SS, Thakral SK (1994) Weed suppression potential in *Brassica* species. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, p 168

Yamane A, Fujikura J, Ogawa H, Mizutani J (1992a) Isothiocyanates as allelopathic compounds from *Rorippa indica* Hiern. (Cruciferae) roots. J Chem Ecol 18:1941–1954

Yamane A, Nishimura H, Mizutani J (1992b) Allelopathy of yellow fieldcress (*Rorippa sylvestris*): identification and characterization of phytotoxic constituents. J Chem Ecol 18:683–691

Yokota T, Sakai H, Okuno K, Yoneyama K, Takeuchi Y (1998) Alectrol and orobanchol, germination stimulants for *Orobanche minor*, from its host red clover. Phytochem 49:1967–1973

Yoneyama K, Takeuchi Y, Yokota T (2001) Natural germination stimulants for *Orobanche minor*. In: Fer A, Thalouarn P, Joel DM, Musselman LJ, Parker C, Verkleij JAC (eds.), Proceedings of the 7th international parasitic weed symposium. Nantes, p 123

YongQing M (1994) Allelopathic effects of wheat straw mulching on corn seedlings growth and development. In: Narwal SS, Tauro P, Dhaliwal GS, Prakash J (eds.), Abstracts, international symposium on allelopathy in sustainable agriculture, forestry and environment, 6–8 Sept 1994, New Delhi, India, p 13

YongQing M, QingHua H (1995) Effect of wheat straw mulching on the growth, development and yield of maize. Acta Agric Boreali-Sin 10:106–110

Zemrag A, Bajja M (2001) Characterization of *Orobanche* spp. in Morocco and the effect of some trap crops on *Orobanche crenata* Forsk in faba bean (*Vicia faba* L.). In: Fer A, Thalouarn P, Joel DM, Musselman LJ., Parker C, Verkleij JAC (eds.), Proceedings of the 7th international parasitic weed symposium. Nantes, p 300

Zhang F, Li T, Shan Q, Guo Y, Xu P, Hu F, Tao D (2008) Weed-supression ability of *Oryza longistaminata* and *Oryza sativa*. Alllelopathy J 22:345–352

Zuo S, Zhi J, Shao H, Zhao G (2010) Allelopathy regulates wheat genotypes performance at the enhancement stage by soil water and prohydrojasmon (PDJ). Afr J Biotechnol 9:5430–5440

Zuo SP, Ma YQ, Deng XP, Li XW (2005) Allelopathy in wheat genotypes during the germination and seedling stages. Allelopathy J 15:21–30

Zwanenburg B, Reizelman A (2001) En route to the isolation and characterization of the strigolactone receptor using biotin labelled strigolactone analogues. In: Fer A, Thalouarn P, Joel DM, Musselman LJ, Parker C, Verkleij JAC (eds.), Proceedings of the 7th international parasitic weed symposium. Nantes pp 102–105