PRELIMINARY STUDIES REGARDING SOME ALLELOPATHIC INTERACTIONS IN VEGETABLES INTERCROPPING SYSTEMS

STUDII PRELIMINARE PRIVIND UNELE INTERACȚIUNI ALELOPATICE LA SISTEMELE DE INTERCROPPING CU PLANTE LEGUMICOLE

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Abstract. *The paper presents a summary of the scientific and technical achievements regarding the allelopathic phenomenon and its application in the weed management of different culture systems. The paper is particularly referring to the definition and content of the allelopathy phenomenon as well as on how it operates on different agricultural crops. Particular emphasis is on the use of allealopathy in ecological vegetable crops. Research has highlighted the main species with allelopathic reaction that are used in different vegetable crops. Thorough researches has taken into account the biochemical and physiological mechanisms by which the allelopathic phenomenon is manifested at the level of culture plants. The optimization of some practices for efficient use of solutions in weed management is of great importance.*

Key words: weed management, ecological vegetable crops, physiological mechanisms, biochemical mechanisms

Rezumat. *Lucrarea prezintă un rezumat al realizărilor științifice și tehnice privind cunoașterea fenomenului alelopatic și aplicarea acestuia în diferite sisteme de cultură, în vederea combaterii buruienilor. Lucrarea face referire specială asupra definiției și conținutului fenomenului de alelopatie precum și asupra modului de acțiune în diferite culturi agricole. Accent deosebit este pus pe folosirea alelopatiei în culturile ecologice legumicole. Cercetările au pus în evidență principalele specii cu reacție alelopatică care sunt folosite în diferite culturi legumicole. Aprofundarea cercetărilor a avut în vedere cunoașterea mecanismelor biochimice și fiziologice prin care se manifestă fenomenul alelopatic față de plantele de cultură. De majoră importanță este optimizarea unor practici de utilizare eficientă economic a soluțiilor de combatere a buruienilor.*

Cuvinte cheie: combaterea buruienilor, culturi ecologice, mecanisme fiziologice, mecanisme biochimice

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DEFINITION AND CONTENT OF THE ALLELOPATHY PHENOMENON

Allelopathy "sympathies and antipathy from nature". Allelopathy as defined by the International Allelopathy Society "any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influence the growth and development of agricultural and biological systems" (International Allelopathy Society, 1996). The phenomenon though existing in nature since centuries has drawn special attention over couple of decades (Hussain *et al.*, 2007).

A characteristic feature of plants is their ability to synthesize a wide range of natural products, the so-called secondary metabolites. Up till now more than 4500 terpenoids, 700 polyketides, 750 polyacetylenes, 500 phenylpropanoids, 1200 flavonoids, 400 non-protein amino acids, 100 glucosinolates, 50 cyanogenic glycosides, 100 amines and over 400 alkaloids have been described. Many of these compounds are used by man as pharmaceuticals, flavours, fragrances, colours, stimulants, hallucinogens, poisons, pesticides or as lead structure for the organic chemists to other more powerful substances and, therefore, plant allelochemicals are often economically important (Rizvi and Rizvi, 1992).

For more than 100 years' biologists and chemists have tried to answer the question as to why plants invest so much energy and care in the formation of these secondary products. The main function seems to be chemical defense against microorganisms (viruses, bacteria, fungi), phytophagous animals (nematodes, mollusks, insects, vertebrates) and against other competing plant species ("allelopathy") (Mothes, 1955; Paech, 1950).

RESEARCH HISTORY

The word allelopathy is derived from two Greek words: "allelon", meaning "of each other", and "pathos", meaning "to suffer" (Rizvi et al., 1992). This ancient concept was known to classical researchers in the Greek and Roman era. Detrimental effects of crop plants on other plants were observed by Theophrastus and by Pliny II, (Farooq *et al.*, 2011; Willis, 1985), while De Candolle considered allelopathy to be soil sickness. The term "allelopathy" was first used by Austrian plant physiologist Molísch, who defined it as the chemical interaction among plants and microorganisms (Farooq *et al.*, 2011).

Allelopathy, if studied closely, is a very old component of agricultural sciences. Inhibitory effects of crop plants on other crop plants were observed over 2000 years ago, but no scientific studies were done on the subject until early in the twentieth century.

During the long development of agriculture, the earliest reference concerning phytotoxicity appears in a volume called "Enquiry into Plants", written by Theophrastus (c. 300 B.C.). He also reported that chickpea does not re-invigorate soil but rather exhausts it. Earlier than that, the Greek philosopher Democritus had reported the use of naturally occurring plant products as a practical method of controlling weeds and that the trees could be killed by treating their roots with a mixture of lupine flowers soaked in hemlock juice (Rizvi et al., 1992).

In his encyclopedic work, Natural History, Plinius (first century A.D.) gives numerous examples of apparent allelopathic interactions. Plants, such as chickpea, barley, fenugreek and retch, were reported to scorch-up corn lands (Rizvi *et al.*, 1992).

Shreiner and his associates published a series of papers starting in 1909 in which they presented evidence that some soils will cease to provide the life support of a continuous single cropping system due to an addition of growth inhibitors released into the soil by certain crop plants. This was the early beginnings of allelopathy and autotoxicity (Rice, 1984).

PLANT SPECIES WITH ALLELOPATHIC PROSPECTIVE

Many plants, in particular rice, sunflower, sorghum, wheat, eucalyptus, mulberry, billy goat weed, white tephrosia, basil, kablingparang, Mexican marigold, thyme, neem, celery, california pepper, parsley etc., have strong allelopathic potential, which may be used for managing weeds, insect pests and diseases effectively (tab. 1). Nonetheless, special care is required in this regard to avoid any detrimental impact of the allelopathic phenomenon on agricultural systems (Farooq *et al.*, 2011).

Table 1

Plant species with allelopathic prospective

Species	Allelopathic interactions	Reference
Trifolium spp.	- weed suppressive species; - control the cabbage root fly *Delia radicum* (L.); - reduce soil compaction and providing soil protection during the fall and winter; - snap beans (*Phaseolus vulgaris* L.) planted into white clover can reach full yield potential without any added nitrogen.	Arevalo *et al.*, 2005; Hartwig and Ammon, 2002; Finch and Collier 2000; Hooks and Johnson, 2003; Zehnder *et al.*, 2007; Meyling *et al.*, 2013
Petroselinum crispum	- inhibitory effect on various weed species (hoary cress); - allelopatic potential against *Fusarium oxysporum* f. sp. cucumeris.	Jia *et al.*, 2011; Valcheva and Popov, 2013; Dhima *et al.*, 2009; Ravlić *et al.*, 2014
Apium graveolens	- inhibitory effect on various weed species - insecticidal, nematicidal, antifungal and phytotoxic activities.	Bewick *et al.*, 1994; Sbai *et al.*, 2017
Satureja hortensis	- inhibitory effect on various weed species (*Amaranthus retroflexus* and *Chenopodium album*);	Hazrati *et al.*, 2017
Ocimum basilicum	- inhibitory effect on various weed species.	Mekky *et al.*, 2019; Islam *et al.*, 2014

Brassica spp.	- protect against erosion, suppress weed growth, and temporarily conserve soil nitrogen.	Bell and Muller, 1973; Siemens *et al.*, 2002; Stivers-Young, 1998; Weston, 1996
Secale cereale	- rye and its residues release secondary metabolites that accumulate near the soil surface to further inhibit weed seed germination and growth; - rye residues apparently reduce weed seed germination and seedling growth by shading, lowering of soil temperatures, moderating diurnal temperature fluctuations, and acting as a physical barrier to prevent light from reaching the soil surface; - rye mulches in tomatoes also showed strong broadleaf weed suppression;	Barnes and Putnam, 1983; Barnes and Putnam, 1987; Bertholdsson *et al.*, 2011; Burgos *et al.*, 1999; Burgos and Talbert, 2000; Jabran *et al.*, 2015; Nair *et al.*, 1990; Mwaja *et al.*, 1995; Schulz *et al.*, 2013; Shilling *et al.*, 1985; Vidal *et al.*, 1994
Sorghum spp.	- is used as a green manure or cover crop for suppression of weeds in nursery crops, alfalfa, and vegetable rotations;	Able *et al.*, 2001; Czarnota *et al.*, 2001; Einhellig and Souza, 1992; Einhellig *et al.*, 1993; Gonzalez *et al.*, 1997; Nimbal *et al.*, 1996a; Nimbal *et al.*, 1996b; Meazza *et al.*, 2002; Rasmussen *et al.*, 1992; Rimando *et al.*, 1998; Weston, 1996
Hordeum vulgare	- inhibitory effect on various weed species (*Chenopodium album* L. and *Sinapis arvensis* L); - faba bean–barley, lupin–barley, and pea–barley intercrops had 64, 27, and 55% higher protein yields, respectively, compared to sole crop barley;	Bertholdsson, 2004; Bouhaouel *et al.*, 2014; Corre-Hellou *et al.*, 2011; Fujii 2001; Hidoto *et al.*, 2015; Lodhi *et al.*, 1987; Overland, 1966; Wu *et al.*, 2000
Lotus corniculatus	- reduce onion thrips damage; - inhibitory effect on various weed species;	Gombač and Trdan, 2014; Zagrobelny *et al.*, 2004

These species can be manipulated to suppress weeds in a cropping system as a rotational crop, cover crop, or mulch, using it as a cover crop is the most common method for weed control.

PRACTICES FOR APPLYING ALLELOPATHY IN WEED MANAGEMENT

Global concerns about herbicidal and pesticide use, their residues in soil and plant systems as well as their hazardous effects on ecology and environment have diverted the attention of plant scientists to find eco-friendly approaches to plant protection against weeds, diseases and insects. Similarly, mechanical weed control requires extra soil turn-over, which can disturb soil structure and deplete soil fertility. Mechanical weed control is not always effective and can be expensive and lack durability (Jabran *et al.*, 2015).

The world is still in search of and in the process of developing farming techniques, which are sustainable for environment, crop production and protection as well as socio-economic points of view. Integrated weed management is one of such approaches where allelopathy can play its eco-friendly role in weed management (Hussain *et al.*, 2007).

In field crops, allelopathy can be used following rotation, using cover crops, mulching and plant extracts for natural pest management (tab. 2).

Allelopathic cover crops, main crops and the weeds suppressed by cover crops (Jabran *et al.*, 2015).

Table 2

Wees suppressed by cover crop mixture (Jabran *et al.*, 2015)

Cover crop MIXTURE	Main crop	Weeds suppressed
Annual ryegrass, rye, bristle oat, common vetch, radish	Common bean, tomato	*Brachiaria plantaginea*, *Ipomoea grandifolia*, *Bidens pilosa* L., *Euphorbia heterophylla* L.;
Sorghum sudangrass [*Sorghum bicolour* (L.) Moench Sorgum sudanense (Piper) Staph.]	Broccoli	Broad leaved weeds;
Rye, hairy vetch, barley triticale, Austrian winter pea	Organically grown maize-soybean	*C. album*, *Amaranthus hybridus* L., *Thlaspi arvense* L., *Taraxacum officinale* (L.) Weber ex F.H.Wigg., *Stellaria media* (L.) Vill., *Elymus repens* (L.) Gould, *Panicum crus-galli* L., Setaria glauca (L.) P. Beauv.
Hairy vetch, subterranean clover, oat/hairy vetch	Tomato	*A. retroflexus* and *C. album*

Application of allelopathic plant extracts can effectively control weeds and insect pests. Lower doses of herbicides may help to reduce the development of herbicide resistance in weed ecotypes. Allelopathy thus offers an attractive environmentally friendly alternative to pesticides in agricultural pest management (Farooq *et al.*, 2011).

The most important practices for the application of allelopathy in weed control is: the use of natural or modified allelochemicals as herbicides, genetic transfer of allelopathic traits into commercial crop cultivars, the use of allelopathic plants in crop rotation, companion plantings and smother crops, the use of phytotoxic mulches and cover crop management for weed suppression, especially in conservation and no-tillage crop production.

PERSPECTIVES FOR USING ALLELOPATHY IN ROMANIA

Nevertheless, the increasing of the chemical control has become overwhelming economical border, and more important, it could pose a serious threat of the public health and of the environment as it has been proved in recent studies from which the following facts are concluded: a) a considerable decreasing of the crop yields; b) the appearance of highly resistant species to commercial innocuous products traditionally used; c) a clear and ever growing pollution on the phreatic al layer. During last few decades the extensive use of synthetic herbicides and pesticides has been the cause of concern from both environmental and health considerations (Macias, 1994).

In the context of sustainable development, agriculture needs to reduce its negative environmental impact. The soil is still the main link of the agricultural chain and as such is the most susceptible to pollution. As regarding the soil type distribution in Romania, the highest percent of plots is given by Chernozems (29.1%), followed by Luvisols (21.1%), Fluvisols (11.6%), and Eutric Cambisols (11.0%) (Dumitru *et al.*, 2011). In this respect, it becomes necessary to innovate and to find alternative methods of preserving the quality of soils, allelopathy being of real interest through its proven role in the sustainable management of weeds, diseases and pests, as well as in increasing soil fertility.

CONCLUSIONS

Allelopathy helps us learning from nature how a specific plant can biochemically interact with another and can represent the key for sustainable management of agricultural ecosystems.

Suppressing weeds by harnessing the allelopathic phenomenon is included among the important innovative weed control methods.

Allelopathy is a complex process that requires thorough research as it can influence many aspects of plant ecology, including germination, growth, plant sequence, plant community structure, domination, diversity and productivity

The allelopathic phenomenon may have a special economic utility. The inclusion of allelopathy in agricultural systems through intercropping can reduce production costs, but also may result in higher net harvests. In addition, crop cultivation in mixtures improves resource efficiency (soil, water, nutrients and light).

The use of allelopathic species may be useful in reducing NO_2 emissions, in improving the fertiliser use rate and in reducing soil pollution. Furthermore, allelopathy can be a safe and sustainable tool for addressing the biotic and abiotic challenges to which crops are subject.

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