ROLE OF ALLELOPATHY IN CORN-WEEDS INTERFERENCE

A. J. Al-Maliki **I. S. Al-Saadawi**

ABSTRACT

Field observation revealed that companion weeds of corn crop (*Zea mays* L.) were significantly reduced in corn field. This interference could be attributed to competition and/or allelopathy. To test if allelopathy of corn is involved in the observed interference, several field measurements and plastic house and laboratory experiments were conducted. Results of field measurements revealed that weed density in corn stands was reduced between 49 and 68% of control (non-corn stand) and reduced weed biomass between 68 and 50% of control. Subsequent plastic house experiments showed that incorporation of root residues of corn in soil at 4 and 8 g/kg soil reduced whole plant dry weight of *Echinochloa colonum* L by 64 and 71% of control, and whole plant dry weight of *Amaranthus retroflexus* L by 54 and 63% of control, respectively. These results of the experiments suggest that allelopathy of corn root residues is responsible for weed reduction and it contains allelopathic compounds which may release during decomposition into the soil and become available to be up taken by test weeds. Subsequent work confirmed this suggestion. Analyses by high pressure liquid chromatograph (HPLC) h\ave shown that the root extracts contain sizeable amount of phenolics and these phenolics comprised of 4 mono phenolics (gallic, p-coumaric, ferulic and p-hydroxy benzoic acids) and 5 polyphenolic compounds (catechin, rutin, qurcetine, luteolin and kaemferol). Subsequent work on the extraction of phenolics by root exudates using XAD-8 resin and identification by HPLC indicated the presence of all the above phenolics except gallic and p-hydroxy benzoic acids. Biological activity test showed that root exudates reduced germination of *P. oleracea* and *E. colomum* by 65 and 62 % of control and seedling length by 28 and 28% of control, respectively. These results suggest that allelopathy of root exudates is involved in the interference of crop with weeds in addition to root residues.

Thus it appears that allelopathy is involved in the interference of corn-weeds, with competition accentuating its effect.

INTRODUCTION

Allelopathy is an ecological term which was first introduced by Prof. Hans Molisch in 1937 (1) and derived from two Greek words "Allelon" means mutual and "Pathos" means harm. Rice(2), who was the pioneer in the growing of this field, defined allelopathy based on Molisch concept as any direct or indirect positive or negative biochemical interactions among all classes of plants and the microbes throughout the production of chemical compounds released into the environment. During the last six decades, Allelopathy research has broadened to new areas including the plant– insect, nematodes, pathogens, aquatic ecosystem interactions. Hence, in 1996, International Allelopathy Society broadened its definition, "Allelopathy refers to any process involving secondary metabolites produced by plants, microorganisms, viruses and fungi that influence the growth and development of agricultural and biological systems" (3).

College of Scie., Baghdad Univ., Baghdad, Iraq.

The chemical compounds with allelopathic potential are secondary compounds called allelochemicals or allelochemics, which are present in sizeable amounts in all parts of allelopathic plant including roots, rhizomes, stems, leaves, fruits, seeds and flowers. They may be released from plants into the environment by volatilization, root exudation, leaching and decomposition of plant residues (2,3,4).

Allelopathy plays a major role in natural ecosystems by determining vegetational patterning, plant dominance, plant succession, plant biodiversity, preventing seed decay and causing seed dormancy (2). Also, allelopathy has a significant role in agricultural ecosystems such as weed-crop, crop-weed, crop-crop, forestry and nutrient cycling (5).

Corn (*Zea mays* L.) is an important crop growing in two seasons in Iraq. It is one of the most important crop grown throughout the world . It is used as food, fodder and also utilized as a raw material in industries. (6).

The allelopathic potentials of corn residues have been studied thoroughly by several investigators.(7) found that corn residue reduced corn yield as compared to no residue treatment. (8)reported that the toxicity of corn and sorghum (*Sorghum bicolor*L.) residues persisted for about 22 to 28 weeks of decomposition. The phytotoxic compounds released from the decomposing corn residue were identified as phenolics acids by Chou and Patrick (9) and Higgs *et al* (10) reported continuous corn yielded 502 kg/ha less than the yield of corn in rotation. A similar magnitude of yield reduction of corn in continuous corn was obtained by Slife (11) who found that the allelopathic corn residues may be responsible for the reduction of corn yield grown in monoculture. (12).

Field observations indicated the presence of poor growth of companion weeds in corn field due to strong interference between corn plants and the weeds. This interference can be attributed to competition and / or allelopathy of root exudates and root residues. However the allelopathic potential of root exudates and residues against companion weeds has not investigated. Therefore, the following experiments were conducted to test if allelopathy of root exudates and corn root residues contribute in the reduction of weed density and growth of companion weeds. Another aim is to extract and identify allelochemicals in root exudates and root residues of corn.

MATERIAL AND METHODS

Determination of density and dry weight biomass of weeds grown in corn fields.

This experiment was primarily conducted to verify the field observations which indicated that the population density and growth of weeds in corn field is less than that grown in adjacent non corn cultivated area. Three corn field sites were chosen in Kut and Baghdad governorates. The sites were received nitrogen and phosphorus fertilization as recommended for this crop (13), and not subjected to any herbicidal activities. For weed measurements, four wood quadrates (50 × 50 cm) were randomly placed in selected corn field sites and adjacent non corn cultivated areas (control) at 75 and 90 (DAS) in Kut and Baghdad sites, respectively. Weed counts per quadrate were made then all weeds were clipped at the ground surface, oven dried at 70 ºC for 72 h and weighed by electrical balance to record the biomass. Data on weed density and biomass was converted to express as per m^2.

The data were statistically analyzed by analysis of variance (ANOVA) using SAS (14) program was used to effect of difference factors in study parameters. Differences among treatment averages were compared using Least Significant Difference (LSD) at 0.05 probability level.

Effect of corn root residues on weeds.

This experiment was performed to find out if the corn roots have allelopathic potential against the companion weeds. Corn roots were collected from a corn field at the College of Agriculture, University of Baghdad. The roots was washed with tap water to get rid of the dust and the suspended materials, cut in to small pieces and dried in an electric oven at 70 °C for 48 hours. The root pieces was ground by electrical grinder to obtain a fine powder , placed inside clean nylon bags and kept in the refrigerator until use.

The residues were mixed with loam soil at 4 and 8 g per kg soil and placed in plastic pots of one kg capacity. Pots filled with the same amount of soil alone were used as control. Thirty seeds of each of *Echinochloa colonum* L. and *Amaranthus retroflexus* L. were sown in their respective pots and the pots were irrigated with tap water up to the field capacity. The pots were placed in plastic house in May 2018. Ten days after sowing, seed germination in each pot was counted and the seedlings were allowed to grow for additional week then thinned to the three largest plants per pot. Forty days after sowing plant length of seedlings of *E. colonum* and *A. retroflexus* were recorded, then the seedlings were carefully removed from the pots by running water, separated into roots and shoots and oven dried at 70 ºC for 72 h. The Dry weight of roots, shoots and whole plants was measured.

The experiment was laid out in a (CRD) with four replications. Least significance difference (LSD) test was applied at 0.05 probability level to compare treatment means.

Effect of corn residues on chlorophyll content of *Echinochloa colonum* L.

This experiment was conducted to find out the reduction in growth in E. colonum L observed in the above experiment is related to the reduction in chlorophyll content. A given number of E. colonum seeds are sown in pots containing soil mixed with residues of corn at rates of zero (control), 4 and 8 g per kg soil. Seven days after sowing, The seedlings were thinned to the largest three per pot and allowed to grow for additional six weeks.

Chlorophyll content was determined in leaves of seedlings of each treatment by taking 0.2 g fresh plant leaf material and grinding them in 20 ml of 80% acetone using mortar using pestle (15). Concentrations of chlorophylls a, b and total chlorophyll and chlorophyll (a/b) ratio were quantified in the samples by reading the absorbance of chlorophyll extract at 663 and 645 nm using spectrophotometer the applied the following equations (16).

chlorophyll a = 12.7 (A 663) −2.69 (A 645)

chlorophyll b = 22.9 (A 645) −4.68 (A 663)

Where A 663 and A 645 are absorption at 663 and 645 nm, respectively, and 12.7 and 22.9 are constants.

Effect of corn root residues on ions content in *Echinochloa colonum* L.

This experiment was basically conducted to find out if inhibition of ions uptake could be one of the allelopathic mechanisms by which corn roots reduced growth of weeds. Plants from previous experiment were used for ions content determination. After 40 days from planting, *E. colonum* plants from each

treatment were dried at 70 ˚C for 3 days, ground by electrical grinder and digested by mixture of H_2SO_4 and $HCLO_4$(4 : 1) for mineral analysis. Total nitrogen was determined by the macro-Kjeldahl method (17) and total phosphorus by the vandomolybdophsphoric colorimetric method (18). Potassium, K, Mg, Fe ,Ca and Zn were determined by atomic absorption spectrophotometer. Ions determination was carried out at the laboratories of biology department, College of Science, Baghdad University. The experiment was replicated four times and each replicate consists of three plants.

Extraction and identification of phytotoxins in corn root residues

Corn roots were collected from a field at the College of Agriculture, University of Baghdad during the growing season of 2017. The roots were washed with tap water to get rid of the dust and the suspended materials, cut in to small pieces and dried in electric oven at 70 ° C for 48 hours. The residue was ground by electrical grinder to obtain a fine powder. After that, the powder was kept inside clean nylon bags in the refrigerator until use. For extraction, Thirty gram of plant powdered was added to tube containing 15 ml of chloroform with constant stirring for 24 hours at the ambient temperature. The extract was placed in a ultrasonic device for 15 minutes. Then 100 ml of butanol was added and then transferred to the separation funnel. The polar organic layer (butanol layer) was collected and transferred to the rotary evaporator to dry the extract and the residues were taken up by 3 ml acetonitrile . The extract was kept in refrigerator until analyzed by high performance liquid chromatography (HPLC) Using conditions listed in table1 and table2.

Table1: Separation conditions for phenolics in root exudates and root residues of corn plants

Parameter	Characteristic
Column types	C – 18
Column dimensions	50 length ×4.6mm
Flow rate of recorder	1.4 ml / min
Detector	UV-Vis SPD-10 AVP spectrophotometer at 280 nm
Volume of injection sample	25 µg/ml
Mobile phase	Solvent A:0.1%phosphoric acid in deionized Water, Solvent B:acetonitrile,50:50V/v
Temperature	35°C

Table 2: Separation conditions of polyphenols from root exudates and root residues of corn plants

Parameter	Characteristic
Column types	C – 18
Column dimensions	25 cm ×4.6mm
Flow rate of recorder	1ml / min
Detector	UV-Vis SPD-10 AVP spectrophotometer at 360 nm
Volume of injection sample	20 µg/ml
Mobile phase	Solvent A: Methanol :D.W :acetic acid (85 : 13 : 2) ,while B : Methanol : D.W : acetic acid (25 : 70 : 5)
Temperature	25°C

Collection of phenolics in root exudates

Phenolics of root exudates were collected and extracted from living maize seedlings of the test cultivars using a direct resin adsorption method described by Kong *et al*. (19). Seeds of corn were planted in plastic pots contain acid washed sand. After 10 days two uniform seedlings at the 3rd leaf stage were transplanted into small pot containing 45 g XAD-8 resin and 150 ml of 1mM MES -Tris buffer at pH 5.5 + 0.5mM CaSO4 solution, and the pots were placed

in a sterile environment growth chamber at 25±1˚C with a 12 h photoperiod (light intensity 2000 lux), and watered once daily to maintain the volume of the solution the same during the course of experiment. After 10 days, the seedlings were carefully separated from the resin, and then the resin and solution were transferred to a column (5×20 cm). Water was first allowed to drain from the column and the resin was washed with distilled water and then eluted three times with 50 ml methanol. The methanol fractions were pooled and evaporated to dryness under vacuum by rotary evaporator (Heidolph 2, with Rotacool mini and vacuum, Germany) at 45 °C and the residues were taken up by 3 ml methanol and stored at -20 °C until use. To determine total phenolics, the residues collected from elution of XAD-8 resin were used to quantify phenolics by the Folin-Denis method (20).

Isolation, identification and quantification of phenolics in root exudates

Identification and quantification of individual phenolic acid in root exudates were performed by HPLC system (Shimadzu Corporation, Kyoto, Japan) equipped with two Shimadzu LC-10 ATVP reciprocating pumps, a variable UV-VIS detector (Shimadzu SPD-10 AVP) and a C-R6A Chromatopak data processors .The conditions used in separation of phenolics are listed in table (1) and table (2). Standards were run similarly for identification and quantification. Concentration of each isolated compound based on standard curve was determined by the following equation:

$$\text{Concentration (ppm)} = \frac{\text{Area of the sample}}{\text{Area of the standard}} \times \text{Concentration of the standard} \times \text{Dilution factor}$$

Biological activity of root exudates against weeds

Collection of root exudates

Seeds of corn were sterilized by soaked in 1% sodium hypochlorite solution for 5 min, followed by 5 times rinsing in sterilized distilled water. The seeds were planted in acid washed sand and incubated in growth chamber at 25±1˚C with a 12 h photoperiod (light intensity 2000 lux). After 10 days 3 uniform corn seedlings at the 2nd leaf stage were transplanted in pot of 180 ml capacity. Ten pots with 30 seedlings were made for the process of collection. All pots were watered whenever necessary to maintain the volume of the solution the same during the course of experiment. After 3 weeks, the seedlings were moved away from the pots and the growing solution were pooled, reduced to 50% of its volume by rotary evaporator under vacuum at 45 °C and stored at - 20 °C until use.

Biological activity of root exudates

The methods of biological activity determination was basically similar to Equal Compartment Agar Method developed by Wu *et al.* (21) with considerable modification. A semi solid agar medium was made by dissolving 3.5 g agar in 500 ml of root exudates solution obtained from the above section and autoclaving for 30 minutes. Control was made in a similar manner except root exudates solution is replaced by distilled water. After quite cooling, the medium was poured in sterilized transparent plastic containers at a rate of 50 ml medium per container (150 ml capacity). The containers were covered by their respective covers and kept under laboratory condition for cooling. Seeds of *E.*

***colonum* L. and *P. oleracea* L were sterilized by soaked them separately in 1% sodium hypochlorite solution for 5 min, followed by 5 times rinsing in sterilized distilled water. Twenty-five seeds of each weed species were sowed on the agar of each container and placed in a controlled environment growth chamber with appropriate dark/light period. After 10 DAS, seed germination was counted then the seedlings of each weed species were carefully removed from the pots, separated into roots and shoots and their length were recorded. The experiment was laid down in a Complete Randomized Design with 4 replications. Differences among treatment averages were compared using LSD at 0.05 probability level (14).**

RESULTS AND DISCUSSION

Identification of weeds in corn field

Weed flora appeared in the corn fields during the course of study comprised mainly of several monocot and dicot weed species (Table3). Sixty per cent of them were dicot and 40% were monocot Field observations revealed that their densities and growth were varied among the sites of study.

Table 3: Weeds found in the test corn fields.

Scientific name	Common name	Local name
***Chenopodium album* L.**	**Lambs quarters**	رغيلة
***Cyperus rotundus* L.**	**Cocograss,purple nutsedge**	سعد
***Portulaca oleracea* L**	**Pigweed**	برين البري
***Convolvulus arvensis* L.**	**Convolvulus**	مديد
***Sorghum halepense* L.**	**Johnson grass**	سفرندة
***Amaranthus retroflexus* L.**	**Red-root amaranth**	عرف الديك
***Raphanus raphanistrum* L.**	**Wild radish**	فجيلة
***Malva parviflora* L.**	**Mallow Cheese weed**	خباز
***Echinochloa colonum* L.**	**Jungle rice**	دهنان
***Cynodon dactylon* L.**	**Bermuda Grass**	ثيل

Weed density and dry weight biomass were drastically reduced in corn stand compared to adjacent non corn stands (control) in all sites tested (Table 4). However the reduction in weed density and dry weight biomass is considerably varied among the sites of study. Weed density and biomass in corn stand were significantly reduced by 49 and 68% over non corn stand in site 1 of Baghdad location. While the reduction of weed population and dry weight biomass was 68 and 50% of control in site 1 and 66 and 63% of control in site 2 of Kute location, respectively.

Table 4: Density and dry weight biomass of weeds grown under corn and adjacent non corn stands in selected sites of two provinces.

Provinces	Sites	Stands	Weed density (Plants/m^2)	Dry weight biomass (g/m^2)
Baghdad	**1**	**Inside corn stand**	**9.25**	**18.20**
		Outside corn stand	**18.25**	**57.67**
		LSD ≤ 0.05	**4.89**	**7.71**
Kute	**1**	**Inside corn stand**	**34.25**	**74.40**
		Outside corn stand	**108.25**	**149.37**
		LSD ≤ 0.05	**14.63**	**16.07**
Kute	**2**	**Inside corn stand**	**17.50**	**95.50**
		Outside corn stand	**52.00**	**256.12**
		LSD ≤ 0.05	**7.42**	**21.52**

Effect of root residues of corn on growth of *Echinochloa colonum* L. weed

Corn root residues incorporated in to the soil significantly inhibited all test growth parameters of E. colonum compared to the control (Table5). In most cases, the reduction in growth parameters was significantly increased with the increasing residues concentration. Application of corn residues at 4 and 8 g/kg soil inhibited root dry weight of E. colonum by 68 and 74% of control, shoot dry weight by 60 and 68% of control and whole plant dry weight by 64 and 71 % of control, respectively. Moreover, seedling length was reduced by 25 and 38 % of control when corn residues applied to the soil at 4 and 8 g/kg soil, respectively.

Table 5: Effect of root residues of corn on growth of *Echinochloa colonum* L weed.

Corn root residues (g/kg soil)**	Dry weight (mg/pot)*			Plant height* (cm)
	Shoots	Roots	Whole plant	
0 (Control)	125.00 a	116.51 a	241.50 a	16.00 a
4	50.00 b	37.50 b	87.50 b	12.00 b
8	40.00 c	30.00 c	70.00 c	10.00 b
LSD ≤ 0.05	8.49	7.73	13.84	3.19

* Means within each colonum followed by the same letters are not significantly different according to Duncan's multiple range test. **Each number is an average of four replicates and each replicate consist of three plants.

Effect of root residues of corn on growth of *Amaranthus retrofexus* L weed

Corn root residues mixed with the soil significantly affected all growth parameters of *A. retroflexus* tested (Table6). Incorporation of corn root residues at rates of 4 and 8 g/kg soil significantly inhibited root dry weight of *A. retroflexus* root by 57and 62% of control, shoot dry weight by 50 and 66% and whole plant dry weight by 54 and 63% of control, respectively. Similarly, seedling length of *A. retroflexus* was reduced up to 38 and 46% of control when corn root residues mixed with soil at 4 and 8 g/kg soil, respectively.

Table 6: Effect of root residues of corn on growth of *Amaranthus retrofexus* L weed.

Corn root residu (g/kg soil)**	Dry weight (mg/pot)*			Plant height (cm)
	Shoots	Roots	Whole plant	
0 (Control)	204.50 a	408.10 a	612.60 a	13.00 a
4	102.90 b	177.10 b	280.00 b	8.00 b
8	70.00 c	156.40 b	226.70 c	7.00 b
LSD≤0.05	17.56	28.06	33.75	2.86

* Means within each colonum followed by the same letters are not significantly different according to Duncan's multiple range test. **Each number is an average of four replicates and each replicate consist of three plants.

Effect of corn residues on chlorophyll content in leave of *Echinochloa colonum* L.

Incorporation of corn residues at 4 g/kg soil significantly reduced chlorophyll b content in leaves of *E. colonum* L. while chlorophyll a and total chlorophyll were considerably inhibited (Table 7). However, at the higher corn residues, content of chlorophylls a and b and total chlorophyll were significantly reduced by 14, 13 and 14% of control, respectively. The ratio of chlorophyll a /b was significantly decreased by incorporation of corn residues at 8 g/kg soil, only.

Table 7: Effect of corn residues on chlorophyll content in leave of *Echinochloa colonum L.*

Corn root residues (g/kg soil)	(µg/mg dry weight)			Chlorophyll a/b
	Chlorophyll a*	Chlorophyll b*	Chlorophyll a+b*	
0 g / kg (Control)	20.35 a	17.38 a	37.73 a	1.17 b
4 g / kg	17.41 a	15.04 b	32.45 a	1.15 b
8 g / kg	9.56 b	6.24 c	15.80 b	1.53 a
LSD ≤ 0.05	4.63	4.85	6.92	0.27

*** Means within each colonum followed by the same letters are not significantly different according to Duncan's multiple range test.**

Effect of root residues of corn on ions content in *Echinochloa colonum* L.

Incorporation of corn root residues in the soil significantly affected the uptake of nitrogen, potassium and zinc (Table8), while the uptake of the other test minerals was not significantly affected. Nitrogen uptake was significantly inhibited by application of root residues at rates of 4 and 8 g /kg soil. However, no significant difference was found in nitrogen uptake between 4 and 8 g/kg treatments. Potassium uptake was inhibited by the higher rate of corn residues only. Zinc uptake significantly increased at the lower rate of corn residues then decline to the control treatment level.

Table 8: Effect of root residues of corn on ions content in *Echinochloa colonum L.*

Corn root residues (g/kg soil)	% *					ppm
	N	P	K	Ca	Mg	Zn
Control	0.70 a	0.28 a	2.30 a	0.53 a	0.42 a	86 b
4 g	0.50 b	0.20 a	2.40 a	0.50 a	0.41 a	97 a
8 g	0.40 b	0.26 a	1.80 b	0.60 a	0.42 a	81. b
LSD ≤ 0.05	0.17	NS	0.34	NS	NS	8.6

***Each number is an average of four replicates and each replicate consist of three plants.**

Separation and identification of phytotoxins in corn root residues and root exudates

Results of chemical analysis by HPLC indicated the presence of several allelochemicals of phenolic in nature in root residues of test corn cultivars, *viz*., gallic, coumaric, ferulic, p-hydroxybenzoic acid, catechin, rutin , qurcetine, luteolin and kaemferol were also observed in root residues of corn cultivars (Table 9, Fig1). The concentration of the isolated allelochemicals was found in the following order: p-hydroxybenzoic acid > kaemferol > ferulic acid > rutin > qurcetine > catechin > p-coumaric acid > gallic acid > luteolin and the total concentration of these allelochemicals 269.65µg/ml.

Table 9: Isolation and quantification of phenolic acids collected from root exudates and root residues of corn plant.

Compounds	Root exudates (µg/ml)	Root residues (µg/ml)
Gallic acid	----	12.60
p-coumaric acid	15.80	26.34
ferulic acid	9.24	37. 93
p-hydroxybenzoic acid	-----	75.17
Catechin	23.18	28.03
Rutin	26.76	34.19
Qurcetine	12.03	29.55
Luteolin	8.31	10.66
Keamferol	14.49	44.73
Total	109.81	269.65

All the above allelochemicals except gallic and hydroxybenzoic are also present in the root exudates of corn cultivar (Table 9). Generally, the identified allelochemicals are less in root exudates than in root residue of corn plant.

Quantification of total phenolics in root exudates and root residues.

The results showed that phenolics are present in sizeable amount in root exudates and root residues of corn cultivars (Fig1). However, the amount of these compounds appeared to be higher in root residues (0.99 mg/g) than in root exudates (0.65 mg/g).

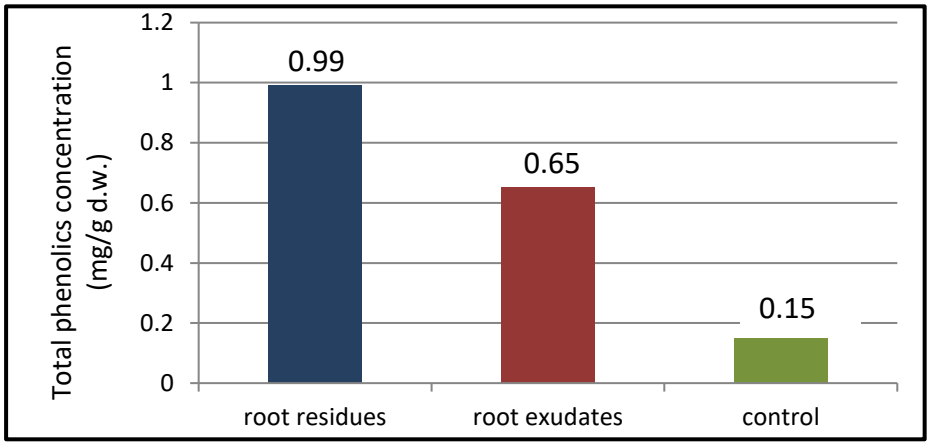

Fig. 1: Total phenolics extracted from root exudates and root residues of corn plant.

Biological activity of root exudates against test weeds

Root exudates of corn seedling significantly affected seed germination and seedling growth of *Portulaca oleracea* and *Echinochloa colonum* weeds. Root exudates significantly inhibited seed germination of *P. oleracea* and *E. colomum* by 65 and 62% of control, respectively. Also, application of root exudates of corn seedling significantly reduced root, shoot and seedling lengths of *P. oleracea* by 32, 21and 28% of control, respectively (Table10). Similarly, root, shoot and seedling lengths of *E. colonum* grown in root exudates solution of corn seedlings were significantly inhibited by 24, 33and 28% of control, respectively. The response of the test weeds to the inhibitory effect of root exudates of corn was almost similar.

Table10: Biological activity of root exudates against *Portulaca oleracea* and *Echinochloa colonum* weeds.

Test Weed	Treatments	Average root length (mm)	Average shoot length (mm)	Average plant length (mm)	Per cent germination
P. oleracea					
	Control	18.25 a	10.50 a	28.75 a	86
	Root exudates*	12.50 b	8.25 b	20.75 b	65
	LSD ≤ 0.05	2.98	NS	5.63	
E. colomum					
	Control	19.00 a	20.75 a	39.75 a	85
	Root exudates*	14.50 b	14.00 b	28.50 b	62
	LSD ≤ 0.05	5.24	4.83	3.84	

*** Each number is an average of 4 replicates.**

Plant interference is an ecological phenomenon by which plant species interfere with other plant species in natural and agricultural ecosystems leading to the superiority of one species and decline the other (2). This interference may be taken place by allelopathy or competition or both (22,2). Several researchers have focused on the role of competition and allelopathy in the interference of plant species in natural ecosystems and found that allelopathy is the major cause of interference with competition accentuating its effect (23,24,25).

In agroecosystems, crop-weed interference is interesting subject that attracts agronomists to research on the possible role of allelopathy of crops in biological weed control (5, 26). In our study , The significant reduction of weed density and weed dry biomass in corn stand compared to noncorn stand (Table 4) is suggested that allelopathy is involved in the interference, in addition to competition. Corn has been reported to have strong allelopathic top (Leaves and stem) residues (5, 27, 28) but their allelopathic effect of root residues and root exudates on weeds have not been tested. Our results revealed that root residues of corn showed strong inhibitory effect on test companion weeds (Tables 5 and6). This suggests that allelopathy is responsible for weed reduction and corn root residues contain allelopathic compounds which may release during decomposition into the soil and become available to be uptake by test weeds. Subsequent work confirmed our suggestion. Chemical and Chromatographic analyses revealed that the root extracts contain sizeable amount of phenolics and these phenolics comprised of 4 mono phenolics (gallic, p-coumaric, ferulic and p-hydroxybenzoic acid, and 5 polyphenolic compounds (catechin, rutin, qurcetine, luteolin and kaemferol) (Fig1, Table 9). No attempt was made to determine their biological activity, however these compounds are reported to be water soluble and when imbibed by the germinating weed seeds, hamper their germination and subsequent seedling growth, thus contributing to overall decline in the density and vigor of weed community (29).

The results of this study showed that inhibition of chlorophyll content and uptake of some ions by the corn residues (Tables 7 and 8) are among the mechanisms by which they affect the test weed species. Other mechanisms, however, are not excluded. These phytotoxins are reported to have inhibitory effects on several processes such as inhibition of chlorophyll biosynthesis, respiration, photosynthesis, ions uptake, hormones biosynthesis, cell division, cell elongation and ultra-structures, inhibition of the activity of some enzymes involved in essential metabolic processes (2,30). Phenolics also caused inhibition in membrane stability and The degree of inhibition is concentration dependent in the rhizosphere (31,32). Other researchers found that several phenolic acids including caffeic acid, p-coumaric acid, ferulic acid, gallic acid, p-hydroxybenzaldehyde, vanillic acid and vanillin significantly reduced water relations, dry matter production, leaf expansion, height, leaf production of 3-week-old soybeans (*Glycine max* L.). At concentrations of 10^{-3} M, These compounds were severely reduced stomatal conductance of fully expanded leaves and caused marked reductions in leaf chlorophyll content, reduced leaf stomata conductance and Leaf transpiration and assimilate rate (rate of dry matter production per unit leaf area(33,34).

It is noteworthy to mention that all the identified phenolics except Gallic and p-hydroxybenzoic acids were found in root exudates. This suggests that these compounds might be either not exuded and / or exuded in to the rhizosphere and transformed to another compounds by the action of soil

microorganisms. Reports indicated that several phenolics are subjected to different chemical processes in soil and change from toxic and non toxic compounds and vice versa (2,35). Others indicated that many compounds are exudated from the roots, which may affect the growth of microorganisms and associated plants. Determination of allelochemicals in root exudates is difficult because microbial activity may alter primary exudates. In a soil environment, transitions by rhizosphere microorganisms may inactivate the original exudation compounds and in other cases may create new active allelochemicals. The exudation vary according to plant species, age, plant nutrition, light, temperature and microbial activity around the roots (3).

Although the phenolics exuded from root are relatively small, nevertheless the additive or synergistic effects of these compounds becomes more detrimental than single compound. This is confirmed by the result presented in (Table10) which show that root exudates of corn significantly reduced root, shoot and seedling growth of *E. colonum and P. oleracea* These results are in agree with the results of several researchers who found that root exudates of rice, cucumber, sorghum and wheat were toxic to different weed species (36, 37, 38). In addition, root exudates of corn and other allelopathic plants continue releasing phenolics in to the rhizosphere along the life cycle of the plant and this leads to accumulation of phytotoxins in effective level. Several investigators showed that phytotoxic phenolics in field soil amended with allelopathic crop residues (sunflower, sorghum and wheat) were increased significantly after residue incorporation in soil and continued until six weeks then declined. During this period significant reduction in weed density and dry biomass were observed (39, 40, 41, 42).

The results of this study have shown that corn crop have high inhibitory properties against companion weeds. This may lead some researchers to focus on the possibility of using this phenomenon in biological control of weed or reduce it. Mechanical weed control requires added soil rolling, which can disrupt soil structure and reduce soil fertility (43). Mechanical weed control is not always active and lack permanency and can be expensive (44). Likewise, herbicide-resistant weeds, environmental concerns and health influences are the major restrictions in herbicide application.

This study leads to the conclusion that allelopathy of corn is the major components of interference between corn and companion weeds with competition accentuating its effect.

REFERENCES

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

2- Rice, E. L. (1984). Allelopathy, 2nd ed. Academic Press, Orlando, Florida.

3- Narwal, S. S., Palaniraj, R. and Sati, S. C. (2005). Role of allelopathy in crop production. Herbologia 6:31 -66.

4- Kim, S. Y.; S. K. Datta; R. P.Robles; K. U. Kim; S. C. Lee and D. H. Shin (1993). Allelopathic effect of sorghum extract and residues on selected crops and weeds. Korean Journal of Weed Sci.,14:34-41.

5- Singh, H.P.; D. R. Batish and R. K. Kohli (2001). Allelopathy in agroecosystems: an overview. Journal Crop Protection, 4:1-41.

6- Nazir, S.; E. Bashir and R. Bantel (1994). Crop Production- National Book Foundation,Islamabad.

7- Bhowmik, P.C. and J.D. Doll (1982). Corn and soybean response to allelopathic effects of weed and crop residues. Agronomy Journal,74:601-606.

8- Guenzi, W.D.; T.M. Mccalla and F.A. Norstadt (1967). Presence and persistence of phytotoxic substance in wheat, oat, corn, and sorghum residues. Agronomy Journal, 59:163-165.

9- Chou, C.H. and Z.A. Patrick (1976). Identification and phytotoxic activity of compounds during decomposition of corn and rye residues in soil. Journal of Chemical Ecology. 2:369-387.

10- Higgs, R.L.; W.H. Paulson; J.W. Pendleton; A.F. Peterson; J.A. Jackobs and W.D. Shrader (1976). Crop Rotation and Nitrogen, Univ. of Wisconsin Res. Bul. R2761.

11- Slife, F. W. (1976). Economics of herbicide use and cultivars tolerance to herbicides. Annual Corn and Sorghum Res. Conf., 31, 77–84.

12- Jabran, K.; G. Mahajan; V. Sardana and B. S. Chauhan (2015). Allelopathy for weed control in agricultural systems. Crop Protection, 72: 57–65.

13- General Authority for Guidance and Agricultural Cooperation (1991). Recommendations on the use of chemical fertilizers, agricultural extension series. Baghdad. Iraq, p:286.

14- SAS. (2012). Statistical Analysis System, User's Guide. Statistical. Version 9.1th ed. SAS. Inst. Inc. Cary. N.C. USA.

15- Sudhakar, P.; P. Latha and P. V. Reddy (2016). Chapter 15 -Plant Pigments." In *Phenotyping Crop Plants for Physiological and Biochemical Traits.* Academic Press. p:121-27.

16- Arnon, D. I. (1949). Copper enzymes in isolated chloroplasts. Polyhenoloxidases in Beta vulgari. Journal of Plant Physiology. 24: 1-15.

17- Chapman, H.D. and P.F. Pratt (1961). Methods of Analysis for Soils, Plants, and Waters .University of California, Riverside, California. p:150-160.

18- Jackson, M.L. (1958). Soil Chemical Analysis. Prentice-Hall, Englewood Cliffs, New Jersey, p:498.

19- Kong, C. H.; F. Hu; P. Wang and J.L. Wu (2008). Effect of allelopathic rice varieties combined with cultural management options on paddy field weeds. Pest Management Scie., 64: 276-82.

20- Ben-Hammouda, M.; J.K. Robert and C.M. Harry (1995). Phytotoxicity of extracts from sorghum plant components on wheat seedlings. Crop Scie., 35:1652-1656.

20- Wu, H.; P. James; D. Lemerle and T. Haig (2000). Laboratory Screening for Allelopathic Potential of Wheat (*Triticum Aestivum*) Accessions against Annual Ryegrass (*Lolium Rigidum*). Crop and Pasture Sci., 51: 259-266.

21- Muller, C. H. (1966). The Role of Chemical Inhibition (Allelopathy) in Vegetational Composition. Bulletin of the Torrey Botanical Club, 93: 332-351.

22- Alsaadawi, I. S. and N.M.M. Salih (2009). Allelopathic potential *of Cyperus rotundus* L. I. Interference with crops. Allelopathy J., 23: 297-304

23- Alsaadawi, I. S. and E. L. Rice (1982). Allelopathic effects of *Polygonum aviculare* L. I. Vegetational patterning. Journal of Chemical Ecology, 8: 933-1009.

24- Alsaadawi, I. S.; F.A. Sakeri and S. M. Aldulaimy (1990). Allelopathic inhibition of Cynodon dactylon L. Pers. and other plant species by *Euphorbia prostrata* L. Journal of Chemical Ecology, 16: 2747-2754.

25- Weston, L.A. (1996). Utilization of allelopathy for weed management in agro-ecosystems. Agronomy J., 88: 860-866.

26- Almezori, H. A.; I. S. Alsaadawi and T. R. Alhadithy (1999). Allelopathic effects of corn residues on the subsequent corn. Allelopathy J., 6: 193-20.

27- Kato-Noguchi, H.; Y. Sakata; K. Takenokuchi; S. Kosemura and S. Yamamura (2000). Allelopathy in Maize I. Isolation and identification of allelochemicals in maize seedlings. Plant Production Science J., 3(1):43-46.

28- Gallandt, E.R.; M. Liebeman and D.R. Huggins (1999). Improving soil quality: Implications for weed management. Journal of Crop Production, 2: 95-121.

29- Weir, T.L.; P. Sang-Wook and J.M. Vivanco (2004). Biochemical and physiologicalmechanisms mediated by allelochemicals. Current in Plant Biology, 7:472-479.

30- Lyu, S.W.1. and U. Blum (1990). Effects of ferulic acid, an allelopathic compound, on net P, K, and water uptake by cucumber seedlings in a split-root system. J Chem Ecology, 8:2429-39.

31- Yu, J. Q. and Y. Matsui (1997). Effects of root exudates of cucumber (*CucumisSativus*)and allelochemicals on ion uptake by cucumber seedlings. *Journal of Chemical Ecology*, 23: 817-27.

32- Einhellig, F.A.; J.C.G. Galindo; Molinillo, J.M.G., Cutler, H.G. (2004). Mode of allelochemical action of phenolic compounds. In Allelopathy: Chemistry and Mode of Action of Allelochemicals; CRC Press: Boca Raton, FL, USA.

33- Li, Z.H.; Q. Wang; X. Ruan; C.D. Pan and D.A. Jiang (2015). Phenolics and Plant Allelopathy Molecules, 15: 8933-8952.

34- Blum, U. and S.R. Shafer (1988). Microbial populations and phenolic acids in soil. Soil Biology and Biochemistry, 20:793-800.

35- Ma, Y.Q.; M. Zhanga; Y.L. Li; J.Y. Shuib and J. Zhou (2014). Allelopathy of rice *(Oryza sativa L.)* root exudates and its relations with Orobanche cumana Wallr. and Orobanche minor Sm. Germination. J Plant Interaction, 9: 722-730.

36- Yu, J.Q.; S.F. Ye; M.F. Zhang and W.H. Hu (2003). Effects of root exudates, aqueous root extracts of cucumber (*Cucumis sativus L.*) and allelochemicals on photosynthesis and antioxidant enzymes in cucumber. Biochemical and Systematics Ecology, 31:129-139

37- Alsaadawi, I. S. and S. M. Al-Hadithy (1986). Al-Hadithy. S. M. and Arif.M. B. and Arif, M. B. 1986. Effect of three phenolic acids on chlorophyll content and ions uptake in cowpea seedling. J. Chemical Ecology, 12: 221-227.

38- Lahmoud, N. R. and I. S. Alsaadawi (2014). Weed control in wheat using sorghum residues and less herbicide. Allelopathy J., 34: 277-286.

39- Alsaadawi, I.S.; H.A. Hadwan and H.M. Malih (2018). Weed management in cow pea through combined application of allelopathic sorghum residues and less herbicide. Journal of advanced agricultural Technologies, in press.

40- Sarbout, A. K. (2015). Combining effect of sunflower residues and lower rate of trifluralin herbicide on weeds in *Vigna sinensis* L., mycorrhizal Association and Nitrification. Ph.D. Dissertation, Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq.

41- Al-Khateeb, T.A. (2014). Allelopathic potential of two sorghum cvs. on weeds ,mung been and symbiotic nitrogen fixation and possible rapid identification of allelopathic potential by pcr technique.Ph.D. Dissertation ,Dept.of Biology, College of Science, University of Baghdad, Iraq.
42- Smith, R.G.; M.R. Ryan and F.D. Menalled (2011). Direct and indirect impacts of weed management practices on soil quality.In: Hatfield, J.L., Sauer, T.J. (Eds.), Soil Management: Building aStabl Base for Agriculture. Soil Science Society on America. p: 275-286.
43- Bond, W. and A. Grundy (2001). Non-chemical weed management inorganic farming systems. Weed Res. 41: 383-4.

عمل الاليلوباثي في التعارض بين الذرة الصفراء والادغال المرافقة

اثمار جاسم المالكي ابراهيم شعبان السعداوي

الملخص

الاختزال يمكن ان يكون مرده الى عملي التنافس او الاليلوباثي او لكليهما معا. ولمعرفة فيما اذا كان للاليلوباثي دورا في اختزال الادغال, نفذت العديد من القياسات الحقلية وتجارب البيت الزجاجي والمختبرية.

أشارت القياسات الحقلية في ثلاثة مواقع مختلفة ان كثافة الادغال في حقل الذرة البيضاء قد انخفضت بنسبة تراوحتا بين 49 و68% عن المقارنة (الادغال خارج حقل الذرة الصفراء), كما انخفض الوزن الجاف للادغال في تلك المواقع بنسبتي تراوحت بين 68 و50% عن المقارنة. واظهرت التجارب اللاحقة ان اضافة مخلفات الذرة الصفراء بمعدل 4 و8 غم قد اختزلتا الوزن الجاف لدغل الدهنان بنسبتي 64 و71 عن المقارنة (بدون اضافة مخلفات) ودغل عرف الديك بنسبتي 54 و63% عن المقارنة. وتبين من التحاليل التي اجريت ان الانخفاض في النمو الناجم من اضافة المخلفات بالنسب اعلاه سببه الانخفاض في محتوى اوراق الادغال من الكلوروفيل وبعض الايونات المعدنية. ان هذه النتائج تفترض ان لمخلفات الذرة الصفراء تأثيراً اليلوباثيا مسؤولاً عن اختزال نمو الادغال وان تلك المخلفات تحوي مركبات اليلوباثية تتحرر في اثناء تحللها وتصبح جاهزة لتاخذ من قبل الادغال. لقد ايدت التجارب اللاحقة هذا الافتراض, اذ بينت التحاليل بجهاز الكروماتوكرافي السائل عالى الاداء high performance liquid chromatographان يحوي مستخلص جذور الذرة الصفراء 4 مركبات فينولية احادية وهي احماض gallic و-p coumaric وferulic وp-hydroxy benzoic و5 مركبات فينولية متعددة وهي مركبات catechin و rutinوqurcetine وluteolin وKaemferol. وبينت تقنية الاستخلاص باستخدام التحاليل راتنجات XAD-8 والتحليل بجهاز الفصل الكوماتوكرافي السائل عالى الاداء ان افرازات جذور الذرة الصفراء هي الاخرى تحوي على تلك المركبات الفينولية باستثناء المركبين gallic and p-hydroxy benzoic acids. وعند اختبار النشاط البايولوجي لافرازات الجذور تبين انها اختزلت انبات بذور دغلي البربين والدهنان بنسبتي 65 و62% عن المقارنة واطوال بادراتهما بنسبتي 28 و28 عن المقارنة على التوالي. وهذه النتائج تشير ان للافرازات عملاً اليلوباثيا في الحد من نمو الادغال.

تشير نتائج هذه الدراسة الى ان للاليلوباثي عملاً في التعارض بين الذرة الصفراء والادغال المرافقة بالاضافة الى عامل التنافس الذي يزيد في التاثير النهائي في الادغال.

كلية العلوم، جامعة بغداد، بغداد، العراق.