Available online at http://www.journalijdr.com

International Journal of DEVELOPMENT RESEARCH

ISSN: 2230-9926

International Journal of Development Research
Vol. 5, Issue, 07, pp. 4926-4931, July, 2015

Full Length Research Article

PHYTOTOXIC EFFECT OF PLANT EXTRACTS FROM ASTERACEAE ON GERMINATION OF *ECHINOCLOA CRUS-GALLI* GROWTH

***Yasser A. El-Amier, Mohammed A. Abbas and Salwan H. Dawood**

Botany Department, Faculty of Science, Mansoura University, Egypt

ARTICLE INFO

Article History:
Received 04th April, 2015
Received in revised form
18th May, 2015
Accepted 07th June, 2015
Published online 30th July, 2015

Key Words:
Phytotoxic,
Asteraceae,
Wild species,
Desert.

ABSTRACT

In Egypt *Echinocloa crus-galli* is one of the most successful yield-limiting weeds in the rice fields that its control mostly relies on herbicides. Plant species *Nauplius graveolens, Picris asplenioides, Reichardia tingitana* and *Urospermum picroides* were collected from naturally growing population in coastal (Deltaic Mediterreanean coast) and inland desert WadiHagul of Egypt. The phytochemical analysis of the selected species in the present study showed that, they contain relatively high contents of tannins, saponins, flavonoids, alkaloids and phenols. At 500 µg/ml the scavenging activity of *Nauplius graveolens, Picris asplenioides, Reichardia tingitana* and *Urospermum picroides* extracts were 14.3%, 6.25%, 7.73% and 4.14, respectively. The allelopathic effect of the extracts from the different tested species exhibited reduction of *Echinochloa crus-galli* seed germination. Also, the allelopathic activities of different extracts of the four species significantly inhibited shoot and root growth of *Echinochloa crus-galli* at both low and high concentrations.

INTRODUCTION

Agriculture sector especially crop production is under immense pressure. Weeds are the most stubborn competitors of crops causing substantial reduction in yield by sharing light, air, water, nutrients and space (Semenov and Halford, 2009; McDonald *et al.,* 2009). The phenomenon of allelopathy, where a plant species chemically interferes with the germination, growth or development of another plant species has been known for over 2000 years. Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, from the release of biochemicals, known as allelochemicals (Fraenkel 1959; Stamp 2003). Allelochemicals are diverse in nature and structure and thus lack common mode of action as well as direct and indirect effects on plants. Most allelochemicals are classified as secondary metabolites such as phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids, with mixtures of different compounds sometimes having a greater allelopathic effect than individual compounds alone (Willis, 2010). Also, they are produced as off shoots of the primary metabolic pathways of the plant.

****Corresponding author: Yasser A. El-Amier***
Botany Department, Faculty of Science, Mansoura University, Egypt

These allelochemicals interfere with the cell division, hormone biosynthesis, mineral uptake and transport and membrane permeability (Rizvi *et al*., 1992; Kruse *et al*., 2000). Many plant species are most susceptible to allelochemicals at the seedling stage, thus phytotoxic activity of allelochemicals is responsible for growth suppression of weeds (Inderjit and Olofsdotter, 1998; Narwal *et al.,* 1998). The family Asteraceae is one of the largest families of vascular plants. It is an advanced and botanically highly specialized family of mainly herbaceous plants. According to Funk *et al.* (2005), the Asteraceae is the richest vascular plant family in the world, with 1.600-1.700 genera and 240.00-300.00 species. This family is distributed over most of the earth and in almost all habitats particularly in semiarid region of the tropics, subtropics and warm temperate regions of South, Southeast and East Asia, Africa and Central South America (Rahman *et al*., 2008). The genera: *Nauplius, Picris, Reichardia* and *Urospermum* attracted the attention of many scientists to study their uses (El-Marsy *et al*., 1980; Abdel Salam *et al*., 1982; Amer *et al*., 1984; Akssira *et al*., 2006; Zidorn *et al*., 2007; Znini *et al*., 2012; Ramdani *et al*., 2014; El Alfy *et al*., 2015). In Egypt *Echinocloa crus-galli* is one of the most successful yield-limiting weeds in the rice fields which its control mostly relies on herbicides. Increasing use of herbicides might lead to enhance environmental pollution and human exposure to toxic materials (Zimdahl, 2004).

Several workers have shown that allelopathy plays an important part in weed and weed interaction (Tajuddin *et al*., 2002; Abd El-Gawad, 2014) and weed crop interaction (Olofsdotter *et al*., 1999; Naderi and Bijanzadeh, 2012; El-Amier and Abdullah, 2014). In the present study, the phytotoxic effect of some wild Asteraceae species on germination and seedling growth of *Echinocloa crus-galli* growing in rice fields are evaluated. The phytochemical screening of the study species was investigated.

MATERIALS AND METHODS

Plant material

Plant species (*Nauplius graveolens, Picris asplenioides, Reichardia tingitana* and *Urospermum picroides*) were collected from naturally growing population in coastal (Deltaic Mediterreanean coast) and inland desert WadiHagul of Egypt. The plant material was handly cleaned, washed several times distilled water to remove dust and other residues, dried at room temperature in shaded place for several day till complete dryness and ground into powder, then preserved in well stopped bottles (AOAC, 1990).

Phytochemical analysis

Studied species were collected and prepared as previously mentioned. The phenol content was determined spectrophotometrically (Sadasivam and Manickam, 2008). Tannin was estimated according to the method of Van Burden and Robinson (1969). Saponin content was estimated by the method adopted by Obdoni and Ochuko (2001). Flavonoid content was estimated by Bohm and Kocipai-Abyazan, (1994), while alkaloids were determined according to Harborne (1973).

DPPH free radical scavenging activity

Antioxidant activity was determined by using a stable free radical (1,1-diphenyl-2-picrylhydrazyl) DPPH (Lim and Quah, 2007) as follows: 2 ml of 0.15 mM DPPH was added to 1 ml of various plant extracts (about 20 g of powdered samples were extracted with 200 ml of methanol 50 %) in different concentrations. A control was prepared by adding 2 ml of DPPH to 1 ml solvent (methanol 50 %). The mixture was incubated at the room temperature for 30 min. The absorbance was recorded at 517 nm and the antioxidant activity was expressed as:

$$\% \text{ Radical scavenging activity} = [1 - (A_{sample}/A_{control})] \times 100$$

Preparation of extracts

For bioassay tests, stock extracts (10% w/v) were diluted with distilled water to obtain various concentrations of 10%, 20%, 30% and 40% (w/v). The solutions were filtered through double layers of muslin cloth followed by Whatman No. 1 filter paper. The pH of the mixtures was adjusted to 7 with 1 M HCl, and then mixtures were stored in a refrigerator at 4 °C until further use (Rice, 1972).

Allelopathy bioassay

Twenty seeds were placed on each filter paper in addition to 10 mL of plant extract for each petri dish. Five replicate samples were placed at 25 °C in a dark growth chamber for 15 days. A control sample was assigned with distilled water, a seed with a radical of 0.5 cm was considered to be germinated. Daily readings of the germinated seeds were recorded during the experimental period and final the measurements of the shoot and root growth were recorded.

RESULTS AND DISCUSSION

Phytochemical analysis

The phytochemical analysis of selected species (*Nauplius graveolens, Picris asplenioides, Reichardia tingitana* and *Urospermum picroides*) indicated that almost all plants are important and there is a need to develop techniques for judicious utilization and sustainable development (Table 1). *Naupliusgraveolens* contained highest contents of flavonoids (5.51mg/g dry weight) and alkaloids (4.67mg/g dry weight). *Reichardia tingitana* and *Picris asplenioides* contained highest contents of tannins (12.54 and 13.69 mg/g dry weight), saponins (7.13 and 5.27 mg/g dry weight) and phenolic (8.17 and 8.77 mg/g dry weight), respectively. *Urospermum picroides* low contents of active constituents, except phenolics (9.31 mg/g dry weight). The phytochemical analysis of the wild plants in this study are relatively comparable except to that obtained by El-El-Amier *et al.* (2015) on some wild Aizoaceae species (*Aizoon canariense, Mesembryanthemum crystallinum, M. forsskaolii* and *M. nodiflorum*) and Ramez (2015) on *Launaea* species (*L. capitate, L. mucronata, L. nudicaulis* and *L. spinosa*) growing in Egyptian Desert, but lower than those reported by El-Amier and Abdullah (2014) on *Calligonum polygonoides*, *Cakile maritima* and *Senecio glaucus*

Antioxidant activity

The evaluation of the antioxidant activity between the four plant extracts is showed in Figure 1. By increasing the plant extract concentration there was a corresponding continuous increase in scavenging activity. In case of *Nauplius graveolens, Picris asplenioides, Reichardia tingitana and Urospermum picroides* extracts the increase was up to 500 µg/ml where the scavenging activity was 14.3%, 6.25%, 7.73% and 4.14, respectively.

Table 1. The concentration of the active constituents in mg/g dry weight for the selected plant species

Bioactive constituent	*Reichardia tingitana*	*Nauplius graveolens*	*Picris asplenioides*	*Urospermum picroides*
	mg/g dry weight			
Tannins	12.54±0.05	10.01±0.07	13.69±0.06	9.20±0.04
Saponins	7.13±0.06	6.08±0.06	5.27±0.04	5.01±0.03
Flavonoids	5.06±0.10	5.51±0.07	4.80±0.06	4.24±0.04
Alkaloids	4.18±0.06	4.67±0.05	3.87±0.03	3.14±0.05
Phenolics	8.17±0.03	9.15±0.04	8.77±0.09	9.31±0.04

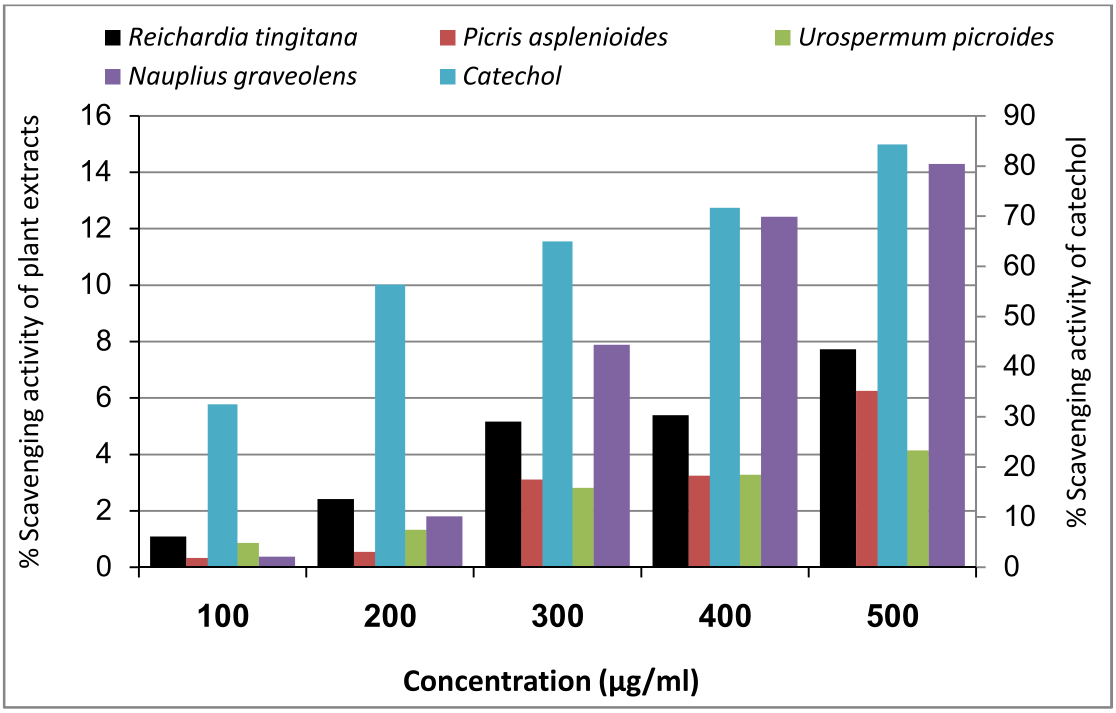

Figure 1. Scavenging activity of methanolic extract of tested species

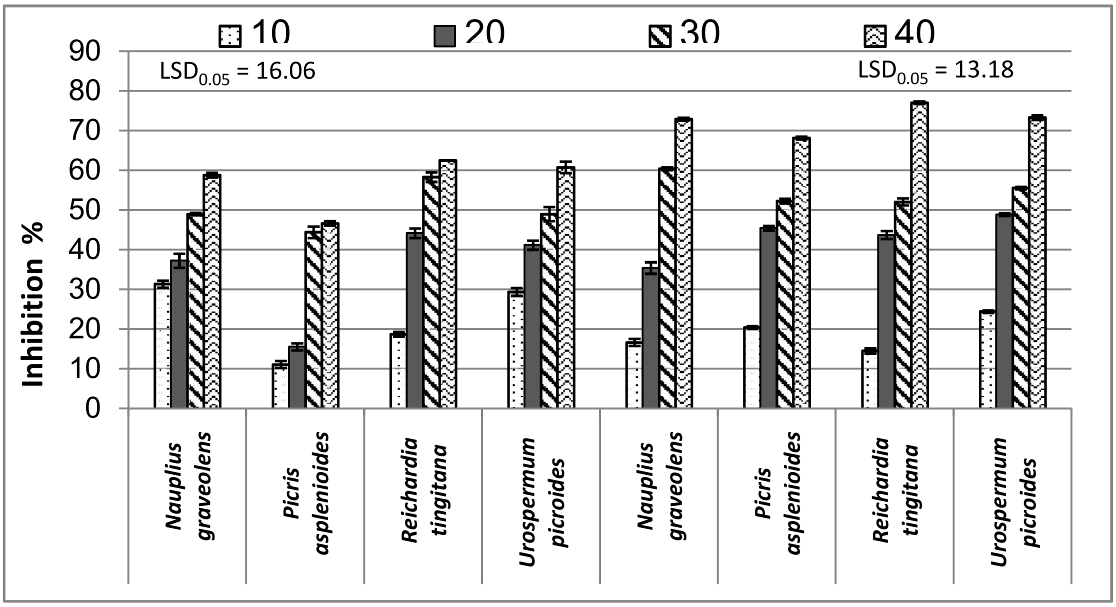

Figure 2. Effect of four plant extracts on the germination inhibition percentage (mean value ± standard error) of the *Echinochloa crus-galli* after 4 DAT

Allelopathic potentiality

This experiment aims to study allelopathic effect of four wild Asteraceae species (*Nauplius graveolens, Picris asplenioides, Reichardia tingitana* and *Urospermum picroides*). The aqueous and methanol extract were prepared in 10, 20, 30 and 40 g/l. The allelopathic effect of four species extracts on the germination percentage of *Echinochloa crus-galli* after four days after treatment (DAT) are shown in Figure 2. After 4 days of treatment, all extracts significantly reduced the germination of *Echinochloa crus-galli*. *Urospermum picroides* recorded the greatest inhibition percentage of 60.78% and 73.33% at 40 g/l concentration under aqueous and methanol extracts, respectively. The extract of *Reichardiatingitana* attained the highest effective (77.08%) at 40 g/l under methanol extract, while under aqueous extract is 62.5% at 40g/l. *Nauplius graveolens, Picris asplenioides* attained the moderateallelopathic potential at different concentrations (Figure 2). The different extracts of four wild plants were also significantly inhibited shoot growth of *Echinochloa crus-galli* are showed in Figure 3, where the highest inhibition percentage was also recorded at 40 g/l, especially *Reichardia tingitana* (45.81% and 69.92%) under aqueous and methanol extracts, respectively. *Urospermum picroides* expressed less effect as it inhibited shoot growth (31.58%) at 40 g/l concentration under aqueous extract, while

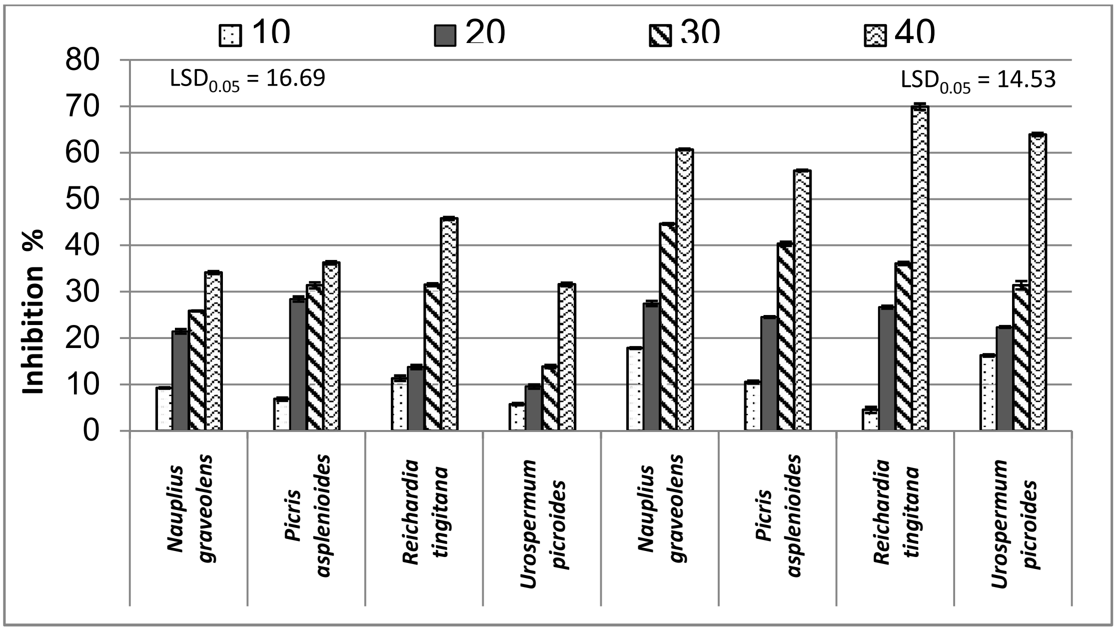

Figure 3. Effect of four plant extracts on shoot growth inhibition percentage (mean value ± standard error) of the *Echinochloa crus-galli* after 4 DAT

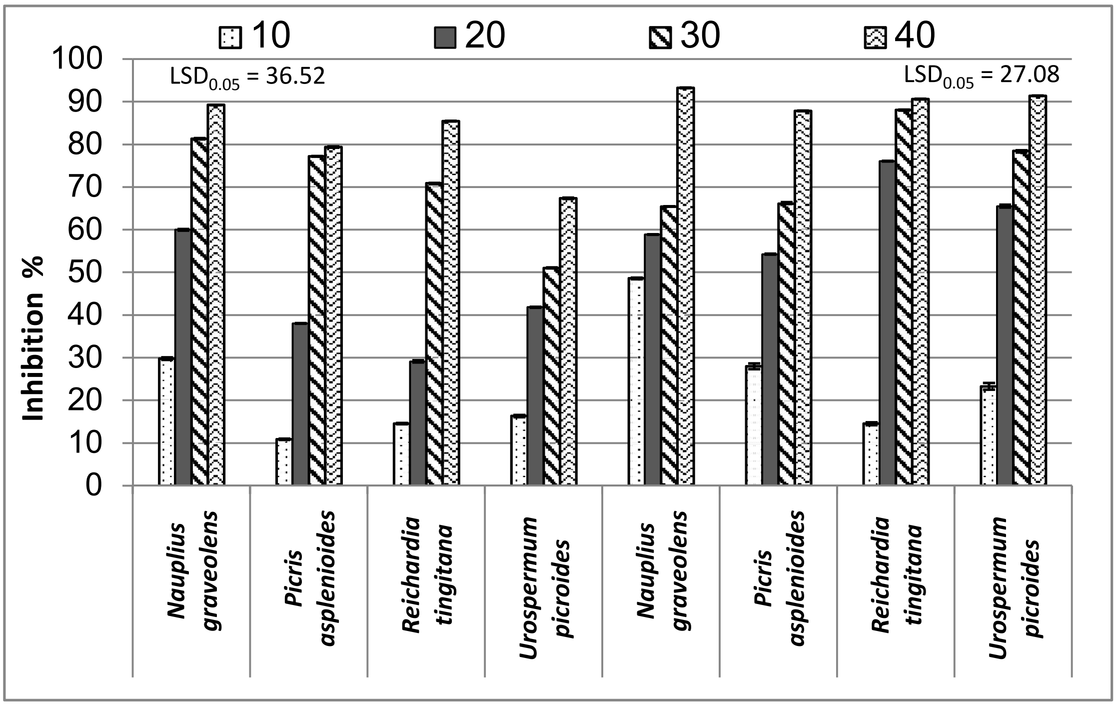

Figure 4. Effect of four plant extracts on root growth inhibition percentage (mean value ± standard error) of the *Echinochloa crus-galli* after 4 DAT

Picris asplenioides attained 56.14% at 40 g/l under methanol extract. Generally, all extracts of the tested wild plants significantly reduced the shoot growth of *Echinochloa crus-galli* at concentration-dependent manner. In many studies, it was found that root growth was inhibited more than shoot growth (Inderjit and Dakshini, 1995). On the other hand, root growth is sensitive to autotoxic chemicals at low concentrations, more than hypocotyl growth and seed germination (Chon *et al*., 2000 and 2003). Also, the allelopathic activities of different extracts of the four species were significantly inhibited root growth of *Echinochloa crus-galli* at both low and high concentrations (Figure 4). The extracts of *Nauplius graveolens* was the most effective as it inhibited root growth by about 89.23% and 93.22% at 40 g/l, followed by *Reichardia tingitana*, where extracts inhibited root growth by about 85.44% and 90.60% at 40 g/l and then *Picris asplenioides*, where extract inhibited root growth by about 79.35% and 87.83% at 40 g/l under aqueous and methanol extracts, respectively. *Urospermum picroides* was the least effective as it inhibited root growth by about 67.35% and 91.38% at 40 g/l under aqueous and methanol extracts, respectively.

The allelopathic inhibitions are the result of several compounds such as, phenolics, quinones, sesquiterpene lactones, alkaloids and others alter root morphology (Einhellig, 2002). Although, the cell membrane is an early interface with allelochemicals, relatively little attention has been given to membrane- related effects and their molecular targets (Inderjit and Mukerji, 2006). The phytochemical analysis of *Nauplius graveolens, Picris asplenioides, Reichardia tingitana and Urospermum picroides* in the present study showed that, they contain relatively high contents of tannins, saponins, flavonoids, alkaloids and phenols. Previous investigation on these plant species revealed that, the presence of sesqueterpine lactones and glycoside (Abdel-Mogib *et al*., 1993; Zidorn *et al*., 2007), phenolics (Recio *et al*., 1992) and essential oil (El Alfy *et al*., 2015) from *Reichardia tingitana*. Glucoside of urospermal A (Abdel Salam *et al*., 1982), sesquiterpene lactones and glycosides (Balboul *et al*., 1997) were isolated from *Urospermum picroides*.

Naupliolide, a sesquiterpene lactone (Akssira *et al*., 2006) and essential oil Znini *et al*. (2012) were isolated form *Nauplius graveolens*. Hence the allelopathic potential of the selected species could be attributed to these bioactive compounds. Aqueous extract of some plant species may contain some toxic substances (Habib and Abdul Rehman, 1988). These substances probably inhibit the germination and seedling growth of other plants species (Al-Charachafchi *et al*., 1987), which was due to their interference with indol acetic acid metabolism, or synthesis of protein and ions uptake by the plants (Hussain and khan, 1988). These phenolics inhibit the germination and seedling growth of same plant species or others by their effects on metabolic processes of germination and growth (Castro *et al*., 1984). Finally, it could be concluded that, the selected four wild species could be used as biocontrol or biofriend for controlling management of the nuisance weed *Echinochloa crus-galli* which intensively competing summer crops in Egypt.

REFERENCES

Abdel Salam, N.A., Mahmoud, Z.F., Ziesche, J. and Bohlmann, F. 1982. Aglucoside of urospermal A. *Phytochemistry*, 21(11): 2746-2747.

Abd El-Gawad, A.M. 2014. Ecology and allelopathic control of *Brassica tournefortiiin* reclaimed areas of the Nile Delta, Egypt. *Turk. J. Bot*., 38: 347-357.

Abdel-Mogib, M., Agyad, S.N., Abuo-Elzahab, M.M. and Dawidar, A.M. 1993. A sesquiterpene glucoside from *Richardia tingitana*. *Phytochemistry*, 34: 1434-1435.

Akssira, M., Mellouki, F., Salhi, A., Alilou, H., Saouf, A., El Hanbali, F., Arteaga J. F. and Barrero A. F. 2006. Naupliolide, a sesquiterpene lactone with a novel tetracyclic skeleton from *Nauplius graveolens* subsp. *Odorus*. *Tetrahedron Letters*. 47: 6719–6721.

Al-Charchafchi, F.M.R., Redha, F.M.J. and Kamel, W.M. 1987. Dormancy of *Artemisia herba alba* seeds in relation to endogenous chemical constituents. *Journal of Biological Science Researches*. 18: 1-12.

Amer, M.M.A., Salama, O.M., Bohlmann, F. and Ziesche, J. 1984.Urospermal, a glucoside from *Urospermum picroides*. *Phytochemistry*, 23: 692–693.

AOAC 1990. Official Methods of Analysis, 15th ed. Association of Official Analytical Chemists, Arlington, Virginia, USA.

Balboul, B. A., Ahmed, A. A., and Dsuka, H. 1997.Sesquiterpne lactones and glucosides from *Urospermum picroides*. *Phytochemistry*, 45(2): 368-373.

Boham, B. A., and Kocipai-Abyazan, R. 1994. Flavonoids and condensed tannin from leaves of Hawaiian *Vccinium vaticulatum* and *V. calycinium*. *Pacific Sci*, 48:458-463.

Castro, P.R.C. Rodrigues, J.C. Rabelo, R.F.A. Viega, G.P.P. Lima, P. J. and Denbanda, I.M. 1984. Allelopathic action of some weed extracts on rice. *Plant Physiology*, 41: 369-381.

Chon, S.U., Coutts, J.H. and Nelson, C.J. 2000. Effects of light, growth media and seedling orientation on bioassays of alfalfa autotoxicity. *Agron. J*., 92: 715–720.

Chon, S.U., Kim, Y.M. and Lee, J.C. 2003. Herbicidal potential and quantification of causative allelochemicals from several Compositae weeds. *Weed Research*, 43: 444-450

Einhellig, F.A., 2002. The Physiology of Allelochemicals Action: Clues and Views. In: Allelopathy: From Molecules to Ecosystems, Reigosa, M.J. and N. Pedro (Eds.). Science Pub. Inc., USA and UK. ISBN, 13: 978-1578082544, pp: 1-23.

El-Masry, S., Saleh, M.R., Ghazy, N.M. and Vuilhorgne, M., 1980. Isolation and structure elucidation of sesqueterpine lactones from *Reichardia tingitana* L. Roth var. orientalis (L) Asch. Et Schweinf. *Acta. Pharmcol. Sin*. 17(3):137-142.

El-Alfy, T., El-Tantawy, M., Abdel Motaal, A. and Gamal, F. E., 2015 pharmacological, Biological. Study and GCIMS analysis of the essential oil of the aerial parts and the alcohol soluble fractions of the N-hexane extract of the flowers of *Reichardia tingitana* L. *Candian Journal of pure and Applied sciences* 9(1): 3167-3175.

El-Amier, Y. A., Haroun, S. A., El-Shehaby, O. A. and Al-hadithy, O. N., 2015. Antioxidant and antimicrobial of properties of some wild Aizoaceae species growing in Egyptian Desert. *Journal of Environmental Sciences*, Mansoura Univ

El-Amier, Y.A. and Abdullah, T. J., 2014. Allelopathic Effect of Four Wild Species on Germination and Seedling Growth of *Echinocloa crus-galli* (L.) P. Beauv. *International Journal of Advanced Research*, 2(9), 287-294.

Farooq, M., Bajwa, A.A., Cheema, S.A. and Cheema, Z.A., 2013. Application of allelopathy in crop production. *Int. J. Agric. Biol*., 15: 1367–1378

Fraenkel, G. S., 1959. The Raison d'Etre of secondary plant substances. *Science*, 129: 1466–1470.

Funk, W.C., Donnelly, M.A., Lips, K.R. 2005. Alternative views of amphibian toe-clipping. *Nature* 433: 193.

Habib, S.A. and Abdul-Rehman, A.A., 1988. Evaluation of some weed extracts against dodder on alfalfa (*Medicago sativa*). *Journal of Chemical Ecology*.14: 443-452.

Harborne, J.B., 1973. Phytochemical Methods, London. Chapman and Hall, Ltd., 49-188.

Hussain, F. and Khan, T.W., 1988. Allelopathic effects of Pakistani weed *Cynodon dactylon* L. *Journal Weed Science Research*, 1: 8-17.

Inderjit, K. and Dakshini, K.M.M., 1995. Allelopathic potential of an annual weed *Polypogon monspeliensis*, in crops in India. *Plant and Soil*, 173: 251-256.

Inderjit, K. and Dakshini, K.M.M., 1998. The use of washed test material as control in laboratory bioassay for allelopathy. *Tropical Agriculture*, 75: 396-400.

Inderjit, B. and Mukerji, K.G., 2006. Allelochemicals: Biological Control of Plant Pathogens and Diseases. *Springer Science and Business Media*, p 46.

Kruse, M., Strandberg, M. and Strandberg, B. 2000. Ecological effects of allelopathic plants – a Review. National Environmental Research Institute, Silkeborg, Denmark. 66 pp. – NERI Technical Report No. 315.

Lim, Y. Y. and Quah, E. P. L. 2007. Antioxidant properties of different cultivars of *Portulaca oleracea*. *Food chem*., 103:734 – 740.

McDonald, A., Riha, S., Ditommaso, A. and Degaetano, A. 2009. Climate change and the geography of weed damage: analysis of U.S. maizesystems suggests the potential for significant range transformations Agric. *Ecosyst. Environ*., 10: 131–140.

Naderi, R., and Bijanzadeh, E. 2012. Allelopathic potential of leaf, stem and root extracts of some Iranian rice (Oryza sativa L.) cultivars on barnyard grass (*Echinochloa crus-galli*) growth. *Plant Knowledge J*. 1(2): 37-40.

Narwal, R.P., and B.R. Singh. 1998. Effect of organic materials onpartitioning, extractability and plant uptake of metals in an alumsoil. *Water Air Soil Pollut*, 103:405–421.

Obadoni, B.O., and Ochuko, P.O. 2001. Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. *Global J. Pure Appl. Sci*., 8:203-208.

Olofsdotter, K. 1998. Foreign direct investment, country capabilities and economic growth, Weltwirtschaftliches Archiv, 134(3), 534-547.

Olofsdotter, M., Navarez, D., Rebulanan, M. andStreibig, J.C. 1999. Weed suppressing rice cultivars - does allelopathy play a role. *Weed Res*., 39: 441-454

Rahman, A., Patel, V., Maselko, J., and Kirkwood, B.2008. The neglected ‘m’ in MCH programmes–why mental health of mothers is important for child nutrition. *Trop Med Int Health*., 13: 579-83.

Ramdani, M., Lograda, T., Chalard, P., Figueoedo, G., Laidoudi, H. and Oanoughi, A. 2014 Chemical Composition, Antimicrobial activity and chromos number of *Ubospermum dalechampii* from Algeria. *Sch. Acad. J. Pharm*., 3(6): 447-482.

Ramez, B. M. 2015. Ecological study and economic potentialities of some species of genus *Launaea* in Egypt. M.Sc. Thesis, Fac. Sci. Mansoura Univ., Egypt.

Recio, M. C., Giner, R. M., Hermengildo, M., Peris, J. B., Marinez, S. and Rioss, J. L. 1992. Phenolics of *Reichardia* and their taxonomic implications. *Biochemical systematics and Ecology*. 20: 449-452.

Rice, E.L. 1972. Allelopathic effect of *Andropogon virginicus* and its persistence in old field. *Amer. J. Bot*., 59: 752-755.

Rizvi, S. J. Haque, H. H., Singh, V. and Rizvi, V.K. 1992. A discipline *calledallelopathy*. In: Allelopathy Basic and Applied Aspects, pp: 1–8.Rizvi, S.J.H and V. Rizvi (eds.). Chapman and Hall, London.

Sadasivam, S. and Manickam, A. 2008. Biochemical Methods. 3rd ed. New Age Intern., Limited, New Delhi.

Stamp, N. 2003. Out of the Quagmire of plant defense hypotheses. *The Quarterly Review of Biology*, 78: 23–55.

Semenov, M. A. and Halford, N. G. 2009. Identifying target traits and molecular mechanisms for wheat breeding under a changing climate. *J. Exper. Bot*., 60: 2791–2804.

Tajuddin, T., Watanabe, S., Masuda, R., Harada, K. and Kawano, S. 2002. Application of near infrared transmittance spectroscopy to the estimation of protein and lipid contents in single seeds of soybean recombinant inbred for quantitative trait loci analysis. *J. Near Infrared. Spectrosc.*, 10(4): 315-325.

Van-Buren J. P. and Robinson, W. B. 1969. Formation of complexes between protein and tannic acid. *J Agri. Food Chem*., 17: 772-777.

Willis, R. J. 2010. The History of Allelopathy. Dordrecht, The Netherlands: Springer.

Zidorn, C., Elmerer, E., Heller, W., Johrer, K., Feommberger, M., Greil, R., Guggenberger, M., Ongania, K. and Stuppner, H. 2007. A new sesquiterpene Lactone sulfate from *Richardia gaditana* (Asteraceae). Z. Naturforsch., 62(b): 132-134.

Zimdahl, R. L. 2004. Weed-Crop competition. A Review, 2nd Edition, Blackwell publishing Ltd., Oxford, UK, 220.

Znini, M., Cristofari, G., Majidi, I., Ansari, A., Bouyanzer, A., Poolini, J., Costa, J. and Hammouti, B. 2012. Green approach to corrosion inhibition of mild steel by essential oil of *Asteriscus graveolens* (forssk.) in sulphuril acid medium. *Int. J. Electrochemical Sci*., 7-3959-3981.

****