Biosciences, Biotechnology Research Asia Vol. **6**(2), 855-862 (2009)

Allelopathic substances of *Parthenium* weed and interactions of *Solanum melongena*

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(Received: September 25, 2009; Accepted: November 08, 2009)

ABSTRACT

A study was conducted to explore the post observation indicated that *Parthenium hysterophorus* strongly react with *Solanum melongena*. Aqueous extracts of 20 and 40% (w/v) obtained from root extracts of *Parthenium* increased the total chlorophyll and carotenoids content over control. The toxicity of plant part extracts was also concentration dependent. The inflorescence caused more inhibition than root extract. It appears that allelopathy is the major components of interactions with competitors probably accentuating its effect. It was also found that allelopathy is an important component of the interactions. The inhibitory potential of the extracts was increased with concentration.

Key words: Aqueous extracts, chlorophyll content, total soluble sugar.

INTRODUCTION

The phenomenon of allelopathy has existed for thousands of years. Intensive scientific research into the recognition and understanding of allelopathy has only occurred over the past few decades. These activities have shown significant prospects for allelopathy being utilized for increasing our reliance on synthetic pesticides and improving the ecological environment. Recent research has demonstrated possibilities of such prospects in reality. Reports as early as 300 BC document that many crop plants (e.g. chick pea, barley, bitter vetch) destroyed weeds and inhibited the growth of other crop plants. The soil sickness problem in agriculture was specifically related to exudates of crop plants (Rice, 1979). However, intensive scientific research on this phenomenon only started this century. Research on the recognition and understanding of allelopathy has been well documented over the past few decades (Rice, 1979; Rizvi and Rizvi, 1992).

Chemicals that impose Allelopathic influences are called allelochemicals or allelochemics, They may be largely classified as secondary plant metabolites, which are generally considered to be those compounds (such as alkaloids, phenolics, flavonoid, terpenoids, and glucosinolates) which do not play a role in primary metabolic processes essential for a plant's survival, and are produced as offshoots of primary metabolic pathways. In contrast to which comprises several hundreds of low molecular weight compounds, ten of thousands of secondary substances are known today, but only a limited number has been implicated as allelochemicals (Rice, 1979). Allelochemics are present in virtually all plant tissues, including leaves, flowers, fruits, stems, roots, rhizomes, seeds and pollen. They may be released from plants into the environment by means of four ecological processes: volatilization, leaching, root exudation, and decomposition of plant residues. As demand increases for sustainable agriculture and concern grows regarding the extensive use of synthetic chemicals (e.g. contamination of environment, herbicide resistance, increasing cost), attention is focused on reducing reliance upon synthetic herbicides and finding alternative strategies for weed management. Several workers have shown that allelopathy plays an important role in weed and weed interaction and weed crop interaction (Jabeen and Ahmed, 2009).

For present experiment *Parthenium* has been chose. P. hysterophorus L (Congress grass, Congress weed, Carrot weed, the "Scourge of India") is an exotic weed that was accidentally introduced in India in 1956, through imported food grains. (Lonkrar, *et al*., 1974). The plant is thermo and photo sensitive; hence it grows round the year. Chemical analysis has indicated that all plants parts contain toxins from the chemical group of sesquiterpene lactones (Oudhia and Tripathi, 1998). Narwal (1994) has isolated many allelochemicals such as parthenin, p-coumaric acid, caffeic acid coronopollin and sesquiterpene, lactones, from the aqueous extracts of *Parthenium* responsible for allelopathic effects on other plants.

A comprehensive survey of literature revealed that the allelopathic effect of *Parthenium* with lower concentrations enhanced the growth parameters of various crops (An, Pratley and Haig, 1998). Weeds are an important factor in the management of all lands and water resources but their effect is greatest on agriculture (Dave and Jain; Sharma, *et al.,* 2009) So, Keeping in view the present studies have been conducted to use positive allelopathic potential of *Parthenium* on growth parameters of S. *melongena* L. (Brinjal/Eggplant, family Solanaceae) a short lived perennial plant often cultivated as an annual.

MATERIAL AND METHODS

Study Site

A systematic survey of Ballia (25" N 45' latitude and 84" E 10' longitude, sea level 69.9 meter) and its surroundings areas was done to study the interaction of the target weed *P. hysterophorus* L with *S. melongena* L. The plants of *P. hysterophorus* were collected from the college campus. Two parts of the plant (root and flower) were used for the preparation of extracts. *Parthenium* parts were cut into the fine pieces (2mg/ml) and soadked in lukewarm water and left for 24hrs at room temperature. After that the material was sieved and stock solution of the extract was prepared. From this stock solution different concentrations (20, 40, 60, 80 and 100%) were prepared against control (00 %) in glass distilled water (DW) for the spray treatment at different stages of growth (Pre flowering, flowering and post flowering).

Cultural Practices

The fire clay posts (size, 30 cm diameter and 30 cm height) filled with equal weight (3 kg) of sandy loam soil in all the pots taken from agriculture field of college campus S M M Town PG College, Ballia. The soil has pH 6.8 and soil testing has suggested that soil contain 0.56% organic carbon, 18 kg/hectare phosphate and 210 kg/hectare potash. Five gram home garden fertilizer (loamy soil 40%, sand 20%, cow dung 20%, and leaf manure 20%) was thoroughly mixed in the soil at the time of filling of pots.

The experiment was set up in the month of March, 2008 (average temperature 34 – 11^{o}C. The plant selected for the study is *S melongena* L., Neelam Long. For each treatment, triplicate pots were maintained and three plantlets were planted in each pot. The soil of each pot was thoroughly watered i.e. 1000 ml/pot. The treatment was given at 3 stages (Pre flowering, flowering and post flowering). The growth of S. *melongena* plants was recorded at 15, 35 and 65 DAP (Days after planting). Growth parameters taken were root and shoot length, fresh weight, dry weight, leaf area and biochemical parameters like chlorophyll (Arnon, 1949) and catrotenoids content (Jensen and Jensen, 1972).

Statistical Analysis

All the data collected on growth, productivity and biochemical attributes were subjected to statistical analysis of variance subjected to randomized block design as described by Panse and Sukhatme (1985).

RESULTS

From the observations it is clear that the extracts of different plants parts of *Parthenium* affected the Parameters of *Solanum*. As studied at three different stage of growth the pattern of affect is almost similar for one extract but different for other. Pre flowering, 15 DAP (Table-1). In relation to root length with 20 and 40% of root and flower extracts showed 53.33, 33.33 and 26.66, 33.33% increasing. But with 100% of root extracts showed decreasing i.e. –13.33% over control. While, with 80 and 100% of flower extract showed suppressing value i.e. -16.66 and –13..33%. -44.44% of shoot length was increased with 20% of root extracts and maximum inhibition was recorded with 100% of root and flower extracts i.e. -16.67 and -22.22%. But with 40% of flower extracts is very sensitive for *Solanum* and showed maximum increase i.e. 28.89% over control. But in relation with fresh weight all the concentrations of root extracts showed maximum increase i.e. 17.91, 76.07, 60.12, 34.97 and 28.83% respectively. With 20 and 40% of flower extracts showed growth also i.e. 6.75 and 2.45%. But with 60, 80 and 100% flower extracts showed decrease i.e. -4.29, -14.7 and -38.65% respectively over control.

All the conc. Of root extracts showed pronounced increase in dry weight i.e. 11.11, 75.92,

Table 1: Effect of *Parthenium* extracts on different parameters of *Solanum* after 15 DAP

	Root Extract					Flower Extract				
Parameters/ Conc. (%)	**Root length (cm)**	**Shoot length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**LA/ Plant (cm^2)**	**Root length (cm)**	**Shoot Length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**La/Plant (cm^2)**
00	3.00	18.00	1.63	0.54	15.08					
20	4.60	20.00	1.92	0.60	18.97	3.20	20.08	1.74	0.75	6.09
40	4.00	22.00	2.87	0.95	20.42	4.00	23.20	1.67	0.64	6.24
60	3.80	20.00	2.61	0.87	15.29	3.20	20.60	1.56	0.68	4.50
80	3.60	18.60	2.20	0.73	14.15	2.50	18.50	1.39	0.59	4.53
100	2.60	15.00	2.10	0.70	12.69	2.00	14.00	1.00	0.44	4.74

Table 2: Effect of *Parthenium* extracts on different parameters of Solanum after 35 DAP

	Root Extract					Flower Extract				
Parameters/ Conc. (%)	**Root length (cm)**	**Shoot length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**LA/ Plant (cm^2)**	**Root length (cm)**	**Shoot Length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**La/Plant (cm^2)**
00	3.80	20.60	6.00	1.75	26.25					
20	8.00	23.40	8.00	2.80	87.36	5.00	22.00	6.26	2.26	48.21
40	6.40	24.30	15.14	5.02	117.12	5.70	22.90	4.36	1.26	26.25
60	6.00	22.20	7.35	1.87	88.88	3.50	21.46	4.02	1.09	28.24
80	5.60	19.60	5.30	1.45	82.46	2.70	18.90	3.10	1.00	19.14
100	3.20	15.40	3.24	0.92	61.20	2.00	15.25	2.20	0.98	18.04

Table 3: Effect of *Parthenium* extracts on different parameters of Solanum after 65 DAP

	Root Extract					Flower Extract				
Parameters/ Conc. (%)	**Root length (cm)**	**Shoot length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**LA/ Plant (cm^2)**	**Root length (cm)**	**Shoot Length (cm)**	**Fresh wt (g)**	**Dry wt (g)**	**La/Plant (cm^2)**
00	8.00	32.60	42.34	15.28	300.90					
20	14.00	34.00	60.32	20.36	453.00	10.60	28.20	50.26	16.28	510.25
40	15.20	28.60	70.25	27.86	720.48	8.20	22.50	48.56	15.68	400.00
60	13.60	24.80	50.26	17.26	492.80	7.60	20.90	40.63	13.29	325.66
80	8.60	20.60	51.26	16.89	380.65	5.80	18.40	37.40	12.68	282.56
100	5.00	16.00	45.60	14.89	200.45	4.60	17.80	32.69	11.29	266.57

61.11, 35.18 and 29.63% consecutively. While, with 20% of flower extracts also showed maximum increase i.e. 38.89%. But with 100% of flower extracts showed decreasing i.e. -18.52% over control. With 20, 40 and 60% of root extracts showed remarkable increase in leaf area/plant i.e. 25.79, 35.41, and 1.39% respectively. But with 80 and 100% of flower extracts over control. Fig-1 clearly shows that biochemical estimation on total chlorophyll has stimulatory effect. With 20, 40 and 60% of root extracts showed enhancement i.e. 34.58, 13.08 and 8.41%. On the other hand 80 and 100% of root extracts and all the conc. Of flower extract showed decrease in chlorophyll. Only 20% of root extracts showed maximum increase in the amount of carotenoids contents i.e. 90.47%. But with 20 and 40% of flower extracts showed increase i.e. 19.04 and 28.57% over control. While with 60, 80 and 100% of root extracts and flower extracts showed negative value.

Flowering, 35 DAP (Table-2) with 20% of root extracts showed maximum increase in root length i.e. 110.52. While with 40% of flower extracts showed maximum growth i.e. 50% over control. With 100% of root extracts and 60, 80 and 100% of flower extracts showed decrease i.e. 15.37, -7.89, -28.95 and -47.37% over control. Maximum length was observed in shoot length with 40% of root and flower extracts i.e. 17.96 and 11.16%. On the other hand 80 and 100% of root and flower extracts showed decrease i.e. -48.50, -25.54 and -825, -25.97% over control. Observation on 20, 40 and 60% of root extracts and it was recorded effective result i.e. 33.33, 152.33 and 22.50% respectively in relation to shoot length. Fresh weight was enhanced with only 20% of flower extracts i.e. 4.33% over control. But with 80 and 100% of root extracts showed decrease value i.e. -11.67 and -46.00%. On the other hand 40, 60, 80 and 100% of flower extracts showed decreasing value i.e. -27.33, -33.00, -48.33 and -63.33% in relation to fresh weight over control. With 20, 40 and 60% of root extracts showed enhance dry weight i.e. 60, 186.86 and 6.85%. But with only 20% of flower extracts showed 29.41% increasing over control. While with 80 and 100% of root extracts showed decrease i.e. – 17.14 and -47.43%. On the other hand 40,60, 80 and 100% of flower extracts also showed decrease value i.e. -28, -37.71 and -42.85, -44% over control.

Over all the conc. of root extracts showed good result for leaf area/plant i.e. but with 20 and 40% of root extracts showed the maximum increase i.e. 232.8 and 346.17% over control. But with 20 and 60% of flower extracts also showed increase i.e. 83.66 and 7.59%. While with 80 and 100% of flower extracts showed maximum decrease i.e. -27.08 and -37.28% over control. Fig – 2 shows that 40% of root extracts showed maximum increase i.e. 76.25% in amount of chlorophyll. But with 60, 80 and 100 of root extracts and all the conc. of flower extracts showed decrease value. With 20, 40, and 60% of root extracts showed increase value of carotenoids. While with 80 and 100% of root and all the concl. of flower extracts showed decrease value over control.

Post flowering, 65 DAP (Table-3) In *Solanum* with 20, 40, 60 and 80% of root extracts showed growth in root length i.e. 75, 90, 70 and 7.5%. On the other hand with 20 and 40% of flower extracts also enhanced the value i.e. 32.5 and 2.5%. But with higher conc. i.e. 100% of root extracts maximum decreases is recorded i.e. 37.5% over control. While with 60, 80 and 100% of flower extracts showed maximum decrease i.e. -5.0, -27.5 and 42.5% over control. Maximum shoot length was recorded with 20% of root extracts i.e. 4.29% over control. While all the conc. of flower extracts showed most sensitive decrease i.e. -13.50, -30.98, -35.98, -43.55 and -45.40% respectively, with 20, 40, 60, 80 and 100% of extracts. All the conc. of root extracts showed the pronounced increase in fresh weight i.e. 42.46, 65.91, 18.70, 21.07 and 7.70% over control. But with 20 and 40% of flower extracts also showed maximum increase i.e. 18.70, 14.69% increase over control. With 20 and 40% of root extracts showed increase in dry weight i.e. 33.24 and 32.33% over control. But with 100% of root extracts and 60, 80, 100 of flower extracts showed decrease -2.55, 4.04, -11.67 and -22.79% over control respectively. In relation with leaf area/plant most sensitive observation was recorded i.e. 139.47% of increase over control with 40% of root extracts. But with 20% flower extracts showed 69.57% increase over control and with 80% of root and 80 and 100% of flower extracts showed maximum decrease i.e. -23.41, -6.09 and -32.88%. Fig -3 shows that maximum increase in total chlorophyll i.e. 8.75% with 40% of root over control. While 60, 80 and 100% of root extracts and all the conc. of flower extracts showed decrease percent over control. In relation to carotenoids content, with 20 and 40% of root extracts showed enhanced value i.e. 6.84 and 10.34% over control. But 60, 80 and 100% of root extracts and all the conc. of flower extracts inhibited the amount of carotenoids. The results indicated that the lower concentrations of root extract showed maximum growth in comparison to control. Growth in all the parameters was directly proportional to increasing concentrations of the aqueous extracts. This result showed that flower parts of *Parthenium* have strong allelopathic effect than root part.

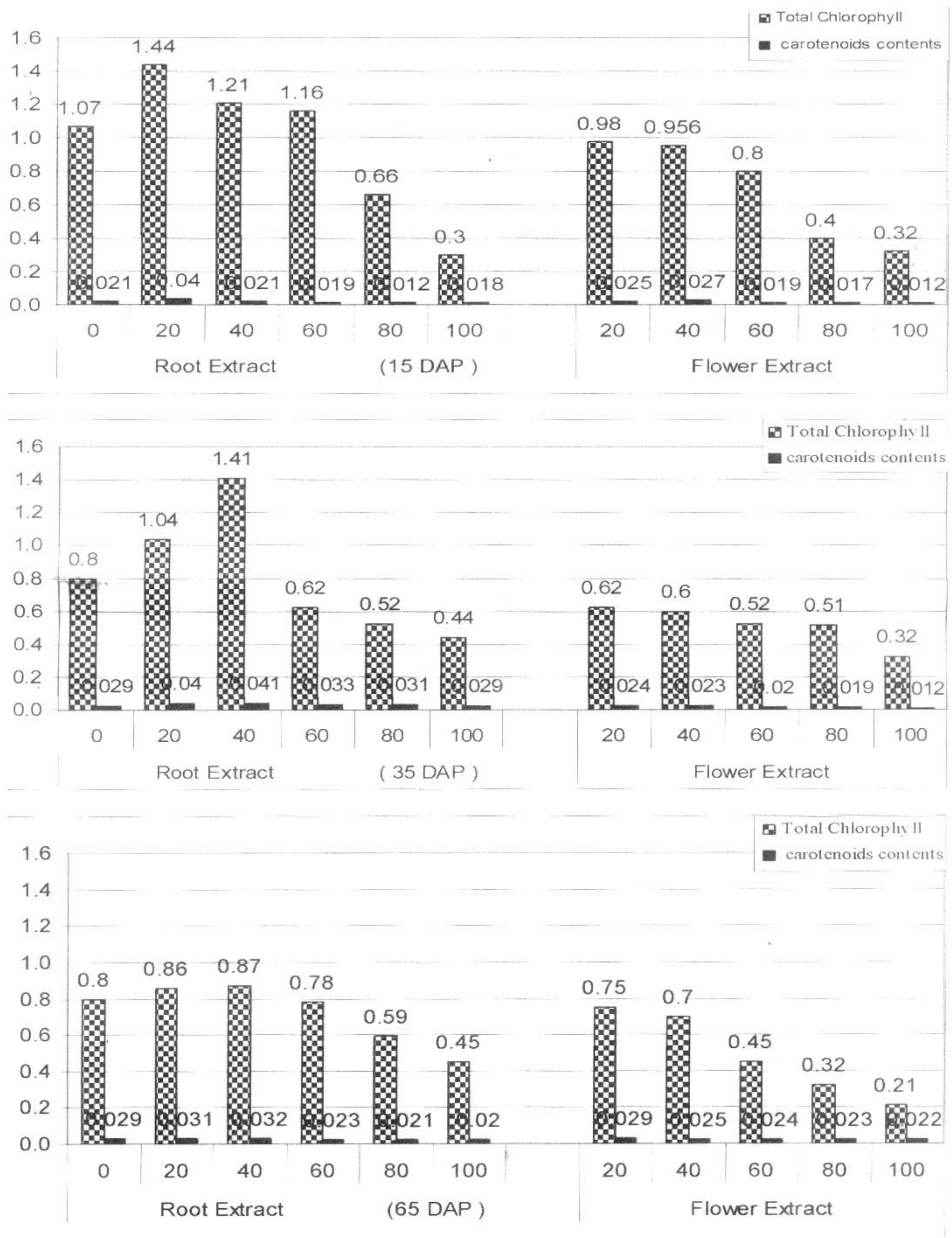

Fig. 1-3: Effect of *Parthenium* extract on different parameters of *Solanum* after 15, 35 and 65 DAP

DISCUSSION

The present investigations revealed that *P. hysterophorus* has strong allelopathic potential against *S. melongena*. Aqueous root extracts of the species employed in various concentrations caused significant enhancement in growth of the test crop species. Under the allelopathic stress, the growth of the allelopathic was severely depressed. Dosage effect was highly pronounced and directly proportional to the increasing concentrations of aqueous root, flower extracts. Root extracts of *Parthenium* invariably stimulate the growth parameters of test crops but the effect was more pronounced in higher concentrations. These results are in line with earlier finding (Kill and Yun, 1992). In pot experiments, root growth in terms of root length was markedly suppressed by flower extracts of *Parthenium* in the test species. Similar observations have also been demonstrated by Hsu *et al*., (1989) and Lawerence *et al*., (1991). Spray applications of allelopathic extract employed in higher concentrations probably affected the photo synthetic activity of leaves due to which the growth in terms of length and dry weight was markedly influenced. Furthermore, the allelochemicals are also known to reduce uptake of nutrients (Kolesnichenko and Aleikina, 1976), suppress the activity of growth hormones such as IAA and Gibberellins (Kefeli and Turetskaya, 1976) and disturb the process of photosynthesis (Barkosky *et al*., 1999), which may result in declined shoot growth. It has also been suggested that other basic plant processes such as respiration, chlorophyll synthesis, hormonal balance, protein synthesis, permeability and plant water relation may also altered by allelopathic compounds (Yamane *et al*., 1992).

The reduced root growth under allelopathic stress may also be attributed to reduced shoot growth with higher concentrations of plants parts of *Parthenium*. This indicates, the availability of the inhibitory chemicals in higher concentrations in flowers than in roots (Kanchan and Jaychandra, 1980). Among the treatments, 80 and 100% of flower extracts had the strongest inhibitory effect. The extracts of *Parthenium* induced a variety of chromosomal aberrational dividing cells, which increasing concentrations and duration of exposure (Rajendra, 2005). Serivastava et al., (1985) revealed that aqueous extracts of inflorescence inhibited the growth.

Chemicals were reported to have allelopathic potential on various agronomic crops and weds (Stephen and Sowerby, 1996; Mersie and Singh, 1987) and vegetables. Where as lower concentration of root extracts stimulate the growth parameters than flower extracts. p-Anisic, p-hydroxy-benzoic and vanillic acid in the root. p-Anisic and Benzoic acids are present which are further used as solvents, additive and penetrating agents. Vanillic acid might be used as stimulating agent. Allelochemical may alter the rate at which ions are absorbed by plants (Singh, Et al., 2008). All these chemicals are present in different parts of *Parthenium* showed stimulation at lower concentration. Similar effect of root extracts of *Parthenium* was reported by Wakjira *et al*., (2006) and also stated that the aqueous extracts of flower seriously inhibited the growth of lettuce. The increased root growth of test species with lower concentrations of root extracts may also be attributed to increase the mitotic activity of root cells under allelopathic stress. *Solanum* test species exhibited a variable response with respect to extract concentrations. The varied susceptibility of different species to such extracts. According to Kanchan and Jaychandra (1979) and Pandey (1994), *Parthenium* is one of the best known plant invaders in the world linking allelopathy to exotic invasion. Allelopathy is expected to be an important mechanism in the plant invasion process. Lack of co-evolved tolerance of resident vegetation to new chemicals produced by the invader could allow these newly arrived species to dominate natural plant communities (Hierro and Callaway, 2003). *P. hysterophorus*, because of its invasive capacity and allelopathic properties, has the potential to disrupt natural ecosystems (Evans, 1997).

The leaf and shoot extract had strong inhibitory effect to root elongation of brinjal and to shoot elongation in crucifers and wild Asteraceae. Thus, sensitivity to allelochemicals and extent of inhibition varied with species and organs of the test species with higher concentration Allelopathic effect of *P. hysterophorus* may be an important mechanism involved in invasive success of this plant.

Allelochemicals of this plant can be exploited as a source of natural weedicide to control other invasive species. Weeds in cropping systems are most often considered to be detrimental. However, the interaction of weeds with crops may be positive. In a study where controlled densities of wild mustard (*Brassica campestris* **L.**) were interpolated with broccoli (Brassica oleracea var. Premium crop), crop yield increased by as much as 50% compared with broccoli planted alone (Jimenez-Osornio, J. J. and Gliessman, S. R., 1987). The development of weed management strategies that make use of allelopathic crop plants is receiving increased national and international attention (Ewston and Agron 1997). Key areas of allelopathy research are: selectively to enhance allelopathic traits of crop cultivars in breeding programs; to transfer allelopathic genes into commercial cultivars through modern biotechnology; to enhance their weed-killing capability; and to identify and characterize those substances involved in strong allelopathic activity and to use then either directly as natural herbicides, or as models for developing new and biotechnology, research on these areas will be enhanced. Allelopathy will become an important component in the development of future integrated weed management strategies. Biological activities of receiver plants to allelochemicals are known to be concentration dependent with a response threshold. Responses are, characteristically, stimulation or attraction at low concentrations of allelochemicals, and inhibition or repellence as the concentration increases (Lovett, 1989). These phenomena have been widely observed in allelochemicals from living plants, in allelopathic effects from decaying plant residues, and from the gross morphological level to the biochemical level, including other growth-regulating chemicals and herbicides. From above discussion we concluded that *S. melongena* was more sensitive to inhibitory effects of flower extracts than root extracts of *P. hysterophorus*. Allelopathic effect of *P. hysterophorus* may be an important mechanism involved in invasive of this plant. Allelochemicals of this plant can be exploited as a source of natural weedicide to control other invasive species.

One of the authors (I.S.) is indebted to the Head, Botany Department and Principal of the College, for providing necessary facilities to do the work.

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