CATRINA (2015), 12 (1):95 -99

Allelopathic effect of saponins isolated from *Trigonella hamosa* L. and *Solanum lycopersicum* L. on germination and growth of *Allium cepa* L.

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ABSTRACT

The allelopathic effect of saponins isolated from methanolic extract of *Trigonella hamosa* and *Solanum lycopersicum* (donor species) on germination and growth of *Allium cepa* (recipient species) was investigated in this study. Results revealed that saponins significantly inhibited seed germination and plumule growth rate of *Allim cepa*. Germination percentages of seeds treated with high concentration of *S. lycopersicum* and *T. hamosa* saponins (0.5 %) were 46 % and 40%, respectively, with a significant negative correlation ($p< 0.05$). Inhibition of growth rate was more noticed in case of seedlings treated with *S. lycopersicum* saponins than that treated with *T. hamosa* saponins. The relationship between the variation in saponins concentration and both germination and growth rate of *A. cepa* seedlings was significant ($p< 0.05$) as evaluated by ANOVA analysis.

Keywords: Allelopathy, saponins, *Solanum lycopersicum*, *Trigonella hamosa*, *Allium cepa*, growth, germination.

INTRODUCTION

The word allelopathy was first used by Molisch (1937) when describing the beneficial and deleterious chemical interactions of plants and microorganisms (Willis, 1985). Allelopathy plays an important role in the evolution of plant communities, exotic plants invasion and replant failure (Ridenour and Callaway, 2001; Bhowmik and Inderjit, 2003).

It could be indirect effects, that is, via degraded chemicals and through the effect of chemicals on availability of nutrients that effect of toxins from one crop on the yield of the next crop (Guenzi *et al.,* 1967; Yakle and Cruse, 1984; Leather and Einhellig, 1988; Inderjit, 2012).

Saponins are a group of higher plants secondary metabolites in which hydrophilic sugars are attached to a lipophilic steroid or triterpenoid moiety (Harborne *et al.,* 1999). Many plant species are able to produce and release bioactive secondary metabolites compounds such as saponins into the environment, which have allelopathic effects and are capable of suppressing the growth of other plants (Russo *et al.,* 1997; Romeo and Weidenhamer, 1998; Foy, 1999; Batish *et al.,* 2002; Inderjit *et al.,* 2011; Devi and Dutta, 2012). Such chemicals are present in all plant tissues including leaves, stems, roots, rhizomes, flowers, fruits and seeds, and even in pollen grains (Leather and Einhellig, 1986; Basil *et al.,* 2003).

Furostane saponins named hamoside were isolated from the seeds of *Trigonella hamosa* (Rajesh *et al.,* 1986; Hamed, 2007). Generally, genus Trigonella contains approximately 4 to 8 % saponins and about 1% alkaloids (Srinivasan, 2006). *Solanum lycopersicum* as one of the most important vegetable crops worldwide, commonly known as a tomato, has steroidal saponins, lyconosides and seroidal pseudoalkaloid oligoglycoside (Tiossi *et al.,* 2012).

The present work was performed to study the allelopathic effect of saponins isolated from two plants; *S. lycopersicum* as an edible crop, and *T. hamosa* as a weed, on germination and growth of *A. cepa*.

MATERIALS AND METHODS

Materials

S. lycopersicum and *T. hamosa* were collected from fields at Aswan governorate. Plants were previously identified according to Tackholm (1974). Seeds of *A. cepa* were purchased from market at Aswan.

Methods

Plant Extraction

S. lycopersicum and *T. hamosa* were carefully collected from some agricultural fields and separately shade dried then ground to powder using an electrical grinder. The air shade dried powder (450 g) of each plant species was filled in a conical flask and extracted using MeOH 80% by maceration until exhaustion (Hamed *et al.,* 2011). The solvent removed by evaporation under vacuum at 45^{o}C using rotary evaporator obtaining 17 grams crude extract of *S. lycopersicum* and 15 grams of *T. hamosa*.

Separation of saponins

Eight grams from crude extract from each plant extract were dissolved separately in a small quantity of H_2O and were loaded on a water preconditioned short C18 column (6x10 cm, LiChroprep_ RP-18, granules diameter 40-60 μm, Merck) and eluted with H_2O to remove sugars, 20%, 40% MeOH to remove phenols, 60% and 80% MeOH (fractions containing saponins), respectively. Fraction containing saponin from each plant were loaded onto a small Sepadex column and eluted with MeOH to obtain 100% pure saponins fraction (Hamed *et al.,* 2012). Three different concentrations of saponins from each plant (0.5, 0.25 and 0.125 %) were prepared.

Germination Bioassay

A. cepa seeds were sterilized using diluted solution of mercuric chloride (0.5 % for 5 minutes). Fifteen seeds were put in each sterilized petri dish. The dishes were divided into three sets; the first one was irrigated by

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equal volume (5ml) of different concentrations (0.125, 0.25 and 0.5%) of *S. lycopersicum* (3 dishes for each concentration). The same was done for the second set except irrigation by *T. hamosa* saponins. The third set was irrigated by the same volume of distilled water as a control. All sets were put in growth chamber at suitable temperature (25^{o}C) and illumination (12:12 h dark: light). The records of germination percentage as well as plumule and radicle lengths were followed for 15 days after sowing.

Statistical analysis

One-way analysis of variance (ANOVA) through the statistical computer programme MINITAB was used to test the significance of quantitative data of germination and growth.

RESULTS

Germination Bioassay

The germination percentage of *A. cepa* seeds treated with different concentrations of *S. lycopersicum* and *T. hamosa* saponins was presented in Fig 1. Data showed that germination percentage of *A. cepa* seeds was suppressed with all concentrations of saponins isolated from the two plants in comparison with control. Germination percentages of seeds treated with high concentration of *S. lycopersicum* and *T. hamosa* saponins (0.5 %) were 46 % and 40%, respectively with a significant negative correlation ($p < 0.05$).

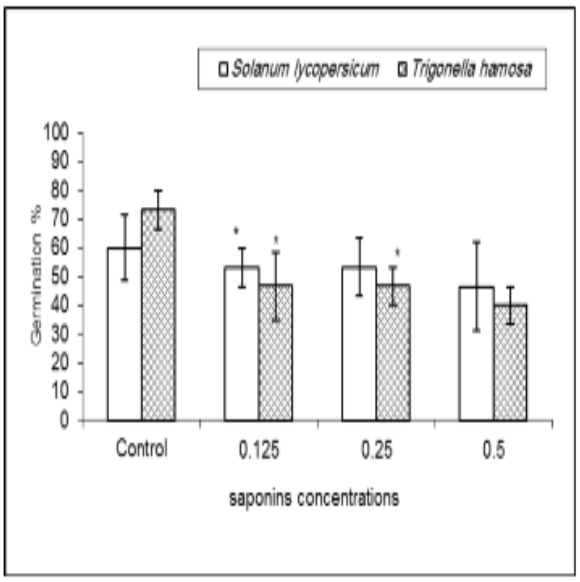

Figure (1): Germination percentages of *Allium cepa* seeds at different concentrations of saponins extracted from *Solanum lycopersicum* and *Trigonella hamosa saponins* (*means significant differences at $p < 0.05$).

Growth bioassay

Growth was measured in terms of radicle and plumule lengths. The plumule growth rate of *A. cepa* is shown in Fig 2 (a & b).

The plumule growth rate was decreased by increasing saponins concentration. A remarkable decrease in growth rate was observed in seedlings treated with S. lycopersicum at all concentrations.

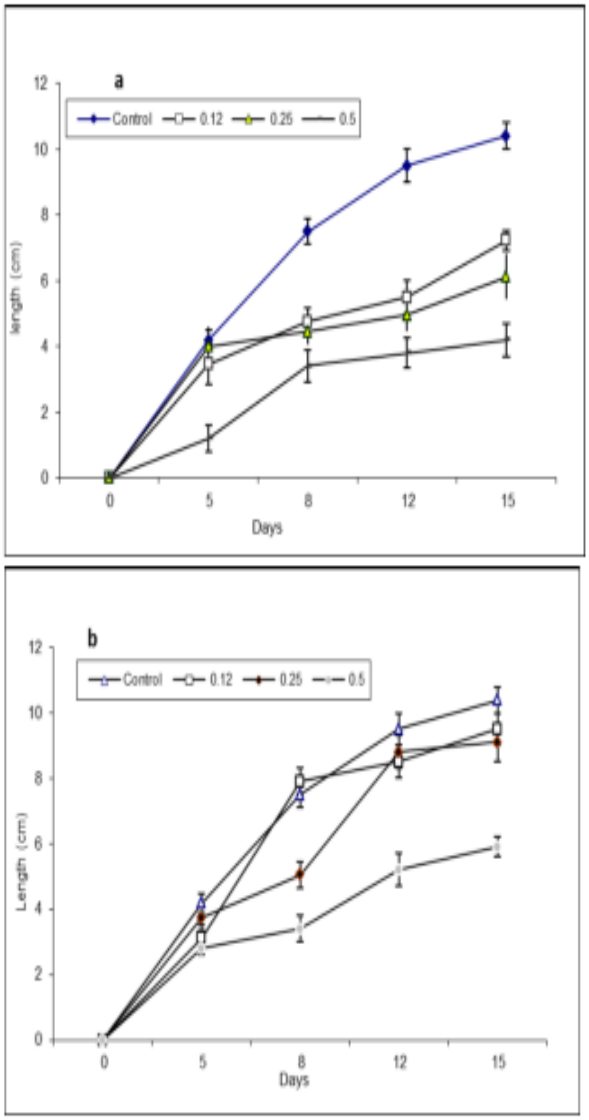

Figure (2): Plumule growth rate of Allium cepa treated with (A) Solanum lycopersicum saponins, (B) Trigonella hamosa saponins.

In case of seedlings treated with T. hamosa saponins, the highest concentration of (0.5 %) was more effective on growth rate than the other concentrations. Data of radicle and plumule lengths that showed in figure 3a & b revealed significantly decrease in growth with increasing in S. lycopersicum saponins. Otherwise, a slightly decrease in radical and plumule length was observed in case of seedlings treated with T. hamosa saponins.

Generally, the data obtained prove that saponins isolated from *S. lycopersicum* are inhibitory for growth of *A. cepa* more than that isolated from *T. hamosa* saponins, the contrary was detected regarding seeds germination.

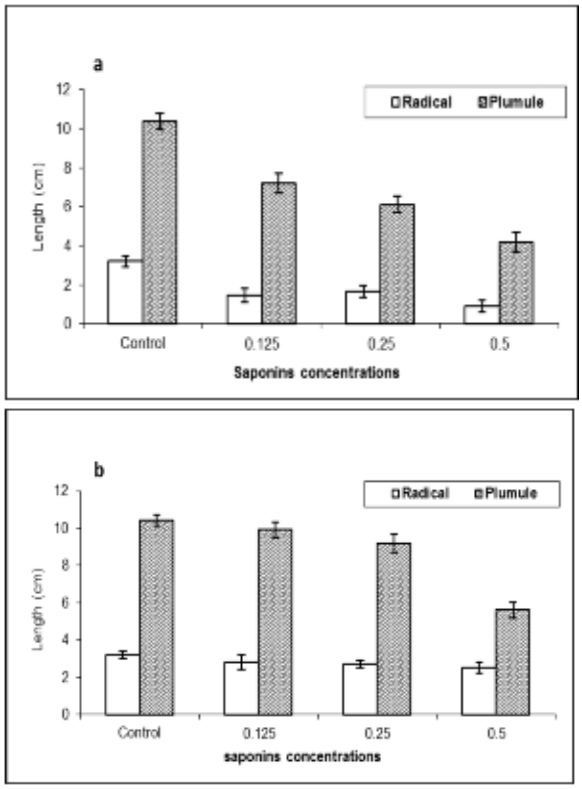

Figure (3): Radical and plumule lengths of Allium cepa treated with (A) Solanum lycopersicum saponins, (B) Trigonella hamosa saponins.

DISCUSSION

The present work showed the allelopathic effect of saponins as phytochemicals which can be found in most vegetables, beans and herbs on germination and growth of Allium cepa. Saponins as secondary metabolites precursor were isolated from two plants; S. lycopersicum and T. hamosa.

Regarding to seeds germination Fig 1, data showed that germination of A. cepa seeds was affected negatively by adding saponins with different concentrations specially in case of T. hamosa saponins. These findings were in agreement with several studies. Oleszek and Jurzysta, in 1987 found that crude saponins of alfalfa roots inhibit the germination of winter wheat seeds. Cyrpus rotunds and Aloe ferox extract which include saponins has an inhibition effect on the seed germination of wheat (Gupta and Mittal, 2012) and Tomato (Arowosegbe et al., 2012). According to our data, saponins not only inhibit A. cepa seeds germination but also inhibit the growth of seedlings. It is clear that saponins isolated from S. lycopersicum inhibit the growth more than that isolated from T. hamosa. Many studies were compatible with these data, that Medicago sativa plants were found to contain water-soluble substances such as saponins, significantly inhibited both germination and growth of alfalfa, and Lactuca sativa (Chung and Miller 1990; Tsuzuki et al., 1999; Tran and Tsuzuki, 2002; Seiji and Tatsuro, 2003).

The inhibition effects of saponins refer to its ability to decrease the diffusion rate of oxygen through the membranes of seeds (Marchaim et al., 1975). Moreover, allelochemicals like saponins when released to the soil, inhibit germination, shoot and root growth of other plants, affect nutrients uptake or naturally occurring symbiotic relationship, thereby destroying the plant's usable source of nutrients (Abu-Romman and Shibli, 2010).

CONCLUSION

The conclusion of this study that sapnins isolated from two plants, one of them is a wanted crop and the other is unwanted weed, have an inhibition effect on germination and growth of *A. cepa*. Where most of farmers are resorting to cultivate some crops side by side at the same field, especially with tomatoes, the study proves that crops could have negative impacts to each other, as the same as to the impact of the undesirable weeds that grow in the field. Therefore, it is recommended to avoid planting many crops side by side that it would affect the germination and growth of each other, resulted in decreasing of crop productivity.

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التأثير الاليلوباثى للصابونينيات المعزولة من نباتى الطماطم والنفل البرى على إنبات ونمو نبات البصل

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الملخص العربى

يهدف هذا البحث الى دراسة التأثير الاليلوباثى للصابونينيات المعزولة من نبات الطماطم ونبات النفل البرى على انبات ونمو نبات البصل. واوضحت الدراسة ان الصابونينيات المعزولة من هذين النباتين لها تأثير مثبط على انبات بذور نبات البصل، حيث وصلت نسبة الانبات فى التركيزات العالية (٠.٥%) الى ٤٠% فى حالة الصابونينيات المعزولة من نبات النفل ٤٦% فى حالة صابونينيات نبات الطماطم. واتضح من الدراسة ايضا انه للصابونينيات فعل مثبط لنمو بادرات نبات البصل، وكان للصابونينيات المعزولة من نبات الطماطم تأثيراً اكثر وضوحاً على نمو البادرات من تلك التى تم عزلها من نبات النفل البرى. واكد التحليل الاحصائى العلاقة بين فِعل الصابونينيات المثبط للنمو وزيادة تركيزاتها فى المحلول.