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The allelopathic effect of *Euphorbia hirta* and *Vesicular Arbuscular Mycorrhiza* (VAM) on growth of eggplant (*Solanum melongena* L.)

Ayoub Zeyada Elhag*, Talal Sayed Abdelhaleem Musa, Mohamed Osman Gafar

Khartoum North, College of Agricultural Studies, Sudan University of Science and Technology, Sudan

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Key words: *E. hirta*, VAM, Allelopathic, Eggplant, Growth.

Abstract

Pot experiment was conducted in winter (2010/2011), at the experimental farm of the College of Agricultural Studies, Sudan University of Science and Technology, to investigate the allelopathic effect of *Euphorbia hirta* and Vesicular Arbuscular Mycorrhiza (VAM) on growth of eggplant. 10kg of oven sterilized soil mixture (2:1 silt loam and sand, respectively) were packed in 25×25cm pots. *Euphorbia hirta* powder at 0.04, 0.08 and 0.12% and 0.2% of VAM w/w of soil were thoroughly mixed, in addition to control with soil mixture only. 1-month old eggplant seedlings were transplanted in each pot. 0.7 g urea was added with the irrigation water twice at three weeks interval from transplanting. Irrigation and pest control were done when required. Evaluated growth parameters were plant height, branches and leaves/plant, shoot and root fresh and dry weight, days to 50% flowering as well as percentage of mycorrihza on root hairs. The experimental units were in completely randomized design with four replications. Addition of *E.hirta* (0.04%) or VAM increased all plant growth parameters. The highest values, however, were obtained with addition of 0.04% euphorbia with VAM (0.2%). Days to 50% flowering were reduced at the higher euphorbia concentrations (above0.08%). The lower euphorbia concentration (0.04%) increased VAM growth. It could be concluded that *E. hirta* at low concentrations with mycorrhiza had synergistic effect on growth of eggplant, whereas, high concentrations had antagonistic effects on both eggplant growth and VAM activity. So addition of *E. hirta* at low concentrations (0.04% as powder) in combination with VAM inoculation could be recommended for good growth of eggplant.

* **Corresponding Author:** Ayoub Zeyada Elhag ✉ zadhag@yahoo.com

Introduction

Eggplant which belongs to the family Solanaceae is an important vegetable. It is rich in minerals, calcium, magnesium, potassium, sodium and phosphorus. It is widely grown in Asia (China and India) with an area of 1159 thousand hectares. It becomes of increasing importance in Arabic countries with Egypt on the top (FAO, 1998). In Sudan it comes after tomato among the members of this family with 10% of the average area (400 thousand hectares) under vegetables (Federal Ministry of Agriculture and Forestry, 2008). Like most crops it is interfered with weeds through competition and allelopathy, resulting in direct great losses in its growth and yield. Allelopathy is a mechanism that weeds often utilize to affect germination dynamics and growth of field crops (Mishra *et al*.,2004, Kadioglu *et al.,* 2005; Tanveer *et al,* 2010).Living or dead weeds left in the soil have deleterious effects on the same or subsequent crops by releasing allelochemicals (Batish *et al.,* 2007). These allelochemicals are reported to be present in almost all plant parts (Rice, 1984; Singh *et al.,* 2003). However, differences are observed among species regarding their allelopathic potential and their ability to produce toxins in various parts (Alam *et al*., 2001; Veenapani, 2004). Among 7500 species of *Euphorbiaceae* which have allelopathic activity on crops is *Euphorbia hirta*. It is found in field crops growing in semi arid zones. It is fast growing during autumn and spring. Its allelopathic potential of extracts, residues and root secretions (Rice*.,* 1984) have been reported against crops like pea, tomato, wheat, chickpea, cotton, alfalfa, lettuce, groundnut, and soybean. Saswade and Dhumal (2012) studied the allelopathic effect of E.*hirta* and *Celosia argentea* on seedling growth of *Sorghum bicolor*, *Vigna radiata* and *Cicer arietinum*. They found that lower concentration (1:4%) of leaf extracts of both allelopathic plants was more effective to stimulate biochemicals, whereas higher concentration (1:1%) was inhibitory. Sakeri and Al-Dulaimy (1990) found that allelopathy is the major component of the interference by *E. prostrata* against *Amaranthus retroflexus*, Medicago *sativa* and Gossypium *hirsutum*. *E. heloscopia* decreased shoot and root growth of wheat and lentil (Tanveer *et al*., 2010). Moreover, magnitude of allelopathic suppression is believed to vary with sample preparation and extraction techniques (Zieliński and Koztowska, 2000; Jabeen and Ahmed, 2009 and Tantiado and Saylo, 2012).

Arbuscular mycorrhizal fungi (AMF) are soil-borne microorganisms living symbiotically with most land plants and in most ecosystems. They play a key role in facilitating nutrient uptake especially phosphorus by crops in low-input farming systems (Bagayoko *et al*., 2000 and Auge, 2001). Musa (2012) found that tomato did not have an effect on either mycorrhizal colonization or *Phelipanche* germination. 42-day mycorrhizal plants significantly reduced *Phelipanche* germination in comparison to non-mycorrhizal controls. Stem diffusates from non-mycorrhizal plants significantly increased germination than diffusates from the corresponding mycorrhizal ones. No mycorrhizal colonization was detected in un-inoculated control plants. Adding AMF resulted in a significant increase of branching of tomato plants. Dry weights were slightly increased through manure application when no nitrogen was applied and significantly at 36 kg N ha^{-1}. Fakhro *et al*., (2010) reported that *Piriformospora indica* colonized tomato roots increased leaves biomass by 20% and decrease disease severity caused by *Verticillium dahliae* by 30%. They considered it a growth promoting endophyte for tomato, both in soil and hydroponic cultures. Moreover, many researchers stated that Arbuscular mycorrhiza (AM) increased fresh weight (Kaliqa and Sanders, 2000).It also promoted growth, rooting of cuttings, seed production and yields of some crops (Al- Karaki *et al.* 2004, Turk *et al.* 2006, Nagarathna *et al.* 2007 and Farahan *et al*., 2008). Regarding the previous studies the objectives of the present study was to evaluate the effect of AMF and phytotoxic activity of E. *hirta* on growth of eggplant.

Materials and methods

This study was conducted during the winter season 2010/2011, at the experimental farm of the College of

Agricultural Studies, Sudan University of Science and Technology. The effect of the allelopathic relationship between *E.hirta* and Vesicular Arabsicular Mjcorrhiza (VAM) on growth of eggplant was investigated in pot experiment.

Medium and Practices

The soil used was a mixture of silt loam and sand in a ratio of 2:1, respectively. The mixture which was oven sterilized (in an oven at 160°C for two hours) was packed in plastic pots (25×25cm). Each pot contained 10 Kg of the soil to which four quantities (0.04, 0.08 and 0.12% w/w of soil) of *E. hirta* powder and no or 0.2% w/w of soil of VAM were added and thoroughly mixed, in addition to a control without euphorbia and micorrhiza. Three 1-month seedlings were transplanted in each pot and thinned to one plant per pot after three weeks. Urea at the rate of 0.7g/pot with irrigation water was added twice at three weeks interval from transplanting. The transplants were irrigated every other day and sprayed against jassid and white fly with confidor (commercial insecticide) at 0.1% concentration.

Growth Parameters

Evaluated growth parameters were plant height, plant number of branches and leaves, shoot and root fresh and dry weight, days to 50% flowering and percentage of micorrihza on root hairs.

Statistical Design and Analysis

The experimental units were in completely randomized design with four replications. The collected data were analyzed with the soft ware package MSTATC (version 3). The means were compared using the least significant difference (LSD) at p≤ 0.05 (Steel *et al.*, 1997).

Results and discussion

As in Table 1 addition of micorrhiza (0.2% w/w of soil) increased all plant growth parameters (plant height by 37.8 and 49.8%, number of branches by 47.6 and 43.0% and number of leaves by 66.7 and 44.1%) after 60 and 75 days from planting, respectively. Addition of euphorbia alone or with micorrhiza, also showed positive effects on plant growth, however, the increment in the three evaluated parameters was higher at the lowest concentration (0.04% w/w of soil.). The highest values were obtained with addition of 0.04% euphorbia alone or with micorrhiza.

Table 1. Effect of euphorbia and mycorrhiza on vegetative growth of eggplant after 60 and 75 days from transplanting.

Euphorbia (E) + Mycorrhiza (Mc) concentrations (% of soil w/w)	Plant height(cm) After (days)		Branches/ plant After(days)		Leaves/plant After(days)	
	60	75	60	75	60	75
Control (0.0)	12.7	20.1	6.3	12.8	6.3	11.8
0.2 Mc	17.5	30.1	9.3	18.3	10.5	17.0
0.04 E	16.1	28.7	9.0	17.3	9.3	15.5
0.08 E	15.5	26.0	7.5	14.5	7.8	14.0
0.12 E	12.5	22.0	7.8	13.0	9.0	18.0
0.04 E + 0.2 Mc	19.6	30.0	10.3	19.3	11.3	19.3
0.08 E + 0.2 Mc	18.4	26.4	9.5	16.0	10.3	16.0
0.12 E + 0.2 Mc	17.3	26.8	9.0	15.0	8.8	16.3
LSD at P ≤ 0.05	6.1	9.7	3.0	5.7	5.5	8.1

Similar results had been reported by many researchers. They had attributed growth inhibition to allelopathic potential of different plants. Rice (1984) reported that allelopathic potential of euphorbia extracts, residues and root secretions were found against crops like pea, tomato, wheat, chickpea, cotton, alfalfa, lettuce, groundnut, and soybean. Sakeri and Al-Dulaimy (1990) found that allelopathy is the major component of the interference by *E. prostrata* against *Amaranthus retroflexus*, *Medicago sativa* and *Gossypium hirsutum*. Jabeen and Ahmed (2009) found that low concentration of *E. hirta* promoted growth while high concentration reduce or inhibit maize growth. *E. heloscopia* decreased shoot and root growth of wheat and lentil (Tanveer *et al.*, 2010). Ghodaka *et al.* (2012) reported that low

extracts concentration of *E. hirta* stimulated the root and shoot growth while high concentrations (75%) of *E. microphylla* showed marked stimulation of shoot growth. Saswade and Dhumal(2012) studied the allelopathic effect of E.*hirta* and *Celosia argentea* on seedling growth of *Sorghum bicolor*, *Vigna radiata* and *Cicer arietinum*. They found that lower concentration (1:4%) of leaf extracts of both allelopathic plants was more effective to stimulate biochemicals, whereas higher concentration (1:1%) was inhibitory. Moreover, magnitude of allelopathic suppression is believed to vary with sample preparation and extraction techniques (Zieliński and Koztowska, 2000; Jabeen and Ahmed, 2009 and Tantiado and Saylo, 2012).

Table 2. Effect of euphorbia and mycorrhiza on plant fresh and dry weight and days to 50% flowering of eggplant.

Euphorbia (E) + Mycorrhiza (Mc) concentrations	Shoot weight(g)		Root weight (g)		Days to 50% flowering
(% of soil w/w)	Fresh	Dry	Fresh	Dry	
Control (0.0)	40.0	20.3	37.5	19.5	77.3
0.00 E + 0.2 Mc	51.5	28.0	47.5	22.8	71.3
0.04 E	45.0	25.3	40.0	19.8	73.3
0.08 E	45.0	24.5	42.5	20.0	73.5
0.12 E	43.0	22.5	40.0	19.8	68.3
0.04 E + 0.2 Mc	45.5	25.0	42.5	19.8	72.5
0.08 E + 0.2 Mc	45.0	23.8	40.0	19.8	67.0
0.12 E + 0.2 Mc	42.5	22.5	39.0	19.8	78.8
LSD at P ≤ 0.05	16.5	6.0	19.1	2.7	8.0

The same effects (Table2) of both micorrhiza and euphorbia on the fresh and dry weight of shoot and root were obtained; however, the highest values were recorded by addition of micorrhiza alone. The earliest flowering (10 days earlier) was obtained with addition of both 0.08% and micorrhiza or 0.12% euphorbia alone. Weber *et al.* (1993) noticed that at flowering in 'high mycorrhizal' plants, mycorrhizal root length, total phosphorus uptake and shoot biomass were significantly higher than in 'low mycorrhizal' plants. At maturity, however, shoot biomass was similar and harvest index was higher in 'low mycorrhizal' plants than in 'high mycorrhizal' plants. This negative effect on reproductive growth was related to the shallow root distribution in the soil profile and a lower root: shoot ratio in the 'high mycorrhizal' plants. The same was reported by Bagayoko *et al.* (2000) and Auge (2001). They stated that mycorrhiza play a key role in facilitating nutrient uptake especially phosphorus by crops in low-input farming systems.

Table 3. Allelopathic relationship between euphorbia and mycorrhiza.

Euphorbia (E) + Mycorrhiza (Mc) Concentrations (% of soil w/w)	Density of Mc on roots (%)
Control	0.0
0.00 E + 0.02 Mc	35.7
0.04 E + 0.02 Mc	50.5
0.08 E + 0.02 Mc	39.9
0.12 E + 0.02 Mc	30.9

Moreover, many researchers stated that Arbuscular mycorrhiza (AM) increased plant fresh weight (Kaliqa and Sanders, 2000). It also promoted growth, rooting of cuttings, seed production and yields of some crops (Al-Karaki *et al.*, 2004, Turk *et al.*, 2006, Nagarathna *et al.*, 2007 and Farahan *et al.*, 2008). Kasim (2011) showed that inoculations with AM fungi increased tomato seedling growth and their shoot fresh weight. Fakhro *et al.* (2010) reported that *Piriformospora indica* colonized tomato roots

increased leaves biomass by 20% and decrease disease severity caused by *Verticillium dahliae* by 30%. They considered it a growth promoting endophyte for tomato, both in soil and hydroponic cultures.

Musa (2012) found that tomato did not have an effect on either mycorrhizal colonization or *Phelipanche* germination. AMF resulted in a significant increase of branching of tomato plants. Dry weights were slightly increased through manure application when no nitrogen was applied and significantly at 36 kg N ha^{-1}. The allopathic effect was reflected by the positive effect of euphorbia on mycorrhiza growth and development up to 0.08% (Table3). Higher euphorbia concentrations above 0.08% had a negative effect on micorrhiza growth. Similar positive interaction of mycorrhiza and nematode with rhizobium resulted in a higher increase of root nodulation. Mycorrhiza association with rhizobium produced higher root nodulation than rhizobium alone (Ugwuoke and Eze, 2010). Also *Centaurea maculosa* and Alliaria exhibited very similar results as shown by Prati and Bossdorf (2004) and Callaway *et al*. (2008). It has been suggested that allelopathy may be of vital significance in two-tier farming, especially if new species of tree or grass are considered.

Allelopathic inhibition typically results from a combination of allele-chemicals which interfere with several physiological processes in the receiving plant or microorganism (Anonymous, 2015).

It could be concluded that *E. hirta* at low concentrations with mycorrhiza had synergestic effect on growth of eggplant, whereas high concentrations had phytotoxic effects on both eggplant growth and mycorrhizal activity. So addition of *E. hirta* at low concentrations (0.04% as powder) in combination with VAM inoculation could be recommended for good growth of eggplant in pots

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