Effect of Artemisinin and Its Derivatives on Germination and Seedling Growth of Three Weed Species

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ABSTRACT

The effects of four sesquiterpenes, artemisinin, dihydroartemisinin, artemether and artesunate on seed germination and seedling growth of three common weeds, namely *Phalaris minor*, *Panicum repens* and *Silybum marianum* were investigated. The tested sesquiterpenes showed promising herbicidal activity against these weeds. Artemether was the most effective compound with complete inhibition of seed germination of *P. minor* at concentrations of 50 and 100 µM, whereas artesunate was the less effective compound at all tested concentrations. The tested compounds were more potent germination inhibitors against *P. minor* than *P. repens* and *S. marianum*. Dihydroartemisinin revealed the highest inhibitory effect on seed germination of *P. repens* and *S. marianum*. Furthermore, the tested compounds revealed a strong inhibition of root growth of the three weeds. Artemether showed the highest root growth inhibition against *P. minor* (EC_{50} = 1.20 µM), while artesunate was the most potent compound against *P. repens* (EC_{50} = 0.39 µM) and *S. marianum* (EC_{50} = 10.0 µM). In general, the tested compounds were more effective against *P. minor* than *P. repens* and *S. marianum*. On the other hand, artemether, dihydroartemisinin and artesunate caused the highest shoot growth inhibition against *P. minor*, *P. repens* and *S. marianum*, respectively. Although the four sesquiterpenes strongly inhibited root and shoot growth of the three weeds, the inhibition of root growth by all compounds was greater than that of shoot growth. The results of the present study indicated that artemisinin derivatives, dihydroartemisinin, artemether and artesunate, were more effective than artemisinin. This finding assured the importance of chemical modification of this class of natural compounds for obtaining new compounds with promising herbicidal activity.

Key words: sesquiterpenes, artemisinin derivatives, herbicidal activity, *Phalaris minor*, *Panicum repens*, *Silybum marianum*.

INTRODUCTION

Weeds cause more crop yield loss and add more crop production costs than other plant pests and pathogens. They reduce crop quality and quantity. Synthetic herbicides are the most widely method used for controlling of weeds; however, the intensive use of herbicides increased weed resistance. It is estimated that over 307 resistant strains of dicots and 73 resistant strains of monocots have been identified over the world (Heap, 2006).

Plant-derived secondary compounds have great potential in the development of environmentally safe herbicides with novel molecular sites of action (Duke *et al.*, 2000). Recently, the use of medicinal and allelopathic plants has been suggested as an alternative weed management under sustainable agriculture (Fujii, 2001; Hong *et al*. 2003; Singh *et al*. 2003).

Artemisinin is a naturally occurring antimalarial sesquiterpene endoperoxide lactone isolated from the shoots of *Artemisia annua* (Klayman, 1985). Its poor solubility in water and organic phases has led to the development of derivatives to increase solubility, metabolic and chemical stability and bioavailability (Ploypradith, 2004). Several research groups have developed a series of synthetic artemisinin analogues in order to address solubility and persistence problems associated with the use of these compounds in malaria treatment. Dihydroartemisinin and other derivatives including ethers and esters (artemether and artesunate, respectively) are more potent drugs than artemisinin and are available as commercial drugs in China and other countries (Dayan *et al*. 1999). Artemisinin and several of its structural analogues are also potent plant growth inhibitors (Duke *et al.*, 1987 and 1988; Chen and Leather, 1990; Ditomaso and Duke, 1991). It has been reported that artemisinin was a selective phytotoxin with herbicidal activity similar to cinmethylin (Bhowmik and Inderjit 2003).

Phalaris minor Retz. (littleseed canarygrass, family Poaceae) is an annual invasive troublesome weed of wheat fields. It interferes with growth and development of wheat affecting the crop quality and yield. The intensive use of synthetic herbicides over the world to manage it has led to development of resistant weed (Batish *et al.* 2007). *Panicum repens* L. (torpedograss, family Poaceae) is a rhizomatous graminaceous weed of 17 crops in 27 countries (Holm *et al.* 1977a; Murphy *et al.* 1992). Torpedograss is one of the most invasive, perennial grass species of terrestrial, wetland and aquatic

natural areas in tropical and subtropical regions worldwide (Sutton 1996). *Silybum marianum* (L.) Gaertn. (milk thistle, family Asteraceae) is a serious weed in many areas of North and South America, Africa, Australia, and the Middle East. Milk thistle is grown commercially as a medicinal plant in Europe, Egypt, China, and Argentina (Holm *et al.* 1997b).

In our continuous efforts to find new natural compounds with potential use for weed control (Abdelgaleil *et al.* 2009; Abdelgaleil 2010; Saad *et al.* 2012), the herbicidal activity of four endoperoxide sesquiterpenes namely, artemisinin, dihydroartemisinin, artemether, and artesunate was evaluated against three common weeds *P. minor*, *P. repens*, and *S. marianum* to explore their potential as natural herbicides.

MATERIALS AND METHODS

1. Tested seeds

Phalaris minor Retz. (littleseed canarygrass), *Panicum repens* L. (torpedograss), and *Silybum marianum* (L.) Gaertn. (milkthistle) field biotype were collected from Alexandria Desert Research Station Farm, Alexandria, Egypt. All undersized or damaged seeds were discarded, and the seeds of uniform size were selected. Germination tests were carried out before experiments and the germination percent were 60% for littleseed canarygrass, 95% for torpedograss and 90% and for milkthistle.

2. Tested chemicals

Four endoperoxide sesquiterpenes artemisinin 99% (1), dihydroartemisinin 99% (2), artemether 99% (3) and artesunate 99% (4) (Fig.1) were purchased from Shaanxi Scipharmni-Tech Industry Co. Ltd, Xiam, Shaanxi, China.

3. Phytotoxicity of endoperoxide sesquiterpenes

The effects of the endoperoxide sesquiterpenes (artemisinin, dihydroartemisinin, artemether and artesunate) were evaluated on the germination of *P. minor*, *P. repens* and *S. marianum* and subsequent seedling growth. The tested sesquiterpenes were dissolved in dimethyl sulfoxide (DMSO) followed by dilution with distilled water to obtain a stock solution of 100 µM. The concentration of DMSO in this solution was 0.5% v/v. Then a series of concentrations (1, 5, 10 and 50 µM) were prepared by dilution with distilled water. An aqueous solution of DMSO (0.5% v/v) was used as control treatment. Three replicates, each of 20 seeds, were used for each treatment using Petri dishes (9 cm) lined with Whatman No. 2 filter paper. Six milliliters of each test solution were added to each Petri dish. Petri dishes were placed in the bottom of 0.1 mm thick polyethylene bags (15 × 30 cm) that were expanded to contain air and then closed at the top with rubber bands to prevent the loss of moisture. The Petri dishes were kept on a germination cabinet at 20±1ºC with 12 h photoperiod. Germination percentages and root and shoot lengths were recorded after 11 days of sowing for *P. minor* and *P. repens*, and after 7 days of sowing for *S. marianum*. The growth inhibition percentages (I %) of root and shoot lengths were calculated from the following equation: I (%) = [1- T/C] ×100; where T is the length of shoot or root in treatment (cm) and C is the length of shoot or root in control (cm). The concentrations causing 50% inhibition (EC_{50}) of root or shoot growth were calculated from probit analysis (Finney 1971).

4. Statistical analysis

Germination percentages, root lengths and shoot lengths were subjected to one-way analysis of variance followed by Student–Newman–Keuls test (Cohort software Inc. 1985) to determine significant differences among mean values at the probability level of 0.05.

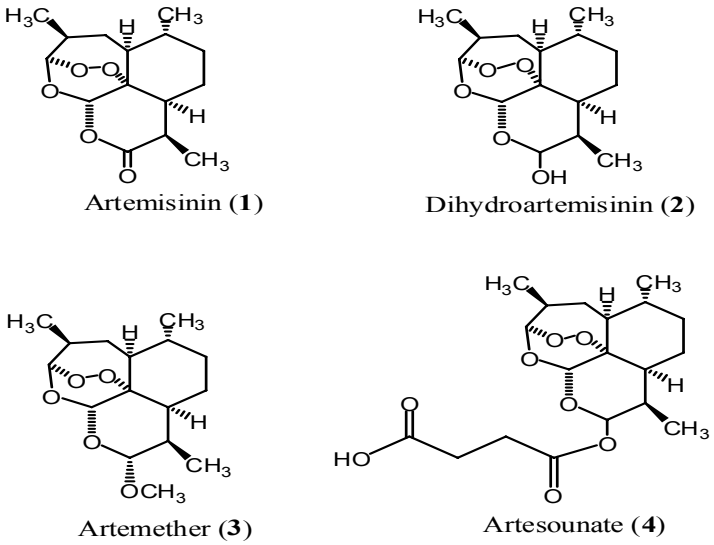

Figure1. Chemical structure of artemisinin and artemisinin derivatives.

RESULTS AND DISCUSSION

1. Effect of sesquiterpenes on seed germination

The effect of the four tested sesquiterpenes artemisinin (1), dihydroartemisinin (2), artemether (3), and artesunate (4) on the germination percentages of the three weeds *P. minor*, *P. repens*, and *S. marianum* is shown in Table 1. The results showed that all of the tested compounds caused significant inhibition of *P. minor* germination at all of the tested concentrations except the lowest concentration of 1 µM. Artemether (3) was the most effective compound with complete inhibition of seed germination at concentrations 50 and 100 µM. Artesunate (4) was the less effective compound at all of tested concentrations. Artemisinin (1) and dihydroartemisinin (2) exhibited similar inhibitory effect on seed germination of this weed. In the case of *P. repens*, the tested compounds showed no significant inhibition of seed germination at the concentrations of 1. 5 and 10 µM. At 50 µM, the tested compounds exhibited significant reduction of germination with compounds 2 and 3 being more effective than compounds 1 and 4. Complete inhibition of seed germination was observed when seed treated with compounds 2 and 3 at the concentration of 100 µM. When tested against *S. marianum*, the sesquiterpenes showed weak inhibitory effect on germination. There were no significant reduction of seed germination at the tested concentrations of compounds 3 and 4. Compound 2 caused significant reduction of seed germination at concentrations of 50 and 100 µM, while compound 1 showed significant reduction of seed germination at the concentration of 100 µM.

The results of germination bioassay on the three weeds indicated that *P. minor*, an annual narrow-leaf weed, was more sensitive to the tested compounds than *P. repens*, a perennial narrow-leaf weed, whereas *S. marianum*, an annual or biannual broad-leaf weed, was the less sensitive one to all tested compounds. Compounds 1, 2 and 3 were reported to possess inhibitory effect on seed germination of *Lactuca* and *Arabidopsis* (Dayan *et al.* 1999). Artemisinin (1) inhibited seed germination of redroot pigweed (Lydon *et al.* 1997) and several monocot and dicot vegetables and weeds (Chen and Leather 1990; Duke *et al.* 1987). Other sesquiterpenes and sesquiterpene lactones have been shown to inhibit seed germination (Baruah *et al.* 1994; Batish *et al.* 2002; Barbosa *et al.* 2004; Abdelgaleil *et al.* 2009; Saad *et al.* 2012).

2. Effect of sesquiterpenes on root growth

The inhibitory effects of the four sesquiterpenes on root growth of *P. minor*, *P. repens* and *S. marianum* in terms of root length and percentages of root growth inhibition relative to control are shown in Table 2. The tested compounds revealed a strong inhibition of root growth of *P. minor* in a concentration-dependent manner.

Table 1: Effect of artemisinin and its analogues on seed germination of *Phalaris minor*, *Panicum repens*, *Silybum marianum*[a]

Conc (µM)	Germination %			
	Phalaris minor			
	Artemisinin (1)	Dihydroartemisinin (2)	Artemether (3)	Artesunate (4)
0	60.0 ± 0.0a[b]	60.0 ± 0.0a	60.0 ± 0.0a	60.0± 0.0a
1	43.3 ± 3.34b	53.3 ± 3.34a	50 ± 5.78b	56.7 ± 3.34a
5	33.3 ± 3.34bc	36.7 ± 3.34b	33.3 ± 3.34c	43.3 ± 6.67bc
10	30 ± 5.78bc	26.7 ± 6.67b	23.3 ± 3.34d	40 ± 6.67bc
50	23.3± 3.34c	13.3 ± 3.34c	0.0 ± 0.0e	26.7 ± 8.83bc
100	3.3± 3.34d	10.0 ± 0.0c	0.0 ± 0.0e	13.3 ± 6.67c
	Panicum repens			
0	97.0 ± 3.34a	97.0 ± 3.34a	97.0 ± 3.34a	97.0 ± 3.34a
1	97.0 ± 3.34a	93.0 ± 6.67a	90.0 ± 5.78a	97.0 ± 3.34a
5	90.0 ± 5.78a	90.0 ± 0.0a	83.0 ± 6.67a	93.0 ± 3.34a
10	83.0 ± 8.83a	77.0 ± 8.83a	80.0 ± 5.78a	87.0 ± 3.34a
50	60.0 ± 5.78b	53.0 ± 6.67b	53.0 ± 3.34b	70.0 ± 5.78b
100	53.0 ± 3.34b	0.0 ± 0.0c	0.0 ± 0.0c	43.0 ± 3.34c
	Silybum marianum			
0	86.7 ± 3.33a[b]	86.7 ± 3.33a	86.7 ± 3.33a	86.7 ± 3.33a
1	83.3 ± 3.33ab	83.3 ± 3.33ab	86.7 ± 3.33a	86.7 ± 3.33a
5	83.3 ± 3.33ab	80.0 ± 0.0ab	76.7 ± 3.33a	86.7 ± 3.33a
10	76.7 ± 3.33 ab	73.3 ± 3.33abc	76.7 ± 3.33a	80.0 ± 0.0a
50	70.0 ± 5.78ab	70.0 ± 5.78bc	73.3 ± 3.33a	76.7 ± 3.33a
100	66.7 ± 3.33b	63.3 ± 3.33c	70.0 ± 5.78a	73.3 ± 3.33a

[a] Data are expressed as means ±SE from experiments with three replicates of 20 seeds each.
[b] Means within a column sharing the same letter for each weed are not significantly different at the 0.05 probability level.

Artemether (3) was the most active compound followed by artesunate (4), artemisinin (1) and dihydroartemisinin (2) with EC_{50} values of 1.20, 1.72, 2.21 and 2.95 µM, respectively. Compounds 2, 3 and 4 caused complete inhibition of root growth at concentrations of 50 and 100 µM.

The tested compounds showed strong inhibition of root growth of *P. repens* with compound 4 (EC_{50} = 0.39 µM) being the most effective one. At the lowest concentrations of 1, 5 and 10 µM, compound 4 exhibited the highest reduction of root growth with growth inhibition percent of 68.3, 90.2 and 95.1%, respectively. At the highest concentrations of 50 and 100 µM, all of the tested compounds caused strong growth reduction as the root growth inhibition ranged from 92.7% to 100%. On the other hand, the tested compounds caused significant inhibition of root growth of *S. marianum* at all of the tested concentrations compared with control. Compound 4 was the most potent while compound 1 was the less effective one. In general, the tested compounds were more effective against *P. minor* than *P. repens* and *S. marianum* except compound 4 which was more effective against *P. repens* than *P. minor*.

The results of this study are consistent with previous studies on artemisinin and its derivatives. For example, artemisinin strongly reduced the root growth of *Lemna minor* at concentrations of 5 and 10 µM (Stiles *et al.* 1994). Chen and Leather (1990) reported that artemisinin inhibited root formation in bush bean *(Phasoleus vulgaris)* seedlings at levels as low as 10.0 µM. Duke *et al.* (1987) also reported that artemisinin inhibited roots and shoots of lettuce *(Lactuca sativa),* redroot pigweed *(Amaranthus retroflexus),* pitted morning glory *(Lpomoea lacunosa),* and common purslane *(Portulaca oleracea)* at 33.0 µM. Dayan *et al.* (1999) stated that artemisinin (1), dihydroartemisinin (2) and artemether (3) inhibited root growth of *Lactuca* and *Lolium* at concentrations of 35 and 350 µM.

Table 2: Effect of artemisinin and its analogues on root growth of *Phalaris minor*, *Panicum repens* and *Silybum marianum*[a]

Conc (µM)	Artemisinin (1)		Dihydroartemisinin (2)		Artemether (3)		Artesunate (4)	
	Phalaris minor							
	Root length (cm)	I (%)[b]	Root length (cm)	I (%)	Root length (cm)	I (%)	Root length (cm)	I (%)
0	3.27± 0.18a[c]	0.0	3.27± 0.18a	0.0	3.27± 0.18a	0.0	3.27± 0.18a	0.0
1	2.03± 0.09b	37.9	2.67± 0.18b	18.2	1.6± 0.06b	49.2	2.3± 0.35b	28.7
5	1.53± 0.09c	53.0	1.3± 0.09c	57.7	0.97± 0.12c	70.3	0.33± 0.03c	89.9
10	0.4± 0.06d	87.8	0.17± 0.03d	94.8	0.03± 0.03d	99	0.27± 0.03c	91.7
50	0.2± 0.06d	93.9	0.0 ± 0.0d	100	0.0 ± 0.0d	100	0 ± 0c	100
100	0.07± 0.07d	97.9	0.0 ± 0.0d	100	0.0 ± 0.0d	100	0 ± 0c	100
EC_{50}[d]	2.21		2.95		1.20		1.72	
	Panicum repens							
0	4.1± 0.12a[c]	0.0	4.1± 0.12a	0.0	4.1± 0.12a	0.0	4.1± 0.12a	0.0
1	3.9 ± 0.03a	4.9	3.2± 0.17b	22.0	3.2± 0.09b	22.0	1.3± 0.15b	68.3
5	2.4± 0.19b	41.5	1.3± 0.12c	68.3	2.9 ± 0.06b	29.3	0.4± 0.06c	90.2
10	0.6± 0.1c	85.4	1.0 ± 0.03c	75.6	2.5± 0.17c	39.0	0.2± 0.0c	95.1
50	0.3± 0.03cd	92.7	0.1 ± 0.03d	97.6	0.2 ± 0.03d	95.0	0.16 ± 0.03c	96.1
100	0.1± 0.03d	97.6	0.0 ± 0.0d	100	0.0 ± 0.0d	100	0.1 ± 0c	97.6
EC_{50}	5.40		2.98		10.63		0.39	
	Silybum marianum							
0	5.67 ± 0.09a[c]	0.0	5.67 ± 0.09a	0.0	5.67 ± 0.09a	0.0	5.67 ± 0.09a	0.0
1	4.10 ± 0.0b	27.7	4.13 ± 0.06b	27.2	4.20± 0.06b	25.9	4.10± 0.06b	27.7
5	3.67 ± 0.03c	35.3	3.77 ± 0.03c	33.5	3.77± 0.03c	33.5	3.63± 0.03c	36.0
10	2.87 ± 0.03d	49.4	2.87 ± 0.03d	49.4	2.93±0.03d	48.3	2.87± 0.03d	49.4
50	2.63 ± 0.06e	53.6	2.10 ± 0.06e	63.0	1.93 ± 0.03e	66.0	1.10± 0.0e	80.6
100	2.10 ± 0.06f	63.0	0.83 ± 0.03f	85.4	1.67 ± 0.03f	70.5	0.83 ± 0.03f	85.4
EC_{50}	21.32		10.35		13.57		10.0	

[a] Data are expressed as means ± SE from experiments with three replicates of 20 seeds each.
[b] I = inhibition.
[c] Means within a column sharing the same letter are not significantly different at the 0.05 probability level.
[d] EC_{50} = concentration of compound causing 50% root growth inhibition.

3. Effect of sesquiterpenes on shoot growth

The effects of the four sesquiterpenes on the shoot growth of *P. minor*, *P. repens* and *S. marianum* are summarized in Table 3. Compound 3 (EC_{50} = 8.05 µM) showed the highest shoot growth reduction of *P. minor*, followed by compound 1 (EC_{50} = 13.17 µM), whereas compound 4 (EC_{50} = 21.06 µM) was the less effective one. On the other hand, compound 2 caused the highest shoot growth inhibition of *P. repens*, followed by compound 1 and 4 with EC_{50} values of 20.78, 22.74 and 28.79 µM, respectively. In the case of *S. marianum*, compound 4 showed the strongest shoot growth inhibition, whereas compound 1 revealed the lowest growth inhibition. The inhibitory effects of the tested compounds on root and shoot growth of *P. minor* were more potent than those of sesquiterpenes isolated from *Eupatorium adenophorum* (Kundu *et al.* 2013). As was observed in the effect of compounds on root growth, the tested compounds exhibited the strongest shoot growth inhibition on *P. minor*, followed by *P. repens* and *S. marianum*.

The results revealed that the inhibitory effects of the tested compounds on root growth were greater than on shoot growth. These results are consistent with those reported elsewhere for other sesquiterpenes and some plant extracts (Chung and Miller 1995; Turk and Tawaha 2002; Abdelgaleil *et al.* 2009; Saad *et al.* 2012). This finding might be expected, because it is likely that roots are the first to absorb the allelochemical compounds from the media (Turk and Tawaha, 2002). It was also observed that the inhibitory effect of tested sesquiterpenes on root and shoot growth was greater than that on germination. Similarly, Leather and Einhellig (1985) demonstrated that bioassays determining seedling growth are usually more sensitive than those measuring germination.

The modes of action of artemisinin and its analogues on the seedling growth remain unknown. However, several studies were conducted to illustrate the mechanisms of action of these compounds and other sesquiterpene lactones. For examples, Dayan *et al.* (1999) stated that artemisinin and its analogues inhibited cell division and reduced chlorophyll contents of lettuce and rye. Picman (1986) reported that sesquiterpene lactones react with the -SH group of amino acids, proteins, and enzymes.

Table 3: Effect of artemisinin and its analogues on shoot growth of *Phalaris minor*, *Panicum repens* and *Silybum marianum*[a]

Conc (µM)	Artemisinin (1)		Dihydroartemisinin (2)		Artemether (3)		Artesunate (4)	
	Phalaris minor							
	Shoot length (cm)	I (%)[b]	Shoot length (cm)	I (%)	Shoot length (cm)	I (%)	Shoot length (cm)	I (%)
0	4.8± 0.12a[c]	0.0	4.8± 0.12a	0.0	4.8± 0.12a	0.0	4.8± 0.12a	0.0
1	4.43± 0.15a	7.7	4.77± 0.15a	0.6	4.53± 0.26a	5.6	4.53± 0.29a	5.6
5	3.37± 0.27b	29.8	4.0± 0.29b	16.3	4.1± 0.31a	14.6	4.17± 0.17a	13.1
10	2.6± 0.21c	45.8	1.93± 0.23bc	59.8	1.7± 0.21b	64.6	3.13± 0.24b	34.8
50	1.63± 0.17d	66.0	1.53± 0.18c	68.1	0.0 ± 0.0c	100	1.8± 0.12c	62.5
100	0.23± 0.4e	95.2	0.7± 0.06d	85.4	0.0 ± 0.0c	100	0.47± 0.24d	90.2
EC_{50}[d]	13.17		16.35		8.05		21.06	
	Panicum repens							
0	2.1± 0.09a[c]	0.0	2.1± 0.09a	0.0	2.1± 0.09a	0.0	2.1± 0.09a	0.0
1	1.9± 0.09ab	9.5	2.1± 0.03a	0.0	2.0± 0.03a	4.7	2.2± 0.1a	-4.7
5	1.8± 0.09b	14.3	1.8± 0.06b	14.3	1.9± 0.06ab	9.5	2.1± 0.07a	0.0
10	1.7± 0.06b	19.0	1.7± 0.03b	19.0	1.8± 0.0.09b	14.3	2.0± 0.03a	4.7
50	0.6± 0.07c	71.0	0.6± 0.09	71.0	1.1 ± 0.09c	47.6	0.8± 0.0b	61.9
100	0.3 ± 0.06d	85.7	0.0 ± 0.0d	100	0.0 ± 0.0d	100	0.2± 0.03c	90.5
EC_{50}	22.74		20.78		28.79		37.99	
	Silybum marianum							
0	2.23± 0.07a[c]	0.0	2.23± 0.07a	0.0	2.23± 0.07a	0.0	2.23± 0.07a	0.0
1	1.83± 0.03b	17.9	1.93± 0.03b	13.5	1.77± 0.03b	20.6	1.90± 0.06b	14.8
5	1.50± 0.0c	32.7	1.70± 0.06c	23.8	1.70± 0.0b	23.8	1.80± 0.06b	19.3
10	1.37± 0.03c	38.6	1.50± 0.06d	32.7	1.50± 0.06c	32.7	1.60± 0.0c	28.3
50	1.17± 0.07d	47.5	1.13± 0.03e	49.3	1.07 ± 0.03d	52.0	1.07± 0.03d	52.0
100	1.17 ± 0.03d	47.5	0.93 ± 0.03f	58.3	1.03 ± 0.03d	53.8	0.80± 0.06e	64.1
EC_{50}	> 100		50.86		60.63		43.27	

[a] Data are expressed as means ± SE from experiments with three replicates of 20 seeds each.
[b] I = inhibition.
[c] Means within a column for each weed sharing the same letter are not significantly different at the 0.05 probability level.
[d] EC_{50} = concentration of compound causing 50% shoot growth inhibition.

Moreover, parthenin caused damage to the cell membrane, reducing dehydrogenase, protease, and peroxidase activities, and reducing chlorophyll content as well as affecting protein content and respiration of water hyacinth weed and mung bean plant (Batish *et al.* 2002; Pandey 1996). Finally, parthenolide has been shown to inhibit acetolactate synthase, which is a target enzyme for several classes of commercial herbicides (Abdelgaleil *et al.* 2009).

CONCLUSION

From the present study, it could be concluded that artemisinin and its analogues have promising herbicidal activity against *P. minor*, *P. repens*, and *S. marianum*. These compounds are more effective against narrow-leaf weeds than broad-leaf weeds. Moreover, artemether(3) showed stronger herbicidal activity than artemisinin(1) indicating that derivatization and/or structure modification are an important step for obtaining new compounds with interesting herbicidal activity.

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الملخص العربى

تأثير مركب الأرتيميزينين ومشتقاته على إنبات ونمو بادرات ثلاث أنواع من الحشائش

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تم دراسة تأثير أربع مركبات من السسكيوتربينات وهى artemisinin و dihydroartemisinin و artemether وartesunate على إنبات بذور ونمو المجموع الخضرى والجذرى لثلاث من الحشائش الشائعة وهى حشيشة الفلاريس وحشيشة البانيكم وحشيشة الخرشوف البرى. السسكيوتربينات المختبرة أظهرت فاعلية واعدة ضد الحشائش المختبرة. مركب artemether كان أعلى المركبات المختبرة فاعلية حيث سبب تثبيط كامل لإنبات بذور الفلاريس على تركيزات ٥٠ و ١٠٠ ميكرومولار بينما مركب artesunate كان أقل المركبات فاعلية على كل التركيزات المختبرة. بصفة عامة كل المركبات المختبرة كانت أكثر تثبيطاً لإنبات بذور الفلاريس عن البانيكم والخرشوف البرى. مركب dihydroartemisinin كان أعلى المركبات تثبيطاً لإنبات بذور حشيشة الفلاريس وحشيشة الخرشوف البرى. بالإضافة إلى ذلك فإن المركبات المختبرة أظهرت تثبيط قوى لنمو المجموع الجذرى للحشائش. مركب artemether كان أعلى المركبات تثبيطاً لنمو المجموع الجذرى لحشيشة الفلاريس (EC_{50} = 1.20 µM) بينما مركب artesunate كان أعلى المركبات تثبيطاً ضد حشيشتى البانيكم (EC_{50} = 0.39 µM) والخرشوف البرى (EC_{50} = 10.0 µM). بصفة عامة المركبات المختبرة كانت أكثر فاعلية ضد حشيشة الفلاريس عن البانيكم والخرشوف البرى. على الجانب الأخر مركبات artemether و dihydroartemisinin وartesunate أظهرت أعلى تثبيط لنمو المجموع الخضرى لحشيشة الفلاريس وحشيشة البانيكم وحشيشة الخرشوف البرى على الترتيب. بالرغم من أن المركبات المختبرة أظهرت تثبيطاً قوياً لنمو كل من المجموع الجذرى والمجموع الخضرى وكان التثبيط للمجموع الجذرى أعلى من التثبيط للمجموع الخضرى. النتائج المتحصل عليها من هذه الدراسة تشير إلى أن المشتقات artemether وdihydroartemisinin وartesunate أكثر فاعلية على الحشائش المختبرة من مركب الأرتيميزينين artemisinin. هذه النتائج تؤكد أهمية تعديل أو تحوير التركيب الكيميائى لهذه المجموعة من المركبات للحصول على مركبات واعدة فى مكافحة الحشائش.