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Application of plant based extracts for the control the green pit scale insect (*Asterolicanium phoenicis* Rao.) with yield enhancement on date palm

Khalid O. A. M. Eldoush[1], Awad K. Taha[1], Tag Elsir I. M. Idris[2], Omar A. A. Sidahmed[3*], Fakhr Eldeen A. Musa[4] and Hatim G. Mardi[5]

[1]Department of Plant Protection, Faculty of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan; [2]Department of Horticulture, Faculty of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan; [3]Department of Plant Protection, Faculty of Agriculture, Omdurman Islamic University, P.O. Box 382 Omdurman, Sudan; [4]National Research Center, Khartoum, Sudan; [5]ElObeid Research Station, Agricultural Research Corporation, ElObeid, Sudan

Abstract: A field study was carried out at Alghaba Agricultural Scheme, Northern State, Sudan, to investigate the effects of the powder of argel (*Solenostemma argel* Del. Hyne.) and usher (*Calotropis procera* Ait.) on adult females of the green pit scale insect (*Asterolicanium phoenicis* Rao.), in addition to their effects on date palm production. The powder of each plants was applied under three doses (100 g. powder/ tree as a soil dressing, 100 g. powder /10 Liter water/ tree for spraying and 100 g. powder as a soil dressing + 100 g. powder /10 Liter water for spraying/ tree). The synthetic insecticide Actara 25 W.G. Thimethoxam (Neonicotinoid) was used as a standard insecticide. All treatments of the study gave higher percentages of mortality of adult females compared to untreated control up to the 8th week after application. The mortality percentages of adult females ranged between 40 to 66% and 31 to 41% for argel and usher plants based extracts, respectively. According to the results of this study, argel and usher application in soil (100g. powder / tree) should be recommended as an effective treatment to control the green date palm pit scale insect. Also, the results showed that these plant –based extracts have a positive effect on date palm yield.

Key words: *Asterolicanium phoenicis, Solenostemma argel, Calotropis procera,* Sudan, Alghaba.

إستخدام مستخلصات نباتية من الحرجل والعشر لمكافحة الحشرة القشرية الخضراء (*Asterolicanium phoenicis* Rao.)مع رفع إنتاجية نخيل البلح

خالد عثمان علي محمد الدوش[١] وعوض خلف الله طه[١] وتاج السر ابراهيم محمد ادريس[٢] وعمر احمد عبدالله سيداحمد[٣] وفخرالدين عوض موسي[٤] وحاتم جمعه مرضي[5]

[١] قسم وقاية النبات، كلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا، شمبات-السودان; [٢] قسم البساتين، كلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا، شمبات- السودان ; [٣] قسم وقاية المحاصيل، كلية الزراعة، جامعة أمدرمان الإسلامية، أمدرمان- السودان. [٤] المركز القومي للبحوث، الخرطوم- السودان; [٥] محطة بحوث الابيض، هيئة البحوث الزراعية، الأبيض- السودان

ملخص: أجريت دراسة حقلية في مشروع الغابة الزراعي بالولاية الشمالية ، السودان ، لبحث فعالية مسحوق كل من الحرجل (*Solenostemma argel* Del. Hyne.) *والعشر* (*Calotropis procera* Ait.) علي الإناث البالغة للحشرة القشرية الخضراء المدرعة (*Asterolicanium phoenicis Rao.*) , بالاضافة الى تاثيرآتهم على انتاج نخيل البلح. طبق مسحوق كل نبات تحت ثلاث جرعات (١٠٠ جرام مسحوق لكل شجرة كمعاملة تربة، ١٠٠ جرام مسحوق لكل ١٠ لتر ماء للرش لكل شجرة و ١٠٠ جرام مسحوق كمعاملة تربة + ١٠٠ جرام مسحوق لكل ١٠ لتر ماء للرش لكل شجرة). أستخدم المبيد المصنع أكتارا ٢٥ W.G. Thimethoxam (Neonicotinoid) كمبيد قياسي. كل المعاملات في الدراسة أعطت نسب موت عالية للإناث البالغة مقارنة مع الشاهد غير المعامل حتي الإسبوع الثامن بعد المعاملة. تراوحت نسب الموت للإناث البالغه بين ٤٠ الي ٦٦% و٣١ الي ٤١% لمستخلصات نباتي الحرجل والعشر علي التوالي. طبقاً لنتائج هذه الدراسة، يمكن أن يوصي باستخدام الحرجل والعشر في التربة (١٠٠ جرام مسحوق لكل شجرة) كمعاملة فعالة لمكافحة حشرة النخيل القشرية الخضراء المدرعة. ايضاً اظهرت النتائج ان لهذة المستخلصات النباتية تأثير موجب على انتاج نخيل البلح.

*Corresponding Author, *Email*: a.omerahmed@yahoo.com
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Introduction

The date palm tree (*Phoenix dactylefera* L.) is one of the earliest crop plants that had been cultivated for its fruit for at least 5000 years BC. Sudan is ranked number eight among the main date producing countries of the Arab world. It produces about 3% of the total production of the Arab world (Zaid, 2005). The date palm culture in the Northern State suffers from many problems that negatively affect both growth and yield. Among the major problems are the inadequate cultural practices and infestation by pests and diseases (Obeid, 1987).

The date palm green pit scale insect (*Asterolicanium phoenicis* Rao.), was introduced in 1976 to Golid area through illegal importation of one infested off-shoot from Saudi Arabia. Because of lack of natural biological control agents in Sudan, it has become a serious pest to date palms in the Northern State in an area of around 5000 ha, infesting around one million trees in Golid, Dongla and Alghaba areas. The insect attacks the leaflets, leaf rachis and fruits. It causes chlorosis, degeneration of the leaves (Plates 1 and 2) and malformation of fruits (Plates 3) before maturity, leading to losses in production in range of 30-50 kg per palm (Ali et al., 1993; Idris et al., 2006).

Plate 1. Damage of the green pit scale insect on the frond of date palm.

Botanical insecticides have long been proposed as attractive alternatives to synthetic chemical insecticides for pest management because they are reputed to pose little threat to the environment or to human health (Isman, 2005). More than 1000 species of plants have been reported to have chemicals in leaves, stems, flowers, seeds and roots which have insecticidal property, but only a few of them have been used for practical insect control on a commercial scale in the past (Badshah et al., 2004). Argel (*Solenostemma argel* Del. Hyne.) is an erect perennial shrub up to 2 feet high with numerous branches carrying opposite decussate leaves. It is a desert plant, wide spread in Central and Northern parts in Sudan and some neighbouring countries. Usher (*Calotropis procera* Ait.) is a small wild shrub up to 4 m long, with large broad leaves evergreen and grows abundantly in arid and semi-arid regions of the world. These shrubs are commonly used in folk medicine in North Africa. The chemical poisons of these plants are mostly alkaloids. Alkaloids are plant products, which are nitrogenous in nature. They are heterocyclic compounds having strong effects on the nervous system of animals and cause death (Stoll, 2000; Badshah et al., 2004).

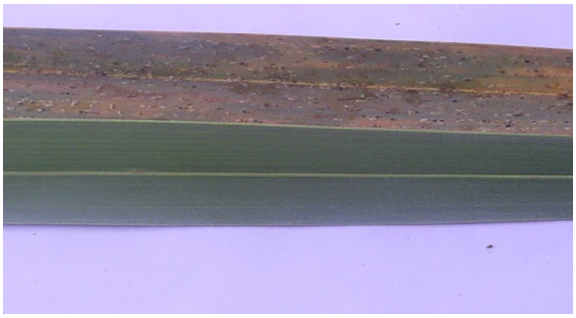

Plate 2. A comparison between ‘’a healthy and a green pit scale insect infested’’ date palm leaflets.

Various researchers e.g., Ali (2004), Badshah et al. (2004), Hag El Tayeb et al. (2009) and Sidahmed et al. (2009) have studied Argel (*S. argel*) and Usher (*C. procera*) extracts for their toxicity against different insect species. Sidahmed et al. (2009) mentioned that, argel shoot aqueous filtrates significantly increased the mortality of adult females of the white scale insect *Parlatoria blanchardii* in the date palm trees. In addition, the study of El-kamali (2001), asserted that, the application of argel shoot aqueous extract against (*Culex* sp.), was more effective as a biocide than the extract of each part alone. The

present study aimed to investigate the effects of argel (*S. argel*) and usher (*C. procera*) against the adult females of the green pit scale insect under natural conditions, in addition to their effect on date palm production.

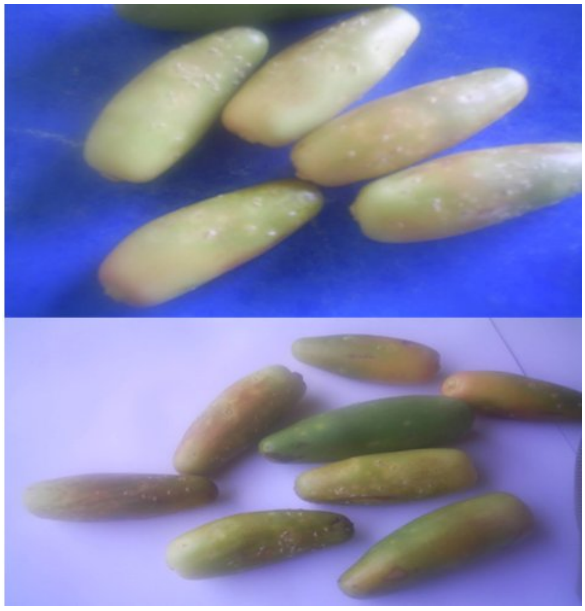

Plate 3. Date palm fruits infested by the green pit scale insect.

Materials and Methods

The field experiments were conducted in two sites, which were Gharb Dongola village and Elkinduwa village (Plate 4) at Alghaba Scheme, Northern State, Sudan. Alghaba Scheme is located between latitude 18°-19° N and longitude 29°38'-30°45' E. The region lies in the desert zone with no rainfall, but the relative humidity was 35% and 15% RH during the applications time. Monthly average for minimum and maximum temperature varied between 8.1-25.1°C and 24.5-42.9°C during January and May, respectively (MST, 2007). Two treatments were applied in each site during the date season of 2007 (e.g. the first in January and second in May). Within each site, 4 rows, each containing 5 date palm trees of similar age (10-15 years), variety Barakawi, were chosen randomly and represented a block. Each date palm tree represented a replicate. Barakawi is considered the dominant commercial cultivar in the state and the most affected by the green pit scale insect. At the scheme, irrigation is applied regularly at two weeks interval. The experiment was laid out in a Completely Randomized Design (Gomez and Gomez, 1984).

Plate 4. The study farm at sites (a) Gharb Dongola and (b) Elkinduwa.

Preparation of plants aqueous filtrates

Dry fresh argel shoot parts were bought from local market. Fresh leaves of Usher plant were collected from the Faculty of Agricultural Studies fields at Shambat, and left to dry for one week at room temperature. All plants were ground by a grinder (Moulinex). The plant aqueous filtrate was prepared from a mixture of the plant powder with tap water, stirred manually for 5-10 minutes and was left for 24 hrs at room conditions. Then the mixture was filtered through a cotton cloth. All spraying extracts were freshly prepared at each time for field application.

Application of treatments

The two treatments were applied in the same manner at the two sites. Three doses of each plant extract: (100g. powder/ tree as a soil dressing, 100g. powder /10 Liter tap water/ tree for spraying and 100g powder as a soil dressing + 100g powder/10 Liter tap water for spraying/tree) were applied. Each plant powder was added to soil 50cm away from trunk base (Plate 5) and then irrigated to insure plant powder solubility. The plants aqueous filtrates

were sprayed early in the morning using a knapsack sprayer (SEMCO 14 P.M. / Japan). The synthetic insecticide Actara 25 W.G. Thimethoxam (Neonicotinoid) was applied according to a recommended dose (20g/palm) as a soil application (Ahmed, 2005). The untreated control palms were sprayed with water only.

Plate 5. ''Soil dressing area'' around tree trunk.

Counts of adult females of the green pit scale insect

Counts of dead adult females were made at fortnightly intervals. From each palm, 2 leaflets were randomly detached from each direction i.e., a total of 8. From these, four leaflets were chosen randomly for data collection. At the laboratory, an area of 1cm² at the base, the middle and the tip of the leaflet was examined under a binocular microscope to calculate the percentage mortality of the adult females infesting the leaflet. Any female was considered dead when the colour of its scale had been changed from green to black or brown. If there was any doubt about the death of any female, its scale can be raised up by a fine pin and by means of an air current, the dead one can be blown out. In case of the living adult, it can be found moving around itself for certain seconds before its mouth parts were released from the leaflet. Pre-spray count was recorded before treatments application.

Treatments yield comparison

After harvest, an average (mean) yield/tree was calculated for each treatment. Two bunches were chosen randomly from each tree and weighted. The mean weight of each bunch (in Kg) was multiplied by the actual number of bunches of each tree, and an average (mean) yield / tree was calculated for each treatment.

Statistical analysis

Data were transformed from percentage to arcsine according to Gomez and Gomez (1984). Data was subjected to analysis of variance. Data analysis was done with the aid of MStatC computer program (version 2.10). Means were separated by Duncan's multiple range test at 0.05% confidence limits.

Results

January Treatment

Gharb Dongola site

The results in Table 1 show that all treatments have increased the mortality of the adult females significantly over the control up to the 12th week. In the 2nd week argel (soil + spray) ranked top over other treatments. Up to the 8th week mostly no significant differences were noticed between treatments. In the 12th week, Actara was the best, although it was not significantly different from two argel treatments. All usher treatments ranked second.

Elkinduwa site

The results in table 2 also showed that all treatments have increased the mortality of the adult females significantly over the control up to the 12th week. In the 2nd week usher spray, usher (soil + spray) and Actara ranked top. From the 4th week up to the 8th week, almost, no significant differences were shown between all treatments. In the 12th week, also all treatments showed higher mortalities over the control, except argel soil treatment which was not significantly different from the control.

Table 1. Mean percent mortality of adult females of the green pit scale insect treated at Gharb Dongola (January treatment).

Treatments	Mortality % in weeks after application					
	Pre count	2nd wk.	4th wk.	6th wk.	8th wk.	12th wk.
Untreated Control	(34.9)36.21bc	(35.7)36.70c	(39.3)38.83b	(40.8)39.72c	(43.2)41.10b	(41)39.80d
Argel soil 100g	(31.9)34.38c	(78.5)62.39b	(84.9)67.11a	(84.1)66.49a	(76.8)61.18a	(52.2)46.25bc
Argel spray 100g	(35.7)36.70abc	(78.7)62.49b	(83.9)66.32a	(82.6)65.36a	(75.0)60.01a	(59.8)50.66ab
Argel soil + spray	(41)39.81ab	(86.5)68.47a	(80.9)64.10a	(83.7)66.22a	(76.5)61.02a	(57.8)49.46ab
Usher soil 100g	(30.6)33.56bc	(85.5)67.62ab	(77.4)61.59a	(82.9)65.57a	(78.5)62.36a	(56.4)48.65b
Usher spray 100g	(39.5)38.94ab	(79.5)63.09b	(79.4)62.98a	(77.9)61.98b	(76.7)61.32a	(56.8)48.93b
Usher soil + spray	(42.3)40.56a	(78.4)62.33b	(78.1)62.10a	(79.6)63.18ab	(74.0)59.32a	(56.7)48.85b
Actara 25WG 20g	(40.9)39.75ab	(82)64.91ab	(83.7)66.22a	(81.7)64.67ab	(76.7)61.15a	(64.0)53.14a
CV%	7.34%	6.03	6.25	4.01	6.57	6.22
LSD	3.565	4.793	4.954	3.199	4.291	3.886
SE±	1.231	1.644	1.718	1.164	1.481	1.342

*Original means are shown within brackets.

*Means were transformed (arcsine transformations).

*Arcsine transformed means were seprated by Duncans multiple range test at alpha = 0 .05

Table 2. Mean percent mortality of adult females of the green pit scale insect treated at Elikinduwa (January treatment).

Treatments	Mortality % in weeks after application					
	Pre count	2nd wk.	4th wk.	6th wk.	8th wk.	12th wk.
Untreated Control	(41.7)40.24a	(35.8)36.75c	(38.7)38.48c	(34.6)36.04c	(42.7)40.79c	(43.2)41.09c
Argel soil 100g	(42.8)40.87a	(77.0)61.32ab	(82.5)65.25a	(82.5)65.24a	(77.4)61.63ab	(50.9)45.54bc
Argel spray 100g	(43.1)41.03a	(74.5)59.65b	(85.7)67.76a	(83.3)65.86a	(79.5)63.08a	(57.2)49.14b
Argel soil + spray	(42.4)40.62a	(74.8)59.88b	(84.0)66.44a	(80.7)63.98ab	(77.5)61.70ab	(67.0)54.97a
Usher soil 100g	(38.7)38.48a	(75.7)60.50b	(75.5)60.33b	(82.7)65.43a	(78.6)62.47a	(57.3)49.21ab
Usher spray 100g	(35.6)36.61ab	(79.6)63.12a	(82.3)65.13a	(80.3)63.63ab	(76.5)61.ab	(57.1)49.07b
Usher soil + spray	(40.9)39.76ab	(82.5)65.25a	(80.4)63.72ab	(76.1)60.76b	(71.7)57.83b	(58.2)49.72ab
Actara 25WG 20g	(33.7)35.50b	(82)64.87a	(85.1)67.29a	(84.2)66.60a	(79.8)63.29a	(55.7)48.27b
CV%	8.38	4.58	4.8	4.33	4.98	9.1
LSD	4.248	4.248	3.845	3.419	3.807	5.705
SE±	1.466	1.466	1.327	1.18	1.314	1.969

*Original means are shown within brackets.

*Means were transformed (arcsine transformations).

*Arcsine transformed means were seprated by Duncans multiple range test at alpha = 0 .05

May Treatment

Gharb Dongola site

The results in table 3 show that most of the treatments have increased the mortality of the adult females significantly over the control up to the 12th week. However, in the 12th week, three of the treatments {e.g. argel soil, usher spray and usher (soil + spray)} lost their efficiency and were not significantly different from the untreated control.

Table 3. Mean percent mortality of adult females of the green pit scale insect treated at Gharb Dongola (May treatment).

Treatments	Mortality % in weeks after application					
	Pre count	2nd wk.	4th wk.	6th wk.	8th wk.	12th wk.
Untreated Control	(37.6)37.79a	(36.7)37.29c	(35.8)36.74b	(39)38.63b	(39.3)38.80	(42.1)40.46c
Argel soil 100g	(38.8)38.53a	(77.9)61.94ab	(81.0)64.17a	(76.0)60.69a	(75.2)60.14b	(42.2)40.53c
Argel spray 100g	(36.7)37.29a	(81.7)64.67a	(80.1)63.48a	(77.6)61.74a	(79.9)63.35ab	(51.5)45.87b
Argel soil + spray	(37.4)37.69a	(75.6)60.37b	(79.1)62.80a	(79.9)63.38a	(76.9)61.26ab	(54.3)47.44b
Usher soil 100g	(39.0)38.63a	(78.1)62.07ab	(83.8)66.28a	(81.6)64.63a	(80.1)63.47ab	(50.2)45.11b
Usher spray 100g	(33.0)35.07a	(73.8)59.20b	(82.8)65.47a	(79.5)63.09a	(82.3)65.14a	(41.8)40.25c
Usher soil + spray	(38.3)38.22a	(78)62.05ab	(78.0)62.01a	(79.7)63.19a	(79.3)62.97ab	(44.9)42.09c
Actara 25WG 20g	(39.2)38.78a	(74.1)59.38b	(79.8)63.30a	(78.1)62.07a	(77.2)61.46ab	(60.1)50.84a
C.V.%	6.65	4.04	4.94	4.77	5.49	5.25
LSD	3.252	3.057	3.8.77	3.689	4.238	2.981
SE±	1.122	1.055	1.338	1.273	1.461	1.029

*Original means are shown within brackets.

*Means were transformed (arcsine transformations).

*Arcsine transformed means were seprated by Duncans multiple range test at alpha = 0 .05

Elkinduwa site

According to results in table 4 all treatments have increased the mortality of the adult females significantly over the control up to the 12th week. In the 12th week all argel treatments and Actara ranked top, while the other treatments ranked intermediate.

Effects of the treatments on Date palm Yield

The efficiency of the plant extracts in controlling the green pit scale insect was also reflected in comparison of date palm yield at the end of the season. An average yield increase of 25% and 20% was shown by trees treated by argel and usher, respectively, compared to the mean yield of untreated trees at the two sites (Table 5).

Table 4. Mean percent mortality of adult females of the green pit scale insects treated at Elikinduwa (May treatment).

Treatments	Mortality % in weeks after application					
	Pre count	2nd wk.	4th wk.	6th wk.	8th wk.	12th wk.
Untreated Control	(33.3)35.25a	(33.8)35.52d	(33.4)35.29c	(37.1)37.55b	(39.5)38.96b	(37.7)37.86c
Argel soil 100g	(33.6)35.40a	(79.9)63.33a	(78.7)62.54ab	(78.8)62.08a	(80.2)63.59a	(55.8)48.34a

Argel spray 100g	(35.4)36.48a	(80.1)63.49a	(78.2)62.20b	(78.4)62.28a	(82.3)65.15a	(54.7)47.70a
Argel soil + spray	(36.5)37.15a	(77.8)61.92ab	(79.8)63.27ab	(81.9)64.79a	(83.5)66.00a	(52.2)46.24a
Usher soil 100g	(35.1)36.34a	(74.7)59.82bc	(77.2)61.49b	(78.2)62.17a	(82.4)65.23a	(47.3)43.47ab
Usher spray 100g	(33.4)35.29a	(73.2)58.82c	(79.2)62.84ab	(78.1)62.07a	(80.7)63.96a	(43.7)41.39bc
Usher soil + spray	(35.2)36.39a	(78.8)62.57ab	(79.4)63.02ab	(79.4)63.02a	(83.1)65.68a	(47.2)43.40ab
Actara 25WG 20g	(37.2)37.55a	(76.0)60.64ab	(82.9)65.57a	(79.6)63.13a	(83.9)66.33a	(54.9)47.81a
CV%	9.93	8.7	3.77	3.97	4.03	8.88
LSD	4.66	2.797	2.904	3.068	3.277	5.125
SE±	1.609	.9655	1.002	1.059	1.114	1.7.69

*Original means are shown within brackets.

*Means were transformed (arcsine transformations).

*Arcsine transformed means were seprated by Duncans multiple range test at alpha = 0 .05

Table 5. The effects of treatments on date palm yield.

Treatments	Mean yield / palm tree/treatment (kg.)	
	Gharb Dongola site	Elkinduwa site
Untreated Control	24.99d	35.25c
Argel soil100g	38.05b	51.47a
Argel spray100g	31.57bcd	54.84a
Argel soil+spray	28.51cd	39.98bc
Usher soil100g	28.56cd	42.18bc
Usher spray100g	29.45cd	40.92bc
Usher soil +spray	47.12a	40.65bc
Actara25WG20g	35.82bc	49.06ab
CV%	16.57	18.88
LSD	7.088	8.563
SE±	2.447	2.956

Means followed by the same letter are not significantly different at the P 5% level of probability by DMRT.

Discussion

In this study, argel and usher were tested for the control of the adult females of the green pit scale insect in comparison to Actara and untreated control twice a year (e.g. in January and May).

In Gharb Dongola, adult females were effectively controlled during the two tests from the second to the 8th week after application by all treatments but on the 12th week the effectiveness declined, while Actara maintained relative control efficiency over the test periods (Tables 1, 3). These results suggest that the effectiveness of botanicals might be limited to 8-10 weeks after application and retreatment thereafter might be advantageous in the control of the green pit scale insect. Also, at Elkinduwa, all treatments made in the two tests showed control efficiency against the adult females up to the 8th week (Tables 2, 4). In the 12th week, although some treatments were still effective, but decline in efficiency was noticed among others, including the standard insecticide Actara. These results also reflect the need for retreatment after the 8-10th week.

The results of the present study showed efficiency of argel extracts as control agent. These are in agreement with Sidahmed et al. (2009) who reported that, Argel shoot aqueous filtrates significantly increased the mortality of adult females of the white scale insect

(*Parlatoria blanchardii*) in the Northern State. Also, Al-Doghairi et al. (2004) mentioned that bioactive effects of methanolic extracts of shoot parts of argel were mainly attributed to the presence of a variety of bioactive organic substances mainly terpenes, pergnine, glycosides, alkaloids and sterols. Usher water extract was also efficient in the present study. Earlier studies by Erdman (1983), Al-Robai et al. (1993), Hussein et al. (1994) and Mohammed (1999) reported the presence of alkaloids, flavonoids, cardiac glycosides as well as sterols and usharin in the entire parts of usher plant (*C. procera*). The effects of these compounds are explained in the studies of Blades and Mitcheell (1986) and Ongilagha et al. (2004), who mentioned that the alkaloids and flavonoids of many plants have a repellent and antifeeding effects against many insect pests. Also, the results of Ahmed et al. (2006) showed that, (*C. procera*) aqueous extract has a repellent and antifeeding effects against the melon lady bird (*Henosepilachana elateri*). Moreover, Hag El Tayeb et al. (2009) confirmed that, the water extracts of argel and usher (1 %) have toxic effects similar to the recommended dose of the synthetic insecticide Temphos against mosquito larvae.

The results of the present study also showed that, the botanical extracts have a positive effect on yield. Comparison of the date yield shown in Table 5 indicated that, at the two sites, both argel and usher treatments showed an average increase in yield over the control of 25% and 20%, respectively. This might be related mostly to their insecticidal effects.

This study suggests that both argel and usher represent efficient botanical alternatives for chemical insecticides. They belong to the same plant family Asclepidiaceae and they grow wild in Sudan. Argel is subject to collection and sold in local markets for about 2.0 SDG / pound (ca.0.8 US.$). According to the results of the present study its cost /palm was estimated to be about 0.5 SDG only. Usher grows wild also and is not collected or sold, and its use would be for no cost. In comparison, the cost of the recommended dose of Actara costs around 12.5 SDG per palm (ca. 5 US $).

In conclusion, it is clear that, the use of the plant materials in pest control could become an important cheap supplement to imported synthetic pesticides. In the present study, the application of argel and usher seems safer and economically feasible. In addition, their effectiveness against the green pit scale insect is almost alike; however, argel seems to be of preference, as it increased yield in most cases compared to usher.

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