Efficacy of *Aloe vera* extract on the growth of *Schefflera arboricola* plants and its resistance to pyriform scale *Protopulvinaria pyriformis* (Cockerell).

Magd el Din F. Rida , Asmaa M. Taha , Naglaa M. Mostafa and Samar E. Hussein
Ornamental Plants Research Department, Horticulture Research Institute, Agriculture Research Center, Alexandria, Egypt.

ABSTRACT

During the seasons of 2021 and 2022, two studies were conducted at Antoniades Research Branch, Horticulture Research Institute, A.R.C. Alexandria. The first study was conducted to investigate the effect of different doses of the extract of *Aloe vera* leaves on the growth of *Schefflera arboricola*. The extract was prepared at six concentrations (0.0, 20, 40, 60, 80, and 100%) and sprayed on schefflera plants. The plants were treated eight times (two-week apart).The results showed that spraying schefflera plants with the *Aloe vera* leaves extract at 60% resulted in the greatest increase in all evaluated vegetative, root development parameters, and chemical analyses, in both experimental seasons. The other study was conducted to evaluate the ability of using the extract of *Aloe vera* leaves at the same proportions to suppress the infestation of the pyriform scale *Protopulvinaria pyriformis* (Cockerell), which infects schefflera plants. Malthion 2ml/L and the extract of *Aloe vera* leaves at the same concentrations were sprayed on the infected plants. The results showed that using of Malathion at 2ml/L resulted in the greatest percentage reduction of pyriform scale, followed by the use of *Aloe vera* extract at 100%.

Keywords: *Aloe vera* extract - *Schefflera arboricola*. - Pyriform scale.

INTRODUCTION

Schefflera arboricola belongs to the Araliaceae family. Its common name is umbrella tree. It is native to Southeast Asia. It forms a slender tree shape, the upright stem bearing finger-like leaves with eight or so 10-15 cm long oval leaflets borne in a circle on leafstalks up to 15 cm long. The leaflets near the top of the circle are usually smaller than those at the base. It can grow to about 1.8 meters tall. It is used as an indoor plant (Jane and Graham, 1997).

Aloes are succulent perennial plants. They belong to the Liliaceae family. The genus Aloe contains about 400 species, of which *Aloe vera* (L.) is the best known. (Barišić et al., 2014). The plant's stem is quite short. It can reach a height of 80-100 cm. Its leaves have a lanceolate shape and are densely covered with spines. The leaves have a thick fleshy appearance. The color of the leaves is green to greyish green, there is a gel in the middle of the leaf tissue. (Kumar et al., 2010).

Aloe vera leaf extract (AVLE) contains many essential amino acids such as methionine, threonine, phenylalanine, isoleucine, leucine, lysine, valine, tryptophan, and non-essential amino acids such as alanine, arginine, asparagine, cysteine, glutamic acid, glycine, histidine, proline, serine, tyrosine, glutamine, and aspartic acid. The extract contains monosaccharides (glucose, cellulose, mannose, and aldopentose), lignin, macronutrients (N, P, K), secondary nutrients (Ca, Mg), and trace elements (Zn, Fe, Mn, Cu) and vitamins (C, B1, B2, B6, niacin, choline, enzymes, inositol, aloin, isobarbaloin, aloe emodin, natural hormones (auxins, gibberellin, and salicylic acid) as reported by Amit and Shweta (2016) and Hamouda et al. (2014).

The pyriform or heart-shaped scale *Protopulvinaria pyriformis* (Cockerell)

(Hemiptera: Coccidae) **Fig. (1)** is found throughout the Palearctic region, equatorial and subequatorial Africa, the Middle East region, North and South America. (Ben-Dov, 1993). A variety of fruit trees and ornamental plants infested with pyriform scale have been discovered in the areas where it has been documented. In recent years, studies have shown that it has entered new areas, as it has been recorded on the laurel plant in Malta (Mifsud and Procelli, 2011) and on the shrub *Schefflera* sp. (Family: Araliaceae) in Egypt (Karam, 2013). As a result of excessive honeydew production by the pyriform scale, the host plant becomes covered with sooty mould. Affected leaves wilt and drop, slowing plant growth. Significant economic impact can result from sap withdrawal, host deterioration, honeydew production, and sooty mould. (Gill 1988 and Diaz et al., 2005).

Fig.(1). *Schefflera arboricola* leaves infected by pyriform scale *Protopulvinaria pyriformis.*

Artificial insecticides are harmful to the environment (Silva et al., 2005; Campiche et al., 2006 and Rocha et al., 2006). Plant extracts are advantageous, effective, and safe alternative pest control strategy as they have lower stability and toxicity than synthetic insecticides (Silva et al., 2005; Campiche et al., 2006 and Rocha et al., 2006). These natural insecticides, such as *Aloe vera* extract (Marzanna et al., 2019) contains terpenoids, components which protect plants by inducing a variety of consequences in insects, such as behavioral and physiological responses (Tedeschi et al., 2001).

The aim of this study was to see how different doses of the extract of Aloe vera leaves affect the development of Schefflera arboricola as well as the control of the pyriform scale Protopulvinaria pyriformis (Cockerell), which attacks its leaves.

MATERIALS AND METHODS

Two studies were carried out at the Antoniades Research Branch of the Horticulture Research Institute in Alexandria, A.R.C. during two consecutive seasons in 2021 and 2022.

The first study: Effect of the extract of *Aloe vera* leaves (AVLE) on the growth of *Schefflera arboricola* plants

On the 27th of March 2021(first season) and the 3rd of April 2022 (second season), homogenous one-year old plants of *Schefflera arboricola* with an average of nine leaves were transplanted into plastic pots (16 cm diameter) filled with a mixture of sand and clay (1:1, v/v). The first season started on March 30, 2021, while the second season

started on April 6, 2022. Six different concentrations of AVLE were prepared and sprayed on the plant leaves using a hand-sprayer until run off point. The spraying was done biweekly eight times .The study was terminated on the 30th and 6th August 2022, in the first and second seasons, respectively.

Preparation the extract of *Aloe vera* leaves (AVLE):

A simple method was chosen to prepare, as two kilograms of fresh leaves were washed under running tap water. The weighted leaves were cut with a clean knife and placed in a plastic basin containing 4 liters of water for 72 hours in a refrigerator at 7ºC. At the end of the 72 hours the soaked leaves were crushed and mixed with the soaking water in a blender. The obtained mixture was filtered through a piece of regular 2 mm sieve and it was considered as 100% AVLE. This extract was diluted by tap water to 20 %, 40 %, 60 % and 80%. (Wilson, 2020).

Determination of plant hormone content in *Aloe vera* leaf extract.

It was carried out at the Alexandria University Institute of Graduate Studies and Research's Central Laboratory by using High Pressure Liquid Chromatographic analysis (HPLC). Gibberellic acid (GA_3) was measured using the technique described by (Bhalla et al., 2010), while indole acetic acid (IAA) and indole butyric acid (IBA) contents were determined using the method described by (Sheikian and Bina, 2016).

During the two seasons, the following data were gathered.

Plant growth characteristics

Plant height (cm), number of leaves, leaf fresh and dry weights (g), leaves area (cm^2) by the method of Mahmoud (2013), stem dry weight (g), stem diameter (mm), root volume (cm^3) and root dry weight (g).

Chemical analysis:

Chlorophyll a and b contents (mg/100 g FW) were done by the method of Moran (1982) and carotenoid contents (mg/100 g FW) was estimated according to Wellburn (1994) while the total carbohydrate content (DW %) was determined by the method of Dubios et al. (1956).

Statistical analysis

The experimental design was a completely randomized design (CRD), consists of six treatments with three replicates each, and each treatment had four plants. The means of the different variables were compared using the "Least Significant Difference (L.S.D.)" test at 5% level of probability. (Snedecor and Cochran, 1989).

The second study: The ability of using the extract of *Aloe vera* leaves (AVLE) at the same concentrations to suppress the infestation of pyriform scale *Protopulvinaria pyriformis* (Cockerell) on *Schefflera arboricola* plants.

The extract *of Aloe vera* leaves was prepared by the same way in the first study.

Field experiment

Field trials were carried out on the 26th of Sept. 2021 and the 25th of Sept. 2022 in the gardens of Antoniades. Three insect infested plants were selected for each treatment. Six concentrations of AVLE (0.0, 20, 40, 60, 80, and 100%) were prepared in addition to Malthion 2ml/L (recommended dose). The concentrations were sprayed on the plant leaves with a hand sprayer until the leaves were saturated.

Data collection

Ten randomly treated *Schefflera arboricola* leaves per replicate were selected, placed in paper bags and transferred to the laboratory. The leaves were examined by counting live and dead individuals on both leaf surfaces using an 8x magnifying glass. Pre- and post-treatment inspections were performed after 1, 2, and 3 days. (Mesbah et al., 2009).

Reduction percentage of scale insect

The population was used to evaluate the tested materials. It was calculated using the equation of Henderson and Tilton (1955):

Reduction percentage = 1- (No. in control before treatment x No. in treated after treatment)/No. in control after treatment x N. in treated before treatment)

Data from treated plant sources were compared with control plots.

RESULTS

Plant hormones contents in *Aloe vera* leaf extract (AVLE).

The linearity of the assay technique was studied for the measurement of GA_3 in the concentration ranges of 100, 500, 1000, and 5000 g/ml, and the curve was linear over these concentrations and showed a linear regression (R_2 = 0.9998) and a slope of 52.862 Fig.(2).

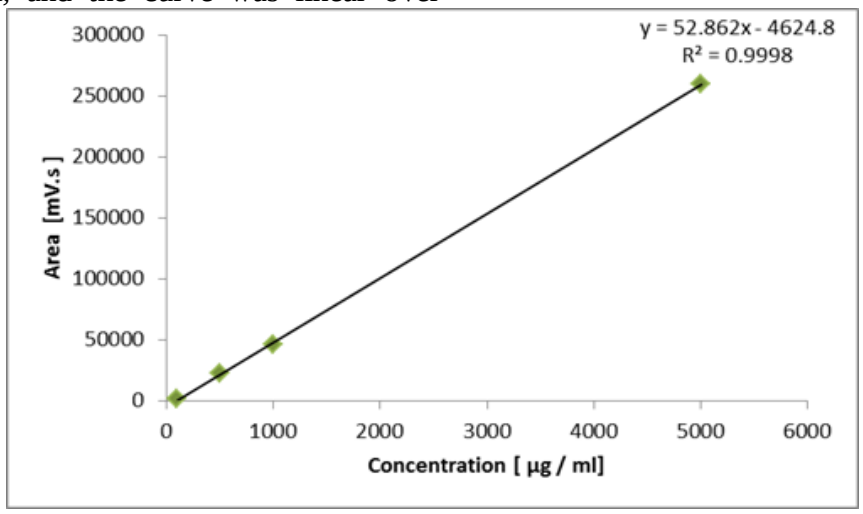

Fig. (2). Regression for concentrations versus area of gibberellic acid (GA_3) standard.

The peak area of GA_3 at 500 µg/ml standard preparation appeared at a retention time of 2.97 minutes and recorded 22602.9 mV.s **(Fig.3)** and the peak area of the prepared sample injected into the chromatograph appeared at a retention time of 2.85 minutes and recorded 22477.96 mV.s **Fig.(4).**

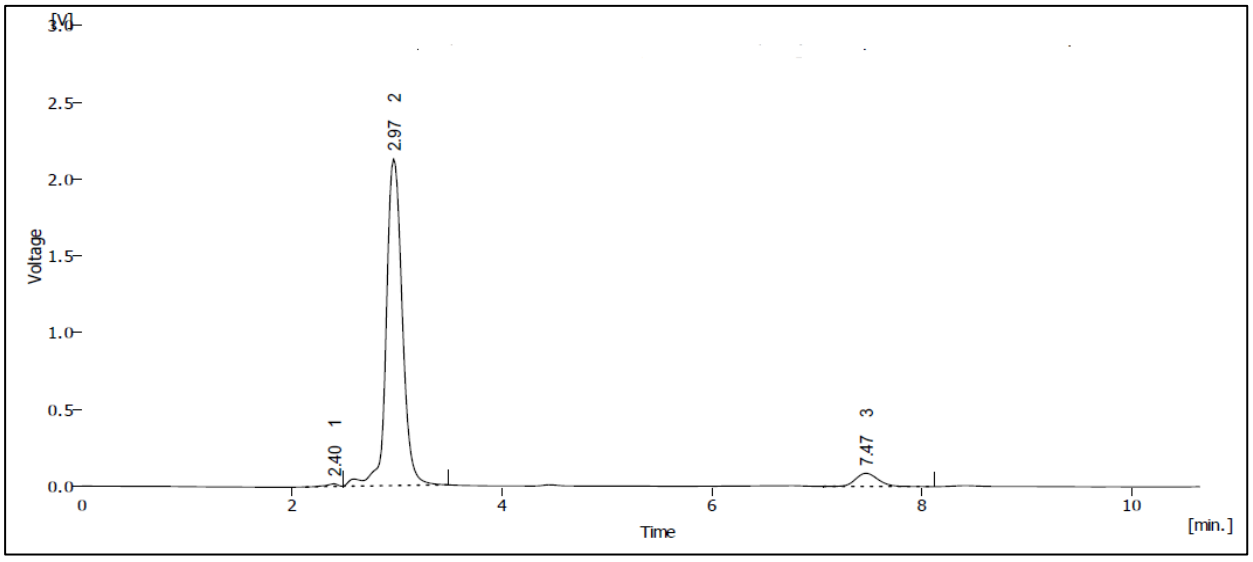

Fig. (3). The chromatogram of gibberellic acid (GA_3) at 500 µg/ml

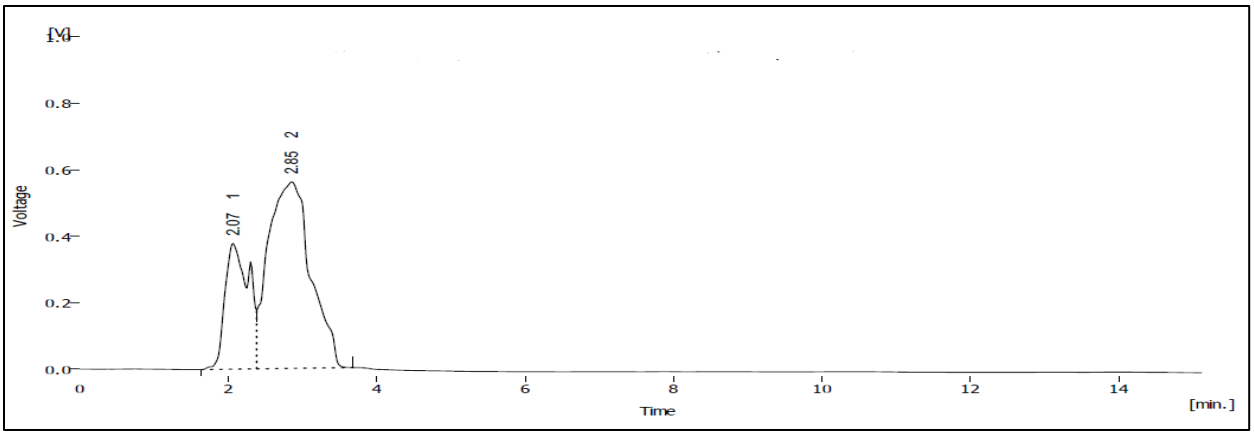

Fig. (4). The chromatogram of AVLE sample

The linearity of the IBA test method was determined in the range of 10, 50, 100, 500 and 1000 µg/ml and the curve was linear over these concentrations and showed a linear regression (R^2 = 0.9999) and a slope of 52.979 **Fig. (5).**

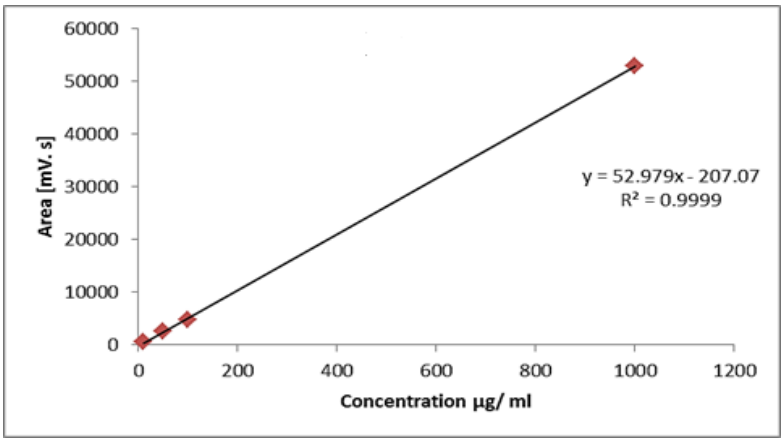

Fig. (5). Regression for concentrations versus area of indole butyric acid (IBA) standard

The linearity of the IAA assay was determined in the range of 5.10, 50,100, 500, and 1000 *µg/ml* and the curve was linear over these concentrations and showed a linear regression (R^2 = 0.9874) and a slope of 43.701 **Fig. (6).**

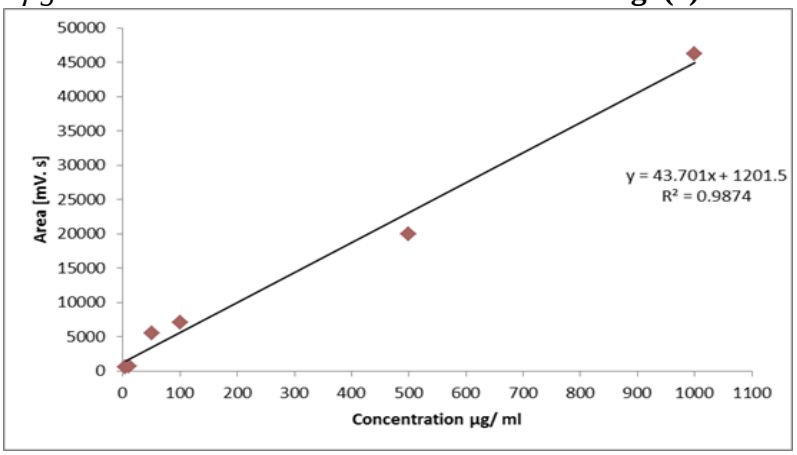

Fig. (6). Regression for concentrations versus area of standard indole acetic acid (IAA)

The peak area of IBA at 10 *µg/ml* standard preparation appeared at retention time of 24.22 minutes and recorded 523.131 mV.s. **(Fig. 7)** while the peak area in the prepared sample injected into the chromatograph appeared at retention time 22.65 minutes recorded 542.452 mV.s **(Fig. 9).**

The peak area of IAA at 5 µg/ml standard preparation appeared at retention time of 5.11 minutes and recorded 585.361 mV.s. **(Fig. 8)** while the peak area in the prepared sample injected into the chromatograph appeared at retention time of 5.527 min.recorded 438.41 mV.s **(Fig. 9).**

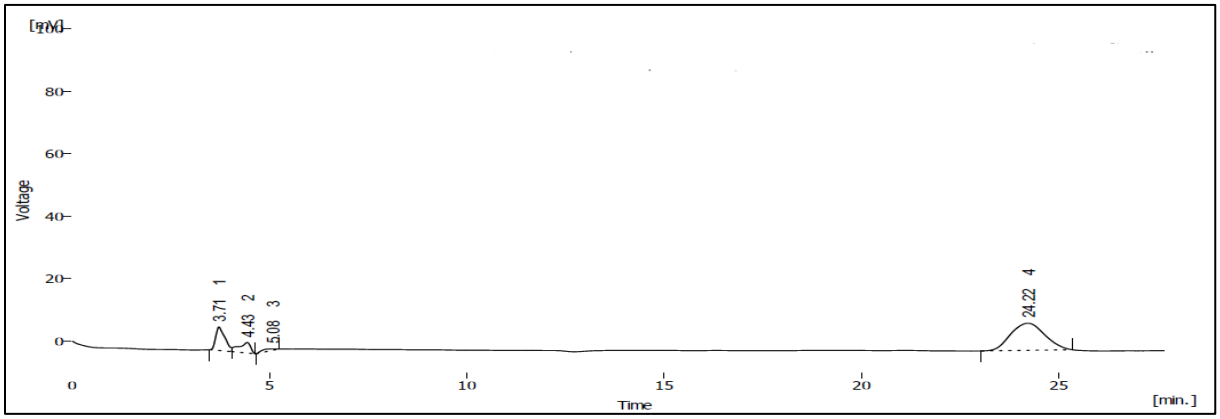

Fig. (7). The chromatogram of indole butyric acid (IBA) at 10 µg/ml

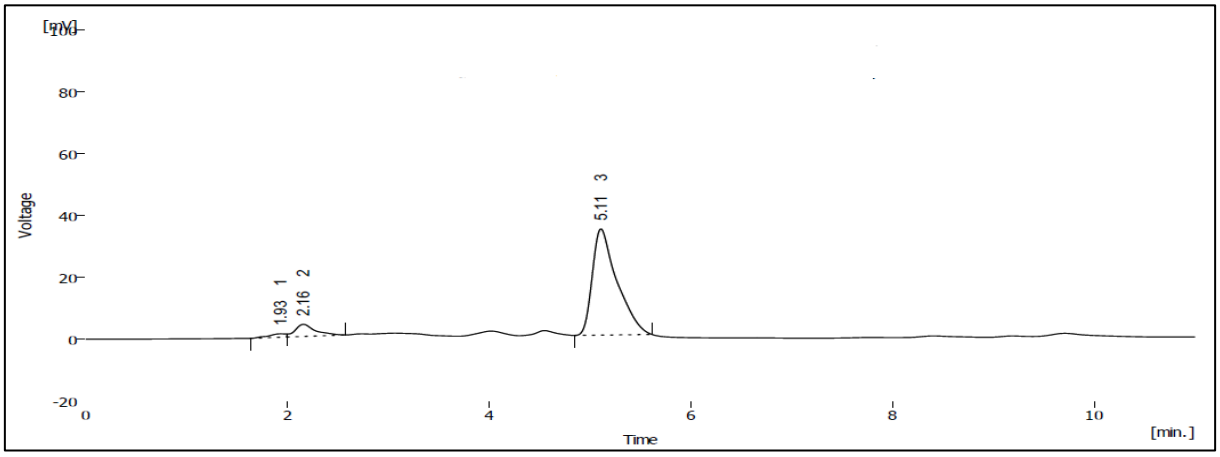

Fig. (8). The chromatogram of indole acetic acid (IAA) at 5 µg/ml

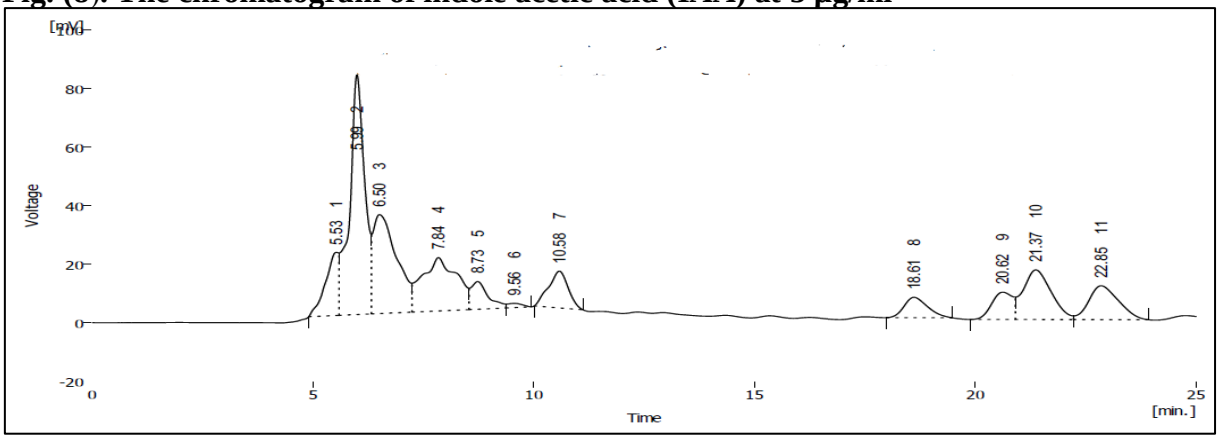

Fig. (9).The chromatogram of AVLE sample

The amount of plant hormones content was calculated and recorded in **Table (1).**

Table (1). The amount of plant hormones (GA_3, IAA, and IBA) in AVLE

Plant hormones	Amount (µg/ml)
GA_3	512.71
IAA	9.92
IBA	14.14

The first study: Effect of the extract of *Aloe vera* leaves (AVLE) on the growth of *Schefflera arboricola* plants

Vegetative growth characteristics:

Table (2), clarified that spraying AVLE at different doses on schefflera plants significantly affected the plant height, number of leaves, fresh and dry weight of leaves in both seasons.

Furthermore, **Table (2)** showed that the highest significant increase in leaf number in the season of 2021 was obtained after foliar application of AVLE at 60% while spraying the AVLE at 60% or 80% resulted in the highest significant increase in leaf number in the season of 2022 at the same level of significance.

Moreover, **Table (2)** showed that the greatest significant increase in fresh weight of leaves was achieved after application of AVLE at 60% in the season of 2021 and at 60% or 40% in the season of 2022. The greatest significant increase in dry weight of the leaves was recorded after spraying AVLE at 60% in the season of 2021 and 40%, 60%, and 80% in the season of 2022.

Table (2). Mean of plant height (cm), leaves number, fresh and dry weights of leaves (g) of *Schefflera arboricola* plant after foliar application of AVLE at different concentrations.

Treatment of AVLE	Plant height (cm)		Leaves number		Leaves fresh weight (g)		Leaves dry weight (g)	
	2021	2022	2021	2022	2021	2022	2021	2022
Control	35.97	36.53	13.39	13.92	40.99	42.29	8.49	8.74
20%	41.86	41.00	14.78	14.78	48.59	49.46	10.32	10.42
40%	42.47	43.06	14.89	15.17	52.44	54.67	10.71	11.03
60%	45.67	44.99	18.06	17.72	59.98	59.44	12.31	12.12
80%	41.72	40.86	16.31	16.81	49.01	52.74	10.51	11.05
100%	38.26	37.57	13.11	13.64	46.04	47.16	10.21	10.15
L.S.D at 0.05	**4.09**	**3.45**	**1.67**	**1.52**	**5.36**	**6.67**	**1.45**	**1.55**

According to **Table (3)** in the two studied seasons, there were substantial changes in leaf area, stem diameter, and stem dry weight after foliar spraying of AVLE at different doses.

The maximum significant increase in leaf area was obtained after applying AVLE at 60% in the season of 2021 and 40%, 60%, and 80% in the season of 2022 at the same level of significant. Also, **Table (3)** showed that using AVLE at 60% or 40% resulted in the maximum significant increase in stem diameter, with no significant variation between them in the seasons 2021 and 2022. The greatest significant increase in the dry weight of the stem was recorded after applying the extract of *Aloe vera* leaves at 60% in the season of 2021, while in the season of 2022 it was obtained after applying of the extract of *Aloe vera* leaves at the concentration of 20%, 40%, and 60% at the same level of significant.

Table (3). Mean of leaves area (cm^2), stem diameter (mm), and stem dry weight (g) of *Schefflera arboricola* after foliar application AVLE of at different concentrations.

Treatments of **AVLE**	**Total leaves area (cm^2)**		**Stem diameter (mm)**		**Stem dry weight (g)**	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**
Control	993.21	1023.83	7.61	7.76	2.42	2.66
20%	1165.00	1193.35	8.54	8.63	3.79	3.96
40%	1277.22	1352.02	8.86	8.91	3.55	3.71
60%	1453.58	1430.52	9.24	9.19	4.67	4.55
80%	1233.44	1313.73	8.41	8.67	2.98	3.29
100%	1097.11	1108.37	8.42	8.53	3.11	3.31
L.S.D at 0.05	**152.28**	**171.34**	**0.58**	**0.43**	**0.85**	**0.87**

Root growth parameters:

Table (4) revealed that the maximum significant increase in root volume was recorded after spraying AVLE at 20, 40, 60, or 80% at the same level of significant in both experimental seasons. Moreover, Table (4) showed that the maximum significant increase in root dry weight was observed after foliar spraying of AVLE at the concentration of 20, 40, or 60%, with no significant variation between them in the two studied seasons.

Table (4). Mean of roots volume (cm^3) and roots dry weight (g) of *Schefflera arboricola* plants after foliar application of AVLE at different concentrations.

Treatment of **AVLE**	**Roots volume (cm^3)**		**Roots dry weight (g)**	
	2021	**2022**	**2021**	**2022**
Control	18.89	19.31	4.03	4.23
20%	37.50	33.75	7.28	6.92
40%	34.17	32.22	6.19	6.06
60%	33.33	31.39	6.08	6.20
80%	31.39	31.11	5.28	5.42
100%	28.06	25.83	5.31	5.30
L.S.D at 0.05	7.77	5.54	1.28	1.18

Chemical analysis:

Table (5) showed that there is a significant difference in chlorophyll a (chl-a), chlorophyll b (chl- b), and carotenoid contents, and the maximum substantial values were recorded after foliar treatment of the AVLE at 40, 60, or 80%, with no significant differences among them, in the two experimental seasons.

Table (5) also showed that the maximum significant increase in carbohydrate content was seen after foliar application of AVLE at 20, 40, or 60%, with no significant difference among them in the two seasons.

Table (5). Mean of chlorophylls (a & b), carotenoids and total carbohydrate contents of *Schefflera arboricola* plants after foliar application of AVLE at different concentrations.

Treatments Of (AVLE)	**Chlorophyll a (mg/100g)**		**Chlorophyll b (mg/100g)**		**Carotenoids (mg/100g)**		**Total carbohydrates (D.W. %)**	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Control	18.51	18.74	6.68	6.83	11.46	11.85	16.72	16.45
20%	22.26	22.33	8.36	8.52	14.41	14.26	18.29	20.02
40%	29.59	28.36	11.15	10.45	17.35	16.59	18.26	23.74
60%	32.79	32.72	11.52	11.55	19.30	19.39	23.63	23.98
80%	28.08	27.56	9.55	9.45	16.61	16.37	13.13	12.41
100%	22.02	21.56	7.50	7.25	13.78	13.44	12.08	11.77
L.S.D at 0.05	**7.47**	**7.08**	**3.00**	**3.12**	**3.88**	**3.81**	**6.68**	**7.45**

The second study: The ability of using extract of *Aloe vera* leaves (AVLE) at the same concentrations to suppress the infestation of pyriform scale *Protopulvinaria pyriformis* (Cockerell), on *Schefflera arboricola* plants.

Fig. (10). illustrated that the percentage reduction of pyriform scale *Protopulvinaria pyriformis* insects differed among the studied treatments (Malthion and different doses of AVLE**).** The use of Malthion at 2ml/L resulted in the greatest reduction percentage (95.37%) in the season of 2021 and (95.83%) in the season of 2022, followed by using AVLE at 100% which recorded (68.6%) and (71.47%) in the first and second seasons, respectively. Moreover, the same figure showed that the reduction percentage decreased by decreasing the concentration of AVLE. This decrease was observed in both seasons. The results showed that AVLE can be used as an alternative bio-insecticide. The ability to use this extract is improved by increasing its concentration.

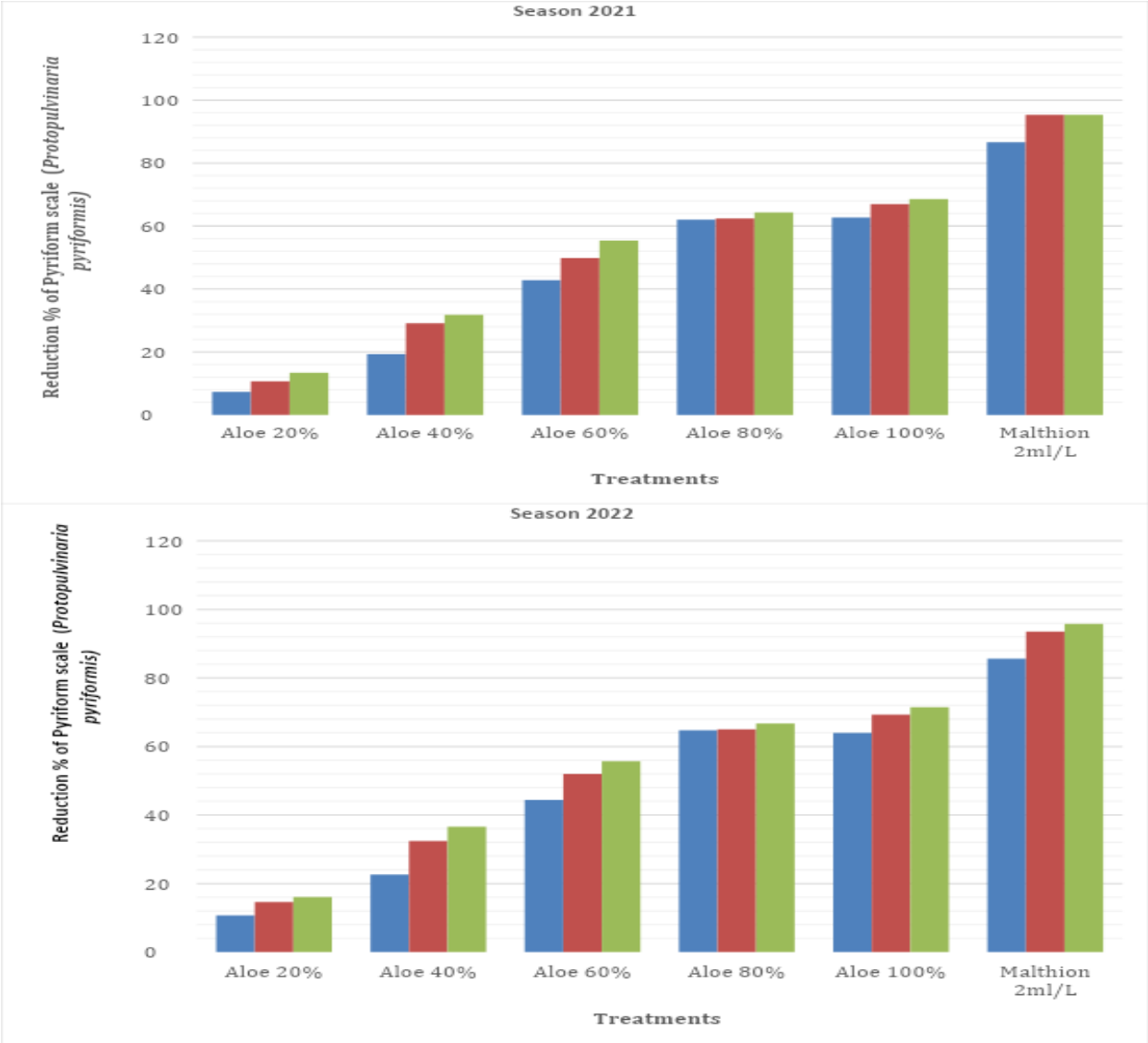

Fig. (10). Reduction percentage of pyriform scale after treatment with different concentrations of AVLE and Malathion (2m/L) in the 2021 and 2022 seasons.

DISCUSSION

In the first study, concerning the effect of the extract of *Aloe vera* leaves (AVLE) on the growth of schefflera plants the highest increase in all studied vegetative growth, root development parameters, and chemical analyses was found after spraying schefflera leaves with the extract at 60% in both seasons. The presence of active constituents in *Aloe vera* leaves extract, such as tryptophan, which is involved in the formation of auxin, which promotes plant elongation as well as gibberellin **(Table 1)**, which stimulates cell division, leading to an improvement in the formation of leaves, leaf weight, and leaf area (Hamouda et al., 2014), can explain the increase in vegetative growth parameters. Furthermore, the beneficial effects of the extract on vegetative growth characteristics may be related to the other organic components in this extract such as minerals, amino acids, and vitamins (Rajeswari et al., 2012; Sahu et al., 2013 and Sheikh et al., 2013).These findings are consistent with those of Mady (2008) and Hamouda et al. (2012). The increase in root growth parameters may be related to the extract of *Aloe vera* leaves which affects the growth of plant tissues by increasing cell membrane permeability, oxygen uptake, respiration, photosynthesis, root and cell elongation, and ion transport, which affect plant growth (Dongzhi et al., 2004; Padmaja et al., 2007 and El-Shayeb, 2009). Furthermore, the inclusion of IAA, IBA (Table 1), and ABA in the composition of Aloe vera extract, as noted by El Sherif (2017), as well as several amino acids and vitamins (Hamman, 2008), could explain its ability to promote root developmental traits. The observed increase in chlorophyll concentration after application of the extract may be due to the presence of Mg, trace elements (Fe) in the extract, which are involved in the composition of the chlorophyll pigment structure, according to Amit and Shweta (2016).

The results of the second study regarding the ability of using *Aloe vera* leaves extract (AVLE) to suppress pyriform scale infestation revealed that spraying the extract at 100 % on Schefflera leaves infested with pyriform scale resulted in reduction in the percentage of scale. The presence of active components such as saponins, phenolic compounds, enzymes such as catalase, lipase, and others in the extract may explain these results (Joseph and Raj, 2010 and Park and Jo, 2006). According to Chaieb (2010), saponins act on insects by interfering with the process of ecdysone synthesis through their interaction with cholesterol, which is involved in the production of the ecdysteriod hormone, thus blocking its production, as well as having a cytotoxic effect on the cells.

Recommendations

From the previous results, it could be recommended to spray schefflera plants *with* 60% *Aloe vera* extract eight times (at two weeks interval) during the spring growing season to improve its growth. This treatment resulted in the greatest increase in plant height and number of leaves. In addition, 100 % *Aloe vera* extract can be used as a bio insect agent to control the pyriform scale which attacks schefflera plants in late summer and early autumn, as this treatment increased its reduction rate.

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الملخص العربي

مدى فاعلية مستخلص نبات الصبارعلى نمو نباتات الشفليرا ومقاومتها للإصابة بالحشرة القشرية الرخوة الكمثرية

مجد الدين فؤاد رضا ، اسماء محمد طه ، نجلاء محمد مصطفى ، سمرالسيد حسين

قسم بحوث الزينة وتنسيق الحدائق- معهد بحوث البساتين- -مركز البحوث الزراعية الأسكندرية -جمهورية مصر العربية

تم إجراء تجربتين خلال عامي 2021 و2022 في فرع بحوث أنطونيادس، معهد بحوث البساتين مركز البحوث الزراعية بالأسكندرية.

التجربة الأولى: دراسة تأثير تركيزات مختلفة من مستخلص نبات الصبارالبلدي على نمو نبات الشفليرا . تم إعداد ستة تركيزات من مستخلص الصبار (صفر ، 20، 40، 60، 80 و100 %) وتم رشها على الأوراق ثمانية مرات (رشه كل أسبوعين). أظهرت النتائج أن أعلى زيادة في الصفات المدروسة (الصفات الخضرية، صفات الجذور والتركيب الكيماوي) وتم الحصول عليها بعد رش أوراق نبات الشفليرا بمستخلص الصبار بتركيز 60 % في كلا الموسمين.

التجربة الثانية: أجريت دراسة إمكانية إستخدام مستخلص نبات الصبار بنفس التركيزات السابقة لمكافحة الحشرة القشرية الرخوة الكمثرية التي تهاجم نباتات الشفليرا. تم رش المستخلص بنفس التركيزات السابقة بالإضافة إلى إستخدام ملاثيون 2 ملي /لتر على نباتات مصابة بالحشرة . أظهرت النتائج أن أعلى نقص في أعداد الحشرة تم الحصول عليه من إستخدام الملاثيون 2 ملي/لتر يليه رش مستخلص الصبار بتركيز 100 %.