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Modeling the Use of Medicinal Plant Extracts and Oils for Weed Control: Allelopathic Effects on Water Hyacinth (*Eichhornia crassipes*)

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THE EXPERIMENTS were conducted in pots and artificial canals under wire-house conditions, Agricultural Research Center (ARC), Egypt, during 2022 - 2024. To study the potential effects of aqueous sweet basil extracts, aromatic oils such as camphor and basil oils, and white vinegar 6% on water hyacinth (*Eichhornia crassipes*). The results mentioned that using crude sweet basil extract at the concentrations (2- 8%), and camphor oil at rates (400-1600 cm^3 fed^{-1}%) significantly reduced key growth traits of water hyacinth. Crude sweet basil extract at rates (1 and 2 l fed^{-1}), basil and camphor oil at concentrations (100 and 200 cm^3 fed^{-1}), as well as white vinegar at rates 6 and 12 l fed^{-1} were significantly decreased water hyacinth traits, compared to untreated control. Crude extract of sweet basil (2 +2 l fed^{-1}), white vinegar 200 + 200 l fed^{-1}, camphor and basil oils 200 + 200 cm^3 fed^{-1} caused a significant reduction in growth traits of water hyacinth. Nano-emulsion of sweet basil extract (2 + 2 l fed^{-1}), camphor and basil oils (200 + 200 cm^3 fed^{-1}), and 99% acetic acid (3 + 3 l fed^{-1}) resulted in over 55% mortality of water hyacinth plants within 21 days. In conclusion, this study recommends the use of nano-emulsions of sweet basil extract (90% SL), camphor and basil oils 10% SL as well as acetic acid 99% as a bio-herbicide for water hyacinth control in small irrigation and drainage canals.

Keywords: Nano emulsion, water hyacinth control, sweet basil extract, camphor and basil oil, acetic acid and white vinegar.

Introduction

Water hyacinth (*Eichhornia crassipes*) recorded in Egypt in the 1870s, monocotyledon member, family (*Pontederiaceae)*, perennial weeds, Williams (2017). Egyptian Government, Ministry of Irrigation and Water Resources recorded that the evapotranspiration by aquatic weeds about 40% loss of Egypt's share of water annually, Kassas (1980) and Goldsmith and Hildyard (1984).

Mechanical control of water hyacinth is widely used and environmentally friendly, but it is extremely costly, amounting to millions of Egyptian pounds annually.In Egypt, herbicides applications facing very harsh legislation because of the potential risks involved due to the problems, which associated with herbicides and the objections to using them on water, there is a new developing interest regarding natural product-based herbicides, Wells and Clayton (2005) and El-Shahawy (2015). Chemicals and natural compounds, as acetic acid, citric acid, formic acid, and propionic acid can be using for the control of water hyacinth. The efficacy increased with the increase concentration of natural compounds from 10, 15, and 20%. Formic and propionic acids caused died of water hyacinth plant earlier than the other acids or the herbicide glyphosate. Acetic acid came after formic and propionic acids in terms of efficacy, El-Shahawy (2015). Essential oils extraction from aromatic plants, they contains a variety of volatile molecules such as terpenes and terpenoids, phenols- and aliphatic components have prooxidant effects on the cellular level, (Bakkali *et al.*, 2008 and Mekky *et al.*, 2019). Essential oil of *Xanthium strumarium* L. leaves were sesquiterpenoids represented the major constituents (72.4%), including oxygenated (61.78%) and non-oxygenated (10.62%) sesquiterpenes, followed by monoterpenes (25.19%), exhibited significant allelopathic potential regarding the germination and growth of the noxious weed, Abd El-Gawad *et al* (2019). Essential oil compounds Juniper camphor (24.7%), sinensal (7.7%), 6-epi-shyobunol (6.6%), zingiberene (5.8%), bisabolol (5.3%), and T-muurolol (4.7%) were a significant allelopathic activity management of weeds is recommended for the characterization of the pure major compounds, particularly juniper camphor, (Assaeed *et al.*, 2020). Allelopathic potential of Parthenium

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(*Parthenium hysterophorus* L.) has toxic and phytotoxic of phenolic and terpenoids, which have inhibitory activity of water hyacinth. P-hydroxybenzoic acid appeared to be of potential at 100 ppm. Major sesquiterpene lactone parthenin is other allelochemical, which has been shown to be a potential herbicidal for water hyacinth at 100 ppm, Kathiresan (2013) and Pandey (2015). The use of a mixture of fatty alcoholsoctanol and decanolas the plant growth regulator and inhibited the growth and killed the terminal meristems of a wide variety of plants, USDA, Agricultural Marketing Service (2016).

Nanoemulsions of basil oil have antimicrobial and immune-stimulant effect in the cultured fish. Nanoemulsion basil oil has inhibitory effect on bacterial at lower concentration than Pure basil oil with save for *Oreochr omisniloticus* and increased immunity in fish, El-Ekiaby (2019). Emulsions are used to stabilize and increase the efficacy of oils in aqueous solutions, when this emulsion system tends to reach Nano metric size, Echeverría and Albuquerque (2019). *Ocimum basilicum* having official acceptance medicines product, and the extract of *Ocimum basilicum* formulated exhibited good physical properties and commercial product marked improvement, Khan *et al* (2020). Many formulations as Nanoemulsions have been used for pest toxicity target. Nanoemulsion of camphor oil is the most effective material than the camphor essential oil, Marouf *et al* (2021).

Improve oral bioavailability of hydrophobic drugs like black seed oil with formulate them into self – Nanoemulsifying drug delivery system (SNEDDS). The best formulation of SNEDDS obtained from tween 80 as surfactant and PEGS 400 as co-surfactant (2:1) with ratio of oil and mix surfactant-co-surfactant 1:8,hasa good physical characteristic and stability, (Priani *et al.*, 2022). Hydrocinnamic acid occurs naturally in the rhizosphere and regulatory roles in plant–plant and plant–microbe communities and the herbicides activity for weed control, (Robles *et al.*,2022).

The aim of this study is prepared formulation from neutrals plant extracts which have an herbicide effect such as aqueous sweet basil extract, camphor and basil oils, white vinegar and acetic acid for overcome the water hyacinth problems in small irrigation and daring canals by applicable method and eco-friendly of the agricultural environmental.

Materials and Methods

All experiments were conducted under wire-house conditions at the Weed Research Central Laboratory between 2022 and 2024 unless otherwise specified, Agricultural Research Center (ARC) during 2022 to 2024, to study the potential effect of aqueous sweet basil extract at different concentration (e. g., 0.5 and 1, 2, 4, 6, 8%), aromatic oils such as camphor and sweet basil oils at concentration (0.005 and 0.01, 0.02, 0.04, 0.06 and 0.08%), white vinegar 6% acetic acid at the concentration 3 and 6%, acetic acid 99% at concentration 1.5 + 1.5% with one week interval, and water as the controls. Acetic acid (99%), aromatic oils using commercials oils, and aqueous extract of sweet basil as follow:

Plant materials preparations:

Mature plants of sweet basil were collected from Giza Agriculture Research Station, (ARC) during 2021 and 2022 spring seasons. The aboveground parts were collected and then washed with sterilized distilled water, air dried for two weeks at room temperature in a dark room under laboratory conditions, then in an oven at 60 °C until complete dryness and weight stability. The dried aboveground parts were crushed into powder and stored at room temperature till used.

Extraction procedures:

The plants of sweet basil extracted for 72 h with deionized water at the ratio 25 g powder sweet basil: 100 cm³ deionized water as solvent for each sample then each sample was filtered through Whitman No. 1 then the crude extractions became ready for experimental test purposes and were kept under laboratory conditions. Water hyacinth plants were collected from irrigation canals in El-Qanater al-Khairiya, Qalyubia Governorate. The plants carefully washed several times under tap water, then transferred to the treatment application units, which are pots with a diameter of 25 cm or artificial canals (2 m long, 75 cm wide and one meter depth) for each water hyacinth control treatment. Water loss of water hyacinth studies was transferred to large pots with a diameter of 50 cm. The plants were sprayed thoroughly (during the evening) at the different concentrations per treatment. The plants were monitored for 21 and 45 days after the treatments. In the other experiments, the sweet basil extract was examined in combination with camphor oil, as well as the development of oil-in-water emulsions for the increased effective formulation of camphor and sweet basil oils. Chemical parameters of water were analysis according to Cottenie *et al*. (1982), Table 1.

Table 1. Analysis of water sample.

pH	EC dSm^{-1}	Anions meq L^{-1}				Cationsmeq L^{-1}			
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
8.23	0.518	-	1.35	1.00	3.26	0.89	1.35	3.19	0.185

Effects of natural biochemical treatments on water hyacinth control:

Preliminary experiment: Experiment aimed to estimate the best and economical concentration/s of aqueous sweet basil extract and camphor oil for water hyacinth control:

The treatments were: -

1 - Untreated (control).
2- Aqueous extract of the basil plant at the rate 2 l fed^{-1}.
3- Aqueous extract of the basil plant at the rate 4 l fed^{-1}.
4 - Aqueous extract of the basil at the rate 6 l fed^{-1}.
5 - Aqueous extract of the basil plant at the rate 8 l fed^{-1}.
6- Camphor oil at the rate 200 cm^3 fed^{-1}.
7 - Camphor oil at the rate 400 cm^3 fed^{-1}.
8 - Camphor oil at the rate 600 cm^3 fed^{-1}.
9 - Camphor oil at the rate 800 cm^3 fed^{-1}.

The pots experiment (First experiment)

The treatments were:

1 - Untreated (control).
2- Aqueous extract of the basil plant at the rate 1 l fed^{-1}.
3- Aqueous extract of the basil plant at the rate 2 l fed^{-1}.
4- Camphor oil at the rate 100 cm^3 fed^{-1}.
5- Camphor oil at the rate 200 cm^3 fed^{-1}.
6- Basil oil at the rate 100 cm^3 fed^{-1}.
7- Basil oil at the rate 200 cm^3 fed^{-1}.
8 - White finger 6% acetic acid at the rate 6 l fed^{-1}.
9- White finger 6% acetic acid at the rate 12 l fed^{-1}.

The artificial canals (Second experiment):

The development of an effective formulation for aqueous basil extract and aromatics oils under study on water hyacinth control. The mixed oil with water for more stability without separated the oil from the water can be using Nano-emulsion of the preparation of camphor and basil oils and aqueous sweet basil extract. The preparation comprises sweet basil was contented 90 ml aqueous sweet basil with 5 ml of camphor oil and 5 ml tween the sum is 100 ml (90% aqueous basil)The preparation comprises 10 ml of basil or camphor oil mixed with 80 ml distilled water then 10 ml tween the sum is 100 ml (camphor 10% SL). The simple preparation method the formulated as sweet basil 90% SL, camphor oil 10% SL and basil oil 10% SL were more stability in storage and easy used with the increased the effectiveness on water hyacinth control.

Two experiments in the same time one in pots with using the crude sweet basil extract, basil and camphor oils as well as white vinegar compared to using formulation from sweet basil extract, basil and camphor oil (SL) as well as acetic acid 99%, in artificial canals photo (1).

Photo 1. pots and artificial canals experiment.

The treatments of pots experiment:

1- Untreated (control).
2- Crude aqueous sweet basil extracts at the rate 2 + 2 l fed^{-1} with one week between the first and second spray.
3- Crude camphor oil at the rate 200 + 200 cm^3 fed^{-1}.
4- Crude basil oil at the rate 200 + 200 cm^3 fed^{-1}.
5- White vinegar at the rate 200 + 200 l fed^{-1}.

The treatments of artificial canals:

1- Untreated (control).
2- Aqueous sweet basil 90% SL at the rate 2 + 2 l fed^{-}1.
3- Camphor oil 10% SL at the rate 200 + 200 cm^3 fed^{-1}.
4- Basil oil 10% SL at the rate 200 + 200 cm^3 fed^{-1}.
5- Acetic acid 99% at the rate 3+3 l fed^{-1}.

In all experiments the treatments were applied twice a week interval between the first and the second spray. The treatments were replicated six times in the pots experiment and four times in artificial canals in a randomized complete block design.

Data were recorded: - The characteristics studied of water hyacinth and estimates before and after 21 and 45 days from the treatments application except leaf width, green and dry leaves after 45 days:

1- The size of the water hyacinth plant.
2- The size of the roots of the water hyacinth plant.
3- The size of the air plant of water hyacinth.
4- The total weight of the water hyacinth plant.
5- Average plant length.
6- Average number of daughters per plant.
7- Average number of green leaves.
8- Average leaf width after 45 days.
9- Number of green leaves after 45 days.
10- Number of dry leaves after 45 days.

Statistical analysis:

The statistical design used in this study is a completely randomized design with four replications. All the data were statistically analyzed Discovering statistics using SPSS, third edition, Andy Field 2009. One way ANOVA and comparing several means, to compared the means fallow up Smart Alex's Solutions, chapter 11.

Gas chromatography: analyze for sweet basil extract, camphor and basil oil

The GC model 7890B from Agilent Technologies was equipped with flame ionization Central Laboratories Network, National Research Centre, and Cairo, Egypt. Separation was achieved using DB-624 column (30 m x 320 µm internal diameter and 1.8 µm film thickness).Analyses were carried out using hydrogen as the carrier gas at a flow rate of 1.5 ml/min at a split-1:50 mode, injection volume of 1 µl and the following temperature program: 40 °C for 1 min; rising at 10 °C /min to 200 °C and held for 1 min ; rising at 20 °C /min to 220 °C and held for 1 min ; rising at 30 °C /min to 250 °C and held for 3min. The injector and detector (FID) were held at 250 °C and 250 °C, respectively. Detector gases: nitrogen make-up gas 25 ml/min, hydrogen 40 ml/min, air 400 ml/min.

Table 2. Chemical composition of the sweet basil extract.

RT	Compound	Area %
15.24	PLUCHIDIOL 2-CYCLOPENTEN-1-ONE, 2,5,5-TRIMETHYL- 3-CYANO-5,5-DIMETHYLTETR AFURAN-2-ONE Chloramben, methyl ester 5,5,8a-Trimethyl-3,5,6,7,8,8a-hexa hydro-2H-chromene	7.73
18.83	Methyl 10-trans,12-cis-octadecadienoate 9,12-Octadecadienoic acid (Z,Z)-, methyl ester 9,12-Octadecadienoic acid, methyl ester METHYL OCTADECA-9,12-DIENOATE 9,12-Octadecadienoic acid (Z,Z)-, methyl ester	6.60
19.37	9,12-Octadecadienoic acid (Z,Z)- 9,12-OCTADECADIENOIC ACID (Z,Z)- 9,12-OCTADECADIENOIC ACID	6.38
23.58	Diisooctyl phthalate Bis(2-ethylhexyl) phthalate Phthalic acid, di(2-propylpentyl) ester 1,2-BENZENEDICARBOXYLIC ACID 1,2-BENZENEDICARBOXYLIC ACID, DIOCTYL ESTER	4.84
18.90	9-Octadecenoic acid, methyl ester, (E)- 9-OCTADECENOIC ACID (Z)-, METHYL ESTER 6-Octadecenoic acid, methyl ester, (Z)- 11-Octadecenoic acid, methyl ester 9-OCTADECENOIC ACID (Z)-, METHYL ESTER	3.75
16.61	MANNOSE d-Mannose 2-AMINOETHANETHIOL HYDROGEN SULFATE (ESTER) DODECANOIC ACID, 2,3-BIS(ACETYLOXY)PROPYL ESTER Dodecanoic acid, 2,3-bis(acetyloxy)propyl ester	3.38
26.13	Squalene 2,6,10,14,18,22-TETRACOSAHEX AENE 2,6,10,15,19,23-HEXAMETHYL-	3.31
9.00	2,7-Octadiene-1,6-diol, 2,6-dimethyl- 2,7-OCTADIENE-1,6-DIOL, 2,6-DIMETHYL- 2,7-Octadiene-1,6-diol, 2,6-dimethyl- 1,7-Octadiene-3,6-diol, 2,6-dimethyl- 2,6-DIMETHYL-1,7-OCTADIENE- 3,6-DIOL #	3.02
8.03	PHENOL, 5-METHYL-2-(1-METHYLETHYL)- Thymol Phenol, 2-methyl-5-(1-methylethyl)-	2.95
13.26	2-Cyclohexen-1-one, 4-(3-hydroxy-1-butenyl)-3,5,5-trime thyl-, [R-[R*,R*-(E)]]- 2-CYCLOHEXEN-1-ONE, 4-(3-HYDROXY-1-BUTENYL)-3,5,5-RIMETHYL-, [R-[R*,R*-(E)]]- 4-DECEN-6-YNEDIOIC ACID, DIMETHYL ESTER 2-Cyclohexen-1-one, 4-(3-hydroxy-1-butenyl)-3,5,5-trim ethyl- 2-CYCLOHEXEN-1-ONE, 3-(2-BUTENYL)-2,4,4-TRIMETHYL-, (Z)-	2.78

Table 3. Chemical composition of the basil and camphor oil.

RT (min.)	Compound Basil oil	Area Sum%	RT (min.)	Compound Camphor oil	Area Sum%
5.6	1-Decanol	6.67	5.87	Ecogonin	35.96
7	Heneicosane	1.45	6.96	Heptacosanol	1.55
7.7	Nonanal	1.41	8.46	D-(+)-Camphor	2.51
10.1	Camphor	4.04	8.64	Linoleic	1.76
10.4	3-Undecyne	9.14	9.75	Squalane	26.43
12.2	Bulnesene	18.5	10.99	Bergenin	5.84
16.6	Eicosanoic acid	4.52	11.37	Palmitelaidic acid	0.63
17.7	Lupeol	1.48	11.57	Elaidic acid	0.69
18	Isolongifolo	26.57	11.64	Cis-Vaccenic acid	0.81
18.2	Trans-Farnesol	1.85	11.77	Phytanic acid	2.23
18.6	Squalene	1.4	11.82	1-Stearoyl-rac-glycerol	0.72
19.1	Stigmasterol	2.42	16.67	Tetradec-11-en-1-ol	1.89
19.5	Erucic acid	0.45	18.21	Octadecanoic acid, 4-hydroxy-, methyl ester	13.93
20.4	Betulin	5.62	21.30	Nonacosane	2.24
21.4	Ledol	8.1	22.61	1-Oleoyl-2-palmitoyl-rac-glycerol	2.81

Results and Discussion:

Table (4) showed that the homogeneity of variances test between the different unites of water hyacinth traits before applied different concentration of sweet basil extract and camphor oil in preliminary experiment for determined the suitable concentration for water hyacinth control were not significantly differences and suitable for compared the different effect of water hyacinth control treatments.

Table 4. Homogeneity test of variances before application sweet basil extract and camphor oil at different concentrations on water hyacinth growth traits.

Water hyacinth growth traits	Levene Statistic	df1	df2	Sig.	Range of mean traits
Main factor (sweet basil extract and camphor oil)					
Weight g/plant	0.376	2	41	0.689	56 – 67 g/plant
plant size (cm^3)	2.400	2	41	0.103	81 – 92 cm^3/plant
air plant size (cm^3)	0.623	2	41	0.541	43 – 57 cm^3/air plant
Root size (cm)	1.783	2	41	0.181	40 – 43 cm^3/roots plant
Sub-factor (different concentrations)					
Weight g/plant	1.561	8	35	0.172	51 – 70 g/plant
plant size (cm)	1.208	8	35	0.323	68 – 111 cm^3/plant
air plant size (cm)	1.639	8	35	0.149	32 – 62 cm^3/air plant
Root size (cm)	0.895	8	35	0.531	21 – 49 cm^3/roots plant

Table (5) the static analyses pointed out that the camphor oil and sweet basil extract significantly reduced water hyacinth plant weight (g), plant size, air plant and root size compared to the untreated (control). The different concentrations of sweet basil extract and camphor oil showed no significant differences in the effect on water hyacinth plant weight, plant size, air plant, and root size. Camphor oil was more effective and significantly reduced all water hyacinth traits under study than sweet basil extract. The highest reduction on fresh weight, plant and root size was obtained at the rate of 600 cm^3 $fed^{-1}$of camphor, followed by camphor at the rate 200 cm^3 fed^{-1}then sweet basil extract at the rate 400 cm^3 fed^{-1}. These results due to inhibition enhancing the biosynthesis of essential amino acids and stopping cell division and plant growth. This result agrees with that obtained by El-Shahawy (2015) and Wells and Clayton (2005). Some chemicals and natural compounds, as acetic acid, citric acid, formic acid, and propionic acid, can be using for the control of water hyacinth. The efficacy increased with the increase in concentration of natural compounds from 10, 15, and 20%. Formic and propionic acids caused died of water hyacinth plant earlier than the other acids or the herbicide glyphosate. Acetic acid came after formic and propionic acids in terms of efficacy, but citric acid ranked last, El-Shahawy (2015).

Table 5. Allelopathic effect of different concentrations of camphor oil and sweet basil extract on water hyacinth growth traits.

Water hyacinth traits and descriptive	Control	Camphor oil /rate fed^{-1} 200 cm^3	400 cm^3	600 cm^3	800 cm^3	Sweet basil extract/rate fed^{-1} 2 L	4 L	6 L	8 L
Weight g/plant	90.4 a	9.0 b	15.3 b	3.5 b	20.8 b	20.8 b	8.8 b	28.0 b	14.8 b
Std. Deviation	34.0	10.4	10.4	4.7	17.2	3.0	6.2	14.8	13.0
Main factor	90.4				12.1				18.1
Std. Deviation	33.99				12.3				11.9
F				14.39	Main	59.8			
Sig				0.0001		0.0001			
plant size (cm^3)	122.9 a	16.3 b	28.8 b	16.3 b	18.8 b	38.8 b	23.8 b	30.0 b	25.0 b
Std. Deviation	53.7	18.9	20.16	18.9	13.2	4.8	16.0	4.1	16.8
Main factor	122.9				20.0				29.4
Std. Deviation	53.7				16.8				12.4
F				10.07	Main	45.4			
Sig				0.0001		0.0001			
air plant size (cm^3)	77.1 a	5.0 b	12.5 b	6.3 b	7.5 b	13.8 b	11.3 b	16.3 b	10.0 b
Std. Deviation	41.3	5.84	8.7	9.5	6.5	2.5	8.5	2.5	8.2
Main factor	77.1				7.8				12.8
Std. Deviation	41.3				7.5				6.0
F				8.6	Main	39.7			
Sig				0.0001		0.0001			
Root size (cm^3)	57.1 a	11.3 b	16.3b	10.0 b	11.3 b	25.0 b	12.5 b	13.8 b	15.0 b
Std. Deviation	20.5	13.2	11.9	12.2	8.5	4.1	10.4	4.8	10.8
Main factor	57.1 a				12.2				16.6
Std. Deviation	20.5				10.6				8.9
F				10.3	Main,	43.9			
Sig				0.0001		0.0001			

Table (6) reported that the correlation between different concentration of sweet basil extract and camphor oil was non significantly with the water hyacinth plant weight (g), plant size, air plant size and root size before applied these treatments, but the correlation between sweet basil extract or camphor oil was negative and highly significant with the above water hyacinth traits after 45 days from applied sweet basil extract and camphor oil.

The correlation between water hyacinth plant weight and plant size, air plant and root size were positive and highly significant after 21 days from applied the sweet basil extract or camphor oil. Plant size was positive and highly significant correlation with air plant and root size. Some chemicals and natural compounds, as acetic acid, citric acid, formic acid, and propionic acid can be using for the control of water hyacinth. These results are attributed to the inhibitory effects of sweet basil extract and camphor oil on water hyacinth growth traits, likely due to interference with respiration, gas exchange, and cell division. These results were agreement with the resulted obtained (Bakkali *et al*., 2008), Shahawy (2015), USDA, Agricultural Marketing Servic (2016) and (Assaeed *et al*., 2020). The efficacy increased with the increase concentration of natural compounds from 10, 15, and 20%. Formic and propionic acids caused died of water hyacinth plant earlier than the other acids or the herbicide glyphosate. Acetic acid came after formic and propionic acids in terms of efficacy, but citric acid ranked last, El-Shahawy (2015).

Table 6. Pearson correlation between water hyacinth growth traits as well as water hyacinth control by different concentrations of sweet basil extract and camphor oil.

Water hyacinth traits	Weight g/plant	Weight g/plant after	plant size (cm)	plant size (cm) after	air plant size (cm)	air plant size (cm) after	Root size (cm)	Root size (cm) after
				Sweet basil extract				
Concentration %	083	-.572(**)	-.109	-.570(**)	-.005	-.534(**)	-.468(*)	-.598(**)
Weight g/plant before		-.008	.308	-.030	.342	-.100	-.004	-.162
Weight g/plant after			.147	.966(**)	-.030	.807(**)	.192	.895(**)
plant size (cm) before				.179	.674(**)	.173	.532(**)	.094
plant size (cm) after					.044	.822(**)	.187	.942(**)
air plant size (cm) before						.028	.361	-.016
air plant size (cm) after							.195	.777(**)
Root size (cm)								.080
				Camphor oil				
Concentration %	-.243	-.537(**)	-.105	-.562(**)	-.096	-.537(**)	-.137	-.577(**)
Weight g/plant		.312	.339	.239	.190	.121	.350	.119
Weight g/plant after			.439(*)	.970(**)	.353	.824(**)	.267	.915(**)
plant size (cm)				.462(*)	.868(**)	.417(*)	.636(**)	.393(*)
plant size (cm) after					.375(*)	.841(**)	.280	.952(**)
air plant size (cm)						.334	.281	.325
air plant size (cm) after							.273	.806(**)
Root size (cm)								.181

** Correlation is significant at the 0.01 level and* Correlation is significant at the 0.05 level

Table (7) showed that the homogeneity of variances test between the different unites of water hyacinth plant experiment in the traits (fresh weight (g), plant length, air plant size and root size) before applied the treatments, in the first pots experiments the traits of water hyacinth plants were not significantly differences and suitable for compared the effect of different water hyacinth control.

Table 7. Test of Homogeneity of Variances in water hyacinth traits before applied the treatments in the pots experiment.

water hyacinth traits	Levene Statistic	df1	df2	Sig.	Range of mean of water hyacinth traits
Weight g/plant	1.561	8	45	0.575	120 – 189
plant length (cm)	1.208	8	45	0.760	54 – 64
air plant size (cm)	1.639	8	45	0.712	93 – 152
Root size (cm)	0.895	8	45	0.222	88 – 185

Table (8) and Fig (1) from the statistical analyze indicated that white vinegar, sweet basil extract, camphor and basil oils treatments were high significantly reduced fresh weight, plant length, root and air plant size of water hyacinth after 45 days from applied the treatments, compared to untreated control in the first and second pots experiments, Photo (2).

Photo (2)

Table 8. Allelopathic effect of white vinegar, sweet basil extract, camphor, and basil oils on water hyacinth growth traits after 45 days from applying the treatments in the first and second pots experiment.

Treatments	Rate fed^{-1}	Weight g/plant	Std. Deviation	plant length (cm)	Std. Deviation	air plant size (cm)	Std. Deviation	Root size (cm)	Std. Deviation
First experiment									
Control	-	193.7 a	31.96	43.50ab	4.46	105.00 a	19.49	130.00 a	31.62
Sweet basil extract	1l	126.0bc	38.66	46.17ab	8.91	54.17bcd	4.92	90.00bc	21.91
Sweet basil extract	2 l	172.0ab	45.38	50.00 a	3.29	65.00 b	22.80	109.17ab	21.55
Camphor oil	100 cm^3	142.0bc	42.20	42.67 b	4.89	62.50bc	7.58	95.00bc	18.44
Camphor oil	200 cm^3	119.5 c	30.38	49.50 a	4.18	52.50bcd	14.41	82.50 c	10.84
Basil oil	100 cm^3	124.8bc	52.12	47.17ab	2.64	42.50 d	14.40	78.33 c	13.66
Basil oil	200 cm^3	112.2 c	27.53	42.00 b	7.54	46.67 cd	10.80	90.83bc	17.15
White Vinegar	6 l	111.8 c	28.02	34.50 c	4.09	48.33bcd	6.83	90.00bc	13.04
White Vinegar	12 l	133.7bc	21.94	32.50 c	2.73	53.33bcd	9.83	94.17bc	7.36
F	-	3.536		8.526		11.408		4.183	
Sig	-	0.003		0.0001		0.0001		0.001	
Second experiment									
Control	-	41.67 a	8.62	23.83 a	2.99	25.83 a	10.20	52.50a	10.84
Sweet basil extract	1l	44.5 a	9.73	21.67ab	3.26	19.17ab	12.81	27.50bc	6.89
Sweet basil extract	2 l	28.00 c	4.73	20.00abc	1.55	15.00 b	4.47	26.67bc	2.58
Camphor oil	100 cm^3	30.33bc	7.23	19.75abc	4.85	21.67ab	6.83	23.33c	8.75
Camphor oil	200 cm^3	37.00ab	7.48	18.67bc	3.88	15.00 b	5.47	33.33b	6.83
Basil oil	100 cm^3	26.17 c	8.18	16.17 c	4.26	14.17 b	4.91	27.50bc	4.18
Basil oil	200 cm^3	28.33bc	8.02	16.83 c	3.71	15.83 b	3.76	26.67bc	6.83
White Vinegar	6 l	28.67bc	5.04	16.33 c	1.86	17.50ab	8.21	25.83bc	4.91
White Vinegar	12 l	28.38bc	4.58	16.17 c	2.58	13.33 b	2.58	29.17bc	3.76
F	-	5.073		4.06		1.885		10.425	
Sig	-	0.0001		0.001		0.086		0.0001	

In the First experiment the greatest reduction percentage in fresh weight was resulted from white vinegar at the rate 6 l fed^{-1}, followed by basil oil at 200 cm^3 fed^{-1}, camphor oil at 200 cm^3 $fed^{-1}$and sweet basil extract at 1 l fed^{-1}, but the lowest reduction was resulted from sweet basil extract at 200 cm^3 fed^{-1} basil oil at 200 cm^3 fed^{-1} gives the lowest value of root and air plant size, followed by basil oil at 200 cm^3 fed^{-1} and white vinegar at 6 l fed^{-1}. In the second experiment the greatest reduction in fresh weight was resulted from basil oil at 100 cm^3 fed^{-1}, followed by sweet basil extract at the rate 2 l fed^{-1}, basil oil at 200 cm^3 fed^{-1} and white vinegar at 12 l fed^{-1}, but the lowest reduction was resulted from sweet basil extract at 1l fed^{-1},camphor oil at 200 cm^3 fed^{-1} gives the lowest value of root and air plant size, followed by Camphor oil at 0.01% and white vinegar at 6%.

The greatest plant weight, plant length, root and air plant size was obtained under untreated control in the first and second experiments. Basil oil at concentration 200 cm^3 fed^{-1} and white vinegar at concentration 6 l fed^{-1} gives the high reduction in fresh weight of water hyacinth more than 42% of water hyacinth fresh weight after 45 days from applied the treatments, followed by camphor oil at 200 cm^3 fed^{-1}more than 38%, sweet basil extract 1 l fed^{-1} more than 34%, white vinegar at 12l fed^{-1} more than 31%, camphor oil at 100 cm^3 fed^{-1}more than 26% and the lowest reduction was 11% resulted from sweet basil extract at 2 l fed^{-1}, compared to untreated control in the first experiment.

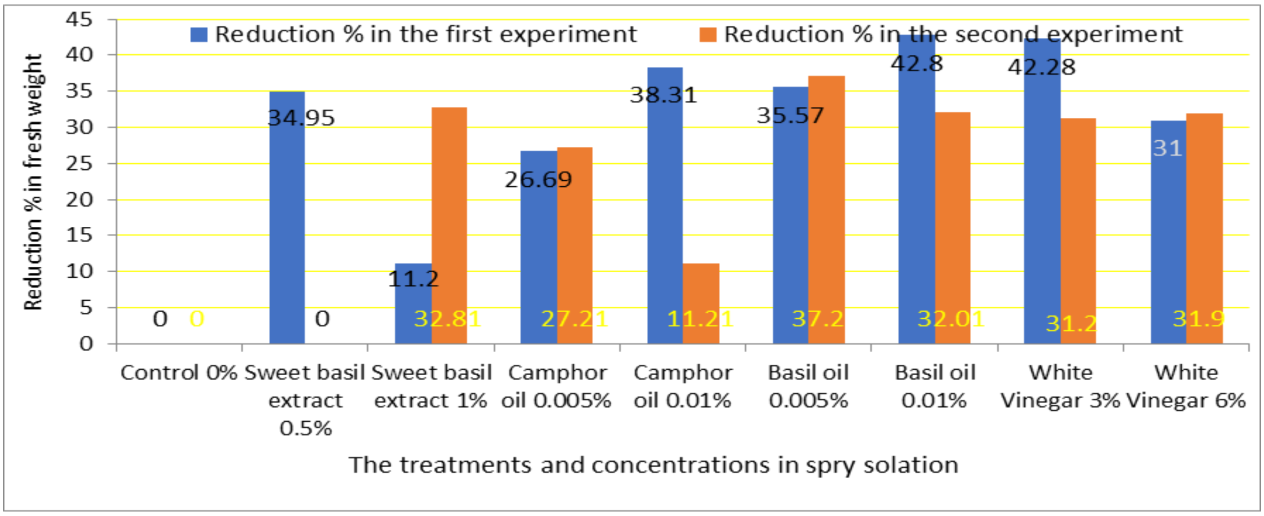

Fig. 1. The effect of sweet basil extract, white vinegar, camphor and basil oils at different concentration on the reduction % of water hyacinth fresh weight after 45 days from applied the treatments.

Basil oil at the rate 100 cm^3 fed^{-1} more than 37%, sweet basil extract at the concentration 2 l fed^{-1} and basil oil at the rate 200 cm^3 fed^{-1} the reduction was more than 32% and white vinegar at the rate 12 and 6 l fed^{-1} the reduction was more than 31% and the lowest reduction percentage was 0% produced from sweet basil extract at the concentration at the rate 1 l fed^{-1} in the second experiment.

Table (9) showed that the homogeneity of variances test between the different of experimental unites of water hyacinth traits before applied the treatments (sweet basil extract at the rate 2 l fed^{-1}, white vinegar at the rate 200 + 200 l fed^{-1}, camphor and basil oil at the rate 200 + 200 cm^3 fed^{-1} in the comparative experiments between the formulation and crude white vinegar, sweet basil extract camphor and basil oils on the reduction of water hyacinth traits were not significantly differences and suitable for presented the effectiveness of the treatments under studying, except number of daughter/plant and plant size in the first experiment and number of green leaves, leaf width and air plant size were significantly.

Table 9. Test of Homogeneity of Variances in water hyacinth traits before applied the treatments in the two pots experiments.

Water hyacinth traits	Levene Statistic	Sig.	Range of mean of water hyacinth traits	Levene Statistic	Sig.	Range of mean of water hyacinth traits
	First experiment			Second experiment		
Plant weight g/plant	1.63	0.24	107 - 154	0.31	0.87	107 - 155
number of daughter	4.57	0.02	1.3 – 1.5	1.21	0.36	1.3 – 1.5
number of green leaves	1.23	0.36	7 - 13	4.47	0.03	7 – 15
number of dry leaves	3.44	0.05	2 – 4	0.23	0.92	2 – 4
plant length	2.05	0.16	36 – 45	2.09	0.16	36 – 45
Leaf width cm	1.16	0.39	7 – 8	4.48	0.03	7 – 8
Roots size cm^3	2.48	0.11	49 – 65	2.17	0.15	49 – 66
Air plant size cm^3	3.49	0.05	102 - 145	4.59	0.02	85 – 143
Plant size cm^3	3.90	0.04	151 - 210	3.30	0.06	138 - 209

Table (10 a and 10 b) indicated that all water hyacinth traits in this study was highly significant reduced by crude white vinegar at the rate 200 l fed^{-1}, sweet basil extract at the rate 200 cm^3 fed^{-1} camphor and basil oils at the rate 200 cm^3 fed^{-1}, compared to untreated control units in the mean of two experiments.

Table (10 a) reported that basil oil and white vinegar produced the lowest weight (g/plant), number of green leaves and length of water hyacinth plant, followed by sweet basil extract and camphor oil. The greatest of water hyacinth plant length, weight and number of green leaves were obtained from untreated control.

Table 10 a. Allelopathic effect of sweet basil extract, white vinegar, sweet basil extract and camphor oils on water hyacinth growth traits after 45 days from applied the treatments in mean of two pots experiments.

Treatments	Rate fed^{-1}	Weight g/plant	Std. Deviation	No. of green leaves / plant	Std. Deviation	No. of dry leaves/ plant	Std. Deviation	plant length (cm)	Std. Deviation
Control	-	241.5 a	36.6	15.00 a	4.00	8.17 b	2.79	66.00 a	6.35
White vinegar	200 + 200 l	55.67 b	16.5	5.00 b	0.94	11.17ab	2.32	26.83 c	6.04
Camphor oil	200 + 200 cm^2	85.5 c	11.3	3.17 b	3.49	9.67 b	2.06	30.00 bc	3.16
Basil oil	200 + 200 cm^2	53.17 b	15.9	4.83 b	0.98	12.83 a	1.17	32.67 bc	7.94
Sweet basil extract	2 + 2 l	67.5bc	15.05	5.33 b	1.03	10.00ab	3.16	36.33 b	8.69
F	-	86.10		21.68		3.18		32.73	
Sig	-	0.0001		0.0001		0.0310		0.0001	

Table (10 b) from the data mentioned that the lowest leaf width, plant size, root and air plant size were obtained from white vinegar and camphor oil, followed by basil oil and sweet basil extract. The greatest value of leaf width, plant size, root, and air plant size resulted from the untreated control.

Table 10 b. Allelopathic effect of sweet basil extract, white vinegar, basil extract, basil, and camphor oils on water hyacinth growth traits after 45 days from applying the treatments in a mean of two pots experiments.

Treatments	Rate fed^{-1}	leaf width (cm)	Std. Deviation	Root size (cm^3)	Std. Deviation	air plant size (cm^3)	Std. Deviation	plant size (cm^3)	Std. Deviation
Control	-	8.00 a	0.71	134.2 a	20.59	135.83a	21.31	270.00 a	31.94
White vinegar	200 l	5.50 b	1.48	35.0 b	7.07	46.67b	9.34	81.67 b	16.02
Camphor oil	200 + 200 cm^2	3.17 c	3.05	35.8 b	7.36	43.33b	13.66	79.17 b	18.01
Basil oil	200 + 200 cm^2	5.67 b	0.60	44.2 b	3.76	46.67b	8.75	90.83 b	8.01
Sweet basil extract	2 + 2 l	6.17ab	0.81	49.2 b	17.72	46.67b	10.33	95.83 b	18.28
F	-	5.61		61.96		53.43		101.33	
Sig	-	0.002		0.0001		0.0001		0.0001	

Fig (2) pointed that the highest reduction percentage (77.98) was resulted from basil oil at the rate 200 cm^3 fed^{-1} followed by white vinegar at the rate 200 + 200 l fed^{-1} the reduction was (76.95%), sweet basil extract at the rate 2 + 2 l fed^{-1} the reduction was (72.05%) and camphor oil at the rate 200 + 200 cm^3 fed^{-1} the reduction percent was 64.6, compared to untreated control, which was 0% reduction in water hyacinth fresh weight.

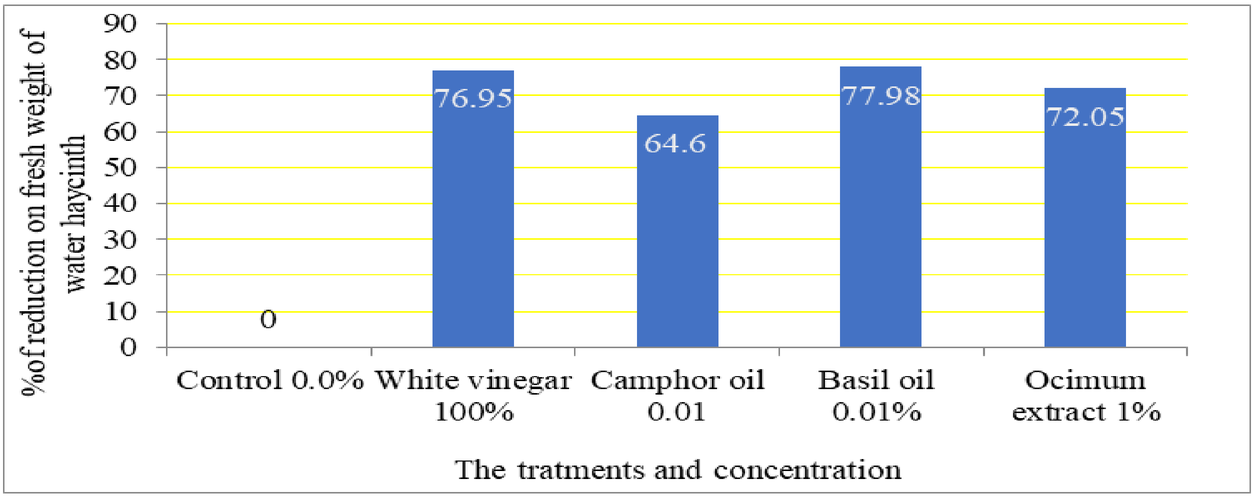

Fig. 2. Effect of crude white vinegar at concentration100% (200+ 200 l fed^{-1}), sweet basil extract at 0.01% (2 + 2 l fed^{-1}), camphor and basil oils at the concentration 0.01% (200 + 200 cm^3 fed^{-1}) on reduction % of water hyacinth fresh weight after 45 days from the applied treatments.

Table (11) showed that the homogeneity of variances test between the different experimental unites of water hyacinth traits before applied the formulation acetic acid 99% at the rate 3 + 3 l fed^{-1}, sweet basil extract 90% SL at the concentration at the rate 2 + 2 l cm^3 fed^{-1}, camphor and basil oil 10% SL at the rate 200 + 200 cm^3 fed^{-1} not significantly differences and suitable for presented the effectiveness of the treatments under studying, except the plant weight in the first experiments and number of green leaves of water hyacinth plant was significantly differences.

Table 11.Test of Homogeneity of Variances in water hyacinth traits before applied the treatments in pots and artificial canal experiments.

Water hyacinth traits	Artificial canal experiment			Pots experiment		
	Levene Statistic	Sig.	Range of means of water hyacinth traits	Levene Statistic	Sig.	Range of means of water hyacinth traits
total weight	4.730	0.021	134.33 – 177.03	1.024	0.43	120.00 – 171.50
number of green leaves	1.518	0.269	7.80 – 10.40	5.575	0.01	7.00 – 10.50
number of dry leaves	2.517	0.108	2.07 – 2.87	0.643	0.64	1.75 –3.25
plant length	2.158	0.148	39.2 – 42.00	0.411	0.80	45.25 – 48.50
leaf width	1.292	0.337	8.20 – 8.83	0.866	0.51	7.00 – 7.63
size of roots	0.804	0.550	56.67 – 67.00	0.938	0.47	52.50 – 57.5
size of shoot	0.838	0.531	131.67 – 159.33	0.636	0.65	91.25 – 118.75
size of plant	0.460	0.764	189.07 – 224.33	0.747	0.58	148.75 – 177.5
Number of. plants	2.851	0.082	17.67 – 25.00	1.024	0.43	
mortality rate	.	.				

Fig (3) shows the extent of oil dispersion in water. In the absence of a spreading agent, oil droplets collect on the surface of the water. However, effective formulations can be created by adding a spreading agent, such as Tween 80%, to increase the dispersion and distribution of oils in the water. This helps the increased diffusion of the active ingredients in the spray solution, which leads to increased bio-herbicide efficiency.

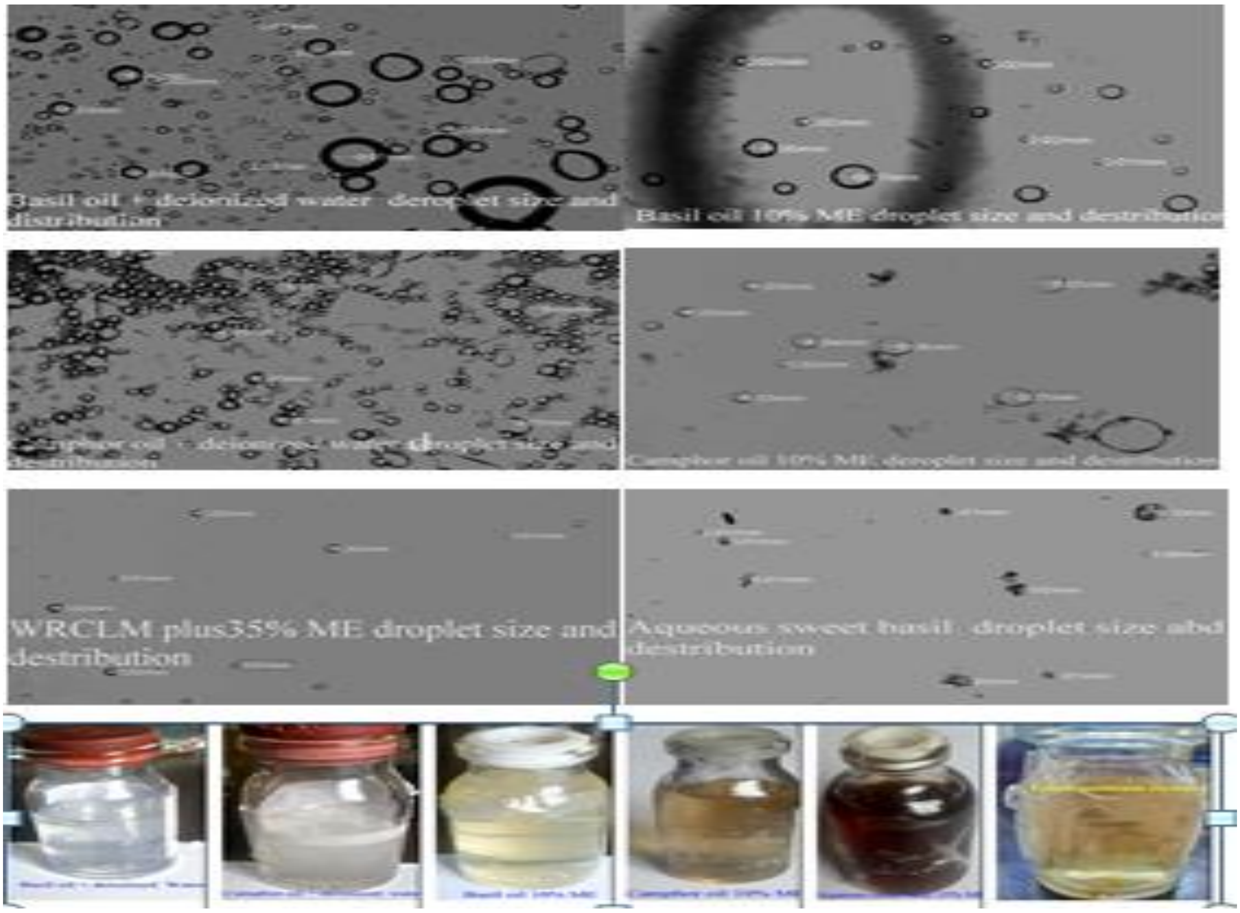

Fig. 3. Forms of basil and camphor oils and sweet basil extract distribution in deionized water and formulation in form ME.

Table (12 a and 12b) and **fig (4)** mentioned that acetic acid 99%, Nano-emulsion of sweet basil extract 99% SL, camphor and basil oils 10% SL were highly significantly reduced of water hyacinth fresh weight (g), number of green leaves/plant, length of plant (cm), leaf width (cm), plant, air plant and root size (cm^3) and number of plants/canal, compared to untreated control units. These results are due to the effect of the treatments under study on preventing vegetative propagation of water hyacinth plants Fig (4), as well as the effect of acetic acid on the pH of the growth medium, which affects the utilization of nutrients, the effect on the respiration process and gas exchange by essential oils, and the effect on cell division and reproduction.

Fig. 4.

Table (12 a) shows that the greatest plant length, weight, leaf width and number of green leaves/plant resulted from untreated control, but the lowest values were obtained from acetic acid, followed by camphor oil, sweet basil extract and basil oil. These results due to contact with acetic acid and camphor oil, which break down cell walls and inhibit cell division, by inhibition of protein synthesis and root elongation by sweet basil extract, camphor and basil oils.

Table 12 a. Allelopathic effect of formulation of sweet basil extract, acetic acid, camphor and basil oils on water hyacinth growth traits after 21 days from applied the treatments in mean of two artificial canal experiments.

Treatments	Rate fed^{-1}	Weight g/plant	Std. Deviation	No. of green leaves/ plant	Std. Deviation	plant length (cm)	Std. Deviation	leaf width (cm)	Std. Deviation
Control	-	259.7a	44.10	13.7a	5.68	64.3a	9.07	7.7 a	0.58
Acetic acid 99.%	3 + 3	42.7c	7.77	0.00 c	0.00	21.3c	3.06	0.0 d	0.00
Camphor oil 10% SL	200 + 200 cm^3	43.7c	16.01	4.7bc	0.58	30.7bc	4.16	4.3c	0.58
Basil oil 10% SL	200 + 200 cm^3	91.7b	13.32	5.33b	0.57	43.7 b	2.52	6.0 b	1.00
Sweet basil extract 99% SL	2 + 2 l	62.0bc	3.61	5.00b	1.00	35.3b	10.97	5.33bc	0.58
F	-	51.20		10.77		16.84		62.08	
Sig	-	0.0001		0.001		0.0001		0.0001	

Table (12 b) reported that the greatest plant size, air plant and root size and number of plants/canal was obtained from untreated control, but the lowest values were obtained from acetic acid, followed by camphor oil, sweet basil extract and basil oil. These results due to contact with acetic acid and camphor oil which break down cell walls and inhibit cell division, by inhibition of protein synthesis and root elongation by sweet basil extract, camphor and basil oils as well as due to inhibition of the photosystem at absorbed by the leaves and roots, with translocation and accumulation in the apical meristems

Table 12 b. Allelopathic effect of formulation of sweet basil extract, acetic acid, camphor and basil oils on water hyacinth growth traits after 21 days from applied the treatments in mean of two artificial canal experiments.

Treatments	Rate fed^{-1}	Root size (cm^3)	Std. Deviation	air plant size (cm^3)	Std. Deviation	plant size (cm^3)	Std. Deviation	Total number of plant/canal	Std. Deviation
Control	-	136.7 a	30.55	126.7 a	10.41	263.3 a	31.75	25.0 a	4.00
Sweet basil extract 99% SL	3 + 3	30. 0 c	5.00	35.0 b	5.715	66.7 c	11.55	17.7c	4.62
Camphor oil 10% SL	200 + 200 cm^3	31.7c	7.64	40.0 b	5.00	70.0 c	8.66	20.3c	1.53
Basil oil 10% SL	200 + 200 cm^3	65.0 b	5.00	43.30 b	2.89	108.3 b	7.64	23.3 b	1.53
Acetic acid 99.%	2 + 2 l	45.0 bc	5.00	41.7 b	2.89	86.7bc	2.89	22.7bc	0.58
F	-	27.48		129.60		79.28		2.89	
Sig	-	0.0001		0.0001		0.0001		0.07	

Fig 5 and 6 presented that the inter crude the sweet basil extract, camphor and basil oil in formulation by using Nano emulsion stimulant the effect of sweet basil extract and earlier presented the symptom effect of acetic acid 3 + 3 l fed^{-1} in artificial canal than the symptom effect white vinegar 6% acetic acid at the rate 200 + 200 l fed^{-1} on water hyacinth plant in pots, fig (5). Crude extract of the plant under study caused more reduction in fresh weight, plant size, root and air plant size, but less water hyacinth plant, which died until after 45 days from the treatments.

Fig. 5. Effect of extracts on artificial canals.

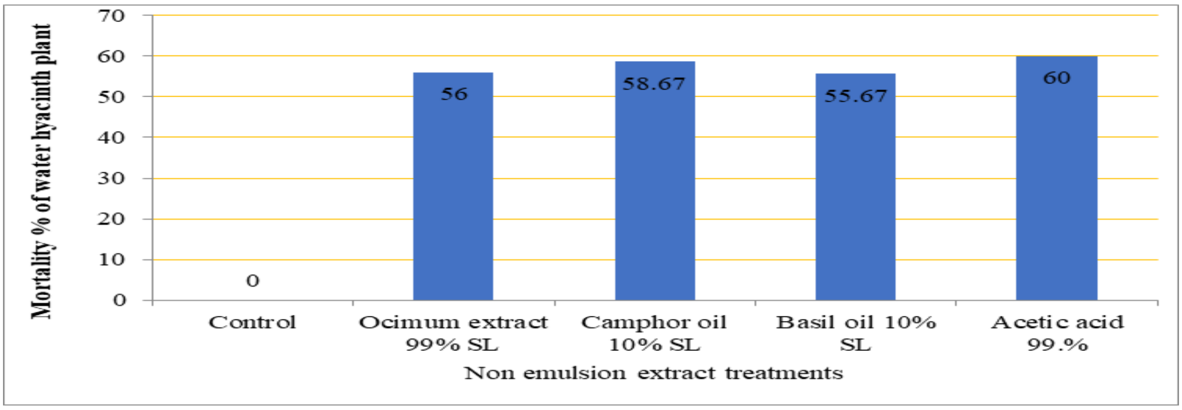

Fig. 6. Effect of Non emulsion extracts treatments on water hyacinth mortality %.

Figure (6) Mortality % after 21 days from the Formulation of the treatments applied in artificial canal experiment. Nano emulsion of sweet basil extract, camphor and basil oil caused the die of water hyacinth plant more than 55% after 21 days from applied the treatments under study and 100% mortality after 45 days from applied the Nano emulsion of sweet basil extract at the concentration 1 + 1%, camphor and basil oil at 200 + 200 cm^3 fed^{-1} and acetic acid 99% at the concentration 3 + 3 l fed^{-1}. Nano emulsion of basil oil has antimicrobial and immune-stimulant effect in the cultured fish. Nano emulsion basil oil has inhibitory effect on bacterial at lower concentration than Pure basil oil with save for *Oreochr omisniloticus* and increased immunity in fish, El-Ekiaby (2019).

Emulsions are used to stabilize and increase the efficacy of oils in aqueous solutions, when this emulsion system tends to reach Nano metric size, Echeverría and Albuquerque (2019) *Ocimum basilicum* having official acceptance medicines product, and the extract of *Ocimum basilicum* formulated exhibited good physical properties and commercial product marked improvement, (Khan*et et al.*,2020). Many formulations as Nanoemulsions have been used for pest toxicity target. Nanoemulsion of camphor oil is the most effective than camphor essential oil (Marouf *et al.*, 2021). Improve oral bioavailability of hydrophobic drugs like black seed oil by formulating them into a self-nanoemulsifying drug delivery system (SNEDDS). The best formulation of SNEDDS obtained from tween 80 as surfactant and PEG 400 as co-surfactant (2:1) with a ratio of oil and mix co-surfactant-surfactant 1:8. It has good physical characteristics and stability (Priani *et al.*,2022). Hydro-cinnamic acid occurs naturally in the rhizosphere and plays regulatory roles in plant–plant and plant microbe-communities and the herbicides activity for weed control (Robles *et al.*, 2022).

Conclusion

1- Aqueous extract of basil, white vinegar, camphor and basil oils caused a reduction in the water hyacinth growth traits (plant weight and height, leaf width, plant size, root and air size).

2- Increasing the concentrations of the crude basil extract from 2 to 16 l fed^{-1} and camphor oil from 100 to 1600 cm^3 fed^{-1} did not cause a significant increase in the herbicidal potentiality of the water hyacinth control.

3 – Repeated applications crude aqueous extract of basil at a concentrations of 2 + 2 l fed^{-1}, crude basil and camphor oils at 200 + 200 cm^3 fed^{-1}, and white vinegar at 200 + 200 l fed^{-1} with a week between each spray, led to a significant increases in reduction of the growth of the water hyacinth plant in terms of weight, size, and plant length after 45 days of spraying, but did not lead to the mortality of all the water hyacinth plants to 45 days after applied the treatments.

4 - Nano emulsion of camphor and basil oils and aqueous extract of basil plant led to a significant increase and rapid effect on water hyacinth plant, as spraying with a concentration of 2 + 2 l fed^{-1} of the aqueous extract of basil and at 200 + 200 cm^3 fed^{-1} of basil and camphor oils led to an increase in the deficiency in the growth characteristics of water hyacinth and death of more than 55% after 21 days of spraying and complete death of plants 100% death of water hyacinth plant at 45 days after spraying under all study treatments.

5– Through this study, we recommend that the Nano emulsion of basil aqueous extract at 2 + 2 l fed^{-1}, camphor and basil oils at 200 + 200 cm^3 fed^{-1} and acetic acid 99% at 3 + 3 l fed^{-1} can be used in the spray solution and sprayed twice, with one week between each spray, to control water hyacinth in irrigation and drainage canals.

Consent for publication:

All authors declare their consent for publication.

Author contribution:

The manuscript was edited and revised by all authors.

Conflicts of Interest:

The author declares no conflict of interest.

References

Abd El-Gawad, A.; A., Elshamy. A., El Gendy; A. Gaara and A., Assaeed (2019) Volatiles profiling, allelopathic activity, and antioxidant potentiality of *Xanthium Strumarium* leaves essential oil from Egypt: evidence from chemometrics analysis. Molecules 24, 584: 1-12.

Absy, R. and Abd EL-Fattah, H.M., 2022. Comparative Performance of Herbicides for Grassy Weed Management in Winter Wheat (Triticum aestivium L.) under Egyptian Conditions. *Egyptian Journal of Agronomy*, *44*(1), pp.75-81.

Andy Field book (2009) One way ANOVA and comparing several means, to compared the means fallow up Smart Alex's Solutions, chapter 11"Comparing several means". Discovering statistics using, SPSS, pp. 1-26.

Assaeed, A.; A., Elshamy; A., El Gendy; B., Dar; S., Al-Rowaily and A., Abd-El Gawad (2020) Sesquiterpenes-rich essential oil from above ground parts of *Pulicari asomalensis* exhibited antioxidant activity and allelopathic effect on weeds Agronomy 10, 399: 1-14.

Bakkali , F.; S., Averbeck; D., Averbeck and M., Idaomar (2008) Biological effects of essential oils--a review. Food Chem. Toxicol; 46(2):446-475.

Cottenie, A.; M. Verloo; L. Kiek ; G. Velghe and R. Camerlynek (1982). Chemical analysis of plants and soils" Lab. Anal. and Agroch. State.

Deef, H.E., 2012. Alleviation of Allelopathic Effect of Launae sonchoids Weed on Wheat Growth by Salicylic Acid. *Egyptian Journal of Agronomy*, *34*(1), pp.19-37.

Echeverría, J. and R.D.D.G., Albuquerque (2019) Nanoemulsions of essential oils: new tool for control of Vector-Borne diseases and in vitro effects on some parasitic agents. Medicines (MDPI) DOI:10.3390/medicines 6020042.

El-Ekiaby, W. T. (2019) Basil oil Nanoemulsion formulation and its antimicrobial activity against fish pathogen and enhance disease resistance against *Aeromonashy drophila* in cultured Nile tilapia. Egypt .J. Aquac 9 (4):13-33.

El-Shahawy, T. A. (2015) Chemicals with a natural reference for controlling water hyacinth (*Eichhornia crassipes*, Mart) Solms. J. of Plant Protection Research, Vol. 55, l (3): 294-300.

Goldsmith, E. and N., Hildyard (1984) Water losses: exceeding gains? Chapter 5. In: The Social and Environmental Effects of Large Dams. Vol. 1.Overview.WadebridgeEcologicalCentre, Worthyvale Manor Camelford, Cornwall PL32 9TT,UK.

Kassas, M. (1980) Environmental aspects of water resources development.p.1–6.

Kathiresan, R, M. (2013) Allelopathy for bio-control of water hyacinth. Proceedings of the 4th World Congress on Allelopathy, August, Wagga, Australia: 1-13.

Khan, B. A.; S.,Ullah; M.K., Khan; S. M., Alshahrani and V. A., Braga (2020) Formulation and evaluation of *Ocimum basilicum* base demulgel for wound healing using animal model. Saudi Pharmaceutical Journal 28: 1842–1850.

Mahmoud, G.I. and Gaballa, H.S., 2024. Comparative study between chemical and allelochemical treatments on faba bean vegetation growth and broomrape control. *Egyptian Journal of Agronomy*, *46*(2), pp.281-294.

Marouf, A. E.; F., Harras, E. A., Shehata and G. E., Abd-Allah (2021) Efficacy of camphor oil and its Nano emulsion on the cotton leaf worm, Spodoptera Littoralis. Egypt. Acad. J. Biolog. Sci., 13 (2):103-108.

Mekky, M. S.; A. M. A., Hassanien; E. M. Kamel and A. E. A. Ismail (2019) Allelopathic effect of *Ocimum basilicum* L. extracts on weeds and some crops and its possible use as new crude bio-herbicide. Contents lists available at Science Direct Annals of Agricultural Sciences journal homepage: www.elsevier.com/locate/aoas.

Pandey, D.K. (2015) Allelochemicals from *Parthenium* for water hyacinth control. Indian Journal of Weed Science 47(3): 321–328.

Parsons, W.T. and E.G., Cuthbertson (2001) Noxious weeds of Australia. 2nd ed. Collingwood, Victoria, Australia, 698 p.

Priani, S. E.; S. S, Maulidina; F., Darusman; L., Purwanti and D., Mulyanti (2022) Development of self-Nano emulsifying drug delivery system for black seed oil (*Nigella sativa* L.). Journal of Physics: Conf. Series 1469, : 1-6.doi:10.1088/1742-6596/1469/1/012022

Robles, A. M.; A. C., Peralta; J. G., Zorrilla; G., Soriano; M., Masi; S. V., Rodríguez; A., Cimmino; M. F., Aparicio (2022) Identification of structural features of hydrocinnamic acid related to its allelopathic activity against the parasitic weed *Cuscuta campestris*. Plants 11, 2846: 1-11. https:// doi.org/10.3390/plants11212846.

USDA, Agricultural Marketing Service, Agricultural Analytics Division for the USDA National Organic Program (2016) Fatty alcohols (Octanol and Decanol).Technical Evaluation Report, P.1-16.

Wells, R.D.S. and J.S., Clayton (2005) Mechanical and chemical control of aquatic weeds: costs and benefits. In: Encyclopedia of Pest Management. DOI: 10.1081/E-EPM-120024643.

Williams, A. E. (2017) Chapter water hyacinth Van Nostr and .s Scientifc Encyclopedia, Copyright © 2006 John Wiley & Sons, Inc. DOI: 10.1002/0471743984.vse7463.pub 2: 1-12.