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Research Article

Evaluation Efficacy of Secondary Metabolites Present in Plant Extracts of *Solanum elaeagnifolium* and *Withania somnifera* in Controlling Cabbage Pests

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ABSTRACT

The study aimed to determine the population density of peach potato aphid (*Myzus persicae*) and two-spotted spider mite (*Tetranychus urticae*) on cabbage plants and to evaluate the efficacy of plant extracts in controlling these pests. GC-MS analysis of the ethanol and aqueous extracts of *Withania somnifera* confirmed the presence of a range of biologically active compounds, which may explain the biological effects observed in subsequent pest bioassays. The population density of both pests appeared on cabbage plants during the early growth stages, with the highest population density of *M. persicae* recorded in December and that of *T. urticae* in November. Following treatment with the ethanolic extract of *W. somnifera* at a 10% concentration, mortality of *M. persicae* and *T. urticae* reached 89.3% and 82.6%, respectively, after 24 h under laboratory conditions. In field experiments, the plant extracts also demonstrated effectiveness in pest management, with *W. somnifera* extract showing the greatest potency. The mortality rate caused by the ethanolic extract of *W. somnifera* was highest at 81% for green peach aphid and 72.2% for two-spotted spider mite. The efficacy shown by the ethanol extract of *S. elaeagnifolium* can be considered moderate since, after seven days of treatment, relative effectiveness values were recorded at 68.3% for *M. persicae* and 61.2% for *T. urticae*. Lowest effectiveness was observed with aqueous extract of *S. elaeagnifolium*.

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Introduction

Aphids are considered among the most damaging pests of agricultural crops worldwide. They cause significant economic losses to farmers and cultivators by their direct feeding, honeydew secretion, and mainly by transmitting viruses (Dedryver et al., 2010). More than five thousand species of aphids have been reported all over the world. Therefore, an effective management strategy is urgently needed (Favret, 2014).

The peach potato aphid, *Myzus persicae* (Sulzer), is a

highly polyphagous species. It feeds on plants belonging to more than 40 families. Its major hosts include several economically important crops such as the peach, potato, and cabbage. Apart from these, it can also act as a vector in transmitting about 100 plant viruses (Van Emden and Harrington, 2007).

Tetranychus urticae Koch, two spotted spider mite is also a serious pest with an exceptionally wide host range. Included among the long list of plants it attacks peppers, tomatoes, potatoes, melons, and strawberries as well as

roses and other ornamentals. The mites feed by puncturing the leaf cells so that feeding marks appear first as pale speckles on the leaves which later turn chlorotic patches where green tissue has been destroyed (Fasulo and Denmark 2009).

The development and application of biopesticides remain crucial in understanding the impact of plant secondary metabolites on pest populations (Ahmed and Ali, 2009, Zhao et al., 2021, Abdel Dayem and AL-Ani, 2025. Earlier studies revealed that secondary metabolites derived from plants contain insecticidal and acaricidal properties, thus very effective when used within any pest management program (Al-Jboori and Esmaeel, 2011; Al-Naemi et al., 2012; Al-Khazraji et al., 2016). *Solanum elaeagnifolium* Cav. is a species of the Solanaceae family native to the Americas. Commonly known as silverleaf nightshade, it has a wide distribution in the southwestern United States and there are also several common names by which this plant can be identified-prairie berry, silverleaf nettle, white horse nettle, and silver nightshade (Cronquist et al., 1984).

In South Africa it is known as silver-leaf bitter-apple or standbys. Most species of the genus *Solanum* bear glandular trichomes on stems, leaves and inflorescences that produce bioactive compounds with insecticidal properties (Mentz et al., 2000; Szafranek et al., 2008). *Withania somnifera* (L.) Dunal commonly known as ashwagandha or Indian ginseng or winter cherry is a perennial shrub belonging to family solanaceae native from middle east, north Africa some parts of southern Europe up to Indian subcontinent (Munir et al.,2022). The plant comprises many bioactive compounds. Most important among them are alkaloids, withanolides (steroidal lactones), sterols, flavonoids, phenolics, saponins, glycosides and volatile oil (Kaur et al., 2022). Forty withanolides and twelve alkaloids have been identified so far in which withaferin A is a major component. Due to the structural similarity between the withanolides and ginsenosides of *Panax ginseng*, *W. somnifera* is often referred to as Indian Ginseng (Gomez et al., 2023). The present study was conducted to investigate the seasonal incidence and population dynamics of key sucking pests infesting cabbage (*Brassica oleracea* L.) and to evaluate the efficacy of selected plant extracts in their management.

Materials and Methods

Collection of plant samples

Leaves of *Solanum elaeagnifolium* Cav. (wild eggplant) were collected from the Abu Ghraib/Al-Madfai area, while *Withania somnifera* (L.) Dunal samples were collected from the gardens of the Plant Protection Directorate, Abu Ghraib.

Preparation of plant extracts

Extraction procedures were carried out in the Department of Plant Biotechnology, Al-Nahrain University. Fresh leaves of *W. somnifera* and *S. elaeagnifolium* were thoroughly washed with tap water, shade-dried, and ground into a fine powder. Distilled water and ethanol were used as extraction solvents. For each extraction, 50 g of powdered plant material was soaked in 250 ml of either ethanol or sterilized distilled water for 24 h with intermittent shaking. The mixtures were then filtered through Whatman No. 1 filter paper. The ethanol extracts were concentrated under reduced pressure using a rotary evaporator at 50°C for one hour (Abdul Hadi and Al-Khazraji, 2021). Both ethanolic and aqueous extracts were subsequently dried at 45°C in an oven to obtain the crude powdered extracts, which were stored at 4°C until further use.

Stock solutions were prepared by diluting the crude extracts to a concentration of 20% (extract: solvent ratio of 1:5), followed by the preparation of working solutions at 10%, 5%, and 2.5% concentrations (Al-Ani et al., 2025).

Phytochemical analysis

Phytochemical screening using GC-MS

The phytochemical constituents of the ethanolic and aqueous extracts of *W. somnifera* were identified using Gas Chromatography-Mass Spectrometry (GC-MS) at Ibn Al-Beetar Laboratories, Ministry of Industry and Minerals, Baghdad.

The analysis was performed using an Agilent Technologies 7820A GC system coupled with a 5977E mass selective detector (MSD). The separation was achieved on an HP-5MS capillary column (30 m × 0.25 mm i.d, 0.25 μm film thickness). The mass range was set from m/z 25-1000.

Identification of compounds was based on the comparison of retention indices and mass spectral fragmentation patterns with those available in the NIST and Wiley spectral libraries.

Field preparation

A field located at the College of Agricultural Engineering Sciences, University of Baghdad, was prepared for the experiment. The field was divided into two sectors, each consisting of three rows. Each row measured 12 m in

length and 1 m in width, with 1 m spacing between adjacent rows. White cabbage plants (*Brassica oleracea* var. *capitata*, Globe variety) were transplanted on September 18, 2022.

The first sector was designated to study the population density and seasonal occurrence of the green peach aphid and the two-spotted spider mite on cabbage plants. Random samples were collected weekly, with three replicates (each row representing one replicate). Ten leaves per replicate were collected and placed in labeled polyethylene bags indicating the replicate number. The samples were then transported to the laboratory for examination under a light microscope to identify and count the various developmental stages of both pests. The experiment was laid out using a randomized complete block design (RCBD).

Evaluation of the efficacy of plant extracts in pest control

Biological evaluation

Cabbage leaves naturally infested with both the green peach aphid and the two-spotted spider mite were collected for the bioassay. The infested leaves were placed in 9 cm Petri dishes containing sterilized medical cotton moistened with sterile distilled water. The numbers of nymphs and adults of *M. persicae* were recorded before treatment. Aqueous and ethanolic extracts of *W. somnifera* and *S. elaeagnifolium* were prepared at concentrations of 10%, 5%, and 2.5%, and 3 ml of each extract was applied to the leaves using a spray tower. Control treatments were sprayed with distilled water only. The same procedure was followed for *T. urticae* larvae, nymphs, and adults. All treated Petri dishes were incubated at $27 \pm 1^\circ\text{C}$, and mortality was assessed after 24 h. Each treatment was replicated three times for each pest and concentration. The percentage mortality was calculated and corrected using Schneider and Orell's equation (Shaaban and Al Mallah, 1993).

Field evaluation

A 10% concentration is selected and applied in the field for efficacy testing of plant extracts under field conditions and their assumed role in decreasing infestations of green peach aphid and two-spotted spider mite on cabbage since this concentration recorded high mortality in laboratory bioassay. The field experiment comprises three plots as replicates. Each plot is subdivided into five experimental units, forming an RCBD. Cabbage plants were sprayed with aqueous and ethanolic extracts of *W. somnifera* and *S.*

elaegnifolium on vegetative parts using a hand sprayer. Ten leaves per experimental unit were sampled with three replications per treatment including control hence samples carried to laboratory where level infestation by pests was determined. Observations were recorded one day pre-treatment and at 1, 3, 7, and 14 days post-treatment. The relative efficacy of each plant extract was determined according to Henderson and Tilton's equation as cited by Ahmed and Al-Khazraji (2024).

Experimental design and statistical analysis

Lab bioassay data were analyzed under a Completely Randomized Design. Field data were analyzed as RCBD. The mortality rate was corrected by the formula of Schneider and Orell. All statistical analyses were carried out using GenStat release 12.1, discovery edition three software, and comparison of treatment means is made using the Least Significant Difference (LSD) test at a 5% level of probability.

Result and Discussion

Phytochemical analysis

Based on the GC-MS analysis (Figure 1), several phytochemicals were identified in the ethanolic extract of dry leaves of *W. somnifera*, including a compound eluted at a retention time (RT) of 12.770 (moderate possibly a flavonoid or sugar derivative water soluble antioxidant), 8.605 (strong Withanolides semi-polar immunomodulatory), 21.401 (possibly a flavonoid or sugar derivative), 24.655 (withaferin A amphipathic anti-inflammatory) and 29.978 (moderate steroid-like compound non-polar cytotoxic).

That is in line with what Ahmad et al. (2023) observed, reporting that *W. somnifera* bears high-value metabolites known as withanolides (WTDs). Bioactive compounds have very high potentials for therapy; hence they are used for various medicinal uses leading to overexploitation of natural *W. somnifera* populations.

Ethanol is capable of dissolving both non-polar and semi-polar compounds. Withanolides, alkaloids, and steroidal lactones are among the major groups of such compounds found in the plant. The aqueous extract contains mainly polar compounds-including sugars, amino acids, and glycosylated bioactives. GC-MS analysis results from an aqueous dry leaf extract of *W. somnifera* showed the presence of several phytochemicals possessing antimicrobial activity as well as those involved in wound healing and skin care (Figure 1).

Prominent peaks were observed at retention times

21.007, 21.259, and 21.492 min which most probably are isomers or fragmentations of a major bioactive compound. Other peaks were noticed at 25.979, 28.657, and 30.688 min may correspond to secondary metabolites frequently reported in species of *Withania* like steroids or fatty acids or alkaloids or triterpenoids. As shown in Figure 2, withaferin, a well-known anti-inflammatory compound characteristic of *Withania* spp.

was eluted at a retention time of 20.787 min while β -sitosterol eluted at 28.657 min is known for its antioxidant properties. The results agreed with earlier phytochemical reports which highlighted the insecticidal potential of *W. somnifera* against several pests such as *Bemisia tabaci*, *T. urticae*, *Aphis craccivora*, *Spodoptera littoralis* and *Nezara viridula* (Al- Jourany and Al-Khazraji, 2021; Ragab et al., 2024).

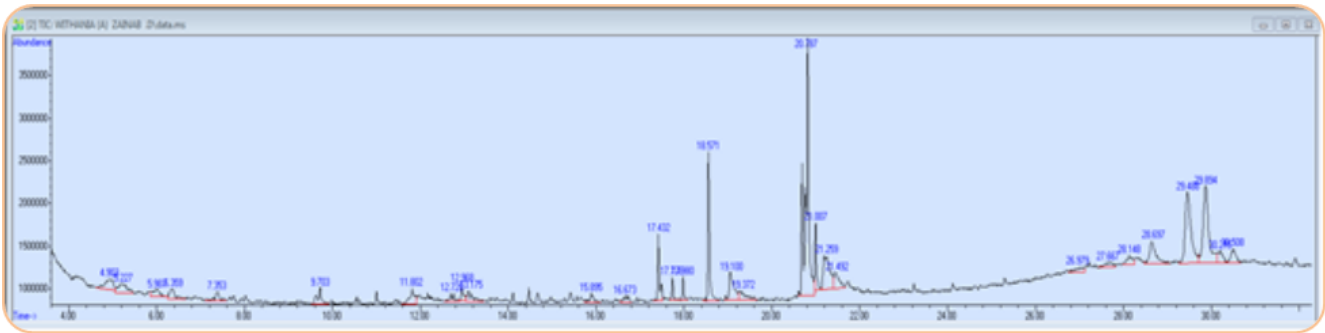


Figure 1. GC-MS analysis of the ethanolic extract of dried leaves of *W. somnifera*.

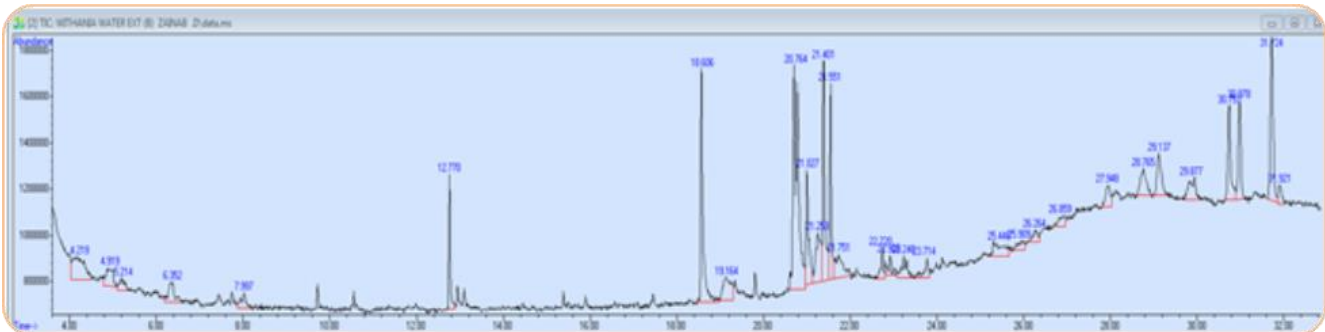


Figure 2. GC-MS analysis of the aqueous extract of dried leaves of *W. somnifera*.

Population density of the pest on cabbage plants

The population density resulting from the infestation of the green peach aphid presented in Figure 3 showed that the initial appearance of the insect occurred during the first week of October, with a low population density of approximately two adults per leaf. The nymphs appeared first in the second week of October and then slowly built up an aphid population. A maximum density of adults was recorded in the second week of December, with 37 adults per leaf. The figure depicts a uniphase population peak of *M. persicae* at the end of December, which might be attributed to conducive environmental conditions for its development. Green peach aphids initially appear on six species belonging to the family Brassicaceae at low populations (Kumar and Paul, 2017) and gradually increase as these host plants grow older or mature. They further reported that maximum

multiplication took place when temperatures started declining.

For two-spotted spider mites, results show that they infest cabbage plants early in their growth stage when only very low numbers are present; one and two-thirds eggs per leaf and one adult per leaf. The first record of the appearance of larvae and nymphs was made during the first week of November at a density level of two individuals per leaf. Thereafter, *T. urticae* built up its population gradually to reach its highest density during the second week of November with eight eggs per leaf, twenty-three individuals per leaf, and seven adults per leaf. Thereafter, the mite population declined as the plants matured, reaching the lowest densities of all developmental stages by the end of December. The figure also showed two peaks in egg production during the second and fourth weeks of November, while a single

peak for larvae and nymphs, as well as for adults, was observed in the second week of December. The relatively low population density of *T. urticae* on cabbage and eggplant, in addition to the prevailing

temperature conditions during November, might have been due to the presence of several nearby greenhouses cultivating cucumber inside plastic houses from September until late spring.

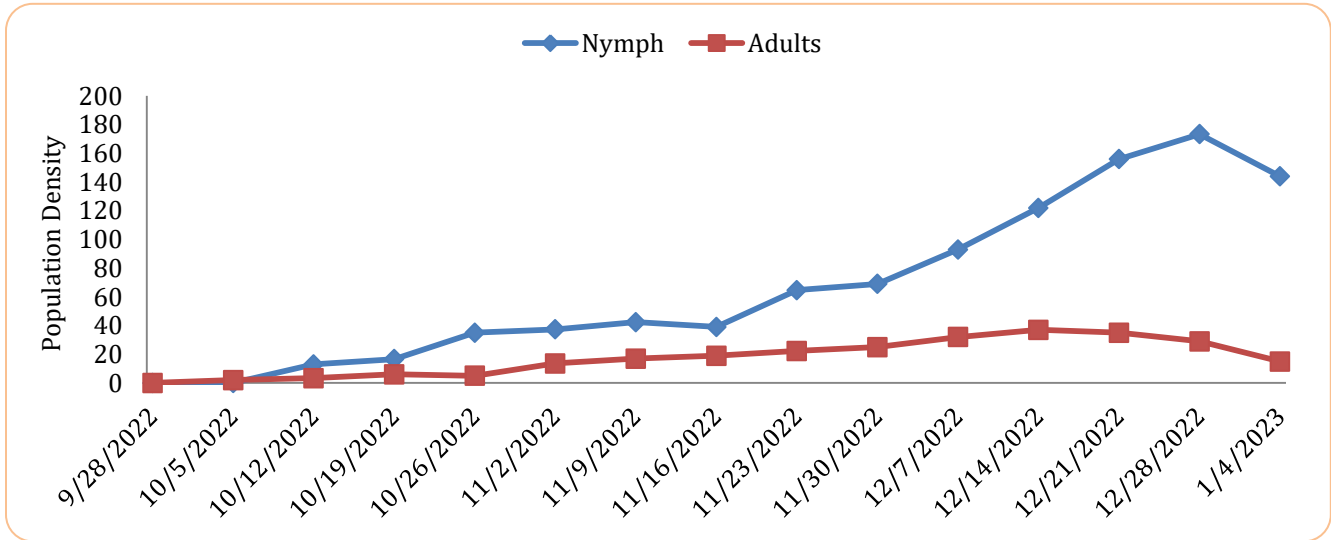


Figure 3. Population Density of the green peach aphid on white cabbage plants.

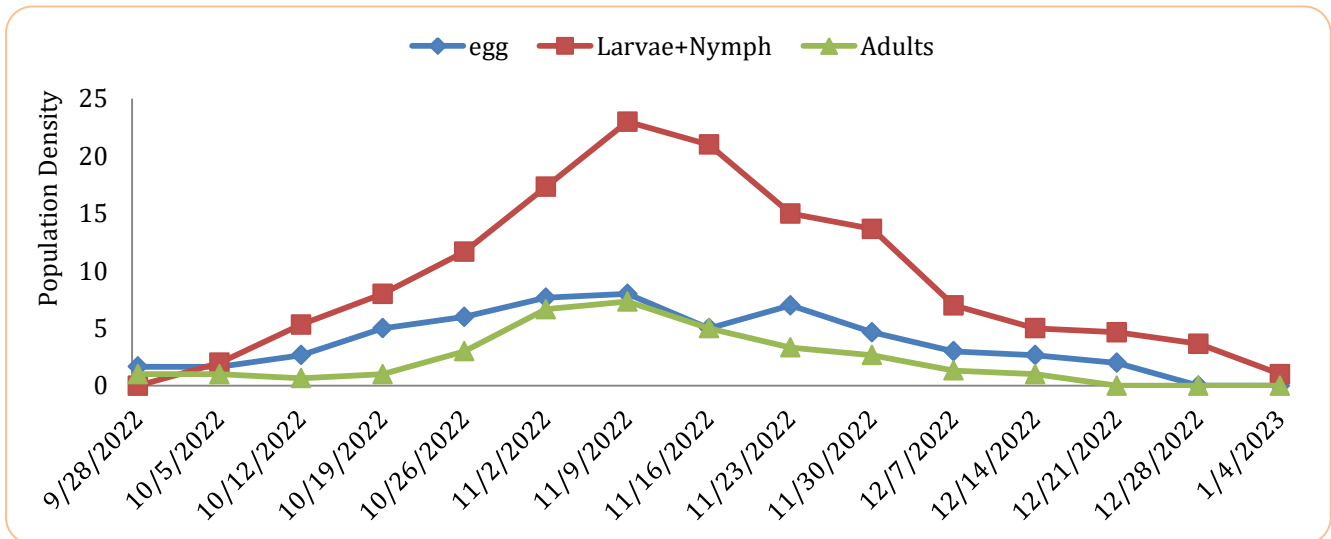


Figure 4. Population density of the two-spotted spider mite on white cabbage plants.

Percentage of pest mortality in the laboratory

Table 1 shows that after 24 h of treatment by ethanolic extract of *W. somnifera* at 10% concentration, the mortality reaches its highest level 89.3%. Aqueous extract from *W. somnifera* gave a result in mortality of 71.7% at the same concentration applied on *M. persicae*. Lowest mortalities were recorded for both two extracts at 2.5% concentrations; 60% and 43.3% respectively. Green peach aphid mortality reached 80% and 63.3%

when treated with 10% ethanolic and aqueous extracts of *S. elaeagnifolium* respectively while lowest mortalities 51.7 and 36.7 were recorded by the same extracts at lower concentrations. There were significant differences among tested plant extracts as shown by statistical analysis. The mortality of motile stages of two-spotted spider mite reached 82.6% and 65% at 10% concentration of ethanolic and aqueous extracts of *W. somnifera*, respectively. The lowest mortality rates were

50.6% and 38.3%, with ethanolic and aqueous extracts, respectively. Previous studies showed that methanolic extracts from leaves and seeds of *S. elaeagnifolium* exhibited insecticidal activity against *M. persicae*, *Phthorimaea operculella* and *Tribolium castaneum*. Among this only seed extract was toxic which caused a

mortality rate (23.6%) on *M. persicae* (Ben Hamouda et al., 2015). Our results agree with those obtained by Kobaisy et al., (2024) who reported that the active compound in *S. elaeagnifolium* is tentatively identified as being a steroidal saponin; compounds known to have strong insecticidal activity.

Table 1. Percentage mortality of the green peach aphid and the two-spotted spider mite treated with different plant extracts.

Plant Extracts	Mortality percentage for <i>M. persicae</i> at concentrations of			Mean
	10%	5%	2.5%	
<i>W. somnifera</i> ethanolic extracts	89.3	76.7	60.0	75.3
<i>W. somnifera</i> aqueous extracts	71.7	66.7	43.3	60.6
<i>S. elaeagnifolium</i> ethanolic extracts	80.0	64.0	51.7	65.2
<i>S. elaeagnifolium</i> aqueous extracts	63.3	49.3	36.7	49.8
Mean	76.1	64.2	47.9	62.7
L.S.D. (P = 0.05) for extracts = 6.86, for concentrations = 5.94, for extracts × concentrations = 11.88				
Plant Extracts	Mortality percentage for <i>T. urticae</i> at concentrations of			Mean
	10%	5%	2.5%	
<i>W. somnifera</i> ethanolic extracts	82.6	61.6	50.6	65.0
<i>W. somnifera</i> aqueous extracts	65.0	51.6	38.3	51.6
<i>S. elaeagnifolium</i> ethanolic extracts	70.0	53.3	41.6	55.0
<i>S. elaeagnifolium</i> aqueous extracts	50.0	43.3	35.0	42.7
Mean	66.9	52.5	41.4	53.6
L.S.D. (P = 0.05) for extracts = 5.86, for concentrations = 5.07, for extracts × concentrations = 10.15				

The relative effectiveness of plant extracts in controlling the green peach aphid under field conditions

As shown in Table 2, plant extracts were effective in the control of green peach aphid with *W. somnifera* being most effective. Its relative effectiveness reached 44.7% one day after treatment and a maximum of 81% seven days after application for the ethanolic extract. The aqueous extract had relative effectiveness of 42% one day after treatment to a maximum of 71% seven days after treatment and declined to 60.6% fourteen days after treatment on cabbage plants. The ethanolic extract of *S. elaeagnifolium* showed 32.4% relative effectiveness one day after treatment increasing to 68.3% seven days after application. The aqueous extract from the same plant showed maximum relative effectiveness up to sixty-point nine percent (60.9%), seven (7) days post-treatment with highly significant differences between both ethanolic and aqueous extracts of *S. elaeagnifolium*. Hyder et al. (2022) found that five botanical extracts worked effectively against *M. persicae*. Three of them are from *Citrullus colocynthis* and *Nicotiana tabacum* L., while the other two were seed oils of *Trachyspermum*

ammi and *Azadirachta indica*, plus *W. coagulans*. Botanical oils were extracted both by ethanol extraction as well as boiling extraction method. Highest mortality was recorded for *T. ammi* oil extract (81.7%), followed by *C. colocynthis* (76.5%), *N. Tabacum* (63%), *A. indica* (56.5%) and *W. coagulans* (50%). Ben Hamouda et al. (2015) reported almost similar results on *T. castaneum*, the main reason attributed towards their insecticidal activity was due to presence glycoalkaloids like solamargine, solasonine and solasodine which caused insects mortality.

The relative effectiveness of plant extracts in controlling two-spotted spider mites under field conditions

Table 3 showed that there was a considerable effect of the tested plant extracts on the two-spotted spider mite. The ethanolic and aqueous extracts of *W. somnifera* showed relative effectiveness values of 38.3% and 34.3%, respectively, with no significant difference between the two extracts. The highest relative effectiveness was recorded seven days after treatment as 72.2% for the ethanolic extract and 69.6% for the aqueous extract. The *S. elaeagnifolium* ethanolic and

aqueous extracts showed a relative effectiveness of 29.0% and 26.3%, one day after treatment while maximum effectiveness reached 61.2% and 53.6%,

seven days after treatment. Statistical analysis showed that there were significant differences in relative effectiveness between the treatments.

Table 2. Relative effectiveness of plant extracts against green peach aphids under field conditions.

Treatments	% Relative effectiveness				Mean
	1 day	3 day	7 day	14 day	
<i>W. somnifera</i> ethanolic extracts	44.7	75.8	81.0	77.9	69.8
<i>W. somnifera</i> aqueous extracts	42.0	57.7	71.0	60.6	57.8
<i>S. elaeagnifolium</i> ethanolic extracts	32.4	63.3	68.3	64.4	57.1
<i>S. elaeagnifolium</i> aqueous extracts	30.3	48.8	60.9	55.2	48.8
Mean	37.4	61.4	70.3	64.5	58.4
L.S.D.(P=0.05) for treatments 7.56, for days 8.62, for treatments× days 15.12					

Table 3. Relative efficacy of plant extracts against two-spotted spider mites under field conditions.

Treatments	% Relative effectiveness				Mean
	1 day	3 day	7 day	14 day	
<i>W. somnifera</i> ethanolic extracts	38.3	62.9	72.2	71.0	61.1
<i>W. somnifera</i> aqueous extracts	34.3	55.7	69.6	56.7	54.1
<i>S. elaeagnifolium</i> ethanolic extracts	29.0	58.5	61.2	54.5	50.8
<i>S. elaeagnifolium</i> aqueous extracts	26.3	50.8	53.6	40.4	42.8
Mean	32.0	57.0	64.1	55.6	52.2
L.S.D.(P=0.05) for treatments 7.39, for days 6.89, for treatments×days 14.78					

Conclusion

The results of this research showed that the green peach aphid and two-spotted spider mite were major pests of cabbage because they attacked the crop from its early growth stage to maturity. Their population densities at different growth stages of the plant could be attributed to changes in leaf composition by nutritional compounds responsible for pest growth and development as both pests' densities varied with different stages of plant growth. GC-MS analysis showed a wide variety of bioactive compounds in ethanol and aqueous extracts from *W. somnifera* and *S. elaeagnifolium* that explain their effectiveness in pest control. The ethanol extract was more effective, hence causing higher mortality rates within laboratory assays as well as significantly reducing the number of pests under field conditions which implies that such plant extracts could be used to integrate into pest management programs as environmentally friendly alternatives to synthetic pesticides.

Authors' Contributions

EH and HI designed the study; ZS prepared the materials, collected and analyzed the data; EH and HI supervised the studies; ZS and HI wrote the manuscript; all the authors proofread and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger

SDG 12: Responsible Consumption and Production

SDG 15: Life on Land

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