EAS Journal of Biotechnology and Genetics
Abbreviated Key Title: EAS J Biotechnol Genet
ISSN: 2663-189X (Print) & ISSN: 2663-7286 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-3 | Issue-1 | Jan-Feb-2021 | DOI: 10.36349/easjbg.2021.v03i01.002

Research Article

Phytochemical Analysis of Pyrethrum Plant Extract and its Anti-Aphid Effect On African Nightshades (*Solanum Scabrum* Mill)

Korir VJ[1*], Sikuku PA[1] and Musyimi DM[1]

[1]Department of Botany, Maseno University, Private Bag, Maseno, Kenya

Article History
Received: 02.01.2020
Accepted: 14.01.2020
Published: 20.02.2021

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: African nightshades (*Solanum scabrum)* are one of indigenous vegetables widely consumed in Kenya. Yield losses due to aphids are estimated to about 84-96% in Kenya. Aphids have developed resistance to synthetic pesticides. There is need to identify ecofriendly alternatives such as the use of botanicals like pyrethrum which are cheaper and safe to protect this potential vegetable specifically against insect pests which includes aphids, black-ants and white flies that severely reduce the yields. Plants secondary metabolites constitute a major source of bioactive substances. Pyrethrum extracts contain active ingredients which block the voltage gated sodium channels in nerve axon insects, resulting in a knockdown effect, hyperactivity, and convulsions hence death of insect pests. Little has been documented on the anti-aphid effect of pyrethrum leaf, flower and root extracts on aphids. Information on secondary metabolites in pyrethrum flower, root and leaf extracts is lacking. The objectives of this study were to determine the phytochemical constituents in pyrethrum flower, leaf and root parts and to determine the effect of different concentration levels of pyrethrum extracts on aphids affecting *S. scabrum.* The study was conducted at Maseno University farm. A field experiment was laid in Randomized Complete Block Design with three replications. Five treatments consisting of 0%, 33%, 67% and 100% pyrethrum flower, root and leaf extracts and duduthrin were applied. Phytochemical screening of extracts was carried out. *Solanum scabrum* seeds were locally sourced from the Botanic Garden, Maseno University, germinated and raised in 3m by 1m plots caged with mosquito net. After four weeks the seedlings were thinned to 9 seedlings per plot. Aphids (*Aphis fabae*) were obtained from International Center of Insect Physiology and Ecology-Nairobi were reared then introduced to every seedling (10 aphids) in all plots. Aphid population was determined weekly on leaves and by use of yellow water pan traps after treatment application. The data was subjected to analysis of variance and means were separated using Least Significant Difference at P = 0.05. The study revealed that pyrethrum flower, leaf and root extract contained phenols, saponins, alkaloids, flavonoids, tannins and phytosterols. Triterpenoids were absent in the leaf extracts. Phenols, flavonoids and triterpenoids were more in flowers than in root and leaf extract. The root exhibited more amounts of saponins, alkaloids and phytosterols. Aphid population was significantly ($p \leq 0.05$) reduced in all plant treated with pyrethrum extracts. Outstanding concentration were 100% and 67% pyrethrum flower and root extracts which recorded zero number of aphids on day 69th, 76th and 83rd day but leaf extracts showed a reduced effect. The use of 100% pyrethrum flower or root extracts is recommended to farmers in aphid control so as to realize improved yield and production of *S. scabrum* in order to reduce the overdependence on synthetic pesticides.

Keywords: *Solanum scabrum*, Phytochemical, Pyrethrum extracts, Duduthrin, Aphids.

INTRODUCTION

African nightshades (*Solanum scabrum* Mill). is one of the commonly consumed African indigenous vegetable in Kenya [1] and its role in balanced diet is indisputable. *Solanum scabrum* has been gaining attention in recent years and have become more economically competitive compared to other vegetables [2]. This is attributed to higher levels of nutrients than those in exotic vegetables such as kales and collards [1]. Most of rural communities in Kenya depend on these nutrient-dense vegetables as food, important income source and for medicinal purposes [3]. In contrast, this vegetable has received little research attention compared to other food crops despite their short growing cycles, economic benefits and role in ensuring food security [2], this could be attributed to its low leaf yields and frequent pest attack. Insect pests remain one of the most significant constraints to nightshade production [4]. Farmers need information on cheap, effective and safe ways particularly botanicals to

***Corresponding Author: Korir VJ**

protect this potential vegetable specifically against insect pests which includes aphids, black-ants and white flies that severely reduce the yields [5].

African nightshades in Kenya are severely damaged by aphids [5]. *Aphis fabae* reduces both weight and caloric content of young African nightshades by as much as 64 and 113%, respectively, depending on the number of feeding aphids and yield losses due to aphids are estimated to be about 84-96% in Kenya [6]. Aphids are tiny, 1-3 mm long, soft-bodied, pear-shaped insects. They can be winged or wingless and vary tremendously in colour and shape, and feed on almost every part of the plant [7]. Aphids have been known to cause the greatest manace on *Solanum spp,* kales, wheat and several crops because they are serious phloem feeders and persistent in a farm [8]. Aphids feed by sucking plant sap, feeding on the growing tips and undersides of leaves, where they congregate in large numbers [7]. Aphids can attain very high densities on young plant, and direct feeding of aphid's results into reduced growth rates, yields of green leaves, chlorosis and reduced stem reserves and storage organs [9]. Aphids also have very short life cycle, high reproductive rate and are resistant to different insecticides which make their management and control difficult [10], hence the need to come up with a better and proper control method in order to realize improved Solanum productivity.

Majority of smallholder vegetable farmers use synthetic chemicals to reduce this crisis yet their use has not substantially reduced the pest losses [11]. Additionally, overzealous and indiscriminate use of many synthetic pesticides has resulted in a number of environmental and toxicological problems. A potential means to break the reliance on pesticides is by using alternative sources like plant extracts. These plant based products possess bioactive compounds called secondary metabolites which are preferred because they are environmentally safe, locally available and cheap and effective with no side effects or resistance [10]. Or can be integrated with other practices for effective pest management.

Plants secondary metabolites constitute a major source of bioactive substances. One widely proven organic insecticidal plant extracts are those from pyrethrum [10]. Pyrethrum belongs to the family Compositae; the largest family among the angiosperms with a world-wide distribution [12]. There are three species of pyrethrum namely, the *Chrysanthemum cinerariaefolium*, *Chrysanthemum roseum*, and *Chrysanthemum coccineum;* these plants are economically important as a natural source of insecticide [13]. Pyrethrum has bioactive substances which are insecticidal [13]. Information on secondary metabolites in pyrethrum flower, root and leaf extracts is lacking.

Pyrethrum extracts contain active ingredients which block the voltage gated sodium channels in nerve axon insects, resulting in a knockdown effect, hyperactivity, and convulsions hence death of insect pests. This occurs when the insects ingest or are exposed to these botanicals. Pyrethrum flower extracts are sprayed on broccoli plants for protection from several common insect pest including aphids, leafhoppers and spider mites. Haouas *et al*. [14] investigated insecticidal activity of flower and leaf extracts from *Chrysanthemum* species against flour beetle (*Tribolium confusum).* They reported that high toxicities were noted in flower methanolic extracts as compared to leaf methanolic extracts. Little has been documented on the anti-aphid effect of pyrethrum leaf, flower and root extracts on aphids. Additionally, Qureshi *et al*. [10] used garlic and pyrethrum flower to evaluate insecticidal effect against grass grub beetles (*Costelytra zealandica)*, a rapid knockdown was observed from extracts compared to synthetic insecticide used. However, these studies of Haouas *et al*. [14] and Qureshi *et al*. [10] disregarded the use of pyrethrum root extracts which perhaps might have a distinct toxicity and has not been done hence the need to investigate the anti-aphid effects of different concentrations of pyrethrum flower, root and leaf extracts on aphids affecting *Solanum scabrum*.

MATERIALS AND METHODS

Experimental Site

The study was carried out at Maseno University farm between March- June, 2018. Confirmatory study of the same was repeated in September to December, 2018. The experimental area lies at latitude 0º1'N0º12'S and longitude 34º25'E-34º47'E. The soils are classified as acrisol, deep reddish brown friable clay with pH ranging from 4.5 to 5.5. Soil organic carbon and phosphorus contents are 1.8% and 4.5 mg kg-1, respectively [15]. It is approximately 1,500 m above the sea level and receives an annual mean precipitation of 1,750 mm with bimodal pattern of distribution and the mean air temperature is 28.7ºC with a 40% relative humidity [16].

Collection of Pyrethrum

Pyrethrum flowers, leaves and roots were collected from Kenya Agriculture and Livestock Research Organization (KALRO) - Kitale branch. The flowers, leaves and roots were packed in separate bags and transported to Maseno University, Maseno, Kenya. The plant parts were sundried in shade until completely dry for ten days according to the procedure of Cox [17], who reported that the process of drying under sun light helps in increasing pyrethrin content. They were ground separately using heavy duty laboratory mill into fine powder then stored in airtight plastic containers at room temperature (25 ºC) for extractions. This kind of storage prevented moisture absorption from the atmosphere.

Preparation of Pyrethrum Extracts

Pyrethrum plant extracts were prepared weekly during the study period by quantifying 100 grams of dry flowers, 100 grams of dry leaves and 100 grams of dry roots separately. Each part of the pyrethrum was soaked in 250 ml of 70% ethanol under fume hood at room temperature for 3 days to extract most bioactive compounds [14]. For the case of extract preparation, ethanol solvent was used this is in accordance to Nowrid [18] who reported that the use of ethanol in extract preparation will result in to collection of highest amount of extracts compared to methanol. Ethanol dissolves more bioactive compounds in pyrethrum. The solvents and different parts of pyrethrum (flower, leaves and roots) were filtered using filter paper (Whatman no. 1). The extracts were taken to dryness under vacuum at 35°C and then dissolved in acetone to obtain a final concentration of 100%. Different concentrations that is 67% and 33% was prepared from the final extract [14]. The choice of the different fore mentioned concentrations was based on the procedure of Jangam *et al*. [19] where they stated that for highest % repellency to be found in plant extracts, 100% followed by 67% concentration level should be employed and minimum % repellency is seen in 33% in some selected herbal plants for pest management (among them is pyrethrum). As the dose increases, the repellant effect also increased. The use of such plant extracts can control the population of serious pests like aphids and mealybugs in an environmental friendly way Jangam *et al*., [19].

Phytochemical Screening

The solvent extracts of pyrethrum plant parts i.e. flower, leaf and root) were subjected to routine qualitative chemical analysis to identify the nature of phytochemical constituents present in sample [20]. The varying amount was distinguished from the intensity of their colours. The choice of phytochemicals screened was linked to their cytotoxic, deleterious and defensive mechanisms against phytophagous insects like aphids

Determination of Phytosterols

To 3 ml of flower extracts, chloroform was added then filtered. The filtrates were treated with 3 drops of acetic anhydride, boiled and cooled. Concentrated Sulphuric acid was added. Formation of brown ring at the junction indicated the presence of phytosterols. The procedure was repeated for leaf and root extracts.

Determination of Alkaloids

To 3 ml of flower extracts, 1 ml of dilute Hydrochloric acid was added then filtered. Two drops of Mayer's reagent was then added to the filtrate. Formation of yellow coloured precipitate or turbidity indicated the presence of alkaloids. The procedure was repeated for leaf and root extracts.

Test for Phenols

To 3 ml of flower extracts, 3 drops of ferric chloride (5%) solution was added. Formation of bluish black colour indicated the presence of phenols. The procedure was repeated for leaf and root extracts.

Test for Flavonoids

To 3 ml of flower extracts, two drops of sodium hydroxide solution was added. Formation of intense yellow colour, which became colourless on addition of dilute acid, indicated the presence of flavonoids. The procedure was repeated for leaf and root extracts.

Test for Saponins

To 3 ml of flower extracts, 2 ml of water was added then shaken. Formation of foamy lather indicated the presence of saponins. The procedure was repeated for leaf and root extracts.

Triterpenoids

To 3 ml of flower extracts, a piece of tin and 2 drops of thionyl chloride was added. Formation of violet or purple colour indicated the presence of triterpenoids. The procedure was repeated for leaf and root extracts.

Detection of tannins

To 3 ml of flower extract, 1% gelatin solution containing sodium chloride was added. Formation of white precipitate indicated the presence of tannins. The procedure was repeated for leaf and root extracts.

Preparation of Plot and Planting of African nightshades (*Solanum scabrum*)

The land measuring 18.5m by 13m was cleared first and primary cultivation carried out. Secondary cultivation followed after one week [21]. Forty-five (45) experimental plots were prepared following the procedure of Ahmed [22], Kora and Teshemo [23] with some modifications. The total number of plots was used following the five treatments used for every pyrethrum flower, leaf and root part and three replications. A plot of 3m by 1m was prepared by raising the soil about 15 cm above ground [24]. A path of 50cm was left between plots and 100cm path between blocks. African nightshades (*Solanum scabrum*) seeds were locally sourced from School of Agriculture, Maseno University. Di-Ammonium Phosphate (DAP) fertilizer rich in nitrogen and phosphorus was applied to the soil and mixed thoroughly before sowing. Six sowing lines (rows) at a spacing of 40 cm were made in every plot and 3 seeds were sown. Watering was done twice daily, in the morning and evening [21; Muthomi and Musyimi [25] for good growth. After four weeks, seedlings were thinned to 9 seedlings per plot according to Carnot *et al*. [5]. Each seedling had a spacing of 40 cm by 40cm on slightly raised beds [21]. The plots were caged using mosquito net placed vertically above and to a depth of 50cm in order to minimize migration and monitor the

aphid population [26]. The plots were manually maintained weed-free. African nightshades (*Solanum scabrum*) took 12 weeks to mature.

Rearing of Aphids and Infestation of Vegetables

Aphids (*Aphis fabae*) free from viruses were obtained from International Center of Insect Physiology and Ecology (ICIPE)-Nairobi. To obtain enough aphids for the study, the aphids were reared on three potted disease-free *Solanum scabrum* seedlings in Maseno University greenhouse for two weeks prior to their introduction to vegetables in caged experimental plots in the farm. Enough aphids were collected from the spreader plants and 10 aphids (constant number) were introduced to each 5 weeks-old African nightshades seedling [8]. Aphid population was monitored for 10 days to ensure equal infestation, also the movement of aphids on the plant following introduction was observed [8].

Determination of Aphid Population

Aphid population was assessed following the procedure used by Muthomi *et al*. [25]. Aphid population was monitored on leaves and by use of yellow water pan traps. Leaves were used to monitor wingless (apteral) aphids while the yellow water pan traps were used to monitor winged (alate) aphids. Five plants were randomly selected from each plot with 9 plants [22] and counting of aphids from each plant was done every 24 hours after treatment application to the vegetable till the end of experiment. Treatments used were: 0%, 33%, 67% and 100% of pyrethrum flower, leaf and root extracts and a synthetic chemical Duduthrin® (Lambda-cyhalothrin 17.5g/litre) was used as standard check and sterile water as untreated control. The rate 25ml/litre of water was used since it is the rate recommended for aphids, thrips, leafhoppers and caterpillers [10]. In the untreated plot (negative control), the seedlings were sprayed with sterile water and the standard check plot (positive control) was sprayed with synthetic chemical Duduthrin® at a rate of 35ml/20litre of water. The spraying was done in the evening using knapsack sprayer at seven-day interval according to Ahmed, [22] throughout the season to get full control of the target (aphids) pests, keeping in mind good coverage of the plant. Treatments were therefore applied when the aphid population reached economic threshold Level *viz*. 35% of infested irrespective of the stage of growth. The threshold was achieved when the tallied number of aphids per plant reached 30 aphids. The average number of aphids detected in each count was computed for each treatment. The yellow water pan traps consisted of yellow basins ¾ filled with water and a few drops of liquid detergent added to break the surface tension to make the trapped insects sink to the bottom and most of them died hence were disposed. Two water pan traps were placed in each plot. The traps were replaced weekly and aphid counts taken [27].

DATA ANALYSIS

Data collected were subjected to statistical analysis using SAS Procedure (SAS Institute, 1998). Means were separated and compared using the Least Significant Difference (LSD) at p=0.05 [29].

RESULTS

Determination of Phytochemicals in Pyrethrum Flower, Root and Leaf Parts

The phytochemical screening of flower, leaf and roots parts of pyrethrum indicated the presence of phenols, saponins, alkaloids, flavonoids, tannins and phytosterols (Table 1). Triterpenoids were absent in pyrethrum leaf extract as shown in Table 1. Findings from this study showed that different pyrethrum parts contain varying amounts of secondary metabolites and was distinguished by the intensity of the colours. Pyrethrum flower extracts recorded the highest amount of phenols, flavonoids and triterpenoids, average amount of saponins, alkaloids, tannins and little amount of phytosterols. Pyrethrum leaf extracts showed average amount of phytosterols, alkaloids, phenols, flavonoids, tannins, little amount of saponins but triterpenoids were absent. Pyrethrum root extracts indicated a higher amount of saponins, alkaloids and phytosterols but showed little amount of phenols, flavonoids and tannins.

Table-1: Secondary metabolites in pyrethrum (*Chrysanthemum cinerariaefolium*) flower, leaf and root extracts

Secondary Metabolite	Presence or Absence in Plant Parts		
	Flowers	Leaves	Roots
Phytosterols	+	++	+++
Alkaloids	++	++	+++
Phenols	+++	++	+
Flavanoids	+++	++	+
Saponins	++	+	+++
Triterpenoids	+++	—	++
Tannins	++	++	+

Key

+++: Present in high amount +: Present in little amount
++: Present in average amount —: Absent

Determination of Effect of pyrethrum extracts on aphid population on *Solanum scabrum*

The effect of different concentrations of pyrethrum extracts on aphid population on *Solanum scabrum* are presented in Tables 2. From the results different concentrations i.e. 33%, 67% and 100% of pyrethrum flower, root and leaf extracts showed no significant difference ($p \geq 0.05$) in aphid number in day 60 but the fore mentioned concentrations were significantly different in Day 62,69,76 and 83. *Solanum scabrum* treated with 100% pyrethrum flower extracts recorded zero (0.00 aphids) number of aphids on 69th and 83rd days while 67% recorded zero count (0.00 aphids) on 76th and 83rd days. The effect of duduthrin on aphid population was not significantly different ($p \geq 0.05$) from the effect of 100%, 67% and 33% pyrethrum flower treatments. On 76th day, plants treated with duduthrin recorded zero aphid count but the number increased to 11 aphids on 83rd day. From the results, different concentrations of pyrethrum root extracts showed no significant effect on aphid population on 60th day. On 62nd day, significant effect on aphid population was noted from 33%, 67% and 100% pyrethrum root extracts as compared to control (0%) which maintained a higher aphid count of 126 aphids. Though, aphids were sensitive to 33% pyrethrum flower, root and leaf extracts, their number was not greatly reduced. A similar fore mentioned observation was noted on 69th, 76th and 83rd days. On 76th and 83rd days plants treated with 67% pyrethrum root extracts significantly reduced aphid population to zero, also on 69th day plants treated with 100% pyrethrum root extracts caused 100% kill of aphids. *Solanum scabrum* treated with varying concentrations of pyrethrum leaf extracts on 60th day showed no significant difference in the aphid population. On 62nd, 76th and 83rd days, significant effect on aphid population were noted from 33%, 67% and 100% pyrethrum leaf extracts as compared to control (0%) where the number of aphids continuously increased. Aphid number varied significantly in treatments 33%, 67% and 100% pyrethrum leaf extracts as compared to control but aphid population on *Solanum scabrum* treated with duduthrin did not differ significantly with 33% on 76th day. *Solanum scabrum* treated with control showed no significant effect ($p \geq 0.05$) on aphid number therefore, a higher aphid number observed all through. The pyrethrum extracts used in the study were found to be more or as effective as the standard check Duduthrin® (Lambda-cyhalothrin 17.5g/litre). There were significant interactions between pyrethrum extract concentration.

Table-2: Effect of different concentrations (33%, 67% and 100%) of pyrethrum flower, leaf and root extracts on aphid population on *Solanum scabrum* from 60th to 83rd days

Plant parts	Treatments Extract concentrations	*Days*				
		Day 60	*Day 62*	*Day 69*	*Day 76*	*Day 83*
Flower	0%	100.67a	160.33a	195.00a	266.00a	323.00a
	33%	107.00a	77.00b	6.00b	2.67b	1.67b
	67%	104.00a	53.00bc	3.33b	0.00b	0.00b
	100%	106.67a	39.00c	0.00b	7.67b	0.00b
	Duduthrin	104.67a	40.00c	15.00b	0.00b	11.00b
	LSD	46.45	31.46	29.95	29.07	24.63
Root	0%	108.00a	126.00a	168.00a	203.00a	251.00a
	33%	104.00a	45.00b	8.67b	1.33b	3.00b
	67%	108.67a	47.33b	5.33b	0.00b	0.00b
	100%	112.33a	58.00b	0.00b	5.33b	2.00b
	Duduthrin	110.33a	48.33b	18.00b	2.33b	3.00b
	LSD	66.68	50.55	21.92	31.89	35.34
Leaf	0%	103.00a	142.00a	180.00a	207.67a	275.33a
	33%	107.00a	86.00b	19.33bc	8.33b	4.33b
	67%	105.33a	71.67b	27.33b	11.00b	2.67b
	100%	104.00a	67.33b	2.33c	2.33b	5.00b
	Duduthrin	102.00a	67.67b	18.00bc	3.67b	6.67b
	LSD	47.77	48.67	24.85	30.55	26.96

Means with the same letter down the column are not significantly different at $p \leq 0.05$.

DISCUSSION

Phytochemical constituents of pyrethrum (*Chrysanthemum cinerariaefolium* Vis)

In the present study, the extracts of flower, leaf and roots of pyrethrum showed the presence of alkaloids, flavonoids, phytosterols, phenols, tannins, triterpenoids and saponins. The concentration of the bioactive compounds varied in pyrethrum plant parts with each part showing a distinct amount. Pyrethrum flower extracts recorded the highest amount of phenols, flavonoids and triterpenoids, average amount of saponins, alkaloids, tannins and little amount of phytosterols. Pyrethrum leaf extracts showed average amount of phytosterols, alkaloids, phenols, flavonoids, tannins, little amount of saponins but triterpenoids were

absent. Pyrethrum root extracts indicated a higher amount of saponins, alkaloids and phytosterols but showed little amount of phenols, flavonoids and tannins. The distinct insecticidal potency of each pyrethrum plant part against aphids might have been attributed to the variation in phytochemicals. Pyrethrum plant extracts and its phytoconstituents have been reported for anti-feedant, repellant and insecticidal activities [14]. Basically when botanicals are used for insecticidal purpose, their value is dependent on the phytochemicals they possess [30].

Alkaloids have been reported as the most important group of natural substances playing an important role in plant defenses. Their presence in pyrethrum flower and root extracts may have contributed largely to anti-aphid activity of these extracts. This is attributed by their plant defensive mechanisms against phytophagous insects. It has been suggested that they constitute part of plant defense along with terpenoids, phenols, flavonoids, tannins and steroids [17]. Pyrethrum leaf extracts showed anti-aphid activity despite the fact that the amounts of the phytochemicals they possess were little to average. This may be due to the fact that these compounds are insecticidal even at low concentrations. This is in agreement with the finding of Rattan [31] who reported that insecticidal compounds are effective in low levels and their mechanism of action differ, but many affect acetylcholine receptors in the nervous system or membrane sodium channels of nerves. In tomato, alkaloids, phenolics, proteinase inhibitors and the oxidative enzymes when ingested separately result in a reduced affect, but act together in a synergistic manner, affecting the insect during ingestion, digestion and metabolism.

Flavonoids present in pyrethrum extracts may have contributed largely to anti-aphid activity through their cytotoxicity and interaction with different enzymes through complexation. This is in line with the finding of Hare [32] who reported that both flavonoids and isoflavonoids protect the plant against insect pests by influencing the behavior, and growth and development of insects Shripad *et al.* [33] reported insecticidal and antimicrobial activities of flavonoids isolated from *Ricinus communis* against *C. chinensis*. The anti-aphid activity may be attributed to the synergistic effects of phenolic compounds which include flavonoids.

Both pyrethrum flowers and root extracts had average amount of tannins. Tannins may have played a larger role in destroying aphids as they are known to have a strong deleterious effect on phytophagous insects. This agrees with those of Sharma *et al*. [34] who found out that tannins affect the insect growth and development by binding to the proteins, reduce nutrient absorption efficiency and cause midgut lesions. Tannins are astringent (mouth puckering) bitter polyphenols and act as feeding deterrents to many insect pests. When ingested, tannins reduce the digestibility of the proteins thereby decrease the nutritive value of plants and plant parts to herbivores. Role of tannins in plant defense against various stresses and their induction in response to insect damage has been studied in many plants [35].

In a study done by De Geyter *et al.* [36], the insecticidal and deterrent activity of crude fruit sap extract of *S. incanum* was attributed to the presence of saponins, which were associated with the alterations in the feeding behaviour, molting process, interaction with hormones that regulated the growth and caused death at different stages of development. Additionally, in a study carried out by Marianna *et al*. [37], the pesticidal activity of saponins was attributed to their wide spectrum of action and its amplitude of physiological impacts therefore saponins may have played an important role in control of aphids.

Effects of pyrethrum extracts on aphid population on *Solanum scabrum*

Results indicated that pyrethrum root extracts caused significant reduction in aphid population (61.27 aphids) as compared to flower extracts and leaf extracts. The reduction in number of aphids after application of different parts of pyrethrum (flower, roots and leaf) extracts depicted the presence of bioactive compounds which may have caused the death of aphids. *Solanum scabrum* treated with 100% pyrethrum flower extracts recorded zero (0.00 aphids) number of aphids on 69th and 83rd days while 67% recorded zero count (0.00 aphids) on 76th and 83rd days The zero count of aphids observed in plants treated with 100% flower extracts on Day 69 and 67% on day 76 indicated the effectiveness of pyrethrum extracts at different forestated concentration levels. Alkaloids have plant defensive mechanisms against phytophagous insects which affect acetylcholine receptors in the nervous system or membrane sodium channels of nerves. Terpenoids, phenols and steroids ingested separately act together in a synergistic manner, affecting the insect during ingestion, digestion and metabolism, flavonoids cause mortality of phytophagous insects through their cytotoxicity and interaction with different enzymes through complexation and tannins possess a strong deleterious effect on insects. These results are in agreement with the findings of Pavela [38] who reported that the extracts derived from *Chrysanthemum cinerariifolium* caused 100% mortality rate against *M. persicae* after 12 days of treatment. This could be due to one or more groups of active principle(s) present in the extracts [39]. Qualitative phytochemical screening revealed that higher amounts of alkaloids, saponins, phytosteroids, phenols and flavonoids were detected in the pyrethrum root and flower extracts. These phytochemicals are important for mediating interactions between plants and their biotic environment and do not have apparent function in physical or biochemical processes [40]. A number of these phytochemicals have

been shown to have insecticidal and also deterrent activities against various insects [39].

In addition, the use of root extracts of pyrethrum showed better anti-aphid effects than leaf extracts of pyrethrum and this may be attributed to the presence of pyrethrins intermediates in roots which are absent in leaf extracts of pyrethrums. In a study done by Ramirez [41], pyrethrins intermediates in pyrethrum root extracts reduced mycelial growth rates of *R. solani*. This is possible owing to the intercellular transport mechanisms of monoterpenoid intermediates which occur in the biosynthesis of pyrethrins [41].

In addition, Pyrethrum flower extracts also showed a drastic mortality of aphids, this may be attributed to a higher recorded amount on phenols and flavonoids. The known active ingredients pyrethrins present in the flower extracts might have resulted into a knockdown effect, hyperactivity, and convulsions hence death of aphids due to blockage of the voltage gated sodium channels in nerve axon. This occurs when the aphids ingest or are exposed to these botanicals. The molecular structure of the pyrethrins allows the long lasting connection to the receptors and thus causes an enduring excitation of the nerve cells by a permanent uncontrolled inflow of Na^+ ions into the cell. This causes the symptom tremor in the insects which leads to a quick death. Insect susceptibility to pyrethrin is attributable to cuticular permeability and sensitivity of internal tissues that control oxidative enzyme systems.

The results indicate that both pyrethrum flower and root extracts may be good remedy for aphid control owing to their effectiveness against the intended pest. It is noticeable that aphids were less affected by pyrethrum leaf extracts as compared to fore mentioned extracts. This may be depicted by reduced amount of saponins and average quantity of phenols, alkaloids, flavonoids and phytosteroids present in pyrethrum leaf extracts. This is also in line with the study by Michuki [42] that, the majority of the active constituents are present in the mature fully opened flower head, whereas the stem/leaves contains only about 0.1% as much. This may be due to translocation of pyrethrins to the intercellular space of leaves and achenes being an adaptation to accumulate larger pyrethrin quantities, or to preserve the bioactivity of these compounds, as pyrethrins are sensitive to UV degradation hence shadowed or greatly reduced in leaves.

With the 100% showing the highest mortality of aphids and 33% with least mortality, this may be attributed to the concentration of bioactive compounds. Undiluted extracts were highly toxic as compared to diluted ones. However, secondary metabolites from different plant species cause physiological and cellular disturbances that include inhibition of acetylcholinesterase, disruption of sodium and potassium ion exchange (by pyrethrin), and interference of mitochondrial respiration [43].

CONCLUSIONS

The present investigation revealed that pyrethrum flower; root and leaf extracts have varying concentration of phytochemical compounds which are anti-aphid. They include: alkaloids, saponins, flavonoids, phytostreroids, phenols, triterpenes, tannins and pyrethrins. Triterpenoids were absent in the leaf extracts. Phenols, flavonoids and triterpenoids were more in flowers than in root and leaf extract. The root exhibited more amounts of saponins, alkaloids and phytosterols. Aphid control can be achieved using 100% and 67% pyrethrum flower and root extracts. It can be harnessed by smallholder farmers instead of depending on expensive synthetic pesticides.

REFERENCES

1. Edmonds, J. M., & Chweya, J. A. (1997). *Black nightshades: Solanum nigrum L. and related species* (Vol. 15). Bioversity International.
2. Kamga, R. T., Some, S., Tenkouano, A., Issaka, Y. B., & Ndoye, O. (2016). Assessment of traditional African vegetable production in Burkina Faso. *Journal of Agricultural Extension and Rural Development*, *8*(8), 141-150.
3. Onyango, M. A., Obiero, H., & Miruka, M. (2000). Indigenous green leafy vegetables in Kenya: a case of a neglected resource. *Participatory technology development for soil management by smallholders in Kenya. KARI. Kenya*.
4. Omondi, J. V. H. (2015). Effects of insecticide treated nets in the management of tomato pests and their impact on natural enemies and yield in Nairobi and Murang'a counties (Master's thesis). *The School of Pure and Applied Sciences of Kenyatta University, Kenya*.
5. Carnot, A. C., Alvarest, T. T. E., Justin, O., Zachée, A., & Fabrice, M. T. (2017). Effect of culture density of black nightshade (Solanum nigrum) on the insect infestation. *Plant*, *5*, 19-26.
6. Ngurwe, J. K., Wanjala, F. M., Ochieno, D. M., & Kiptoo, G. J. (2018). Infestation and damage of black nightshade (Solanum nigrum) by black bean aphid (Aphis fabae) and red spider mite (Tetranychus evansi). *International Journal of Agronomy and Agricultural Research*, *13*(5), 79-88.
7. Capinera, J. (2001). Handbook of vegetable pest. (1st ed.). Academic Press, New York, 270-273.
8. Ashilenje, D. S., Omunyin, M. E., & Okalebo, J. R. (2011). Influence of potassium on aphid incidence and yield of vegetable African nightshades (Solanum L. section Solanum). *Annals of Biological Research*, *2*(3), 317-326.
9. Golawska, S., Krzyzanowski, R., & Lukasik, I. (2010). Relationship between aphid infestation and

chlorophyll content in Fabacea species. *Acta Biologica Cracoviensia. Series Botanica*, *52*(2).
10. Qureshi, M. S., Jackson, T. A., Townsend, R. J., & Saville, D. J. (2002). Toxicity of neem and pyrethrum extracts to adult grass grub. *New Zealand plant protection*, *55*, 298-302.
11. Mamun, M. S. A., & Ahmed, M. (2011). Prospect of indigenous plant extracts in tea pest management. *International Journal of Agricultural Research, Innovation and Technology (IJARIT)*, *1*(2355-2020-1485), 16-23.
12. Ghafoor, A. (2002). Asteraceae. In Ali, S.I., & Qaiser, M. (eds.), Anthemideae in Flora of Pakistan. Jointly published by Department of Botany, University of Karachi and Missouri Botanical Press, *Missoui Botanical Garden, St. Louis, Missouri: U.S.A*, 207.
13. Wandahwa, P., Van Ranst, E., & Van Damme, P. (1996). Pyrethrum (Chrysanthemum cinerariaefolium Vis.) cultivation in West Kenya: origin, ecological conditions and management. *Industrial Crops and Products*, *5*(4), 307-322.
14. Haouas, D., Halima-Kamel, M. B., & Hamouda, M. H. (2008). Insecticidal activity of flower and leaf extracts from Chrysanthemum species against Tribolium confusum. *Tunisian Journal of Plant Protection*, *3*(2), 87.
15. Netondo, G. W. (1999). *The use of physiological parameters in screening for salt tolerance in sorghum (Sorghum bicolor L. Moench) varieties grown in Kenya* (Doctoral dissertation, D. Phil Thesis, Moi University Kenya).
16. Ambede, J. G., Netondo, G. W., Mwai, G. N., & Musyimi, D. M. (2012). NaCl salinity affects germination, growth, physiology, and biochemistry of bambara groundnut. *Brazilian Journal of Plant Physiology*, *24*(3), 151-160.
17. Cox, C. (2002). Insecticide fact sheet: Pyrethrins/Pyrethrum. *Journal of Pesticide Reform*, 22(1), 14-20.
18. Nowrid, N. (2017). *Phytochemical screening and the analysis of antibacterial activity in Chrysanthemum morifolium Ramat* (Doctoral dissertation, BRAC University).
19. Jangam, S.S., Chaudhari, P.S., Chaudhari S.V. & Baheti, K.G. (2014). Herbal plants for insect pest management. *International Journal of scientific and Engineerimg Research*, *5*(3), 356-363.
20. Subasri, G., & Ahmed John, S. (2016). Screening of phytochemical compounds, trace metals and antimicrobial activity of Anacyclus pyrethrum. *International Journal of Advances in Scientific Research*, *2*(1), 32-37.
21. Kipkosgei, L.K., Akundabwani, L.S.M., & Hutchinson, M.J. (2003). The effect of farmyard manure and nitrogen fertilizer on vegetative growth yield, leaf yield and quality attributes of Solanum villosum (Black nightshade) in Keiyo district, Rift Valley. *African Crop Science Conference Proceedings*, 6, 514-518.
22. Ahmed, M.M. (2000). Studies on the control of insect pests in vegetables (okra, tomato and onion) in Sudan with special reference to neem preparations. *PhD thesis, University of Giessen, Germany*.
23. Kora, D., & Teshome, E. (2016). Field evaluation of some botanical extracts against pea aphid Acrythosiphon pisum (Homoptera: Aphididae) on field pea Pisum sativum L. *Journal of Entomology and Zoology Studies*, *4*(4), 336-339.
24. Masinde, P.W., Wesonga, J.M., Ojiewo, C.O., Agong, S.C., & Masuda, M. (2009). Plant growth, water relations and leaf content of Solanum villosum genotypes in response to nitrogen supply. *Dynamic Soil, Dynamic Plant*, 3, 36-47.
25. Muthomi, J.W., & Musyimi, D.M. (2009). Growth responses of African nightshades (Solanum scabrum Mill.) seedlings to water deficit. *Journal of Agricultural and Biological Science*, 5, 24-31.
26. Araka, G.O., Ochara, J., & Wakhisi, J. (2016). Larvicidal efficacy of crude essential oil (leaf extracts) of pyrethrum (Chrysanthemum: Compositae), Eucalyptus camaldulensis Sm (Myrtaceae) and Nicotiana tabaccum (Tobacco L.) (Solanaceace) against third instar larvae of the malaria vector Anopheles gambiae s.s Giles (Diptera: Culicidae). *International Journal of Science and Research*, *5*(3), 370-375.
27. Muthomi, J.W., Nyaga, J.N., Olubayo, F.M., Nderitu, J. H., Kabira, J.N., Kiretai, S.M., Aura, J.A., & Wakahiu, M. (2009). Incidence of Aphid-transmitted viruses in farmer-based sweet potato production in Kenya. *Asian Journal of Plant Sciences*, *8*(2), 166-171.
28. SAS Institute. (1998). SAS/STAT guide for personal computers, Version 6.12 Edition. Cary N. C.
29. Steel, R.G., & Torrie, J.H. (1992). Principals and procedures of statistics. McGraw Hill Book Company Inc. New York.
30. Okwu, D.E. (2001). Evaluation of the chemical composition of indigenous spices and flavoring agents. *Global Journal of Pure and Applied Sciences*, *7*(3), 455-459.
31. Rattan, R. S. (2010). Mechanism of action of insecticidal secondary metabolites of plant origin. *Crop Protection*, *29*, 913 - 920.
32. Hare, J.D. (2011). Ecological role of volatiles produced by plants in response to damage by herbivorous insects. *Annual Review in Entomology*, *56*, 161–80. doi: 10.1146/annurev-ento-120709-144753.
33. Shripad, M.U., Hamlata, M.K., Prashant, S.M., & Vijay, L.M. (2003). Partial characterization and insecticidal properties of Ricinus communis L. foliage flavonoids. *Journal of Pest Management Science*, *59*(12), 1349 – 1354.

34. Sharma, H.C., Sujana, G. & Rao, D.M. (2009). Morphological and chemical components of resistance to pod borer, Helicoverpa armigera in wild relatives of pigeon pea. *Arthropod-Plant Interactions*, 3, 151-161.
35. Roitto, M, Rautio, P, Markkola, A, Julkunen-Tiitto, R, Varama M, Saravesi K (2009). Induced accumulation of phenolics and sawfly performance in Scots pine in response to previous defoliation. *Tree Physiology*, 29, 207–216. doi: 10.1093/treephys/tpn017.
36. De Geyter, E., Smagghe, G., Rahbé, Y., & Geelen, D. (2011). Triterpene saponins of Quillajasaponaria show strong aphicidal and deterrent activity against the pea aphid Acyrthosiphonpisum. *Journal of Pest Management Science*, 2, 22- 35.
37. Marianna, P.D., Greice, G., Vilmar, M., Lidia, M.F. & Gilson, R.P. (2012). Effect of saponin extracted from passiflora alata dryander (Passifloraceae) on development of the spodoptera frugiperda (J.E. Smith) (Lepidoptera, Noctuidae). *Interbational Journal of Plants Resources*, 2, 151-159.
38. Pavela, R. (2009). Effectiveness of some botanical insecticides against Spodoptera littoralis Boisduvala (Lepidoptera: Noctuidae), Myzus persicae Sulzer (Hemiptera: Aphididae) and Tetranychus urticae. *Plant Protection Science*, *45*(4), 161-167.
39. Adeniyi, S. A., Orjiekwe, C. L., Ehiagbonare, J. E. & Arimah, B. D. (2010). Preliminary phytochemical analysis and insecticidal activity of ethanolic extracts of four tropical plants (Vernonia amygdalina, Sida acuta, Ocimum gratissimum and Telfaria occidentalis) against beans weevil (Acanthscelides obtectus). *International Journal of the Physical Sciences, 5*, 753-762.
40. Umar, A. (2016). Evaluation of anti- aphid properties of the aqueous crude fruit sap extracts of Solanum incanum. *MSc thesis, Kenyatta University*, Kenya.
41. Ramirez, A. (2012). Pyrethrum secondary metabolism, biosynthesis, localization and ecology defence compounds. PhD thesis, Wageningen University, Netherlands.
42. Michuki, R.K. (1994). Quantitative and qualitative analysis of pyrethrins and pyrethrosin. MSc thesis, *University of Nairobi, Kenya*.
43. Usta, J., S. Kreydiyyeh, K. Bakajian., & H. Nakkash-Chmaisse. (2002). In vitro effect of eugenol and cinnamaldehyde on membrane potential and respiratory complexes in isolated rat liver mitochondria. *Food Chemicals and Toxicology*, 40, 935–940.

Cite This Article: Korir VJ *et al* (2021). Phytochemical Analysis of Pyrethrum Plant Extract and its Anti-Aphid Effect On African Nightshades (Solanum Scabrum Mill). *EAS J Biotechnol Genet*, *3*(1), 21-29.