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Insecticidal Activity of *Melia azedarach* (L.) Plant Extracts Against Cabbage Flea Beetle [*Phyllotreta cruciferae* Goeze (Coleoptera: Chrysomilidae)]

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Abstract: Insecticidal activity of cold and hot water extract of leaves, immature and mature fruits of *Melia azedarach* were tested against cabbage flea beetle (*Phyllotreta cruciferae*) in the laboratory. Cold and hot water extract were prepared on weight by volume basis (w/v) by mixing 0.625, 1.25, 2.5, 5 and 10g of powder individually in 100ml of water and tested by thin film residue method using 10ml glass test tube. In each treated test tube, 10 healthy flea beetles were introduced and the mortality was recorded continuously for 96hr with 24hr interval period. Results revealed that after 24hr exposure period LC_{50} concentration of 0.778 and 0.741g/100ml was calculated in cold and hot water extract respectively in immature fruits. Among the various plant parts tested, chi-square (x^2) analysis results showed statistically significant difference in cold and hot water extract of leaves and cold water extract of immature fruits at 5% level after 24hr exposure period. In general, irrespective of exposure period and concentration tested, immature fruit extracts showed promising result against cabbage flea beetle. These plants are growing well in the highlands of Ethiopia which will be a potential source for flea beetle management particularly farmers those who are unable to afford the cost of chemical pesticides.

Key words: Plant Extracts · Insecticidal Activity

INTRODUCTION

Phyllotreta cruciferae belongs to the order Coleoptera, family Chrysomelidae is commonly called as flea beetle which cause damage to cabbage seedlings and the feeding is continued till harvesting stage. The typical feeding symptom of adults on the foliage is small round holes looks like "shot-hole" appearance. The young plants with heavy infestation may reduce yield or kill the plants [1]. According to Janet and Denise [2], estimated yield losses of about 10%, where the flea beetles are abundant in fields. In addition to feeding damage, flea beetles also serve as a vector to transmit bacterial and viral diseases [3]. Chemical pesticides are effectively used to protect the crop but due to negative consequences searching eco-friendly alternatives from natural resources are in progress. Plant based pesticides are considered as one of the alternative sources for the development of novel biopesticides. Recent times many plant species are explored well to document scientifically for their bio-potential against pests and vectors [4-8].

Melia azedarach is one of the potential plants belongs to the family Meliaceae; close relative of neem tree. The tree is originated from Asia and now distributed in Northern Australia, Africa, Northern America, tropical South America and Southern Europe [9]. The folklore medicinal values, veterinary and entomological investigations of fruits, seeds and leaves are well reviewed [10, 11]. Azam *et al.* [12] documented traditional uses, pharmaceutical activities, phytochemistry, taxonomy, morphology, distribution and toxic effects. Toxic and feeding deterrent activity of methanolic extract was reported against *Trichoplusia ni* and *Pseudaletia unipuncta* [13]. Mosquito larvicidal activity of crude ethanolic extract was confirmed against third instar larvae of *Culex quinquefasciatus* [14]. The antifeedant and insecticidal activity of immature fruit ethanol and water extracts was reported against Elm leaf beetle (*Xanthogaleruca luteola*) [15]. Aqueous and methanol extract of mature fruit and leaves prevent feeding rate of cabbage aphid (*Brevicoryne brassicae*) [16]. Significant reduction of cabbage aphid population was observed in

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the cabbage field sprayed with aqueous extract of the seeds and leaves [17, 18]. The senescent leaf extract mixed with artificial diet proved to be 100% lethal with antifeedant effect on the larvae of *Spodoptera frugiperda* [19]. The distilled water extract of green and mature fruit extract sprayed citrus field leaf miner (*Phyllocnistic citrella*) population was significantly reduced [20]. The methanolic sequential extract of ripen fruit proved to be highly toxic against first instar larvae of *Spilosoma oblique* [21]. Earlier literature confirmed bio-potential of *Melia azedarach* against many agriculturally important pests. In Ethiopia, particularly, University of Gondar these plants are grown as an avenue tree along the road side of Tewodros and Maraki campus. There is no scientific documentation on bio-potential of this plant extracts against flea beetle (*Phyllotreta cruciferae*). Therefore, present study was undertaken to evaluate cold and hot water extracts of leaves, immature and mature fruits against flea beetles under laboratory condition.

MATERIALS AND METHODS

Insecticidal activity of cold and hot water extract of *M. azedarach* leaves, immature and mature fruits were tested against cabbage flea beetle (*Phyllotreta cruciferae*). The experiment was conducted at Biology laboratory, College of Natural and Computational Sciences, Tewdros campus, University of Gondar, Gondar, Ethiopia from February 2013 to May 2013.

Plant Materials Collection and Processing: *Melia azedarach* leaves, immature (dark green in color) and mature (straw yellow in color) fruits were collected from Atse Tewodros campus, University of Gondar. The selected plant parts were collected randomly from 10 individual plants to avoid any individual effect of the tree. The plant parts were thoroughly washed with tap water and dried under shade to avoid denaturation of bioactive principles. After complete drying, plant parts were powdered individually by using electric blender and fine powder was collected by sieving through kitchen strainer. The powdered materials were used to prepare different concentration of cold and hot water extracts.

Preparation of Concentration: Cold and hot water extract of selected plant parts were prepared on weight by volume basis (w/v) by mixing 0.625, 1.25, 2.5, 5 and 10g of powder individually in 100ml of water. Tap water was used for cold water preparation and 100°C boiled water for 10 minute was used for hot water preparation. The known quantity of plant powder was taken in a conical flask; added 100ml of cold and hot water individually and allowed for 12hr continuous shaking in a shaker to get complete homogenized solution. After shaking, extracts were filtered through muslin cloth and added 2ml of soap solution for emulsification purpose.

Flea Beetles Collection and Maintenance: Cabbage flea beetles (*Phyllotreta cruciferae*) were collected from the cabbage field at Hope of Bridge children village farm, near University of Gondar. The beetles were collected by using insect collection net; transferred to plastic container and brought to the laboratory along with fresh leaves. The beetles were provided fresh cabbage leaves for feeding. The cabbage leaf petiole was tied with water soaked cotton to prevent early drying. These cultures were maintained throughout experimental period.

Insecticidal Activity of Plant Extracts: Insecticidal activity of plant extract was tested by using thin film residue method. In this method, 1 ml of individual concentration of the plant extract was added to 10ml test tube and rinsed for the appearance of uniform layer. Any excess solution in the test tube was discarded and [10] healthy insects introduced to each tested tube and the mouth was plugged with cotton. The test tube rinsed with 1ml of water (mixture of 98 ml of water + 2ml of soap solution) was used as control. The number of dead insects from control and experimental groups were monitored continuously for 96 hr with 24hr interval. The number of dead insects was recorded and percentage mortality was calculated and corrected by using Abbott's formula [22].

Statistical Analysis: The data collected from each experiment was subjected to statistical analysis in order to derive mean and standard deviation. The statistical significant difference for cold and hot water extracts within the plant parts were analyzed by Chi-square analysis. Probit analysis was performed to calculate $LC_{50,}$ LC_{90} concentrations and 95% upper and lower confidence limit for each concentration and exposure period. All the statistical analysis was carried out using SPSS software version 16.

RESULTS

Insecticidal Activity of Leaf Extracts on *P. cruciferae* after 24hr Exposure Period: Mean percentage mortality of flea beetles exposed to cold and hot water extract of *M. azedarach* leaves, immature and mature fruits after 24hr exposure period was presented in Table 1. Result revealed

Table 1: Insecticidal activity of *M. azedarach* extracts on *P. cruciferae* after 24hr exposure period

	Melia leaves		*Melia* immature fruit		*Melia* mature fruit	
Concentration g/100ml	Cold water	Hot water	Cold water	Hot water	Cold water	Hot water
0.625	23.3±5.77	13.3±5.77	33.3±5.77	43.3±5.77	36.6±5.77	33.3±5.77
1.25	60.0±10.0	53.3±5.77	80.0±10.0	70.0±10.0	50.0±10.0	66.6±5.77
2.5	70.0±10.0	60.0±10.0	90.0±10.0	93.3±5.77	76.6±5.77	83.3±5.77
5.0	73.3±5.77	86.6±5.77	93.3±5.77	96.6±5.77	86.6±5.77	93.3±5.77
10.0	83.3±5.77	86.6±5.77	100.0±0.0	100.0±0.0	96.6±5.77	100.0±0.0
LC_{50} (LCL-UCL)	1.340 (0.08-2.96)	1.667 (0.55-3.21)	0.778 (0.13-1.33)	0.741 (0.60-0.86)	1.062 (0.85-1.26)	0.918(0.75-1.06)
LC_{90} (LCL-UCL)	14.246(5.16-449.5)	8.342(4.02-158.05)	2.711(1.57-21.89)	2.392(2.01-3.00)	5.518(4.36-7.58)	3.364(2.79-4.29)
x^2	14.064	17.183	15.790	1.672	2.239	3.418
Significant level	0.003	0.001	0.001	0.643	0.524	0.002

Values are percentage mean±standard deviation of three replications. LCL- Lower confidence limits; UCL- Upper confidence limit; x^2-Chi-square

that maximum percentage mortality of 83.3% was observed in cold water extract at 10g/100ml. The calculated LC_{50} and LC_{90} value was 1.340g/100ml and 14.246g/100ml respectively. The results of x^2 analysis showed statistically significant difference (x^2 = 14.064; p<0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.08-2.96g/100ml and 5.16-449.5g/100ml respectively. In hot water extract of leaves, mean percentage mortality of 86.6% was recorded at 10g/100ml which was on par with 5g/100ml treatment. The calculated LC_{50} and LC_{90} value was 1.667g/100ml and 8.342g/100ml respectively. The results of x^2 analysis showed statistically significant difference (x^2 = 17.183; p<0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.55-3.21g/100ml and 4.02-158.05g/100ml respectively.

Insecticidal Activity of Immature Fruit Extracts on *P. cruciferae* after 24hr Exposure Period: Mean percentage mortality of flea beetles exposed to immature fruit cold and hot water extract was 100% at 10g/100ml treatment. The mortality rate (93.3%) in cold water extract at 5g/100ml was on par with hot water extract (93.3%) at 2.5g/100ml. In general, both cold and hot water extracts showed 50% and above mortality from the treatment 1.25g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.778g/100ml and 2.711g/100ml respectively. The results of x^2 analysis showed statistically significant difference (x^2 = 15.790; p<0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.13-1.33g/100ml and 1.57-21.89g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.741g/100ml and 2.392g/100ml respectively. The x^2 analysis results was statistically not significant (x^2 = 1.672; p>0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.60-0.86g/100ml and 2.01-3.00g/100ml respectively (Table 1).

Insecticidal Activity of Mature Fruit Extracts on *P. cruciferae* after 24hr Exposure Period: Mean percentage mortality of flea beetles was 100% in mature fruit hot water extract at 10g/100ml and it was 96.6% in cold water extract treatment. In general, both cold and hot water extracts showed 50% and above mortality from the treatment 1.25g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 1.062g/100ml and 5.518g/100ml respectively. The x^2 analysis results was statistically not significant (x^2 = 2.239; p>0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.85-1.26g/100ml and 4.36-7.58g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.918g/100ml and 3.364g/100ml respectively. The x^2 analysis results showed statistically significant difference (x^2 = 3.418; p<0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.75-1.06g/100ml and 2.79-4.29g/100ml respectively (Table 1).

Insecticidal Activity of Leaf Extracts on *P. cruciferae* after 48hr Exposure Period: Mean percentage mortality of flea beetles exposed to cold and hot water extract of *M. azedarach* leaves, immature and mature fruits after 48hr exposure period was presented in Table 2. Result revealed that maximum percentage mortality of 93.3% was observed in cold water extract at 10g/100ml. At lower concentration (0.625g/100ml) also observed above 50% mortality. The calculated LC_{50} and LC_{90} value was 0.321g/100ml and 6.253g/100ml respectively. The x^2 analysis results was statistically not significant (x^2 = 0.460; p>0.05). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.12-0.53g/100ml and 4.23-12.08g/100ml respectively. In hot water extract of leaves, maximum mean percentage mortality of 86.6% was recorded at 10g/100ml. The calculated LC_{50} and LC_{90} value was 1.093g/100ml and 4.486g/100ml respectively. The x^2 analysis results was

Table 2: Insecticidal activity of *M. azedarach* extracts on *P. cruciferae* after 48hr exposure period

	Melia leaves		*Melia* immature fruit		*Melia* mature fruit	
Concentration g/100ml	Cold water	Hot water	Cold water	Hot water	Cold water	Hot water
0.625	60.0±10.0	26.6±5.77	83.3±5.77	70.0±10.0	60.0±10.0	60.0±10.0
1.25	73.3±5.77	60.0±10.0	86.6±5.77	73.3±15.27	70.0±10.0	73.3±5.77
2.5	83.3±5.77	80.0±10.0	93.3±11.54	96.6±5.77	86.6±11.54	86.6±11.54
5.0	86.6±5.77	90.0±10.0	96.6±5.77	100.0±0.0	90.0±10.0	96.6±5.77
10.0	93.3±5.77	96.6±5.77	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
LC_{50} (LCL-UCL)	0.321 (0.12-0.53)	1.093 (0.90-1.27)	0.118 (0.02-0.25)	0.443 (0.00-1.04)	0.478 (0.08-0.86)	0.510 (0.34-0.66)
LC_{90} (LCL-UCL)	6.253 (4.23-12.08)	4.486 (3.67-5.82)	1.408 (0.97-2.00)	1.710 (0.92-323.5)	3.458 (2.09-11.80)	2.598 (2.10-3.47)
x^2	0.460	3.081	2.187	12.816	5.705	2.743
Significant level	0.928	0.379	0.534	0.005	0.127	0.433

Values are percentage mean±standard deviation of three replications. LCL- Lower confidence limits; UCL-Upper confidence limit; v-Chi-square

statistically not significant ($x^2 = 3.081$; $p>0.05$).The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.90-1.27g/100ml and 3.67-5.82g/100ml respectively.

Insecticidal Activity of Immature Fruit Extracts on *P. cruciferae* after 48hr Exposure Period: Mean percentage mortality of flea beetles was 100% in immature fruit cold and hot water treatment at 10g/100ml and also hot water extract at 5g/100ml treatment. The mortality rate (96.6%) in cold water extract at 5g/100ml was on par with hot water extract (96.6%) at 2.5g/100ml. In general, both cold and hot water extracts showed 70% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.118g/100ml and 1.408g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.187$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.02-0.25g/100ml and 0.97-2.00g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.443g/100ml and 1.710g/100ml respectively. The x^2 analysis results was statistically significant ($x^2 = 12.816$; $p<0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.00-1.04g/100ml and 0.92-323.5g/100ml respectively (Table 2).

Insecticidal Activity of Mature Fruit Extracts on *P. cruciferae* after 48hr Exposure Period: Mean percentage mortality of flea beetles was 100% in both cold and hot water extract of mature fruit at 10g/100ml treatment. In general, both cold and hot water extracts treatment showed 60% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.478g/100ml and 3.458g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 5.705$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.08-0.86g/100ml and 2.09-11.80g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.510g/100ml and 2.598g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.743$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.34-0.66g/100ml and 2.10-3.47g/100ml respectively (Table 2).

Insecticidal Activity of Leaf Extracts on *P. cruciferae* after 72hr Exposure Period: Mean percentage mortality of flea beetles exposed to cold and hot water extract of *M. azedarach* leaves, immature and mature fruits after 72hr exposure period was presented in Table 3. Result revealed that maximum percentage mortality of 100% was observed in cold water extract of leaves at 10g/100ml. At lower concentration (0.625g/100ml), maximum mortality of 70% was recorded in cold water and it was 36.6% in hot water extract treatment. The calculated LC_{50} and LC_{90} value was 0.276g/100ml and 2.487g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 3.423$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.12-0.43g/100ml and 1.91-3.57g/100ml respectively. In hot water extract of leaves, maximum mean percentage mortality of 100% was recorded at 5 and 10g/100ml treatment. The calculated LC_{50} and LC_{90} value was 0.847g/100ml and 2.306g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.030$; $p>0.05$).The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.72-0.96g/100ml and 1.97-2.84g/100ml respectively.

Insecticidal Activity of Immature Fruit Extracts on *P. cruciferae* after 72hr Exposure Period: Mean percentage mortality of flea beetles was 100% in cold and hot water

Table 3: Insecticidal activity of *M. azedarach* extracts on *P. cruciferae* after 72hr exposure period

	Melia leaves		*Melia* immature fruit		*Melia* mature fruit	
Concentration g/100ml	Cold water	Hot water	Cold water	Hot water	Cold water	Hot water
0.625	70.0±10.0	36.6±11.54	90.0±10.0	80.0±10.0	70.0±10.0	70.0±10.0
1.25	80.0±10	66.6±5.77	93.3±5.77	80.0±17.32	80.0±10.0	86.6±5.77
2.5	90.0±10.0	90.0±10.0	100.0±0.0	100.0±0.0	93.3±11.54	100.0±0.0
5.0	93.3±5.77	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
10.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
LC_{50} (LCL-UCL)	0.276 (0.12-0.43)	0.847 (0.72-0.96)	0.157 (0.02-0.30)	0.313 (ND)	0.386 (0.23-0.52)	0.353 (0.20-0.48)
LC_{90} (LCL-UCL)	2.487 (1.91-3.57)	2.306 (1.97-2.84)	0.710 (0.43-0.94)	1.265 (ND)	1.725 (1.41-2.24)	1.534 (1.25-1.98)
x^2	3.423	2.030	4.083	16.092	4.240	2.915
Significant level	0.331	0.566	0.253	0.001	0.237	0.405

Values are percentage mean±standard deviation of three replications. LCL-Lower confidence limit; UCL- Upper confidence limits; x^2-Chi-square; ND-Not desired

Table 4: Insecticidal activity of *M. azedarach* extracts on *P. cruciferae* after 96hr exposure period

	Melia leaves		*Melia* immature fruit		*Melia* mature fruit	
Concentration g/100ml	Cold water	Hot water	Cold water	Hot water	Cold water	Hot water
0.625	76.6±5.77	70.0±10.0	93.3±5.77	86.6±5.77	80.0±10.0	86.6±5.77
1.25	86.6±5.77	80.0±10.0	93.3±5.77	93.3±5.77	86.6±5.77	93.3±5.77
2.5	100.0±0.0	96.6±5.77	100.0±0.0	100.0±0.0	96.6±5.77	100.0±0.0
5.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
10.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
LC_{50} (LCL-UCL)	0.348 (0.10-0.59)	0.413 (0.26-0.53)	0.101 (ND)	0.211 (0.05-0.35)	0.254 (0.10-0.39)	0.211 (0.05-0.35)
LC_{90} (LCL-UCL)	1.124 (0.72-3.10)	1.528 (1.27-1.95)	0.593 (ND)	0.797 (0.57-1.02)	1.198 (0.94-1.55)	0.797 (0.57-1.02)
x^2	5.481	4.946	5.824	2.986	2.804	2.986
Significant level	0.140	0.176	0.121	0.394	0.423	0.394

Values are percentage mean±standard deviation of three replications. LCL-Lower confidence limit; UCL- Upper confidence limits; x^2-Chi-square; ND-Not desired

extract of immature fruit treatment at 2.5, 5 and 10g/100ml treatment. The mortality rate of 90% and 93.3% was observed in cold water extract at 0.625g/100ml and 1.25g/ml treatment respectively. In general, both cold and hot water extracts showed 80% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.157g/100ml and 0.710g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 4.083$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.02-0.30g/100ml and 0.43-0.94g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.313g/100ml and 1.265g/100ml respectively. The x^2 analysis results showed statistically significant difference ($x^2 = 16.092$; $p<0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was not desired by SPSS software because narrow range of mortality such as 80% at 0.625 and 1.25g/100ml and 100% in 2.5g/100ml and above treatment (Table 3).

Insecticidal Activity of Mature Fruit Extracts on *P. cruciferae* after 72hr Exposure Period: Mean percentage mortality of flea beetles was 100% in both cold and hot water extract of mature fruit at 5 and 10g/100ml treatment. In general, both cold and hot water extracts treatment showed 70% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.386g/100ml and 1.725g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 4.240$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.23-0.52/100ml and 1.41-2.24g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.353g/100ml and 1.534g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.915$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.20-0.48g/100ml and 1.25-1.98g/100ml respectively (Table 3).

Insecticidal Activity of Leaf Extracts on *P. cruciferae* after 96hr Exposure Period: Mean percentage mortality of flea beetles exposed to cold and hot water extract of *M. azedarach* leaves, immature and mature fruits after 96hr exposure period was presented in Table 4. Result revealed that maximum percentage mortality of 100% was observed in cold water extract of leaves at 2.5, 5 and10g/100ml. At lower concentration (0.625g/100ml), maximum mortality of 76.6% was recorded in cold water extract and it was

70% in hot water extract. The calculated LC_{50} and LC_{90} value was 0.348g/100ml and 1.124g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 5.481$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.10-0.59g/100ml and 0.72-3.10g/100ml respectively. In hot water extract of leaves, maximum mean percentage mortality of 100% was recorded at 5 and 10g/100ml treatment. The calculated LC_{50} and LC_{90} value was 0.413g/100ml and 1.528g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 4.946$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.26-0.53g/100ml and 1.27-1.95g/100ml respectively (Table 4).

Insecticidal Activity of Immature Fruit Extracts on *P. cruciferae* after 96hr Exposure Period: Mean percentage mortality of flea beetles was 100% in cold and hot water extract of immature fruit treatment at 2.5, 5 and 10g/100ml. The mortality rate of 93.3% was recorded in cold water extract at 0.625g/100ml and 1.25g/ml treatment. In general, both cold and hot water extracts showed 86.6% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.101g/100ml and 0.593g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 5.824$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was not desired by SPSS software because the percentage mortality was in narrow range such as 93.3% at 0.625 and 1.25g/100ml and 100% in 2.5, 5 and 10g/100ml. The calculated LC_{50} and LC_{90} value of hot water extract was 0.211g/100ml and 0.797g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.986$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.05-0.35/100ml and 0.57-1.02/100ml respectively (Table 4).

Insecticidal Activity of Mature Fruit Extracts on *P. cruciferae* after 96hr Exposure Period: Mean percentage mortality of flea beetles was 100% in both cold and hot water extract of mature fruit at 5 and 10g/100ml treatment. In general, both cold and hot water extracts treatment showed 80% and above mortality from the treatment 0.625g/100ml to 10g/100ml. The calculated LC_{50} and LC_{90} value of cold water extract was 0.254/100ml and 1.198g/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.804$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.10-0.39/100ml and 0.94-1.55g/100ml respectively. The calculated LC_{50} and LC_{90} value of hot water extract was 0.211/100ml and 0.797/100ml respectively. The x^2 analysis results was statistically not significant ($x^2 = 2.986$; $p>0.05$). The range of 95% lower and upper confidence limit (LCL-UCL) of LC_{50} and LC_{90} value was 0.05-0.35g/100ml and 0.57-1.02g/100ml respectively (Table 4).

DISCUSSION

Plants by nature produce thousands of secondary metabolites in which some of them are unpalatable substances such as alkaloids, flavanoids, terpenes, quinone, phenols etc., which is used as defensive chemicals. In many parts of the world several bio-potential plants are exploited well throughout the human history for various purposes including insect repellents, insecticides and antifeedant. Recent time scientific documentation of bio-potential plants and also isolation of novel bioactive compound are increasing considerably to find out eco-friendly alternatives to synthetic chemical pesticides. In the present study, *Melia* extracts were proved to be effective against cabbage flea beetle by increasing percent mortality in the treatment. The percentage mortality of insects is mainly depending on the concentration of plant extracts, parts of the plants used and also period of exposure. Al-Mehmadi and Al- Khalaf [14] also observed increased larval mortality with an increase in the contraction of whole plant extracts. The bio-potential of *Melia* is mainly associated with quantity of toxic principles accumulated in the respective part of the plants. It is reported that many plants belongs to the family Meliaceae are used for commercial product development [13]. The group of biologically active terpenoids accumulated on leaves, fruits and seeds proved to have insecticidal and antifeedant effect against insects [23, 24]. Several researchers suggested that green fruit and leaf extracts are effective on beetles and lepidopterans due to antifeeding nature of active ingredients [25-27].

In the present study, crude extract of green fruit was highly effective in terms of percentage mortality compared to leaf and mature fruit extract. In all the exposure period, irrespective of concentration tested, LC_{50} value of green fruit extract was very low. Similar result was obtained by Chiffelle *et al*., [15] against leaf beetle (*Xanthogaleruca luteola*) fed with leaves treated with water extracts.

The melia plants contain several bioactive limonoids such as meliantriol [28], meliacin, meliacarpin [29] and meliartenin [30]. The increased mortality of the flea beetle may be associated with any one of the compound or more may be affected with the respiratory system of the insects. According to Bullangpoti *et al*. [19] senescent leaf extract inhibit several vital enzymes important to insect survival. It is agreed that if the enzymes are inhibited or inactivated several metabolic process in insect body may be arrested there by insects died. The crude extract was used in the present study may contain mixture of several chemical constituents which may be responsible for insect mortality. Koul and Walia [31] suggested that mixtures of compounds are more effective in reducing pest resistance compared to purified commercial secondary allelochemicals. The crude or partially purified extracts are less expensive and highly efficacious for the control of mosquitoes [32, 33]. In conclusion, laboratory study proved that crude extracts of *M. azedarach* plant extracts were effective against cabbage flea beetle (*Phyllotreta cruciferae*). These plants are growing well in the highlands of Ethiopia which will be a potential source for flea beetle management particularly farmers those who are unable to afford the cost of chemical pesticides.

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