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Research Article

Feeding Deterrent Activity of *Melia azedarach* Linn. and *Phytolacca dodecondra* (L'Herit) Plant Extracts Against Cabbage Flea Beetle, *Phyllotreta cruciferae* (Goeze)

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Abstract: Aim of the study was to evaluate feeding deterrent activity of cold and hot water extracts of *Melia azedarach* and *Phytolacca dodecandra* plant parts against cabbage flea beetle, *Phyllotreta cruciferae*. Tap water was used for cold water extraction and 100°C boiled water was used for hot water extraction. Five concentrations (w/v) such as 0.625, 1.25, 2.5, 5 and 10 g, respectively of powder/100 mL of water was used to check feeding deterrent activity by leaf discs method. Feeding deterrent activity of plant extracts was monitored for 24, 48, 72 and 96 h, respectively post exposure period with 24 h interval. In addition, mean number of feeding holes were recorded after 96 h post exposure period. The cabbage leaf disc treated with 10 g/100 mL of plant extracts recorded 100% feeding deterrent activity after 24 h exposure period. After 48 h exposure period, except for *Melia* mature fruit (96.6%) remaining all the extracts recorded 100% feeding deterrent activity at 10 g/100 mL treatment. After 72 h exposure period, at higher concentration (10 g/100 mL), feeding deterrent activity of cold water extract of *Phytolacca* leaf (96.6%) was on par with hot water extract of *Phytolacca* leaf (96.6%) and immature fruit (96.6%). After 96 h exposure period, except for hot water extract of *Phytolacca* leaves (93.3%), remaining all observed 100% feeding deterrent activity at higher concentration. The mean numbers of feeding holes were decreased in increased concentration of the plant extracts. Irrespective of the concentrations, minimum feeding hole was observed at 10 g/100 mL of cold and hot water extract treatment. These two plant extracts proved to be effective by preventing feeding nature of the insects under laboratory. If these plant extracts may provide similar results under field condition it may be useful for controlling flea beetles damage in cabbage crops.

Keywords: Feeding deterrent, feeding holes, flea beetle, *Melia azedarach*, *Phyllotreta cruciferae*, *Phytolacca dodecandra*, plant extracts

INTRODUCTION

Cabbage, *Brassica oleracea* is one of the important commercial vegetable crops growing widely throughout Ethiopia. According to Helen (2007) cabbage contains many essential nutrients including dietary fibers, carbohydrates, sugars, fats, protein, thiamine, riboflavin, niacin, panthothenic acid, vitamin B6, vitamin C, vitamin K, calcium, iron, magnesium, phosphorus, potassium and zinc. These nutritional rich vegetable crops are damaged by flea beetle, *Phyllotreta* spp. in the early stages of development (Palanisamy and Lamb, 1992) and also transmit bacterial and viral diseases (Grubinger, 2006). The economic damage caused by the flea beetles on crop production to be varied based on population densities. The large populations of the beetles quickly devastate seedlings and also feed on the cotyledons and true leaves. The estimated yield losses of about 10% are common in flea beetles abundant fields (Janet and Denise, 2002). Depending on the climate, two to four generations of flea beetles can be produced over the course of one growing season (Metcalf, 1993).

Chemical pesticides are proved to be effective control strategies but due to their negative consequences searching alternatives from the natural resources is gaining importance in recent times. One of the alternative strategies for environmentally safe pest control program is by using botanical pesticides. Botanical pesticides are traditionally used to control various insect pests and diseases considering as broad spectrum solutions to a particular problem. Botanical treatments are particularly relevant for small scale subsistence farmers (Proctor, 1994). Neem, rotenone, pyrethrins, sabadilla and their mixed formulation are recommended for controlling flea beetles (Ellis *et al*., 1996; Saxena, 1987). The extracts from several species of the family Asteraceae, Euphorbiaceae, Meliaceae, Anacardiaceae was explored well to determine their potential pesticidal effects (Ramos *et al*., 2010).

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Chinaberry berry, *Melia azedarach* belongs to the family Meliaceae is a close relative of neem tree and their extracts have been studied extensively for their bio-efficacy against various insect pests. The insecticidal potential was reported to be equivalent to that of neem extracts (Champagne *et al*., 1989; Lee *et al*., 1991; Chantal and Efat Abou, 2003) particularly berries is extremely poisonous (Fichtl and Adi, 1994). The leaves and bark extracts are commonly used for medicinal purpose in Ethiopia through traditional and scientific practices (Azene, 1993). Several workers have been reported bio-efficacy of fruits, seeds, leaves and barks extracts against aphids and white flies (Abou-Fakher *et al*., 2001; Zaki, 2008; Zaki *et al*., 2008; Birhanu *et al*., 2011; Gebremariam *et al*., 2012). However, in Ethiopia literature pertaining to the feeding deterrent effects on flea beetle, *Phyllotreta cruciferae* is limited.

African soapberry, *Phytolacca dodecandra* belongs to the family Phytolaccaceae is a perennial climbing plants growing rapidly in Ethiopian highland and produce fruits twice in a year from December to February and June to July (Lemma, 1970; Karunamoorthy *et al*., 2008). In Ethiopia and Zimbabwe, unripe fruits are reported to be used to control bilharzias transmitting snails (Schemelzer and Gurib Fakim, 2008); butanol extract of berries to be toxic to snail and fish (Stobaeus *et al*., 1990); useful to control mosquito larvae and housefly (Abate and Fesseha, 1994); strongly toxic to aquatic macro-invertebrates (Karunamoorthi *et al*., 2008) and inhibits egg hatching of *Haemonchus contortus* (Hermandez-Villegas *et al*., 2011). In Ethiopia, there is no published work on bio-efficacy of *Phytolacca* plant extracts against cabbage flea beetle, *Phyllotreta cruciferae*. Therefore, feeding deterrent activity of cold and hot water extracts of leaves, immature and mature fruits of *Melia azedarach* and *Phytolacca dodecandra* were evaluated against cabbage flea beetle, *Phyllotreta cruciferae*.

MATERIALS AND METHODS

The experiment was conducted in the biology laboratory, College of Natural and Computational Sciences, University of Gondar, Gondar, Ethiopia from February 2013 to May 2013.

Collection and processing of plant materials: *Melia azedarach* and *Phytolacca dodecandra* leaves, immature and mature fruits were collected from Atse Tewodros campus, University of Gondar. The parts of the plants were thoroughly washed 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 concentrations of cold and hot water extracts.

Preparation of concentrations: Cold and hot water extracts of selected plant parts were prepared by mixing 0.625, 1.25, 2.5, 5 and 10 g, respectively of powder individually in 100 mL of water. The tap water was used for cold water extraction and boiled (100°C) water was used for hot water extraction. The known quantity of plant powder was taken in conical flask; added 100 mL of water and allowed for 12 h continuous shaking in a shaker to get complete homogenized solution. After shaking, extracts were filtered through muslin cloth and added 2 mL of soap solution for emulsification purpose.

Flea beetles collection and maintenance: Cabbage flea beetle, *Phyllotreta cruciferae* were collected from the cabbage field at Hope of Bridge children village farm, near the 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 cotton soaked with water to prevent early drying. These cultures were maintained throughout experimental period.

Feeding deterrent activity of plant extracts: Feeding deterrent activity of selected concentrations of the plant extracts were tested by applying on both side of the freshly prepared 3 cm cabbage leaf discs. The treated leaf discs were kept in petriplates and introduced 10 healthy flea beetles for each concentration. To prevent early drying of the leaf discs and to maintain moisture content circular Whatmann no 1 filter paper dipped with water was added to petriplate. The leaf discs treated with 2 mL soap solution diluted with 100 mL of water was considered as control. For each concentration experiment was replicated three times. The number of insects on treated leaves and outside were counted continuously for 24, 48, 72 and 96 h, respectively post exposure period and percentage of feeding deterrent activity was calculated. In addition, after 96 h exposure period, numbers of feeding holes for each leaf disc was recorded and mean number of holes were calculated.

Statistical analysis: The data collected for each experiment were subjected to statistical analysis to derive mean and standard deviation. The statistical significant difference for cold and hot water extracts within the plant parts and within the concentrations tested were analyzed by two way Analysis of Variance (ANOVA) by using Microsoft office excel 2007 program. The level of significant difference was compared at 5% level ($p<0.05$).

RESULTS

Feeding deterrent activity of different plant extracts tested at various concentrations after 24 h post exposure period was presented in Table 1. Irrespective of concentrations, cabbage leaf disc treated with 10 g/100 mL of plant extract showed 100% feeding deterrent

Table 1: Percent feeding deterrent activity of plant extracts on *P. cruciferae* after 24 h exposure period

Plant parts tested	Type of water extract	Amount of plant powder used/100 mL of water				
		0.625 g	1.25 g	2.5 g	5.0 g	10.0 g
Melia leaves	Cold	60.0±10.00	73.3±5.77	76.6±15.27	90.0±10.00	100.0±0.0
	Hot	53.3±15.27	66.6±11.54	80.0±10.00	93.3±5.77	100.0±0.0
Melia immature fruit	Cold	80.0±10.00	86.6±5.77	90.0±10.00	96.6±5.77	100.0±0.0
	Hot	63.3±20.18	70.0±10.00	83.3±5.77	100.0±0.00	100.0±0.0
Melia mature fruit	Cold	56.6±5.77	60.0±10.00	66.6±5.77	83.3±5.77	100.0±0.0
	Hot	63.3±5.77	73.3±5.77	86.6±5.77	96.6±5.77	100.0±0.0
Phytolacca leaves	Cold	70.0±10.00	86.6±5.77	86.6±5.77	86.6±15.27	100.0±0.0
	Hot	50.0±10.00	76.6±5.77	80.0±10.00	86.6±5.77	100.0±0.0
Phytolacca immature fruit	Cold	66.6±5.77	73.3±5.77	80.0±10.00	93.3±5.77	100.0±0.0
	Hot	60.0±10.00	76.6±5.77	83.3±11.54	93.3±5.77	100.0±0.0
Phytolacca mature fruit	Cold	53.3±5.77	66.6±5.77	73.3±5.77	86.6±5.77	100.0±0.0
	Hot	46.6±5.77	70.0±10.00	76.6±5.77	100.0±0.00	100.0±0.0

Values are percentage mean±standard deviation of three replications

Table 2: Percent feeding deterrent activity of plant extracts on *P. cruciferae* after 48 h exposure period

Plant parts tested	Type of water extract	Amount of plant powder used/100 mL of water				
		0.625 g	1.25 g	2.5 g	5.0 g	10.0 g
Melia leaves	Cold	63.3±5.77	76.6±5.77	86.6±5.77	86.6±5.77	100.0±0.00
	Hot	60.0±10.00	73.3±5.77	86.6±5.77	96.6±5.77	100.0±0.00
Melia immature fruit	Cold	66.6±5.77	76.6±5.77	83.3±5.77	93.3±5.77	100.0±0.00
	Hot	60.0±17.32	66.6±5.77	76.6±5.77	96.6±5.77	100.0±0.00
Melia mature fruit	Cold	50.0±10.00	56.6±5.77	70.0±10.00	76.6±5.77	96.6±5.77
	Hot	70.0±10.00	80.0±10.00	90.0±10.00	100.0±0.00	100.0±0.00
Phytolacca leaves	Cold	66.6±5.77	80.0±10.00	83.3±5.77	93.3±5.77	100.0±0.00
	Hot	43.3±5.77	73.3±5.77	76.6±5.77	90.0±10.00	100.0±0.00
Phytolacca immature fruit	Cold	63.3±5.77	66.6±5.77	76.6±5.77	86.6±5.77	100.0±0.00
	Hot	56.6±5.77	63.3±5.77	80.0±10.00	86.6±5.77	100.0±0.00
Phytolacca mature fruit	Cold	46.6±5.77	63.3±5.77	76.6±5.77	90.0±10.00	100.0±0.00
	Hot	50.0±10.00	66.6±5.77	70.0±10.00	93.3±11.54	100.0±0.00

Values are percentage mean±standard deviation of three replications

activity. At 5 g/100 mL treatment, hot water extract of *Melia* immature fruit and *Phytolacca* mature fruit observed with 100% feeding deterrent activity compared to other treatments. In general, all the plant extracts at this concentration was recorded more than 80% feeding deterrent activity. At 2.5 g/100 mL treatment, maximum percentage feeding deterrent activity of 90% was recorded in cold water extract of *Melia* immature fruit followed by hot water extract of *Melia* mature fruit (86.6%) and cold water extract of *Phytolacca* leaves (86.6%). The remaining all extracts tested at this concentration was recorded more than 70% feeding deterrent activity. At 1.25 g/100 mL plant extracts treatment, maximum deterrent activity of 86.6% was recorded in cold water extract of *Melia* immature fruit and *Phytolacca* leaves. At lower concentration (0.625 g/100 mL), cold water extract of *Melia* immature fruit was observed 80% feeding deterrence. The two way ANOVA indicates that cold water extracts within plants ($F = 11.06$) and within the concentrations ($F = 60.98$) feeding deterrent activity was statistically significant ($p<0.05$). The interaction within the samples were statistically not significant ($F = 1.4$; $p>0.05$). In hot water extracts, feeding deterrent activity within the plants ($F = 1.56$) and interaction within the samples ($F = 0.82$) were statistically not significant ($p>0.05$). However, within the concentrations results were statistically significant ($F = 87.56$; $p<0.05$).

After 48 h exposure period, except for *Melia* mature fruit (96.6%) remaining all the extracts recorded 100% feeding deterrent activity at 10 g/100 mL treatment (Table 2). At 5 g/100 mL treated leaf disc, maximum repellent activity of 100% was observed in hot water extract of *Melia* mature fruit and the remaining treatment more than 75% repellent activity was observed. At 2.5 g/100 mL plant extracts treated leaf discs, all the treatments were recorded more than 70% deterrent activity. The plant extracts tested at 1.25 g/100 mL, hot water extract of *Melia* immature fruit (80%) and cold water extract of *Phytolacca* leaves (80%) was recorded maximum percentage feeding deterrent activity. At lower concentration (0.625 g/100 mL) except for hot water extract of *Phytolacca* leaves (43.3%) and cold water extract of *Phytolacca* mature fruit (46.6%) remaining all recorded ≥50% per cent deterrent activity. The two way ANOVA demonstrates statistically significant ($p<0.05$) feeding deterrent activity within the plant parts tested for cold water ($F = 13.48$) and hot water ($F = 5.88$) extracts. Feeding deterrent activity within the concentrations were also observed statistically significant difference in cold water ($F = 117.62$) and hot water ($F = 99.33$) extracts. The interaction within the samples of cold water

Table 3: Percent feeding deterrent activity of plant extracts on *P. cruciferae* after 72 h exposure period

Plant parts tested	Type of water extract	Amount of plant powder used/100 mL of water				
		0.625 g	1.25 g	2.5 g	5.0 g	10.0 g
Melia leaves	Cold	66.6±5.77	73.3±5.77	83.3±5.77	86.6±5.77	100.0±0.00
	Hot	56.6±5.77	70.0±10.00	86.6±5.77	100.0±0.00	100.0±0.00
Melia immature fruit	Cold	50.0±10.00	73.3±5.77	80.0±10.00	90.0±10.00	100.0±0.00
	Hot	56.6±15.27	70.0±10.00	73.3±5.77	93.3±5.77	100.0±0.00
Melia mature fruit	Cold	46.6±5.77	50.0±10.00	66.6±5.77	80.0±10.00	100.0±0.00
	Hot	63.3±5.77	76.6±5.77	83.3±5.77	83.3±5.77	100.0±0.00
Phytolacca leaves	Cold	60.0±10.00	73.3±5.77	76.6±5.77	86.6±5.77	96.6±5.77
	Hot	36.6±5.77	63.3±5.77	70.0±10.00	80.0±10.00	96.6±5.77
Phytolacca immature fruit	Cold	56.6±5.77	63.3±5.77	70.0±10.00	83.3±5.77	100.0±0.00
	Hot	53.3±5.77	56.6±5.77	70.0±10.00	80.0±10.00	100.0±0.00
Phytolacca mature fruit	Cold	43.3±5.77	56.6±5.77	70.0±10.00	80.0±10.00	93.3±11.54
	Hot	43.3±5.77	60.0±10.00	66.6±5.77	90.0±10.00	96.6±5.77

Values are percentage mean±standard deviation of three replications

Table 4: Percent feeding deterrent activity of plant extracts on *P. cruciferae* after 96 h exposure period

Plant parts tested	Type of water extract	Amount of plant powder used/100 mL of water				
		0.625 g	1.25 g	2.5 g	5.0 g	10.0 g
Melia leaves	Cold	73.3±5.77	76.6±5.77	86.6±5.77	86.6±5.77	100.0±0.00
	Hot	63.3±5.77	76.6±5.77	90.0±10.00	96.6±5.77	100.0±0.00
Melia immature fruit	Cold	46.6±5.77	76.6±5.77	86.6±5.77	86.6±5.77	100.0±0.00
	Hot	56.6±5.77	76.6±5.77	80.0±10.00	96.6±5.77	100.0±0.00
Melia mature fruit	Cold	50.0±10.00	70.0±10.00	73.3±5.77	86.6±11.54	100.0±0.00
	Hot	66.6±5.77	76.6±11.54	86.6±5.77	90.0±10.00	100.0±0.00
Phytolacca leaves	Cold	66.6±5.77	76.6±5.77	83.3±5.77	100.0±0.00	100.0±0.00
	Hot	60.0±10.00	70.0±10.00	76.6±15.27	83.3±15.27	93.3±5.77
Phytolacca immature fruit	Cold	60.0±10.00	70.0±10.00	86.6±5.77	100.0±0.00	100.0±0.00
	Hot	63.3±5.77	70.0±10.00	83.3±5.77	93.3±5.77	100.0±0.00
Phytolacca mature fruit	Cold	56.6±15.27	70.0±10.00	73.3±11.54	86.6±5.77	100.0±0.00
	Hot	53.3±5.77	70.0±10.00	86.6±5.77	86.6±5.77	100.0±0.00

Values are percentage mean±standard deviation of three replications

(F = 1.53) and hot water extracts (F = 1.21) were statistically not significant ($p>0.05$).

After 72 h exposure period, feeding deterrent activity of *Melia* and *Phytolacca* plant extracts tested against flea beetles were reported in Table 3. At higher concentration (10 g/100 mL), feeding deterrent activity of cold water extract of *Phytolacca* leaf (96.6%) was on par with hot water extract of *Phytolacca* leaf (96.6%) and immature fruit (96.6%). At this concentration, remaining all the extracts tested recorded 100% feeding deterrent activity. At 5 g/100 mL level, 100% feeding deterrent activity was recorded in hot water extract of *Melia* leaves and the remaining showed ≥80% feeding deterrent activity. At 2.5 g/100 mL treatment, maximum deterrent activity of 86.6% was noted in hot water extract of *Melia* leaves followed by cold water extract of *Melia* leaves (83.3%) and hot water extract of *Melia* mature fruit (83.3%). At 1.25 g/100 mL, maximum deterrent activity of 76.6% was recorded in hot water extract of *Melia* mature fruit extract. The deterrent activity of cold water extract of *Melia* immature fruit (73.3%) was on par with cold water extract of *Phytolacca* leaves (73.3%). At lower concentration (0.625 g/100 mL), maximum feeding deterrent activity was recorded in cold water extract of *Melia* (66.6%) followed by hot water extract of *Melia* immature fruit (63.3%) and *Phytolacca* leaves (60%). The two way ANOVA results confirmed statistically significant ($p<0.05$) difference within the plant extracts (cold water F = 8.95; hot water F = 10.75) and within the concentrations (cold water F = 101.62; hot water = 120.23). The interaction within the samples of cold water (F = 1.28) and hot water extracts (F = 1-39) were statistically not significant ($p>0.05$).

After 96 h post exposure period, feeding deterrent activity of plant extracts tested against flea beetle was presented in Table 4. At 10 g/100 mL plant extracts treatment, except for hot water extract of *Phytolacca* leaves (93.3%), remaining all observed 100% feeding deterrent activity. At 5 g/100 mL treatment, 100% deterrent activity was recorded in cold water extract of *Phytolacca* leaves and immature fruits. The deterrent activity of hot water extract of *Melia* immature fruit (96.6%) was on par with hot water extract of *Melia* leaf (96.6%). At 2.5 g/100 mL level, 90% deterrent activity was observed in hot water extract of *Melia* leaves. The hot water extract of *Melia* and *Phytolacca* mature fruit extract, cold water extract of immature fruit of *Melia* and *Phytolacca* was observed 86.6% repellent activity. At 1.25 g/100 mL of plant extracts treatment, all recorded ≥70% deterrent activity. At lower concentration (0.625 g/100 mL), maximum feeding deterrent activity (73.3%) was recorded in cold water extract of *Melia* leaves. The two way ANOVA indicates that cold water extracts within the plants (F = 4.84); within the concentrations (F = 93.09) tested

Table 5: Mean number of *P. cruciferae* feeding holes on treated leaf disc after 96 h exposure period

Plant parts tested	Type of water extract	Amount of plant powder used/100 mL of water				
		0.625 g	1.25 g	2.5 g	5.0 g	10.0 g
Melia leaves	Cold	96.6±7.63	90.6±9.29	66.6±7.63	56.60±7.63	7.66±2.08
	Hot	96.3±17.03	72.3±11.23	25.3±7.63	11.66±4.72	7.6±4.93
Melia immature fruit	Cold	118.3±3.78	95.3±4.50	89.0±3.60	7.60±4.50	2.6±2.08
	Hot	107.0±8.00	74.0±7.93	52.6±11.37	34.30±11.01	5.3±2.51
Melia mature fruit	Cold	71.6±6.50	62.6±15.01	36.6±4.50	2.66±2.08	2.0±1.00
	Hot	71.0±11.00	55.3±7.09	42.0±8.18	9.30±1.52	3.0±1.00
Phytolacca leaves	Cold	150.0±28.35	86.0±10.58	72.0±10.81	18.00±6.00	3.0±2.00
	Hot	145.0±24.06	27.0±5.00	18.0±7.93	2.33±1.52	2.0±1.00
Phytolacca immature fruit	Cold	89.0±12.76	17.3±5.03	17.6±5.68	11.30±1.52	1.6±0.57
	Hot	105.6±13.65	84.0±6.00	62.3±12.50	18.00±5.56	5.0±2.00
Phytolacca mature fruit	Cold	132.3±11.67	95.0±7.00	71.0±7.00	16.60±4.16	1.33±0.57
	Hot	99.6±28.57	57.6±3.05	63.6±7.37	20.30±2.51	12.6±4.04

Values are mean±standard deviation of three replications

and interaction among the samples (F = 1.93) were statistically significant ($p<0.05$). In hot water extracts, within the plants parts tested (F = 2.25) and interaction among the samples were statistically not significant ($p>0.05$). However, within the concentrations (F = 69.60) results were statistically significant ($p<0.05$).

After 96 h post exposure period, mean number of feeding holes by flea beetles were counted and presented in Table 5. The flea beetles feeding shows typical "shot hole" appearance on leaves. The mean numbers of feeding holes were decreased in increased concentration of the plant extracts tested. Irrespective of concentrations, minimum feeding hole was observed at 10 g/100 mL of cold and hot water extract. At 5 g/100 mL applied leaf disc, minimum feeding hole was recorded in hot water extract of *Phytolacca* leaves (2.33) followed by cold water extract of *Melia* mature fruit (2.66) and immature fruit (7.6). Generally, mean number of feeding holes were increased in decreased concentration of the plant extracts applied leaf discs. The two way ANOVA demonstrates statistically significant differences ($p<0.05$) within the plant extracts (cold water F = 59.86; hot water F = 9.71) and within the concentrations (cold water F = 456.41; hot water F = 263.99) tested and interaction among the samples (cold water F = 14.55; hot water 8.18).

DISCUSSION

Botanicals and their extracts have been used since time immemorial for controlling various agricultural pests in the field and storage by believing multiple mode of action, prevent quick resistance development and may not leave residues. In the present study feeding deterrent activity of various parts of *M. azedarach* and *P. dodecandra* plant extracts was varied greatly against flea beetles. Irrespective of concentration, maximum feeding deterrent activity was observed at higher concentration in all the extracts tested. The crude plant extracts may not contain sufficient amount of bioactive principle at lower concentration to prevent the entry of insects in treated leaf disc. Charleston *et al*. (2005) also reported that feeding deterrent effect of *M. azedarach* fruit extract against *Plutella xylostell* larvae was increased at higher doses. Rodriguez and Vendramim (1998) observed repellent action and also malformations in some individuals of *Spodoptera frugiperda* exposed to *M. azedarach* extracts. The parts of *Melia* tree contains some alkaloid and condensed tannins which are able to inhibit development or insect feeding (Mulla and Su, 1999). The present study also agreed with the above reports. In addition, odour of the plant materials on treated leaf disc may be preventing flea beetles to enter on treated environment; as a result most of the time insects are moving around the petriplates thereby percentage of repellent activity was greater at higher concentration. The potential feeding deterrent activity of *P. dodecandra* was also based on the concentration of plant materials. Nurie *et al*. (2012) also observed greater immature larval mortality of *Culex quinquefasciatus* exposed at higher concentration. For example at 1000 ppm concentration of petroleum ether, acetone and benzene extract of *P. dodecandra* berries were reported 100% larval mortality. The *P. dodecandra* contains mostly saponin that may be associated with feeding deterrent activity or lemmatoxin, a molluscidal compound isolated from the fruits (Lemma *et al*., 1972).

The mean number of feeding holes was significantly decreased at higher concentration compared to lower concentration. The bioactive principle in the lower concentration may not be sufficient to deter the feeding rate of the flea beetles. As it is evidenced, at lower concentration most of the insects are entered on treated leaves and started feeding. The part of *Melia* tree contains limonoids such as meliantriol (Lavie and Jain, 1967), meliacin, meliacarpin (Lee *et al*., 1991) and meliartenin (Carpinella *et al*., 2002). Among the limonoids, meliantriol was reported to have strong feeding deterrent properties against desert locust *S. gregaria* (Kraus *et al*., 1981) and meliartenin inhibit feeding rate of *E. panuelate* and *S. eridania* (Carpinella *et al*.,

2002). The low number of feeding holes at higher concentration may be associated with these limonoids. Minimum feeding holes observed with cold water extract of *Phytolacca* at higher concentration may be associated with saponin. The detergent nature of the saponin may not allow the insect to feed on treated leaf discs.

CONCLUSION

M. azedarach and *P. dodecandra* have significant impact on flea beetles by feeding deterrent activities. If these plant extracts provide similar results under field condition it may useful for controlling flea beetles. Because these plants are growing extensively in the study area and it can be easily affordable by small scale farming communities to protect their cabbage crop against flea beetles in an eco-friendly way.

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