

Evaluation of *Melia azedarach* Linn *Croton macrostachys* Hochst and *Schinus molle* Linn Plant Extracts against Cabbage Aphid *Brevicoryne brassicae* Linn and their Natural Enemies *Diaeretiella rapae* (Mintosh) and *Hippodamia tredecimpunctata* Linn

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Abstract: The objective of the present study was to assess bioactive potential of individual and combined effect of aqueous extract of *Melia azedarach* seeds, leaves of *Croton macrostachys* and *Schinus molle* against cabbage aphid *Brevicoryne brassicae* under laboratory and field condition. In the field, interaction of aphid predator, *Hippodamia tredecimpunctata* and nymphal parasitoid, *Diaeretiella rapae* was also observed in treated and control plot. The repellent activity of selected plant extracts was evaluated at 0.625, 1.25, 2.5, 5 and 10% concentration by using leaf disc no choice method. Field experiment was conducted at Bridge of Hope children village farm, Gondar, from October 2011 to January 2012. The selected plant extracts was tested in completely randomized block design method in the field. Six different solution, with 5% concentration was prepared from *M. azedarach*, *C. macrostachys* and *S. molle* and mixed forms such as *M. azedarach* (2.5%) + *C. macrostachys* (2.5%), *M. azedarach* (2.5%) + *S. molle* (2.5%) and *C. macrostachys* (2.5%) + *S. molle* (2.5%) and sprayed. The repellent activity was significantly greater in leaf discs treated with *M. azedarach* and *S. molle* at higher concentration. The number of infested cabbage plants and aphid population in the field was decreased significantly in plant extract treated plots. The aphids nymph parasitized by *D. rapae* and aphid predator *H. tredecimpunctata* population was decreased in treated plot. Total number of cabbage head formation and head weight was maximum in plot treated with *M. azedarach* followed by *S. molle*. These plant extracts are easily accessible and adoptable by farming community to protect their cabbage crops and also it could be one of the useful components for IPM program.

Keywords: *Croton macrostachys*, *Diaeretiella rapae*, *Hippodamia tredecimpunctata*, *Melia azedarach*, parasitoid, plant extracts, predator, *Schinus molle*

INTRODUCTION

Ethiopian agriculture sector is predominantly important for the economy of the country which contributes about 50% to the total GDP and 90% of exports item. In Ethiopia, vegetable crops make significant contribution to household and also in national economy (Fikadu and Dandena, 2006). Cabbage is one of the extensively growing vegetable crops in Ethiopia. The estimated area of cabbage cultivation, annual production and yields per hectare is increasing year by year. According to CSA (2005) reports head cabbage cultivation in Ethiopia is 1843 ha/2004 and 2120 ha/2005; annual production is 8577 ton/2004 and 14208 ton/2005; estimated yield per hectare is 4.7 ton/2004 and 7.2 ton/2005.

One of the constraints in cabbage production is damage caused by wide variety of pests. Cabbage aphid *Brevicoryne brassicae* is one of the important pests (Jankowska and Wiech, 2004) and their damage potential affect the quality and market value of the

cabbage (Birhanu *et al.*, 2011). According to Rauf *et al.* (2005), 70% of farmers growing cabbage crop to spend 25-30% of total production input cost to purchase pesticides. To overcome this situation plant extracts with potential bioactive compounds are one of the best alternative choices to minimize the use of synthetic chemical insecticides.

Melia azedarach belongs to the family Meliaceae are one of the potential bioactive plants extensively studied in laboratory and also in field against several insect pests and vectors. Potential laboratory findings were tested against diamond back moth *Plutella xylostella* and their natural enemies *Cotesia plutella* and *Diadromus collaris* in the cabbage field (Charleston, 2004; Charleston *et al.*, 2005a, b, 2006). The promising repellent activity of aqueous seed extract was reported against cabbage aphid *B. brassicae* under laboratory condition (Birhanu *et al.*, 2011) and also in the field (Kibrom *et al.*, 2012).

Biological activities of plants belong to the genus *Croton* was confirmed by many scientific reports (Peres

et al., 1997, 1998; Suarez *et al.*, 2003; Anazetti *et al.*, 2004; Fisher *et al.*, 2004). The compound cis-dehydrocrotonin isolated from *Croton cajucara* bark inhibits the growth of lepidopteran pest *Heliothis virescens* (Wiegas-Junior, 2003). The dichloromethane extract of *Croton campestris* root barks at 20 ppm have been proved as natural molluscicide due to rich in furano-clerodane (El-Babili *et al.*, 2006). The essential oil and monoterpene ascaridole isolated from *Croton regelianus* have been reported strongly effective against *Aedes aegypti* and larvae of *Artemi* sp., (Torres *et al.*, 2008). According to Karunamoorthi and Ilango (2010) *Croton macrostachyus* proved to have potent mosquitocidal activity against *Anopheles arabiensis*. However, bioactive potential of these plant extracts against cabbage pests and natural enemies' complex was not fully understood in Ethiopian context.

Schinus molle is commonly called as pepper tree native to Peruvian Andes and growing widely in tropical and subtropical countries (Zeven, 1982). In Ethiopia, rural people used to drape branches over their head believing to repel housefly *Musca domestica*. The traditional belief on repellent activities and also feeding deterrent was confirmed by two choice laboratory bioassay methods against houseflies (Wimalaratne *et al.*, 1996). According to Ferrero *et al.* (2006) leaves and fruits proved to have insecticidal and repellent activity against Chagas diseases vector, *Triatoma infestans*. In addition, ethanol and petroleum ether extract was also tested on *Blattella germanica* adults by topical application test (Ferrero *et al.*, 2007). The hexane extract was reported to show good repellency (83.33%) at higher concentration (0.075 mg/L) against oriental cockroach (Deveci *et al.*, 2010). Repellent and insecticidal activity was also confirmed with two stored grain pests *Trogoderma granarium* and *Tribolium castaneum* (Abdel-Sattar *et al.*, 2010). Therefore, due to abundant availability of selected plants in the study area and ample earlier evidences, current research was undertaken to assess the impact of aqueous extracts of *M. azedarach*, *C. macrostachyus* and *S. molle* and their combination against cabbage aphid *B. brassicae* and their nymphal parasitoid *Diaeretiella rapae*; predator, *Hippodamia tredecimpunctata*.

MATERIALS AND METHODS

Collection and processing of plant materials: *Melia azedarach* seeds were collected from Samunaber village, Gondar and the leaves of *Croton macrostachys* and *Schinus molle* were collected from Fasildes preparatory school campus and Edget Feleg High school campus, Gondar town Ethiopia. The specific parts collected from the plants were thoroughly washed with tap water to remove dirt and impurities of foreign particles found to be attached from their natural environment. The well cleaned plant parts were shade dried for fifteen days and powdered by using local coffee grinder. The fine powder was obtained by

sieving through kitchen strainer and used for aqueous extract preparation.

Preliminary laboratory screening of plant extracts:

Preliminary screening test was conducted at Biology laboratory, Department of Biology, University of Gondar. The crude extract was prepared at 0.625, 1.25, 2.5, 5 and 10% concentration, respectively and applied to 3 cm in diameter cabbage leaf discs. The early stage cabbage leaf was collected from the field and used to prepare leaf discs. The circular Whatman 540 hardened ash less filter paper 110 mm thickness was dipped in water and kept inside the petridish to maintain the moisture content. The petiole of the cabbage leaf was tied with water soaked cotton to prevent early drying. The plant extract treated leaf disc with different concentration was air dried and kept inside the petridish. The plant extract was mixed with 0.2% local soap solution as an emulsifier before applying to the leaf disc. The cabbage aphid was collected from the field and brought to the laboratory along with infested leaf. In each treated leaf disc 20 third instar nymphs was released by using fine camel brush and monitored. The leaf disc treated with water was considered as control. The number of aphid on treated and control leaf disc was monitored and the percentage of repellent activity was calculated.

Field experiment: Field experiment was conducted at Bridge of Hope children village farm around University of Gondar from October 2011 to January 2012. The experimental field was located at a latitude and longitude of 12°35'07"N and 37°26'08"E and 2108 masl. The land was prepared in the mid of October 2011 and cabbage nursery was prepared by using *Brassica oleracea* seeds. The seedling was watered twice a day for early stages. The healthy seedling with 5-8 leaves was transplanted to the experimental plots on second week of November 2011. The plants were transplanted with the spacing of 40 cm length × 75 cm width between plants. The drip irrigation method was used to provide watering for every morning regularly and continued up to harvesting period.

Experimental design: Field experiment was conducted in completely randomized block design. Six different stock solution, with 5% concentration was prepared from *M. azedarach*, *C. macrostachys* and *S. molle* and mixed forms such as *M. azedarach* (2.5%) + *C. macrostachys* (2.5%), *M. azedarach* (2.5%) + *S. molle* (2.5%) and *C. macrostachys* (2.5%) + *S. molle* (2.5%). Totally twelve rows of cabbage crops was established. Among them six was experimental and another six was control. In each row 30 cabbage plants were raised and arranged in to five subgroups each with six cabbage plant. Therefore, the replication was considered as five and the treatments were seven including control. The plant extracts was sprayed five times at seven days intervals by using knapsack sprayer.

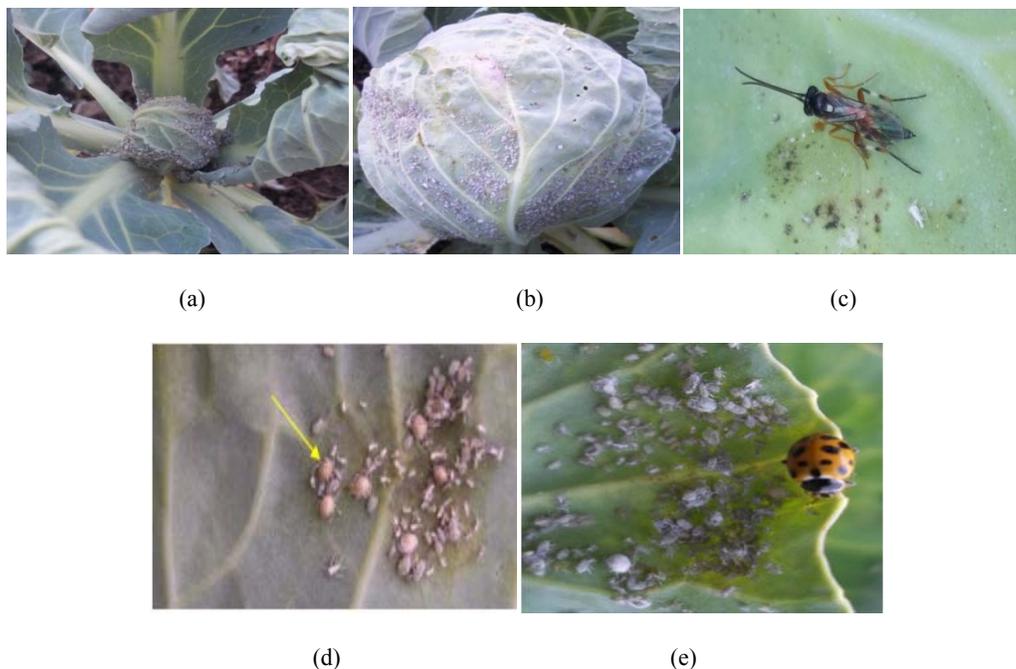


Fig. 1: (a) and (b) Aphid infestation at different stage of cabbage head formation (c) Adult *Diaeretiella rapae* (d) *D. rapae* parasitized aphid nymphs (mummies) (e) *Hippodamia tredecimpunctata* feeding on aphids

Plant damage estimation: Cabbage aphid, *B. brassicae* appearance on cabbage plant was monitored from November 2011 to January 2012. The plant infestation observed at the mid of December 2011 during which the data collection and spraying was started. Before spraying plant extracts, number of infested plants from control and experimental plots were recorded. The percentage of cabbage plant infested by aphids was calculated.

Estimation of aphid population: Cabbage aphid, *B. brassicae* population was recorded before and after application of botanical extracts. Totally five plants was selected randomly from control and experimental group for aphid counting. Among the five plants three leaves were selected for each plant and tagged. The number of aphids from each tagged leaves were recorded by using hand lens and mean number of aphids per leaves was calculated.

Estimation of aphid parasitoid, *Diaeretiella rapae*: Aphid parasitoid, *D. rapae* (Fig. 1c) was observed by parasitized aphid nymphs (mummies) by the appearance of golden brown in colour (Fig. 1d). The parasitized nymphal population was observed after 3rd, 4th and 5th spraying. The parasitized and unparasitized aphid nymphs were identified by using hand lens and recorded from the tagged leaves as mentioned in aphid counting. The data was collected from five replications with six treatment and untreated control. The percentage parasitization rate of *D. rapae* was calculated.

Estimation of coccinellids predator, *Hippodamia tredecimpunctata* (Fig. 1e): Predatory coccinellids, *H. tredecimpunctata* (13 *punctata*) was observed from 1st spraying up to the completion of 5th spraying. The interaction of predator was observed after 2nd spray. The number of predator was recorded from six botanical treatment and untreated control. The number of predator was recorded from one cabbage plant in each replication. The mean number of coccinellids on experimental and control plot was calculated.

Estimation of cabbage head formation: Cabbage head formation in control and experimental plot was recorded during the time of harvest (February 2012). Total number of cabbage plants with head and without head was recorded. The percentage of cabbage plants with head formation was calculated.

Cabbage head weight assessment: Purposive, non random sampling technique was used for cabbage head weight assessment. Totally five healthy cabbage head was selected from five replications of six treatments and control group individually. The weight of each cabbage head was measured and mean weight was calculated.

Statistical analysis: The data collected from repellent activity, aphid populations and coccinellids population were subjected to two way ANOVA with replication to compare the statistical significant within the plant extract tested and the concentration of the plant extract at 5% level. The data on statistical significant on

percentage of infested cabbage plants with aphid, cabbage head weight was compared with two way ANOVA without replication. The data on rate of parasitization by *D. rapae* was analyzed by one way ANOVA. All the descriptive statistical analysis, ANOVA and LSD (Least Significant Difference) test was conducted by using Microsoft excel program and also in SPSS version 16.

RESULTS

Repellent activity of plant extracts: Repellent activity results indicates that after 24 h exposure period 100% repellent activity was observed at 10% concentration in all tested plant extracts (Table 1). However, at 5% concentration of *Melia* and *Schinus* extracts treated cabbage leaves was also showed 100% repellent activity. The result of *Melia* + *Croton* extracts combinations was on par with *Croton* + *Schinus*. The percent repellent activity of *Melia* and *Schinus* extract was significantly different ($p < 0.05$; $LSD = 9.14$) from *Croton* and other treatments. Among the five tested concentrations repellent activity of all the plant extracts was decreased in lower concentrations. At 2.5% concentration, all the tested plant extracts and their combination showed 50% and above repellent activity.

Cabbage plant infestation: Mean number of cabbage plants infested by aphids in experimental plots was reduced after first spray except *Schinus* treatment (66.6%). After second spray, minimum infestation of 23.3% was observed in *Melia* extracts treated plots. The cabbage plant infestation in *Schinus* extract treatment was on par with *Croton*. Among the individual and

combination of the plant extract, maximum infestation of 50% was observed in *Melia* + *Schinus* treated plot. However, in the control plot maximum infestation was 83%. After third spray, minimum infestation of 23.3 and 26.6% was observed in *Melia* and *Schinus* treatments respectively. After fourth spray, number of cabbage plant infestation was remarkably decreased and the regulatory effect of botanical extracts was increased in experimental plots. The cabbage plants treated with *Melia* and *Schinus* extracts, mean percentage of infested plant was 20%. However, number of infested plants in control group was 86.6%. After fifth spray, 10% infestation was recorded from *Melia* extract treated plot followed by *Schinus* and *Croton* (16.6%). In control plots maximum percentage infestation of 90% was observed (Table 2). The two way ANOVA without replication results confirmed statistically significant difference within the plant extracts tested and duration of the spray schedule at 5% level ($p < 0.05$). This will further indicates that repeated application of botanicals was necessary for the achievement of maximum protection in cabbage plants.

Mean number of aphids in control and experimental plots: Mean number of aphid population in experimental and control groups were reported in Table 3. Results revealed that before spraying infestation level in control and experimental groups were statistically not significant ($p > 0.05$; $LSD = 29.85$). After first treatment, mean number of aphid population reduction was statistically significant ($p < 0.05$; $LSD = 29.85$) compared to control. However, within the plant extracts, results were not significantly different ($p > 0.05$; $LSD = 29.85$). After 2nd spray, maximum

Table 1: Mean percentage repellent activity of aqueous extract of different plant extracts against cabbage aphid

Plant extracts tested	Concentration of the plant extracts in %				
	0.625%	1.25%	2.5%	5.0%	10%
<i>Melia</i>	26.6 ^a ±5.77	50.0 ^a ±10.0	76.6 ^b ±5.77	100.0 ^a ±0.00	100.0 ^a ±0.00
<i>Schinus</i>	26.6 ^a ±5.77	46.6 ^{abc} ±15.27	70.0 ^{ac} ±10.0	100.0 ^a ±0.00	100.0 ^a ±0.00
<i>Croton</i>	10.0 ^b ±10.0	33.3 ^b ±5.77	56.6 ^b ±5.77	73.30 ^b ±5.77	100.0 ^a ±0.00
<i>Melia</i> + <i>croton</i>	13.3 ^{bc} ±5.77	40.0 ^{bc} ±10.0	60.0 ^{bc} ±10.0	83.30 ^c ±5.77	100.0 ^a ±0.00
<i>Melia</i> + <i>schinus</i>	20.0 ^c ±10.0	40.0 ^{bc} ±10.0	70.0 ^{ac} ±10.0	86.60 ^c ±5.77	100.0 ^a ±0.00
<i>Croton</i> + <i>schinus</i>	20.0 ^c ±10.0	43.3 ^c ±11.54	66.6 ^c ±5.77	83.30 ^c ±5.77	100.0 ^a ±0.00

Values are percentage mean±standard deviation of three replications; Within the column mean values with same alphabets are statistically not significant ($p > 0.05$; LSD)

Table 2: Mean percentage of cabbage plant infested by cabbage aphid

Plant extracts tested	Percentage of infested cabbage plants after spraying				
	1 st spray	2 nd spray	3 rd spray	4 th spray	5 th spray
<i>Melia</i>	40.0	23.3	23.3	20.0	10.0
<i>Schinus</i>	66.6	40.0	26.6	20.0	16.6
<i>Croton</i>	56.6	40.0	33.3	30.0	16.6
<i>Melia</i> + <i>croton</i>	60.0	46.6	36.6	30.0	23.3
<i>Melia</i> + <i>schinus</i>	56.6	50.0	36.6	26.6	23.3
<i>Croton</i> + <i>schinus</i>	53.3	43.3	36.6	30.0	23.3
Control	63.3	83.3	86.6	86.6	90.0

Within the plant ($F = 17.23$; $p < 0.05$); Spray schedule ($F = 7.94$; $p < 0.05$) by two way ANOVA

Table 3: Mean number of aphids recorded in control and experimental plots

Treatment	Mean number of aphids					
	Before spraying	After 1 st spray	After 2 nd spray	After 3 rd spray	After 4 th spray	After 5 th spray
<i>Melia</i>	131.8 ^a ±22.9	114.2 ^a ±27.1	85.8 ^{ac} ±20.7	48.2 ^a ±20.9	27.8 ^{ac} ±7.900	8.4 ^a ±5.60
<i>Schinus</i>	109.4 ^a ±9.10	92.00 ^a ±16.8	77.6 ^{ac} ±11.9	48.0 ^a ±12.6	37.6 ^{abc} ±14.6	13.2 ^a ±5.4
<i>Croton</i>	115.4 ^a ±18.9	113.0 ^a ±24.1	120.0 ^b ±27.7	97.0 ^b ±26.1	63.8 ^b ±6.100	37.2 ^a ±9.5
<i>Melia+croton</i>	133.2 ^a ±41.1	110.4 ^a ±33.4	96.4 ^{ab} ±31.8	81.2 ^b ±22.9	46.6 ^{bc} ±17.2	16.2 ^a ±3.8
<i>Melia+schinus</i>	126.8 ^a ±47.1	106.0 ^a ±35.5	62.8 ^c ±9.500	40.8 ^a ±13.4	30.2 ^c ±12.70	12.4 ^a ±5.6
<i>Croton+schinus</i>	122.8 ^a ±33.8	109.0 ^a ±26.1	107.6 ^{ab} ±19.9	86.2 ^b ±11.3	63.6 ^b ±13.10	18.4 ^a ±3.0
Control	133.6 ^a ±20.3	148.4 ^b ±17.2	159.4 ^d ±20.3	164.2 ^c ±25.1	190.4 ^d ±33.2	246.6 ^b ±67.6

Values are mean±standard deviation of five replications; Within the column mean values with same alphabets are statistically not significant ($p>0.05$; LSD = 29.85)

Table 4: Mean percentage of *Brevicoryne brassicae* nymphs parasitized by *Diaeretiella rapae* in control and experimental plots

Treatment	Mean number of parasitized aphid nymphs		
	After 3 rd spray	After 4 th spray	After 5 th spray
<i>Melia</i>	42.42 ^a ±19.49	14.50 ^a ±6.05	6.22 ^{ab} ±9.080
<i>Schinus</i>	26.66 ^{bc} ±14.70	14.43 ^a ±4.45	12.66 ^a ±14.07
<i>Croton</i>	16.02 ^{bcd} ±3.10	8.26 ^a ±2.520	1.76 ^b ±1.6900
<i>Melia+croton</i>	14.36 ^{bd} ±3.23	9.17 ^a ±10.68	8.41 ^{ab} ±7.250
<i>Melia+schinus</i>	29.43 ^c ±11.74	14.90 ^a ±7.85	10.29 ^{ab} ±6.97
<i>Croton+schinus</i>	19.63 ^{cd} ±3.50	7.93 ^a ±2.230	7.16 ^{ab} ±7.440
Control	9.87 ^d ±2.620	8.80 ^a ±3.050	9.29 ^{ab} ±2.600
LSD ($p<0.05$)	13.03	7.45	9.90

Values are mean±standard deviation of five replications; Within the column mean values with same alphabets are statistically not significant ($p>0.05$; LSD)

Table 5: Mean number of aphid predator, *Hippodamia tredecimpunctata* recorded in control and experimental plots

Treatment	Mean number of coccinellids				
	After 1 st spray	After 2 nd spray	After 3 rd spray	After 4 th spray	After 5 th spray
<i>Melia</i>	0.0±0.00	0.4 ^a ±0.40	2.8 ^a ±1.16	2.4 ^{ac} ±0.80	0.4 ^a ±0.40
<i>Schinus</i>	0.0±0.00	0.6 ^a ±0.89	2.4 ^a ±1.51	1.4 ^{ab} ±1.51	1.2 ^a ±1.09
<i>Croton</i>	0.0±0.00	0.4 ^a ±0.54	2.0 ^a ±0.79	1.2 ^b ±0.84	1.2 ^a ±0.84
<i>Melia+croton</i>	0.0±0.00	0.8 ^a ±0.81	2.0 ^a ±1.00	1.6 ^{ab} ±1.14	1.4 ^a ±0.89
<i>Melia+schinus</i>	0.0±0.00	0.6 ^a ±0.54	2.2 ^a ±0.84	1.2 ^a ±0.84	1.2 ^a ±0.84
<i>Croton+schinus</i>	0.0±0.00	0.6 ^a ±0.89	2.2 ^a ±1.09	2.0 ^{ac} ±1.0	1.4 ^a ±0.89
Control	0.0±0.00	0.8 ^a ±0.84	3.0 ^a ±1.00	3.0 ^c ±1.22	3.0 ^b ±0.71

Values are mean±standard deviation of five replications; Within the column mean values with same alphabets are statistically not significant ($p>0.05$; LSD = 1.07)

reduction was recorded in *Melia + Schinus* combination compared to other treatment and control. The results of *Melia*, *Schinus* and *Melia + Schinus* combination were statistically not significant ($p>0.05$; LSD = 29.85). After 3rd spray, reduction of aphid population in *Melia + Schinus* treatment was on par with the results of *Melia* and *Schinus* treatment. After 4th spray, maximum reduction was recorded in *Melia* treatment followed by *Melia + Schinus* and *Schinus*. After 5th spray, compared to control all the plant extracts treated plot results were significantly different ($p<0.05$; LSD = 29.85) and within the plant extracts the results were statistically not significant ($p>0.05$; LSD = 29.85). In general, reduction of aphid population was proportionately decreased from 1st to 5th spray.

Mean percentage of *Diaeretiella rapae* parasitized aphid nymphs: The first appearance of nymphal parasitoid *D. rapae* was observed after 2nd spray. After 3rd spray, mean percentage of parasitized nymph (mummies) was recorded at the maximum of 42.42% in

Melia treatment (Table 4) and the result was statistically significant ($p<0.05$; LSD = 13.03) compared to other treatments. After 4th spray, there was a wide fluctuation in all the treatment but the result was statistically not significant ($p>0.05$; LSD = 7.45). However, after 5th spray, parasitization rate was greater in *Schinus* treatment compared to control and other treatment. In addition, except *Croton* treatment remaining all the treatment including control results were statistically not significant ($p>0.05$; LSD = 9.90).

Mean number of aphid predator, *Hippodamia tredecimpunctata*: Aphid predator, *H. tredecimpunctata* was appeared after 1st spraying; mean numbers of predator recorded from experimental and control group was presented in Table 5. The number of predators observed in experimental and control plot after 2nd and 3rd spray was statistically not significant ($p>0.05$; LSD = 1.07). However, after 4th spray, maximum number of predator was observed only in control plot. The results of *Melia*, *Croton + Schinus*

Table 6: Percentage of cabbage head formation and head weight in control and experimental plots

Plant extracts tested	Cabbage plant with head (%)	Cabbage head weight (gm)
<i>Melia</i>	93.34	2070±289.13
<i>Schinus</i>	90.00	1910±257.68
<i>Croton</i>	83.34	1872±300.62
<i>Melia+croton</i>	83.34	1578±483.46
<i>Melia+schinus</i>	83.34	1713±428.48
<i>Croton+schinus</i>	83.34	1718±530.37
Control	73.34	1414±434.40

Cabbage head weight values are mean±standard deviation of five replications

and control was statistically not significant ($p > 0.05$; LSD = 1.07). After 5th spray, number of predators recorded in all the plant extract treatment was statistically not significant. However, compared to control plot reduction of predator population was significantly different ($p < 0.05$; LSD = 1.07) in experimental plot.

Cabbage head formation: Cabbage head formation results revealed that maximum percentage of head formation was recorded in *Melia* treatment and minimum was in control plot. The second best treatment was *Schinus* extract. The plot treated with *Croton* and the combination of three botanical extract treatments showed similar results (Table 6).

Cabbage yield assessment: Cabbage head weight results revealed that maximum mean cabbage head weight was recorded from *Melia* seed extract treatment (Table 6). Among the various botanical treatments minimum average weight of 1578 gm was recorded in plot treated with *Melia* + *Croton* extract. The mean weight of cabbage head collected from the control plot was 1414 gm. Two way ANOVA without replication indicates that within the plant extract treatment cabbage head weight was statistically not significant ($p > 0.05$; F value-1.16; F-table value 2.51). The weight of the individual cabbage head was also not statistically significant ($p > 0.05$; F value 0.86; F-table value 2.78).

DISCUSSION

Recent times searching potential bioactive plants and their secondary metabolites are flourishing well throughout world as an alternative source for pest and vector control program. The plant secondary substances may have multiple modes of actions against insects such as repellents, antifeedant, oviposition deterrent, ovicidal and toxins. In the present study individual and combined effect of *M. azedarach*, *C. macrostachys* and *S. molle* showed various degree of bioactivity against cabbage aphids and their natural enemies. The bioactivity of plant materials are mainly based on toxic nature of secondary metabolites and dissolving nature of those material in a particular solvents used for extraction process. Zaki *et al.* (2008) reported that percentage mortality of aphid was highest in petroleum

ether extract of *Melia* and lowest in alcohol extract of neem. Laboratory study of Birhanu *et al.* (2011) indicates that methanol and aqueous extract of *Mentha piperita* and *Melia azedarach* seed showed promising results against cabbage aphid *B. brassicae*. The authors suggested that aphid mortality may be due to feeding inhibition leading to starvation or stomach poison. The result of current findings efficacy of the plant materials to control cabbage aphids varied among the plant species. The highest concentration of *Melia* and *Schinus* extract showed 100% repellent activity compared to lower concentration. Therefore, concentration level was one of the important factor and many of the plants showed dose depended effect. In the present findings it was observed that most of the time aphids are moving around the petriplates. It may be due to odour of the treated environment aphids are unable to settle on the leaf discs thereby repellency rate was increased.

Mean percentage of aphid infested cabbage plant was decreased in plot treated with *Melia* seed extract. In the field experiment aphid population was decreased and the treatments effect was increased significantly due to repeated spraying of plant extracts. Minimum infestation was observed in plot treated with *Melia* seed extract followed by *Schinus* and *Croton*. The present findings are in agreement with the report of Kruas (2002) who have reported that *Melia* contains a triterpenoid, meliacarpin which reduce the growth of insects or another triterpenoid, toosendanin from *Melia toosendam* which cause stomach poison for chewing insects (Chiu, 1988). Therefore, repeated application of *Melia* seed extracts, cabbage leaves may be unpalatable to aphids due to presence of some bioactive triterpenoids thereby aphid population was reduced.

Aphid parasitoid *D. rapae* was recorded from both treated and untreated fields starting from 3rd spraying. It was found that the size of parasitized and non parasitized aphid population was decreased when number of treatment increased. Maximum number of mummies was observed in *Melia* treated plot immediately after first spraying. After sixth spray, parasitized aphids were decreased in all plant extracts treated plot. It may be due to reduced number of aphids in treated plot parasitoid move to search abundant availability of host in untreated plots. Present findings was corroborate with the report of Charleston *et al.* (2006) they have reported that *Plutella xylostella* parasitoid was significantly higher in plots treated with botanicals particularly the plot treated with syringa (*M. azedarach*).

Aphid predator, lady bird beetle (*H. tredecimpunctata*) population was decreased from plots which had received various types of botanical treatments compared to control. The reduction of predator population may be due to number hosts decreased in treated plot thereby predators moves to untreated plot or direct repellent effect of extracts over the predator. To confirm present findings, Zaki (2008)

also observed number of aphid predator, *C. undecimpunctata* was decreased markedly 7 days after neem azal-S treated field. Further, Zaki *et al.* (1999) observed decreased aphid consumption rate and fecundity of the predators, *C. undecimpunctata* and *Chrysoperla carnea* in some plant extracts treatments.

In general, plant extract treated plot number of head formation was higher compared to untreated control. Among the various plant extract treatment, cabbage head formation was highest in *Melia* seed extract treated plot. This may be due to systematic application of plant extracts aphid infestation was reduced thereby the plant attain normal growth and the head formation was not affected. As it is evidenced in the field observation particularly in control plot growth of the plant was stunted due to aphid infestation. To confirm present findings Charleston *et al.* (2006) reported that number of unmarketable heads significantly higher in control plots than in botanical extract treated plot. The cabbage head weight in the present study was statistically not significant. It may be due to purposive sampling of cabbage head selection. Present study proved that botanicals have significant impact on cabbage aphid and it can be suitable for aphid management in cabbage particularly small scale farming community in order to minimize the use of chemical pesticides or those who are unable to afford the cost of chemical pesticides.

ACKNOWLEDGMENT

First author gratefully acknowledges Ato Alemrew, Farm manager, Hope of Bridge, Gondar children village farm for his generous support to provide land and help in land preparation, transplantation and protection of cabbage plants. The financial assistance received from University of Gondar (UoG/Budget code 6417) under teaching and learning program is deeply acknowledged.

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