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Insecticidal and repellent activity of some plant extracts against *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus)

Sunil Kumar Yadav and Shweta Patel

Abstract

The crude aqueous extracts from *Ageratum conyzoides* (L.), *Parthenium hysterophorus* (L.), *Lantana camara* (L.), *Solanum nigrum* (L.), *Cannabis sativa* (L.), *Calotropis gigantea* (L.), *Livistona chinensis* (Jacq.), *Cassia angustifolia* (Mill.) were tested for their insecticidal and repellent activity against *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus). Leaves of mustard were treated with different concentrations (1%, 3%, 5%, 7% and 10%) by spraying with potter's tower and aphids were allowed to feed for 72 hours. The results revealed that percent mortality was directly related to concentration of plant extract and exposure period. The treatments of *C. angustifolia* seeds and *C. angustifolia* leaves were the most effective causing maximum mortality in *B. brassicae* (up to 100% mortality at 10% and 7% concentrations, respectively, after 72 hours of exposure period) and *M. persicae* (up to 96.67 and 93.33% mortality, respectively, at 10% concentration after 72 hours of exposure period). Whereas the repellent activity was inversely related to concentration of plant extract. In general, the repellent activity was increased up to 48 hours of exposure at low concentrations. However, repellent activity was low at higher concentrations. These plants can be used as botanical insecticide to manage the insect problems.

Keywords: *Myzus persicae*, *Brevicoryne brassicae*, repellent activity, insecticidal activity, plant extracts

1. Introduction

Aphids are small soft-bodied insects and often called plant lice. They cause damage to many host plants directly by sucking the sap and producing necrotic spots in tissues, and indirectly by transmitting disease causing organisms and excreting honeydew on which development of sooty mould interfere photosynthesis [1]. The green peach aphid, *Myzus persicae* (Sulzer), is a cosmopolitan and polyphagous insect infesting hundreds of host plants in over 40 plant families including Solanaceae, Chenopodiaceae, Compositae, Cruciferae, and Cucurbitaceae [2]. Its important hosts are mustard, asparagus, potato, okra, bean, beets, broccoli, Brussels sprouts, cabbage, tomato, carrot, cauliflower, cantaloupe, celery, corn, fennel, kale, kohlrabi, turnip, eggplant, lettuce, parsley, parsnip, pea, pepper, radish, spinach, squash, turnip, cucumber, and watermelon [2]. It causes water stress, wilting, reduces growth rate of the plant, honeydew excretion and most important as vector, transmitting more than 100 plant viruses in about 30 families [3].

Cabbage aphid, *Brevicoryne brassicae* (Linn.) is native of Europe and now found worldwide [4]. It is found to infest on cauliflower, brussels sprouts, broccoli, cabbage, oilseed rape and other members of the genus *Brassica* [4]. Continued sucking the sap from host plants causes yellowing, wilting and stunting of plants [5]. Honeydew excretion reduces photosynthetic area and causes leaf death [6]. It is a vector of more than 23 viruses causing diseases in crucifer plants [7].

Continuous and heavy use of chemical insecticides causes several problems like development of resistance, pest resurgence, secondary pests outbreak, affects non-target insects species and environment, and human health [8]. On the other hand, plants are rich sources of natural substances and have great potential to be formulated as botanical pesticides that can be utilized in the development of environmentally safe alternative methods for insect control in the place of synthetic insecticides [9]. Plants contain secondary metabolites that are deleterious to insect and other herbivores in diverse ways; through acute toxicity, enzyme inhibition and interference with the consumption and/or utilization of food [9]. Therefore, the present study was conducted to evaluate the insecticidal and repellent activity of ten plant extracts against aphids, *Myzus persicae* and *Brevicoryne brassicae* under laboratory conditions.

2. Materials and Methods

The present study was conducted in Department of Entomology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar during December, 2016.

2.1 Collection of plant material

Different plant species from different families were collected from different locations in Pantnagar region. The criteria for selection of the plants, having insecticidal activity, were based on visual observation during which an effort was made to pick up the plants with no infestation of insect pest.

Table 1: Details of plant species evaluated

S.NO.	Common name, Vernacular name (V)	Botanical name (Order: Family)	Plant part used
1	Goat weed, Mahku (V)	<i>Ageratum conyzoides</i> L. (Asterales: Asteraceae)	Leaves
2	Wild carrot weed	<i>Parthenium hysterophorus</i> L. (Asterales: Asteraceae)	Leaves
3	Lantana	<i>Lantana camera</i> L. (Verbenales: Verbenaceae)	Leaves
4	Solanum Makoi	<i>Solanum nigrum</i> Linn. (Solanales: Solanaceae)	Leaves
5	Bhang	<i>Cannabis sativa</i> Linn. (Rosales: Cannabaceae)	Leaves
6	Madar/aak	<i>Calotropis gigantea</i> L. (Gentianales: Apocynaceae)	Leaves
7	Chinese fan palm	<i>Livistona chinensis</i> Jacq. (Arecales: Arecaceae)	Fruits
8	Madar/aak	<i>Calotropis gigantea</i> L. (Gentianales: Apocynaceae)	Seeds
9	Indian senna	<i>Cassia angustifolia</i> Mill. (Fabales: Fabaceae)	Leaves
10	Indian senna	<i>Cassia angustifolia</i> Mill. (Fabales: Fabaceae)	Seeds

2.2 Preparation of plant extracts

For the preparation of plant extracts, collected plant parts were washed to remove the dust and placed on blotting paper for overnight to remove the excess water content. About 250 gm of plant material was added in the 500 ml of water and allowed to boil up to half of the original volume, and then it was cooled. The material was filtered through muslin cloth and filled in the glass bottle and stored in the cool and dry place. For conducting experiment, different concentrations (1%, 3%, 5%, 7% and 10%) were prepared by adding water.

2.3 Bioassay

To conduct bioassay, mustard leaves (*Brassica rapa*) were sprayed with different concentrations of plant extracts with the help of potter's tower. Ten healthy 3rd instar insects (*M. persicae* and *B. brassicae*) were released on treated leaf. Each treatment replicated thrice. Leaves treated with distilled water served as control. Insecticidal and repellent activities were recorded after 24, 48 and 72 hours of release.

2.4 Statistical analysis

The data were subjected to one-way analysis of variance (ANOVA) using completely randomized design (CRD) programme. The data on per cent insecticidal and repellent activity were transformed to angular transformation.

3. Results

3.1 Insecticidal activity of plant extracts against *B. brassicae*

The data presented in Table 2 reveal the insecticidal activity of different plant extracts against *B. brassicae*. The percent mortality of *B. brassicae* was directly related to concentration of plant extract and exposure period. At 1% concentration, 50% or above mortality was observed after 72 hours of exposure and reached its maximum of 60% in the treatment of *C. angustifolia* leaf followed by *S. nigrum* (56.67%) and *C. angustifolia* seed (50%). In case of 3% concentration, 50% or above mortality was found after 48 hours of exposure and increased further after 72 hours of exposure to the maximum of 76.67% in the treatment of *C. angustifolia* leaf followed by *S. nigrum* (66.67%). At 5% concentration, 50% or above mortality was observed after 24 hours of exposure only in the treatment of *S. nigrum* (56.67%). The mortality was further increased up to 72 hours of exposure and recorded maximum of 86.67% in the treatment of *C. angustifolia* leaves followed by *A. conyzoides* and *S. nigrum* which were recorded at

76.67%. At 7% concentration, 50% or above mortality was observed after 24 hours of exposure and found maximum (63.33%) in the treatment of *A. conyzoides*. It was further increased up to 72 hours of exposure and recorded up to 100% mortality in the treatment of *C. angustifolia* leaves followed by *C. angustifolia* seed (86.67%). At 10% concentration, all treatments showed 50% or above mortality after 24 hours of exposure with highest of 76.67% in *C. angustifolia* leaves. The mortality was continue increased up to 72 hours of exposure and reached up to 100% in the treatments of *C. angustifolia* leaf and *C. angustifolia* seed. However, treatments were not statistically significant ($p \leq 0.05$).

3.2 Insecticidal activity of plant extracts against *M. persicae*

The data presented in Table 3 reveal the insecticidal activity of different plant extracts against *M. persicae*. The percent mortality of *M. persicae* was directly related to concentration of plant extract and exposure period. At 1% concentration, 50% or above mortality was observed after 72 hours of exposure and reached its maximum of 60% in the treatment of *C. angustifolia* leaf. It was followed by *C. sativa* (53.33%) and *S. nigrum* (50%). At 3% concentration, 50% or above mortality was observed after 48 hours of exposure only in the treatment of *S. nigrum* (53.33%). It was further increased up to 72 hours of exposure and reached to its maximum of 60% in the treatments of *Cassia* seed, *S. nigrum* and *C. angustifolia* leaves. At 5% concentration, 50% or above mortality was also observed after 48 hours of exposure and found maximum (56.67%) in the treatment of *C. angustifolia* leaves. It was increased after 72 hours of exposure and recorded highest (70%) in the treatments of *C. angustifolia* leaf and *C. angustifolia* seed. At 7% concentration, 50% or above mortality was again observed after 48 hours of exposure with maximum (66.67%) in the treatment of *C. angustifolia* leaves. It was further increased after 72 hours of exposure and recorded maximum (83.33%) again in the treatment of *C. angustifolia* leaves followed by *C. angustifolia* seed (80%). At 7% concentration, 50% or above mortality was once again observed after 48 hours of exposure with maximum (80%) in the treatment of *C. angustifolia* seed. The mortality was further increased after 72 hours of exposure and recorded maximum (96.67%) again in the treatment of *C. angustifolia* seed followed by *C. angustifolia* leaves (93.33%). However, treatments were not statistically significant ($p \leq 0.05$).

3.3 Repellent activity of plant extracts against *B. brassicae*

The data presented in Table 4 reveal the repellent activity of different plant extracts against *B. brassicae*. In general, the repellent activity was inversely related to concentration of plant extract. At 1% concentration, repellent activity of different plant extracts was relatively low after 24 hours of exposure period and found maximum (36.67%) in the treatment of *C. gigantea* leaves. It was increased after 48 hours of exposure and recorded maximum (43.33%) again in the treatment of *C. gigantea* leaves, and decreased after 72 hours of exposure. At 3% concentration, same trend was followed. The repellent activity was relatively low after 24 hours of exposure and increased after 48 hours of exposure to its maximum (30%) in the treatment of *L. chinensis*, then declined after 72 hours of exposure. At 5% concentration, repellent activity was not followed a clear pattern. It was either increased or decreased, or remained constant after 48 hours of exposure. After 72 hours, it was either decreased or remained constant. At 7% concentration, repellent activity was relatively high after 24 hours of exposure, and then declined with increase exposure period. However, zero repellent activity was also observed in some treatments. At 10% concentration, repellent activity was negligible and found zero in most of treatments. The treatments were not statistically significant ($p \leq 0.05$).

3.4 Repellent activity of plant extracts against *M. persicae*

The data presented in Table 5 reveal the repellent activity of

different plant extracts against *M. persicae*. In general, the repellent activity was inversely related to concentration of plant extract. At 1% concentration, repellent activity of different plant extracts was relatively low after 24 hours of exposure period and found maximum (30%) in the treatments of *C. angustifolia* seed and *C. gigantea* leaves. It was increased after 48 hours of exposure and recorded maximum (43.33%) in the treatment of *C. angustifolia* seed, and decreased after 72 hours of exposure. The same trend was followed at 3% concentration. The repellent activity was relatively low after 24 hours and increased after 48 hours of exposure to its maximum (33.33%) in the treatment of *L. chinensis*, then declined after 72 hours of exposure. At 5% concentration, repellent activity was either increased or decreased after 48 hours of exposure. After 72 hours, it was either decreased or increased, or remained constant. At 7% concentration, repellent activity was relatively high and reached up to 23.33% in the treatment of *C. sativa* after 24 hours of exposure, and then declined with an increase in exposure period up to zero in the treatment of *C. gigantea* seed after 72 hours of exposure period. At 10% concentration, repellent activity was relatively high after 24 hours of exposure and reached up to 23.33% in the treatment of *C. gigantea* seed. It was decreased with an increase in exposure period and found zero in most of the treatments after 72 hours of exposure. The treatments were not statistically significant ($p \leq 0.05$).

Table 2: Insecticidal activity of plant extracts against *B. brassicae*

Treatment	Percent mortality of <i>B. brassicae</i>														
	1%			3%			5%			7%			10%		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
<i>C. gigantea</i> (seeds)	13.33 (17.21)*	30.00 (27.99)	46.67 (43.07)	20.00 (26.07)	33.33 (35.21)	43.33 (41.07)	36.67 (37.22)	43.33 (41.07)	56.67 (48.92)	43.33 (41.07)	63.33 (52.77)	76.67 (61.21)	60.00 (51.14)	80.00 (63.92)	93.33 (77.70)
<i>C. angustifolia</i> (seeds)	3.33 (6.14)	26.67 (30.29)	50.00 (44.99)	23.33 (28.07)	43.33 (41.07)	53.33 (47.00)	33.33 (34.92)	53.33 (46.92)	73.33 (59.70)	46.67 (43.07)	66.67 (54.78)	86.67 (68.85)	73.33 (59.70)	86.67 (68.85)	100.0 (90.00)
<i>C. gigantea</i> (leaves)	6.67 (8.85)	23.33 (28.78)	40.00 (39.06)	20.00 (26.07)	43.33 (40.77)	53.33 (46.92)	33.33 (34.92)	56.67 (48.92)	63.33 (53.15)	50.00 (44.91)	63.33 (53.85)	73.33 (59.00)	73.33 (59.00)	90.00 (74.99)	90.00 (74.99)
<i>C. sativa</i>	3.33 (6.14)	16.67 (23.85)	43.33 (41.15)	16.67 (23.36)	36.67 (37.14)	53.33 (46.92)	23.33 (28.78)	50.00 (45.08)	63.33 (52.85)	40.00 (38.85)	63.33 (52.85)	76.67 (61.71)	63.33 (53.85)	80.00 (63.92)	83.33 (66.63)
<i>L. camera</i>	16.67 (19.92)	30.00 (32.29)	46.67 (42.99)	30.00 (32.71)	50.00 (44.99)	56.67 (48.92)	33.33 (34.92)	56.67 (48.84)	66.67 (55.07)	40.00 (33.84)	60.00 (50.93)	73.33 (59.00)	56.67 (48.92)	73.33 (59.21)	86.67 (72.78)
<i>P. hysterophorus</i>	3.33 (6.14)	26.67 (30.99)	40.00 (39.14)	23.33 (28.78)	43.33 (41.07)	56.67 (49.22)	40.00 (39.06)	50.00 (44.99)	66.67 (54.99)	56.67 (49.13)	66.67 (55.07)	76.67 (61.71)	73.33 (64.22)	86.67 (68.85)	83.33 (66.14)
<i>L. chinensis</i>	10.00 (14.99)	30.00 (33.00)	43.33 (41.15)	26.67 (30.99)	43.33 (41.15)	63.33 (52.77)	40.00 (38.85)	50.00 (44.99)	73.33 (59.00)	43.33 (41.07)	63.33 (52.85)	73.33 (59.21)	60.00 (50.93)	80.00 (64.63)	86.67 (68.85)
<i>S. nigrum</i>	13.33 (21.14)	33.33 (35.21)	56.67 (48.92)	43.33 (41.15)	50.00 (44.99)	66.67 (55.07)	56.67 (48.92)	70.00 (57.78)	76.67 (61.92)	60.00 (51.14)	83.33 (66.63)	76.67 (61.92)	66.67 (54.78)	86.67 (72.78)	93.33 (77.70)
<i>C. angustifolia</i> (leaves)	13.33 (21.14)	46.67 (43.07)	60.00 (50.82)	33.33 (34.92)	53.33 (46.92)	76.67 (61.92)	46.67 (43.07)	66.67 (54.78)	86.67 (72.78)	56.67 (48.92)	70.00 (57.78)	100.0 (90.00)	76.67 (61.21)	93.33 (77.70)	100.0 (90.00)
<i>A. conyzoides</i>	6.67 (12.28)	36.67 (37.14)	46.67 (43.07)	43.33 (41.07)	63.33 (52.85)	63.33 (52.85)	46.67 (43.07)	60.00 (51.14)	76.67 (61.21)	63.33 (52.85)	73.33 (59.00)	76.67 (61.92)	73.33 (60.78)	80.00 (68.06)	90.00 (74.99)
Sem	5.47 (7.07)	8.02 (6.10)	8.56 (5.10)	6.67 (4.29)	9.94 (5.95)	7.60 (4.63)	8.09 (4.87)	8.88 (5.36)	8.02 (5.63)	10.80 (7.48)	8.29 (5.29)	5.77 (4.02)	11.35 (7.78)	6.99 (6.65)	4.83 (5.74)
Cd ($p=5\%$)	16.15 (20.88)	23.68 (18.00)	25.26 (15.06)	19.67 (12.96)	29.33 (17.56)	22.42 (13.66)	23.88 (14.36)	26.20 (15.83)	23.68 (16.63)	31.86 (22.08)	24.48 (15.60)	17.03 (11.85)	33.49 (22.97)	20.62 (16.87)	14.24 (16.95)

*Figures in parenthesis are angular transformation

Table 3: Insecticidal activity of plant extracts against *M. persicae*

Treatment	Percent mortality of <i>M. persicae</i>														
	1%			3%			5%			7%			10%		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
<i>C. gigantea</i> (seeds)	3.33 (6.14)*	23.33 (28.78)	50.0 (44.99)	6.67 (12.28)	33.33 (34.22)	56.67 (50.00)	16.67 (19.92)	33.33 (35.00)	60.00 (50.85)	26.67 (30.99)	43.33 (41.15)	63.33 (53.06)	33.33 (35.00)	63.33 (53.15)	73.33 (59.70)
<i>C. angustifolia</i> (seeds)	6.67 (12.28)	30.00 (33.00)	46.67 (43.07)	16.67 (23.36)	26.67 (30.78)	60.00 (51.14)	26.67 (29.99)	36.67 (37.14)	70.00 (61.92)	36.67 (37.14)	60.00 (51.14)	80.00 (63.92)	43.33 (41.15)	73.33 (59.21)	96.67 (83.85)
<i>C. gigantea</i> (leaves)	10.00 (14.99)	26.67 (30.78)	43.33 (41.15)	20.00 (26.07)	30.00 (32.21)	53.33 (47.00)	23.33 (28.07)	36.67 (37.14)	56.67 (49.22)	30.00 (32.21)	60.00 (50.85)	70.00 (56.99)	36.67 (36.93)	63.33 (53.15)	76.67 (61.71)
<i>C. sativa</i>	13.33 (21.14)	33.33 (34.92)	53.33 (46.92)	13.33 (21.14)	36.67 (37.14)	53.33 (47.21)	23.33 (28.78)	33.33 (34.92)	56.67 (48.92)	26.67 (30.29)	53.33 (46.92)	66.67 (55.07)	30.00 (33.00)	56.67 (48.92)	73.33 (59.70)
<i>L. camera</i>	10.00 (14.99)	20.00 (26.07)	46.67 (43.07)	16.67 (23.36)	30.00 (32.71)	36.67 (36.93)	23.33 (28.07)	36.67 (36.93)	50.00 (44.91)	20.00 (22.14)	50.00 (45.08)	56.67 (48.92)	26.67 (30.29)	50.00 (44.70)	76.67 (61.92)
<i>P. hysterothorus</i>	10.00 (14.99)	36.67 (37.22)	46.67 (42.99)	10.00 (18.43)	36.67 (36.93)	43.33 (40.86)	16.67 (23.36)	43.33 (41.15)	46.67 (43.07)	20.00 (26.56)	33.33 (34.63)	60.00 (51.14)	26.67 (30.29)	46.67 (43.07)	63.33 (53.85)
<i>L. chinensis</i>	13.33 (17.21)	36.67 (37.22)	43.33 (41.07)	13.33 (21.14)	40.00 (39.06)	53.33 (46.92)	16.67 (23.85)	43.33 (41.07)	63.33 (52.85)	20.00 (26.07)	56.67 (48.92)	66.67 (54.78)	30.00 (32.21)	56.67 (49.22)	73.33 (59.70)
<i>S. nigrum</i>	6.67 (8.85)	40.00 (39.14)	50.00 (45.08)	20.00 (25.36)	53.33 (46.92)	60.00 (50.93)	23.33 (28.07)	53.33 (46.92)	63.33 (52.85)	30.00 (31.92)	63.33 (53.15)	73.33 (59.21)	36.67 (37.14)	66.67 (55.07)	83.33 (66.14)
<i>C. angustifolia</i> (leaves)	16.67 (19.22)	43.33 (41.07)	56.67 (48.92)	23.33 (28.28)	43.33 (40.86)	60.00 (50.85)	33.33 (34.22)	56.67 (48.92)	70.00 (57.70)	36.67 (37.14)	66.67 (55.07)	83.33 (74.99)	46.67 (43.07)	80.00 (63.43)	93.33 (81.14)
<i>A. conyzoides</i>	10.00 (18.43)	30.00 (32.71)	46.67 (42.99)	16.67 (23.36)	46.67 (43.07)	50.00 (45.08)	30.00 (33.00)	50.00 (44.91)	60.00 (51.14)	36.67 (37.14)	56.67 (48.92)	73.33 (59.99)	40.00 (38.85)	63.33 (52.85)	56.67 (47.76)
Sem	6.32 (7.53)	7.30 (4.50)	8.49 (4.98)	5.86 (4.64)	10.21 (6.32)	11.69 (7.11)	8.36 (6.24)	7.95 (4.75)	10.11 (7.01)	8.49 (6.19)	9.71 (5.80)	9.18 (6.72)	9.36 (5.91)	11.05 (6.69)	10.99 (7.96)
Cd (p= 5%)	18.65 (22.21)	21.54 (13.27)	25.06 (14.98)	17.31 (13.70)	30.14 (18.67)	34.48 (20.97)	24.68 (18.41)	23.47 (14.03)	29.82 (20.69)	25.06 (18.26)	28.67 (17.11)	27.10 (19.83)	27.63 (17.43)	32.61 (19.75)	32.44 (23.48)

*Figures in parenthesis are angular transformation

Table 4: Repellent activity of plant extracts against *B. brassicae*

Treatment	Percent repellency														
	1%			3%			5%			7%			10%		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
<i>C. gigantea</i> (seeds)	13.33 (17.71)*	20.00 (26.56)	10.00 (18.43)	13.33 (17.21)	23.33 (28.28)	6.67 (12.28)	10.00 (18.43)	6.67 (12.28)	3.33 (6.14)	6.67 (12.28)	3.33 (6.14)	0.00 (0.00)	6.67 (8.85)	3.33 (6.14)	0.00 (0.00)
<i>C. angustifolia</i> (seeds)	26.67 (26.07)	30.00 (32.21)	6.67 (12.28)	3.33 (6.14)	23.33 (27.28)	10.00 (18.43)	3.33 (6.14)	6.67 (8.85)	00.00 (0.00)	0.00 (0.00)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>C. gigantea</i> (leaves)	36.67 (36.63)	43.33 (40.86)	16.67 (23.85)	10.00 (18.43)	20.00 (25.36)	10.00 (18.43)	3.33 (6.14)	6.67 (12.28)	3.33 (6.14)	16.67 (23.85)	10.00 (14.99)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)
<i>C. sativa</i>	13.33 (21.14)	20.00 (26.07)	10.00 (18.43)	10.00 (14.99)	13.33 (21.14)	10.00 (14.99)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)	6.67 (8.85)	3.33 (6.14)	0.00 (0.00)	10.00 (18.43)	6.67 (12.28)	3.33 (6.14)
<i>L. camera</i>	10.00 (14.99)	16.67 (23.85)	3.33 (6.14)	20.00 (26.07)	23.33 (28.78)	10.00 (14.99)	6.67 (8.85)	6.67 (12.28)	6.67 (12.28)	0.00 (0.00)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>P. hysterothorus</i>	13.33 (21.14)	20.00 (26.07)	10.00 (14.99)	13.33 (21.14)	16.67 (23.85)	3.33 (6.14)	6.67 (12.28)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>L. chinensis</i>	20.00 (26.07)	20.00 (26.07)	6.67 (12.28)	26.67 (30.29)	30.00 (33.00)	6.67 (12.28)	10.00 (14.99)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>S. nigrum</i>	10.00 (18.43)	16.67 (23.36)	3.33 (6.14)	13.33 (21.14)	20.00 (26.07)	6.67 (12.28)	13.33 (17.21)	10.00 (18.43)	6.67 (12.28)	0.00 (0.00)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)
<i>C. angustifolia</i> (leaves)	16.67 (23.85)	23.33 (28.78)	3.33 (6.14)	13.33 (21.14)	20.00 (26.07)	6.67 (12.28)	13.33 (17.21)	16.67 (23.36)	10.00 (14.99)	10.00 (14.99)	6.67 (12.28)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>A. conyzoides</i>	20.00 (26.07)	26.67 (30.99)	10.00 (14.99)	3.33 (6.14)	16.67 (23.36)	16.67 (23.36)	20.00 (21.93)	23.33 (28.07)	10.00 (14.99)	10.00 (14.99)	6.67 (12.28)	6.67 (12.28)	0.00 (0.00)	0.00 (0.00)	3.33 (6.14)
Sem	8.16 (6.94)	7.22 (4.81)	3.65 (5.65)	5.27 (5.54)	7.07 (4.94)	4.08 (5.80)	6.41 (7.80)	4.83 (6.04)	3.80 (6.22)	3.65 (4.97)	3.33 (5.71)	2.58 (4.75)	2.58 (3.92)	1.8 (3.36)	1.82 (3.36)
Cd (p= 5%)	24.08 (20.47)	21.31 (14.20)	10.77 (16.67)	15.54 (16.37)	20.85 (14.58)	12.04 (17.11)	18.91 (23.02)	14.24 (17.84)	11.21 (18.37)	10.77 (14.66)	9.83 (16.84)	7.61 (14.04)	7.61 (11.57)	5.38 (9.92)	5.38 (9.92)

*Figures in parenthesis are angular transformation

Table 5: Repellent activity of plant extracts against *M. persicae*

Treatment	Percent repellency														
	1%			3%			5%			7%			10%		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
<i>C. gigantea</i> (seeds)	26.67 (26.15)*	40.00 (39.14)	16.67 (23.85)	20.00 (26.07)	26.67 (30.99)	10.00 (14.99)	16.67 (23.85)	13.33 (21.14)	3.33 (6.14)	10.00 (18.43)	6.67 (12.28)	0.00 (0.00)	23.33 (28.78)	13.33 (17.71)	0.00 (0.00)
<i>C. angustifolia</i> (seeds)	30.00 (28.07)	43.33 (41.15)	13.33 (21.14)	16.67 (23.85)	23.33 (28.78)	16.67 (23.85)	13.33 (17.71)	16.67 (23.85)	6.67 (8.85)	16.67 (23.85)	10.00 (14.99)	3.33 (6.14)	10.00 (18.43)	6.67 (12.28)	0.00 (0.00)
<i>C. gigantea</i> (leaves)	30.00 (32.71)	40.00 (39.14)	16.67 (23.85)	23.33 (28.28)	26.67 (30.99)	6.67 (12.28)	13.33 (21.14)	16.67 (23.85)	10.00 (18.43)	20.00 (26.56)	13.33 (17.71)	6.67 (8.85)	10.00 (18.43)	6.67 (12.28)	3.33 (6.14)
<i>C. sativa</i>	20.00 (26.56)	30.00 (33.00)	13.33 (17.71)	16.67 (23.85)	26.67 (30.78)	6.67 (12.28)	16.67 (23.85)	10.00 (14.99)	10.00 (18.43)	23.33 (28.78)	16.67 (19.92)	6.67 (12.28)	13.33 (21.14)	10.00 (18.43)	3.33 (6.14)
<i>L. camera</i>	13.33 (17.71)	23.33 (28.78)	10.00 (14.99)	23.33 (28.78)	20.00 (26.07)	16.67 (23.85)	10.00 (18.43)	13.33 (21.14)	6.67 (12.28)	13.33 (21.14)	6.67 (12.28)	6.67 (12.28)	10.00 (14.99)	3.33 (6.14)	3.33 (6.14)
<i>P. hysterophorus</i>	13.33 (21.14)	20.00 (26.07)	10.00 (18.43)	20.00 (26.07)	26.67 (30.99)	13.33 (21.14)	16.67 (23.85)	23.33 (28.78)	10.00 (14.99)	10.00 (18.43)	6.67 (12.28)	3.33 (6.14)	6.67 (12.28)	3.33 (6.14)	0.00 (0.00)
<i>L. chinensis</i>	26.67 (30.99)	36.67 (37.22)	16.67 (19.92)	23.33 (24.14)	33.33 (35.21)	10.00 (14.99)	10.00 (18.43)	13.33 (21.14)	6.67 (12.28)	16.67 (23.85)	10.00 (14.99)	3.33 (6.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>S. nigrum</i>	20.00 (26.56)	36.67 (36.93)	10.00 (14.99)	20.00 (26.07)	26.67 (30.99)	13.33 (21.14)	20.00 (26.07)	13.33 (21.14)	10.00 (14.99)	6.67 (12.28)	10.00 (18.43)	6.67 (12.28)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)
<i>C. angustifolia</i> (leaves)	23.33 (28.78)	40.00 (39.14)	6.67 (12.28)	16.67 (23.85)	26.67 (30.78)	10.00 (18.43)	16.67 (23.36)	10.00 (18.43)	16.67 (23.36)	13.33 (21.14)	6.67 (12.28)	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)	0.00 (0.00)
<i>A. conyzoides</i>	23.33 (28.78)	33.33 (34.92)	10.00 (14.99)	16.67 (23.36)	26.67 (30.29)	10.00 (18.43)	26.67 (30.78)	16.67 (23.85)	6.67 (12.28)	10.00 (14.99)	6.67 (12.28)	3.33 (6.14)	3.33 (6.14)	6.67 (12.28)	3.33 (6.14)
Sem	7.74 (7.13)	5.96 (3.71)	5.16 (6.53)	6.14 (5.28)	5.16 (3.47)	3.65 (4.77)	4.59 (4.10)	3.49 (3.43)	4.47 (6.14)	3.16 (3.65)	4.94 (7.02)	3.65 (6.16)	3.16 (4.74)	3.49 (5.85)	2.35 (4.34)
Cd (p= 5%)	22.85 (21.04)	17.59 (10.94)	15.23 (19.26)	18.13 (15.58)	15.23 (10.24)	10.77 (14.09)	13.55 (12.09)	10.31 (10.13)	13.19 (18.11)	9.32 (10.79)	14.58 (20.72)	10.77 (18.19)	9.32 (13.99)	10.31 (17.27)	6.95 (12.81)

*Figures in parenthesis are angular transformation

4. Discussion

In the present study, the percent mortality of *B. brassicae* and *M. persicae* was found to be increased with an increase in concentration and exposure period. Similar results were found by [10] who worked on *Brevicoryne brassicae* that maximum insecticidal activity of *Mentha piperita* (L.) plant extract was found in the highest concentration and it was increased from 24 hours to 72 hours exposure period. [11] evaluated bio efficacy of aqueous crude fruit sap extract of *Solanum incanum* against *Myzus persicae* and found that different concentrations of extract showed some level of insecticidal and deterrent activities. [12] tested different concentrations (1, 2.5, 5 and 10%) of some plant extracts against *Myzus persicae* and found that the maximum mortality was obtained at the highest concentration after 24 hours of exposure period. The mortality can greatly influence by the exposure period. Prolonged exposure period leads to the greater mortality [13]. [14] tested nine plants including *Ageratum conyzoides* and *Cassia sophera* against cabbage pests including *Brevicoryne brassicae* and found that simple detergent and water extracts of all botanical treatments gave control of cabbage aphid, *Brevicoryne brassicae* equivalent to the synthetic insecticide emamectin benzoate and superior to water or detergent solution. *B. brassicae* can be managed by plant extracts like *Mentha piperita* leaf extract and *Melia azadarach* seed [15]. The use of neem extracts at a weekly basis can be incorporated into an overall control programme of cabbage pests including *B. brassicae* [16]. The aqueous extracts of *L. camera* shows toxic and antifeedant effect (about 22% mortality and reduction in aphid settlement) on *B. brassicae* [17]. The fumigant assays of essential oils are toxic to *B. brassicae* in a dose-dependent manner and have great potential to be used in integrated pest management especially in greenhouses or other closed systems [18]. Ethanol extracts from plants like *Xanthium strumarium* L. (Asteraceae), *Tanacetum parthenium* L. (Asteraceae) and *Hypericum calycinum* L. (Hypericaceae) show maximum mortality in *M. persicae* at the highest concentration (12%) [19]. The extract from *I. verum* also has potential as an eco-friendly biopesticide in integrated pest management

against *M. persicae* [20]. It is also reported that 10% concentration of olive leaves causes up to 100% mortality in *M. persicae* [21]. Plant extracts of *Clibadium sylvestre* and *Derris amazonica* show dose and time dependant mortality in *M. persicae* and greatest effect of the extracts is obtained after 72 hours of exposure [22]. Fumigant activity of essential oils is also dose-dependent against *M. persicae* [23]. Seeds and leaves extracts of *Solanum elaeagnifolium* have insecticidal and repellent activities against *M. persicae* and can be used as alternatives of chemical control [24].

In the present study, the repellent activity was found to be inversely related to concentration of plant extract *i.e.* low repellency of *B. brassicae* and *M. persicae* was observed at higher concentrations (7 and 10%) compared to low concentrations (1 and 3%). This was happened probably because of high mortality in higher concentrations in short period of time. Aphids got moribund in short exposure period and had no chance to move away from treated surface at higher concentrations. At low concentrations, repellency was comparatively good. Aphids can withstand lower concentrations of plant extracts for a certain period of time and have sufficient time to move away from treated surface. However, [10] got some different results that repellent activity of *Mentha piperita* against *B. brassicae* increased with an increase in the concentration. At low concentrations, repellent activity of plant extracts was low after 24 hours of exposure and it was increased after 48 hours of exposure. After 72 hours of exposure, it was again decreased. Aphids took prolonged time to be moribund at low concentrations so that they showed greater repellency till 48 hours after release. The mortality was increased after 72 hours of exposure and most of aphids got died and rest became inactive due to sub lethal effect of treatments. Similar results were also obtained by [10] that repellent activity of *Mentha piperita* against *B. brassicae* increased up to 48 hours and it was decreased after 72 hours of exposure period. The highest repellent index of *Peganum harmala* (over 72%) can be obtained on 1- to 2-d-old *M. persicae* individuals after 48 hours of exposure period [25]. Generally, repellent effect is dose dependent and reduces with the passage of time [26].

5. Conclusion

The laboratory study proves that extracts from these plants show insecticidal and repellent activities against *B. brassicae* and *M. persicae* and can be used as safer alternative to the synthetic insecticides in aphid management after field verification. Further studies are necessary to recognize the active compounds present in the plant extracts for developing plant-based biopesticide.

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7. References

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