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EVALUATION OF DIFFERENT NEEM PRODUCTS IN COMPARISON WITH IMIDACLOPRID AGAINST DIFFERENT MORPHS OF MUSTARD APHID (*LIPAPHIS ERYSIMI* KALT.) ON CANOLA CROP

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ABSTRACT

Studies were conducted to evaluate different neem extracts i.e., Neem leaf extract (10%), Neem seed oil (2.5%), Neem seed cake extract(10%), Neem seed kernel extract (10%) in comparison with imidacloprid (Confidor 70 WG) against different morphs of mustard aphid on *Brassaica napus* L. Among the all treatments imidacloprid and Neem seed oil resulted in maximum (100%) reduction over precount including nymph, wingless and winged adults of *Lipaphis erysimi*, followed Neem seed cake extract (86.13, 89.90 & 68.48%) and Neem seed kernel extract (77.41, 55.11&34.26%).Imidacloprid and neem seed oil showed negative impact on the population increase index of parasitoids and predators of *L. erysimi*. All neem extracts had positive population increase index of mummified aphids. Neem leaf extract resulted in negative population increase index in case of predators. Neem seed kernel extract showed positive index in case of green lacewing and lady bird beetle larvae and Neem seed Cake extract showed positive population increase index in case of only lady bird beetle larvae. Maximum repellency effect was observed with both Neem leaf extract and Neem Cake Extract (97.92%) and minimum in case of Neem seed kernel extract (89.58%). Neem seed oil resulted in maximum mortality of aphids followed by Neem Cake Extract. Reproduction (nymphs/aphid) was minimum with Neem seed oil followed by Neem Cake Extract. Highest net income was obtained by application of imidacloprid followed by Neem seed oil followed by Neem seed cake extract. Being effective against aphids and comparatively safer against natural enemies neem products especially Neem cake extract may be used in eco friendly management of mustard aphid on *B. napus.*

Keywords: Neem leaf extract, Neem seed oil, Neem seed extracts, imidacloprid, *Lipaphis erysimi*, canola

INTRODUCTION

Canola, mustard and sunflower are considered important oilseed crops after cotton seed in Pakistan. In Pothwar region, the most important yield limiting factors are irrigation and pest attack. Almost 21 insects which attack on canola, but aphids are the most destructive of all the insect pests (Agarwal and Datta, 1999). Three species of aphids; turnip/mustard aphid (*Lipaphis erysimi* Kalt.), cabbage aphid (*Brevicoryne brassicae* L.) and green peach aphid (*Myzus persicae* Sulz.) have been reported in canola. Mustard aphid causes damage by making large colonies on leaves, stems and inflorescence, which result in aberration of leaves. These are the most serious and destructive pest of Brassica crops and cause damage to canola plants from early vegetative to maturity stage. The effected plants show stunted growth, withered flowers and impeded pod formation. Plants infested by mustard aphid bear 10-90% yield loss depending upon severity of damage and crop stage (Rana, 2005). Control of aphids is a difficult task because of their rapid growth, mode of reproduction, polymorphic nature and ability to adopt different kinds of environment. Farmers spray insecticides in their fields injudiciously without knowing their mode of action and chemical group which result in insecticide resistance in the pest, destruction of natural enemies and environment pollution (Campiche et al. 2006; Penget al. 2010). So it is necessary to find alternate economical and environmentally safe methods for pest control. Bio pesticides are less expensive, less hazardous and safe for natural enemies. Approximately 2,400 plant species contain pesticidal properties, among which neem is on the top (Thacker, 2002). Neem based insecticides are non-phytotoxic, have good shelf life and also are used against many

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insects. Their active ingredient is azadirachtin, salaanin and meliontriol that comprises powerful insect growth regulator, feeding deterrent, ovipositional deterrence, repellency, reduced fitness, sterility, production of distorted adults and environment tenacity (Isman, 2006). When applied on crop they don't leave any residue. They work as systemic pesticide; immersed into the plant, transferred to all plant tissues and engulfed by the insect which feeding on them. Neem extracts can used to control aphids efficiently (Schmutterer, 1990) and may be suited for comprehension in integrated pest management with no harmful effects on predators (Tanzubil, 1996), parasitoids of mustard aphid (Dhaliwal et al. 1998) and also on egg parasitoids (Abudulai and Shepard, 2003). Due to the importance of canola, economic losses induced by aphids and risk involved in synthetic insecticides, the present study was conducted to find out most effective neem product for the management of different morphs of mustard aphid.

MATERIALS AND METHODS

Research area and experimental plan

Different neem prodcuts were applied on canola to manage mustard aphid at the research area of University Research Farm, Chakwal Road during 2010-11. The experiment was laid out in a Randomized Complete Block Design with 6 treatments and 4 replicates. *Brassica napus* L. (canola) variety Haider was sown on October 28, 2010 in 3m × 4m size plots with 60 cm row to row distance and 20 cm plant to plant distance. Six treatments viz, Neem leaf extract (10%), Neem oil (2.5%), Neem seed cake extract (10%), Neem seed kernel extract (10%), imidacloprid (25 WG) and control (water was applied without mixing any insecticides).

Preparation of neem products

One kg of neem leaves (NLE) were soaked in 5 litres of water for overnight. The next day, they were mashed and after straining it was ready for spray. Twenty five (25) ml neem oil (NSO) was taken for 1 litre of water and added emulsifier like Khadi soap (soap with no detergent, to make the leaf absorb more chemical contents also allowing them to stand the spray liquid on the leaf surface for long time) was added @ 1 ml in 1 litre water and conjured well to check that the oil and water can integrate well. Hundred grams of fine neem seed powder (NSCE) was incurred by mashing neem seed and sifting through sixty meshes sift and added in 1 litre of water (10%). Hundred grams of mildly poked neem kernel powder (NSKE) was accumulated in muslin pouch and soaked overnight in water. The pouch was mashed and the extract was strained and ready to use. Imidacloprid (Confidor 70 WG, Bayer CropScience) was purchased from the local market and applied in the field on canola @ 75gm/ 100 liter of water to compare the results of botanicals with the synthetic. While, in control treatment no application was done. All neem preparations and imidacloprid were applied on March 08, 2011 at seed pod formation stage with the help of hand pressure sprayer (2.5 litre capacity).

Filed Trails and Data Collection

The aphid population (nymph, wingless and winged adult) was counted before spray and 3, 7 and 11 days after spray of each treatment. For the collection of data, 6 shoots were randomly selected from each plot and aphid population was counted from upper 10 cm inflorescence of central shoot. The population / shoot were obtained by dividing the total number of aphids over total number of shoots observed. The population of parasitoids and predators of *L. erysimi* (mummified aphid, green lace wing larvae, syrphid fly larvae and lady bird beetle larvae) was recorded form six randomly selected whole shoots per plot and their average was calculated. Population reduction percentage over precount for nymphs, apterous and alates of mustard aphid was obtained by the formula:

Percentage reduction = (precount- post count/precount) × 100

While population increase index of mummified aphid , green lace wing larvae, syrphid fly larvae and lady bird beetle larvae was calculated by the formula: Population Increase Index = (Mean No. of natural enemy per plant 11 days after treatment - No. of natural enemies per plant before treatment)/(No. of natural enemies per plant before treatment)

Laboratory Experiments and Data Collection

For the study of antifeedent activity of mustard aphid *L. erysimi* (Kalt) four leaf disks (20 mm diameter) of canola were cut with the help of cork borer from those two were treated with the

test solution (NLF 10%, NSO 2.5%, NSCE 10%, NSKE 10%) and remaining two leaf disks were dipped with water only as a control and were allowed to dry and then placed alternately in each petri plates (9 by 50 mm having with ten small holes in tight fitting lid) with their edges barely touching. Four disks in each petri plates were removed from the same leaflet. Six replicates, each with 12 aphids were used for each time interval and concentration. The deterrency of test solution was determined 72 hr after treatment of the leaf disks.

To check the toxicity of different neem products against *L. erysimi* in lab conditions (24±1, 70±5R.H), , aphids were reared 3 days on treated leaves disk with test solution (NLF 10%, NSO 2.5%, NSCE 10% and NSKE 10%, Water) and then moved to fresh disks to observe the mortality, new leaves provided every three days. Four petri dish used and in each replicate four aphids were used. Aphid mortality was observed on daily basis for three days.

The effect of neem products (NLF 10%, NSO 2.5%, NSCE 10% and NSKE 10%) on reproduction of mustard aphid, *L. erysimi* (Kalt) on canola leaves was evaluated by rearing aphids on leaf disks treated with test solution of neem for three days. There were four replicates for each treatment. Adults were reared for further 3 days on fresh leaves while aphids exposed as 4th instars were reared for further study. Aphid survival and numbers of live and dead offspring were recorded on daily basis.

Crop Yield and Cost Benefit Ratio

After the maturity of the crop yield data from all treatments were also observed and then converted into kg/hectare bases by multiplying the yield per pot with 10,000 and dividing by plot size. After calculating crop yield net income and CBR of each treatment was found out by following the method used by Sultana et al. (2009).

STATISTICAL ANALYSIS

The data were analyzed by using MSTATC package and means were compared by using Duncan's Multiple Range Test (DMRT) at 0.05% probability level (Gomez and Gomez, 1984).

Table 1: Effect of different neem preparations in comparison with imidacloprid on nymphal population of *Lipaphis erysimi* on *Brassica napus* L.

Treatment	Before Spray	(Nymph) 1st Spray		2nd Spray	
		Mean ± SE	Reduction (%)	Mean ±SE	Reduction (%)
Neem leaf extract (10%)	130.08	86.61±3.50b	33.42	47.15±7.11b	63.75
Neem oil (2.5%)	170.45	22.38±7.77e	86.87	00.00 ±0.00e	100.00
Neem seed cake extract (10%)	182.29	43.88±3.38d	75.93	25.28 ±11.53d	86.13
Neem seed kernel extract (10%)	156.24	69.55± 2.64c	55.49	35.29 ±7.20c	77.41
Imidacloprid (25WG)	155.12	11.33±4.95f	92.70	00.00 ±0.00e	100.00
Control (water)	153.29	194.37±6.64a	-26.80	162.42 ±31.08a	-5.96
DMRT at 0.05		7.56		7.43	

Means having similar letters are not significantly different at 5% DMRT

Percentage reduction = (precount- post count / precount) × 100

Table 2: Effect of different neem preparations in comparison with imidacloprid on apterous population of *Lipaphis erysimi* on *Brassica napus* L.

Treatment	Before Spray	(Apterae) 1st Spray		2nd Spray	
		Mean ± SE	Reduction (%)	Mean ±SE	Reduction (%)
Neem leaf extract (10%)	24.08	14.95±0.88b	37.92	12.10±0.98b	49.75
Neem oil (2.5%)	15.49	05.58±1.28d	63.98	00.00±0.00e	100.00
Neem seed cake extract (10%)	20.99	12.00±0.75c	42.83	02.12±0.61d	89.90
Neem seed kernel extract (10%)	22.7	15.45±0.53b	31.94	10.19±2.94c	55.11
Imidacloprid (25WG)	17.74	04.11±1.78d	76.83	00.00±0.00e	100.00
Control (water)	19.58	24.57±0.99a	-25.49	28.52±8.24a	-45.66
DMRT at 0.05		1.49		1.18	

Means having similar letters are not significantly different at 5% DMRT

Percentage reduction = (precount- post count / precount) × 100

Table 3: Effect of different neem preparations in comparison with imidacloprid on alate population of *Lipaphis erysimi* on *Brassica napus* L.

Treatment	Before Spray	(Alates) 1st Spray		2nd Spray	
		Mean ± SE	Reduction (%)	Mean ±SE	Reduction (%)
Neem leaf extract (10%)	1.33	1.08±0.05a	18.80	0.79± 0.03b	40.60
Neem oil (2.5%)	0.64	0.53±0.12c	17.19	0.00± 0.00d	100.00
Neem seed cake extract (10%)	0.92	0.92±0.02b	0.00 *	0.29± 0.10c	68.48
Neem seed kernel extract (10%)	1.08	0.94±0.25b	12.96	0.71± 0.12b	34.26
Imidacloprid (25WG)	0.8	0.44±0.12c	45.00	0.00± 0.00d	100.00
Control (water)	0.85	1.11±0.04a	-30.59	1.38 ± 0.06a	-62.35
DMRT at 0.05		0.09		0.11	

Means having similar letters are not significantly different at 5% DMRT

Percentage reduction = (precount- post count / precount) × 100

Table 4: Effect of different neem preparations in comparison with imidacloprid on the population of mummified aphids on *Brassica napus* L.

Treatment	Before Spray	(Mummified aphids) 1st Spray		2nd Spray	
		Mean ± SE	Population Increase Index	Mean ±SE	Population Increase Index
Neem leaf extract (10%)	9.66	15.177 ±0.912 b	0.571	18.550 ±1.273 c	0.920
Neem oil (2.5%)	10.66	10.068 ±1.862 c	-0.056	09.274 ±1.040 d	-0.130
Neem seed cake extract (10%)	8.54	14.302 ±1.221 b	0.675	18.677 ±1.475c	1.188
Neem seed kernel extract (10%)	10.62	11.523 ±1.176 c	0.085	21.954 ±1.987b	1.067
Imidacloprid (25WG)	10.25	04.303 ±0.641 d	-0.580	07.080 ±1.088d	-0.309
Control (water)	11.21	25.273 ±1.540 a	1.255	37.650 ±2.623a	2.359
DMRT at 0.05		1.92		3.212	

Means having similar letters are not significantly different at 5% DMRT

Population Increase Index = (Mean No. of mummified aphids per plant 11 days after treatment – No. of mummified aphids per plant before treatment) / (No. of mummified aphids per plant before treatment)

Table 5: Effect of different neem preparations in comparison with imidacloprid on the population of green lacewing on *Brassica napus* L.

Treatment	Before Spray	(Green lace wing) 1st Spray		2nd Spray	
		Mean ± SE	Population Increase Index	Mean ±SE	Population Increase Index
Neem leaf extract (10%)	0.16	0.107±0.023 b	-0.331	0.108 ±0.042 b	-0.325
Neem oil (2.5%)	0.24	0.040±0.021 b	-0.833	0.068 ±0.032 b	-0.717
Neem seed cake extract (10%)	0.16	0.080±0.024 b	-0.500	0.081 ±0.032b	-0.494
Neem seed kernel extract (10%)	0.04	0.093±0.024 b	1.325	0.192 ±0.060 b	3.800
Imidacloprid (25WG)	0.08	0.013±0.013 b	-0.838	0.081 ±0.032 b	0.013
Control (water)	0.12	0.287±0.066 a	1.392	0.330 ±0.085 a	1.750
DMRT at 0.05	0.17	0.095		0.115	

Population Increase Index = (Mean No. of green lacewing per plant 11 days after treatment - No. of green lacewing per plant before treatment) / (No. of green lacewing per plant before treatment)

Means having similar letters are not significantly different at 5% DMRT

Table 6: Effect of different neem preparations in comparison with imidacloprid on the population of Syrphid fly on *Brassica napus* L.

Treatment	Before Spray	(Syrphid fly) 1st Spray		2nd Spray	
		Mean ± SE	Population Increase Index	Mean ±SE	Population Increase Index
Neem leaf extract (10%)	0.92	0.36±0.096 b	-0.61	0.34 ±0.130 b	-0.63
Neem oil (2.5%)	1.54	0.04±0.021 c	-0.97	0.03±0.018 c	-0.98
Neem seed cake extract (10%)	1.21	0.30±0.091 bc	-0.75	0.23±0.069bc	-0.81
Neem seed kernel extract (10%)	1.75	0.28±0.103 bc	-0.84	0.11±0.109 bc	-0.94
Imidacloprid (25WG)	1.62	0.03±0.018 c	-0.98	0.10±0.055 bc	-0.94
Control (water)	0.87	1.15±0.186 a	0.32	0.64±0.185 a	-0.26
DMRT at 0.05	0.93	0.27		0.29	

Population Increase Index = (Mean No. Syrphid fly per plant 11 days after treatment - No. of Syrphid fly per plant before treatment)/ (No. of Syrphid fly per plant before treatment)

Means having similar letters are not significantly different at 5% DMRT

Table 7: Effect of different neem preparations in comparison with imidacloprid on the population of lady bird beetle on *Brassica napus* L.

Treatment	Before Spray	(LBB) 1st Spray		2nd Spray	
		Mean ± SE	Population Increase Index	Mean ±SE	Population Increase Index
Neem leaf extract (10%)	0.83	0.454 ±0.082b	-0.452	0.482±0.105b	-0.419
Neem oil (2.5%)	0.45	0.081 ±0.032c	-0.822	0.233±0.048bc	-0.488
Neem seed cake extract (10%)	0.25	0.218 ±0.043c	-0.112	0.288±0.062bc	0.169
Neem seed kernel extract (10%)	0.22	0.246 ±0.044c	0.126	0.398±0.107b	0.821
Imidacloprid (25WG)	0.14	0.136 ±0.045c	0.000	0.068±0.032c	-0.503
Control (water)	0.08	0.828 ±0.128a	9.247	1.287±0.236a	14.918
DMRT at 0.05		0.190		0.250	

Population Increase Index = (Mean No. lady bird beetle per plant 11 days after treatment - No. of lady bird beetle per plant before treatment) / (No. of lady bird beetle per plant before treatment)

Means having similar letters are not significantly different at 5% DMRT

Table 8: Effect of different neem preparation in comparison with imidacloprid on canola crop yield and cost benefit ratio

Treatments	Yield (kg/ha)	Yield increase after spray (kg/ha)	Total income (Rs/ha)	Cost of treatment / ha (Rs.)	Benefit over Control (Rs.)	Net income (Rs/ha)	CBR
T_1 (NLE)	1224 c	594	29700	2400	2400	27300	11.38
T_2 (NSO)	1472 ab	843	42150	4400	4400	37750	8.58
T_3 (NSCE)	1365 c	800	40000	3600	3600	36400	10.11
T_4 (NSKE)	1429 b	736	36800	4000	4000	32800	8.20
T_5 (Imid.)	1557 a	928	46400	1600	1600	44800	28.00
T_6 (Control)	629.9 d	-	-	-	-		-

Means having similar letters are not significantly different at 5% DMRT
Yield increase after spray (kg/ha) = net yield-control yield
BCR= Net income ÷ Cost of treatment
NLE= Neem leaf extract (10%); NSO= Neem oil (2.5%); NSCE= Neem seed cake extract (10%);
NSKE= Neem seed kernel extract (10%); Imid= Imidacloprid (25 WG @ 80 g/ 100 Lit. H2O)

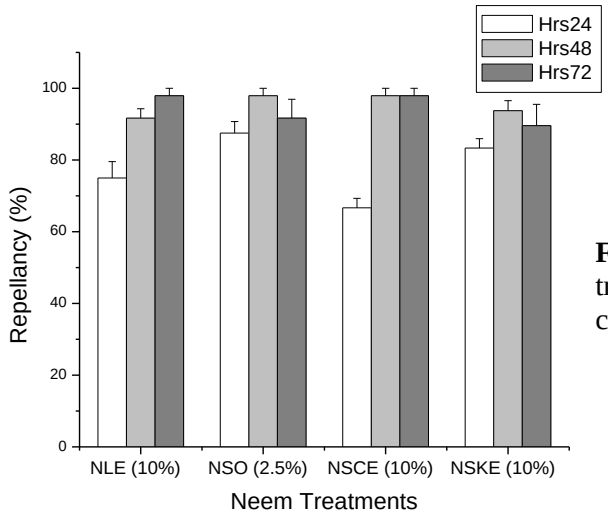

Fig. 1: Repellancy (%) of different neem treatments against *Lipaphis erysimi* in laboratory conditions

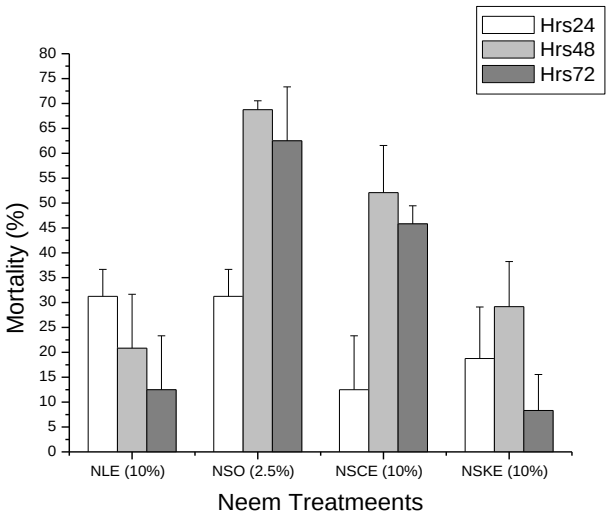

Fig. 2: Mortality (%) of different neem treatments against *Lipaphis erysimi* in laboratory conditions

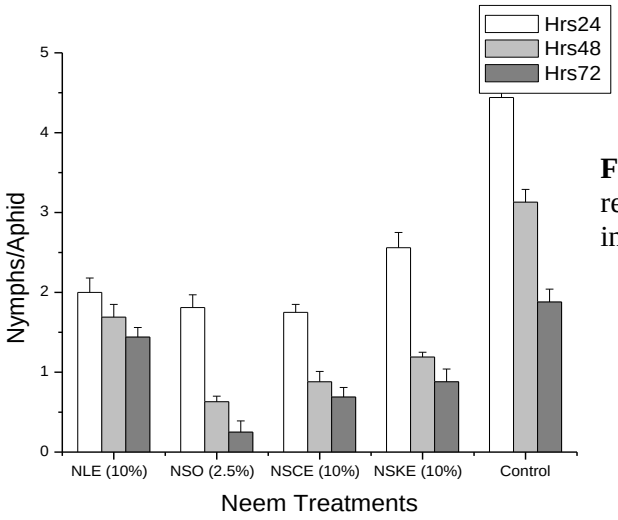

Fig. 3 : Effect of of different neem treatments on reproduction (nymphs/aphid) of *Lipaphis erysimi* in laboratory conditions

RESULTS AND DISCUSSION

The analysis of data regarding effect of different neem treatments along with imidacloprid on nymphal population of *L. erysimi* on *B. napus* revealed significant differences. After 1st spray imidacloprid showed maximum reduction in *L. erysimi* nymphs followed by Neem oil and Neem Seed Cake Extract, whereas Neem Leaf Extract showed minimum nymphal reduction. After 2nd spray the almost the same trend was observed; imidacloprid and neem oil showed hundred percent reduction in *L. erysimi* nymphs, while neem seed cake extract and neem seed kernel extract also showed 86.13 and 77.41 percent reduction. First application of different neem products in comparison with imidacloprid on apterous population of *L. erysimi* on *B. napus* in field conditions revealed statistically similar results among imidacloprid and neem oil followed by neem seed cake extract. Second application of treatments showed same trend; imidacloprid and neem oil showed hundred percent reduction in *L. erysimi nymphs,* while neem seed cake extract also showed 89.90 percent reduction. In case of alate population of *L. erysimi* different neem preparation again showed the same pattern and neem oil showed statistically similar results in comparison with imidacloprid with hundred percent reduction in winged aphids. Neem seed cake extract showed comparatively better results among different aqueous solutions and neem leaf extract and neem seed kernel extract remained less effective.

The effectiveness of different neem preparations against aphids is confirmed by many previous studies. Chanchal and Lal (2009) found Neem seed kernel extract (5%), neem oil (2%) and neem leaf extract (5%) effective against mustard aphid and recorded 53.88, 52.13 and 35.65 per cent aphid reduction over control, respectively. Sultana et al. (2009) reported 65% reduction in mustard aphid population with Neem Kernel extract + Jet powder in mustard. Lowery el al., (1993) proved the effectiveness of neem seed oil against aphids and found up to 50% reduction with 0.4% neem oil in the field conditions. Sigh and Lal (2012) conducted a two years experiments to assess the effect of seven different botanical leaves, neem leaf extract (*Azadirachta indica*), Congress grass leaf extract (*Parthenium hysterophorus*) Lemmon grass leaf extract (*Cymbopogon citrates*), Bhang leaf extract (*Cymbopogon citrates*), Garlic leaf extract (*Allium sativum*),Punch phuli leaf extract (*Lantana camera*) and Marigold Leaf extract (Tageteserecta) on mustard aphid and found Indian neem leaf extract to reduce the aphid population to a great extent causing maximum level of aphid mortality (77.33% and 71.76%). These studies advocate the effectiveness of neem preparations and their utilization as aphicide in mustard.

Field application of different neem preparations showed varied response against natural enemies of *L. erysimi*. All the neem preparations had positive impact on population indices of mummified aphids except neem oil followed by imidacloprid which showed negative population indices after both sprays (Table 4). Except neem seed kernel extract all the neem products and imidacloprid had negative population increase index for green lace wing

larvae after 1st spray, after 2nd spray almost same trend was observed except imidacloprid which showed slightly positive 0.013 population increase index (Table 5). All neem treatments and imidacloprid resulted in negative population increase index for syrphid fly after both sprays (Table 6). The population increase index of lady bird beetles also exhibited negative trend in all treatments including imidacloprid except neem seed cake extract and neem seed kernel extract (Table 7).

There may be two possible reasons of less population of natural enemies on plots where the neem formulations had effectively reduced the aphid population. First may be the less availability of hosts as a food, and second may be the toxic or repellent effect of neem preparations on natural enemies. These assumptions are supported by the findings of various workers. Khedkar et al. (2012) evaluated some botanicals for safety of natural enemies of mustard aphid and found Ardusa leaf extract (10%) to be safer to the natural enemies of aphid viz., coccinellids (grubs and adults), chrysopids (eggs), syrphid fly (larvae) and *Diaeretiella rapae* (parasite) and honey bees followed by azadirachtin (0.0006 and 0.0008%), neem leaf extract (10%), NSKE (5%) and neem oil (0.5%). Dhaliwal et al. (1998) reported 91.24% mortality of *L. erysimi* on cabbage with nimbicine and reported on toxic effect in parasiotoids (*Microplitis similis* and *Apantelese glomeatus*) while feeding ratio of lady bird beetle on *L. erysimi* was higher on plants treated with neem extract and lesser for aphids treated with endosulfan. .Lowery and Isman (1996) found no adverse effect on the beneficial insects of *Myzus persicae* applied with neem extracts showing that neem extracts could be used with bio control agents. Conversely Rathod et al. (2002) recorded significant less mummification due to *D. rapae* on mustard aphid in plots treated with NSE (5%) followed by neem oil (1%) and tobacco leaf extract (2%).

Neem leaf extract showed increasing trend in repellency from 75 percent after 24 hours to 97.92 percent after 72 hours. Neem seed oil exhibited increasing trend from up to 48 hours (97.92%) and declined slightly (91.67%) after 72 hours. Neem seed cake extracts showed 66.67 percent aphid repellency which increased to 97.92 after 48 hours and remained same after 72 hours. Neem seed kernel extract followed the trend as revealed by neem seed oil and showed decline from 93.75 to 89.58 percent repellent effect after 48 to 72 hours (Fig.1). Very impressive repellent effect of all neem products was observed against *L. erysimi* and neem seed cake extract was the most effective product. These results are in conformity with the investigations of Nisbet et al (1994) who treated *M. persicae* diet with azadirachtin at 25 ppm and found antifeedant effects and reduced fecundity of tested aphids. Neem formulation NSE was observed highly feeding detetrrent and reducing the growth of rose aphid and chrysanthemum aphid by Koul (1999).

The results regarding mortality of aphids after 24, 48 and 72 hours respectively, are shown in Fig 2. Neem seed oil showed maximum mortality among all treatments followed by neem seed cake extract. Neem leaf extract and neem seed kernel extract showed comparatively less mortality. These findings are supported by many previous studies. Pandey et al. (1987) found 80% mortality of *L. erysimi* in the laboratory with application neem extract (1.5%) using leaf dip method after 72 hours. Neem Azal-T/S was found highly effective against nymph and adults of *M. persicae* in laboratory studies (Bolhalder et al. 1997).

The effect of different neem products on reproduction of *L. erysimi* is shown in Fig. 3.All the treatments resulted in significant decrease in reproduction (nymphs/aphid) as compared to control treatment. However neem seed oil proved comparatively most effective with less numbers of off springs followed by neem seed cake extract. In a previous study, Koul (1998) reported disruption of fertility and fecundity in the adults of *Brevicoryne brassicae* due to neem seed extract and azadirachtin at 30-60 ppm. According to him the major effects of neem were embryonic mortality and failure of ecdysis, furthermore these effects were linear and dose dependent. Tang et al. (2002) found a drastic reduction in fecundity of adult brown citrus aphids due to the application of neem seed extract (4.5%) on citrus seedlings.

The effect of different neem preparation in comparison with imidacloprid on canola crop yield is shown in Table 8. The net income was maximum by the use of imidacloprid followed by neem seed oil and neem seed kernel extract. Maximum CBR was observed in plots treated with imidacloprid followed by neem leaf extract and neem kernel extract. In this manuscript a comprehensive study was planned

to investigate the effectiveness of neem products both in field and laboratory conditions to present detailed information on mustard aphid, its natural enemies and cost benefit ratio. These investigations advocate the effectiveness of neem products against all morhps of L. erysimiin the field. Except neem seed oil all the neem preparations have positive population increase index of aphid parasitoids. The population of aphid predators remained low in the treated plots and generally they exhibited negative population increase index. Lab studies based on repellency, mortality and reproduction rate also revealed encouraging results. Based on these findings, it can be concluded that neem based formulations can be used on mustard to promote eco friendly management of *L. erysimi* avoid ill effects of chemical pesticides.

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