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Management of mustard aphid (*Lipaphis erysimi*) on rapeseed mustard (*Brassica napus*) using biopesticides under organic farming conditions

S. Singh[1], G. Singh[2] and R. Singh[3]

[1]*School of Organic Farming, Punjab Agricultural University, Ludhiana-141 004, India*
[2]*Department of Entomology, Punjab Agricultural University, Ludhiana-141 004, India*
[3]*Department of Zoology, Punjab Agricultural University, Ludhiana-141 004, India*

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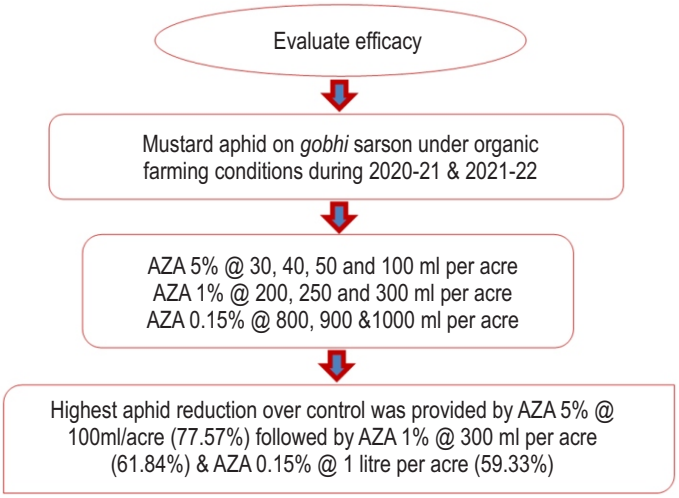
***Corresponding Author Email:** subashsingh@pau.edu ***ORCiD:** https://orcid.org/0000-0001-6965-4377

Abstract

Aim: To manage mustard aphid, *Lipaphis erysimi* Kalt on rapeseed-mustard through neem formulations, which are the safest, eco-friendly and cost effective and can hold promise to keep this pest below economic threshold levels.

Methodology: The neem formulations, AZA5% @ 30,40,50 and100ml per acre, AZA1% @ 200, 250 and 300 ml per acre and AZA 0.15% @ 800, 900 and 1000 ml per acre were evaluated against *L. erysimi* on rapeseed- mustard under organic farming conditions at Organic Research Area of School of Organic Farming, Punjab Agricultural University, Ludhiana during 2020-21 and 2021-22.

Results: A highest efficacy against *L. erysimi* with 83 and 84.99% treated over untreated control plots was recorded with AZA 5% @100 ml per acre at 5 days of spray during both years of study, followed by AZA 1% @ 300 ml per acre (61.84%) and AZA 0.15% @ 1000 ml per acre (59.33%). The coccinellid population at 10 days after spray was non-significant (0.03 to 0.21), but numerically more in untreated control plots. The highest seed yield was recorded in AZA 5% @ 100 ml (18.38 q ha^{-1}), AZA1% @ 300 ml (16.70q ha^{-1}) and AZA 0.15% @ 1000 ml (15.75 q ha^{-1}) over untreated control plots (13.91q ha^{-1}). The highest economic returns were obtained with AZA 5% @ 100ml (Rs.22408.72 ha^{-1}), AZA 1% @ 300ml (Rs.16424.22 ha^{-1}) and AZA 0.15% @ 1000ml (Rs.10285.68 ha^{-1}) treatment, respectively.



Interpretation: Management of *L. erysimi* on rapeseed mustard can be obtained with AZA 5% @ 100 ml, which caused 84 per cent reduction over control at 5 days after spray and also gave net returns of Rs.22408.72q ha^{-1}, which will not only increase the farm income but is eco-friendly in nature.

Key words: Azadirachtin, Biopesticide, *Lipaphis erysimi,* Organic farming, Rapeseed- mustard

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Introduction

Rapeseed mustard (*Brassica napus*) is the third most important edible oilseed crop worldwide, grown in many countries including India where they account for nearly one-third of edible oil production. Mustard seeds and oil are both staple ingredients in Indian cuisine due to many health benefits as they contain many plant proteins (Singh, 2024). Mustard oil gives relief from arthritis and rheumatism and has been used for massaging purpose. The seeds are used as condiment for preparing various vegetable and curries, pickling and leaves as vegetable. Many by-products like mustard cake,meal and husks can provide additional farm income (Dinda *et al.,* 2016). India is the second largest producer of rapeseed mustard after China. Rapeseed mustard is vulnerable to attack of various insect pests, and more than three dozen insect pests are known to be related with rapeseed mustard crop in India (Singh, 2024; Srivastava and Guleria, 2003). Among them, mustard aphid, (*Lipaphis erysimi* Kalt.) mustard sawfly (*Athalia lugens*), cabbage butterfly (*Pieris brassicae*), diamondback moth (*Plutella xylostella*) and painted bug (*Bagrada hilaris*) are serious insect pests (Ali and Rizvi, 2008; Ali *et al.,* 2009; Pradhan *et al.,* 2020).

Mustard aphid causes damage by making large colonies particularly on the inflorescence. The effected plants show stunted growth, withered flowers and impeded pod formation and development of sooty molds on the honey dew excreted by aphids. Both nymphs and adults suck the sap from leaves, buds and pods and may cause curling of infested leaves, and in later stage the plants may wither and die, and the infected field gives sickly and blighted in appearance (Das and Islam, 1986).Different studies have reported 10-90% plant damage and 65-96% yield loss from in different *Brassica* spp. (Rana, 2005). Farmers rely heavily on insecticides for its management which is considered a quick and easy solution to manage insect pests in agriculture. On the other hand, pesticide contamination cause danger to human health and environment, non-target organisms ranging from beneficial soil microorganisms to insects, plants, fish and birds (Pertile *et al.,* 2020). Use of insecticides in agriculture also results in the development of insecticide resistance in pests, reduction of natural enemies and environment pollution (Anani *et al.,* 2020).

The use of chemical pesticides is a major source of pollution, an important cause for biodiversity loss and negative health impacts on humans and animals. By affecting pollinators, soil microorganisms and pest control agents, pesticide use also threatens key ecosystem services (Pelsoi *et al.,* 2021). Diseases linked to exposure of pesticides range from various types of cancers to neurological disorders, growth retardation in children and effects on reproductive capacity, infertility and reduced immunity against diseases (Rakhimol *et al.,* 2020). The discharge of pesticides into water bodies during leaching or runoff may cause death of aquatic fauna whereas water pollution and accumulation of pesticides in water bodies can further move from aquatic animals to humans and animals due to bio- magnification. So, the danger associated with the use of conventional insecticides has necessitated the need to find alternate economical and environmentally safe methods, especially biopesticides for pest control. Biopesticides are less expensive, sustainable, less hazardous and safe for natural enemies and human beings and its domestic animals (Pan *et al.,* 2023). Biopesticides are phytochemical compounds that exhibit complex mechanisms of mode of action which may reduce resistance development in insect pest and are sustainable in nature. Approximately, 2400 plant species contain pesticidal properties, among which neem is of primary importance (Kumar *et al.,* 2021).

Neem based insecticides are non-phytotoxic, have good shelf life and are used against many insects. Their active ingredients are azadirachtin, salannin, salanol and melantriol, etc. that comprises powerful insect growth regulators, feeding deterrent, ovipositional deterrence, repellency, reduced fitness, sterility, production of distorted adults and environment tenacity (Lengai *et al.,* 2020). Azadirachtin inhibites the release of protoraxicotrophic hormone (PTTH) from the corpora cardiac glands and ecdysone from the brain ring glands complex (BRC's) thereby disrupting the development of insects. Neem extracts can be used to control aphids efficiently with no harmful effects on predators and parasitoids of mustard aphid (Abudulai and Shepard, 2003). Taking in to consideration the importance of canola, economic losses induced by aphids and risk involved in synthetic insecticides, the present study was conducted to find out the most effective neem product for the management of different morphs of mustard aphid.

Materials and Methods

Raising of crop: For evaluating different biopesticides, rapeseed-mustard crop (variety GSC-7) was sown during 3rd week of October during Rabi seasons 2020-21 and 2021-22 at Integrated Farming System, School of Organic Farming, Punjab Agricultural University, Ludhiana (PAU) as per Package of Practices for mustard crop for farmers of Punjab (Buttar and Kaur, 2023) in Randomized Block Design under organic farming conditions. The size of each plot was 5×4 m with three replicants in each treatment. The variety GSC-7 was selected due to its susceptibility against the attack of mustard aphid.

Biopesticides and their application: Different neem biopesticides, azadirachtin (AZA) 5% @ 30, 40, 50 and 100 ml per acre, AZA 1% @ 200, 250 and 300ml per acre and AZA 0.15% @ 800, 900 and 1000ml per acre were evaluated against mustard aphid during Rabi seasons 2020-21 and 2021-22. These concentrations were selected based on literature survey, *i.e.,* efficacy on other insect pests in rice, basmati, maize, soybean, cotton, okra and brinjal crops (Singh and Sarao, 2023; Sarkar *et al.,* 2016). The test formulations were compared with untreated control where only water was sprayed. The spray was done through manually operated knapsack sprayer keeping the direction of spray towards the apical portion of the plant. The sprays of the above biopesticide treatments with different concentrations were applied when the mustard aphid reached at

economic threshold level, *i.e.,* 50-60 aphids per 10 cm terminal portion of the central shoot (Singh, 2024). The treatments were applied by dissolving different selected biopesticides in 100 l of water per acre using hollow cone type nozzle. The incidence of aphid was recorded as number of aphids per 10 cm terminal portion of the central shoot from10 randomly selected plants in each replicated plot before spray and 1, 3, 5 and 7 days after spray (DAS). The records of natural enemies were also made in all the treatments before spray and 1, 3, 5 and 7 DAS. Yield data was recorded at harvest on whole plot basis and calculated on per hectare basis. Phytotoxic effects if any were also observed during the experiment.

Statistical analysis: The resulting data obtained under field conditions were statistically analyzed through Randomized block designusing square root transformations under CPCS1 programme (Cheema and Singh, 1990).

Results and Discussion

Among evaluated doses of all treatments, AZA 5% @ 100 ml per acre gave significantly better results against mustard aphid as compared to lower dosages and untreated control during both years of study (Table1, 2). The highest per cent reduction over control (PROC) of 83.0 and 84.99 per cent was observed at highest dose of 100 ml per acre at 5 DAS of neem biopesticides during 2020-21 and 2021-22, respectively. However, AZA 5% @ 30, 40, 50 ml per acre resulted into highest aphid reduction as 73.33, 77.05,80.15 per cent during the year 2020-21 and 75.43, 79.28, 82.01 per cent in 2021-22, respectively, at 5 DAS. Hence, AZA 5% showed efficacy with highest aphid reduction with increase in the concentration of biopesticide and days after spraying. Similarly, AZA 1%@ 300 ml proved significantly better as compared to lower dosages 200 and 250 ml per acre and untreated control plots during 2020-21 and 2021-22 against mustard aphid (Table 1, 2).

Similarly, AZA 1% @ 200 and 250 ml per acre also resulted in 59.31 and 62.28 per cent aphid reduction over control during 2020-21 whereas 60.42 and 65.14 per cent during 2021-22 each five days post application of biopesticides. Hence, AZA 1% also showed increased efficacy in causing per cent reduction over control of mustard aphid with increase in concentration of insecticide and days after spraying, *i.e.,* highest per cent reduction over control of 67.0 and 70.47 per cent was recorded at highest dose of 300 ml per acre each 5 days after post application of biopesticide during 2020-21 and 2021-22, respectively. Spray of AZA 0.15% @ 1000 ml per acre recorded highest per cent reduction over control against mustard aphid at 5 (DAS) days after application (63.90, 65.38%) than at 1 DAS (46.40, 48.30%) and 3 DAS (60.51, 62.66%) during 2020-21 and 2021-22, respectively. Over aphid reduction was recorded to be 76.43, 61.84 and 59.33 % when AZA 5 % @ 100 ml, Eco neem plus (AZA 1%) @ 300 ml and AZA 0.15 % @ 1000 ml was applied under field conditions (Table 3). Hence, it can be concluded that neem formulations, AZA 5%, AZA 1% and AZA 0.15% showed increased efficacy in causing per cent reduction over control against mustard aphid with increased concentration of biopesticide and days after spraying, *i.e.,* highest per cent reduction over control was recorded at highest dose of formulations evaluated after five days of spraying during 2020-21 and 2021-22. . Different plant allelochemicals deter feeding by phytophagous insects (Singh *et al*., 2011; Koul *et al*., 2013).

Plant limonoids show antifeedant and growth inhibitory activities against a number of insects (Singh *et al.,* 2011), and more specifically azadirachtin (AZA) a bioactive compound present in neem has potent insecticidal properties (Koul and Wahab, 2004). Furthermore, a variety of modes of action, such as acute toxicity, feeding reduction, growth disruption, oviposition suppression and repellence have been predicted by the allelochemical action of AZA. We have tried to standardize the efficacy data based on causing per cent reduction over control at different time intervals at field level, because AZA is a slow acting compound and hence, observation time also become an important variable in evaluating the toxicity of neem biopesticide. In previous studies also the highest per cent reduction (100%) in aphid population was obtained with neem @ 100 ml when it was used at 1: 205 g ml^{-1} after 3rd spray (Ali *et al.,* 2010). Aziz *et al.* (2014) reported maximum reduction (100%) of nymph, wingless and winged adults of *L. erysimi* over pre-count when neem seed oil (2.5%) was used. In a study, Biswas (2013) recorded 81 per cent pest reduction with 50 g neem seed l^{-1} of water in treated plots followed by 75 g neem seed l^{-1} in treated plots (80% reduction).

Pal *et al.* (2020) also studied the effect of biorational approaches for managing mustard aphid, *L. erysimi* on seed yield and obtained benefit with azadirachtin (1: 37.6) after 15 days of application. Coccinellids and chrysopids are amongst the important predators of aphids. But indiscriminate use of insecticides causes disrupts of their life cycle which may produce asynchronization between biocontrol agents and their food/hosts (herbivore pests). Hence, selection of insecticides is important to conserve the non-target species which are helpful in reducing the crop pests and act as biocontrol agents without harming the environment. The coccinellid population recorded at various dosages of biopesticides ranged from 0.03 to 0.21 after 10 DAS, however the difference among them was non-significant but population was lower in treated as compared to control (Table 1, 2). Singh (2024) reported 48.28-50.06 per cent aphid reduction by applying homemade neem extract @ 4.0 l ha^{-1} with highest population of predators and mustard yield (13.83 and 16.24 q ha^{-1}) over untreated control plots (11.30 and 14.60 q ha^{-1}) in 2020-21 and 2021-22, respectively.

Bhatta *et al.* (2019) recorded 88.00 and 56.87 per cent aphid reduction due to neem extract on mustard in laboratory and field conditions, respectively, which corroborates with the present findings. Ashraf *et al.* (2018) reported 39.21 and 37.81 per cent aphid reduction on application of neem seed and neem leaf extracts in a closely related aphid species, *i.e.,* cabbage aphid, *Brevicoryne brassicae* on mustard crop. In a study, Biswas (2013) illustrated that use of neem extract is safe and ecofriendly

Table 1: Efficacy of neem biopesticides against *L. erysimion* rapeseed –mustard under organic farming conditions (2020-21)

Treatments	Dose per acre	Aphid incidence (nos. per 10 cm terminal portion of the central shoot)									Coccinellids (nos. per plant)				
		BS	1DAS	PROC	3DAS	PROC	5DAS	PROC	7DAS	PROC	BS	1DAS	3DAS	5DAS	7DAS
Azadirachtin 5%	30ml	50.00	26.53 (5.25)	48.84	19.80 (4.56)	62.41	14.33 (3.91)	73.33	15.73 (4.09)	71.32	1.87	1.33	1.33	1.53	1.40
Azadirachtin 5%	40ml	49.07	24.20 (5.02)	53.34	17.87 (4.34)	66.08	12.33 (3.65)	77.05	13.47 (3.80)	75.46	1.47	1.47	1.47	1.60	1.27
Azadirachtin 5%	50ml	50.13	22.00 (4.80)	57.58	15.80 (4.10)	70.00	10.67 (3.42)	80.15	12.06 (3.61)	78.01	1.80	1.53	1.13	1.67	1.20
Azadirachtin 5%	100ml	49.27	19.26 (4.50)	62.85	13.20 (3.77)	74.94	9.13 (3.18)	83.00	11.07 (3.47)	79.83	1.80	1.80	1.47	1.27	1.60
Azadirachtin 1%	200ml	49.07	29.73 (5.54)	42.67	26.13 (5.21)	50.38	21.86 (4.78)	59.31	22.73 (4.87)	58.57	1.53	1.40	1.27	1.27	1.47
Azadirachtin 1%	250ml	50.20	28.67 (5.45)	44.73	23.13 (4.91)	56.08	20.27 (4.61)	62.28	21.13 (4.70)	61.48	1.80	1.33	1.13	1.53	0.80
Azadirachtin 1%	300ml	49.27	26.73 (5.26)	48.46	20.93 (4.68)	60.25	17.73 (4.33)	67.00	19.46 (4.52)	64.52	1.47	1.27	1.00	1.13	1.33
Azadirachtin 0.15%	800ml	49.60	31.73 (5.72)	38.82	25.00 (5.10)	52.53	23.46 (4.95)	56.33	24.73 (5.07)	54.92	1.80	1.40	1.07	1.67	1.27
Azadirachtin 0.15%	900ml	49.20	29.27 (5.50)	43.57	23.07 (4.90)	56.20	21.53 (4.75)	59.93	22.80 (4.88)	58.44	1.60	1.33	1.20	1.47	1.73
Azadirachtin 0.15%	1000ml	49.13	27.80 (5.37)	46.40	20.80 (4.67)	60.51	19.40 (4.52)	63.90	20.46 (4.63)	62.70	1.47	1.40	1.27	1.33	1.40
Untreated control	-	49.73	51.87 (7.27)	-	52.67 (7.33)	-	53.73 (7.40)	-	54.86 (7.47)	-	1.47	1.60	1.47	1.60	1.67
CD (p=0.05)		NS	(0.18)		(0.20)		(0.14)		(0.16)		NS	NS	NS	NS	NS

BS: Beforespray; PROC: Per cent reduction over control; DAS: Days afterspray; Values in parentheses are square root transformations

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Table 2: Efficacy of neem biopesticides against *L. erysimion* rapeseed-mustard under organic farming conditions (2021-22)

Treatments	Dose per acre	Aphid incidence (nos. per 10 cm terminal portion of the central shoot)									Coccinellids (nos. per plant)				
		BS	1DAS	PROC	3DAS	PROC	5DAS	PROC	7DAS	PROC	BS	1DAS	3DAS	5DAS	7DAS
Azadirachtin 5%	30ml	50.07	25.60 (5.16)	49.87	18.60 (4.43)	64.32	13.20 (3.77)	75.43	15.00 (4.00)	72.56	1.40	1.40	1.47	1.47	1.47
Azadirachtin 5%	40ml	49.93	23.06 (4.90)	54.83	17.00 (4.24)	67.39	11.13 (3.48)	79.28	11.93 (3.60)	78.17	1.27	1.33	1.53	1.53	1.20
Azadirachtin 5%	50ml	50.20	21.13 (4.70)	58.62	14.46 (3.93)	72.25	9.67 (3.26)	82.01	10.60 (3.41)	80.61	1.20	1.40	1.27	1.60	1.27
Azadirachtin 5%	100ml	50.13	17.86 (4.34)	65.01	11.93 (5.60)	77.11	8.06 (3.01)	84.99	9.20 (3.19)	83.17	1.60	1.80	1.40	1.33	1.73
Azadirachtin 1%	200ml	49.80	28.73 (5.45)	43.73	25.20 (5.12)	51.66	21.26 (4.72)	60.42	22.13 (4.81)	59.51	1.47	1.40	1.33	1.33	1.53
Azadirachtin 1%	250ml	50.00	27.53 (5.34)	46.08	21.80 (4.77)	58.18	18.73 (4.44)	65.14	19.53 (5.53)	64.27	0.80	1.00	1.20	1.47	1.00
Azadirachtin 1%	300ml	49.73	25.06 (5.10)	50.91	19.40 (5.52)	62.79	15.87 (4.11)	70.47	16.52 (4.18)	69.76	1.33	1.33	1.07	1.20	1.27
Azadirachtin 0.15%	800ml	50.40	30.20 (5.58)	40.86	23.87 (4.99)	54.22	21.80 (4.77)	59.43	22.80 (4.88)	58.29	1.27	1.33	1.13	1.60	1.20
Azadirachtin 0.15%	900ml	50.06	27.86 (5.37)	45.43	21.46 (4.73)	58.82	20.53 (4.64)	61.79	21.20 (4.71)	61.22	1.73	1.53	1.27	1.40	1.80
Azadirachtin 0.15%	1000ml	49.73	26.40 (5.23)	48.30	19.47 (4.52)	62.66	18.60 (4.43)	65.38	19.47 (4.52)	64.39	1.40	1.47	1.33	1.47	1.33
Untreated control	-	50.46	51.07 (7.22)	-	52.13 (7.29)	-	53.67 (7.39)	-	54.66 (7.46)	-	1.40	1.60	1.53	1.27	1.53
CD (p=0.05)		NS	(0.17)		(0.18)		(0.10)		(0.08)	NS	NS	NS	NS	NS	NS

BS:Beforespray; PROC: Per cent reduction over control; DAS: Days afterspray; Values inparentheses are square root transformations

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Table 3: Pooled per cent aphid reduction and effect of neem biopesticides on seed yield of gobhisarson

Treatments	Dose per acre	Per cent aphid reduction over control			Yield(qha^{-1})		
		2020-21	2021-22	Pooled Mean	2020-21	2021-22	Pooled Mean
Azadirachtin5%	30 ml	64.15	65.55	64.85	14.70	15.90	15.30
Azadirachtin5%	40 ml	68.15	69.92	69.04	15.90	16.20	16.05
Azadirachtin5%	50 ml	71.60	73.37	72.49	17.55	17.10	17.33
Azadirachtin5%	100 ml	75.28	77.57	76.43	18.75	18.00	18.38
Azadirachtin 1%	200 ml	52.87	53.83	53.35	16.35	15.45	15.90
Azadirachtin 1%	250 ml	56.27	58.42	57.35	16.70	15.60	16.15
Azadirachtin 1%	300 ml	60.19	63.48	61.84	17.05	16.35	16.70
Azadirachtin0.15%	800 ml	50.77	53.20	51.99	14.80	14.67	14.74
Azadirachtin0.15%	900 ml	54.64	56.82	55.73	15.50	14.93	15.22
Azadirachtin0.15%	1000 ml	58.48	60.18	59.33	15.75	15.75	15.75
Untreated control	-	-	-	-	14.27	13.55	13.91
CD (p=0.05)	**-**	**-**	**-**	**-**	**0.47**	**0.78**	**-**

Table 4: Economic benefits of neem biopesticides for the management of *L. erysimi* on *gobhi* sarson

Treatments	Dose per acre	Yield (q ha^{-1})	Additional yield over control (q ha^{-1})	Gross returns (Rs ha^{-1})	Treatment cost (Rs ha^{-1})	Net returns over control (Rs ha^{-1})
Azadirachtin 5%	30 ml	15.30	1.39	10225.33	1850	8375.33
Azadirachtin 5%	40 ml	16.05	2.14	15742.59	2300	13442.59
Azadirachtin 5%	50 ml	17.33	3.42	25158.72	2750	22408.72
Azadirachtin 5%	100 ml	18.38	4.47	32882.88	5000	27882.88
Azadirachtin 1%	200 ml	15.90	1.99	14639.14	2900	11739.14
Azadirachtin 1%	250 ml	16.15	2.24	16478.22	3500	12978.22
Azadirachtin 1%	300 ml	16.70	2.79	20524.22	4100	16424.22
Azadirachtin 0.15%	800 ml	14.74	0.82	6032.21	2700	3332.21
Azadirachtin 0.15%	900 ml	15.22	1.31	9636.82	2975	6661.82
Azadirachtin 0.15%	1000 ml	15.75	1.84	13535.68	3250	10285.68
Untreated control	-	13.91	-		-	-

Price of organic sarson=Rs.7356.35 per quintal; Rs.8500 per quintal; Labour cost for spraying one hectare =Rs. 250/-; AZA 5% @ Rs.900 100 ml^{-1}; AZA 0.15% @ Rs.550 l^{-1}; AZA 1% @ Rs.240 100 ml^{-1}

towards for pollinators and natural predators, especially coccinellid predators attacking aphids.

Biopesticides are derived from naturally occurring compounds that are easily biodegradable, species specific and generally affect target pest and their closely related species as compared to conventional synthetic insecticides, thereby acting as a promising alternative to synthetic insecticides. Generally, plants families reported to contain bioactive compounds includes Lauraceae, Rutaceae, Lamiaceae, Myrtaceae, Asteraceae, Apiaceae, Poaceae, Zingiberaceae, Piperaceae, Liliaceae and Solanaceae (Koul *et al.,* 2014). As the biocontrol agents are an important part of Integrated Pest Management thus, selection and use of biopesticides is important and can be explored for maximum use in agriculture. Azadirachtin is safe to the mammals with LD_{50} of 5000 mg kg^{-1} in rats whereas it is chronically safe for human consumption with dose @ 15 mg kg^{-1} b.wt. day^{-1} (Fernandes *et al*., 2019).

In the present study, total yield of rapeseed mustard obtained was 18.38, 16.70 and 15.75 q ha^{-1} when AZA 5 % @ 100 ml, AZA 1% @ 300 ml and AZA 0.15% @ 1000 ml were applied (Table 3) which was significantly higher than untreated control (13.91 q ha^{-1}) with 32.13, 20.05 and 13.22 per cent more yield as compared to control, respectively which will increase the farm income and food security without causing harm to the environment. In a study by Ali *et al.* (2010) the total yield of mustard crop recorded was significantly higher (14.40 q ha^{-1}) when neem was used at 1: 1.25 gm l^{-1} concentration.The economic benefit of biopesticides in terms of net additional returns over control of Rs. 22408.72, Rs.16424.22 and 10285.68 per ha were obtained when AZA 5% @ 100 ml, AZA 1% @ 300 ml and AZA 0.15% @ 1000 ml were used against *L. erysimi* in rapeseed-mustard crop (Table 4).

It can be concluded that management of mustard aphid on rapeseed and mustard can be done with the use of AZA 5% @

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100 ml per acre which caused highest aphid reduction (84.0)at 5 DAS and also gave highest economic returns of Rs.22408.72 per ha, which will not only increase the farm income but is also safe to natural predators and environment.

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