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Biointensive integrated management of *Lipaphis erysimi* Kalt. (Homoptera: Aphididae) in *Brassica* spp.

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Abstract: Field experiment was conducted at Regional Research station, Samargopalpur, Rohtak (Haryana) during *Rabi* season of the year 2015-2016 to evaluate bioefficacy of various treatments against mustard aphid, *Lipaphis-erysimi* on Indian mustard. Treatments were : T_1–*Verticillium lecanii* @ 10^8 CS/ml, T_2–*Beauveria bassiana* @ 10^8 CS/ml, T_3 - Neem seed kernel extract @ 5%, T_4 - Neem seed methanol extract @ 5%, T_5 - *V. lecanii* @ 10^8 CS/ml + Clipping of infested twigs, T_6 - *B. bassiana* @ 10^8 CS/ml + Clipping of infested twigs, T_7 - NSKE @ 5% + Clipping of infested twigs, T_8 - *V. lecanii* @ 10^8 CS/ml + NSKE @ 5%, T_9 - *B. bassiana* @ 10^8 CS/ml + NSKE @ 5%, T_{10} - Dimethoate 30EC @ 250 ml/acre. Dimethoate was found to be most effective in reducing the aphid population (95.03 %) followed by *V. lecanii* @ 10^8 CS/ml + NSKE @ 5% (88.52 %), NSKE @ 5% + Clipping of infested twigs (87.77 %) and *B. bassiana* @ 10^8 CS/ml + NSKE @5% (86.91 %) after ten days of spray. The highest seed yield was recorded in treatment dimethoate 30EC (1702 kg/ha) followed by *V.lecanii* @ 10^8 CS/ml +NSKE @ 5% (1635 kg/ha), NSKE @ 5% + Clipping of infested twigs (1626 kg/ha) and *B.bassiana* @ 10^8 CS/ml + NSKE @ 5% (1617 kg/ha). Dimethoate was found to be highly costeffective with highest cost benefit ratio (1:14.92) followed by NSKE @ 5% + clipping ofinfested twigs (1:13.81) and NSKE @ 5% (1:11.41).

Key words: Dimethoate, *Lipaphis erysimi*, Mustard aphid, NSKE, Seed yield

INTRODUCTION

Oilseed Brassicas, collectively known as rapeseed-mustard comprise traditionally grown indigenous species, namely toria (*Brassica rapa* L. var. toria), brown sarson (*Brassica rapa* L. var. brown sarson), yellow sarson (*Brassica rapa* L. var. yellow sarson), Indian mustard (*Brassica juncea*), black mustard (*Brassica nigra*) and taramira (*Eruca sativa*), which have been grown since about 3,500 BC along with non -traditional species like gobhi sarson (*Brassica napus*) and Ethiopian mustard or karan rai (*Brassica carinata*). India is one of the largest rapeseed mustard growing countries in the world, occupying the first position in area and second position in production after China (Khavse *et al*., 2014). India accounts for 14.8 % of rapeseed production at global level and occupies prime position in the World (Singh, 2014). Among the seven edible oilseeds (Groundnut, rapeseed mustard, soybean, sunflower, sesame, safflower and niger) cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy (Shekhawat *et al*., 2012). In India, during 2013-14, rapeseed and mustard were grown over an area of 6.70 million ha area with production and productivity of 7.96 m tonnes and 1188 kg/ha respectively (Anonymous, 2015). Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat and West Bengal states accounted for nearly 86.5% area and 91.4% production of rapeseed-Mustard in the country during 2012-13 (Anonymous, 2015a). Among oilseed *Brassica* species, major area is under *B. juncea* which contributes about 80% of the total rapeseed-mustard production in the country. In Haryana, during 2013-14, rapeseed and mustard were grown on 0.54 million ha area with production and productivity of 0.88 m tonnes and 1639 kg/ha, respectively (Anonymous, 2015b).

The realization of full yield potential ofrapeseed mustard is prevented by various factors but main reason is that-these energy rich crops are generally grown on marginal and sub marginal lands under rainfed conditions and are also severally affected by vagaries of biotic (weeds, diseases and insect-pests) and abiotic (drought, frost and salinity) stresses. Insect pests are important biotic constraints that posed severe threat to mustard from germination to harvest and about 50 insect species have been found infesting the rapeseed-mustard in India (Sharma and Singh, 2010), out of which about a dozen of species are considered as major pest (Singh, 2009). Among them, the aphid species that damage rapeseed-mustard in India include

Lipaphis erysimi, *Brevicornae brassicae* L. and *Myzuspersicae* Sulzer (Sarangdevot *et al.,*2006). Among these, *L. erysimi* referred as both the turnip and mustard aphid is one of the major limiting factors causing up to 96 percent yield losses (Sharma and Kashyap 1998; Singh and Sharma 2002 and Shylesha *et al*., 2006). Verma and Singh, 1987 recorded 15% reduction in oil content due to mustard aphid infestation. Aphid sucks the cell sap from the stems, twigs buds, flowers and developing pods causing a significant loss in yield. Kular and Kumar (2011) reported that the losses in seed yield ranged from 6.5 to 26.4 per cent of different *Brassica* species (*B. juncea*, *B. napus*, *B. carinata*, *B. rapa* and *E. sativa*) by the infestation of mustard aphid.

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. A number of chemical insecticides have been found effective against this pest in different parts of the country (Singh and Verma, 2008; Singh and Singh, 2009). But the indiscriminate use of the insecticides has resulted into several problems like environmental pollution, health hazards to human beings, toxicity to pollinators & natural enemies etc. (Singh, 2001). So it is necessary to find alternate economical and environmentally safe methods for pest control. The botanicals and bio-agents are more compatible with the environmental components, eco-friendly with plant health and nonhazardous to human being. Meena *et al*. (2013) evaluated microbial agents and bio-products for the management of mustard aphid and found that the per cent reduction of aphid population after 10 days of spray was maximum under dimethoate 30EC @ 300 g a.i/ha (91.00%) followed by NSKE @ 5% (83.20%), *B. bassiana* @ 5 g per litre of water (78.00%), cow urine @ 50 litre per ha (76.33%), onion extract @ 5% (76.00%), tobacco extract @ 5% (75.40%), *V. lecanii* @ 5 g per litre of water (75.0%) and *M. anisopliae* @ 5 g per litre of water (74.0%). Keeping the above facts in mind the present investigation was undertaken to evaluate the eco-friendly bio-products.

MATERIALS AND METHODS

The present investigation was carried out during *Rabi* season of the year 2015-16 at Regional Reasearch Station, Samargopalpur, Rohtak (Haryana), India. Experiment was conducted in a completely randomized block design with ten treatments including control and replicated thrice with plot size of 4.2×3m on mustard cv. RH 0749. The crop was sown during first fortnight of November with row to row and plant to plant distance as 30cm and 10cm respectively and all the standard agronomic practices were followed to raise the good crop. Sowing was done 13th November, 2015 i.e. under late sown conditions to ensure heavy aphid infestation. A fertilizer dose of 80 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha was given to all the plots uniformly. Crop was irrigated once at the time of flowering. Eleven treatments including control were T1: *Verticillium lecanii* @ 10^8CS/ml (Conidial Spore per millilitre), T2: *Beauveria bassiana*@ 10^8CS/ml, T3: NSKE @ 5%, T4: Neem Seed Methanol Extract @ 5%, T5: *V.lecanii*@ 10^8CS/ml + Clipping of infested twigs, T6: *B. bassiana*@ 10^8CS/ml + Clipping of infested twigs, T7: NSKE @ 5% + Clipping of infested twigs, T8: *V.lecanii*@ 10^8CS/ml + NSKE @ 5%, T9: *B.bassiana*@ 10^8CS/ml + NSKE @ 5%, T10: Dimethoate 30EC @ 250 ml/acre and T11: Control with no spray. The population of aphids was counted from ten randomly selected plants from each plot one day before and 3, 7, and 10 days after spray of insecticides. The aphids were counted from the top 10 cm apical twigs of these selected plants with the help of a magnifying glass. The numbers of aphids/plant were converted into % reduction of aphid population over the control. Yield was recorded from net plot area and converted in to kilogram per ha and data were statistically analyzed. The incremental cost benefit ratio was calculated by prevailing market price of mustard seed, cost of insecticides and labour used with the following formula.

Cost benefit ratio = Additional profit over the control – Cost of treatment.

RESULTS AND DISCUSSION

Before treatment, mean aphid population ranged from 19.62 to 25.90 aphids/10cm main apical shoot and found to be non-significant which indicates that the aphid population was uniformly distributed. Aphid population decreased in all treated plot at 3rd day after spray, and ranged from 3.93 to 15.56 aphids/10cm main apical shoot as compared to control with the highest population of 27.07 aphids/10cm main apical shoot.The minimum aphid population (3.93 aphids/10 cm main apical shoot) was recorded in treatment T_{10}: Dimethoate 30 EC and it was significantly superior over rest of the treatments. Similar results were obtained at 7th and 10th day after spray. The mean aphid population ranged from 3.11 to 12.60 aphids/10cm main apical shoot at 7th day after spray and 1.97 to 9.80 aphids/10cm main apical shoot at 10th day after spray.

The per cent aphid reduction over control after ten days of spray was found to be maximum (95.03 %) in treatment T_{10}: Dimethoate 30 EC followed by T_8: *V. lecanii* @ 10^8CS/ml + NSKE @ 5% (88.52 %), T_7: NSKE @ 5% + clipping of infested twigs (87.77 %), T_9: *B. bassiana* @ 10^8 CS/ml + NSKE @ 5% (86.91 %), T_5: *V. lecanii* @ 10^8 CS/ml + clipping of infested twigs (86.71 %), T_6: *B. bassiana* @ 10^8 CS/ml + clipping of infested twigs (84.09 %) and T_3: NSKE @ 5% (82.63 %). Minimum reduction in aphid population

Table 1. Efficacy of various treatments against mustard aphid during 2015-16

Sr No.	Treatment	Mean number of aphids/10 cm main apical shoot				Aphid reduction over control (%) 10 DAS	Yield (kg/ha)	Increased in yield over control (%)
		Pre-treatment	3 DAS	7 DAS	10DAS			
T_1	*Verticillium lecanii* @ 10^8 CS/ml	24.97 (5.09)	14.27 (3.91)	11.0 (3.47)	7.43 (2.90)	81.30	1575	13.80
T_2	*Beauveriabassiana* @ 10^8 CS/ml	25.90 (5.18)	15.56 (4.06)	11.90 (3.59)	8.17 (3.03)	79.44	1554	12.31
T_3	Neem seed kernel extract @ 5%	23.90 (4.98)	12.84 (3.72)	9.49 (3.24)	6.90 (2.81)	82.63	1584	14.45
T_4	Neem seed methanol extract @ 5%	24.23 (5.01)	14.13 (3.89)	12.60 (3.69)	9.80 (3.28)	75.33	1517	9.59
T_5	*V. lecanii* @ 10^8 CS/ml + Clipping of infested twigs	19.96 (4.56)	10.86 (3.44)	8.36 (3.06)	5.27 (2.50)	86.71	1608	16.18
T_6	*B. bassiana* @ 10^8 CS/ml + Clipping of infested twigs	22.73 (4.86)	11.73 (3.56)	9.03 (3.17)	6.33 (2.71)	84.09	1595	15.27
T_7	NSKE @ 5% + Clipping of infested twigs	19.62 (4.54)	8.64 (3.10)	6.86 (2.80)	4.86 (2.40)	87.77	1626	17.49
T_8	*V. lecanii* @ 10^8 CS/ml + NSKE @ 5%	20.17 (4.59)	7.84 (2.97)	6.11 (2.66)	4.56 (2.33)	88.52	1635	18.14
T_9	*B. bassiana* @ 10^8 CS/ml + NSKE @ 5%	20.10 (4.59)	9.20 (3.19)	7.77 (2.96)	5.20 (2.49)	86.91	1617	16.81
T_{10}	Dimethoate 30EC @ 250 ml/acre	20.93 (4.65)	3.93 (2.21)	3.11 (2.03)	1.97 (1.72)	95.03	1702	22.98
T_{11}	Control (Unsprayed)	20.57 (4.63)	27.07 (5.29)	32.78 (5.81)	39.73 (6.38)		1384	
CD (P = 0.05)	---	NS	(0.38)	(0.30)	(0.28)	---	23.98	---

Figures in parentheses are square root transformations, DAS = Days after spray

Table 2. Economic analysis of different treatments against mustard aphid, *L. erysimi*

Sr No.	Treatment	Cost of insecticides (Rs./ha)	Labour charge (Rs/ha)	Total expenditure on insecticide (Rs/ha)	Mean yield (kg/ha)	Gross income* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T_1	*Verticillium lecanii* @ 10^8 CS/ml	1280	352	1632	1575	52763	6399	1:3.92
T_2	*Beauveriabassiana* @ 10^8 CS/ml	1280	352	1632	1554	52070	5706	1:3.50
T_3	Neem seed kernel extract @ 5%	235	352	587	1584	53064	6700	1:11.41
T_4	Neem seed methanol extract @ 5%	8281	352	8633	1517	50808	4444	1:0.51
T_5	*V. lecanii* @ 10^8 CS/ml + Clipping of infested twigs	1280	352	1632	1608	53868	7504	1:4.60
T_6	*B. bassiana* @ 10^8 CS/ml + Clipping of infested twigs	1280	352	1632	1595	53444	7080	1:4.34
T_7	NSKE @ 5% + Clipping of infested twigs	235	352	587	1626	54471	8107	1:13.81
T_8	*V. lecanii* @ 10^8 CS/ml + NSKE @ 5%	1515	352	1867	1635	54773	8409	1:4.50
T_9	*B. bassiana* @ 10^8 CS/ml + NSKE @ 5%	1515	352	1867	1617	54158	7794	1:4.17
T_{10}	Dimethoate 30 EC @ 250 ml/acre	362	352	714	1702	57017	10653	1:14.92
T_{11}	Control (Unsprayed)				1384	46364		

*Mustard seed rate @ 3350 Rs/qt

over control after ten days of spray was recorded in treatment T_4: neem seed methanol extract @ 5% (75.33 %) followed by T_2: *B. bassiana* @ 10^8 CS/ml (79.44 %) and T_1: *V. lecanii* @ 10^8 CS/ml (81.30 %).Gour and Pareek(2003) and Konar and Paul (2005) also observed that dimethoate was the most effective insecticide against mustard aphid. The present studies are further supported by work of Singh *et al*. (2014) who found that dimethoate @ 300g a.i. ha^{-1} was effective against aphid population causing 91.1, 93.5 and 96.2 per cent reduction in aphid population after 3, 7 and 10 days of spray respectively. Singh *et al*. (2008) while testing entomopathogenic fungi against the mustard aphid found that *V. lecanii* @10^8 spores/ml was effective in controlling the aphid population by 75.79 per cent. Singh (2007)reported 79.4 per cent reduction in aphid population after 10 days of application of NSKE @5%. Singh and Lal (2011) reported that use of NSKE @ 5% alone was effectivein reducing the mustard aphid population significantly while in combination with mechanical (hand removal) and botanical (NSKE) was found to be more effective. Nagar *et al*. (2012) revealed that dimethoate @ 300 g a.i/ha and NSKE @ 5% reduced the aphid population by90.87 % and 84.48 %, respectively after 10 days of spray. Meena *et al*. (2013) found 91.0,83.2, 78.0 and 75.0 per cent reduction in aphid population after 10 days of spray of dimethoate 30EC @ 300 g a.i/ha, NSKE @ 5%, *B. bassiana* @ 5 g per litre of water and *V. lecanii* @ 5 gper litre of water, respectively (Table 1). Kumar (2011) reported that the pooled mean aphid population in the spray of *V. lecanii* @ 10^8 CS/ml was 11.8, 14.0 and 17.0 aphids/plant as against 64.4, 84.3 and 73.8 aphids/plant in the control after 3, 7 and 10 days of treatment.

Among the different treatments, the maximum seed yield of 1702 kg/ha was recorded in treatment T_{10}: Dimethoate 30 EC and it was found significantly superior over rest of the treatments.The next most effective treatment was T_8: *V. lecanii* @ 10^8 CS/ml + NSKE @ 5% (1635 kg/ha) which remained on par with T_7: NSKE @ 5% + clipping of infested twigs (1626 kg/ha) and T_9: *B. bassiana* @ 10^8 CS/ml + NSKE @ 5% (1617 kg/ha). The treatment T_5: *V. lecanii*@ 10^8 CS/ml + clipping of infested twigs (1608 kg/ha) and T_6: *B. bassiana* @ 10^8 CS/ml + clipping of infested twigs (1595 kg/ha) were found on par with each other. The treatment T3: NSKE @ 5% (1584 kg/ha) was found on par with treatment T_1: *V. lecanii* @ 10^8 CS/ml (1575 kg/ha). The least effective treatment was T_4: neem seed methanol extract @ 5% (1517 kg/ha). The minimum seed yield (1384 kg/ha) was recorded in untreated plot(Table 1).

The highest C:B (1:14.92) was obtained from treatment T_{10}: Dimethoate 30 EC followed by T_7: NSKE @ 5% + clipping of infested twigs (1:13.81), T_3: NSKE @ 5% (1:11.41), T_5: *V. lecanii* @ 10^8 CS/ml + clipping of

infested twigs (1:4.60), T_6: *B. bassiana* @ 10^8 CS/ml + clipping of infested twigs (1:4.34) and T_9: *B. bassiana* @ 10^8 CS/ml + NSKE @ 5%) (1:4.17). The lowest C:B (1:0.51) was obtained from treatment T_4: Neem seed methanol extract @ 5% followed by T_2: *B. bassiana* @ 10^8 CS/ml (1:3.50) and T_1: *V. lecanii* @ 10^8CS/ml (1:3.92). Meena *et al.* (2013) evaluated microbial agents and bio-products for the management of *L. erysimi* and found the most favourable c ost-benefit ratio under the treatment i.e. dimethoate 30 EC @ 300 g a.i/ha (1:38) followed by neem seed kernel extract @ 5% (1:18) (Table 2).

Conclusion

From the present findings, it may be concluded that though dimethoate 30EC was most effective in managing mustard aphid but there is urgent need to adopt eco and user friendly pest control methods against mustard aphidto conserve the pollinators and natural enemies as well as to protect the human health. Among non-chemical methods, *V. lecanii* @ 10^8 CS/ ml + NSKE @ 5% and NSKE @ 5% + clipping of infested twigs may be recommended as most economic and effective treatments for the management of mustard aphid, *L. erysimi* on Indian mustard.

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