Original Research Article

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Evaluation of Some Insecticides and Biopesticides for Management of Barley Aphid (*Rhopalosiphum maidis*)

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ABSTRACT

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The bioefficacy of the treatments evaluated against aphid on barley crop showed that lowest population of 19.32, 20.81, 20.88, 20.95 and 21.13/ tiller was recorded in acetamiprid (0.004%), imidacloprid (0.005%), fipronil (0.01%), thiamethoxam (0.005%) and dimethoate (0.03), respectively and were found statistically at par in their efficacy. The *Beauveria bassiana* (1 g/l), NSKE (5.0%), imidacloprid (8 g/ kg), thiamethaxam (8 g/ kg) and acetamiprid (8 g/ kg) registered 42.57, 42.97, 48.47, 49.26 and 51.60 aphids/ tiller, respectively. The highest aphid population was recorded in untreated control (81.23/ tiller). The data of seed yield revealed that maximum yield of 34.25 q ha⁻¹ was recorded in the plots treated with imidacloprid (0.005%) followed by acetamiprid (0.004%), thiamethoxam (0.005%), fipronil (0.01%) and dimethoate (0.03%) which gave 33.85, 33.01, 32.90 and 32.58 q ha⁻¹ seed yield, respectively and all these found statistically at par each other and proved significantly superior over rest of the treatments. The maximum net profit (Rs. 11444 ha⁻¹) was recorded from plots treated with imidacloprid (0.005%) which gave benefit cost ratio of 7.43 followed by acetamiprid (0.004%), imidacloprid (0.005%), thiamethoxam (0.005) and dimethoate (0.03%) with benefit cost ratio of 8.66, 7.43, 5.42 and 8.04, respectively.

Introduction

Barley, *Hordeum vulgare* Linn. (family: Gramineae) is an important cereal crop of Rabi season grown in India. The chapattis made up of barley flour are very palatable and can be easily digested even by the persons suffering from stomach ailments. Besides an ideal feed and fodder for livestock, the crop has acquired the status of an industrial crop in malting and brewing. This crop could perform better under moisture stress and saline conditions than other cereal crops. The grains of barley contain 12.5 per cent moisture, 11.5 per cent albuminoids, 74.0 per cent carbohydrate, 1.3 per cent fat, 3.9 per cent

crude fibre and 1.5 per cent ash. In Rajasthan, it is cultivated in about 307,936 ha area with an annual production to the tune of 957,896 tonnes (Anonymous, 2013).

The crop is infested by a number of insect pests, viz., armyworm, *Mythimna separata* (Haworth); ghujhia weevil, *Tanymecus indicus* (Faust); termite, *Odontotermes obesus* (Ramb.); cutworms, *Agrotis* spp.; shoot fly, *Atherigona naquii* (Styskal); pink borer, *Sesamia inferens* (Walker); jassids, *Amrasca basalis* (Baly); barley aphid, *Rhopalosiphum maidis* (Fitch) and *R. padi* (Linn.) (Singh,

1983). Among these insect pests, the aphid, *R. maidis* is most serious and regular insect pest of this crop (Sharma, 1990; Kumawat and Jheeba, 1999). Both nymphs and adults cause damage by sucking the cell sap from the leaves, stems and earheads. Due to rapid multiplication of the aphid, usually the entire shoot is covered and with the result of continuous desapping by such a large population, yellowing, curling and subsequent drying of leaves takes place which ultimately lead to reduction in size of earheads (Bhatia and Singh, 1977). The aphid also acts as a vector of barley yellow dwarf virus. The use of various systemic insecticides for the management of insect pests of barley have been suggested but sometimes the survivor individuals soon build up their population because of rapid multiplication in the absence of natural enemies. Keeping this in view, most of the workers have emphasized the use of newer and safe insecticides with noval mode of action including biopesticides. These insecticides are required only in small dosages as compared to older class of compounds. The neonicotinoids, namely, imidacloprid, thiamethoxam etc. were found effective against aphids and other sucking insect pests in many commercial crops (Wing *et al.*, 2000; Radha *et al.*, 2006 and Kaur *et al.*, 2012). The new molecules of insecticides need evaluation on scientific lines.

Materials and Methods

The experiment was laid out in simple randomized block design (RBD) with eleven treatments (insecticides and biopesticides) including untreated control, each replicated thrice. The plot size was 3.0 x 2 m² keeping row to row distance of 25 cm. The genotype RD-2052 recommended for this region was used for the experiment and sown on 15th November, 2014. Ten insecticides and biopesticides were used for testing their bioefficacy against aphid, *R. maidis* on barley

crop. The details regarding insecticides and biopesticides and their dosages are given in table 1. All the insecticides and biopesticides were applied as a foliar spray by using pre-calibrated knapsack sprayer. Two sprays were applied when aphid population reached at ETL, 16 aphids per tiller (Ba-Angood and Stewart, 1980). An untreated control (plain water) was maintained for comparison. The first insecticidal spray was given on 14nd January and second on 3th February after rebuild up of pest population (20 days after first spray) in *Rabi*, 2014-15. The insecticidal solution was prepared according to the following formula:

$$V = \frac{C \times A}{\% \text{ a.i.}}$$

Where,

V = Volume of insecticide

C = Concentration required

A = Amount of spray solution needed (600 l ha⁻¹)

% a.i. = Percentage of active ingredient of the insecticide

The aphid population was recorded on five randomly selected and tagged plants (5 tillers/plant) in each plots one day before and 1, 3, 7 and 15 days after application of the insecticides and biopesticides.

Interpretation of data

The data obtained were taken into consideration for calculating the analysis of variance after subjecting to $\sqrt{X+0.5}$ transformation. The grain yield was recorded in individual treatment replication-wise and converted into per hectare. The data on grain per hectare were subjected to analysis of variance. The increase in yield of grain over control was calculated for each treatment by the following formula:

Increase in yield (%) =

$$\frac{\text{Yield in treatment} - \text{yield in control}}{\text{Yield in control}} \times 100$$

The economics of various treatments was worked out by computing the cost of insecticides as well as their cost of application. The gross income was worked out by multiplying the yield with the wholesale rate of barley grains prevailing at the time of threshing. The benefit cost ratio was calculated by taking the net return and total expenditure of the treatment into account.

Results and Discussion

The bioefficacy of the treatments evaluated against aphid on barley crop showed that lowest population of 19.32, 20.81, 20.88, 20.95 and 21.13/ tiller was recorded in acetamiprid (0.004%), imidacloprid (0.005%), fipronil (0.01%), thiamethoxam (0.005%) and dimethoate (0.03), respectively and were found statistically at par in their efficacy.

The *Beauveria bassiana* (1 g/ l), NSKE (5.0%), imidacloprid (8 g/ kg), thiamethoxam (8 g/ kg) and acetamiprid (8 g/ kg) registered 42.57, 42.97, 48.47, 49.26 and 51.60 aphids/ tiller, respectively. The highest aphid population was recorded in untreated control (81.23/ tiller). The data of seed yield revealed that maximum yield of 34.25 q ha⁻¹ was recorded in the plots treated with imidacloprid (0.005%) followed by acetamiprid (0.004%), thiamethoxam (0.005%), fipronil (0.01%) and dimethoate (0.03%) which gave 33.85, 33.01, 32.90 and 32.58 q ha⁻¹ seed yield, respectively and all these found statistically at par each other and proved significantly superior over rest of the treatments. The maximum net profit (Rs. 11444 ha⁻¹) was recorded from plots treated with imidacloprid (0.005%)

which gave benefit cost ratio of 7.43 followed by acetamiprid (0.004%), imidacloprid (0.005%), thiamethoxam (0.005) and dimethoate (0.03%) with benefit cost ratio of 8.66, 7.43, 5.42 and 8.04, respectively.

Effect of insecticide or biopesticide on population of aphid, *R. maidis*

In the present investigation, the overall bioefficacy of the treatments against aphid on barley crop showed that lowest population of 19.32, 20.81, 20.88, 20.95 and 21.13/ tiller was recorded in acetamiprid (0.004%), imidacloprid (0.005%), fipronil (0.01%), thiamethoxam (0.005%) and dimethoate (0.03), respectively and were found statistically at par in their efficacy. The present findings are in conformity with that of Babu and Sharma (2003) and Bhargava (2009) who reported that imidacloprid was most effective against aphid on wheat and barley crop, respectively. Similarly, Radha *et al.*, (2006) and Bhat and Baba (2007) reported that imidacloprid was the most effective insecticide against corn leaf aphid, *R. maidis* on maize crop get support the present findings (Table 2).

Khurana and Yadav (1995) and Yadav and Jain (1999) reported that dimethoate was most effective insecticide against aphid on barley crop which corroborates with the present findings. Study conducted by Srivastava and Bhatia (2005) revealed that thiamethoxam was most effective insecticide against barley aphid, supports the present findings. The results are also in agreement with that of Babu *et al.*, (2006) who revealed that thiamethoxam proved to be highly effective in suppressing the aphids on barley crop. Bhargava (2009) too reported that imidacloprid was most effective followed by thiamethoxam when applied as seed treatment against barley aphid, partially support the present findings. The *Beauveria bassiana* (1

g/l), NSKE (5.0%), imidacloprid (8 g/ kg), thiamethoxam (8 g/ kg) and acetamiprid (8 g/ kg) registered 42.57, 42.97, 48.47, 49.26 and 51.60 aphids/ tiller, respectively and less effective. The highest aphid population was recorded in untreated control (81.23/ tiller). The findings are in conformity with the findings of Radha *et al.*, (2006) who reported that neem insecticide, nimbecidine was least effective against *R. maidis* on maize crop. Similarly, Sachan *et al.*, (2006) reported that NSKE and neem oil were least effective insecticides against mustard aphid *L. erysimi*, partially support the present findings. The present findings are also in agreement with those of Nirmala *et al.*, (2006) who reported that fungus isolates of *Beauveria bassiana*, *M. anisopliae* and *Verticilium lecanii* were pathogenic to *R. maidis*. The order of effectiveness of all treatments was acetamiprid (0.004%)= imidacloprid (0.005%)= fipronil (0.01%)= thiamthoxam (0.005%)= dimethoate (0.03%)> *Beauveria bassiana* (1 g/l)= NSKE (5.00)= imidacloprid (8 g/ kg)= thiamethoxam (8 g/ kg)= acetamiprid (8 g/ kg).

Effect of insecticide or biopesticide on the seed yield of barley

All the plots treated with insecticides and biopesticides gave significantly higher seed yield of barley over untreated control except seed treatment with thiamethoxam. The data of seed yield revealed that maximum yield of 34.25 q ha⁻¹ was recorded in the plots treated with imidacloprid (0.005%) followed by acetamiprid (0.004%), thiamethoxam (0.005%), fipronil (0.01%) and dimethoate (0.03%) which gave 33.85, 33.01, 32.90 and 32.58 q ha⁻¹ seed yield, respectively and all these were found statistically at par with each other and proved significantly superior over rest of the treatments. The next effective treatments were *B. bassiana* (1 g/ l) and NKSE (5%) which gave seed yield of 28.34 and 27.85 q ha⁻¹, respectively and formed a non-significant group. The minimum seed yield (27.42, 26.90 and 26.60 q ha⁻¹) was obtained in the seed treatment with imidacloprid (8 g/ kg), acetamiprid (8 g/ kg) and thiamethoxam (8 g/ kg) which were significantly inferior to rest of the treatments, respectively and were comparable each other (Table 3).

Table.1 Details of insecticides and biopesticides used

S.No.	Common name	Trade Name	Formulation	Conc. (%) / dosage
1.	Imidacloprid	Gaucho	70 WS	8 g kg ⁻¹
2.	Acetamiprid	Pride	20 SP	8 g kg ⁻¹
3.	Thiamethoxam	Cruiser	70 WS	8 g kg ⁻¹
4.	Imidacloprid	Confidor	17.8 SL	0.005
5.	Acetamiprid	Pride	20 SP	0.004
6.	Thiamethoxam	Actara	25 WG	0.005
7.	Fipronil	Regent	5 SC	0.01
8.	<i>Beauveria bassiana</i>	Racer-BB	1.15 WP	1 g l ⁻¹
9.	NSKE	-	Lab. prepared	5.0
10.	Dimethoate (Check)	Rogor	30 EC	0.03
11.	Control (untreated)	-	-	-

NSKE: Neem seed kernel extract

Table.2 Evaluation of some insecticides and biopesticides against aphid, *Rhopalosiphum maidis* (Fitch)

S.N o.	Insecticides	Conc. (%) dosage	*Mean aphid population days after											
			Pre- treatment count	First spray					Pre- treatment count	Second spray				
				1	3	7	15	Mean		1	3	7	15	Mean
1.	Imidacloprid [#]	8 g/kg	37.80 (6.19)	37.87 (6.19)	39.37 (6.31)	40.62 (6.41)	46.61 (6.86)	40.45 (6.40)	48.25 (6.98)	48.36 (6.99)	52.62 (7.29)	51.52 (7.21)	41.58 (6.49)	48.47 (7.00)
2.	Acetamiprid [#]	8 g/kg	34.34 (5.90)	35.34 (5.99)	36.78 (6.11)	42.37 (6.55)	44.51 (6.71)	38.67 (6.26)	52.74 (7.30)	52.82 (7.30)	54.38 (7.41)	53.41 (7.34)	44.65 (6.72)	51.60 (7.22)
3.	Thiamethoxam [#]	8g/kg	36.29 (6.07)	38.77 (6.27)	40.68 (6.42)	41.17 (6.46)	43.26 (6.62)	40.03 (6.37)	49.36 (7.06)	50.25 (7.12)	52.56 (7.28)	51.85 (7.24)	42.26 (6.54)	49.26 (7.05)
4.	Imidacloprid	0.005	48.57 (7.00)	22.53 (4.80)	9.66 (3.19)	23.81 (4.93)	31.74 (5.68)	27.26 (5.27)	44.25 (6.69)	21.58 (4.70)	12.52 (3.61)	17.29 (4.22)	8.40 (2.98)	20.81 (4.62)
5.	Acetamiprid	0.004	56.34 (7.54)	29.34 (5.46)	15.74 (4.03)	26.53 (5.20)	29.38 (5.47)	31.47 (5.65)	39.36 (6.31)	17.34 (4.22)	9.78 (3.21)	19.52 (4.47)	10.62 (3.33)	19.32 (4.45)
6.	Thiamethoxam	0.005	48.25 (6.98)	21.37 (4.68)	13.34 (3.72)	23.51 (4.90)	31.12 (5.62)	27.52 (5.29)	42.41 (6.55)	19.41 (4.46)	8.39 (2.98)	18.69 (4.38)	15.86 (4.04)	20.95 (4.63)
7.	Fipronil	0.01	45.44 (6.78)	20.34 (4.57)	16.63 (4.14)	22.31 (4.78)	28.33 (5.37)	26.61 (5.21)	42.74 (6.58)	17.22 (4.21)	11.25 (3.43)	20.12 (4.54)	13.05 (3.68)	20.88 (4.62)
8.	<i>Beauveria bassiana</i>	1g/l	48.34 (6.99)	48.57 (7.00)	40.35 (6.39)	34.36 (5.90)	37.28 (6.15)	41.78 (6.50)	46.23 (6.84)	48.27 (6.98)	42.38 (6.55)	43.08 (6.60)	32.88 (5.78)	42.57 (6.56)
9.	N.S.K.E.	5.00	46.57 (6.86)	45.53 (6.78)	38.15 (6.22)	36.54 (6.09)	42.22 (6.54)	41.80 (6.50)	48.45 (7.00)	50.13 (7.12)	43.44 (6.63)	42.92 (6.59)	29.91 (5.51)	42.97 (6.59)
10.	Dimethoate (Check)	0.03	52.34 (7.27)	24.38 (4.99)	18.17 (4.32)	28.53 (5.39)	31.81 (5.68)	31.05 (5.62)	44.71 (6.72)	20.28 (4.56)	12.42 (3.59)	18.83 (4.40)	9.39 (3.14)	21.13 (4.65)
11.	Control (Untreated)	-	51.35 (7.20)	53.57 (7.35)	54.32 (7.40)	54.25 (7.40)	56.10 (7.52)	53.92 (7.38)	58.23 (7.66)	58.29 (7.67)	54.28 (7.40)	53.84 (7.37)	42.24 (6.54)	53.38 (7.34)
	SEm ±		0.30	0.23	0.25	0.24	0.25	0.25	0.23	0.26	0.27	0.23	0.17	0.25
	CD (5%)		0.89	0.68	0.75	0.71	0.74	0.73	0.67	0.76	0.80	0.66	0.52	0.72

Figures in the parentheses are $\sqrt{X+0.5}$ values.

*Mean of three replications

[#] Seed treatment

Table.3 Effect of insecticides and biopesticides on seed yield of barley

S.No.	Insecticides/ biopesticides	Conc.(%)/ dosage	Mean seed yield (q ha ⁻¹)
1.	Imidacloprid*	8 g/ kg	27.42
2.	Acetamiprid*	8 g/ kg	26.90
3.	Thiamethoxam*	8 g/ kg	26.60
4.	Imidacloprid	0.005	34.25
5.	Acetamiprid	0.004	33.85
6.	Thiamethoxam	0.005	33.01
7.	Fipronil	0.01	32.90
8.	<i>B. bassiana</i>	1 g/ l	28.34
9	NSKE	5.0	27.85
10.	Dimethoate (Check)	0.03	32.58
	Control	-	22.96
	S.Em.±		1.33
	CD (p=0.05)		3.92

*Seed treatment

Table.4 Comparative economics of insecticides and biopesticides in managing aphid on barley in Rabi, 2014-15

S.No.	Insecticides/ Biopesticides	Conc. (%) or dosage	Yield (q ha ⁻¹)	Total increase in yield over control (q ha ⁻¹)	Per cent increase in yield over control	Return of increased yield (Rs)*	Total cost/ expenditure (Rs)**	Net profit (Rs ha ⁻¹)	B:C ratio
Seed treatment									
1.	Imidacloprid	8 g/ kg	27.42	4.46	19.42	5129	3130	1909	0.61
2.	Acetamiprid	8 g/ kg	26.90	3.94	17.16	4531	2010	2431	1.21
3.	Thiamethoxam	8 g/ kg	26.60	3.64	15.85	4186	3450	646	0.19
Spray									
4.	Imidacloprid	0.005	34.25	11.29	49.17	12984	1540	11444	7.43
5.	Acetamiprid	0.004	33.85	10.89	47.42	12524	1296	11228	8.66
6.	Thiamethoxam	0.005	33.01	10.05	43.77	11558	1800	9758	5.42
7.	Fipronil	0.01	32.90	9.94	43.29	11431	4080	7351	1.80
8.	<i>B. bassiana</i>	1 g/ l	28.34	5.38	23.43	6187	1242	4945	3.98
9	NSKE	5.0	27.85	4.89	21.30	5624	3120	2504	0.80
10.	Dimethoate (check)	0.03	32.58	9.62	41.89	11063	1224	9839	8.04
11	Control	-	22.96	0	0.00	0.0	0.0	0.0	0.0

* Price of barley seed at current season was Rs. 1150/- q⁻¹

** It includes cost of insecticides and labour charges

The order of effectiveness of insecticides in descending order on the basis of seed yield of barely was found to be: imidacloprid (0.005%), acetamiprid (0.004%), thiamethoxam (0.005%), fipronil (0.01%), dimethoate (0.03%), *B. bassiana* (1g/ l), NSKE (5%), imidacloprid (8 g/ kg), acetamiprid (8 g/ kg), thiamethoxam (8 g/ kg). The present findings are in agreement with that of Sekhar and Singh (2001) who reported that per cent increase in yield over control in wheat crop was higher in the treatment of imidacloprid (125 g a.i. ha⁻¹) when applied against aphids infesting wheat crop. The findings are also in close agreement with those of Yadav and Jain (1999) who reported that the treatments of dimethoate (0.03%) gave highest seed yield in barley crop when applied as foliar spray. Srivastava and Bhatia (2005) reported that thiamethoxam (50 g a.i. ha⁻¹) was most effective in protecting the grain yield.

The findings are in partial agreement with Radha *et al.*, (2006) who reported that neem product, nimbecidine was the least effective and gave lower seed yield as compared to synthetic insecticides.

Economics of treatments

The maximum total increase in yield (11.29 q ha⁻¹) and per cent increase in yield (49.17 %) over control was recorded in the plots treated with imidacloprid 0.005 per cent followed by acetamiprid 0.004 per cent (10.89 q ha⁻¹ and 47.42%), thiamethoxam 0.005 per cent (10.05 q ha⁻¹ and 43.77%), fipronil 0.01 per cent (9.94 q ha⁻¹ and 43.29%) and dimethoate 0.03 per cent (9.62 q ha⁻¹ and 41.89%) as evident in table 4. The total and per cent increase in yield over control in the treatment of *B.bassiana* was 5.38 q ha⁻¹ and 23.43 per cent, respectively and in NSKE these were 4.89 q ha⁻¹ and 21.30 per cent, respectively. The minimum total and per cent increase in yield over control was recorded in the seed treatment of imidacloprid (4.46 q ha⁻¹, 19.42) followed by acetamiprid (3.94 q ha⁻¹, 17.16) and thiamethoxam (3.64 q ha⁻¹, 15.85). The maximum net profit (Rs. 11444 ha⁻¹) was recorded from plots treated with imidacloprid

(0.005%) which gave benefit cost ratio of 7.43 followed by acetamiprid (0.004%), imidacloprid (0.005%), thiamethoxam (0.005) and dimethoate (0.03%) in which benefit cost ratio of 8.66, 7.43, 5.42 and 8.04, respectively was recorded. The benefit cost ratio in the treatment of *B. bassiana*, fipronil and seed treatment with imidacloprid and acetamiprid resulted in the middle order. The negative benefit cost ratio of 0.80 and 0.19 was recorded in the treatments of NSKE and seed treatment of thiamethoxam due to their higher cost and low yield exhibited by them. Khurana and Yadav (1995) recommended dimethoate (0.03%) against aphid on barley crop on the basis of efficacy and economics of insecticides, extend support for the present findings. Sachan *et al.*, (2006) reported that dimethoate (0.03%), thiamethoxam (0.03%) and imidacloprid (0.04%) gave maximum benefit cost ratio, and neem products gave least benefit cost, corroborate the present findings. Bhat and Baba (2007) also reported that the maximum net profit was obtained from imidacloprid treatment against *R. maidis* on maize crop.

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