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Field Efficacy of Some New Generation Insecticides Against Maize Aphid (*Rhopalosiphum maidis*) and its Effect on Yield

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ABSTRACT

A field experiment was conducted at the Field Laboratory, Department of Entomology, Bangladesh Agricultural University (BAU), Mymensigh during *Rabi season* of 2017-18 to find out the efficacy of some new generation insecticides against maize aphid and its effects on yield. BARI Hybrid Butta-9 variety was used as experimental crop and four insecticides *viz.* Imidagold 20SL@ 0.1, 0.3 & 0.5 ml/L; Ambush 1.8 EC@ 1.5, 2.5 & 3.0 ml/L; Hadhak 45WP@ 0.2, 0.4 & 0.6 g/L and Suspend 5SG@ 0.5, 1.0 & 1.5 g/L were used as experimental treatments. Results clearly showed Imidagold 20SL resulted in the greatest reduction of aphid infestation and increased the grain yield compared to the all tested insecticides where the doses of 0.5 ml/L and 0.3 ml/L of this insecticide were statistically similar. Thereafter, the result was followed by Ambush 1.8 EC, Hadhak 45WP and Suspend 5SG, respectively, while the highest plant infestation, the lowest grain yield and the lowest benefit cost ratio were obtained from untreated control. Moreover, there had a positive and significant co-relation between percent reduction of plant infestation and yield increase. In addition, data also revealed that the use of Ambush 1.8 EC @ 3.0 ml/L performed second best treatment. Therefore, it can be concluded that the maize farmers can use Imidagold 20SL@ 0.3 ml/L or Ambush 1.8EC @0.3 ml/L for effective management of maize aphid under field condition.

Introduction

Maize (*Zea mays* L.) is the second important cereal crops after rice in Bangladesh (Ahmed, 2016). It is considered as a staple food in many countries of the world. In Bangladesh, the production of maize is about 2.81 MT in 2018-2019 (BBS, 2020). But the production of maize is very low compare to neighbor country. In country, maize is produced less than 30% in *kharif season* and more than 70% in *Rabi season*. About 90% of the home-grown maize is feeding a burgeoning poultry and fish feed industry and rests are used as human food (Alam *et al.,* 2019a, c). It can be processed into a variety of food and industrial products including starch, flour, dent, waxy, salad, sweeteners, oil, beverages, glue, industrial alcohol, and fuel ethanol. Its grain contains about 45-50% of oil that is used in cooking. Maize is a photo-insensitive and C_4-cycle crop that's why it can be grown throughout the year (Alam *et al.,* 2019a). The infestation caused by insects on maize is increasing day by day due to continuous cultivation. Of different insect pests, maize aphid, *Rhopalosiphum maidis* is one of the important serious insect. It can attack maize at any stage of growth decreasing its yield. It is a polyphagous pest, i.e., it also attacks mustard, sorghum, barley and others horticultural crops. Nymphs and Adult are very much aggressive and cannibalistic in nature. So, they suck cell sap from all parts of the plant (Alam *et al.,* 2014). Thus, it causes hamper on pollination and also introduces various types of virus and fungus on cobs and plant. In case of maize, it is reported to cause 5-7% yield loss when favorable environmental condition as well as susceptible varieties prevails (Patil *et al.,* 2018 and Alam *et al.,* 2015a, b; 2018, 2020a, b). In this reason, the infestation of maize aphid is considered as one of the most limiting factors of maize yield (Alam *et al.,* 2019a, c; 2020a, b). However, insecticides are considered as main tools for controlling maize aphid in Bangladesh. Farmers usually use a lot of insecticides indiscriminately and frequently. As a result, it causes environmental pollution, outbreak of secondary pests, insecticide resistance, abatement in biodiversity of natural enemies, pesticides residues in grain and food adulteration. Finally, it also creates the imbalance in ecosystem.

Cite This Article

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Therefore, to reduce the environmental pollution and to conserve the eco-system, suitable insecticide with optimum dose is necessary to develop & adopt eco-friendly and sustainable management system for crop cultivation. Of the many options, use of new generation insecticides is the alternative to manage the pest and develop the eco-system so that farmers can get a satisfactory yield as well as consumers can get fresh and safe food. From the above scenario and fact, in this present research, we have managed several new generation insecticides that are available in the local market from different groups for the management of maize aphid, *R. maidis* under field conditions and their effect on maize grain yield.

Materials and Methods

Experimental layout and location

The research was carried out in the Field Laboratory of the Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during *Rabi season* of 2017-18. The research site was situated at 24.75 N latitude and 0.50 E longitudes at an average altitude of 18m above the mean sea level. The site of experiment belongs to the Sonatola series of the dark grey floodplain soil type under Old Brahmaputra Floodplain Agro-Ecological Zone (AEZ-9) (Alam *et al.*, 2019a, b). The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications maintaining five treatments including untreated control.

Land preparation, variety and crop development

The land was prepared well with a power tiller followed by laddering and leveling the surface of the soil. All fertilizers were applied during land preparation except urea and Muriate of Potash (MOP). One-fourth of urea and MOP were applied at the time of final land preparation. The nitrogen, phosphorus, potassium, sulphur and zinc fertilizers were applied in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 260, 80, 140, 50 and 4.5 kg/ha, respectively (FRG, 2012). Remaining urea and MOP were applied at three equal installments at pre-vegetative stage, full vegetative stage and early corn formation stage. Maize *var.* BARI Hybrid Butta-9 variety was used as experimental crop. The crop was sown in 1st week of November, 2017 in line with raise bed, which is the normal sowing date being practiced in the experimental fields with a plot size of 10 m^2 (4m×2.5m), spacing of 60×30cm between row to row and plant to plant, respectively, and the distance was 70cm between the two plots. Total number of plots was 39. Weeding, irrigation and other intercultural operation were done properly as and when necessary for better growth and development of maize plants.

Treatments, doses and spraying

Four new generation insecticides *viz.* Imidagold 20SL (Imidacloprid), Ambush 1.8EC (Abamectin); Hadhak 45WP (Imidacloprid 25% + Thiram 20%) and Suspend 5 SG (Emamectin Benzoate) were selected as experimental treatments for this study. All chemical insecticides were collected from the local market of Sadar, Mymensingh. The detailed specifications (doses, group, etc.) of selected insecticides are presented in Table 1. At three stages of maize growth i. e. vegetative, inflorescence and cob formation, the plants were monitored regularly to confirm the infestation level caused by aphid and when considerable plants, inflorescence & cobs were found to be infested, then treatments were prepared and applied according to the experimental specifications stated below. Spraying was started at morning time to avoid bright sunshine and drift caused by strong wind.

Table 1. Specification of different tested insecticides

Trade name	Active ingredients	Group	Doses
Imidagold 20 SL	Imidacloprid 20SL	Insecticides	0.1, 0.3 & 0.5 ml/L
Ambush 1.8 EC	Abamectin 1.8EC	Avermectin	1.5, 2.5 & 3.0 ml/L
Hadhak 45WP	Imidacloprid 25% + Thiram 20% 45WP	Insecticides	0.2, 0.4 & 0.6 g/L
Suspend 5 SG	Emamectin Benzoate 5 SG	Insect Growth Regulator	0.5, 1.0 & 1.5g/L

Data collection parameters and procedure

Data were collected on 2, 5 and 7 days after spraying (DAS). The following parameters: Total number of plants, number of healthy and infested plants per plot, percent plant infestation, percent reduction of plant infestation, yield (t/ha) of healthy and infested grain, percent increase of yield over control and benefit cost ratio were considered for the efficacy evaluation of the selected insecticides. However, healthy and infested plants were counted from randomly selected five plants from each treated plots after each spraying of treatments. After harvesting of cobs, the grain was received from each treated plot along with control. Then these grains were weighted and recorded, and thereby, yield data were converted into ton per hectare according to treatment. All data of all stages were collected and compiled into average value. The percentage infestation of the plant was calculated by using the following formula (Alam *et al.,* 2019a):

$$\text{Infestation of plant (\%)} = \frac{\text{Number of infested plants}}{\text{Total number of plants}} \times 100$$

The percent reduction of infestation over control was calculated using the following formula:

$$\% \text{ reduction of infested plant over control} = \frac{\text{Infestation (\%) in control} - \text{infestation (\%) in treatment}}{\text{Infestation (\%) in control}} \times 100$$

The percentage increase of yield over control was calculated by using the following formula:

$$\text{Yield increase over control (\%)} = \frac{\text{Yield in control} - \text{yield in treatment}}{\text{Yield in control}} \times 100$$

The benefit cost ratio (BCR) was calculated on the basis of prevailing market prices of maize grain, insecticides, spraying and cultivation cost etc. Benefit cost ratio was calculated using the following formula:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Total variable cost}}$$

Data analysis

All the recorded data were compiled and tabulated for statistical analysis. The Analysis of Variance (ANOVA) was done with the help of R statistics software version 3.5.3. The treatments means differences were adjudged with Duncan's Multiple Range (DMRT) Test (Gomez and Gomez, 1984) and Least Significant Difference (LSD) when necessary. Relation of variables between the percent increase of yield over control and percent reduction of insect infestation over control was calculated by using Pearson's Correlation Coefficient and Multiple Regression analysis with the R statistics software version 3.5.3 program.

Results

Effect of different insecticidal treatment on aphid population

It was found that the tested four insecticides i.e. Imidacloprid, Abamectin, Imidacloprid 25%+Thiram 20% and Emamectin Benzoate showed efficacy on significant reduction of percent plant infestation by *R. maidis* compared to control (Table 2). Among, all the concentrations of the insecticides tested, the highest percent of plant infestation was found in control with a continuously increasing trend of plant infestation which was ranged from 86.01 to 96.73% and the cumulative mean of infestation was recorded 93.57%. The lowest percent of plant infestation was noted in the treatment of Imidacloprid 20SL @ 0.5ml/L having cumulative mean of plant infestation 21.30% ranged from 4.34 to 42.23% which was statistically significant ($P \leq 0.01$) than other treatments.

However, this treatment i.e. Imidacloporid 20SL @ 0.5ml/L was statistically similar to the doses of 0.3ml/L of Imidacloprid 20SL. Thus, the application of Imidacloprid 20SL@ 0.5 & 0.3ml/L performed best on percent plant infestation of maize. Hence, the cumulative mean of percent plant infestation for Abamectin 1.8EC@ 3.0ml/L, Hadhak 45WP@ 0.6g/L and Suspend 5SG@ 1.5g/L were 27.06, 33.34 and 54.72%, respectively. On the other hand, percent reduction of plant infestation over control was also calculated is shown in Figure 1. It was found that the highest percent (77.24%) of plants were reduced infestation of plant from the use of Imidacloprid 20SL@ 0.5ml/L against the *R. maidis* infestation which was statistically at par with the dose of 0.3ml/L of Imidacloprid 20SL. Besides, the second highest (71.08%) percent reduction of plant infestation over control was recorded in Abamectin 1.8EC @ 0.3ml/L. They were followed by Hadhak 45WP and Suspend 5SG, respectively. These clearly suggested the effective performance of Imidacloprid 20SL@ 0.3ml/L and Abamectin 1.8EC @ 03ml/L against *R. maidis* infestation of maize plant.

Grain yield (t/ha) and Benefit cost ration (BCR)

All the selected insecticides significantly increased the grain yield (t/ha) compared to untreated control (Table 3). In case of control condition, the grain yield was 3.23 t/ha. This yield was increased to 8.43 t/ha when maize plants were treated with Imidacloprid 20SL@ 0.5ml/L and this is the highest yield among the treatments, which was statistically similar to Imidacloprid 20SL@ 0.3ml/L (8.38t/ha).

This result (considering the efficacy of insecticides only) was followed by Abamectin 1.8EC, Hadhak 45WP and Suspend 5SG, respectively. On the other hand, it was also observed that the application of Imidacloprid 20SL@ 0.5ml/L has increased 61.48% grain yield over control (Figure 2), which was statistically at par with the dose of 0.3ml/L of Imidacloprid 20SL. The lowest percent increased of grain yield over control was recorded from Suspend 5SG@ 0.5g/L. In all field trials, the significant effects of the four insecticides on percent increase of yield over control were in the following rand order (lowest percent yield to highest percent yield): Imidagold 20SL<Ambush 1.8EC< Hadhak 45WP<Suspend 5SG. Benefit cost ratio (BCR) analysis of treatments applied against aphid on maize has been done and the results of this analyzed are presented in Table 3. The benefit cost ratio (BCR) in treated plots ranging from 0.54 to 1.46. Imidagold 20SL@ 0.5ml/L treated plots was recorded the highest benefit cost ratio (1.46) which was statistically similar with the dose of 0.3ml/L of Imidagold 20SL. They were followed by 1.22, 1.28, 1.37 in Ambush 1.8EC@ 1.5, 2.5, 3.0ml/L; 1.15, 1.25, 1.33 in Hadhak 45WP@ 0.2, 0.4, 0.6g/L and 0.96, 1.11, 1.20 in Suspend 5SG@ 0.5, 1.0, 1.5g/L, respectively, whereas the minimum benefit cost ratio (0.54) was found in case of untreated plots.

Table 2. Efficacy of different new generation insecticides on the percent reduction of maize plant infestation

Treatments	Doses	BS	Mean percentage of infested plants at			Cumulative Mean
			2DAS	5DAS	7DAS	
Imidagold 20SL	0.1 ml/L	86.02 a	58.75 g	43.36g	20.26gh	40.79g
	0.3 ml/L	86.00 a	42.80 j	18.00 j	4.95j	21.92j
	0.5 ml/L	86.01 a	42.23 j	17.32 j	4.34j	21.30j
Ambush 1.8EC	1.5 ml/L	86.02 a	71.39 e	52.56e	28.35 e	50.77e
	2.5 ml/L	85.90 a	60.13fg	45.50fg	21.54 g	42.39f
	3.0 ml/L	86.00 a	46.71 i	24.78 i	9.69i	27.06i
Hadhak 45WP	0.2 g/L	86.01 a	73.46d	64.03cd	30.26 d	55.91d
	0.4 g/L	86.00 a	60.77 f	46.24f	24.31f	43.77f
	0.6 g/L	85.90 a	50.32 h	30.05h	19.65h	33.34h
Suspend 5 SG	0.5 g/L	86.02 a	81.38 b	68.64b	41.31b	63.78b
	1.0 g/L	86.10 a	77.38 c	64.52c	34.55c	58.82c
	1.5 g/L	85.99 a	73.3de	61.65d	29.22de	54.72d
Control		86.01 a	90.70 a	93.30 a	96.73a	93.57a
CV (%)		12.42	5.78	6.20	5.16	6.97
LSD		0.02	1.91	2.61	1.49	1.55
SE(±)		1.75	0.92	1.26	0.72	0.88

In column, means followed by different letters are significantly different, In column, means followed by same letters are not significantly different, CV= Coefficient of variation, LSD= Least significant difference, SE (±)= Standard error, BS= Before spray and DAS= Day after Spray

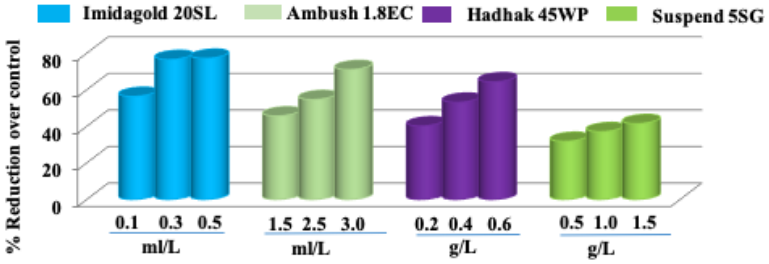

Figure 1. Percent reduction of plant infestation over control when the plants were treated with selected insecticides

Table 3. Efficacy of different new generation insecticides on yield attributes and benefit cost ratio

Treatments	Doses	Grain yield (t/ha)	Benefit Cost Ratio (BCR)
Imidagold 20SL	0.1 ml/L	6.52e	1.30
	0.3 ml/L	8.38a	1.45
	0.5 ml/L	8.43a	1.46
Ambush 1.8EC	1.5 ml/L	5.55g	1.22
	2.5 ml/L	6.04f	1.28
	3.0 ml/L	7.83b	1.37
Hadhak 45WP	0.2 g/L	4.67h	1.15
	0.4 g/L	6.02f	1.25
	0.6 g/L	7.11cd	1.33
Suspend 5 SG	0.5 g/L	4.06j	0.96
	1.0 g/L	4.34i	1.11
	1.5 g/L	5.53g	1.20
Control		3.23k	0.54
CV (%)		5.33	
LSD		0.03	
SE(±)		0.95	

In column, means followed by different letters are significantly different, CV= Coefficient of variation, LSD= Least significant difference and SE(±)= Standard error

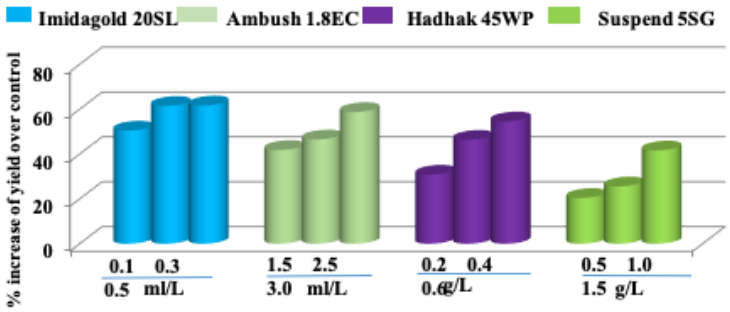

Figure 2. Percent increase of yield over control when the plants were treated with selected insecticides

Correlation between percent reduction of plant infestation over control and percent increase of yield over control

Four new generation insecticides have a significant effect on the reduction of maize plant infestation. But the effects of four insecticides are not equal. Correlation study was done to establish the relationship between percent reduction of plant infestation over control and percent increase of yield over control. From Table 4, it was revealed that highly positive significant correlation was observed between two parameters. It was evident that the equation, Y=0.92 + (0.847)*X, where Y= yield increase over control (%) and X= reduction (%) of plant infestation over control gave a good fit to the data and the co-efficient of determination (R^2 = 0.92***) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the percent reduction of plant infestation over control was strong as well as positively correlated with the percent increase of yield over control. The yield of maize was increased due to the percent reduction of maize plant infestation.

Discussion

Among four insecticides, Imidagold 20SL@ 0.5ml/L found to be the best considering all the parameters studied *viz.* plant infestation, reduction of plant infestation, grain yield (t/ha), benefit cost ratio (BCR) and correlation between the reduction of infestation & percent increase of yield etc. which was statistically similar to the dose of 0.3 ml/L of Imidagold 20SL. The results of the present study are similar to the finding of the study **(**Kumar *et al.,* 2019**)** who indicated that Imidagold 20SL@ 0.3 ml/L showed maximum mortality against maize aphid. Our results have shown that Imidagold 20SL@ 0.3ml/L also caused statistically significant the highest reduction of plant infestation about 77%. Patil *et al.* (2018); Preetha *et al.,*(2012); Zewar, *et al.* (2007) also reported that Imidagold consistently performed superior to other tested insecticides against maize aphid. When considering grain yield of maize, Patil *et al.,* (2018); Preetha *et al.* (2012); Zewar *et al.* (2007) noted that use of Imidagold returned higher yield and maximum reduction of plant infestation on various crops that supported our observations. On the other hand, we also found that, Ambush 1.8EC @ 0.3 ml/L showed the second best efficacy against aphid among four insecticides which supports the previous observations of Patil *et al.*(2018); Preetha *et al.* (2012); Suchail *et al.* (2001) on several crops. But, considering the efficacy of Abamectin, previously, Katare *et al.* (2015) and Singh *et al.* (1979) found that Abamectin (Ambush 1.8 EC) was found as the most effective one followed by Hadhak (Imidcloprid 25% + Thiram 20%) and Suspend (Emamectin Benzoate) against maize aphid. They reported that the efficacy of Abamectin was significantly better in comparison with that of the others. In this study, the Abamectin was also found effective against *R. maidis* but its effectiveness was comparatively lower than the other treatments such as Imidagold (Imidacloprid). The difference was possibly due to the dose of the Abamectin used. It was found that Katare *et al.* (2015) studied the effect of Abamectin using 3.5 ml/L dose and in our study it was 3.0 ml/L. In case of correlation between percent reduction of plant infestation over control and percent increase of yield over control, in our present study showed significantly strong positive correlation between mentioned parameters. Similar type of result was found by Alam *et al.,* (2019a) and Katare *et al.* (2015). These findings is in agreement with the findings reported that Imidacloprid 20SL, Fipronil, Emamectin Benzoate, Imidacloprid 25%+ Thirma 20% and Abamectin provided strongly positive correlation between percent reduction of maize plant infestation over control and percent increase of yield over control (Alam *et al.,* 2019a; Ahmad *et al.,*2017 and Katare *et al.,* 2015).

Conclusion

Considering the findings from the present study, it may be concluded that the application of Imidagold 20 SL@ 0.5ml/L and 0.3ml/L is more effective together for controlling maize aphid considering the grain yield and minimum infested plant of maize. However, based on the benefit cost ratio, Imidagold 20 SL@ 0.3 ml/L is the best. This treatment, therefore, could be recommended to the maize grower for the effective management of *R.*

maidi. In addition, the result also showed that the use of Ambush 1.8 EC@ 3.0 ml/L performed second best treatment. Hence, in addition to Imidagold 20 SL and Ambush 1.8 EC could also be suggested for effective management of maize aphid.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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