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Efficacy of Less Toxic Phytochemicals to Prevent the Insect Vector of *Mungbean Yellow Mosaic Virus* (*MYMV*)

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Abstract

Planting material BARI mungbean-5 and two phytochemicals viz. Imitaf, active ingredient imidacloprid and ACmix, active ingredient chloropyriphos (50%) + Cypermethrin (5%) were used in this experiment. In case of Imitaf, the lowest percent disease incidence (10.12% per plant and 3.51% per plot) and severity (7.21%) were recorded in four times spray (T_4) at 70 DAS. The highest percent disease incidence (36.50% per plant and 11.37% per plot) and severity (23.33%) were recorded in no spray (T_0) at 70 DAS. In case of ACmix, the lowest percent disease incidence (12.21% per plant and 4.21% per plot) and severity (7.53%) were recorded in four times spray (T_4) at 70 DAS. The highest percent disease incidence (36.49% per plant and 11.37% per plot) and severity (36.67%) was recorded in T_0 at 70 DAS. The highest number of flower, no of pod and yield was found in four times spray (T_4) that was higher in Imitaf than ACmix. The highest chlorophyll content was recorded in four times spray (T_4) for Imitaf (49.62 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and ACmix (56.80 $\mu mol \cdot m^{-2} \cdot s^{-1}$), and the lowest chlorophyll content was recorded in T_0 for Imitaf (42.01 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and ACmix (48.34 $\mu mol \cdot m^{-2} \cdot s^{-1}$). However from the results of this experiment it was revealed that Imitaf gave the better performance to control the insect vector (Whitefly) of *MYMV* with four times spray.

Keywords

Mungbean, *MYMV*, Whitefly, Phytochemicals, Bangladesh

1. Introduction

Mungbean (*Vigna radiata* L.) remains under the family Fabaceae. This is an

ancient, cheapest and conventional pulse crop in the world. Almost 90% of world's mungbean production comes from Asia. Mungbean is also widely grown in Bangladesh. It is grown three times in a year covering 43,680 ha with an average yield of 0.78 t/ha [1]. It contains high graded vegetable proteins and satisfactory level of minerals and vitamins. It also contains amino acids especially lysine which is generally deficit in cereal food grains [2]. According to World Health Organization (WHO), per capita per day requirement of pulse is 45 g. But in Bangladesh, only 12 g pulse is available per capita per day. About 6.01 million tons of pulse is required to meet the present per capita requirement of our country [3]. But the mungbean production has not considerably increased yet. The main cause for the low yield is the susceptibility of the crop to insects, weeds and diseases caused by virus, fungus or bacterium of which *Mungbean yellow mosaic virus* (*MYMV*) is one of the most prevalent and destructive viral pathogen in mungbean. *MYMV* is transmitted by white fly (*Bemisia tabaci*). To increase the production it is very important to reduce the virus infection and/or transmission by managing its vectors. We can manage the vector using several measures. We can manage the disease using resistant variety, by practicing crop rotation, implanting slush and burn process; maintain growing time and properly intercultural operation. Besides these management practices, this devastating viral disease can also be managed precisely by applying insecticides properly. Epidemiological factors play crucial role in the development of MYMV and white fly population. The proper time of application of insecticides could be helpful not only to manage whitefly and virus minimizing with the number of sprays. The study of epidemiological factors determined the most conducive environment for the application of pesticides at right time, enhancing the yield of this crop. The prime aim of this study was to evaluate the selected phytochemicals viz. Imitaf, active ingredient imidacloprid and ACmix, active ingredient chloropyriphos (50%) + Cypermethrin (5%) for controlling the insect vectors with the minimum number sprays at the right time.

2. Materials and Methods

2.1. Experiment Location and Duration

The field experiment was conducted at the central Farm under the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The experiment was carried out during the period from March to June 2016.

2.2. Soil Type and Climatic Condition

The soil of the experimental plot belongs to the Tejgaon series under the Agro Ecological Zone, Madhupur Tract (AEZ-28) and the type soil shallow red brown terrace soil with pH 6.5 - 7.5. The experimental site has sub-tropical climatic condition characterized by high temperature, heavy rainfall during May to September and scanty rainfall during rest of the year.

2.3. Collection of Planting Materials and Phytochemicals

BARI Mungbean-5 a variety of Mungbean was collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. The selected phytochemicals namely Im itaf and ACmix were collected from local market.

2.4. Design and Layout of the Experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and two blocks as "Imitaf" and "ACmix". There were seven treatments including a control treatment and 21 (3 × 7) unit plots were laid for each of the block. The size of each unit plot was 3 m^2 (3 m × 1 m) and plot to plot distance was 0.5 m.

2.5. Treatments of the Experiment

Treatments of the experiment were as follows:

T_0 = Control/No spray
T_1 = One time spray (at 30 DAS)
T_2 = Two time spray (at 30, 35 DAS)
T_3 = Three time spray (at 30, 35 and 40 DAS)
T_4 = Four time spray (at 30, 35 40 and 45 DAS)
T_5 = Five time spray (at 30, 35 40, 45 and 50 DAS)
T_6 = Six time spray (at 30, 35 40, 45 50 and 55 DAS)

2.6. Land Preparation and Fertilizer Application

The selected experimental plot was ploughed by power tiller driven rotavator. Finally, the land was leveled and the experimental plot was partitioned equally into the unit plots. Well decomposed cowdung was applied during land preparation. The Triple super phosphate (TSP) and Muriate of potash (MOP) were also applied at final land preparation @ 50 kg/ha and 35 kg/ha respectively. No urea fertilizer was used during the land preparation and as top dressing.

2.7. Sowing of Seeds

Seeds were sown in the main field on 14 March 2016 maintaining line to line distance 30 cm and plant to plant distance 10 cm for better plant growth. Seeding rate was 20 kg/ha of land.

2.8. Management Practices

Several intercultural operations such as thinning of plants, Gap filling, mulching and irrigation were practiced as per necessity to keep the plants healthy. Weeding was done to keep the plots free from weeds and stagnant water was effectively drained out at the time of heavy rains.

2.9. Spraying of Phytochemicals

First spray was started 30 days after sowing (DAS) and other spray was continued

at 5 days after interval upto 55 DAS. The phytochemicals (Imitaf and ACmix) spraying rate was 0.5 ml/L and 1.5 ml/L respectively.

2.10. Parameters Assessed

The following parameters were assessed:

- Number of plants per plot
- Number of infected plants per plot
- Number of leaves per infected plant
- Number of infected leaves per infected plant
- Disease incidence (%) per plot and per plant
- Disease severity (%)
- Number of flower per plant
- Number of pod per plant
- Chlorophyll content
- Yield/plot

All parameter were recorded from each plot at 50, 60 and 70 days after sowing (DAS). For measurement the number of leaves per infected plant, infected leaves per infected plant, flower per plant, pod per plant and chlorophyll content, in total ten (10) plants were randomly selected.

2.11. Disease Incidence (%) and Disease Severity (%)

Disease incidence was defined as the number of plant units sampled that are diseased expressed as a percentage or proportion of the total number of units assessed. For measurement the disease incidence (%) per plant, in total ten (10) plants were randomly selected and then data were collected on the basis of total number of leaf infected.

$$\text{Disease incidence } (\%) = \frac{X_1}{X} \times 100$$

where,

X = Total number of plants assessed/total number of leaves assessed.

X_1 = Number of infected plants/leaves.

Disease severity was defined as the area of a sampling unit affected by disease, expressed as a percentage or proportion of the total area assessed. Data on mosaic disease severity (%) were recorded at an interval of 10 days commencing from first severity and continued up to 3 times.

$$\text{Disease Severity } (\%) = \frac{X_1}{X} \times 100$$

where,

X_1 = Leaf area infected

X = Total leaf area assessed

2.12. Chlorophyll Content in Leaves Per Plant

Chlorophyll content of leaf was measured by using "S-pad meter". From each

plot five plant was selected in each plant 3 leafs were selected randomly for chlorophyll content. Lower leaf, middle leaf and top leaf were measured to define the average chlorophyll content of the plant.

2.13. Statistical Analysis

The collected data were arranged in a excel sheet and then was statistically analyzed by using the computer based software MSTAT-c. The mean data was calculated through ANOVA at 1% level of significant.

3. Results and Discussion

3.1. Effect of Imitaf on Percent Disease Incidence and Severity of *Mungbean Yellow Mosaic Virus* (*MYMV*) at 50, 60 and 70 DAS

After the application of Imitaf up to six times spray, at 50 DAS the lowest disease incidence per plant was found in T_4 (9.32%) followed by T_5 (18.18%). The highest disease incidence per plant in T_3 (25.37%) is statistically similar with T_6 (25.00%). The lowest disease incidence per plot was also found in T_4 (3.34%) and followed by T_5 (6.63%). The highest disease incidence was observed in control treatment (T_0 = 33.59%). The moderate disease incidence per plant was observed per plot was observed in T_0 (9.72%) which is statistically similar with T_1 (9.67%) and T_2 (9.62%) and identical with T_6 (15.33%). The moderate disease incidence was found in T_3 (27.17%).

In case of disease severity at 50 DAS after the application of Imitaf, the lowest disease incidence was measured in T_4 (8.67%) and followed by T_5 (11.67%) and the lowest disease severity was measured in T_0 (23.33%) which is statistically identical with T_1 (18.71%). After the application of Imitaf up to six times at 60 DAS, the lowest disease incidence per plant was found in T_4 (11.10%) and followed by T_5 (24.11%). The highest disease incidence per plant was recorded in control (T_0 = 35.77%), which is statistically similar with T_6 (25.10%) and T_2 (27.93%). The lowest disease incidence per plot was also found in T_4 (3.43%) and followed by T_5 (7.51%). The highest disease incidence per plot was observed in case of control (T_0 = 10.17%) which is statistically similar with T_1 (10.15%), T_2 (9.88%), T_6 (9.14%).

In case of disease severity at 60 DAS after application of Imitaf, the lowest disease severity was found in T_4 (7.23%) and following T_5 (16.33%), the highest disease severity was recorded in control (T_0 = 26.00%), the moderate disease severity per plant was found in T_2 (19.71%). After the application of Imitaf up to six times at 70 DAS, the lowest disease incidence per plant was found in T_4 (10.12%) and followed by T_5 (23.33%). The highest disease incidence per plant was recorded in control (T_0 = 36.50%), the moderate disease incidence per plant was found in T_2 (28.29%). The lowest disease incidence per plot was also found in T_4 (3.51%) and followed by T_5 (7.51%). The highest disease incidence per plot was observed in case of control (T_0 = 11.37%) and followed by T_1 (10.07%) which is statistically similar with T_2 (9.52%) and T_3 (9.42%). In case of disease

severity at 70 DAS after application of Imitaf the lowest disease severity was found in T_4 (7.21%) and followed by T_5 (11.67). The highest disease severity was recorded in control (T_0 = 23.33%). These results are presented in Table 1.

3.2. Effect of ACmix on Disease Incidence (Per Plant and Per Plot) and Disease Severity of *MYMV* at 50, 60, 70 DAS

After the application of ACmix up to six times at 50 DAS, the lowest disease incidence per plant was found in T_4 (14.56%) and followed by T_5 (26.44%). The highest disease incidence per plant was recorded in control (T_0 = 5.21%), which is statistically identical with T_1 (32.015%). The lowest disease incidence per plot was also observed in T_4 (4.78%) and followed by T_5 (6.63%). The highest disease incidence per plot was observed in case of control (T_0 = 9.78%) which is statistically similar with T_1 (9.68%) and statistically identical with T_6 (9.1%).

In case of disease severity at 50 DAS after application of ACmix the lowest disease severity was found in T_4 (10.34%) and followed by T_6 (17.33%). The highest disease severity was recorded in control (T_0 = 21%), which is statistically similar with T_1 (19.86%). After the application of ACmix up to six times at 60 DAS, the lowest disease incidence per plant was found in T_4 (16.82%) and followed by T_5 (26.14%). The highest disease incidence per plant was recorded in control (T_0 = 34.59%), which is statistically similar with T_6 (32.89%) and statistically identical with T_1 (28.24%). The lowest disease incidence per plot was also found in T_4 (4.17%) and followed by T_5 (9.17%). The highest disease incidence per plot was observed in case of control (T_0 = 10.17%) which is statistically similar with T_1 (10.15%).

In case of disease severity at 60 DAS after application of ACmix the lowest disease severity was found in T_4 (12.12%) and followed by T_5 (24.80%). The highest disease severity was recorded in control (T_0 = 36.33%). The moderate

Table 1. Effect of Imitaf on disease incidence (D.I/plant and D.I/plot) and disease severity at 50, 60, 70 DAS in designed treatments.

Treatments	%D.I at 50 DAS		%D.I at 60 DAS		%D.I at 70 DAS		%Severity		
	Per plant	Per plot	Per plant	Per plot	Per plant	Per plot	50 DAS	60 DAS	70 DAS
T_0	33.59 a	9.72 a	35.77 a	10.17 a	36.50 a	11.37 a	23.33 a	26.00 a	23.33 a
T_1	27.34 b	9.67 a	29.36 ab	10.15 a	29.78 b	10.07 a	18.71b	23.33 ab	18.71bc
T_2	27.17 b	9.62 a	27.93 b	9.88 a	28.29 b	9.52 b	17.71bc	19.71 b	17.71bc
T3	25.37 c	7.71 bc	27.74 b	9.24 a	28.27 b	9.42 ab	17.43 bc	18.71 b	17.43 b
T_4	9.32 e	3.34 d	11.10 c	3.43 c	10.12 c	3.51 c	8.67 e	7.23 d	7.21 e
T_5	18.18 d	6.63 c	24.11 b	7.51 b	23.33 b	7.51 b	11.67d	16.33 c	11.67 d
T_6	25.00 c	9.09 ab	25.10 b	9.14 a	25.81 b	9.33 ab	15.33 c	19.70 b	15.33 c
$LSD_{0.01}$	1.64	1.5	6.67	1.48	6.36	2.31	2.96	4.85	2.96
CV%	2.59	6.22	9.93	6.03	9.28	9.64	3.63	6.03	6.62

disease severity per plant was found in T_3 (20.00%) which is identical with T_6 (24.57%). After the application of ACmix up to six times at 70 DAS, the lowest disease incidence per plant was found in T_4 (12.21%) and followed by T_5 (27.79%). The highest disease incidence per plant was recorded in control (T_0 = 34.49%), The moderate disease incidence per plant was found in The lowest disease incidence per plot was also found in T_4 (4.21%) and followed by T_3 (7.51%).The highest disease incidence per plot was observed in case of control (T_0 = 11.37%) which is statistically similar with T_1 (10.07%), and identical with T_2 (9.44%).

In case of disease severity at 70 DAS after application of ACmix the lowest disease severity was measured in T_4 (7.53%) and followed by T_6 (25.67). The highest disease severity was recorded in control (T_0 = 36.67%) and followed by T_1 (30.33%). These results are presented in Table 2.

Disease incidence for both per plant and per plot was recorded the lowest in case of insecticide Imitaf in T_4 and similarly for the ACmix in T_4. The highest disease incidence was recorded in T_0 or in no spray for both insecticides. In case of disease severity for both Imitaf and ACmix was recorded the lowest in T_4 and the highest in control $T_{0..}$ Almost same result was found in the previous work [4] [5] and they also found better result while used Imitaf against *MYMV* in their study.

3.3. Chlorophyll Content in Different Treatment for Both Imitaf and ACmix

Chlorophyll content in different treatment for both the insecticides are presented in Table 3. The lowest amount of chlorophyll content was found for both the insecticides for the control in case of Imitaf it is (42.01 μmol·m^{-2}·s^{-1}) and for the ACmix it is (48.34 μmol·m^{-2}·s^{-1}). The highest amount of chlorophyll content was found for the Imitaf in T4 (49.62 μmol·m^{-2}·s^{-1}) and thus for the ACmix in T4 (56.80 μmol·m^{-2}·s^{-1}).

Table 2. Effect of ACmix on disease incidence (D.I/plant and D.I/plot) and disease severity at 50, 60, 70 DAS in designed treatments.

Treatments	%D.I at 50 DAS		%D.I at 60 DAS		%D.I at 70 DAS		%Severity		
	Per plant	Per plot	Per plant	Per plot	Per plant	Per plot	50 DAS	60 DAS	70 DAS
T_0	35.21 a	9.78 a	34.59 a	10.17 a	36.49 a	11.37 a	21 a	36.33 a	36.67 a
T_1	32.01 b	9.68 a	28.24 b	10.15 a	28.94 ab	10.07 a	19.86 a	26. 57 b	30.33 b
T_2	26.88 c	9.63 a	26.38 b	9.88 a	28.04 b	9.44 ab	19.66 a	26.33 b	29.29 b
T3	26.51 c	7.72bc	25.58 b	9.24 b	27.66 b	7.51 b	19.40 a	20.00 c	28.14 b
T_4	14.56 d	4.78 d	16.82 c	4.17 b	12.21 c	4.21 c	10.34 c	12.12 d	7.53 c
T_5	26.44 c	6.63 c	26.14 b	9.17 c	27.79 b	9.33 ab	18.14 a	24.80 bc	27.71 b
T_6	26.11 c	9.1 ab	32.89 a	10.01 a	34.20 a	9.52 ab	17.33 b	24.57 bc	25.67 b
$LSD_{0.01}$	3.01	1.5	4.50	1.48	1.41	2.31	10.29	4.04	5.78
CV%	4.53	6.11	6.7	8.07	2.01	5.30	8.83	16.29	5.70

Table 3. Chlorophyll content in different treatment for both Imitaf and ACmix.

Treatment	Chlorophyll Content (Imitaf)	Chlorophyll Content (ACmix)
T_0	42.01 c	48.34 d
T_1	47.32 ab	52.98 c
T_2	47.48 ab	53.78 bc
T_3	47.76 ab	55.08 ab
T_4	49.62 a	56.80 a
T_5	47.23 ab	52.90 c
T_6	46.39 b	52.72 c
$LSD_{0.01}$	2.48	1.83
CV%	2.10	4.39

3.4. Relationship between Chlorophyll Content in Imitaf Treated Plants and Disease Incidence at 70 DAS (Figure 1)

Two selective insecticides with different number of spray in different plot were used in the present study regarding chlorophyll content ($\mu mol \cdot m^{-2} \cdot s^{-1}$) and disease incidence (%), it is revealed that increased chlorophyll content was observed with decreased disease incidence. The highest chlorophyll content was observed in T_4 (49.67 $\mu mol \cdot m^{-2} \cdot s^{-1}$) followed by T_3 (47.76 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and T_2 (46.48 $\mu mol \cdot m^{-2} \cdot s^{-1}$) where control treatment showed the lowest chlorophyll content with the highest disease incidence. The relation of chlorophyll content with the disease incidence at 70 DAS per plot was shown below by the bar-graph.

3.5. Relationship between Chlorophyll Content in ACmix Treated Plants and Disease Incidence at 70 DAS (Figure 2)

The highest chlorophyll content was observed in T_4 (56.80 $\mu mol \cdot m^{-2} \cdot s^{-1}$) followed by T_3 (55.08 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and T_2 (53.78 $\mu mol \cdot m^{-2} \cdot s^{-1}$) where control treatment showed the lowest chlorophyll content with the highest disease incidence. The relation of chlorophyll content with the disease incidence at 70 DAS per plot was shown below by the bar-graph.

3.6. Relationship between Chlorophyll Content in Imitaf and ACmix Treated Plants and Disease Severity at 70 DAS (Figure 3)

The highest chlorophyll content was observed in T_4 (49.67 $\mu mol \cdot m^{-2} \cdot s^{-1}$) followed by T_3 (47.76 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and T_2 (46.48 $\mu mol \cdot m^{-2} \cdot s^{-1}$) where control treatment showed the lowest chlorophyll content with the highest disease severity. The relation of chlorophyll content with the disease incidence at 70 DAS per plot was shown below by the bar-graph.

3.7. Relationship between Chlorophyll Content in ACmix Treated Plants and Disease Severity at 70 DAS (Figure 4)

The highest chlorophyll content was observed in T_4 (56.80 $\mu mol \cdot m^{-2} \cdot s^{-1}$)

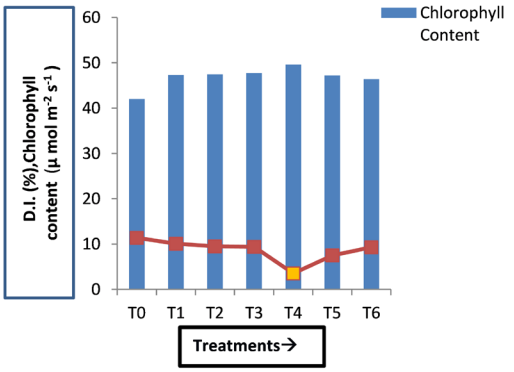

Figure 1. Relationship between chlorophyll content in Imitaf treated plants and disease incidence at 70 DAS.

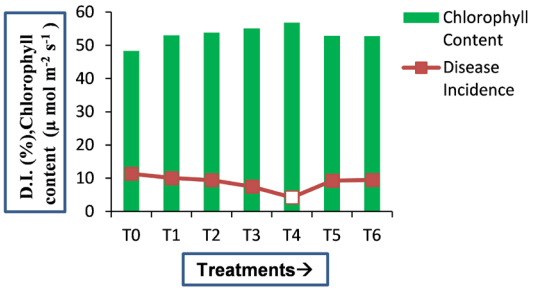

Figure 2. Relationship between chlorophyll content in ACmix treated plants and disease incidence at 70 DAS.

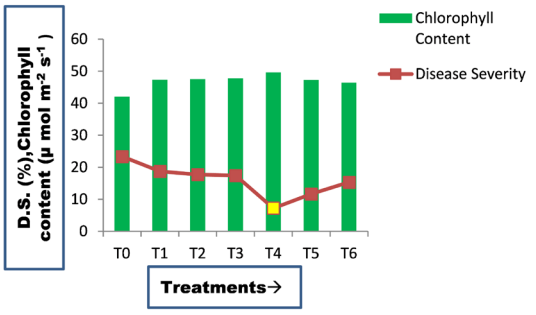

Figure 3. Relationship between chlorophyll content in Imitaf treated plants and disease severity at 70 DAS.

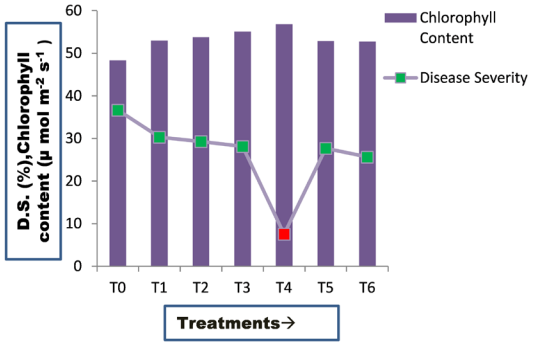

Figure 4. Relationship between chlorophyll content in ACmix treated plants and disease severity at 70 DAS.

followed by T_3 (55.08 μmol·m^{-2}·s^{-1}) and T_2 (53.78 μmol·m^{-2}·s^{-1}) where control treatment showed the lowest chlorophyll content with the highest disease severity.

From this study it was cleared that the minimum chlorophyll content per plant was recorded in control and the maximum chlorophyll content per plant was recorded when Imitaf was sprayed four times than spraying ACmix. Babu *et al.* [6] reported through his experiment that infection of Vigna radiata plants by *MYMV* caused significant reduction in number of pods/plant, seed yield and 100-seed weight. The highest chlorophyll content was found in T_4 and control treatment showed the lowest chlorophyll content because of the highest disease incidence. Here the Relationship between chlorophyll content (μmol·m^{-2}·s^{-1}) and disease severity (%) is revealed that increased chlorophyll content was observed with decreased disease severity. The highest chlorophyll content was found in T_4 where control treatment showed lowest chlorophyll content because of highest disease severity.

4. Conclusion

In this experiment, the highest disease incidence was found in control at 50 DAS, 60 DAS and thus in case of 70 DAS for both of the insecticides Imidacloprid (33.59%, 35.77%, 36.50%) per plant as well (9.72%, 10.17%, 11.37%) per plot and ACmix (35.21%, 34.59%, 36.49%) per plant as well (9.78%, 10.17%, 11.37%) per plot. The lowest disease incidence and disease severity were found in T_4 at 50 DAS, 60 DAS and 70 DAS for both of the insecticides Imidacloprid (23.33%, 26.00%, 23.33%) and ACmix (21%, 36.33%, 36.67%). In case of chlorophyll content, the lowest amount of chlorophyll was observed in control Imidacloprid (42.01 μmol·m^{-2}·s^{-1}) and ACmix (48.34 μmol·m^{-2}·s^{-1}) with the highest disease incidence and disease severity and the highest amount of chlorophyll was found in T_4 Imidacloprid (49.62 μmol·m^{-2}·s^{-1}) and ACmix (56.80 μmol·m^{-2}·s^{-1}) with the lowest amount of disease incidence and disease severity for both the insecticides. From this experiment, it may be conducted that the application of insecticides Imidachloprid with 4 time spraying showed promising performance in management of *Mungbean Yellow Mosaic Virus* (*MYMV*) contributing attributes and yield.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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