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Managing the insect vector and soybean yellow mosaic virus can be achieved through the utilization of different insecticides and resistant cultivars

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Abstract
Soybean (*Glycine max* (L.) Merrill) is a widely cultivated oilseed crop with a chromosome count of 2n=40. Soybean yellow mosaic virus (SYMV) poses a significant challenge to the successful cultivation of soybeans in various nations. The transmission of SYMV occurs through the whitefly known as *Bemisia tabaci* Gennadius. The lowest occurrence of the disease and reduction of the vector population was observed when applying the recommended dose of Imidacloprid 17.8% SL (T_1). The control treatment had the highest disease incidence and vector population. In the present research, we evaluated ten different soybean varieties for their resistance to Soybean Yellow Mosaic Virus (SYMV) in a field conditions, it was found that three varieties, namely JS 97-52, JS 21-05, and RSC 1142, demonstrated resistance to soybean yellow mosaic virus. Furthermore, the study identified six genotypes (JS 20-29, JS 20-69, RVS 24, JS 95-60, JS 20-94 and JS 93-05) with a moderate level of resistance, while only one genotype, JS 335, was found to be highly susceptible. The most effective strategy for managing soybean yellow mosaic virus is to employ these resistant varieties.

Keywords: Soybean, whitefly, yellow mosaic disease, chemical control, resistance

Introduction
Soybean (*Glycine max* L. Merrill) is an important oilseed and cash crop. It have chromosome number (2n=40). After the USA, Brazil, Argentina, and China, India is the fifth-largest producer of soybeans worldwide. In India, it is grown in 12.7 mha area, with production 10.45 mt and productivity 0.82 tonne per ha in 2020–21 (USDA, 2022). In India, the production of soybeans faces challenges from both living organisms (biotic) and non-living factors (abiotic). One of the biotic challenges is the presence of whiteflies, scientifically known as *Bemisia tabaci* (Gennadius). These whiteflies not only cause harm by directly feeding on soybean plants, but they also act as carriers for a harmful virus called the Yellow Mosaic Virus (YMV). This YMV disease results in a substantial yield loss of about 50-60% in soybean crops in central India.

The management of YMD (18.73%) and its vector (3.13/plant) was also found to be successful while imidachloprid 17.8 SL @ 0.5 ml/l was sprayed three times at 15, 30 and 45 DAS (Archana *et al*., 2018) [1]. The insecticides, namely Imidacloprid (11.16%) had the lowest mean percentage of Mungbean Yellow Mosaic Virus-infested plants, followed by Thiamethoxam (20.16%) (Younas *et al.*, 2021) [14]. The 11 highly resistant, 26 resistant, 6 Moderately resistant, 4 Moderately susceptible, 3 susceptible and 3 genotypes (JS 335, JS 97-52 AND RVS 2001-4) Highly Susceptible while in molecular analysis three genotypes (JS 20-29, JS 20-69, JS 20-98) were to be Resistant against yellow mosaic virus on 53 genotypes of soybean (Mishra *et al.*, 2020) [9]. Chemical control are key components in effective management strategies for effectively managing whitefly populations and reducing the occurrence of YMV disease. It is important for the farming communities in the disease-affected districts to be aware of and implement effective management practices for soybean yellow mosaic disease.

Materials and Methods
Experiments were carried out in Jabalpur in 2022 to determine the effectiveness of various insecticides for managing the soybean yellow mosaic diseases by killing the insect vectors of the virus. Six Insecticides *viz.* Imidacloprid 17.8% SL, Acetamiprid 20% SP, Thiamethoxam 25 WG, Triazophos 40 EC, Chlorpyrifos 20 EC, Lambda-cyhalothrin 5 EC were analyzed for

their insecticidal properties against Whitefly (*Bemisia tabaci*). The recommended doses were used for formulation of chemicals in 1 liter of water and spray in field plots. The control treatment was put freely from insecticide spray. The application of these various insecticides occurred 45 and 60 days after sowing.% disease incidence observations were carried out. And vector population observations were carried out at 1 day Before to spraying, 1 and 7 days after spray thereafter, Statistics were used to analyse the data recorded is the vector population. Statistical analysis was performed on the information after tabulation by using a Randomized Block Design.

The objective of the current study was to determine the resistant genotypes of soybeans cultivars *viz*. JS 20-29, JS 20-69, JS 97-52, RVS 24, JS 95-60, JS 335, RSC 1142, JS 93-05, JS 21-05, JS 20-94 to the soybean yellow mosaic disease. The field screening was conducted in 2023 at the Department of Plant Pathology's research site at COA, Jabalpur, JNKVV. Breeder Seed Production Unit, JNKVV, Jabalpur, provided a total of 10 genotypes for collection. % age of disease incidence will calculate by using the following formula.

$$\text{Percentage Disease Incidence} = \frac{\text{Total number of infected plants}}{\text{Total number of plants}} \times 100$$

Table 1: Disease rating scale (Source: AICRP, Annual report 2022-23)

Scale	Description	Disease reaction
0	No symptoms on plants	Highly resistant (HR)
1	1% plant exhibiting mosaicing of leaves symptoms	Resistant (R)
3	1.1-10% plants exhibiting mosaicing and Yellow discolouration symptoms	Moderately resistant (MR)
5	10.1-25% plants exhibiting mosaicing and Yellow discolouration symptoms	Moderately susceptible (MS)
7	25.1-50% plants exhibiting m mosaicing and Yellow discolouration symptoms	Susceptible (S)
9	>50% plants exhibiting mosaicing and Yellow discolouration reduced flowers and pods	Highly susceptible (HS)

Results and Discussion

Experiment 2.1 Effect of insecticides on disease incidence

Various insecticide doses led to a noticeable reduction in the occurrence of soybean yellow mosaic disease. However, the most effective suppression was observed when using the suggested doses. The most minimal occurrence of the disease was documented with the recommended amount of Imidacloprid. As for the control group, it exhibited the highest disease occurrence. In comparison to control treatment (T_7), recommended doses of tested pesticides significantly reduced the incidence of Soybean Yellow Mosaic Disease after two spray. Imidacloprid 17.8% SL (T_1) had the lowest mean percentage of SYMD-infested plants (12.92%), followed by (T_5) Chloropyriphos 20 EC with 17.81%, (T_2) Acetamiprid 20% SP with 19.98% incidence. The highest percentage of SYMD in the case of Triazophos 40 EC (T_4) showed 25.38% incidence followed by Lambda-cyhalothrin 5 EC (T_6) with 23.55%. While Thiamethoxam 25 WG (T_3) showed 21.20%. In the control treatment (T_7), the most plants with Yellow Mosaic virus infestation were counted. In comparison to the other treatments, Imidacloprid insecticide application resulted in the lowest mean disease incidence.

Table 2: Disease incidence of Soybean Yellow Mosaic Virus Disease.

Treatments	Chemical	Dose per liter	Percent Disease incidence after two spray
T_1	Imidacloprid 17.8% SL	0.25 ml	12.92
T_2	Acetamiprid 20% SP	0.30 g	19.98
T_3	Thiamethoxam 25 WG	0.25 g	21.20
T_4	Triazophos 40 EC	1.00 ml	25.38
T_5	Chlorpyrifos 20 EC	1.50 ml	17.81
T_6	Lambda-cyhalothrin 5 EC	0.50 ml	23.55
T_7	Control	-	88.12
C.D. at 5%	-	-	3.32
S.Em±	-	-	1.11

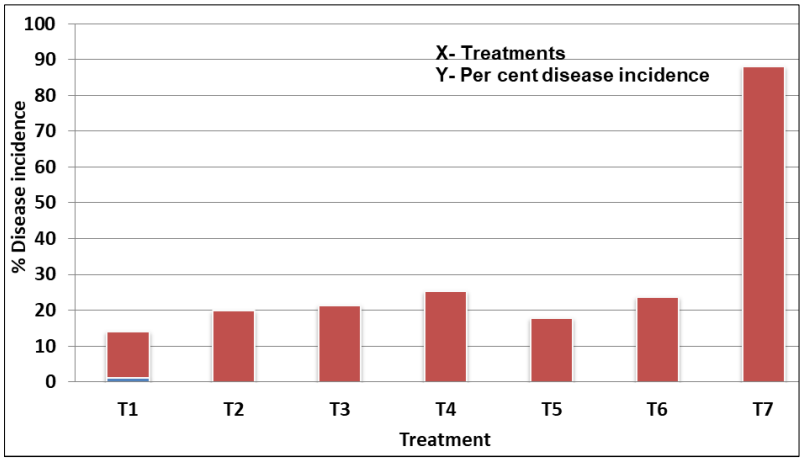

Fig 1: Disease incidence of Soybean Yellow Mosaic Virus Disease

Experiment 2.2 Effect of insecticides on reduction of insect vector (Whitefly)

Application of insecticides significantly reduced the incidence of whiteflies. The number of whiteflies gradually decreased with the use of various insecticides over time. The plot treated with imidacloprid 17.8% SL (T_1) showed the lowest incidence of whiteflies (8.25, 4.37 and 1.25 per plant at 1 day before, 1 and 7 days after spray), these values were followed by Thiamethoxam 25 WG (T_3) at 1 day before, 1 and 7 days after spray (8.77, 4.47 and 1.92 respectively). Additionally, it was clear that other treatments effects on the incidence of whiteflies were significantly different from those of imidacloprid 17.8% SL. On the other hand, the control treatment (T_7), which was also greatly distinct from all other treatments, had the highest incidence of whiteflies in the Soybean field (10.05, 10.67 and 10.45 per plant at 1 day before, 1 and 7 days after spray, respectively). The treatment of Lambda-cyhalothrin 5 EC (T_6) was found to have the highest incidence of whiteflies (7.92, 6.35 and 3.95 at 1 day before, 1 and 7 days after spray, respectively), followed by Triazophos 40 EC (T_4) 9.35, 6.75 and 2.47 at 1 day before, 1 and 7 days after spray. T_2 (Acetamiprid 20% SP) and T_5 (Chloropyrifos 20 EC) showed moderate performance 7.12, 5.65, 3.05 and 9.60, 5.82, 2.62 respectively at 1 day before, 1 and 7 days after spray.

Table 3: Vector population recorded 1 day before and 1 and 7 day after Spraying.

Treatments		Dose per litre	Observed population of vector		
			1 day before spray	1 day after spray	7 days after spray
T_1	Imidacloprid 17.8% SL	0.25 ml	8.25	4.37	1.25
T_2	Acetamiprid 20% SP	0.30 g	7.12	5.65	3.05
T_3	Thiamethoxam 25 WG	0.25 g	8.77	4.47	1.92
T_4	Triazophos 40 EC	1.00 ml	9.35	6.75	2.47
T_5	Chlorpyrifos 20 EC	1.50 ml	9.60	5.82	2.62
T_6	Lambda-cyhalothrin 5 EC	0.50 ml	7.92	6.35	3.95
T_7	Control	-	10.05	10.67	10.45
C.D. @ 5%	-	-	1.074	0.82	0.814
SE m±	-	-	0.359	0.274	0.272

These kinds of results were reported by Mason *et al.*, (2000) [8], Dandale *et al.*, (2001) [5], Dattatray shirale and Uttamrao bidgire (2009) [6], Biswas and Bhunia (2009) [4], Roy *et al.*, (2014) [12]

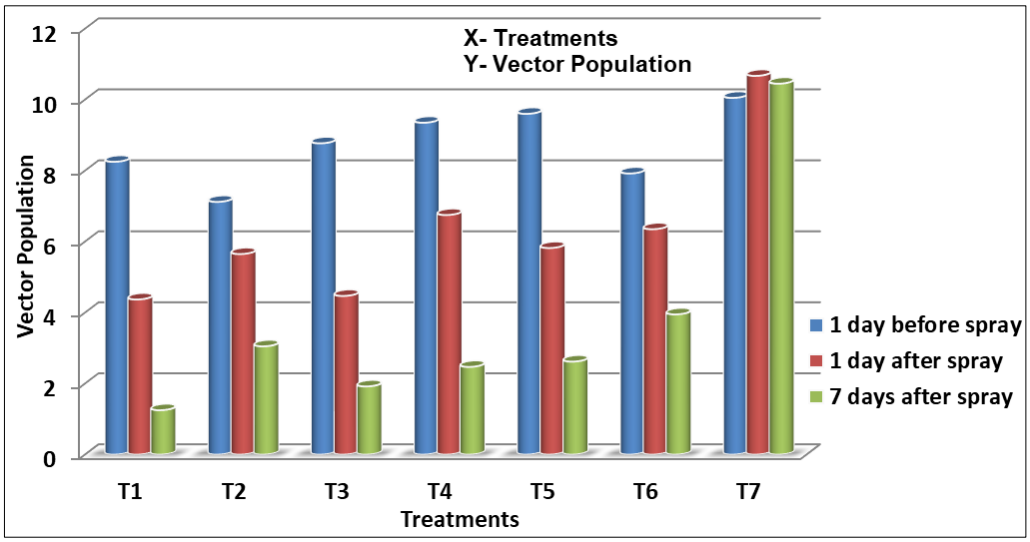

Fig 2: Vector population recorded 1 day before spraying and 1 and 7 day after Spraying

Plate 1: Field view of trial and Spraying of Insecticides in field

Experiment 2.3 Soybean genotypes against Yellow Mosaic Disease

In the current research, an assessment of different soybean genotypes was conducted to gauge their susceptibility to Yellow Mosaic Virus (YMV) disease in real-world field conditions. The results indicated notable differences in their reactions to the disease. This underscores the need for ongoing and consistent evaluation of crop varieties to identify those that exhibit resistance to such diseases. This approach aids in the selection of superior genotypes that display resistance to YMV disease. Ten cultivars were tested for resistance to Soybean Yellow Mosaic Disease. These research founded that three varieties (JS 97-52, JS 21-05, and RSC 1142) with resistance to the disease, 6 cultivars namely JS 20-29, JS 20-69, RVS 24, JS 95-60 and JS 20-94 were found Moderately resistant, while also identifying one highly vulnerable variety, JS 335.

Table 4: Soybean genotypes against soybean yellow mosaic virus

S. No.	Cultivars	Per cent Disease Incidence
1.	JS 20-29	2.30
2.	JS 20-69	2.91
3.	JS 97-52	1.19
4.	RVS 24	3.25
5.	JS 95-60	8.74
6.	JS 335	51.03
7.	RSC 1142	1.22
8.	JS 93-05	31.69
9.	JS 21-05	1.02
10.	JS 20-94	2.13

These kinds of findings were recorded by Akhtar and Haq (2003) 2[], Lal *et al.*, (2005) [7], Raj *et al.*, (2006) [15], Ramteke *et al.*, (2007) [11], Parameshwar *et al.*, (2012) [16], Khan *et al.*, (2013) [17], Talukdar *et al.*, (2013) [13], Kumar *et al.*, (2014) [18], Baruah *et al*., (2014) [3], Pancheshwar *et al*., (2016) [10], Nichal *et al.*, (2018) [19], Amrate *et al.*, (2020) [20], Mishra *et al.*, (2020) [9], Soumia *et al.*, (2020) [21].

Conclusion

In this investigation Imidacloprid 17.8% SL (T_1) had the lowest mean percentage of SYMD-infested plants was 12.92%. The highest mean incidence of SYMD had found with Triazophos 40 EC (T_4) showed 25.38% incidence in compare to other treatments. The plot treated with imidacloprid 17.8% SL (T_1) showed the lowest incidence of whiteflies (8.25, 4.37 and 1.25 per plant at 1 day before, 1 and 7 days after spray). While the treatment of Lambda-cyhalothrin 5 EC (T_6) was found to have the highest incidence of whiteflies (7.92, 6.35 and 3.95 at 1 day before, 1 and 7 days after spray respectively). During study, three types (JS 97-52, JS 21-05, and RSC 1142) that exhibited Resistant. Additionally, they recognized six genotypes that displayed moderate resistance, while only one genotype JS 335 as the most susceptible variety.

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