MANAGEMENT OF YELLOW MOSAIC DISEASE IN SOYBEAN

Abstract

Soybean (*Glycine max* L.) is a valuable crop known for its high protein content of 40 % and quality oil content of 20 %. However, its production is often hampered by pests and diseases, with yellow mosaic disease being a major concern. This disease is caused by mungbean yellow mosaic virus (MYMV) and mungbean yellow mosaic India virus, transmitted by the whitefly (*Bemisia tabaci*), posing a significant threat to soybean cultivation globally. A study conducted at the Agricultural Research Station (ARS) in Bidar, India, in the summer of 2024 aimed to test effectiveness of chemical insectides to manage yellow mosaic disease by controlling its vectors. All treatments were significantly better than the control, with seed treatment using imidacloprid 600 FS and two foliar sprays of flonicamid 50 WG at 0.03 % at 20 and 35 days after sowing had least whitefly population of 3.0 per plant(63 % population reduction over control), minimum disease incidence of 26.00 % (72 % reduceddisease incidence over control) and highest yield of 15.07 q/ha (11.83 q yield improvement over control)proving to be the most effective compared to other treatments.

Key words; *Soybean*, *Mungbeanyellow mosaic virus, Mungbeanyellow mosaic India virus, Bemisiatabaci, Flonicamide.*

Introduction

Soybean is considered a wonder crop due to its high protein and oil content, with 40% and 20 % respectively. The major soybean-producing countries include the USA, Brazil, Argentina, and China, which collectively account for 90 to 95% of global soybean production, while India contributes only 2.5% (Anon., 2023a). Worldwide, soybean is cultivated on 136.03 million hectares, yielding 369.72 million tonnes annually, with average productivity of 2720 kg/ha (Anon., 2023a). In India, soybean is grown on 13.00 million hectares, producing 12.04 million tonnes with a productivity of 930 kg/ha (Anon., 2023b), significantly lower than the global average. The states of Madhya Pradesh, Maharashtra, and Rajasthan are the top soybean producers, accounting for nearly 95 % of the total area. The low productivity of soybean is mainly due to biotic and abiotic stresses. Virus diseases, such as yellow mosaic virus (YMV), soybean mosaic virus (SMV), peanut bud necrosis virus (PBNV), bean pea mottle virus (BPMV), soybean crinkle leaf geminivirus, and cowpea mild mottle carla virus (CMMV), pose a serious threat to soybean production in India (Lal*et al*., 2005). Among these, yellow mosaic disease, caused primarily by mungbeanyellow mosaic India virus (Usharani *et al*. 2004)and mungbean yellow mosaic virus (Morinaga *et al*. 1990), is transmitted by whiteflies (*Bemisia tabaci*) persistently. (Bhattacharyya *et al*., 1999; Nair and Wilson, 1969). This study aimed to manage yellow mosaic disease by controlling whiteflies using chemical insecticides.

Material and methods

The experiment was conducted in the summer of 2024 at the Agriculture Research Station (ARS), Bidar using a randomized block design with nine treatments, including a control, in three replications with spacing of 30 x 10 cm. The trial was set up in the field under natural epiphytotic conditions and recommended agronomic practices were followed. The plots were irrigated during moisture stress, and manual weeding was carried out twice at critical growth stages - first at 15 days after sowing and then at 30 days after sowing. Yellow sticky traps were placed in all treatments except the control for whitefly monitoring. A susceptible variety, JS-335, was used for disease management. The treatments includedseed treatment with Imidacloprid 600 FS at 5 ml/kg seeds, except for the control. Two sprays of insecticides and botanicals were applied at 20 days after sowing

(DAS) and 35 DAS. Whitefly populations on the top three trifoliate leaves per plant were visually counted on five randomly selected plants in each treatment two days after spraying. Disease incidence was recorded at the vegetative, flowering, and pod-filling stages, and yield per plot was measured at harvest. The data was analyzed statistically using one-way analysis (ANOVA) and the Tukey test was applied at α=0.05 (95% interval).

Results and Discussion

The study evaluated disease incidence, vector population and yield for each treatment. The maximum whitefly population was seen in the control plot (T9) with an average population of 8.3 per plant followed by treatment including only seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky traps with an average whitefly population of 7.3 per plant. The minimum whitefly population was observed in treatment (T4)Seed treatmentwith imidacloprid 600 FS at 5ml/kg seed followed by yellow sticky trap followed by foliar sprayofflonicamide 50 WG at 0.03 per cent with mean whitefly population was 3.0 per plant (Table 1.&Fig 1.).

The disease incidence varied from treatment to treatment and maximum disease incidence was seen in control (T9) with 93.01 per cent disease incidence which is followed by seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap (T1) with 59.93 per cent disease incidence and least disease incidence was observed in seed treatment by imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of flonicamide 50 WG at 0.03 per cent (T4) with disease incidence of 26 per cent.

The maximum yield was recorded in treatment involving seed treatment by imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of flonicamide 50 WG at 0.03 per cent after sowing with a mean yield of 15.07 q/ha followed by treatment (T8) which includes imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trapfollowed by foliar spray of afidopyropen 50 g/l DC at 0.2 per cent with a mean yield of 13.8 q/ha and minimum yield was recorded in control plot with a mean yield of 3.24 q/ha.

Seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of flonicamide50 WG at 0.03 per cent (T4) had shown minimum disease incidence of 26 per cent, least mean whitefly population (3.0 whiteflies/plant) and recorded significantly maximum yield of 15.07 q/ha which was on par with seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of afidopyropen 50 g/l DC at 0.2 per cent (T8) with disease incidence of 29 per cent, mean whitefly population of 3.3 whiteflies per plant and yield of 13.8 q/ha, remaining treatments were found to be on par with each other except seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of azadirachtin 1500 ppm at 0.2 per cent. Whereas in the control plot highest disease incidence of 93.01 per cent, with maximum whitefly population (8.3 per plant) and the lowest yield of 3.24 q/ha was recorded (Table 1., Fig. 2.&Fig. 3.).

The benefit-cost ratio of treatment was calculated and it ranged from 0.5-1.96 seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of flonicamide 50 WG at 0.03 per cent (T4) had shown as the best treatment with B:C ratio of 1.96 and next best treatment was found to be seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of afidopyropen 50 g/l DC at 0.2 per cent (T8) with a benefit-cost ratio of 1.79. The lowest recorded B: C of 0.5 observed in the control plot.

Similar findings were reported by Rao *et al*. (2021), who observed that seed treatment with thiamethoxam (5.0 g/kg) followed by two sprays of acetamiprid (4%) + fipronil (4%)

(2.0 ml/l) resulted in the lowest mean incidence of mungbean yellow mosaic virus (MYMV), with incidence of 3.75 per cent and 4.84 per cent during the *kharif* and *rabi* seasons, respectively. Additionally, this treatment also led to a reduction in the whitefly population of 4.14 and 2.95 per plant during the same periods. In comparison, seed treatment with imidacloprid 600 FS (5.0 ml/kg) and two sprays of flonicamide (0.2 ml/l) were also effective but not as superior in controlling MYMV incidence and whitefly populations.

Flonicamide 50 WG operates as a systemic insecticide with a distinct mode of action that targets the nervous systems of insects. This insecticide is a selective antagonist of nicotinic acetylcholine receptors (nAChRs) in insects, disrupting normal neurotransmission (Gordon, 2020). Specifically, flonicamide interferes with acetylcholine binding to these receptors, significantly inhibiting feeding behaviour. Insects that ingest flonicamide cease feeding within a few hours, which limits the damage they can inflict on crops (Smith and Brown, 2019). Prolonged exposure to flonicamide impairs the insect's ability to maintain essential physiological functions, resulting in eventual death (Johnson, 2018). A notable feature of flonicamide is its high selectivity for insects, which minimizes its impact on non-target organisms such as humans, animals and beneficial insects. This selectivity arises from the interaction with insect nAChRs, which differ from those found in mammals. Consequently, flonicamide 50 WG is effectively utilized in agriculture to control pests including aphids, whiteflies and thrips, owing to its efficacy and low toxicity to non-target species.

Management of disease completely by any single approach is notpossible,therefore integrating different approacheslike to identify/developresistantgermplasm whichcouldbehigh-yielding andwill be the sourceof resistance infuturebreedingprograms (Amrate*et al.*, 2023; Rehman *et al.*, 2023; Widyasari*et al*., 2020), seed treatment, standard agronomic practices, use of biological methods, use of botanicals, vector control and chemical management, management can be done effectivelyanother novel approach management by using RNAi targeting the coat-protein region will be more effectivein managing the disease without any off targets (Kumari *et al.*, 2018). By interpreting the whitefly population and disease incidence, it was confirmed that seed treatment with imidacloprid 600 FS at 5 ml/kg seed followed by yellow sticky trap followed by foliar spray of flonicamide 50 WG at 0.03 per cent gave efficient results.

Conclusion

The most effective treatment was seed treatment with imidacloprid 600 FS at 5 ml/kg, followed by yellow sticky traps and a foliar spray of flonicamide 50 WG at 0.03 per cent. This combination resulted in the lowest disease incidence (26%) and the lowest mean whitefly population (3.0 whiteflies/plant). The combination of multiple methodsof chemical treatment, physical trapping, and chemical controlillustrates an effectiveIPM strategy for managing yellow mosaic disease. Each component of the approach targets a different aspect of the pest lifecycleImidacloprid seed treatment targets early-stage pests, preventing initial infestation by whiteflies, which are the primary vectors of the virus.Yellow sticky traps act as a monitoring and control mechanism, effectively reducing the number of adult whiteflies and helping to prevent further spread of the disease.Flonicamide foliar spray targets adult whiteflies directly, reducing the population and limiting the potential for viral transmission to the plants.This combination minimizes the reliance on a single method and can lead to more sustainable pest control practices, reducing the likelihood of resistance development. Future management strategies could adopt this multi-pronged approach for more consistent and long-term control of YMD.

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Authors' contribution

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Conflict of interest

Authors have declared that there is no conflict of interest.

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Table 1. Management of Yellow mosaic disease in soybean during *Summer* 2024 at ARS Bidar

Tr. No.	Treatment details	No. of Whitefly/ plant (No.)	Disease incidence (%)	Yield (q ha^{-1})	Total cost (Rs.)	Gross returns (Rs.)	Net profit (Rs.)	B:C
T_1	Seed treatment with imidacloprid 600 FS @ 5ml/kg seed followed by yellow sticky trap	7.3	59.93 (50.58) *	7.70	42986	43890	904	1.02
T_2	T_1followed by FS of azadirachtin1500 ppm @ 0.2 at 20 DAS and 35 DAS	6.0	52.00 (46.15)	8.50	43626	48450	4824	1.11
T_3	T_1 followed by FS of fipronil 5 SC @ 0.1 at 20 DAS and 35 DAS	4.3	34.00 (37.64)	11.80	43766	67260	23494	1.54
T_4	T_1 followed by FS of flonicamide50 WG @ 0.03 at 20 DAS and 35 DAS	3.0	26.00 (30.64)	15.07	43836	85842	42006	1.96
T_5	T_1followed by FS of dimethoate 30EC @ 0.20 at 20 DAS and 35 DAS	4.6	38.00 (38.06)	11.27	43586	64182	20596	1.47
T_6	T_1 followed by FS of acephate 95 SG @ 0.1 at 20 DAS and 35 DAS	4.3	40.33 (39.42)	11.09	43292	63156	19864	1.46
T_7	T_1 followed by FS of difenthiron 50 WP @ 0.1 at 20 DAS and 35 DAS	4.0	41.33 (40.01)	11.45	43906	65208	21302	1.49
T_8	T_1followed by FS of afidopyropen 50 g/l DC @ 0.2 at 20 DAS and 35 DAS	3.3	29.00 (35.21)	13.80	43998	78660	34662	1.79
T_9	Control	8.3	93.01 (72.84)	3.24	37986	18981	-19005	0.50
	S.Em±	0.68	2.47	0.37				
	CD at 5	2.03	7.41	1.11				
	CV	23.38	9.31	6.12				

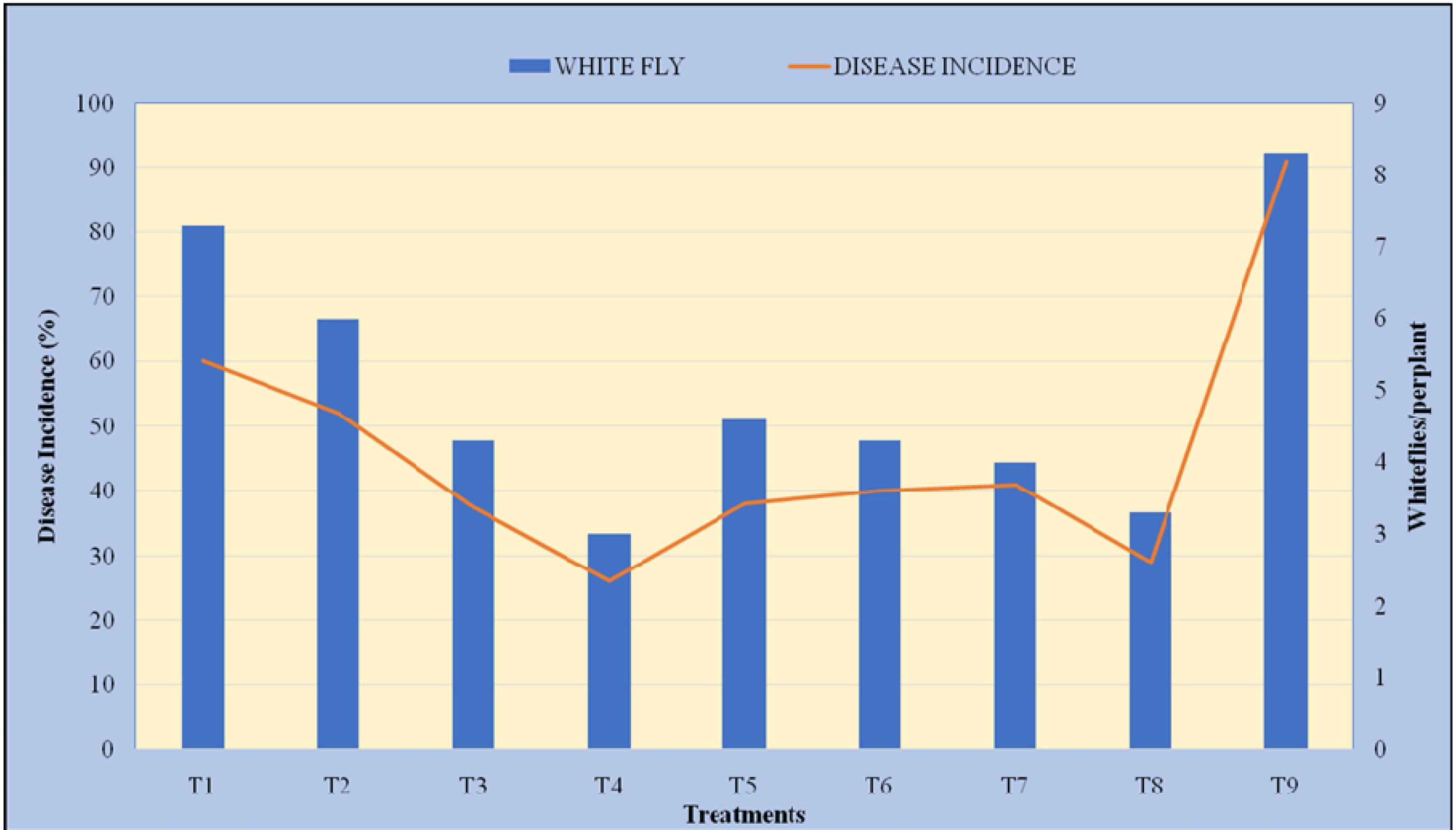

Fig. 1. Effect of different treatments on whitefly population and YMD incidence in soybean during *summer*, 2024 at ARS, Bidar

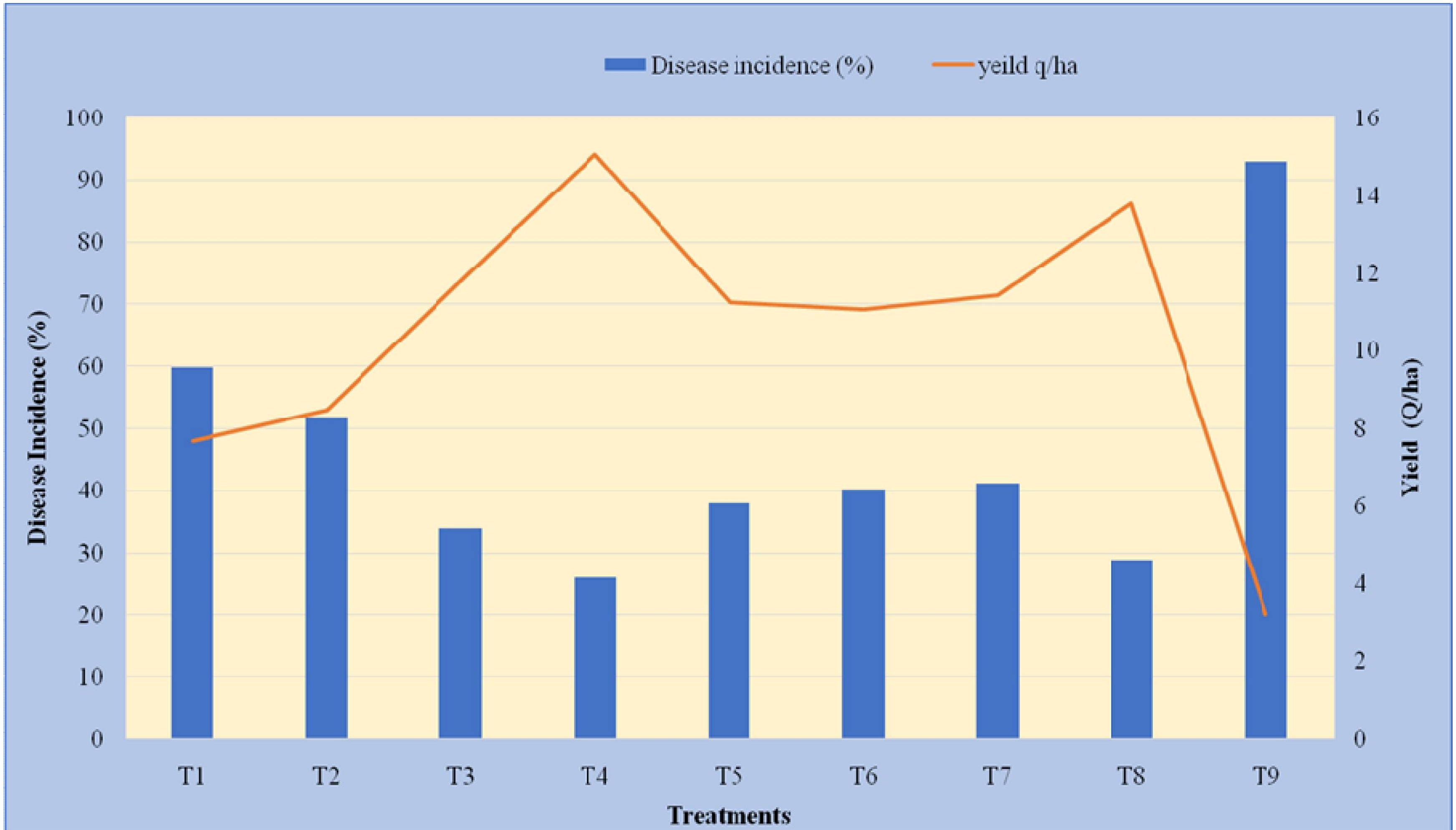

Fig. 2. Effect of different treatments on YMD incidence and yield in soybean during *summer*, 2024 at ARS, Bidar

Seed treatment with imidacloprid 600FS at 5ml/kg

Control

T1 + Foliar spray of flonicamide 50 WG at 0.03% at 20 DAS and 35 DAS

T1 + Foliar spray of afidopyropen 50 g/l DC at 0.2% at 20 DAS and 35 DAS

Fig. 3. Management of yellow mosaic disease in soybean