

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(8): 1009-1014
www.biochemjournal.com
Received: 23-05-2026
Accepted: 28-06-2026

R Ramjegathesh
National Pulses Research
Centre (TNAU), Vamban,
Pudukkottai, Tamil Nadu,
India

L Karthiba
Tamil Nadu Agricultural
University, Coimbatore, Tamil
Nadu, India

R Ramesh
National Pulses Research
Centre (TNAU), Vamban,
Pudukkottai, Tamil Nadu,
India

PS Shanmugam
Tamil Nadu Agricultural
University, Coimbatore, Tamil
Nadu, India

M Paramasivan
Rice Research Station,
Ambasamudram, Tirunelveli,
Tamil Nadu, India

P Ahiladevi
Tamil Nadu Rice Research
Institute, Aduthurai,
Thanjavur, Tamil Nadu, India

M Deivamani
ICAR-Krishi Vigyan Kendra,
Pappaparatti, Dharmapuri,
Tamil Nadu, India

K Chitra
ICAR-Krishi Vigyan Kendra,
Virinjipuram, Vellore, Tamil
Nadu, India

Corresponding Author:
R Ramjegathesh
National Pulses Research
Centre (TNAU), Vamban,
Pudukkottai, Tamil Nadu,
India

Integrated plant disease management strategy for managing sterility mosaic disease and with their vector in redgram (*Cajanus cajan* L.)

R Ramjegathesh, L Karthiba, R Ramesh, PS Shanmugam, M Paramasivan, P Ahiladevi and M Deivamani and K Chitra

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8S1.9563>

Abstract

Sterility mosaic disease (SMD) is one of the most economically important diseases of redgram (*Cajanus cajan* L.), causing significant yield losses through infection by the sterility mosaic virus and its transmission by the eriophyid mite. Integrated disease management offers a sustainable approach for minimizing disease incidence while improving crop productivity. The present study was conducted during Kharif 2023 to evaluate an integrated plant disease management (IPDM) strategy for the management of sterility mosaic disease and phytoplasma disease in redgram under multi-location field conditions in Tamil Nadu. Field experiments were carried out at TNAU-Coimbatore, National Pulses Research Centre Vamban, Pudukkottai, KVK-Pappaparatti, Dharmapuri and KVK-Virinjipuram, Vellore using the variety CO 9 in a randomized block design with three treatments and seven replications. The IPDM package consisted of seed treatment with *Bacillus subtilis* (Bbv57) and *Rhizobium*, followed by imidacloprid 600 FS, sorghum intercropping, rogueing of infected plants up to 45 days after sowing, foliar application of *B. subtilis* (Bbv 57) at 30 days after sowing and need based foliar spraying of fenazaquin for mite management. Pooled analysis across the four locations demonstrated that the IPDM package significantly reduced sterility mosaic disease incidence (6.91%) and mite population (2.66 mites leaf⁻¹) compared with farmers' practice (13.34% and 4.47 mites leaf⁻¹, respectively) and the untreated control (22.60% and 6.78 mites leaf⁻¹, respectively). The IPDM treatment also recorded the highest grain yield (942 kg ha⁻¹) and benefit cost ratio (1.92). The results indicate that the integrated disease management package effectively suppressed sterility mosaic disease and its vector, enhanced grain yield and improved economic returns, highlighting its potential as a practical and sustainable disease management strategy for redgram cultivation.

Keywords: Sterility mosaic disease, Redgram, Integrated disease management, Eriophyid mite, *Bacillus subtilis*, grain yield

Introduction

Redgram or pigeonpea (*Cajanus cajan* L. Millsp.) is one of the most important grain legumes cultivated in tropical and subtropical regions of the world. It serves as a major source of dietary protein, carbohydrates, minerals, vitamins and essential amino acids particularly for vegetarian populations in developing countries. India is the largest producer and consumer of pigeonpea, where the crop contributes significantly to food and nutritional security, livelihood improvement and sustainable agriculture through its ability to fix atmospheric nitrogen and improve soil fertility (Saxena (2008) [18]; FAO (2023) [3]. Despite its agronomic and economic importance, pigeonpea productivity remains considerably below its potential due to the prevalence of several biotic and abiotic constraints (Sharma *et al.* 2011) [20]. Among the biotic stresses, sterility mosaic disease (SMD) is considered one of the most devastating diseases of pigeonpea causing yield losses ranging from 30 to 95% depending on the stage of infection, cultivar susceptibility and environmental conditions (Nene (1973) [12]; Reddy *et al.* (1993) [17]; Jones *et al.* (2004) [8]. The disease is caused by *Pigeonpea sterility mosaic virus* (PPSMV-I and PPSMV-II), belonging to the genus *Emaravirus* and is transmitted by the eriophyid mite *Aceria cajani* in a persistent manner (Jones *et al.* (2004) [8]; Elbeaino *et al.* (2015) [2].

Infected plants exhibit characteristic symptoms including mosaic mottling, chlorotic ring spots, reduced leaf size, excessive vegetative growth, shortened internodes, bushy appearance and complete or partial sterility due to failure of flowering and pod formation. Early infection results in severe yield losses, making SMD one of the most economically important diseases of pigeonpea worldwide (Kulkarni *et al.* (2003)^[10]; Sayiprathap *et al.* (2024)^[19].

The eriophyid mite, *Aceria cajani*, is highly host-specific and survives on infected volunteer plants and perennial pigeonpea, serving as the principal vector responsible for disease spread. Environmental factors such as warm temperatures, moderate humidity and the continuous availability of infected host plants favour rapid multiplication and dispersal of the mite population (Kulkarni *et al.* (2003)^[10]; Vasudha *et al.* (2024)^[21]. Consequently, effective management of the vector forms the cornerstone of sterility mosaic disease management. Although acaricides provide rapid suppression of mite populations, indiscriminate chemical use may increase production costs, promote pesticide resistance and adversely affect beneficial organisms and environmental quality (Agrios (2005)^[11]; Ghosh *et al.* (2013)^[5].

Integrated Plant Disease Management (IPDM) is widely recognized as a sustainable strategy that combines biological, cultural, mechanical, and chemical methods to suppress disease development while minimizing environmental risks. Seed treatment with beneficial microorganisms such as *Bacillus subtilis* improves seedling establishment, suppresses plant pathogens through antibiosis and induced systemic resistance and enhances plant growth (Kloepper *et al.*, 2004 9; Ongena and Jacques, 2008) 13. Likewise, *Rhizobium* inoculation improves nodulation, biological nitrogen fixation, and overall crop vigour (Graham and Vance, 2003). Cultural practices such as intercropping and timely roguing reduce inoculum sources and interrupt disease spread, while need-based application of acaricides and insecticides effectively suppresses vector populations (Pande *et al.* (2012)^[14]; Ghosh *et al.* (2013)^[5].

Although several management practices have been developed individually for the control of sterility mosaic disease or its vector, comprehensive evaluation of integrated disease management modules under diverse agro-climatic conditions remains limited. Multi-location validation is essential because disease incidence, vector populations and treatment efficacy are influenced by environmental conditions, cropping systems and local agronomic practices (Sharma *et al.* (2011)^[20]; ICRISAT, (2021)^[7]; Sayiprathap *et al.* (2024)^[19]. Such evaluations provide reliable information for recommending sustainable disease management technologies for large-scale adoption.

Therefore, the present investigation was undertaken during Kharif 2023 to evaluate an Integrated Plant Disease Management (IPDM) strategy for the management of sterility mosaic disease and phytoplasma disease in redgram under multi-location field conditions in Tamil Nadu. The study assessed the effectiveness of an integrated package comprising seed treatment with *Bacillus subtilis* and *Rhizobium*, imidacloprid seed treatment, sorghum intercropping, roguing of infected plants, foliar application of *B. subtilis* and foliar application of fenazaquin for vector management in reducing disease incidence, suppressing vector populations, and improving grain yield and economic returns.

Materials and Methods

Experimental sites

Field experiments were conducted during Kharif 2023 at four locations in Tamil Nadu, India, namely Tamil Nadu Agricultural University (TNAU), Coimbatore district, the National Pulses Research Centre (NPRC), Vamban, Pudukkottai district, Krishi Vigyan Kendra (KVK), Papparpatti, Dharmapuri district and Krishi Vigyan Kendra (KVK), Virinjipuram, Vellore district to evaluate the efficacy of an Integrated plant disease management strategy for the management of sterility Mosaic Disease (SMD) in redgram.

Experimental design and treatments

The experiment was laid out in a Randomized block Design with three treatments and seven replications using the redgram variety CO 9. The treatments consisted of:

T₁: IPDM package (SMD)

- Seed treatment with *Bacillus subtilis* (Bbv57) @ 10 g kg⁻¹ seed and *Rhizobium* @ 25 g kg⁻¹ seed, followed by imidacloprid 600 FS @ 5 g kg⁻¹ seed
- Sorghum intercropping
- Roguing of infected plants up to 45 days after sowing (DAS)
- Foliar application of *Bacillus subtilis* (Bbv 57) @ 1% at 30 DAS
- Need-based foliar application of fenazaquin 10 EC @ 1 ml L⁻¹ for mite management

T₂: Farmer's practice

The crop was maintained according to the prevailing farmer's management practices.

T₃: Untreated control

No plant protection measures were imposed.

Disease and vector assessment

Observations were recorded on sterility mosaic disease incidence and mite population under each treatment. Disease incidence was expressed as percentage, while mite population was recorded as the number of mites per leaf.

Yield and economic analysis

Grain yield was recorded at harvest and expressed as kilograms per hectare (kg ha⁻¹). The economic performance of each treatment was evaluated by calculating the benefit (B) ratio to determine the profitability of the IPDM strategy relative to the farmer's practice and untreated control.

Statistical analysis

The experiment was conducted with seven replications in a randomized block design. Treatment means were compared using the Least Significant Difference (LSD) test at the 5% probability level, and treatments sharing the same letter were considered not significantly different.

Results and Discussion

Effect of integrated plant disease management on sterility mosaic disease

The integrated plant disease management (IPDM) package significantly reduced sterility mosaic disease (SMD) incidence compared with the farmer's practice and untreated control across all experimental locations. The pooled

analysis revealed that the IPDM package (T_1) recorded the lowest SMD incidence (6.91%), followed by the farmer's practice (13.34%), whereas the untreated control exhibited the highest disease incidence (22.60%) (Table 1). The reduction in disease incidence under the IPDM package may be attributed to the combined effect of seed treatment with *Bacillus subtilis* and imidacloprid, sorghum intercropping, timely roguing of infected plants, foliar application of *B. subtilis* and need-based management of mite. The integration of these components likely reduced the primary inoculum and restricted disease spread during crop growth. Centre-wise observations also demonstrated the superiority of the IPDM package. The lowest SMD incidence was recorded at Dharmapuri (4.35%), followed by Vellore (5.63%), Pudukkottai (6.35%) and Coimbatore (10.74%) (Table 2). In contrast, the untreated control consistently recorded the highest disease incidence at all locations, ranging from 16.22% to 30.07%. These results indicate that the integrated management strategy effectively minimized disease development under different agro-climatic conditions, demonstrating its consistency and adaptability.

Effect on mite population

The IPDM package substantially suppressed the mite population, the principal vector of sterility mosaic disease. The pooled mite population under the IPDM treatment was 2.66 mites leaf⁻¹, compared with 4.47 mites leaf⁻¹ in the farmer's practice and 6.78 mites leaf⁻¹ in the untreated control (Table. 1). The lower mite population observed in the IPDM treatment may be attributed to the combined effect of seed treatment, biological interventions, and need-based application of fenazaquin, which effectively reduced vector abundance and consequently limited disease transmission. A similar trend was observed across all experimental centres. The IPDM package recorded mite populations of 4.26, 1.57, 2.50, and 2.30 mites leaf⁻¹ at Coimbatore, Pudukkottai, Dharmapuri and Vellore respectively (Fig. 1). In comparison, the untreated control recorded the highest mite populations at all locations, confirming the effectiveness of the integrated package in suppressing the vector population under diverse field conditions.

Effect on grain yield

Reduction in disease incidence and mite population was reflected in improved grain yield. The pooled analysis indicated that the IPDM package produced the highest grain yield (942 kg ha⁻¹), followed by the farmer's practice (767 kg ha⁻¹), while the untreated control recorded the lowest yield (673 kg ha⁻¹) (Table 1). The increase in yield under the IPDM package can be attributed to reduced disease pressure, effective vector management, and better crop health throughout the growing season.

The centre-wise results further confirmed the superiority of the integrated management strategy. The highest grain yield was recorded at Coimbatore (1034 kg ha⁻¹), followed by Pudukkottai (951 kg ha⁻¹), Dharmapuri (895 kg ha⁻¹) and Vellore (889 kg ha⁻¹) (Table 2). In every location, the IPDM package significantly outperformed the farmer's practice and untreated control, indicating that the technology is effective across different production environments.

Benefit cost ratio

Economic analysis demonstrated that the integrated

management package was the most profitable treatment. The pooled benefit ratio was highest under the IPDM package (1.92), followed by the farmer's practice (1.52), whereas the untreated control recorded the lowest value (1.11) (Table. 1). The higher economic return obtained under the IPDM package reflects the combined benefit of reduced disease incidence, lower vector population, and increased grain yield.

Across individual locations, the IPDM package consistently recorded the highest benefit ratio, with values of 2.24 at Coimbatore, 2.14 at Pudukkottai, 1.85 at Dharmapuri and 1.44 at Vellore district (Table. 2). These findings demonstrate that adoption of the integrated management strategy not only improves crop health and productivity but also enhances farm profitability under varying agro-ecological conditions.

Overall, the multi-location evaluation demonstrated that the integrated plant disease management package effectively reduced sterility mosaic disease incidence and mite population while increasing grain yield and economic returns. The consistent performance across locations suggests that the IPDM package can serve as a practical and economically viable strategy for the management of sterility mosaic disease in redgram under field conditions.

Discussion

The present investigation demonstrated that the integrated plant disease management (IPDM) package significantly reduced sterility mosaic disease (SMD) incidence, suppressed the eriophyid mite (*Aceria cajani*) population, and enhanced grain yield and economic returns across all four experimental locations. The superior performance of the IPDM module over the farmer's practice and untreated control confirms the effectiveness of integrating biological, cultural, and need-based chemical approaches for the management of vector-borne diseases in pigeonpea. Similar observations have been reported by Jones *et al.* (2004) [9], Sharma *et al.* (2011) [20], Ghosh *et al.* (2015) [4] and Sayiprathap *et al.* (2024) [19], who emphasized that integrated management practices provide more durable suppression of SMD than reliance on a single control measure.

Sterility mosaic disease remains one of the most destructive constraints to pigeonpea production in the Indian subcontinent, where severe infections may result in yield losses ranging from 30 to 95%, depending on crop stage, cultivar susceptibility and environmental conditions (Nene, (1973) [12]; Reddy *et al.* (1993) [17]; Jones *et al.* (2004) [8]. The lower disease incidence recorded in the present study under the IPDM package may be attributed to the synergistic action of seed treatment with *Bacillus subtilis*, biological enhancement through *Rhizobium*, sorghum intercropping, timely removal of infected plants and effective suppression of vector populations through need-based application of acaricides and insecticides. Similar integrated approaches have been shown to reduce primary inoculum and interrupt disease transmission under field conditions (Pande *et al.* (2012) [14]; Rajeswari *et al.* (2016) [16]; Prabhavathi and Ramappa (2019) [15].

The substantial reduction in mite population observed in the present investigation highlights the pivotal role of vector management in SMD suppression. Since *Aceria cajani* is the exclusive vector of *Pigeonpea sterility mosaic virus* (PPSMV), reduction in vector abundance directly limits

virus spread within the crop. Earlier investigations by Kulkarni *et al.* (2003) ^[10], Kumar *et al.* (2003) ^[11], Jones *et al.* (2004) ^[8] and Vasudha *et al.* (2024) ^[21] demonstrated a strong positive relationship between mite population and disease incidence, emphasizing that timely vector control is fundamental for effective disease management. The lower mite population observed under the IPDM package in the present study is therefore consistent with these earlier findings.

Biological components included in the IPDM package may also have contributed to improved crop health and disease suppression. Seed treatment with *Bacillus subtilis* has been reported to enhance seedling vigour, improve nutrient uptake, suppress plant pathogens through antibiosis and competition, and induce systemic resistance in several crops (Kloepper *et al.* (2004) ^[9]; Ongena and Jacques (2008) ^[13]. Similarly, *Rhizobium* inoculation enhances nodulation and biological nitrogen fixation, resulting in improved plant growth and greater tolerance to biotic stresses (Graham and Vance (2003) ^[6]). The integration of these beneficial microorganisms with cultural and chemical practices likely contributed to the superior performance of the IPDM package.

Intercropping with sorghum and timely roguing of infected plants probably reduced disease spread by minimizing inoculum sources and creating a less favourable environment for vector movement. Cultural practices have long been recognized as important components of integrated disease management because they reduce pathogen survival and delay secondary spread without increasing pesticide

dependence (Agrios (2005) ^[1]; Pande *et al.* (2012) ^[14]. Their inclusion in the present study complements the biological and chemical interventions, resulting in effective disease suppression across diverse agro-climatic conditions.

The significant increase in grain yield and benefit ratio obtained under the IPDM package reflects the cumulative benefits of effective disease and vector management. Reduced disease pressure enabled better crop growth, flowering, pod development, and grain filling, ultimately resulting in higher productivity. Similar improvements in yield and profitability following integrated management of pigeonpea diseases have been reported by Sharma *et al.* (2011) ^[20]; Rajeswari *et al.* (2016) ^[16]; Ghosh *et al.* (2015) ^[4] and Prabhavathi and Ramappa (2019) ^[15]. The higher benefit ratio further demonstrates that the additional cost of implementing the IPDM package was compensated by increased grain yield and economic returns, making the technology suitable for adoption by farmers.

Overall, the consistent reduction in disease incidence and vector population, together with increased grain yield and economic returns across four locations, demonstrates that the integrated plant disease management package represents an effective, environmentally compatible, and economically viable strategy for managing sterility mosaic disease in pigeonpea (Fig. 2). Future studies should validate the technology across additional agro-climatic zones and cropping seasons, while also evaluating its effectiveness under conditions where phytoplasma disease occurs naturally.

Table 1: Integrated disease management of sterility mosaic disease in redgram (Pooled data)

S. No	Treatments	SMD incidence %	Mite (nos./leaf)	Yield (kg/ha)	BC Ratio
T ₁	IPM Package (SMD)				
	• Seed treatment with <i>Bacillus subtilis</i> (Bbv 57) @ 10g/kg and <i>Rhizobium</i> 25g/kg of seed followed by imidacloprid 600 FS @ 5g/kg	6.91 ^a (15.00)	2.66 ^a	942 ^a	1.92
	• Intercropping with sorghum				
	• Rogue out infected plants upto 45 DAS				
	• Foliar spray of <i>Bacillus subtilis</i> (Bbv 57) @ 1% at 30DAS				
	• Need based foliar spraying of azadirachtin 1000 ppm or fenazaquin 10 EC @ 1 ml/lit				
T ₂	Farmer's practice	13.34 ^b (21.16)	4.47 ^b	767 ^b	1.52
T ₃	Untreated check	22.60 ^c (28.27)	6.78 ^c	673 ^c	1.11
	CD (0.05%)	2.45	1.13	42.76	

For each treatment, numbers followed by the same letter are not significantly different according to LSD test at $p < 0.05$

Table 2: Effectiveness of Integrated Disease Management against Sterility Mosaic Disease in Redgram across Different Locations

S. No	Treatments	Coimbatore			Pudukkottai			Dharmapuri			Vellore		
		SMD-DI (%)	Yield (kg/ha)	BC ratio	SMD-DI (%)	Yield (kg/ha)	BC ratio	SMD-DI (%)	Yield (kg/ha)	BC ratio	SMD-DI (%)	Yield (kg/ha)	BC ratio
T ₁	IPM Package (SMD)	10.74 ^a (19.13)	1034 ^a	2.24	6.35 ^a (14.43)	951 ^a	2.14	4.35 ^a (12.04)	895 ^a	1.85	5.63 ^a (13.73)	889 ^a	1.44
T ₂	Farmer's practice	15.45 ^b (23.14)	812 ^b	1.80	10.99 ^b (19.06)	812 ^b	1.82	7.28 ^b (15.65)	712 ^b	1.23	17.28 ^b (24.56)	732 ^b	1.24
T ₃	Untreated check	30.07 ^c (33.26)	698 ^c	1.17	16.22 ^c (23.62)	727 ^c	1.24	18.22 ^c (2.27)	658 ^c	1.02	19.52 ^c (26.22)	608 ^c	1.02
	CD (0.05%)	2.32	59.64		3.17	49.29		1.13	38.56		1.15	23.56	

*Values are mean of seven replications; SMD-DI-Sterility Mosaic Disease-Disease Incidence

For each treatment, numbers followed by the same letter are not significantly different according to LSD test at $p < 0.05$

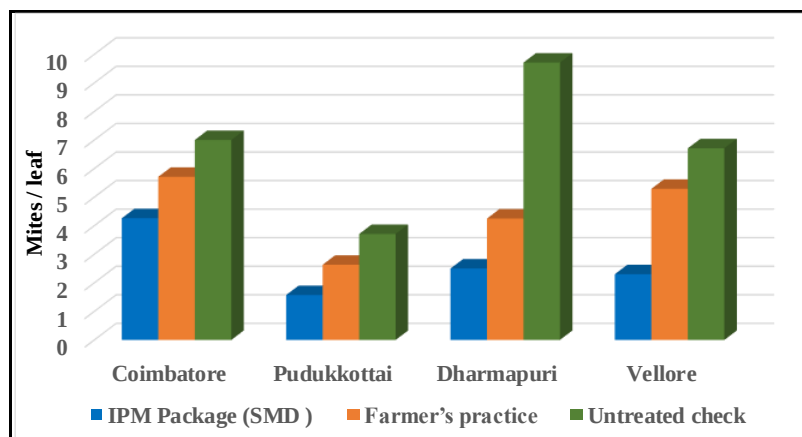
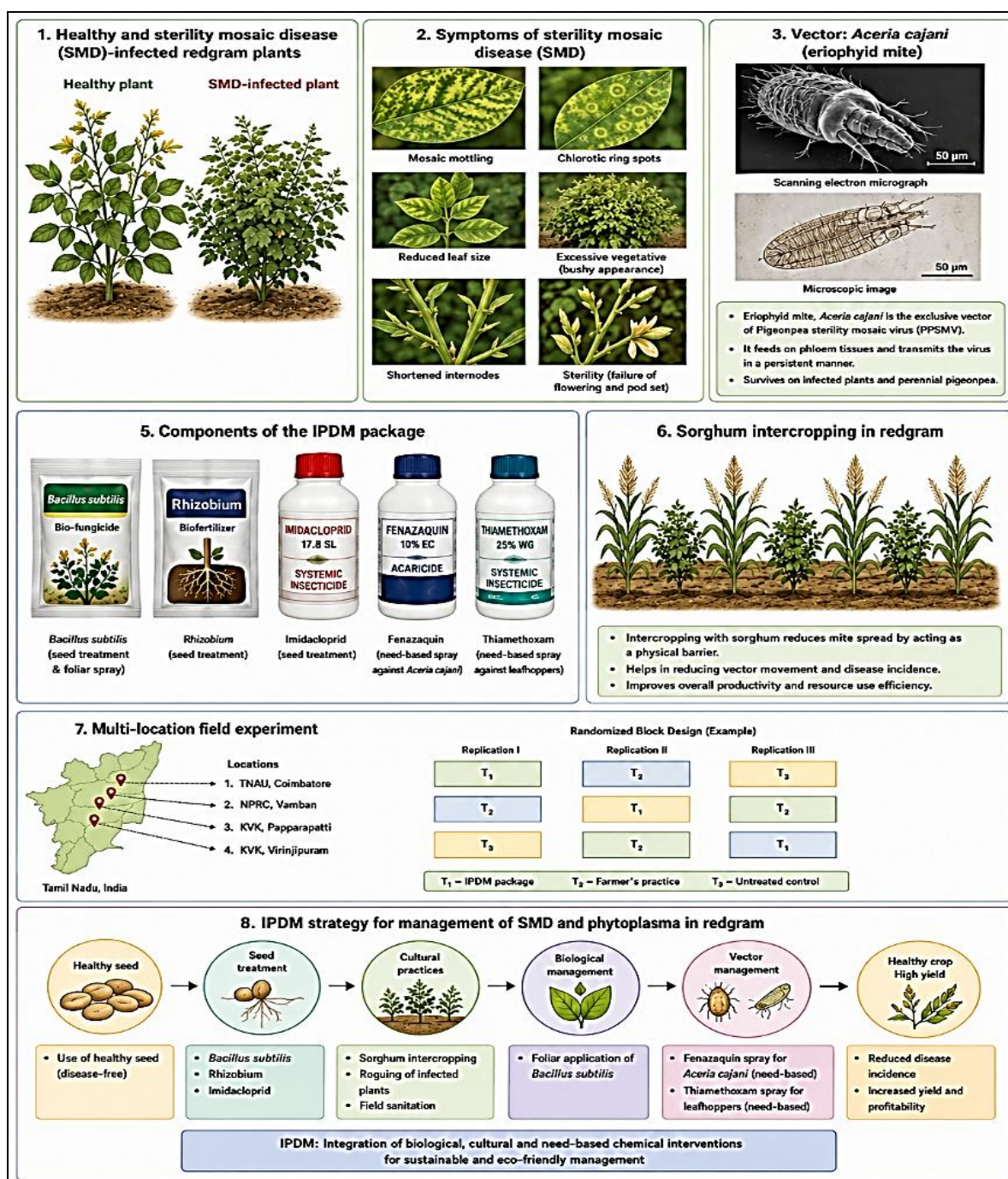


Fig 1: Effect of IPDM on *Aceria cajani* Population in Redgram across Locations



Source: AI-assisted scientific illustration by Jones *et al.* 2004 [8]; Kulkarni *et al.* 2003 [10]; Ghosh *et al.* 2013 [5]; Sayiprathap *et al.* 2024 [19]

Fig 2: Over all view of IPDM in redgram Sterility Mosaic Disease

Acknowledgement

The authors sincerely acknowledge Tamil Nadu Agricultural University, Coimbatore for providing the necessary facilities and institutional support for this study. The authors also acknowledge the valuable assistance of the technical and field staff in conducting the experiments and collecting data.

References

1. Agrios GN. Plant pathology. 5th ed. Burlington, MA, USA: Elsevier Academic Press; 2005.
2. Elbeaino T, Digiario M, Uppala M, Sudini H. Deep sequencing of Pigeonpea sterility mosaic virus genomes and identification of two distinct emaraviruses associated with sterility mosaic disease of pigeonpea. *Archives of Virology*. 2015; 160:2047-2056.
3. Food and Agriculture Organization of the United Nations (FAO). FAOSTAT statistical database. Rome, Italy: FAO; 2023. Available from: <https://www.fao.org/faostat/>
4. Ghosh R, Sharma M, Pande S, Kumar PL. Integrated management of pigeonpea diseases for sustainable production. *Indian Phytopathology*. 2015;68(3):243-252.
5. Ghosh R, Sharma M, Telangre R, Pande S. Occurrence and management of major diseases of pigeonpea. *Crop Protection*. 2013; 54:259-270.
6. Graham PH, Vance CP. Legumes: importance and constraints to greater use. *Plant Physiology*. 2003; 131:872-877.
7. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Pigeonpea disease compendium. Patancheru, Hyderabad, India: ICRISAT; 2021.
8. Jones AT, Kumar PL, Saxena KB, Kulkarni NK, Muniyappa V, Waliyar F. Sterility mosaic disease the “green plague” of pigeonpea: advances in understanding the etiology, transmission and control of a major virus disease. *Plant Disease*. 2004; 88(5):436-445.
9. Kloepper JW, Ryu CM, Zhang S. Induced systemic resistance and promotion of plant growth by *Bacillus* species. *Phytopathology*. 2004; 94(11):1259-1266.
10. Kulkarni NK, Kumar PL, Muniyappa V, Jones AT, Reddy DVR. Transmission of Pigeonpea sterility mosaic virus by *Aceria cajani*. *Annals of Applied Biology*. 2003; 142:181-187.
11. Kumar PL, Jones AT, Reddy DVR. A review of sterility mosaic disease of pigeonpea. *Plant Virus Epidemiology*. 2003; 15:1-18.
12. Nene YL. A survey of viral diseases of pulse crops in Uttar Pradesh. Pantnagar, India: G.B. Pant University of Agriculture and Technology; 1973.
13. Ongena M, Jacques P. *Bacillus* lipopeptides: versatile weapons for plant disease biocontrol. *Trends in Microbiology*. 2008; 16(3):115-125.
14. Pande S, Sharma M, Ghosh R. Disease management strategies for pigeonpea. *Information Bulletin*. Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics; 2012.
15. Prabhavathi NM, Ramappa HK. Integrated disease management of sterility mosaic disease in pigeonpea. *Journal of Food Legumes*. 2019; 32(2):105-108.
16. Rajeswari E, Smitha KP, Kamalakannan A, Alice D, Bapu JRK. Management of pigeonpea sterility mosaic disease through integrated disease management practices. *Legume Research*. 2016; 39(4):648-650.
17. Reddy MV, Nene YL, Sheila VK. Pigeonpea: disease management. Wallingford, UK: CAB International; 1993.
18. Saxena KB. Genetic improvement of pigeonpea—a review. *Tropical Plant Biology*. 2008; 1:159-178.
19. Sayiprathap BR, Sudini H, Sharma M, Kumar PL, Ghosh R, Elbeaino T. Sterility mosaic disease of pigeonpea (*Cajanus cajan*): current status, disease management strategies, and future prospects. *Plants*. 2024; 13:2146.
20. Sharma M, Ghosh R, Pande S. Integrated disease management in grain legumes: current status and future prospects. *Journal of Food Legumes*. 2011; 24(1):1-14.
21. Vasudha A, Ramesh S, Prasad PS, Kumar R. Temperature predicts the population dynamics of *Aceria cajani* and efficacy of acaricides in pigeonpea. *Agricultural Science Digest*. 2024; 44:757-761.