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Integrated management of *Phytophthora blight* in pigeonpea under farmers' field conditions

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Abstract
Phytophthora blight, caused by *Phytophthora drechsleri f.* sp. *cajani*, is a major soil-borne disease that constrains pigeonpea production in rainfed agro-ecosystems. Frequent heavy rainfall and poor drainage aggravate disease severity, resulting in substantial yield losses. On-farm trials were conducted during the kharif seasons of 2022-23 and 2023-24 at Uplai (Khurd) and Uplai (Budruk), Ta. Madha, in the Solapur district of Maharashtra, to evaluate the effectiveness of an integrated disease management (IDM) module compared with farmers' practice. The trials were laid out in 15 farmers' fields under rainfed conditions. Results revealed that the IDM module comprising seed treatment with *Trichoderma* @ 5 g kg^{-1} seed, followed by two foliar sprays of Metalaxyl 4% + Mancozeb 64% @ 1.5 g l^{-1}, significantly reduced disease incidence, with a pooled reduction of 61.4 per cent over farmers' practice. The IDM treatment also recorded higher yield (20.6 q ha^{-1}) and a benefit-cost ratio (2.4). The study conclusively demonstrates that integrated disease management is an effective, economical, and sustainable strategy for managing *Phytophthora blight* in pigeonpea under rainfed farming systems.

Keywords: *Cajanus cajan*, *Phytophthora blight*, integrated disease management, *Trichoderma*, rainfed agriculture, economics

Introduction
Pigeonpea (*Cajanus cajan* L.) is one of the most important pulse crops in India, playing a crucial role in ensuring nutritional security by providing dietary protein and improving soil fertility through biological nitrogen fixation. India accounts for nearly 70-75 per cent of the global pigeonpea area and production; however, crop productivity remains low relative to its potential due to several biotic and abiotic constraints (FAOSTAT, 2023; ICAR-IIPR, 2022) [3, 8]. Among these constraints, diseases caused by soil-borne pathogens are a major threat to sustainable pigeonpea production, particularly in rainfed agro-ecosystems (Kannaiyan *et al.*, 1984; Sharma *et al.*, 2015) [9, 14].

In Maharashtra, one of the major pigeonpea-growing states in India, the crop covered 11.11 lakh hectares, with production of 9.82 lakh tonnes and an average productivity of 884 kg ha^{-1} during 2023-24, which is still below the achievable yield under improved management practices (DES, Maharashtra, 2024).

Phytophthora blight, caused by *Phytophthora drechsleri* f. sp. *cajani*, is a highly destructive disease of pigeonpea and is widely prevalent in regions with high rainfall and temporary waterlogging (Sharma *et al.*, 2012; Ghosh *et al.*, 2019) [13, 5]. The disease can infect the crop at all growth stages, causing rapid wilting, stem lesions, root rot, plant mortality, and substantial yield losses. Under favourable environmental conditions, yield losses of 20 to 60 per cent have been reported (Kannaiyan *et al.*, 1984; Pande *et al.*, 2013) [9, 12].

Farmers generally rely on repeated applications of chemical fungicides to manage *Phytophthora blight*; however, exclusive reliance on chemicals often results in inconsistent disease control due to the soil-borne nature of the pathogen, higher production costs, and environmental concerns (Sharma *et al.*, 2016; Singh *et al.*, 2020) [15, 16]. In this context, Integrated Disease Management (IDM), which integrates biological control agents, cultural practices, and need-based fungicide application, has emerged as a more effective and sustainable approach for managing soil-borne diseases in pulse crops (Pande *et al.*, 2011; Ghosh *et al.*, 2021) [4, 11].

Seed treatment and soil application of antagonistic microorganisms, such as *Trichoderma* spp., have been reported to suppress soil-borne pathogens, enhance plant vigour, and significantly reduce the incidence of *Phytophthora blight* in pigeonpea (Harman *et al.*, 2004; Dubey *et al.*, 2020; Meena *et al.*, 2022) [6, 2, 10]. Therefore, the present study was conducted to evaluate the effectiveness of an IDM module for managing *Phytophthora blight* of pigeonpea under farmers' field conditions.

Materials and Methods

Experimental Site and Farming Situation

The on-farm trials were conducted during the kharif seasons of 2022-23 and 2023-24 at Uplai (Khurd) and Uplai (Budruk), Ta. Madha, in Solapur district, Maharashtra. The region has a semi-arid climate with erratic rainfall. The trials were conducted under rainfed conditions, where temporary waterlogging is common during periods of heavy rainfall, creating favourable conditions for *Phytophthora blight.*

Experimental Design and Treatments

A total of 15 on-farm trials were conducted in farmers' fields following standard KVK methodology. Two treatments were evaluated:

- **T_1: Farmers Practice (FP)**
  Spraying of Thiophanate methyl

T_2: Integrated Disease Management (IDM)

1. Seed treatment with *Trichoderma* @ 5 g kg^{-1} seed
2. Two foliar sprays of Metalaxyl 4% + Mancozeb 64% @ 1.5 g l^{-1} at 15-day intervals, starting from 15 days after germination

The technology was sourced from the Indian Institute of Pulses Research (IIPR), Kanpur.

Observations Recorded

The following observations were recorded:

- Percent disease incidence (PDI)
- Grain yield (q ha^{-1})
- Benefit-cost ratio (BCR)

Disease incidence was calculated based on the number of infected plants in the field. Yield data were recorded at harvest. Economic analysis was conducted using prevailing market prices.

Statistical Analysis: Data collected over two years were pooled and analysed statistically. Critical difference (CD) at the 5 per cent level and coefficient of variation (CV) were computed to assess the significance of treatment effects.

Results and Discussion

Effect on *Phytophthora Blight* Incidence

The integrated disease management module significantly reduced *Phytophthora blight* incidence compared with farmers' practice in both years of experimentation (Table 1) and Fig 1-4). The pooled mean disease incidence under IDM treatment was 8.8 per cent, whereas farmers' practice recorded a higher incidence of 22.8 per cent, resulting in a 61.4 per cent reduction compared with farmers' practice.

The reduction in disease incidence under the IDM module may be attributed to the combined effect of biological and chemical components. Seed treatment with *Trichoderma* suppresses soil-borne pathogens through mechanisms such as competition, mycoparasitism, and antibiosis, thereby reducing initial inoculum levels (Harman *et al.*, 2004) [6]. Similar reductions in *Phytophthora blight* incidence have been reported earlier in pigeonpea through integrated approaches (Sharma *et al.*, 2012; Pande *et al.*, 2011) [13, 11].

Effect on Yield: Effective disease management under the IDM module led to a significant increase in yield. The pooled mean yield under IDM treatment was 20.6 q ha^{-1}, compared with 16.4 q ha^{-1} under farmers' practice. Improved crop stand and reduced plant mortality under IDM treatment contributed to higher yields.

Earlier researchers working on integrated disease management of pulse crops have also reported a positive association between reduced disease incidence and increased yield (Pande *et al.*, 2011) [11]. Effective suppression of *Phytophthora blight* improves nutrient uptake and overall crop growth, thereby enhancing productivity.

Economic Analysis

The IDM module recorded a higher benefit-cost ratio (2.4) than farmers' practice (1.8), indicating better economic returns. Although the IDM treatment incurred additional input costs, the higher yield offset the investment, resulting in higher profitability. Similar economic benefits of IDM practices in pigeonpea have been documented earlier (Sharma *et al.*, 2012; IIPR, 2016) [13, 7].

Conclusions

This study clearly shows that integrated disease management (IDM) is a proven, sustainable approach for controlling *Phytophthora blight* in pigeonpea grown under rainfed conditions. The IDM approach, which includes seed treatment with *Trichoderma* and two foliar sprays of Metalaxyl + Mancozeb, reduced disease incidence by 61.4% compared with farmers' usual practices. This effective disease control improved plant health, increased yield, and boosted economic returns.

Table 1: Integrated disease management for *Phytophthora blight* and yield enhancement in pigeonpea (pooled data)

Treatment	Percent Disease Incidence PDI (%)			Reduction of PDI over FP (%)	Yield (q/ha)			BCR		
	2022-23	2023-24	Pooled	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_1 - Farmers' Practice (Thiophanate methyl spray)	22.5	23.2	22.8	-	15.7	17.2	16.4	1.8	1.9	1.8
T_2 - IDM module (Seed treatment with *Trichoderma* @5 g/kg + two sprays of Metalaxyl 4% + Mancozeb 64% @1.5 g/l)	8.6	9.1	8.8	61.4	19.9	21.3	20.6	2.4	2.5	2.4
CD (p = 0.05)	2.1	2.3	2.2	-	1.5	1.6	1.6	-	-	-
CV (%)	9.4	9.8	9.6	-	8.7	9.1	8.9	-	-	-

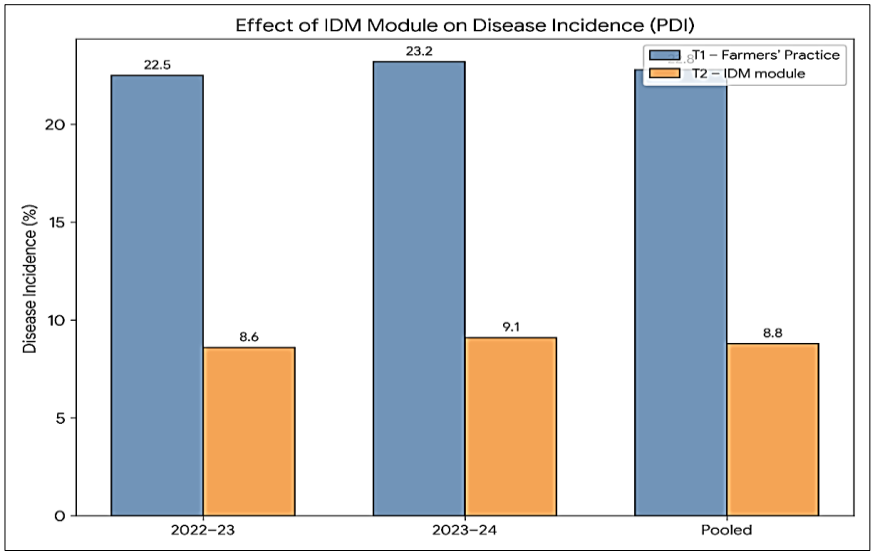


Fig 1: Effect of IDM Module on Disease Incidence (PDI)

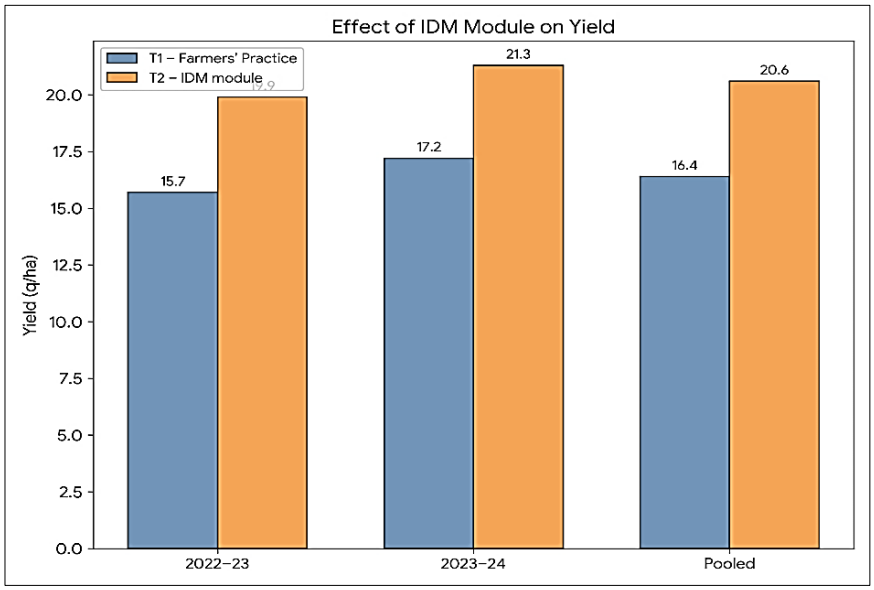


Fig 2: Effect of IDM Module on Yield

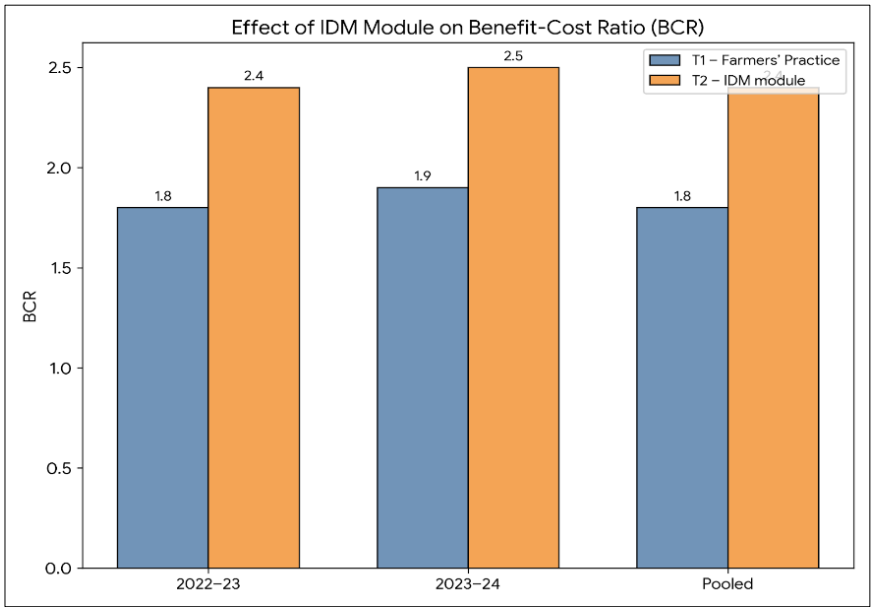
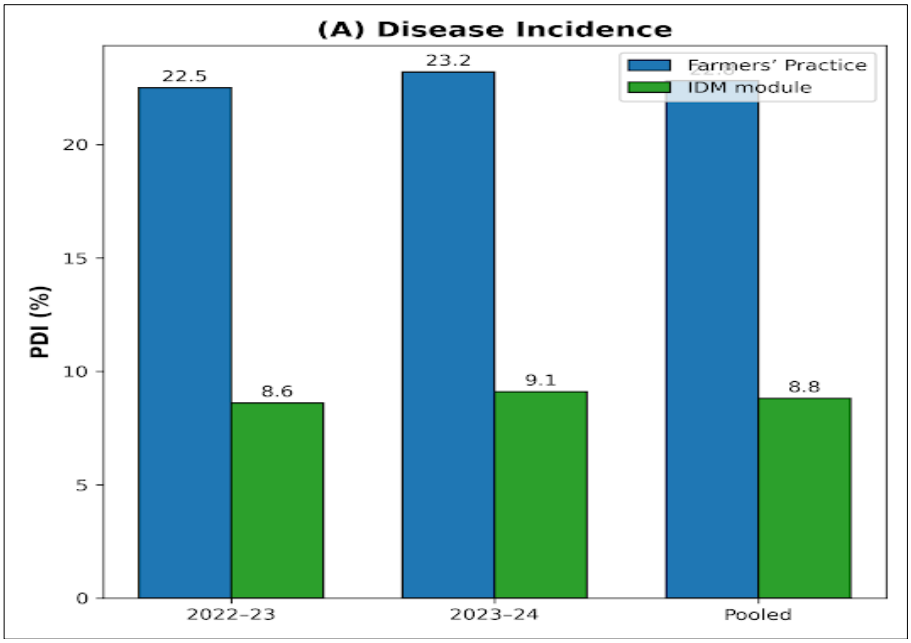
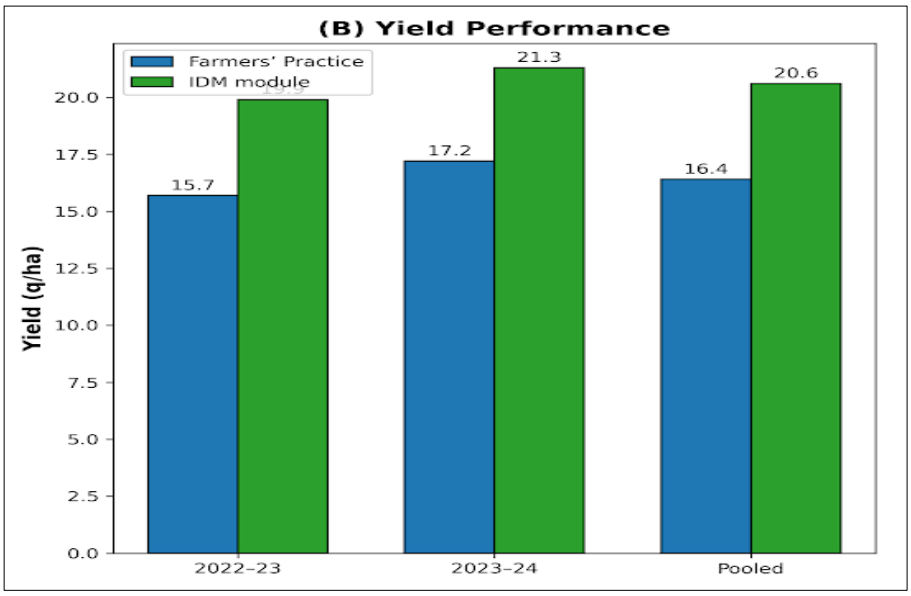


Fig 3: Effect of IDM Module on Benefit-Cost Ratio (BCR)





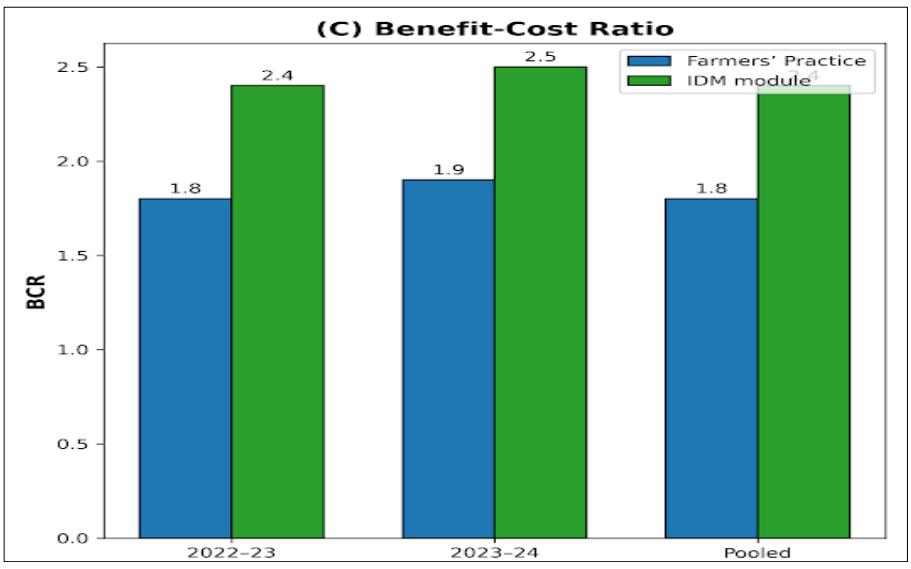


Fig 4: (A) Disease Incidence (PDI), 9B) Yield Performance, (C) Benefit-Cost Ratio

The integrated approach produced higher yields and a better benefit-cost ratio than traditional practices, demonstrating its economic soundness. Implementing this IDM strategy can help reduce yield losses from *Phytophthora blight* and improve the productivity and profitability of pigeonpea in rainfed areas prone to disease.

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