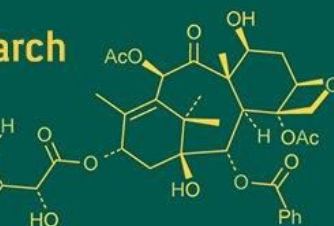
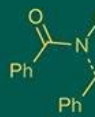


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Impact of disease management practices on disease incidence, yield and proximate composition of sweet basil (*Ocimum basilicum* L.)

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Abstract

Sweet basil (*Ocimum basilicum* L.) is a high-value medicinal and aromatic crop cultivated for its essential oil and commercial importance; however, dry root rot caused by *Macrophomina phaseolina* poses a serious threat to crop productivity and quality. Based on prior in-vitro screening, effective disease management components were selected and evaluated under field conditions as integrated disease management (IDM) strategies. Field trials were conducted using combinations of bio-agents, organic amendments and chemical inputs to assess their effect on disease incidence, growth, yield and biochemical (proximate) composition of sweet basil. Among the tested treatments, soil application of farmyard manure (1 kg/m²) enriched with *Trichoderma viride* and *Pseudomonas fluorescens* (talcbased formulations @ 2.0%) at planting time resulted in minimum dry root rot incidence and significantly improved plant growth and yield parameters. The same treatment also maintained crop quality, with essential oil content being highest among treatments, while other proximate constituents showed no significant variation. The study demonstrates that integration of biologically effective components selected through laboratory screening can successfully manage dry root rot under field conditions while sustaining yield and quality of sweet basil. This eco-friendly IDM approach offers a practical and sustainable solution for disease management in medicinal and aromatic crops.

Keywords: Sweet basil (*Ocimum basilicum*), dry root rot, integrated disease management (IDM), *Macrophomina phaseolina*, bioagents, proximate composition

Introduction

Sweet basil (*Ocimum basilicum* L.) belonging to the family Lamiaceae is one of the most important aromatic plants cultivated for its essential oil, medicinal properties, and pharmaceutical applications. The crop holds a prominent position in the genus *Ocimum* due to its diverse therapeutic uses and high commercial value (Reis *et al.*, 2007) ^[17]. In India, sweet basil is grown commercially in states such as Madhya Pradesh, Punjab, Uttar Pradesh, and Jammu & Kashmir, with expanding cultivation driven by increasing demand in national and international markets (Patel and Kushwaha, 2013) ^[15].

Dry root rot of sweet basil is caused by *Macrophomina phaseolina* (Tassi, 1901) ^[20] Goid., a soil-borne, necrotrophic pathogen with a wide host range. The pathogen is widely distributed in tropical and subtropical regions and is known to infect more than 500 plant species (Das and Indira, 2008). Disease development is favored by high temperature and moisture-stress conditions, often resulting in considerable yield losses (Tesso *et al.*, 2005) ^[21]. The pathogen can infect the crop at different growth stages, from seedling to maturity, and affects various plant parts including roots, stems, leaves, pods, and seeds (Mukharji and Bhasin, 1986) ^[13]. Typical symptoms include dark brown to grey lesions on the stem, followed by wilting, defoliation, and eventual plant death (Reis *et al.*, 2007; Abawi and Pastor-Corrales, 1990) ^[17, 2].

Macrophomina phaseolina is a highly persistent soil-borne pathogen capable of surviving as microsclerotia for extended periods in dry soil conditions. These survival structures enable rapid infection when favorable conditions occur; making disease management difficult through single control measures (Sinclair, 1989) ^[18]. The lack of resistant cultivars and the wide host range of the pathogen further complicate management strategies.

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Integrated disease management (IDM) has emerged as a viable approach for controlling soil-borne diseases by combining biological, botanical, and chemical methods. Botanicals and plant oils have gained attention due to their antifungal activity and environmental safety. Several plant extracts have been reported to inhibit mycelial growth of *M. phaseolina* by disrupting fungal metabolism and cell wall integrity (Sindhan *et al.*, 2002; Khaire *et al.*, 2018) [19, 9]. Essential oils from neem and tulsi are widely recognized for their antifungal properties. The effectiveness of neem oil against soil borne pathogen has been reported by Kumar *et al.* (2019) [11].

Biological control agents such as *Trichoderma viride* and *Pseudomonas fluorescens* are widely recognized for their antagonistic activity against *M. phaseolina*. These bioagents suppress pathogen growth through competition, antibiosis, mycoparasitism, and induction of host defense enzymes (Anand *et al.*, 2009) [3]. Induced systemic resistance plays a crucial role in disease suppression by enhancing the activity of defense-related enzymes such as peroxidase, chitinase, and polyphenol oxidase, thereby limiting pathogen colonization (Kuc, 1982; Ye *et al.*, 1990) [10, 23].

In modern agriculture, fungicides play an important role in the management of plant diseases. Recent studies have also included the new-generation fungicides with improved modes of action and lower risk of resistance, which have shown effectiveness against several soil-borne pathogens, including *Macrophomina phaseolina* (Gandhi and Rao, 2019; Karibasappa *et al.*, 2020) [16, 8].

Apart from disease suppression, IDM practices influence crop growth and quality. Disease management strategies not only reduce disease incidence but also affect proximate composition parameters such as protein, fibre, carbohydrate, oil, and ash content in plants. Improvement in crop quality through effective disease management has been reported earlier, highlighting the importance of evaluating management practices beyond disease control alone (Sohalbiani *et al.*, 2011) [1].

Considering the economic importance of sweet basil and the destructive nature of dry root rot, there is a need to identify effective, environmentally sustainable disease management strategies. Therefore, the present study was undertaken to evaluate different biological, botanical, and chemical alternatives under integrated disease management practices for controlling dry root rot of sweet basil caused by *Macrophomina phaseolina*, with special emphasis on disease reduction and improvement in crop quality parameters.

Materials and Methods

Experimental Site

The field experiment was conducted during the kharif season at the experimental field of ACRIP on MAP&B, Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh, India in 2020.

Experimental Design and Crop Details

The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. Each plot measured 3 × 2 m², with a row-to-row spacing of 40 cm and plant-to-plant spacing of 30 cm. A local sweet basil (*Ocimum basilicum*) variety was used for the study. Sowing was done as per recommended agronomic practices.

Source of Bioagents and method of application

Bioagents such as *Trichoderma viride* and *Pseudomonas fluorescens* were obtained from authenticated laboratory cultures maintained at JNKVV, Jabalpur. Talc-based formulations were used for soil and foliar applications. Farmyard manure (FYM) was thoroughly mixed with talc-based formulations of *T. viride* and *P. fluorescens* and incubated for 7 days under shade conditions before application. The enriched FYM was applied uniformly to the soil at planting time. Foliar sprays of bioagents, botanical oil, and fungicides were applied using a knapsack sprayer at recommended concentrations. Sprays were initiated at the onset of disease symptoms and repeated at 15-day intervals.

Treatment Details

The following integrated disease management treatments were evaluated under field conditions:

- T₁: Soil application of FYM (1 kg/m²) enriched with *Trichoderma viride* + *Pseudomonas fluorescens* (each @ 2.0%) at planting
- T₂: T₁ + three foliar sprays of *P. fluorescens* (2.0%) at disease onset
- T₃: T₁ + three sprays of neem oil @ 300 ppm
- T₄: T₁ + three sprays of *P. fluorescens* (2.0%) + neem oil @ 300 ppm
- T₅: T₁ + three sprays of Trifloxystrobin 25% + Tebuconazole 50% @ 0.1% at 15-day intervals
- T₆: T₁ + three sprays of Copper oxychloride @ 0.25% at 15-day intervals
- T₇: Control (untreated)

Observation on Disease Incidence

Disease incidence was recorded periodically by counting the number of infected plants in each plot. Percent disease incidence was calculated using the formula given by (Waller *et al.*, 2002) [22]:

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{total number of plants}} \times 100$$

Yield Assessment

Harvesting was carried out at crop maturity. Yield was recorded on a plot basis and expressed in appropriate units after conversion.

Determination of Quality Parameters

Moisture content of sweet basil samples was determined by oven-drying method following AOAC (2010) [4] procedures. Crude protein content was estimated using the Kjeldahl method and calculated by multiplying nitrogen content with a conversion factor. Crude fiber content was determined following standard AOAC (2010) [4] methodology involving acid and alkali digestion. Total ash content was estimated by incinerating dried samples in a muffle furnace at 550-600 °C until constant weight was obtained. Essential oil was extracted from fresh leaves using hydro-distillation method with a Clevenger apparatus. Oil content was expressed as percentage based on fresh weight of plant material.

Statistical Analysis

The field data were subjected to analysis of variance (ANOVA) appropriate for Randomized Block Design. Treatment means were compared using critical difference

(CD) at 5% level of significance. Statistical analysis was performed following standard procedures.

Results and Discussion

Field evaluation of integrated disease management revealed significant differences among treatments with respect to disease incidence and disease control. Treatment T₁ recorded the minimum disease incidence (5.33%) along with the maximum disease control over check (68.05%). This was followed by treatments T₂ and T₃, which showed moderate reduction in disease incidence with disease control of 43.98% and 31.94%, respectively. Higher disease incidence and lower disease control were recorded in the remaining treatments, with the lowest disease control over check observed in T₄. The untreated control recorded the

maximum disease incidence. The superior performance of treatment T₁ under field conditions indicates the effectiveness of antagonistic properties of the bioagents against the pathogen. Similar observations were reported by Rathore *et al.* (2020) [16], Godara and Suresh Kumar (2018) [7], and Manjunatha *et al.* (2013) [12]. Treatment T₁, comprising only bioagents, exhibited superior performance, likely due to their strong antagonistic activity against the pathogen. The relatively lower effectiveness of treatments combining bioagents with other inputs may indicate possible interactions among the applied components. However, such interactions were not examined in the present study, and further research is required to assess their compatibility under field conditions.

Table 1: Effect of Integrated Disease Management (IDM) on disease incidence and disease control over check

	Treatments	Disease incidence %	% Disease control over check
T ₁	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time.	5.33	68.05
T ₂	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time + three sprays of talc-based formulation of <i>P. fluorescence</i> @ 2.0% on the onset of disease symptoms.	9.33	43.98
T ₃	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time +three spray of neem oil @ 300 ppm.	11.33	31.94
T ₄	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time + three sprays of <i>P. fluorescence</i> @ 2.0% and neem oil @ 300 ppm.	14	16.20
T ₅	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time + three spray of Trifloxystrobin 25%+ Tebuconazole 50% at 0.2% concentration with 15 days interval.	12	28.24
T ₆	Soil application of FYM (1kg/m ²) enriched with <i>Trichoderma viride</i> + <i>Pseudomonas</i> talc based formulation each @ 2.0% at planting time + three sprays of Copper oxychloride @ 5000 ppm at 15 days intervals.	12.66	24.07
T ₇	Control(untreated)	16.66	0
	C.D.	1.28	7.01
	SE(m)	0.41	2.25
	SE(d)	0.58	3.18
	C.V.(%)	6.13	12.85

Effect of IDM on growth and yield parameters

Integrated disease management practices significantly influenced leaf, inflorescence, stem and total plant yield of sweet basil. Treatment T₁ recorded the highest leaf, stem, inflorescence, and whole plant yield. Other treatments showed variable responses across different yield components. The improvement in yield parameters under IDM treatments can be directly linked to effective disease suppression, which reduced disease pressure and allowed better nutrient uptake, enhanced photosynthetic efficiency,

and improved plant vigor. Reduced pathogen stress under integrated disease management likely facilitated healthier root systems and improved physiological performance of the plants. Similar relationships between disease management and yield improvement have been reported earlier in crops affected by soil-borne pathogens Manjunatha *et al.* (2013) [12], Rathore *et al.* (2020) [16] and Godara and Suresh Kumar (2018) [7]. The lowest yields observed in the untreated control plots further confirm the detrimental impact of dry root rot on crop productivity under field conditions.

Table 2: Effect of disease management practices on leaf, inflorescence, and stem yield of sweet basil crop

Treatments	leaf yield ton/ha	inflorescence yield ton/ha	Stem-yield ton/ha	Whole plant yield ton/ha
T ₁	5.75	10.82	19.32	35.92
T ₂	4.90	9.12	17.75	31.79
T ₃	4.78	7.52	16.88	29.19
T ₄	4.63	9.00	15.66	29.32
T ₅	4.76	9.08	15.81	29.67
T ₆	4.99	8.94	15.59	29.53
T ₇	4.32	7.45	14.65	26.44
C.D.	0.35	0.57	0.92	0.88
SE(m)	0.11	0.18	0.29	0.28
SE(d)	0.16	0.26	0.41	0.40
C.V.	4.05	3.59	3.10	1.63

Effect of IDM on proximate composition

The proximate composition of healthy sweet basil leaves was analyzed using standard methods of A.O.A.C. (2010). Among the quality parameters studied, essential oil content, which is the major economic component of sweet basil, was found to be significantly higher in treatment T₁ (0.97%). In contrast, other proximate components such as moisture, fibre, protein, ash, and carbohydrate content did not show

significant variation among the treatments and were statistically comparable with the control. The absence of significant variation in most proximate composition parameters indicates that the applied disease management practices did not adversely affect the quality of sweet basil, while the increase in essential oil content under T₁ suggests a positive influence of bioagent-based treatment on crop quality.

Table 3: Influence of disease management practices on the proximate components of crop.

Treatments	Healthy leaf moisture%	Healthy leaf oil%	Healthy leaf fibre%	Healthy leaf protein%	Healthy leaf ash%	Healthy leaf carbohydrate %
T ₁	13.44	0.97	26.57	18.29	16	24.73
T ₂	17.64	0.75	22.78	12.56	16	30.25
T ₃	13.68	0.48	11.6	21.07	16	37.17
T ₄	14.63	0.94	14.35	15.33	15.66	39.07
T ₅	11.64	0.68	15.17	24.17	16.33	32.00
T ₆	12.52	0.87	20.16	17.96	14.66	33.81
T ₇	11.4	0.93	12.30	22.03	15.66	37.66
C.D.	3.81	0.03	1.05	0.70	1.84	4.48
SE(m)	1.22	0.01	0.33	0.22	0.62	1.44
SE(d)	1.73	0.01	0.47	0.32	0.88	2.03
C.V. %	15.63	2.67	3.33	2.09	6.85	7.43

Conclusion

Under field conditions, soil application of FYM (1 kg/m²) enriched with *Trichoderma viride* and *Pseudomonas fluorescens* (talc-based formulations @ 2.0%) at planting proved most effective in reducing dry root rot incidence of sweet basil. This treatment also resulted in maximum yield of leaf, inflorescence, and stem, while maintaining standard quality parameters. The highest leaf oil content, the most important economic trait of sweet basil, was also recorded under this treatment. The results indicate that integration of selected bio-agents with organic amendments offers an eco-friendly and sustainable strategy for managing dry root rot and improving crop productivity. However, multi-season and multi-location validation is required before large-scale adoption.

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