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Eco-Friendly Management of Rhizome rot and Wilt complex disease of Ginger in Hill Zone of West Bengal with emphasis on bacterial wilt

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Ginger cultivation in the hilly agro-climatic zone of West Bengal is confronted with significant challenges owing to the rhizome rot and wilt complex disease. This disease is caused by many pathogens, including *Ralstonia solanacearum*. The objective of this study was to create environmentally friendly strategies for disease management by integrating biological agents with fungicides. The two-year trial showed that the combination of *Trichoderma viride* and *Pseudomonas fluorescens*, followed by soil drenching with metalaxyl MZ, led to the lowest occurrence of disease. A correlation study demonstrated that there was a positive relation between disease incidence, elevated temperatures and rainfall. These findings highlight the need of employing integrated management strategies that take into account both biological and environmental aspects in order to effectively control diseases in ginger cultivation.

Keywords : Biological agents, Ginger disease, integrated management, *Ralstonia solanacearum*

INTRODUCTION

Ginger (*Zingiber officinale* Rose) has been cultivated for centuries in the hilly agro-climatic zone of West Bengal for its culinary as well as medicinal preparations. It is one of the main cash crops grown commercially, covering an area of nearly one thousand hectares with a production of 9.68 thousand metric tonnes. The average yield of this crop is much lower than its potential yield due to the attack of different diseases caused by fungi, bacteria, and nematodes, collectively called the rhizome rot and wilt complex (Sharma *et al*. 2002). Among these pathogens, a gram-negative, short-rod bacterium belonging to biovar III of the genus *Ralstonia solanacearum* (Sharma *et al*. 2017) is the most serious (Sarma and Anandaraj, 2000), followed by some species of fungi like *Fusarium* and *Pythium* and nematodes.The bacterial pathogen *Ralstonia solanacearum* was first described by Erwin F. Smith in 1896 in potatoes and tomatoes as *Bacillus solanacearum*. The soil- and seed-borne nature of this pathogen makes the disease very difficult to manage, and hundred percent yield loss has been reported in some places (Habetewold *et al*. 2015; Kassa *et al*. 2016). Initially, the disease appears as wilting and drooping of the lower leaves of the old shoots without yellowing. As the disease progresses, wilting and yellowing of the upper leaves take place. The infected rhizomes become water-soaked, the pseudo-stem can be pulled easily, which emits a foul smell. The bacterium enters the vascular system of the ginger plant and multiplies, thereby clogging the xylem and obstructing the transportation of water (Meng, 2013).The symptoms vary according to the pathogen, ginger varieties, growth stage of the crop, and environmental factors in fungal infection. However, in general, the infection starts as a water-soaked lesion at the collar region of the pseudostem and spreads to the rhizome and leaves, resulting in soft rot in the rhizomes and yellowing in the leaf tips, which slowly spread to the leaf blades.

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The variation in weather within a small area makes the area unique among the other parts of the nation, resulting in Darjeeling Hills being one of the richest bio-diversities in the world (Dikshit *et. al*. 2014), and several workers have worked on the effect of weather parameters on plant diseases (Ali *et al*. 2014). Considering this fact, a survey undertaken by the Regional Research Station of Uttar Banga Krishi Viswavidyalaya, Kalimpong, in 2005–06 indicated that the months of June and July were the peak periods for the dissemination of the disease. Considering the significance of ginger cultivation in the hills of West Bengal, an experiment was conducted to develop eco-friendly management practices by combining some bio-agents and fungicides at the Regional Research Station of the university in Kalimpong district.

MATERIALS AND METHODS

The experiment was conducted during the ginger growing season for two consecutive years (2021 and 2022) in the sick plot of the Regional Research Station (Hill Zone) of Uttar Banga Krishi Viswavidyalaya, located at Kalimpong Hills. The Kalimpong Hills lie between 26° 31' to 27° 13' N latitudes and 87° 59' to 88° 53' E longitudes and are situated at an altitude of about 1076 m above m.s.l. The average summer and winter temperatures are 24.6 °C and 15.2 °C, respectively. The ginger variety Gorubathaney was planted in plots measuring 3 x 3m during the 1st week of February in 2021 and 2022, respectively, following a standard package of practices. The experiment was conducted following a random block design (RBD) with seven treatments such as T_1: *Trichoderma viride*; T_2: *Pseudomonas fluorescens*; T_3: *T. viride* + *Pseudomonas fluorescens*; T_4: *T. viride* + *Pseudomonas fluorescens* + soil drenching with COC 2g l^{-1}; T_5: *T. viride* + *Pseudomonas fluorescens* + soil drenching with Mancozeb 2g l^{-1}; T_6: *T. viride* + *Pseudomonas fluorescens* + soil drenching with Metalaxyl MZ 1.0 g l^{-1}; T_7: Control (no management).

The bio-agents were applied 21 days before the planting after mixing them with well-decomposed FYM (10g kg^{-1} of FYM), followed by two soil drenching with fungicides at 30-day intervals, starting 15 days after the emergence of pseudostems. The population of pathogens was estimated before sowing and after harvest of the ginger crop. The percentage disease incidence (PDI) was recorded after every fifteen-day interval starting from 75 to 120 days after sowing (DAS) using the following formula :

$$PDI = \frac{\text{Number of infected/wilted plants X100}}{\text{Total number of plants}}$$

The results were correlated with weather parameters to examine the influence of weather parameters on severity of disease. The data on weather parameters maximum and minimum temperature (°C), morning and evening relative humidity (%) and rainfall (mm) were obtained from GKMS, AMFU, RRS (HZ), UBKV, Kalimpong.

RESULTS AND DISCUSSION

The cultivation of ginger in the Hill Zone has been depicted in Fig. 1 (A-D). Several workers have combined different management strategies to formulate the management strategy for the rhizome rot and wilt complex disease of ginger (Sharma *et al*. 2024). The present trial aims to develop eco-friendly management of rhizome rot and wilt complexes of ginger in the hilly agro-climatic zone of West Bengal by combining different bio-agents. The result of this trial is presented in Table 1. It appears from the Table that there was a significant difference among treatments for PDI and yield. It was further noted that the lowest disease incidence (3.173 to 12.7) was recorded in both years as compared to control when the combination of *T. viride* and *Pseudomonas fluorescens* was applied in soil, followed by soil drenching with Metalaxyl MZ 1.0 g l^{-1} (T_6). However, the highest disease incidence (6.35 to 25.39) was recorded when *Trichoderma viride* alone was applied (T_1).

Linear correlation coefficient analysis among weekly ginger wilt incidences with the preceding week's weather parameters was worked out and presented in Table 2. Disease development under natural conditions was found to be influenced by environmental factors. We recorded observations from the 25th standard meteorological week (SMW). The first appearance of the disease was

Table 1 : The percentage disease incidence of bacterial wilt in different treatments

Treatments	75 DAS		90 DAS		105 DAS		120 DAS	
	2021	2022	2021	2022	2021	2022	2021	2022
T_1	6.35 (2.681)	7.93 (2.962)	12.69 (3.687)	12.81 (3.668)	14.29 (3.910)	23.87 (4.972)	19.0 (4.455)	25.39 (5.133)
T_2	12.69 (3.655)	14.34 (3.883)	15.87 (4.098)	15.93 (4.105)	22.33 (4.826)	19.10 (4.462)	27.0 (5.286)	26.98 (5.285)
T_3	11.11 (3.465)	11.11 (3.465)	14.28 (3.876)	12.69 (3.687)	17.57 (4.301)	17.52 (4.240)	22.2 (4.812)	22.22 (4.776)
T_4	4.76 (2.400)	7.93 (2.962)	11.11 (3.465)	9.52 (3.184)	12.69 (3.687)	12.69 (3.687)	15.9 (4.101)	19.16 (4.469)
T_5	1.59 (1.467)	6.35 (2.681)	6.35 (2.681)	9.52 (3.184)	14.36 (3.885)	9.52 (3.184)	15.9 (4.097)	12.69 (3.687)
T_6	0.00 (1.00)	3.17 (1.933)	3.17 (1.933)	6.35 2.681)	11.11 (3.465)	7.93 (2.962)	12.7 (3.688)	11.11 (3.465)
T_7	15.93 (4.105)	17.58 (4.302)	23.80 (4.965)	22.33 (4.826)	25.39 (5.133)	30.16 (5.557)	27.0 (5.287)	27.00 (5.287)
C.D.	0.713	1.03	0.801	0.961	0.618	1.057	0.678	0.756
SE(m)	0.229	0.331	0.257	0.309	0.199	0.339	0.218	0.243
SE(d)	0.324	0.468	0.363	0.436	0.281	0.48	0.308	0.343
C.V.	14.784	18.066	12.613	14.764	8.241	14.157	8.32	9.161

(Figures in the parenthesis are transformed values)

Table 2: Correlation coefficient of rhizome rot and wilt complex of ginger with weather parameters

Variables	2021	2022
PDI	1	1
Maximum temperature	0.940	-0.182
Minimum temperature	0.861	0.581
Minimum relative humidity	-0.819	0.814
Maximum relative humidity	-0.933	0.857
Rainfall	0.071	.988*

observed 75 days after planting (DAP) in 2021 and 2022 respectively, which progressed thereafter. It is revealed from data (Table 1) that disease incidence varied from 1.59 to 27.0 percent during the year 2021 and from 3.17 to 30.16 percent during 2022. The maximum percentage of disease incidence was observed during the first week of August 2021 and 2022, respectively.

Fig.1 :(A-D): Ginger cultivation. A- Seed Rhizome selection; B- Experimental field after mulching; C-Planting of Ginger; D-Ginger three months after planting

The results indicated a highly significant correlation between disease incidence and maximum temperature (0.940), minimum temperature (0.861), and rainfall (0.071), while it was negatively correlated with minimum relative humidity (-0.933) and maximum relative humidity (-0.819) during the year 2021. However, a negative correlation with maximum temperature (-0.182) and a positive correlation with minimum temperature (0.581), minimum relative humidity (0.814), maximum relative humidity (0.857), and rainfall (0.988) were observed in 2022.

The correlation result of bacterial wilt incidence to weather parameters shows that high rain fall and high temperature were found to have a positive and significant correlation, whereas low daily temperature and low rainfall were found to be negatively correlated. It was also noted that pH, soil, air temperature and moisture have a great influence and relationship on the survival and incidence of the pathogen (Jibat and Alo, 2020).

CONCLUSION

The study investigated eco-friendly ginger rhizome rot and wilt complex disease control in West Bengal's hilly agro-climatic zone. The lowest disease incidence was achieved *using Trichoderma viride* and *Pseudomonas fluorescens*, followed by soil drenching with metalaxyl MZ. High temperatures and rainfall have been positively associated with disease incidence, according to a correlation study. These findings emphasized the need for coordinated biological and environmental disease management in ginger cultivation.

DECLARATION

Conflict of interest. Authors declare no conflict of interest.

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