ENHANCEMENT OF SYSTEMIC RESISTANCE TO SOIL BORNE PATHOGENS OF GINGER BY ENRICHED SPENT MUSHROOM SUBSTRATE OF *Pleurotus sajor-caju*

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ABSTRACT OF THE THESIS
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ABSTRACT

Spent mushroom substrate (SMS) is the composted organic material retained after a crop of mushroom. The world mushroom industry needs to discard more than 50 million tons of SMS every year. The latest research throw light on the efficient use of SMS for the disease management of crop plants. A preliminary study on the use of SMS of *Pleurotus* spp. as mulch for the management of rhizome rot complex disease of ginger under pot culture condition was carried out in the Department of Plant Pathology, College of Horticulture, Vellanikkara. In this study, among the various SMS used, the paddy straw SMS of *P. sajor-caju* as mulch recorded the highest biometric characters and least disease incidence compared to control. Hence this project was proposed as the continuation of the above study to evaluate the efficacy of enriched SMS of *P. sajor-caju* in enhancing growth and systemic resistance for the management of soil borne pathogens of ginger under field conditions.

SMS of *P. sajor-caju* was produced during three different periods viz., March-April, June-July and November-December (2013) at six different locations of Kerala viz., College of Horticulture, Vellanikkara (Thrissur dist.), farmer’s field at Kodakara (Thrissur dist.), Perinjanam (Thrissur dist.), Krishnagiri (Wayanad dist.), Mananthavady (Wayanad dist.) and College of Agriculture, Vellayani (Thiruvananthapuram dist.). Enumeration of microflora of these SMS was carried out and a total of 47 fungal and 45 bacterial isolates were obtained. The antagonistic efficiency of these isolates were evaluated against the five pathogens viz., *Pythium aphanidermatum, Fusarium oxysporum, Rhizoctonia solani, Sclerotium rolfsii* and *Ralstonia solanacearum* under *in vitro* conditions. All the isolates from SMS showed antagonistic property against one or the other soil borne pathogens, with varying degree of inhibition. Mutual compatibility between the most efficient fungal and bacterial antagonists was evaluated to develop an effective microbial consortium for enriching the SMS and could be used against the soil borne diseases of ginger.
Biosoftening efficiency of selected fungal and bacterial antagonists on SMS was evaluated. Two separate experiments were carried out with the selected antagonists effective against fungal and bacterial pathogens. For each experiment, five fungal antagonists, five bacterial antagonists and three compatible pairs were selected based on the *in vitro* evaluation of antagonistic efficiency and mutual compatibility studies. SMS was enriched separately with different antagonists and standardized the period for biosoftening of SMS as mulch for ginger cultivation. A period of 15 days was selected as most suitable for biosoftening the SMS as mulch with optimum antagonistic fungal and bacterial population. Wide range of C:N ratio was recorded by the SMS enriched with each antagonists. By considering the C:N ratio along with external appearance, the treatments having C:N ratio of 30:1 to 45:1 were selected, since it was the most suitable stage to be used as mulch in ginger.

The effectiveness of biosoftened SMS against rhizome rot and bacterial wilt diseases of ginger was evaluated in two pot culture experiments. Three fungal and bacterial antagonists each and one compatible pair of antagonists which were selected based on the *in vitro* evaluation of antagonistic and biosoftening property were used for enriching the SMS. After enrichment, the SMS were kept for 15 days for biosoftening and were applied as mulch in the experiments. Observations on germination percentage and other growth parameters *viz.*, number of tillers/plant, number of leaves/tiller and height of tillers were recorded at one month intervals from two months after planting (MAP). Challenge inoculation of pathogens was done at 45 days after germination and per cent disease incidence was recorded at 7 and 14 days after inoculation (DAI).

In the experiment for the management of *P. aphanidermatum*, the lowest disease incidence was observed in T7 (SMS softened with P1F1, M1F2) on 14th day after inoculation (DAI). This treatment also recorded the highest number of tillers, number of leaves/tiller and height of tillers and rhizome yield. In the experiment for the management of *R. solanacearum*, the treatment T2 (SMS softened with T1F2) was found to be the most efficient one, which recorded the least disease
incidence at 14 DAI, whereas the highest values for biometric characters and rhizome yield were recorded by T_7 (SMS softened with K_1B_1 + T_2B_1).

The activity of phenol and defense related enzymes such as peroxidase (PO), polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL) were estimated by spectroscopy, before challenge inoculation with pathogen and at one, three and five days after the challenge inoculation. For estimation, leaf samples were collected separately from the pot culture experiments I and II for the management of *P. aphanidermatum* and *R. solanacearum* respectively. The treatments which recorded less disease incidence in both the pot culture experiments exhibited the highest activity of defense related enzymes and phenol. The highest activity of defense related enzymes and phenol was recorded at 5 DAI. Thus the present study showed that in addition to direct antagonism and plant growth promotion, induction of defense related enzymes was also contributed by SMS to enhance resistance against invasion of soil borne pathogens of ginger.

Field evaluation of the selected treatments from pot culture experiments showed the lowest disease incidence in the treatment T_2 (SMS softened with T_1F_2) followed by T_5 (SMS softened with P_1F_1+M_1F_2). Statistically these were on par with each other. The treatment T_5 (SMS softened with P_1F_1+M_1F_2) recorded the highest germination percentage, number of tillers, number of leaves/tiller and rhizome yield also. Analysis of primary nutrients *viz.*, nitrogen, phosphorus and potassium in SMS, plant and soil from field experiment was conducted. Among these, SMS softened with P_1F_1+M_1F_2 recorded the highest percentage of N, P and K. This treatment recorded the highest nutrient content in ginger rhizome and soil also.

Attempts were also made to identify the fungal and bacterial antagonists selected for field experiment. Based on the cultural and morphological characters, the fungal antagonists *viz.*, Kr_1F_4, T_1F_2, P_1F_1 and M_1F_2 were tentatively identified as *Trichoderma viride* (Pers.), *T. viride* (Pers.), *T. koningii* (Oudem.) and *T.*
*harzianum* (Rifai) respectively. The identification got confirmed from National Centre for Fungal Taxonomy (NCFT), New Delhi. The bacterial antagonists selected for field experiment were also identified based on cultural, morphological, biochemical and 16s rRNA sequence analysis. The three bacterial antagonists P₃B₂, T₂B₁ and K₁B₁ were identified as *Bacillus safensis*, *B. methylotrophicus* and *Burkholderia gladioli* respectively.

Spent mushroom substrate is rich in microflora and these microflora exert antagonistic activities against soil borne pathogens. It stimulates the natural defense system in plants, provide necessary nutrients for plant growth and also improve soil physical condition. From field evaluation it was found that the SMS softened with *T. viride* recorded the lowest disease incidence and which enhanced systemic resistance to soil borne pathogens of ginger by defense related enzymes and phenol. The results were on par with the SMS softened with consortium of antagonists, *T. koningii* and *T. harzianum* (P₁F₁+M₁F₂). The highest rhizome yield and other growth parameters were also contributed by the SMS softened with *T. koningii* and *T. harzianum*. The content of nitrogen, phosphorus and potassium were also recorded the highest in this SMS. So from the present study it can be concluded that the SMS softened with *T. koningii* and *T. harzianum* can be used as mulch in ginger which was found equally effective to induce systemic resistance against soil borne pathogens and to enhance growth parameters and rhizome yield.