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Eco-friendly management of incitant *Rhizoctonia solani*, the causing sheath blight in Kodo millet

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Abstract
Sheath blight caused by *Rhizoctonia solani* is one of the most serious diseases worldwide. The disease is currently managed only by the excessive application of chemical fungicides which are toxic and not environmentally friendly. Therefore, greater emphasis should be given to biological control as being both safe and effective. A field experiment was conducted during *kharif* 2017, at Agricultural Research Station, Vizianagaram for the management of banded sheath blight disease in kodo millet by using potential biocontrol agents *viz*., *Bacillus subtilis, Pseudomonas fluorescens* and *Trichoderma asperellum*. Lowest sheath blight intensity (49.33%) was recorded in T_7 *i.e.* soil application of value added *P. fluorescens* + *T. asperellum* + *B. subtilis* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) followed by 53.33% in T_1 *(i.e.,* Seed treatment with *Trichoderma asperellum* @ 10 g/kg) and the highest (61.33%) in T_6 whereas it was 76.00% in the control. And high grain (1274.07 kg/ha) and fodder yield (2233.33 kg/ha) was found in T_7 whereas, it was 459.26 kg/ha and 1390.30 kg/ha in the control respectively. In mean of all locations the lowest sheath blight intensity (22.11) was recorded in T_7 *i.e.* soil application of value added *P. fluorescens* + *T. asperellum* + *B. subtilis* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) and the highest (31.31%) in T_3 whereas it was 41.24% in the control.

Keywords: Kodo millet, bio control, *R. solani*

Introduction
Kodo millet (*Paspalum scrobiculatum*) is one of the hardiest crops grown in Madhya Pradesh, Maharashtra, and Uttar Pradesh and various other parts of India. Minor millets like kodo is also described as nutritious millet and has received far less research and development attention than other crops with regard to crop improvement and utilization. It is the main source of protein and minerals in the daily diets of tribal and weaker section living in remote rural areas. Millets are nutritionally superior than other cereals. The millet contains a high proportion of complex carbohydrate and dietary fiber which helps in prevention of constipation and slow release of glucose to the blood stream. Glycemic index is an important tool used in treating people with diabetes, cardiovascular disease management and weight regulation programs. Millets including Kodo contain water soluble fiber and this property may be utilized for maintaining or lowering blood glucose response among diabetic and CVD patients. Glycemic load (GL) representing both quality and quantity of carbohydrate in a food and allows comparison of the likely glycemic effect of realistic portion of the different foods (Neelam, *et al.*).

Banded blight of kodo millet incited by *Rhizoctonia solani* (Kuhn.) (Basidial stage: *Thanatephorus cucumeris* (Fr.) Donk) is one of the emerging malady in it's successful cultivation. Lalu Das and Girija (1989) for the first time reported as sheath blight of ragi from Vellayani in Kerala, where it occurred in a severe form. The disease was observed in severe form at the Agricultural Research Station in Vizianagaram, The widespread adoption of new, susceptible, high-yielding cultivars with large numbers of tillers, and the changes in cultural practices associated with these cultivars, favor the development of sheath blight and contribute greatly to the rapid increase in the incidence and severity of this disease in rice-producing areas throughout the world (Groth *et al*. 1991; Rush and Lee, 1992) [8, 19]. Furthermore, environmental conditions such as low light, cloudy days, high temperature and high relative humidity also favor the disease (Ou, 1985) [14]. The pathogen overwinters as soil-borne sclerotia and mycelium in plant debris; these constitute the primary inoculums. The disease is characterized by oval to irregular, light grey to dark brown lesions on the lower leaf sheath. In advanced stages, the lesions enlarge rapidly and coalesce to cover large portions of the sheath and leaf lamina. At this stage, the disease symptom is characterized by a series of copper or brown color bands across the leaves giving a very characteristic banded appearance.

Control of the pathogen is difficult because of its ecological behavior, its extremely broad host range and the high survival rate of sclerotia under various environmental conditions (Groth *et al*. 2006) [9]. In the absence of a desired level of host resistance, the disease is currently managed by excessive application of chemical fungicides, which have drastic effects on the soil biota, pollute the atmosphere, and are environmentally harmful. Some potentially effective fungicides are highly phytotoxic to the crop and, if the disease is not severe, these fungicides may reduce yield (Groth *et al*. 1990) [7]. It is difficult to achieve control through host resistance or fungicides, therefore, biological control may be effective in minimizing the incidence of sheath blight (Das and Hazarika, 2000) [3]. So an experiment was conducted at Agricultural Research Station, Vizianagaram during *Kharif* 2017.

Materials and Methods

A field experiment was conducted during *kharif* 2017, at Agricultural Research Station, Vizianagaram for the management of banded blight disease in finger millet by using potential biocontrol agents like *Bacillus subtilis*, *Pseudomonas fluorescens* and *Trichoderma asperellum*. These isolates were collected from Department of Biological control, Vizianagaram. The experiment was laid out in randomized block design (RBD) with three replications at spacing of 22.5×10 cm with 3×3 m plot size. Standard agronomic practices of NPK-50kg, 40kg, 25kg were followed at the time of crop growth period. A susceptible variety (Co 3) was used in this experiment by imposing the following treatments: (Table 1)

The disease severity and yield were recorded and the data was statistically analysed by following the standard procedures (Gomez and Gomez, 1984) [5]. Banded blight (Anon, 1996) [1] was recorded by using 0 to 9 scale (Table 2). The percent disease index (PDI) was calculated by using the following formula:

$$\text{PDI} = \frac{\text{Sum of all the numerical ratings}}{\text{Number of observations} \times \text{Maximum disease grade}} \times 100$$

Table 1: Treatments

T1	Seed treatment with *Trichoderma asperellum* @ 10 g/kg
T2	Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg
T3	Seed treatment with *Bacillus subtilis* @ 10 g/kg
T4	Soil application of value added *P.f.* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) applied over an acre at the time of sowing
T5	Soil application of value added *T.a.* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) applied over an acre at the time of sowing
T6	Soil application of value added *B.s.* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) applied over an acre at the time of sowing
T7	Soil application of value added *P.f.* + *T.a.* + *B.s.* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) applied over an acre at the time of sowing
T8	Control

Table 2: Standard Evaluation System (SES) scale for sheath blight disease

Score	Description	Reaction
0	No incidence	No disease/HR
1	Vertical spread of the lesions up to 20% of plant height	R
3	Vertical spread of the lesions up to 21-30% of plant height	MR
5	Vertical spread of the lesions up to 31-45% of plant height	MS
7	Vertical spread of the lesions up to 46-65% of plant height	S
9	Vertical spread of the lesions up to 66-100% of plant height	HS

Statistical analysis: The data was analyzed by applying statistical tools of ANOVA (Analysis of variance) technique for drawing conclusions from the data. Critical difference (C.D) was calculated to see the significant and non-significant difference between the mean values of sheath blight PDI in all the treatments.

Results and Discussion

All the treatments were found significantly superior over check in controlling the disease. Among all the treatments tested, the lowest sheath blight intensity (49.33%) was recorded in T_7 *i.e.* soil application of value added *P. fluorescens* + *T. asperellum* + *B. subtilis* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) followed by 53.33% in T_1 *(i.e.,* Seed treatment with *Trichoderma asperellum* @ 10 g/kg) and the highest (61.33%) in T_6 whereas it was 76.00% in the control. And high grain (1274.07 kg/ha) and fodder yield (2233.33 kg/ha) was found in T_7 whereas, it was 459.26 kg/ha and 1390.30 kg/ha in the control respectively (Table 3).

Table 3: Management of banded sheath blight in Kodo Millet

Treatments	Sheath blight (Vizianagaram)	Grain Yield (Kg/ha)	Fodder Yield (Kg/ha)	Sheath blight (Mean of all centres)	Grain Yield (Kg/ha)	Fodder Yield (Kg/ha)
T_1	53.33	1255.56	2131.44	25.87	1662.47	2291.85
T_2	59.33	992.59	1638.22	28.22	1688.03	2135.00
T_3	65.33	751.85	1506.38	31.31	1682.84	2140.93
T_4	58.67	1033.33	1659.26	26.41	1608.77	2101.11
T_5	54.67	1225.93	2040.74	24.00	1604.57	2425.37
T_6	61.33	840.74	1588.89	29.89	1442.47	1942.59
T_7	49.33	1274.07	2233.33	22.11	1671.36	2695.37
T_8 (Control)	76.00	459.26	1390.30	41.24	1141.98	1794.07

Mean	59.75	979.17	1773.61	28.63	1562.81	2190.79
CD	10.27	233.26	365.87	7.42	293.54	502.54
CV %	9.82	13.60	11.78	14.79	10.73	9.70

In mean of all locations the lowest sheath blight intensity (22.11) was recorded in T_7 *i.e.* soil application of value added *P. fluorescens* + *T. asperellum* + *B. subtilis* (one kg talc formulation mixed in 25 kg FYM or vermicompost, incubated for 15 days) and the highest (31.31%) in T_3 whereas it was 41.24% in the control.

Patro and Madhuri (2014) reported that *P. fluorescens* + *T. harzianum* followed by *P. fluorescens* alone and *T. harzianum* alone are effective against *R. solani*. Pal *et al.* (2015) revealed that seed treatment + 3 spraying with *T. viride* @ 1% was the most effective bio control treatment recording 10.93% pooled PDI against 34.41% in control plot and its performance was at par with the standard fungicide propiconazole @ 1%. The treatment also exhibited maximum increase in all the yield attributing factors recorded and gave a yield increase of 41.1% over control. The interaction between host and pathogen resulted significant changes in morphological, phenological parameters, which influence the yield and yield traits adversely, there was significant reduction in grain yield plant and fodder yield plant ranging from 2.1 to 18.5% and 8.5 to 26.6%, respectively was recorded in *Rhizoctonia solani* affected plants of little millet (Shailendra Singh Chouhan, 2014) [20]. Srinivas *et al.* (2013) [22] depicts that all the bio-agents stopped the growth of *R. solani* after contact. The order of percent inhibition of *Trichoderma viride* (72.65%)> *Penicillium notatum* (64.07%)> *T. atroviride* (62.51%)>*T. harzianum* (42.18%)> *T. longibrachiatum* (38.29%)> *T. koninzii* (3.14%)> *Aspergillus niger* (1.57%). *T. harzianum* (ThF2-1) gave the maximum inhibition of *R. solani* 618 (Montealegre *et al*. 2014) [11]. Huang *et al* (2012) [10] reported that *B. pumilus* SQR-N43 is a potent antagonist against *R. solani* Q1. *T. harzianum* (Jn14) and *T. hamatum* (T36) were the most effective isolates to inhibit *R. solani* mycelial growth (Barakhat *et al*. 2007) [2]. *Trichoderma* strains were effective both *in vitro* and *in vivo* was reported by Das and Hazarika (2000) [3] and Tewari and Singh (2005) [23] who all found that *T. harzianum* was an effective BCA in controlling rice sheath blight. Patro *et al.* (2017) [4] results revealed that KAVT 5, KAVT 20 and KAVT 22 were found as resistant genotypes. Patro (2016) [15] recorded resistant varieties in Kodo millet under *in-vivo* conditions.

It is also possible to state that the signs that BCAs will be able to control sheath blight are good. Supplementing biological control with other, non-chemical control methods will improve disease control still more. On the other hand, biological control with the antagonists will lower the dependency on synthetic will it is hoped lead to a cleaner environment and healthier foods.

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