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Research Article

Evaluation of bio inoculants fortified Lignite Fly Ash (LFA) against sheath blight (*Rhizoctonia solani Kuhn*) and sheath rot (*Saracladium oryzae* (Sawada) Games and Haksworth) diseases of rice in Cauvery delta region of Tamil Nadu

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ABSTRACT: Sheath blight and sheath rot are the major diseases of rice in Tamil Nadu particularly in Cauvery delta region. Pot culture and field trials were conducted to evaluate the efficacy of consortia application of ecofriendly components viz., Fortified Lignite Fly Ash (LFA), Annamalai Mixture and antagonistic microorganisms against the sheath blight and sheath rot diseases and yield parameters during the kuruvai and samba season of 2016. Among the different combination of eco-friendly components, combined application of *Pseudomonas fluorescens and Bacillus subtilis* as seed treatment@ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage and boot leaf stage plus Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage significantly reduced sheath blight and sheath rot disease incidence in pot culture and field condition. The same treatment recorded the maximum grain yield. All the ecofriendly components treated plants significantly decreased the diseases incidence and increased the grain yield as compared to control.

KEY WORDS: Annamalai Mixture, Antagonistic microorganisms, Fortified Lignite Fly Ash, Sheath blight, sheath rot

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INTRODUCTION

Rice (*Oryzae sativa* L.) is the most important food for over two billion people in Asia. Rice constitutes about 45 percent of total cereal production of India and is the main food source for more than 60 percent of the country's population. In India the crop is cultivated in about 43.85 m ha area with an annual production of 104.79 m tons (www.indiastat.com, 2016). The average productivity is 2002.1 kg/ha. In Tamil Nadu rice crop (paddy) is predominantly grown in the Cauvery delta region which is also known as rice bowl of Tamil Nadu.

As many as 43 diseases are reported on rice (Fakir,2000).Rice crop is suffering from sheath blight caused by *Rhizoctonia solani* Kuhn and sheath rot caused by *Saracladium oryzae* (Sawada) Games and Haksworth are the major diseases in all rice growing areas in the world. The disease sheath blight can cause yield loss of 5.2 - 50 per cent depending on environmental conditions and crop stages (Rajan 1987; Sharma *et al*, 1994). Sheath rot disease of rice yield loss varies from 9.6 to 85% (Sakthivel, 2001). This diseases of rice are being controlled specially by sowing of seed treated with fungicides and fungicide application in the field that break down the natural ecological balance. The use of eco-friendly management practices

may help in avoiding environmental pollution as well as increase the production of pesticide free rice. Considering the above facts the present study was undertaken to find out the efficacy of different eco-friendly management practices of rice diseases for successful crop production.

MATERIALS AND METHOD

Isolation and multiplication of fungal pathogens

The isolate was obtained from rice variety ADT - 36. The infected portion of the leaf sheath along with healthy tissue was cut into small pieces. Infected tissues were separately surface-sterilized by washing with sterilized water and then immersing in 10% bleach solution for 2 min. The samples were rinsed twice with sterile water and blotted dry. The blotted dry leaf sheath of each sample were placed on 2-3 layers of moist blotting paper in Petri dishes and incubated at 21° ± 1°C under 12-h alternate exposure to near ultraviolet light and darkness for 3-4 days. The fungus developed and sporulated on the infected leaf tissue. Using a low-power stereomicroscope, a few conidia were removed with a needle spread onto potato dextrose agar (PDA) medium. The inoculated Petri dishes were then placed in an incubator at 28°C for 3 days (Chowdhury *et al.*2015).

Rice hull and rice grain were added proportionately and thoroughly mixed, transferred to open mouthed bottles and closed with a cotton wool plug. The desired quantity of water was added. The bottles were sterilized at 15psi for 2 hr for two successive days. The medium was used to grow *R. solani* pathogen. From seven days old culture of the pathogen grown in PDA, six discs of nine mm were taken and inoculated into each bottle. The bottles were then incubated at room temperature (28°C) for 14 days and the inoculum thus prepared was used for subsequent studies(Anonymus, 2012).

The isolate of *S. oryzae* was also isolated and multiplied as described above.

Inoculation of the pathogens

The isolates *Rhizoctonia solani* and *Saracladium oryzae* spore coated Rice hull and rice grain are inserted in the sheath region of the plant at early boot stage (Anonymus, 2012).

Preparation of Ecofriendly components

Preparation of bio inoculants

Pseudomonas fluorescens and *Bacillus subtilis* were isolated from the rhizosphere soil of healthy rice cultivating fields by serial dilution technique and prepare as talc based formulation (Vidhyasekaran and Muthamilan 1995)

Preparation of Annamalai mixture

The combined formulation of cow urine, cow dung, sheep dung, poultry litter and neem cake at 100% concentration were taken and mixed thoroughly at the ratio of 1:1:1:1:1(Kurucheve*et al.*, 1999).

Selected animal dungs (cow dung, sheep dung) were collected, shade dried for 1 week and made into powder. The powdered animal dungs were soaked in sterile distilled water and kept overnight. The materials were then filtered through cheese cloth. This formed the standard animal dung extracts solution (100 per cent). Freshly as such forming the standard extracts (100 per cent). Freshly collected urine was used as such forming the standard extract (100 per cent).

Preparation of Fortified Lignite Fly Ash (John Christopher and Kavi Newton, 2017)

Strain of *Pseudomonas fluorescens* and *Bacillus subtilis* were grown in nutrient broth for 48hrs as a shake culture in rotary shaker at150 rpm. At room temperature (25±2°C).Lignite fly ash (class F) was collected from Neyveli lignite corporation, Neyveli. One kg of lignite fly ash was added with 10g of carboxymethylcellulose and mix well. This carriers were autoclaved for 30 min of two consecutive days. One kg of carrier material was added with

Four hundred ml of the each bacterial suspension, containing 9×10^8 colonyforming units (CFU) plus 20 ml of molasses and mixed well and shade dry for 2 hrs under sterile conditions. The above mentioned product is named as Fortified lignite fly ash. Then packed in polythene bags, sealed and stored at room temperature (25±2ÚC). The population of *P. fluorescens* and *B. subtilis* were estimated at monthly interval upto 3 months by using serial dilution technique.

Pot culture experiment

The pot culture study was conducted with 8 treatments and three replications each at Department of Plant Pathology, Annamalai University, Annamalainagar from April to July 2016. Fifteen kg of top soil, collected from a rice growing field, was steam pasteurized and filled in 45 x 30 cm size cement pots. Thirty days old seedling of rice ADT 36 was transplanted in pot. The Ecofriendly components *viz*., *P. fluorescens*, *B. subtilis*, Annamalai mixture, and Fortified lignite fly ash were tested against sheath blight (*R. solani)*and sheath rot (*S. oryzae)*of rice.

The talc based formulation of *P. fluorescens* and *B. Subtilis* were used @ 2 x 10^{-8} CFU g^{-1}. The seeds were treated @ 10 g / kg of seed and dried in shade condition for four hours before sowing, 0.2% conc. of talc based formulation *P. fluorescens* and *B. Subtilis* were used as foliar application and talc based formulation of *P. fluorescens* and *B. Subtilis* were applied to the soil @ 10kg/ha. Newly formulated lignite fly ash was applied to the soil @ 40kg/ha at the time of transplanting in dust formulation and applied to the foliar @ 30kg/ ha during the late booting stage as dust formulation. Twenty per cent conc. of Annamalai Mixture was used for seed treatment and also used as foliar spray during the tillering stage @ 20 lit/ha. The chemical Tricyclazole was used for foliar spray @ 0.6 g/lit as standard chemical check. The artificial inoculation of *R. solani* and *S. oryzae* by insertion placement with spore coated Rice hull and rice grain method into the rice sheath. The inoculated plants were kept in the laboratory for 24 hours to maintain a high relative humidity and subsequently moved to a green house maintained at 28±2°C, 70 to 90% relative humidity, under a light intensity of 85 µmol m-1 S-1, 12 hour photoperiod and subsequently transferred to pot culture yard. The treatments were designed on the basis of the above phenomena and depicted in Table. The disease incidence was assessed at 30th, 45th and 60th DAT.

Assessment of the disease severity

Twelve plants from each pot were randomly selected and tagged for grading the severity of diseases. The severity of two diseases *viz*. sheath blight and sheath rot were recorded following IRRI recommended grading scale (StandardEvaluationSystemforRice,1980). The disease severity was recorded in the three growth stage of the plant namely boot leaf stage, flowering stage and milking stage. The grade of different diseases is given below:

Sheath blight and sheath rot

Disease severity of sheath blight and sheath rot was measured on a 0-5 scale of Standard Evaluation System for Rice (Groth *et al*., 1993)0 = No infection, 1 = Less than 5 per cent of the area of leaf sheath affected, 2 = 6-10 per cent of the area of leaf sheath affected, 3 = 11-25 per cent of the area of leaf sheath affected, 4 = 26-50 per cent of the area of leaf sheath affected, 5 = More than 50 per cent of the area of leaf sheath affected.

Disease severity was then calculated using the following formula:

$$\textbf{Disease severity} = \frac{\sum \mathbf{n} \times \mathbf{v} \times \mathbf{100}\ \%}{\mathbf{N} \times \mathbf{V}}$$

Where, n = number of leaves infected by blast, v = value score of each category attack, N = number of leaves observed and V = value of the highest score.

Field trial

The field trial was conducted during kuruvai season at Kannangudi, Chidambaram, Cuddalore district, Tamil Nadu during April to July 2016 and samba season at Kallour, Trichy district, Tamil Nadu, in a field with a history of sheath blight and sheath rot disease incidence of rice. The trial were laid out in plots (4m x 4m) arranged in a randomized block design. Thirty days old seedlings were planted into the field plots in rows with row / plants spacing of 15 X 10 cm. Three replicated plots were maintained for each treatment. Treatment application details and experimental observation were the same as in green house experiment. Regular cultivation practices were followed as per the recommendation.

Experimental design and data analysis

Data were analyzed using GENSTAT computer statistical package for ANOVA to determine significant differences between treatments. Comparison between means was done using Duncan's Multiple Range Test(DMRT). A regression analysis was done to find out the correlation between the disease levels and percent loss in yield.

RESULTS AND DISCUSSION

Effect of eco friendly components against sheath blight and sheath rot diseases of rice

Pot culture condition:- The pot culture experiment was carried out to evaluate the effect of eco friendly components *viz*., *P. fluorescens* and *B. subtilis,* Annamalai mixture and Fortified lignite fly ash against sheath blight (*R. solani)* and sheath rot (*S. oryzae)* disease incidence of rice. All the ecofriendly components significantly reduced the sheath blight and sheath rot disease incidence than the control (Table1). Among the treatments, combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage along with Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage (T_5) significantly reduced sheath blight disease incidence of 10.11, 11.62and 13.77 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 11.54, 13.05 and 15.87 per cent at 30, 45 and 60 DAT respectively, it is superior than the standard chemical check Tricyclazole. Seed treatment @ 2g/kg and foliar application @ 0.6g/lit of Tricyclazole, at tillering and boot leaf stage (T_6) which recorded sheath blight disease incidence of 12.16, 13.21and 15.89 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 13.39, 15.31 and 17.45 per cent at 30, 45 and 60 DAT respectively, and followed by combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus Annamalai Mixture as seed, foliar spray @ 20 lit /ha at tillering stage and boot leaf stage(T_3) which recorded sheath blight disease incidence of 13.33, 14.35and 16.07 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 14.78, 16.71 and 18.24 per cent at 30, 45 and 60 DAT respectively. The treatments T_3 and T_6 were statistically on par with each other. All ecofriendly components treated plants significantly increased grain yield as compare to control. The results of the present investigation indicates that combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage along with Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage (T_5) significantly increased the grain yield (32g/plant) than other treatments.

Field trial:- (season-1 kuruvai and **season-2 samba)**The field experiment of kuruvai season 2016 revealed that, combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage along with Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage (T_5) showed significantly reduced the incidence of sheath blight disease 7.16, 9.12 and 11.13 per cent at 30, 45 and 60 DAT respectively and sheath rot disease 6.71, 10.80

and 12.90 per cent at 30, 45 and 60 DAT respectively, It was significantly superior than the standard chemical check Trycyclazole T_6, which recorded sheath blight disease incidence of 9.32, 12.17 and 17.18 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 8.62, 12.63 and 14.84 per cent at 30, 45 and 60 DAT respectively, and Combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus Annamalai Mixture as seed, foliar spray @ 20 lit /ha at tillering stage and boot leaf stage(T_3) which recorded sheath blight disease incidence of 10.12, 13.90 and 18.69 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 9.04, 13.95 and 15.08 per cent at 30, 45 and 60 DAT respectively. The treatments T_3 and T_6 were statistically on par with each other. The study showed that not only inhibiting the diseases incidence and also significantly enhance the yield. The plants treated with combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage along with Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage (T_5) recorded the maximum grain yield (3680.34 kg/ha) than all other treatments. All ecofriendly components treated plants significantly increase the grain yield as compare to control.

The field trial was also conducted during the samba season in 2016 which also observe similar trend. The treatment T_5 showed significantly reduced the incidence of sheath blight disease 9.81, 10.02 and 12.34 per cent at 30, 45 and 60 DAT respectively and sheath rot disease 7.32, 9.15 and 11.87 per cent at 30, 45 and 60 DAT respectively, It was significantly superior than the standard chemical check Trycyclazole T_6, which recorded sheath blight disease incidence of 11.28, 13.47 and 18.98 per cent at 30, 45 and 60 DAT respectively and sheath rot disease incidence of 9.21, 13.31 and 15.42 per cent at 30, 45 and 60 DAT respectively. Similarly the plants treated with combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage plus spraying Annamalai Mixture @ 20 lit /ha at tillering stage along with Fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage (T_5) recorded the maximum grain yield (3596.43 kg/ha) than all other treatments. All ecofriendly components treated plants significantly increase the grain yield as compare to control. The chemical treatment (T_6) required 240 grams of Trycyclazole its cost around 500 rupees and the best treatment (T_5) cost around 400 rupees .The best treatment was significantly less expensive than the chemical treatment and also eco friendly.

Sheath blight and sheath rot disease are the most important diseases of rice in Tamil Nadu. Therefore under intensive rice cultivation in Cauvery delta region of Tamil Nadu, there is an urgent need for the development of alternative pest and disease control methods to reduce synthetic chemicals. Karpagavalli and Ramabadran,1997 reported that Lignite Fly Ash (LFA) contains high amounts of Si, Al, Fe, Ca, intermediate amounts of Mg, K, and Na. Silicon-fed plants naturally synthesizes antimicrobial compounds such as salicylic acid, jasmonic acid and ethylene which plays a positive role in both local and systemic resistance. Annamalai Mixture(an organic mixture of plant products and animal excrements) contains volatile ammonia and silica which are fungitoxic against sheath blight and blast diseases of rice and also enhances the yield which might be due to various macro and micro elements present in them (Raja and Kurucheve1998). Joshi *et al.,* 2007 reported that *Pseudomonas* sp., *Bacillus* sp. are excellent colonizers and widely prevalent in rice rhizosphere have been found to be most effective antagonists *in vitro*, under greenhouse and field conditions against *Pyricularia grisea*(blast), *Bipolaris oryzae*(brown spot), *Rhizoctonia solani* (sheath blight), and *Sarocladium oryzae*(sheath rot) diseases of rice. The combined application of *P. fluorescens* mixed with organic manure formulation reduced sheath blight disease and also increased grain yield and grain weight of rice (Prashant Mishra *et al* 2009). The consortia application of different ecofriendly components viz., Fortified Lignite Fly

Table 1. Effect of eco friendly components against sheath blight and sheath rot diseases of rice under pot culture condition

Treatment	Sheath blight						Sheath rot						Grain Yield (g/plant)
	Diseases incidence (%)			Decrease over control (%)			Diseases incidence (%)			Decrease over control (%)			
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	
T_1	16.73 (24.14)^{d}	19.02 (25.85)^{d}	20.26 (26.75)^{d}	23.25 (28.82)^{d}	21.33 (27.50)^{d}	32.28 (34.62)^{d}	18.46 (25.44)^{f}	21.29 (27.91)^{f}	22.49 (28.30)^{f}	16.35 (23.98)^{f}	21.46 (27.59)^{f}	24.50 (29.66)^{f}	27^{e}
T_2	17.39 (24.64)^{e}	20.91 (27.21)^{e}	21.89 (27.89)^{e}	20.22 (26.72)^{e}	13.60 (21.64)^{e}	26.83 (31.19)^{e}	19.53 (26.22)^{g}	23.31 (28.86)^{g}	24.55 (29.70)^{g}	11.50 (19.82)^{g}	14.75 (22.58)^{g}	21.34 (27.51)^{g}	26^{f}
T_3	13.33 (21.41)^{b}	14.35 (22.26)^{b}	16.07 (23.63)^{b}	38.85 (38.55)^{b}	40.65 (39.61)^{b}	46.29 (42.87)^{b}	14.78 (22.60)^{c}	16.71 (24.12)^{c}	18.24 (25.28)^{c}	33.03 (35.07)^{c}	38.36 (38.26)^{c}	38.77 (38.51)^{c}	30^{c}
T_4	15.47 (23.16)^{c}	18.24 (25.28)^{c}	19.58 (26.26)^{c}	29.03 (32.60)^{c}	24.56 (29.70)^{c}	34.55 (36.00)^{c}	17.72 (24.89)^{e}	20.35 (26.81)^{e}	21.94 (27.93)^{e}	19.71 (26.35)^{e}	24.93 (29.95)^{e}	26.35 (30.88)^{e}	28^{d}
T_5	10.11 (18.53)^{a}	11.62 (19.93)^{a}	13.77 (21.78)^{a}	53.62 (47.07)^{a}	51.94 (46.11)^{a}	53.97 (47.27)^{a}	11.54 (19.85)^{a}	13.05 (21.17)^{a}	15.87 (23.47)^{a}	47.71 (43.68)^{a}	51.86 (46.06)^{a}	46.72 (43.11)^{a}	32^{a}

Table 1 Continued

T_6	12.16 (20.40)^{b}	13.21 (21.31)^{b}	15.89 (23.49)^{b}	44.22 (41.68)^{b}	45.36 (42.33)^{b}	46.89 (43.21)^{b}	13.39 (21.46)^{b}	15.31 (23.03)^{b}	17.45 (24.69)^{b}	39.32 (38.83)^{b}	43.52 (41.27)^{b}	41.42 (40.05)^{b}	31^{b}
T_7	16.17 (23.71)^{d}	19.19 (25.98)^{d}	22.16 (28.08)^{d}	25.82 (30.53)^{d}	20.63 (27.01)^{d}	25.93 (27.01)^{d}	15.15 (22.90)^{d}	17.19 (24.49)^{d}	18.10 (25.17)^{d}	31.35 (34.04)^{d}	36.59 (37.22)^{d}	39.24 (38.78)^{d}	19^{g}
T_8	21.80 (27.83)^{f}	24.18 (29.45)^{f}	29.92 (33.16)^{f}	--	--	--	22.07 (28.02)^{h}	27.11 (31.37)^{h}	29.79 (33.07)^{h}	--	--	--	14^{h}
CD (P=0.05)	0.099	0.110	0.129	-	-	-	0.499	0.540	0.569	-	-	-	0.850

T1 – Combined application of *P. fluorescens* and *B. subtilis* as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage, T2 – Application of Annamalai Mixture as seed, foliar spray @ 20 lit /ha at tillering stage and boot leaf stage, T3 – T1 +T2, T4– Application of fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage, T5– T3+ T4, T6– Seed treatment @ 2g/kg, foliar application of Trycyclazole @ 0.6g/lit. at tillering and boot leaf stage, T7– Healthy control (without application of treatment and pathogen inoculation) and T8– Inoculated control.

Table 2. Effect of eco friendly components against sheath blight and sheath rot diseases of rice under field condition (season 1 kuruvai)

Treatment	Sheath blight						Sheath rot						Grain Yield (g/plant)
	Diseases incidence (%)			Decrease over control (%)			Diseases incidence (%)			Decrease over control (%)			
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	
T_1	12.34 (20.56)^{c}	16.20 (23.65)^{c}	21.74 (27.79)^{c}	22.48 (28,30)^{c}	23.44 (28.95)^{c}	16.95 (24.31)^{c}	11.73 (20.02)^{c}	16.78 (24.18)^{c}	19.26 (26.03)^{c}	24.95 (29.96)^{c}	26.53 (31.00)^{c}	33.35 (35.27)^{c}	3369.46^{c}
T_2	13.79 (21.79)^{d}	17.74 (24.90)^{d}	22.91 (32.64)^{d}	13.37 (21.44)^{d}	16.16 (23.70)^{d}	12.49 (20.69)^{d}	12.92 (21.06)^{d}	17.83 (24.97)^{d}	20.86 (27.13)^{d}	17.33 (24.60)^{d}	21.93 (27.92)^{d}	27.82 (31.83)^{d}	3310.70^{d}
T_3	10.12 (18.54)^{b}	13.90 (21.89)^{b}	18.69 (25.69)^{b}	36.43 (37.12)^{b}	34.31 (35.85)^{b}	28.60 (32.32)^{b}	9.04 (17.49)^{b}	13.95 (21.93)^{b}	15.08 (22.85)^{b}	42.16 (40.48)^{b}	38.92 (38.59)^{b}	47.82 (43.75)^{b}	3434.89^{b}
T_4	11.98 (20.25)^{c}	15.41 (21.11)^{c}	20.98 (27.26)^{c}	24.74 (29.82)^{c}	27.17 (31.41)^{c}	19.86 (26.46)^{c}	10.89 (19.26)^{c}	15.94 (23.53)^{c}	18.43 (25.42)^{c}	30.32 (33.41)^{c}	30.21 (33.34)^{c}	36.22 (37.00)^{c}	3378.62^{c}

Table 2 Continued

T_5	7.16 (15.52)[a]	9.12 (17.57)[a]	11.13 (19.48)[a]	55.02 (47.88)[a]	56.89 (48.96)[a]	57.48 (49.30)[a]	6.71 (15.01) a	10.80 (19.18) a	12.90 (21.04) a	57.06 (49.09)[a]	52.71 (46.55)[a]	55.36 (48.07)[a]	3680.34 [a]
T_6	9.32 (17.77)[b]	12.17 (20.41)[b]	17.18 (24.48)[b]	41.45 (40.07) [b]	42.48 (40.67)[b]	34.37 (35.89)[b]	8.62 (17.07) b	12.63 (20.81) b	14.84 (22.65) b	49.32 (44.61)[b]	44.70 (41.95)[b]	48.65 (44.22)[b]	3490.58 [b]
T_7	15.92 (23.51)[e]	21.16 (27.38)[e]	26.18 (30.77)[e]	--	--	--	15.63 (23.28) e	22.84 (28.54) e	28.90 (32.51) e	--	--	--	2518.30[e]
CD (P=0.05)	0.300	0.410	0.520	-	-	-	0.129	0.160	0.180	-	-	-	7.562

T1 – Combined application of P. fluorescens and B. subtilis as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage, T2 – Application of Annamalai Mixture as seed, foliar spray @ 20 lit /ha at tillering stage, T3 – T1 +T2, T4– Application of fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage, T5– T3+ T4, T6– Seed treatment @ 2g/kg, foliar application of Trycyclazole @ 0.6g/lit. at tillering and boot leaf stage and T7–Control.

Table 3. Effect of eco friendly components against sheath blight and sheath rot diseases of rice under field condition (season 2 - samba)

Treatment	Sheath blight						Sheath rot						Grain Yield (g/ plant)
	Diseases incidence (%)			Decrease over control (%)			Diseases incidence (%)			Decrease over control (%)			
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	
T_1	12.87 (21.02)^{c}	17.27 (24.55)^{c}	22.43 (28.46)^{c}	26.24 (30.81)^{c}	25.30 (30.19)^{c}	23.62 (29.07)^{c}	13.21 (21.31)^{c}	17.01 (24.35)^{c}	20.16 (24.35)^{c}	25.07 (30.04)^{c}	28.64 (32.35)^{c}	38.72 (38.48)^{c}	3324.12^{c}
T_2	14.36 (22.26)^{d}	18.46 (25.44)^{d}	23.71 (29.13)^{d}	17.70 (24.87)^{d}	20.15 (26.67)^{d}	19.27 (26.03)^{d}	14.96 (22.75)^{d}	18.89 (25.76)^{d}	22.86 (28.56)^{d}	15.14 (22.89)^{d}	20.76 (27.10)^{d}	30.51 (33.52)^{d}	3297.83^{d}
T_3	11.34 (19.67)^{b}	14.19 (22.12)^{b}	19.90 (26.49)^{b}	35.01 (36.27)^{b}	38.62 (38.42)^{b}	32.24 (34.59)^{b}	10.01 (18.44)^{b}	14.20 (22.13)^{b}	15.86 (22.85)^{b}	43.22 (41.10)^{b}	40.43 (39.48)^{b}	54.16 (47.38)^{b}	3436.03^{b}
T_4	12.29 (20.52)^{c}	16.81 (24.20)^{c}	22.86 (28.56)^{c}	29.57 (32.94)^{c}	27.29 (31.49)^{c}	22.16 (28.08)^{c}	12.91 (21.05)^{c}	16.43 (23.91)^{c}	19.15 (25.95)^{c}	26.77 (35.15)^{c}	31.08 (33.88)^{c}	41.79 (40.27)^{c}	3376.56^{c}

Table 3 Continued

T_5	9.81 (18.25)[a]	10.02 (18.45)[a]	12.34 (20.56)[a]	43.78 (41.42)[a]	56.66 (48.82)[a]	57.98 (49.59)[a]	7.32 (15.69)[a]	9.15 (17.60)[a]	11.87 (20.15)[a]	58.47 (49.87)[a]	61.61 (51.71)[a]	63.92 (53.08)[a]	3596.43 [a]
T_6	11.28 (19.62)[b]	13.47 (21.53)[b]	18.98 (25.82)[b]	35.35 (36.48) [b]	41.73 (40.23)[b]	35.37 (36.49)[b]	9.21 (17.66)[b]	13.31 (21.39)[b]	15.42 (23.12)[b]	47.75 (43.71)[b]	44.16 (41.64)[b]	53.13 (46.79)[b]	3447.39 [b]
T_7	17.45 (24.69)[e]	23.12 (28.73)[e]	29.37 (32.81)[e]	--	--	--	17.63 (24.82)[e]	23.84 (29.22)[e]	32.90 (35.00)[e]	--	--	--	2469.94 [e]
CD (P=0.05)	0.040	0.069	0.089	-	-	-	0.200	0.209	0.249	-	-	-	9.363

T1 – Combined application of P. fluorescens and B. subtilis as seed @ 10g/kg of seed, soil @ 10 kg/ha at transplanting, foliar spray @ 10 kg/ha at tillering and boot leaf stage, T2 – Application of Annamalai Mixture as seed, foliar spray @ 20 lit /ha at tillering stage, T3 – T1 +T2, T4– Application of fortified lignite fly ash as soil @ 40 kg/ha at transplanting and foliar dust @ 30 kg/ha at boot leaf stage, T5– T3+ T4, T6– Seed treatment @ 2g/kg, foliar application of Trycyclazole @ 0.6g/lit. at tillering and boot leaf stage and T7–Control.

Ash (LFA), Annamalai Mixture and *P. fluorescens* and *B. subtilis* have different mode of actions to control the diseases incidence which might be influence the reduce the diseases incidence of sheath blight and sheath rot diseases of rice.

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