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Integration of Seed Treatments, Seedling Dip Treatments and Soil Amendments for the Management of Bakanae Disease in Paddy Variety Pusa Basmati 1121

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ABSTRACT

Bakanae disease of rice caused by *Fusarium fujikuroi* is widespread in all rice growing countries of the world and is of great concern especially in Basmati paddy. Different management practices viz. seed treatments, seedling dip treatments and soil amendments were integrated for the management of bakanae disease in Paddy variety Pusa Basmati 1121. Seed treatment with carbendazim (Bavistin) and *Trichoderma viride* gave 22.7 and 11.4% control of the disease. However, the disease incidence did not vary much amongst different seed treatments under FYM+*T. viride* treated soil conditions. Seed treatment with bavistin and *T. viride* gave 10.1 and 10.2% disease, respectively as against 10.3% in crop grown from untreated seed under FYM+*T. viride* soil condition. Seedling dip in 0.2% bavistin or 0.4% *T. viride* solution before transplanting significantly reduced the disease incidence. Seedling dip treatments with bavistin and *T. viride* solutions resulted in 55.5 and 34.5% control of the disease, respectively, irrespective of soil amendments. The disease incidence was 10.3 and 11.8% in FYM+*T. viride* treated soil and *T. viride* treated soil, respectively as against 13.6% in untreated soil. The highest disease incidence (27.3%) was recorded in non-amended soils (control) transplanted from nursery of untreated seeds and the seedlings dipped in plain water at the time of transplanting. The disease control in FYM+*T. viride* treated soil and *T. viride* treated soil was statistically at par and significantly superior to untreated soil. The grain yield in plots transplanted from all the seed treatment and seedling dip treatment were statistically superior to plots transplanted from nursery raised from untreated seed and seedling dipped in plain water.

Key words: Bakanae disease, bavistin, *Fusarium fujikuroi*, rice, *Trichoderma viride*

INTRODUCTION

Amongst many devastating diseases which affect the economics of rice, bakanae disease is one of them (Yasin *et al*., 2003; Bagga and Sharma, 2006). Bakanae or foot rot disease of rice has been recorded in almost all rice growing countries, especially in Asian countries (Desjardins *et al*., 2000). Bakanae disease was widespread in Peninsular Malaysia and three provinces of Indonesia with the range of disease severity from scale 1-5 and disease incidence from 0.5-12.5% during 2004-2005 main growing seasons (Zainudin *et al*., 2008) but the disease may be responsible for yield losses of up to 50% in Asia in outbreak cases.

The disease can occur both at nursery stage and in the main field. Seedlings which survive the attack in nursery may die soon after transplanting. The affected plants wilt from tip downwards, appear pale yellow in colour, thin and abnormally long or rarely dwarf. These plants may die prematurely or may develop tall tillers and flower earlier than the healthy plants, but the infected plants mostly bear sterile panicles. Highly diseased plants show collar infection and die within 2-6 weeks. There is profuse branching in the roots and adventitious roots may develop from the lower nodes. A pinkish white cottony growth of the fungal mycelium may be observed at the base of the plant. The fungus produces growth stimulating substances known as gibberellins, which are responsible for excessive elongation of the plants (Malonek *et al*., 2005). Besides gibberellins, the fungus also produces a phytotoxin, fusaric acid, a non-specific substance which is toxic to the plants (Desjardins *et al*., 2000).

The name "Bakanae" comes from a Japanese word, meaning abnormal elongation of the plants. The causal organism is *Fusarium fujikuroi* Nirenberg (syn. *Fusarium moniliforme* Sheldon) and the perfect stage is an ascomycetous fungus i.e., *Gibberella fujikuroi* (Saw.) Wr. *Fusarium fujikuroi* is both a seed-borne and soil-borne pathogen of rice which infects the seedlings at the time of germination or at an early growth stage through the roots or crown. This fungus survives under adverse conditions in infected seeds, other diseased plant parts and soil (IRRI, 1983; Ou, 1985; Cumagun *et al*., 2011). The development of bakanae symptoms is influenced by the fungus strain and the environmental conditions such as temperature and moisture. Soil moisture, soil temperature and nitrogen fertilizer influence the development of the bakanae disease of rice (Nyvall, 1999; Kazempour and Elahinia, 2007).

Paddy variety Pusa Basmati 1121 which was released and notified in 2005 has exceptionally high cooking quality and has become very popular among the farmers and rice exporters as it has extra long kernels (about 8 mm in size) with elongation ratio of more than 2.5 times on cooking. But this variety was found to be highly susceptible to bakanae disease (NCIPM, 2009). So, there was a dire need of comprehensive studies on the management of this disease. Hence, an experiment was conducted using integration of different seed treatments, seedling dip treatments before transplanting and soil treatments for the effective management of bakanae disease in paddy cv. Pusa Basmati 1121.

MATERIALS AND METHODS

The experiment was carried out during the year 2007-08 at ICAR-Indian Agricultural Research Institute, Regional Station, Karnal, 132001, Haryana, India. The research findings were validated again during the year 2009-2010.

A field experiment with three seed treatments, three seedling dip treatments and three soil treatments including control was conducted in Paddy variety Pusa Basmati 1121 in split plot Randomized Block Design (RBD) with three replications. The size of each plot was 2×2 m^2 with plant spacing of 15 cm and row spacing of 20 cm each. All the standard recommended practices for growing Basmati rice were followed in raising a good crop. Commercial grade of bioagent *Trichoderma viride* (*T. viride*) was used during the experiment.

Seed treatment: Nursery was raised from untreated seeds and from seeds treated with 0.2% carbendazim (Bavistin) and 0.4% *T. viride* on prepared seed beds.

Soil treatment: *Trichoderma viride* was mixed in slightly wet FYM at the rate of 2.5 kg/60 kg FYM ha^{-1} and incubated at room temperature for 5 days, with occasional stirring of the mixture during the period. This mixture was amended in soil in one experimental plot at the time of land preparation and at the same time second plot was amended with *T. viride* at the rate of 2.5 kg ha^{-1}. Third experimental plot remained free from any amendment which served as control.

Seedling dip treatment: At the time of transplanting, the seedlings were uprooted from nursery plots with different seed treatments separately and sets of these uprooted seedlings were prepared. One set was dipped in solution of 0.2% bavistin, second set in 0.4% *T. viride* solution and third set in plain water, which served as control. The seedling dip treatment was done for 2 h before transplanting and the treated seedlings were transplanted into plots with different soil amendments after randomization.

Observations on disease incidence were recorded in all the treatments 30 and 60 days after transplanting, based on number of elongated, pale and dried plants in the field. Observation on grain yield was also recorded in different treatments.

RESULTS AND DISCUSSION

Statistical analysis of pooled data of 2 years (2007 and 2008) revealed that the disease incidence of bakanae disease of rice varied significantly amongst different seed treatments, seedling dip treatments and soil treatments.

Seed treatments: The plots raised from nursery of bavistin treated seed gave significantly low incidence of bakanae disease (10.2%) followed by plots raised from nursery of *T. viride* treated seed (11.7%). The nursery from untreated seed transplanted in untreated soil had maximum percent disease incidence (15.4%). Bavistin seed treatment gave 10.3% disease as against 14.3% in *T. viride* seed treatment and 15.4% disease incidence in untreated seeds transplanted in untreated or unamended plots (Fig. 1). Seed treatment with

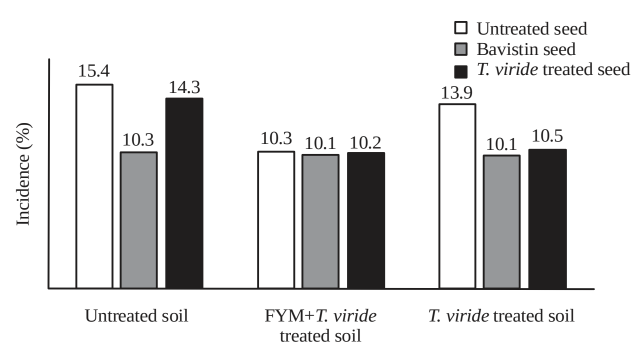

Fig. 1: Effect of seed treatments on percent incidence of bakanae disease in amended fields

Table 1: Effect of seed treatments and soil amendments on incidence of bakanae disease and grain yield in the field

Treatments	Disease incidence (%) Untreated field	FYM+*T. viride* treated field	*T. viride* treated field	Average	Yield (q ha^{-1}) Untreated field	FYM+*T. viride* treated field	*T. viride* treated field	Average
Untreated seed nursery-plain water dip	27.3^{a}	16.5^{a}	21.4^{a}	21.7^{a}	16^{b}	15^{c}	13^{b}	14^{b}
Untreated seed nursery-bavistin dip	9.5^{cd}	5.1^{d}	8.1^{cd}	7.6^{de}	29^{a}	28^{ab}	34^{a}	30^{a}
Untreated seed nursery-*T. viride* dip	9.3^{cd}	9.1^{bcd}	12.2^{bc}	10.2^{cd}	28^{a}	26^{ab}	25^{a}	26^{a}
Bavistin treated seed nursery-plain water dip	13.5^{bc}	14.1^{ab}	13.8^{b}	13.8^{b}	26^{a}	22^{bc}	28^{a}	25^{a}
Bavistin treated seed nursery-bavistin dip	7.0^{d}	6.7^{cd}	6.3^{d}	6.7^{e}	26^{a}	33^{a}	31^{a}	30^{a}
T. viride treated seed nursery-plain water dip	15.2^{b}	11.2^{bc}	11.2^{bcd}	12.5^{bc}	26^{a}	23^{bc}	26^{a}	25^{a}
T. viride treated seed nursery-*T. viride* dip	13.3^{bc}	9.2^{bcd}	9.7^{bcd}	10.7^{c}	28^{a}	34^{a}	28^{a}	27^{a}
LSD 0.05				3.0***				5***

Means followed by same alphabet are non-significant at 5%

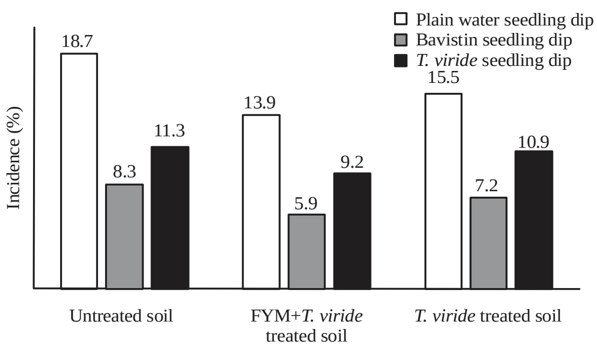

Fig. 2: Effect of seedling dip treatments on percent incidence of bakanae disease in amended soil

bavistin and *T. viride* gave 22.7 and 11.4% control of the disease. However, the disease incidence did not vary much amongst different seed treatments under FYM+*T. viride* treated soil conditions. Seed treatment with bavistin and *T. viride* gave 10.1 and 10.2% disease, respectively as against 10.3% in crop grown from untreated seed under FYM+*T. viride* soil condition.

Seedling dip treatment: Seedling dip in 0.2% bavistin or 0.4% *Trichoderma viride* solution before transplanting significantly reduced the disease incidence. Seedling dip in 0.2% bavistin solution was most effective in reducing the disease incidence as against seedling dip in *T. viride* solution and control i.e., plain water dip for 2 h (Fig. 2). Though at 30 Days after Transplanting (DAT) the effect was not as pronounced but at 60 DAT the effect was quite significant. The disease incidence in all the seedling dip treatments sown in untreated soil were respectively higher than those sown in FYM+*T. viride* and *T. viride* amended soils. Maximum disease incidence was observed in plots raised from seedling dip in plain water under all soil conditions viz. untreated (18.7%), FYM+*T. viride* (13.9%) and *T. viride* (15.5%) soil amendments (Fig. 2). The minimum disease incidence (5.9%) was recorded in plots raised from seedlings subjected to bavistin dip and sown in FYM+*T. viride* amended soil followed by 7.2% in *T. viride* amended soil whereas in untreated soil it was 8.3%. Plots raised from *T. viride* seedling dips gave 9.2, 10.9 and 11.3% disease incidence in FYM+*T. viride*, *T. viride* amended and untreated soils, respectively. Seedling dip in bavistin and *T. viride* solutions resulted in 7.1 and 10.5% disease incidence as against 16.0% disease incidence in plain water dip, irrespective of soil amendments (Fig. 2). Thus, bavistin and *T. viride* seedling dips gave 55.5 and 34.7% control of the disease respectively, as against control, irrespective of soil amendments.

Soil treatments: The disease control in FYM+*T. viride* treated soil was significantly superior to untreated soil and it was statistically at par with *T. viride* treated soil. The disease incidence was minimum in soil amended with FYM+*T. viride* (10.3%) followed by soil amended with only *T. viride* (11.8%) and maximum incidence (13.6%) being in untreated soil. In FYM+*T. viride* amended soils the disease incidence in plots raised from untreated seed was lower (10.3%) than those raised on *T. viride* amended soil (13.9%) and maximum (15.4%) being on untreated soil (Fig. 1). The disease control in FYM+*T. viride* treated soil and *T. viride* treated soil was statistically at par and significantly superior to untreated soil. The disease incidence in plots raised from bavistin treated seeds was almost similar in all soil types (10.3, 10.1 and 10.1% in untreated, FYM+*T. viride* and *T. viride* amended soil, respectively), but the incidence in plots raised from *T. viride* treated seeds sown on untreated soil (14.3%) was higher than those sown on both types of amended soils i.e., FYM+*T. viride* (10.2%) and *T. viride* (10.5%) amended soils. The disease incidence in *T. viride* treated soil was also statistically at par with untreated soil. The highest disease incidence (27.3%) was recorded in non-amended plots (control) transplanted from nursery of untreated seeds and the seedlings dipped in plain water at the time of transplanting (Table 1). Minimum disease incidence of 5.1 and 6.7% was recorded in plots transplanted from nursery raised from untreated seeds and bavistin treated seeds, respectively and subjected to seedling dip in bavistin solution and raised in FYM+*T. viride* amended soil.

Bagga and Sharma (2006) had evaluated different fungicides as seedling treatment for controlling bakanae disease in Basmati rice. They reported that seedling treatment with bavistin at the rate of 0.1% for 6 h was effective in reducing the disease incidence. They also reported that during seedling treatment fungicide efficacy increased as the duration of the treatment increased from 2-6 h. During their study Bhalli *et al*. (2001) found Derosal fungicide (Carbendazim) most effective against *Fusarium moniliforme* causing bakanae disease of rice. They used the fungicide as seed treatment and soil drenching *in vivo* and found most effective results. In their study Kumakura *et al.* (2003) reported that soaking of rice seeds in the suspension of strain SKT-1 of *Trichoderma* sp. gave high control of “Bakanae” disease. This strain has been developed and commercialized with the trade name of “Echohope” against four economically important seed-borne diseases of rice including Bakanae disease (Nagayama *et al*., 2007), while Gergon *et al*. (2007) suggested that seed treatments of rice with NaOCl or Benomyl either as seed protectant or eradicant can effectively manage the bakanae disease of rice.

However, in the present study the disease incidence in plots transplanted from nursery raised from untreated seeds but subjected to seedling dip in bavistin solution was statistically at par with plots transplanted from nursery raised from bavistin seed treatment and subjected to seedlings dip in bavistin solution. These two treatments were statistically superior to rest of the treatments. The disease incidence in plots raised from nurseries of bavistin or *T. viride* seed treatments and subjected to plain water seedlings dip treatment was statistically at par. The disease incidence in plots raised from the nursery of *T. viride* treated seed and seedlings dipped either in *T. viride* solution or in plain water and also plots raised from nursery of untreated seed and subjected to seedling dip in *T. viride* solution at the time of transplanting were statistically at par but lower than control. Also, the plots raised from nurseries of bavistin or *T. viride* treated seeds but seedling dip in plain water were statistically at par. As the disease is primarily reported to be seed-transmitted (Webster and Gunnell, 1992), seed dressing represents the first way to control the spread of the disease. However, our observations are that seed treatment alone may be ineffective in the control of bakanae disease in the field but when it is integrated with seedling dips and transplanted in amended soils, the disease is controlled effectively. Reduction in populations of soil borne phytopathogens and reductions in level of infection through organic amendment is already reported by several workers in different crops (Bonanomi *et al*., 2007; Kamil *et al*., 2009; Rajik *et al*., 2011; Marzano, 2012). *Fusarium moniliforme* causing foot rot/bakanae disease of rice was controlled biologically using fermented products of composts and vermicompost by Manandhar and Yami (2008).

The effect of bacterization of naturally infected seeds on bakanae disease incidence in seedbox and seedbed tests has been studied by Rosales and Mew (1997). They reported reduced disease incidence and effective control of bakanae disease of rice in IR 58 variety using 10 different strains of bacteria during their study in Philippines. Kazempour and Elahinia (2007) reported biological control of *Fusarium fujikuroi*, the causal agent of bakanae disease by rice associated antagonistic bacteria. They reported that the *P. fluorescens* and *B. cereus* isolates have an excellent potential to be used as biocontrol agents of *F. fujikuroi* in rice at the field conditions. *Trichoderma* has been reported to induce resistance against different diseases in paddy (Jean-Berchmans *et al*., 2003; Biswas *et al*., 2010).

Effect of treatments on grain yield: The grain yield in plots transplanted from all the seed treatments and seedling dip treatments were found to be statistically superior to plots transplanted from nursery raised from untreated seed combined with seedling dip treatment with plain water. During interactions (Table 1), grain yield was slightly higher in amended soil as against un-amended soils, irrespective of seed and seedling dip treatments. Though all the treatment combinations (seed treatment, seedling dip treatment and soil amendments) were statistically at par and significantly different from nursery raised from untreated seed combined with seedling dip treatment in plain water, irrespective of soil amendments, but numerically maximum yield (34 q ha^{-1}) was obtained in plots raised from *T. viride* treated seed nursery and seedling dip in *T. viride* solution and nursery raised from untreated seed combined with seedling dipped in bavistin, followed by 33 q ha^{-1} in bavistin treated seed nursery combined with seedling dipped in bavistin and raised on amended soils. However, in soil amended with FYM+*T. viride*, the plots raised from bavistin or *T. viride* seed treatments and seedlings dipped in plain water was statistically at par with nursery raised from untreated seed combined with seedlings dipped in bavistin or *T. viride* solution.

CONCLUSION

It can be concluded that the treatment with both bavistin and *T. viride*, especially the seedling dips at the time of transplanting are very effective in management of bakanae disease in paddy cv. Pusa Basmati 1121 along with soil amendments which also increase grain yield substantially. Minimum disease incidence was found in soil amended with FYM+*T. viride* followed by soil amended with *T. viride* alone and maximum disease incidence being in untreated soil. Thus, the efficacy of bioagent used for the management of bakanae disease in rice can be enhanced through appropriate use of organic substrate along with bio-agent.

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