

DISCUSSION

The world food situation is beset by crises despite the progress made in the production of rice and in the ability of the world to produce enough food to meet everyone's food requirements. Sustainable rice production is recognized as one of the greatest challenges facing scientists today. The crucial factor threatening rice cultivation is the incidence of diseases, which are of fungal, bacterial and viral origin.

Rhizoctonia is an important soil borne fungus causing different types of diseases to a wider variety of plants over a larger part of the world and under more diverse environmental conditions than any other plant pathogenic species. For example, diseases like sheath blight, black scurf of potato, damping off, root rot, charcoal rot, stem rot etc. with its different species viz., *Rhizoctonia solani*, *R. bataticola* and *Rhizoctonia* spp. on important crops like paddy, potato, groundnut, cotton, chilli, soybean etc. (Ogoshi, 1987).

The present investigation has focused on the survey on incidence of sheath blight of rice in four states of India. Collection of sheath blight causing *R. solani* isolates from different geographic regions to study the cultural, morphological and molecular variability and isolation, identification and assessment of biocontrol potential of biocontrol agents against sheath blight pathogen under *in vitro*, *in vivo* and field conditions.

Symptomatology, isolation and identification of the fungus

R. solani infects rice plants at any stage of growth. Lesion started at the base of the culms near the water level on artificial inoculation and ascended to the upper parts of the plants. The lesions on sheath were

initially greenish-grey, ellipsoidal or oval, 2-3 cm long and gradually became greenish white with black brown margin. The sheath blight of rice is a typical disease starting from seedling stage to harvest, indicating the susceptibility of crop at all the stages to infection by *R. solani* which is a soil inhabitant. The similar symptomatic observations were made by several workers (Singh *et al.*, 1990; Roy, 1993; Padhi and Gangopadhyaya, 1998).

The field survey of disease in North-Eastern Dry Zone of Karnataka showed a varied incidence from moderate to severe form of sheath blight. Quite often, the variations in severity could also be due to the presence of pathogenic variability apart from environmental conditions. Therefore, samples of rice plants showing typical sheath blight symptoms were collected from different locations of Karnataka *viz.*, Raichur and Koppal districts during the survey. In addition, isolates of *R. solani* were also obtained from Ludhiana of Punjab, Coimbatore of Tamil Nadu and different rice growing areas of Andhra Pradesh for variability study.

The isolates collected from different regions were maintained in pure form on potato dextrose agar. Twenty-eight isolates obtained from different geographical regions were designated as RS-1 to RS-28. Further, isolates were subjected to Koch's postulates and identified as *R. solani* based on morphological characters described by Ou *et al.* (1972). The present identification system at species level is based on morphological characteristics like colour, diameter and constriction at the branching point, moniloid cells, septal characteristics, nuclear status and anastomosis behaviour (Dasgupta, 1992). Sclerotia were superficial, more or less

globose but flattened below, white when young, became brown or dark brown later. Individual sclerotia measured up to 5 mm and sometimes united to form a larger mass (Ou, 1972). The identity of fungus was confirmed by Dr. P. N. Choudhury, Principal Scientist (Retired), Division of Plant Pathology, Indian Agricultural Research Institute (IARI), New Delhi.

Morphological cultural and pathogenic diversity of *R. solani*

Diversity in morphological characters of 28 isolates of *R. solani* was studied. Morphological characterization of different isolates indicated much variation among the isolates in mycelium colour, appearance, mycelial width, colony margin and diameter and sclerotial number, colour, shape, distribution and texture. The branching of mycelium, constriction and septum remained same in all the isolates tested. Among the 28 isolates, maximum growth was noticed in 15 isolates with 89 mm colony diameter after 13 days of incubation on PDA, while, the least growth was recorded in A.P isolate RS-3 (79 mm) and RS-24 (79 mm) of Tamil Nadu isolate. Further, among the isolates mycelial width was larger in the isolate RS-13 (2.76 μm) whereas least mycelial width was observed in RS-2 and RS-7 (1.81 μm).

The colour of the fungal colony varied from light brown to brown and it was found to be dark brown in four isolates. The right angled branching of mycelia was found with all twenty eight isolates. Surface of colony was flat in sixteen isolates and the remaining were fluffy. The margins of the colonies varied from smooth to irregular. The smooth margin was observed in the majority of isolates and only few were with irregular margin (RS-5, RS-8, RS-13, Rs-17, RS-23 and Rs-26).

The number and size of sclerotia also exhibited variation among the isolates. Most of the Andhra Pradesh isolates and two Tamilnadu isolates i.e., RS-3, RS-4, RS-7, RS-9, RS-10, RS-15, RS-19, RS-21, RS-23, RS-25 and RS-28 produced higher number of sclerotia whereas less sclerotial number was found in isolates RS-2, RS-12, RS-14, RS-17, RS-20 and RS-27. The maximum sclerotial size was observed in isolate RS-23 (180 μm). On other hand, least Sclerotial size was exhibited by isolate RS-7 (47 μm). Similarly, isolates RS-1 and RS-6 failed to produce any sclerotia on the medium. The texture of sclerotia also varied from fine to coarse and their distribution varied from clustered to scattered type.

Good variation was observed in sclerotial colour ranging from brown to blackish brown in 24 isolates while it was greyish in two isolates (RS-11 & Rs-13) and the shape ranged from globose to irregular shape. Diversity in morphological characters such as colony colour, mycelial growth, its margin and topography were appreciable among 28 isolates of *R. solani* under study. The differences were striking particularly in mycelial colour. A glance towards previous investigations supports our present findings. Basu and Gupta (1992) reported that positive correlation was found between the size of sclerotia and pathogenicity. Isolates with larger sclerotia were significantly more virulent than those with smaller sclerotia and without sclerotia. Similarly in the present study variation with respect to sclerotia was quite convincing, with maximum sclerotial size in RS-23 and the least in RS-7 and interestingly RS-1 and RS-6 did not produce any sclerotia, which might inturn reflect their pathogenicity as observed by Gupta and Kolte (1992).

The isolates of *R. solani* are known to differ in their host, type of attack, temperature optima for infection, ability to tolerate high CO₂ levels and ability to survive at different depths of soils, on the host surface or as an aerial pathogen and also in their morphology viz., colony and mycelial characters, number of nuclei per cells, size, shape and type of sclerotia (Ogoshi, 1995). Further studies on isolates of *R. solani* of gramineae plants in Puerto Rico confirmed that, there was variability in morphological, cultural and pathogenicity characteristics among the isolates. Findings are well endorsed by earlier workers (Bansal *et al.*, 1990).

Manoj Kumar *et al.* (2008) isolated 25 isolates of *R. solani* from different regions of Eastern Uttar Pradesh (India) and analysed for their variability using morphological and virulence characteristics. Among the morphological characters, variation was observed in hyphal growth and distribution pattern, colour, size and weight of sclerotia on PDA medium.

Molecular diversity

In a preliminary study, one isolate of *R. solani* was amplified with 30 primers of arbitrary nucleotide sequence. Of these, 4 primers were selected based on amount of polymorphism for analysis of all 28 isolates of *R. solani*. Significant differences were found in RAPD profiles of 28 isolates of *R. solani* with two primers OPC 5 and OPC 2. The primers OPC5, OPC 2, OPA 8, and OPA 11 produced 265 PCR products with molecular weight ranging from 0.5 kb to 2.0 kb in different isolates with diverse finger printing patterns. To test the resolving ability of these primers, cumulative RAPD profiles generated by the primers were analyzed by UPGMA. RAPD analysis of *R. solani* isolates revealed that, all

the isolates shared 78 percent and above similarity. The cumulative analysis of 28 isolates showed 7 clusters. There were 8 isolates in cluster I, nine isolates in cluster II, cluster III has two isolates, five isolates in cluster V, in cluster VI two isolates and isolate number RS- 19 and RS-20 did not share with above cluster and they were kept in cluster IV & VII respectively.

Genetic variability in *R. solani* isolates of different hosts from various places has been studied using RAPD markers by various workers. Genetic variation in Australian isolates of *R. solani* was analysed by RAPD assay (Duncan *et al.* 1993). Isolates originated from different geographic locations in Australia belong to a number of different anastomosis and pectic zymogram groups. Using 4 different Oligonucleotide primers fingerprint patterns were generated for each isolate. All of the anastomosis and pectic zymogram groups (including subgroups) tested could be distinguished. For some groups there was considerable variation in the fingerprint patterns between isolates. This variation was more marked between isolates from different geographic locations. Other groups showed very little variation between isolates. It is concluded that RAPD-PCR analysis is a very useful alternative to anastomosis grouping for identification of isolates of *R. solani*.

Cenis *et al.* (1995) used RAPD analysis to study genetic variation of 38 *R. solani* isolates from different hosts and different areas in Spain. The use of a single primer of an arbitrary sequence differentiated 37 of 38 strains and a combination of 3 primers differentiated all the strains. A great genetic variation within this group of isolates was confirmed.

Yang *et al.* (1995) used RAPD-PCR to characterize isolates of *R. solani* from bare patches in cereal and pasture crops. There was no difference in RAPD-PCR pattern between highly virulent and weakly virulent isolates. Toda *et al.* (1999) characterized 41 isolates of *R. solani* belonging to 11 AGs using RAPD primers. Isolates originated from the same geographical origin or host plants were not always genetically related.

Runhua *et al.* (2002) analysed forty-eight rice sheath blight strains of *Rhizoctonia solani* AG-1 IA from 7 counties of Guangdong Province, China for genetic diversity using the RAPD technique. UPGMA results revealed the existence of abundant genetic diversity among rice sheath blight populations. The genetic variation was very significant in *R. solani* AG-1 IA population from different counties in the Guangdong Province.

Vineeta-Singh *et al.* (2002) studied morphological characteristics, pathogenicity, anastomosis behaviour and RAPD fingerprinting of *R. solani* isolates from the rice fields of Dehradun and Nagina. Neeraja *et al.* (2002) assessed the genetic variability of the 18 isolates of *R. solani* collected from different rice growing regions of India by using RAPD markers. The similarity values of RAPD profiles ranged from 0.41 to 0.85 with an average of 0.66 among the isolates. The percentage polymorphism detected per primer varied from 79.2 to 100%.

Feng *et al.* (2005) characterized pathogenicity and molecular genetic variation of 15 fungal isolates from rice and 7 isolates from maize in Sichuan Province, China. All the isolates were identified as *Rhizoctonia solani* AG-1 IA and showed significant pathogenicity variation. The genetic

variation of these isolates was assessed with RAPD method. The dendrogram derived from RAPD data by UPGMA revealed that the isolates from the same host plant showed similar RAPD marker patterns and were clustered into the same genetic group or subgroup. These results suggest that a certain degree of genetic similarity exists among isolates recovered from the same host, whereas the pathogenicity variation was not related to host origin of isolates and RAPD groups.

Guleria *et al.* (2007) studied the genotypic variability of nineteen isolates of *R. solani* by using 10 ISSR and eight RAPD markers. The size of amplified DNA bands ranged from 0.25 to 3.0 and 0.5 to 4.0 kb with ISSR and RAPD markers, respectively. Combined data set of 155 DNA markers were analysed with UPGMA resulted in five clusters with 49-89% genetic similarity. Most of the isolates showed grouping specific to the host variety. Out of these two types of DNA markers, RAPD markers were able to detect more genetic variability when compared to ISSR markers.

Biological control of sheath blight of rice:

Biological control is an important tool for managing any disease including soil borne ones, particularly as precautionary step in the management of the disease. In addition, identification of effective biocontrol agents would enable wise integration of different components of integrated disease management strategy. Hence, screening of biocontrol agents were tried in laboratory, green house and field experiment to know their relative efficacy in efficient management of the disease.

Chemicals are spectacular, impressive, quick and convincing even to an uneducated farmer but there is also an intensified worldwide concern

about environmental pollution due to escalated use of hazardous pesticides and fungicides. A multitude of microbes has been implicated to be biocontrol agent of plant pathogens sometimes with excellent documentations. Hence, studies were carried out to find effective biocontrol agents against *R. solani* pathogenic to rice.

***In vitro* evaluation of bioagents:**

Antagonists obtained from different places were screened under *in vitro* using dual culture technique and production of volatile compounds to test their efficacy against *R. solani*. *In vitro* screening of biocontrol agents provided preliminary information regarding their efficacy against the fungus and thus served as a guide for green house experiments and field testing. Among eleven *Trichoderma* spp. and eleven *Pseudomonas fluorescens* strains four *Trichoderma* spp. (*T. harzianum* 12, *T. viride* 2, *T. viride* 5, *T. viride* 16) and four strains of *Pseudomonas fluorescens* (*P. fluorescens* 1, *P. fluorescens* 2, *P. fluorescens* 9, *P. fluorescens* 11) were most effective in inhibiting mycelial growth, sclerotial lysis and germination of *R. solani* of all the antagonistic forms of bioagents.

Isolates of *P. fluorescens* were obtained from the rhizosphere of different rice soils (Castric *et al.* 1983; Hagedron *et al.* 1989). It was reported that their antagonistic potential appear to vary a great deal.

In dual culture, Pfr 1 was found to outstand all other isolates significantly inhibited the mycelial growth of the pathogen over control. This was followed by Pfr 2, Pfr 9 and Pfr 11. The ability of *P. fluorescens* isolates to serve as biocontrol agent of sheath blight has been studied by many researchers. The results of dual culture studies showed that

P. fluorescens isolates inhibited the growth of *R. solani* on plates and liquid culture. Members of the genus *Pseudomonas* spp. are well known antagonists to fungi (Kreit, 1949; Kozempour, 2004).

The volatile compounds of the bacterial antagonists had remarkable inhibitory effect on the mycelial growth of the pathogen. Pfr 1 found significantly superior over other isolates with 58.6% reduction of mycelial growth over control. It was followed by Pfr 8, Pfr 10 and Pfr 11. *Pseudomonas* spp. are known to produce volatile compounds such as hydrogen cyanide (Castric and Castric, 1983). Volatile metabolites produced by *Pseudomonas* spp. inhibited the mycelial growth of *R. solani* (Kozempour, 2004).

The extracellular metabolites secreted by the bacterial antagonists had lethal effect on the rice sheath blight pathogen. The metabolites seemed to have strong lethal effect on the mycelial growth of pathogen which was reflected by the reduction of mycelial growth compared to direct mycelial interaction in dual culture and volatile compounds. Pfr 1 was observed to be superior over other isolates with 68.6% of mycelial growth reduction over control. This was followed by the isolates Pfr 12, Pfr 9, Pfr 7 and Pfr 2. Several studies indicated that the antagonistic potential of *P. fluorescens* against various soil borne plant pathogens is correlated with the production of lytic enzymes (Lim *et al.* 1991; Velazhahan *et al.* 1999; Meena *et al.* 2001). *Pseudomonas* spp. are effective root colonizers and can produce antifungal metabolites including hydrogen cyanide and siderophores (O' Sullivan and O' Gara, 1992).

Extra cellular enzymes and antibiotics produced by *Pseudomonas* spp. inhibited mycelial growth of *R. solani* (Kozempour, 2004). *Pseudomonas* spp were most effective in inhibiting mycelial growth of *R. solani in vitro* by producing chitinase, β -1, 3-glucanase, siderophores, salicylic acid (SA) and hydrogen cyanide (HCN) (Nagaraj Kumar *et al.* 2004). Antagonistic ability of *Pseudomonas* strains against *R. solani* was reported by Niza *et al.* (2005) and Xiangmin *et al.* (2007).

Significant highest sclerotial lysis was brought by two *P. fluorescens* isolates, Pfr 1 and Pfr 2 compared to other isolates. Sclerotial germination of the pathogen in KMB was also significantly inhibited by Pfr 1 and it was followed by Pfr 9 and Pfr 10. In soil also the isolate Pfr 1 was significantly superior over other isolates with highest inhibitory effect on the germination of sclerotia of the pathogen. These are in conformity with those of Kozempour (2004).

Induction of resistance in rice plants by fluorescent *Pseudomonads* against sheath blight has been demonstrated by Krishnamurthy and Gnanamanickam (1997). Van Loon *et al.* (1998) have emphasized the use of combination of different treatments and different biological control agents for better disease suppression.

Overall, in the present study the isolates *viz.*, Pfr 1, Pfr 2, Pfr 9 and Pfr 11 were found superior in checking the pathogen's activity in all the *in vitro* techniques employed to screen the isolates. These isolates were found to have significantly highest lethal impact on the pathogen. The isolate Pfr 1 was consistently observed to possess inhibitory effect against

the rice sheath blight pathogen. Therefore, these four isolates were selected for further screening studies in pot culture experiments.

Nine isolates of *Trichoderma viridae* and two isolates of *T. harzianum* were assessed for their biocontrol efficiency against *R.solani* under *in vitro* conditions using dual culture technique and screening for production of volatile compounds. Their potentiality for the production of lytic enzymes and also in solubilization of inorganic phosphate was also recorded.

In dual culture, all the isolates showed inhibitory action against *R. solani*. The isolates *Trichoderma viride* 4, *T. viride* 33 and *T. viride* 12 had highest mycelial growth reduction than the other isolates. The effect of volatile antifungal compounds produced by *Trichoderma* isolates was studied and all the isolates inhibited the mycelial growth of the pathogen through the production of volatile compounds. *T. harzianum* S12 was found to have significantly highest inhibitory ability (63.5%) compared to other isolates.

All the bioagents produced significant quantity of extracellular mycolytic enzymes. *T. harzianum* S12 produced large amount of chitinase (17.77U/ml), β -1,3-glucanase (50.67U/ml) and β -1,4-glucanase (1.25U/ml) followed by *T. viride* 3 which had 16.66U/ml of chitinase activity and *T. harzianum* 10 with 42.77 U/ml of β -1,3-glucanase and (1.15 U/ml) β -1,4-glucanase activity.

Mycolytic enzymes produced by antagonistic microorganisms are very important in biocontrol technology. There are many reports on production of lytic enzymes by microorganisms (Baharum *et al.* 2003;

Huang and Chen, 2004; Gohel *et al.* 2004). Chef (1987) detected glucanase and chitinase enzymes in soil inoculated with *Trichoderma harzianum*. The isolates of *T. harzianum* which were found to differ in their ability to attack *Sclerotium rolfsii*, *R. solani* and *Pythium aphanidermatum* also differed in the levels of mycolytic enzymes produced by them as reported by Elad *et al.* (1982).

Trichoderma spp. are effective in control of soil/ seed borne fungal diseases in several crop plants (Kubicek *et al.* 2001). Major mechanisms involved in the biocontrol activity of *Trichoderma* spp. were volatile antibiotics and hydrolytic enzymes like chitinase and β -1, 3-glucanase. These hydrolytic enzymes partially degrade the pathogen cell wall and leads to its parasitization.

The antagonists *Pseudomonas fluorescence* and *Trichoderma* spp. produced mycolytic enzymes viz β -1, 3-glucanases, β -1, 4-glucanases and lipases (Paul Diby *et al.* 2005). Sitansu and Someshwar (2008) evaluated the antagonistic potential of *Trichoderma* strains against *R. solani* and *Sclerotium rolfsii* pathogens using dual culture technique and production of volatile and non volatile antibiotics.

Several fungi especially, *Trichoderma* spp. was found to be antagonistic against *R. solani in vitro*. Similar results were obtained by earlier workers (Rabindran and Vidhyasekaran, 1996, Chowdhary *et al.* 2003; Feng, 2008; Khair, 2010). *T. harzianum* (rice leaf sheath isolate) was found to be most effective against *R. solani* (Khan and Sinha, 2007).

R. solani is a strict soil borne fungus in nature (Ou, 1985) and the edaphic factors influence sclerotial viability also. There is no well-established technique for assessing the viability other than germinating the sclerotia on the culture medium. The viable population of *R. solani* (RS-23) was drastically reduced in the presence of *Trichoderma harzianum* 12. These observations were in accordance with the findings of Mathur and Gurjar (2002) who recorded that *Trichoderma* isolates, completely overgrew the mycelium of *R. solani* and stopped the formation of sclerotium.

Overall, the isolates *T. harzianum* 12, *T. viride* 2, *T. viride* 16 and *T. viride* 5 were found to have high inhibitory effect on the pathogen and these four isolates were consistently common in both the *in vitro* techniques. Therefore, these isolates were selected for further screening under *in vivo* conditions.

***In vivo* evaluation of biocontrol agents**

The best bioagents identified *in vitro* were imposed under greenhouse condition using rice variety MTU 1010. The plants inoculated with the isolates *P. fluorescens* 2, *P. fluorescens* 1, *T. harzianum* 12 and *T. viride* 3 experienced low disease intensity. *P. fluorescens* 2 found superior over benlate. The results are in agreement with the work of Nandakumar *et al.* (2001) who worked with three plant growth promoting rhizobacterial (PGPR) strains of *Pseudomonas fluorescens*, PF1, FP7 and PB2 for suppression of rice sheath blight pathogen and promotion of plant (rice cv. IR50) growth under glasshouse and field conditions. The application of talc-formulation of *Pseudomonas fluorescens*(PF1, FP7)

strains through seed, root, soil and foliar spray significantly reduced the sheath blight and leaf folder incidence both under greenhouse and field conditions (Radja Commare, 2002).

Field evaluation of bioagents

Isolates of *P. fluorescens* and *Trichoderma* spp. effectively controlled rice sheath blight when it was applied as foliar spray. These results showed that these isolates were effective as foliar spray. Most biocontrol trails have dealt with use of *P. fluorescens* 1, *P. fluorescens* 2, *T. harzianum* 12 and *T. viride* 2 against rice sheath blight. In both greenhouse and field conditions these isolates have consistently reduced the disease intensity and were almost comparable to benlate application.

Cook (1993) emphasized on repeated introduction of antagonists instead of single application for better performance. Timely and augmented applications are necessary to aid the establishment or maintenance of antagonists that have been carefully selected. When rice seeds were treated with certain antagonistic bacteria, the reduction in sheath blight lesion length has been reported (Mew and Rosales, 1986; Lee *et al.*, 1990; Gnanamanickam *et al.* 1992).

Induction of disease resistance against foliar diseases by soil inoculum of fluorescent pseudomonads has also been widely reported (Wei *et al.* 1991; Maurhofer *et al.*1995). Control of diseases with fluorescent pseudomonads applied to the foliage has been reported (Blackman, 1972; Austin, *et al.*1977; Mew and Rosales, 1986; Expert,1995; Blackman *et al.* 1992; Gnanamanckam, 1992; Levy, 1988).

Most studies have shown that *P. fluorescens* and *Trichoderma* spp. have been detected in substomatal cavities of leaves (Blackman, 1972; Spurr and Welty, 1975; Elad and Kirshner, 1992; Manceau and Kazempour, 2001). The epiphytic bacteria could have controlled *R. solani*. Induction of disease resistance against foliar diseases by foliage spray of fluorescent Pseudomonads and *Trichoderma* spp. has also been widely reported (Wei *et al.* 1991; Maurhofer *et al.* 1995; Nusret and Steven, 2004). *Trichoderma* spp. elicits biocontrol mainly by being mycoparasites and by being aggressive competitor of the pathogen. Some species of *Trichoderma* produce antibiotics at low pH. *T. hamatum* and *T. harzianum* produce lytic enzymes (chitinases and glucanases) that attack the hyphae and sclerotia of the pathogen (Nusret and Steven, 2004). Control of diseases with *Pseudomonas fluorescens* and *Trichoderma* spp. applied to the foliage has been reported (Mathivanan *et al.* 2006). Survival of *Pseudomonas fluorescens* and *Trichoderma* spp. in the phyllosphere (Austin *et al.* 1977; McKenzie *et al.* 1991; Elad and Kirshner, 1993; Migheli *et al.* 1994) may explain the effectiveness of foliar sprays. Both direct inhibition of the pathogen and systemically induced resistance in rice plants could be involved in control (Lemanceau and Albouvette, 1993; Benitez *et al.* 2004). The results of field trial in current study indicate the potential usefulness of foliar spray of powder formulations of isolates of *P. fluorescens* and *Trichoderma* spp.

Application of talc formulations of *P. fluorescens* and *T. viride* resulted in a significant reduction of sheath blight incidence and was comparable to the treatment with Carbendazim as reported by Mathivanan

et al. (2005). The number of productive tillers, grains per panicle and grain weight was also significantly increased in the treated plots with commensurate increase in grain and straw yields. Khan and Sinha (2007) evaluated the potentiality of Talc+CMC based formulation of *Trichoderma harzianum* and reported maximum reduction in disease severity and incidence.

The application of fluorescent Pseudomonads to seed (Ravi Kanth and Rathi, 2008), soil (Hebbar *et al.*, 1991) and foliage (Gnanamanickam and Mew, 1992, Ravi Kanth and Rathi, 2008) has also been attempted to control disease.

From all these results it may be concluded that the biocontrol effect of antagonistic bacteria and fungi isolated from foliage of healthy rice plants in rice sheath blight affected field against *R. solani* are adequate for their use at the rice field in different areas of Andhra Pradesh, Karnataka, Punjab and Tamil Nadu states of India. The low intensity of sheath blight of rice with *P. fluorescens* 1 in field conditions is almost comparable to benlate which emerged as a promising isolate to potentially use it as a commercial bioformulation against this disease.