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Biological management of foliar diseases in organic rice cultivation

■ MALLIKARJUN KENGANAL[1]*, YUSUF ALI NIMBARAGI[2] AND G. S. GURUPRASD[3]

[1]Department of Plant Pathology, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA
[2]Agricultural Extension Education Centre, KOPPAL (KARNATAKA) INDIA
[3]AICRP on Rice, Agricultural Research Station, GANGAVATI (KARNATAKA) INDIA

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***Corresponding author:**
Email : mallikarjun_nss@rediffmail.com

ABSTRACT **:**

Organic rice has high demand due to increased health awareness among the consumers about ill effects of high pesticide residues in food commodities which are integral part of every day. The premium price for organic produces and low cost inputs are other attraction among the organic farmers who are keen to cultivate organic rice. In order to overcome the losses in rice due to diseases, suitable non-chemical management strategies are need of the hour. The current experiment was conducted to identify the biointensive rice diseases management opportunities suitable for organic rice growers. Bio inputs such as *Beejamrutha*, *Pseudomonas fluorescens*, *Panchagavyya*, cow urine, vermiwash and *Neem* oil were tested in ten different treatments over two years on organically maintained plot. Seed treatment of rice with *P. fluorescens*, @ 5g/kg followed by dipping of 30days old seedlings in *P. fluorescens* (0.5%) solution for 30 minutes followed by topical application of *P. fluorescens* 5g/l + *Neem* oil 5ml/l at an interval of 15 days beginning from first application at 15 days after transplanting had the lowest incidence of diseases in both the years. The pooled analysis concluded this treatment most effective with lowest incidence of leaf blast (23.27%), bacterial leaf blight (21.36%) and sheath blight (28.38%), respectively compared to control which had 39.31 per cent leaf blast, 37.31 per cent of bacterial leaf blast and 45.78 per cent of sheath blight. This treatment also recorded highest grain yield of 6800kg/h and 7833kg/h during 2014 and 2015, respectively. The average yield recorded was 7316kg/ha with a cost benefit ratio of 2.11. In control, two years average yield was 3740kg/h with the cost benefit ratio of 1.49 which concludes that best treatment recorded has more promising returns with multiple benefits. Organic rice growers can easily adopt with low cost and no dependence on chemical pesticides. Use of *P. fluorescens* and *Neem* oil had neither residue problem nor mode of application making them ideal choice for biointensive management of rice diseases.

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Plant diseases caused by a variety of causal agents reduce crop yields worldwide. In developing countries crop losses are often higher than in the developed countries, mainly because, farming communities lack suitable plant protection measures and resources devoted to their study. It is estimated that 10-15 per cent of the yields in developing countries is lost due to disease attack, and losses can be higher if post harvest diseases are considered. Often 100 per cent yield losses are also recorded in major food crops due to diseases during epidemic times. A recent study dealing with all production constraints (including diseases) for six major crops (wheat, rice, sorghum, chickpea, cassava, and cowpea) in 13 Asian and African farming systems showed that losses caused by diseases ranged from 3 to 14 per cent, whereas yield losses due to all biotic stresses ranged from 16 to 37 per cent and yield losses to all crop production constraints ranged from 36 to 65 per cent (Waddington *et al*., 2010).

Over the decades, application of pesticides has become dominant and routine practice of pest management to save the crops from devastating pests and disease. The developing countries are highly depending on pesticides than developed ones. Increasing food demand is another force behind it. However, problems associated with frequent and heavy use of pesticides are creating many issues. The cost of cultivation is raising, fungicide resistance in pathogens is another concern and increased pesticide residues are contaminating soil, water and air. The total environment we live is at high risk. The increased pesticide residues in food are also harming human health. During the past decade, many reports of mental and physical disability, organ failure, paralysis, fertility disorders and genetic changes are noticed due to heavy pesticide residues in food chain. Rice is the largest consumed staple food crop facing criticism of heavy pesticide residues after vegetables and fruits. Generally rice is affected by more than fourteen foliar diseases causing heavy yield losses. Bhatt (1988) reported more than 65 per cent yield loss in susceptible rice cultivars due to blast disease alone. For every 10 per cent of neck blast about 6 per cent yield reduction and 5 per cent increase in chalky kernels were recorded (Katsube and Koshimizu, 1970). Bacterial leaf blight caused by *Xanthomonas oryzae* pv. *oryzae* Ish. found worldwide and particularly destructive in Asia causes reduction in yield as high as 50 per cent (Rajagopalan *et al*., 1969) and sheath blight caused by *Rhizoctonia solani* reduces the yield by 1.2 to 69 per cent (Naidu, 1992). Other disease of rice such as brown spot caused by *Helminthosporium oryzae*, stem rot caused by *Sclerotium oryzae* and false smut caused by Ustilaginoidea virens also causes considerable yield losses annually. On one side cultivation of rice with these many diseases has necessitated the use of chemical pesticides. The other side, demand for organic rice and no pesticide residue is very huge. Increasing health awareness among consumers about ill effects of higher pesticide residue is driving the need for organically grown rice. This necessitates the need to identify suitable disease management strategies in rice under organic cultivation practices. Premium price to organic produces is another attraction among rice growers to switch towards organic rice apart from added advantages (Whipps and Mequilken, 1993 and Dubey, 1995). In addition, the biological control of plant pathogens is an attractive alternate means of pest control as it resembles the nature's own way of balancing of population of living organisms (Mukherji *et al*., 1992). Hence, unless a complete non-chemical organic disease management strategy is developed, it is difficult to promote organic farming in rice. The present investigation was undertaken to develop a bio-intensive rice diseases management strategies suitable for organic rice farming.

MATERIAL AND METHODS

The field experiment on bio intensive management of major rice diseases of was conducted during *Kharif* for two seasons in 2014 and 2015 at Tunga Bharda command area in a field maintained under organic farming system since five years. The experiment was laid out on well ploughed, harrowed and puddled plot. As a source of nutrition during land preparation and puddling, 10 t of FYM/ha + 5 tons of paddy straw and 10 t/ha of *in situ* grown sunhemp was incorporated in to soil as green manure. In the last puddle, vermi-compost @ 2 t/ha was applied. The experiment comprised ten treatments of each three replications involving seed treatment with beejamrutha or *Pseudomonas fluorescens* followed by foliar spray with *Panchagavyya* or *P. fluorescens* or cow urine or vermiwash and *Neem* oil. The experiment was laid out following Randomized Block Design (RBD). Beejamrutha and *Panchagavvya* were prepared following the method described by Devakumar *et al.* (2014); Palekar (2006) and Ali *et al*. (2011), respectively. Observations on influence of different treatments on incidence of leaf blast, bacterial leaf blight and sheath blight were recorded. The yields obtained in each treatment were subjected to cost benefit ratio analysis using the average cost of cultivation and rice price of two years. The data were subjected to statistical analysis to draw the conclusion.

Preparation of *Beejamrutha*:

It was prepared by using local cow dung and lime. About 2.5 kg of cow dung was soaked in 10 litres of water and 25g of lime in 500ml of water separately overnight. Following day the dung was squeezed out and discarded. The extract was mixed with lime soaked water, to this 5 litres of cow urine was mixed, stirred thoroughly and used for treating the seeds.

Preparation of *Panchagavyya*:

Cow dung 3kg and cow *Ghee* 500g were mixed, kept for 3 days by regular mixing twice a day. On fourth day, cow urine 5 litre, water 5 litre, cow milk 2 litre, cow curd 1 litre, tender coconut water 2 litre, jiggery 2kg, ripened banana 6 and grape juice 1 litre all together were mixed properly in a plastic container and kept for incubation for 18 days. The mixture was stirred properly twice a day (clockwise and anticlockwise) morning and evening. After incubation it was used for foliar spray.

RESULTS AND DISCUSSION

The experiment conducted on biointensive management of rice over two seasons during 2014 and 2015 showed varying response of each treatment imposed and maintained the trend over both the seasons. Biocontrole agents, plant derivatives, organic liquid fertilizers such as *Beejamrutha* and *Panchagavyya* were fond negatively influencing the rice diseases and positively increasing the yield and net returns. Among the different treatments imposed, seed treatment of rice with *P. fluorescens,* @ 5g/kg followed by dipping of 30days old seedlings in *P. fluorescens* 0.5 per cent solution for 30 minutes followed by topical application of *P. fluorescens* 0.5 % + *Neem* oil 5ml/l at an interval of 15 days beggining from first application at 15 days after transplanting had the lowest incidence of leaf blast (26.29%), bacterial leaf blight (19.45%) and sheath blight (30.26%) during 2014 compared to other treatments. The non-treated control plot recorded 43.78 per cent, 35.55 per cent and 49.53 per cent leaf blast, bacterial leaf blight and sheath blight, respectively (Table 1). The treatment had similar trend with lowest leaf blast (18.13%), bacterial leaf blight (21.33%) and sheath blight (26.50%), respectively during 2015. The pooled analysis concluded this treatment most effective in reducing these foliar diseases very effectively with lowest incidence of leaf blast (23.27%), bacterial leaf blight (21.36%) and sheath blight (28.38%), respectively compared to other treatments. This treatment also recorded highest grain yield of 6800kg/h and 7833kg/h during 2014 and 2015, respectively. The average yield orecorded was 7316kg/ha with a cost benefit ratio of 2.11 (Table 2). Use of organic inputs in rice cultivation was found very effective in Cambodian ecosystem (Tann *et al.*, 2012). Similar kind of beneficial advantages by use of biocontrol agents in rice such as endophytic bacteria *Bacillus subtilis* found effective against bacterial leaf blight when applied through seed treatment @ 4g/kg + seedling dip @ 4g/l + soil application @ 500g/ha + foliar application @ 500g/ha which recorded the lowest severity of bacterial leaf blight (31.36 %) (Krishnan Nagendran *et al*., 2013). Sheath blight of rice was found reduced upto 40.82 per cent by foliar spray of *Trichoderma harzianum* (Tewari and Singh, 2005). Use of *Neem* derived products were centre of attraction across the world among organic growers. In rice also *Neem* seed kernel extract, *Neem* cake, *Neem* oil and other such as *Panchagavya*, *P. fluorescens*, *Trichoderma viride* and *Pongamia pinnata* were found useful in reducing the rice diseases. *P. fluorescens* being a well known rihizobacteria was found significantly useful in reducing the leaf blast of rice under organic farming systems (Sireesha, 2013). The other similar treatment except use of *Neem* oil had on par response in terms of disease incidence, yield and cost benefit ratio. Use of *Beejamrutha* and *Panchagavyya* did not influence much in reducing the disease incidence compared to *P. fluorescens* and *Neem* oil. The later which is a preferred natural plant derived pesticide had an added advantage of reducing the pest incidence. Though *Beejamrutha* and *Panchagavyya* are noted growth promoters but could not overtake the damage caused by pathogens and influence as desired. In control, highest incidence of leaf blast (43.78%), bacterial leaf blight (35.55%) and sheath blight (49.53%) were noticed during 2014 and in 2015 also. The pooled analysis of control plot showed 39.31 per cent leaf blast, 37.31 per cent bacterial leaf blight and 45.78 per cent of sheath blight incidence. Yield recorded was also lowest 4080kg/h and 3400kg/ha during 2014 and 2015, respectively with an average of 3740kg/h and cost benefit ratio of 1.49. Among different biological inputs use of *P. fluorescens* had multiple benefits, it was found inducing the disease resistance in rice when applied either through seed treatment or foliar spray (Vidhyasekaran *et al.*, 1997; Shyamala and Sivakumaar, 2012). The *P. fluorescens* induced resistance could be involved with the production of phytoalexins, synthesis of PR proteins and expression of defence-related enzymes against various types of pathogen. Similarly in the present study also use of *P. fluorescens* played key role in reducing the incidences of leaf blast, bacterial leaf blight and sheath blight (Van Loon and Bakker, 2006). The use of this plant growth promoting rhizobacteria (PGPR) in reducing the sheath blight of rice by different approaches such as antagonism, competition for space and essential nutrients and induction of systemic resistance are very well documented (Yellareddygari *et al.*, 2014). Besides, PGPR role in increasing plant or root growth, they directly influence increased N uptake, phosphate solubilization, phytohormone synthesis, and production of iron chelating siderophores. Some PGPR are used commercially to enhance plant growth and health (Wu *et al.*, 2012; Lalande *et al.*, 1989). Seed treatment of

Table 1 : Influence of different bio-intensive inputs on incidence of different diseases of rice under organic farming system

Sr. No.	Treatments	2014			2015			Pooled		
		Disease incidence (%)			Disease incidence (%)			Disease incidence (%)		
		LB	SB	BLB	LB	SB	BLB	LB	SB	BLB
T_1	ST with Beejamrutha, FS of *Panchagayva* 4% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	35.33 (36.41)	42.66 (40.75)	30.85 (33.72)	30.00 (33.19)	32.50 (34.71)	29.47 (32.84)	32.67 (34.82)	37.58 (37.77)	30.16 (33.28)
T_2	ST of Beejamrutha, FS of cow urine 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	36.63 (37.06)	43.70 (41.35)	31.27 (33.96)	30.70 (33.62)	32.63 (34.79)	28.03 (31.95)	33.66 (35.39)	38.17 (38.13)	29.65 (32.97)
T_3	ST of Beejamrutha, FS of *P. fluorescens* 5g/l at 15 day interval from 15 days after transplanting	35.26 (36.36)	40.48 (39.46)	29.04 (32.58)	30.40 (33.44)	32.33 (34.62)	29.50 (32.85)	32.83 (34.93)	36.41 (37.09)	29.27 (32.72)
T_4	ST of Beejamrutha, FS of vermivash 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	37.75 (37.82)	40.87 (39.71)	27.50 (31.59)	28.67 (32.34)	34.77 (36.11)	26.43 (30.90)	33.21 (35.15)	37.82 (37.93)	26.97 (31.26)
T_5	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of *Panchagayva* 4% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	36.92 (37.38)	41.22 (39.90)	28.55 (32.26)	29.30 (32.72)	35.30 (36.43)	27.57 (31.60)	33.11 (35.09)	38.26 (38.19)	28.06 (31.96)
T_6	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of cow urine 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	32.40 (34.62)	36.73 (37.26)	24.48 (29.58)	20.67 (26.99)	33.73 (35.47)	26.53 (30.97)	26.54 (30.94)	35.24 (36.39)	25.51 (30.28)
T_7	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of vermiwash 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	32.70 (34.80)	34.47 (35.83)	24.18 (29.42)	22.90 (28.50)	30.17 (33.30)	24.97 (29.92)	27.80 (31.77)	32.32 (34.60)	24.58 (29.70)
T_8	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of *P. fluorescens* 5g/l + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	26.29 (32.12)	30.52 (33.25)	19.45 (27.47)	18.13 (25.18)	26.50 (30.87)	21.33 (27.41)	23.27 (28.79)	28.38 (32.12)	21.36 (27.44)
T_9	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l, FS of *P. fluorescens* 5g/l at 15 day interval from 15 days after transplanting	28.41 (30.78)	30.26 (33.50)	21.39 (26.11)	19.83 (26.43)	27.80 (31.77)	22.07 (27.90)	23.06 (28.67)	29.16 (32.64)	20.76 (27.09)
T_{10}	Control	43.78 (41.40)	49.53 (44.71)	35.55 (36.56)	34.83 (36.12)	42.03 (40.39)	39.07 (38.65)	39.31 (38.81)	45.78 (42.56)	37.31 (37.63)
	Co-efficient of variance (CV)	15.80	14.62	10.63	10.79	11.43	10.6	12.18	10.57	10.35
	Critical difference (CD)	10.3	10.77	5.46	5.4	7.07	5.5	6.32	6.44	4.81

Table 2 : Influence of different bio-intensive inputs on yield and cost benefit ratio under organic farming system

Sr. No.	Treatments	Yield 2014 (kg/h)	Yield 2015 (kg/h)	Yield Mean (kg/h)	Mean cost of cultivation /h (Rs.)	Gross returns (Rs.)	C:B ratio
T_1	ST with Beejamrutha, FS *of Panchagayva* 4% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5466	4766	5116	50550	76750	1.51
T_2	ST of Beejamrutha, FS of cow urine 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5166	4900	5033	50125	75500	1.51
T_3	ST of Beejamrutha, FS of *P. fluorescens* 5g/l at 15 day interval from 15 days after transplanting	5233	4400	4816	44425	72250	1.62
T_4	ST of Beejamrutha, FS of vermivash 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5666	5766	5717	50550	85750	1.7
T_5	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of *Panchagayva* 4% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5233	5800	5517	50750	82750	1.63
T_6	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of cow urine 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5733	5600	5666	50375	85000	1.69
T_7	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of vermiwash 10% + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	5666	6000	5833	50750	87500	1.72
T_8	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l , FS of *P. fluorescens* 5g/l + *Neem* oil @ 5ml/l at 15 day interval from 15 days after transplanting	6800	7833	7316	52125	109750	2.11
T_9	ST with *P. fluorescens* 5g/kg, seedling dip in *P. fluorescens* 5g/l, FS of *P. fluorescens* 5g/l at 15 day interval from 15 days after transplanting	6300	5866	6083	44625	91250	2.04
T_{10}	Control	4083	3400	3740	37500	56100	1.49

rice with PGPR resulted in increased root and shoot length of seedlings (Lucy *et al*., 2004). Another popular bioagent *T. harzianum isolated from rice* phylloplane was found to be most effective in reducing the rice disease severity and increasing grain yield (Gangwar, 2013). Use of organic manures in rice (Tejeswara Rao, *et al*., 2013) coupled with use of biological inputs for disease management makes it more perfect combination of package for organic rice growers. *Beejamrutha* and *Panchagavyya* though have higher beneficial bacterial population followed by N-fixers, P-solubilizers, fungi and actinomycetes that would mobilize more of plant nutrients and provide plant growth promoting substances and also other micro nutrients required by the plants (Devakumar *et al*., 2014). But both of them could not make any dent in suppressing the diseases recorded. Another organic liquid bioresource, jeevamruta was found useful when combined with recommended dosage of fertilizers but had no direct role in reducing the diseases (Kasbe *et al*., 2015). The results of this experiment emphasis the need to adopt use of *P. fluorescens* for seed treatment, seedling dip and topical application combined with *Neem* oil which was found superior in the experiment and promises effective control of major disease of rice under organic farming system. These treatments are ideally suitable for adoption by organic rice growers at low cost. The outcome has a way forward in reducing the dependence on chemical pesticides and reduces the level of pesticide residues in rice.

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