

Integrated management of banded leaf and sheath blight disease of maize (*Rhizoctonia solani* f.sp. *sasakii*) using biofumigation and microbial Antagonists G.Bindu Madhavi¹,

ABSTRACT

Banded Leaf and Sheath Blight (BLSB) of Maize caused by *Rhizoctonia solani* f.sp. *sasakii* is an economically significant disease worldwide. Sustainable management of BLSB is possible by integration of environmentally safe practices such as microbial antagonists and biofumigation. In our present study, the compatibility of these bioagents with biofumigation effect by mustard crop (using extracts of leaves, shoots, roots and whole plant) was established under laboratory conditions. Greenhouse and field studies were carried out in a randomized complete block design (RCBD) with 10 treatments (replicated thrice) including untreated control against BLSB by integrating microbial antagonists and biofumigant. Elite strains of fungal (*T. harzianum*) and bacterial antagonists (*P. fluorescens*) were selected and evaluated as seed treatment, soil drenching and foliar spray individually and as consortia. The standard chemical check, azoxystrobin was also evaluated individually and in combination with bioagents and biofumigation. Commercially available *P. fluorescens* and *T. harzianum* was also evaluated. Further, these antagonistic strains were proved to be less sensitive to volatiles released by the biofumigant crop mustard under laboratory conditions. Our greenhouse and field evaluation studies indicated that through integration of biofumigation and using consortia of *P. fluorescens* and *T. harzianum* as seed treatment, soil drench and foliar spray and in combination with azoxystrobin as foliar spray, the BLSB incidence was least. Further, this treatment recorded highest seed germination; root length; shoot length; cob length; number of kernels/cob; and seed yield. Same set of treatment combination without azoxystrobin application also performed at par in terms of BLSB reduction and enhancing biometric characteristics and yield, thus indicating that additional fungicidal spray did not have any significant beneficial effects. Soil enumeration of fungal and bacterial antagonists indicated that the population levels of these microflora are affected by biofumigation. Our findings suggested that BLSB disease can be effectively managed and yields can be enhanced in maize by integrating biofumigation and consortia of *T. harzianum* and *P. fluorescens* as seed treatment, soil drench and foliar spray under the conditions evaluated.

Key words: Maize, Banded leaf and sheath blight, *Rhizoctonia solani* f.sp. *sasakii*, *Trichoderma harzianum*, *Pseudomonas fluorescens*, biofumigation

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Table 1. Effect of volatiles released from different parts of mustard plant at different concentrations against radial growth (mm) of *Trichoderma harzianum*.

Treatment	Radial growth of <i>T. harzianum</i> (mm) after 72 h of inoculation					
	1g	Inhibition (per cent)	5g	Inhibition (per cent)	10g	Inhibition (per cent)
leaf	85.0	4.8	77.3	14.1	70.3	21.5
Shoot	85.6	4.1	81	10.0	76.3	14.8
Root	80.0	10.4	73.6	18.2	66.3	26.0
Whole plant	81.6	8.6	78	13.3	70	21.9
Control	89.3	0.0	90	0.0	88.6	0.0
	S. Em ±		CD (0.05per cent)			
Main	0.38		1.10			
Sub	0.29		0.85			

Interaction	0.66		2.14			
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Table.2 Effect of volatiles released from different plant parts of mustard against growth of *Pseudomonas fluorescens* under *in vitro* conditions

Macerated Mustard plant part	Growth of <i>Pseudomonas fluorescens</i>¹		
	24 h	48h	72h
Leaf	++	+++	+++
Shoot	++	+++	+++
Root	++	+++	+++
Whole plant	++	+++	+++
control	+++	+++	+++

¹Rate of growth of *P. fluorescens* strain : +++ = Good; ++ = Moderate; + = Poor; and - = No growth.

Table 3. Evaluation of bio intensive management of BLSB disease and growth parameters of maize under greenhouse conditions

Treatment	Seed germination (per cent)	Cob length (cm)	Cob weight (g)	No. of kernals/ cob	Seed yield (kgha ⁻¹)	100 grain weight (g)	PDI
T ₁ : Pf(ST+SD+FS)	95.3	13.9	213.7	326.7	3450.0	23.1	36.3
T ₂ : Th (ST+SD+FS)	92.3	14.1	213.0	320.3	3626.7	22.4	39.0
T ₃ : Pf & Th (ST+SD+FS)	99.7	15.9	239.3	348.7	4726.0	27.2	20.0
T ₄ : Bfg + Pf (ST+SD+FS)	96.0	15.8	223.0	338.7	4033.3	24.0	24.7
T ₅ : Bfg+ Th(ST+SD+FS)	94.3	15.7	214.3	331.3	3940.0	23.8	34.3
T ₆ : Bfg + Pf & Th (ST+SD+FS)	100.0	18.1	268.0	377.3	5120.0	28.2	7.3
T ₇ : Bfg+ Pf & Th (ST+SD+FS) + FS (azoxystrobin)	100.0	18.2	268.7	380.7	5266.7	28.6	6.0
T ₈ : Azoxystrobin (ST+SD+FS)	95.0	13.8	242.0	336.7	4531.7	27.8	19.3
T ₉ : Commerical Pf & Th (ST+SD+FS)	84.7	12.0	126.3	266.7	1683.3	19.8	79.0
T ₁₀ - Untreated control	84.3	11.3	113.7	231.3	816.7	18.0	84.7
SEm±	0.69	0.46	3.51	4.64	140.6	0.54	1.99
CD (0.05%)	2.05	1.39	10.43	13.79	417.9	1.63	5.93

Th is *Trichoderma harzianum*; Pf is *Pseudomonas fluorescens*; ST is Seed Treatment; SD is soil drenching; FS is foliar spray; azoxy is standandard chemical fungicide, azoxystrobin and Bfg is biofumigation

Table 4. Populations of soil microflora following incorporation of mustard in to the soil in different treatments of greenhouse experiment

Treatment	5 days after incorporation of biofumigant				50 days after incorporation of biofumigant			
	TF x 10 ⁴	B x 10 ⁵	T x 10 ⁴	Px 10 ⁵	TFx10 ⁴	B x 10 ⁵	Tx 10 ⁴	Px 10 ⁵
T1: Pf(ST+SD+FS)	8.2	19.6	5.4	7.8	10.7	23.3	5.4	10.2
T2: Th (ST+SD+FS)	8.6	18.8	5.5	7.2	11.8	20.0	7.3	8.5
T3: Pf&Th (ST+SD+FS)	9.2	19.9	5.9	7.7	13.1	25.0	7.1	12.1
T4: Bfg + Pf (ST+SD+FS)	7.3	18.4	5.7	7.3	15.3	27.0	8.2	15.2
T5: Bfg+ Th(ST+SD+FS)	7.2	18.0	5.4	7.1	15.0	28.0	9.4	14.3
T6: Bfg + Pf&Th (ST+SD+FS)	7.3	18.6	5.4	7.8	18.8	29.2	12.1	18.2
T7: Bfg+ Pf&Th (ST+SD+FS) + FS (azoxystrobin)	7.5	18.5	5.3	7.7	19.2	29.5	12.5	18.2
T8: Azoxystrobin (ST+SD+FS)	10.5	20.0	5.4	8.4	13.0	20.0	5.4	10.3
T9: Commerical Pf&Th (ST+SD+FS)	10.7	19.0	5.6	8.0	11.0	13.0	4.4	7.5
T10- Untreated control	11.0	18.7	5.6	6.8	8.5	11.7	4.6	7.3
		SEm±	CD (0.05%)			SEm±	CD (0.05%)	
	Main	0.27	0.75		Main	0.3	0.83	
	Sub	0.17	0.48		Sub	0.19	0.52	
	Inter	0.54	1.58		Inter	0.6	1.73	

Th is *Trichoderma harzianum*; Pf is *Pseudomonas fluorescens*; ST is Seed Treatment; SD is soil drenching; FS is foliar spray; azoxy is standandard chemical fungicide, azoxystrobin and Bfg is biofumigation

Table 5. Evaluation of bio intensive management of BLSB disease on growth parameters of maize under field conditions.

Treatment	Seed germination (%)	Cob length (cm)	Cob weight (g)	No. of kernals/ cob	Seed yield (kg ha^{-1})	100 grain weight (g)	PDI
T ₁ : Pf(ST+SD+FS)	94.0	18.9	232.3	401.7	6250.0	26.1	36.4
T ₂ : Th (ST+SD+FS)	91.7	19.1	231.7	397.3	6260.0	25.8	39.1
T ₃ : Pf&Th (ST+SD+FS)	98.3	20.9	258.0	421.0	7359.3	29.8	26.1
T ₄ : Bfg + Pf (ST+SD+FS)	95.0	20.5	241.7	413.3	6650.0	28.2	33.0
T ₅ : Bfg+ Th(ST+SD+FS)	92.7	21.0	233.0	407.0	6573.3	27.5	35.1
T ₆ : Bfg + Pf&Th (ST+SD+FS)	98.3	22.0	267.0	456.0	7753.3	31.4	15.1
T ₇ : Bfg+ Pf&Th (ST+SD+FS) + FS (azoxystrobin)	98.7	23.0	286.0	458.7	7900.0	31.8	15.3
T ₈ : Azoxystrobin (ST+SD+FS)	93.7	18.8	260.7	411.3	7165.0	29.0	25.2
T ₉ : Commerical Pf&Th (ST+SD+FS)	87.7	17.0	145.0	345.7	4316.7	24.0	78.7
T ₁₀ - Untreated control	88.0	16.3	132.3	317.7	3503.3	22.0	85.3
SEm \pm	0.97	0.52	3.45	3.86	149	0.51	1.84
CD (0.05%)	2.88	1.57	10.26	11.47	445	1.52	5.46

Th is *Trichoderma harzianum*; Pf is *Pseudomonas fluorescens*; ST is Seed Treatment; SD is soil drenching; FS is foliar spray; azoxy is standandard chemical fungicide, azoxystrobin and Bfg is biofumigation

Table 6. Populations of soil microflora following incorporation of mustard in to the soil in different treatments of field

Treatment	5 days after incorporation of biofumigant				50 days after incorporation of biofumigant			
	TF x 10 ⁴	B x 10 ⁵	T x 10 ⁴	Px 10 ⁵	TFx 10 ⁴	B x 10 ⁵	Tx 10 ⁴	Px 10 ⁵
T ₁ : Pf(ST+SD+FS)	8.0	17.3	4.7	7.8	12.0	21.7	6.8	9.2
T ₂ : Th (ST+SD+FS)	8.0	17.5	4.9	7.3	12.8	22.7	7.5	9.4
T ₃ : Pf&Th (ST+SD+FS)	8.2	17.8	5.2	7.3	15.0	23.0	7.8	13.0
T ₄ : Bfg + Pf (ST+SD+FS)	7.0	16.4	5.0	7.0	15.0	21.0	6.6	11.5
T ₅ : Bfg+ Th(ST+SD+FS)	7.1	16.7	5.2	7.2	15.8	24.0	8.9	10.7
T ₆ : Bfg + Pf&Th (ST+SD+FS)	7.2	17.0	5.4	7.2	17.1	26.3	9.6	12.1
T ₇ : Bfg+ Pf& Th (ST+SD+FS) + FS (azoxystrobin)	7.3	16.7	5.1	7.2	17.7	27.3	9.6	12.3
T ₈ : Azoxystrobin (ST+SD+FS)	8.2	17.7	5.4	7.7	8.8	18.3	5.6	8.1
T ₉ : Commerical Pf&Th (ST+SD+FS)	8.6	17.7	5.6	7.2	10.8	20.0	6.5	8.6
T ₁₀ - Untreated control	9.1	18.2	4.9	7.7	10.5	20.0	5.8	8.47
		SEm±	CD (0.05%)			SEm±	CD(0.05%)	
	Main	0.112	0.31		Main	0.39	1.06 8	
	Sub	0.071	0.196		Sub	0.24	0.67 5	
	Inter	0.224	0.65		Inter	0.77	2.23 6	

