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Biological Management of Rice Sheath Blight caused by *Rhizoctonia solani* Kuhn. under *In-vivo* Condition

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Abstract

Sheath blight caused by *Rhizoctonia solani* is one of the most destructive diseases in rice contributing to significant yield loss. Bioagents and bio-fumigants and their combination were evaluated for their effect on disease severity of rice sheath blight during *kharif* and *rabi* seasons of 2017 under *in-vivo* conditions. During *kharif* 2017, foliar application of propiconazole 25 per cent EC @ 0.1 per cent at 30 days after transplanting (DAT) and 60 DAT was found to be most effective (3.70 and 92.6 %) followed by soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *Pseudomonas fluorescens* @ 5 g/L at 30 DAT (6.48 and 87.04 %) and least effective treatment was foliar application of *Trichoderma viride* @ 5 g/L at 30 DAT (41.66 and 16.68 %) on the basis of mean disease severity and per cent reduction over control. The same trend was noticed during *rabi* 2017. The foliar application of propiconazole 25 per cent EC @ 0.1 per cent at 30 DAT and 60 DAT recorded the lowest per cent of chaffiness and highest per cent decrease over control (7.33 and 80.7 per cent) whereas, the highest per cent of chaffiness and lowest per cent decrease over control was observed in foliar application of *T. viride* @ 5 g/L at 30 DAT (34 and 10.5 per cent). The highest average grain yield per plant and average per cent increase over control was recorded in foliar application of propiconazole 25 per cent EC @ 0.1 per cent at 30 DAT and 60 DAT (13.4g and 94.2%).

Keywords : Bioagents, Bio-fumigants, Disease severity

Rice (*Oryza sativa* L.) is second most important cereal and the staple food for more than half of the world's population. Rice is the most prominent crop of India as it is the staple food for most of the people of the country. In India rice crop is being cultivated in an area of 43.19 m ha with production of 110.5 m tonnes and productivity of 2550 kg ha^{-1}. In Karnataka it occupies an area of 1.01 m ha, production of 2.54 m tonnes and productivity of 2522 kg ha^{-1} (Anonymous, 2017).

Rice is prone to many fungal, bacterial, viral and nematode diseases. Among all pathogenic organisms, fungal pathogens are limiting the rice productivity to great extent. Several out-break of diseases such as blast, sheath blight and bacterial blight have been reported from many rice growing areas of India. Worldwide the annual losses due to rice diseases is estimated to 10-15 per cent, depending upon the age of the plant, time of infection and severity, diseases caused yield loss to the extent of 5.9 to 69 per cent (Venkat Rao *et al.,* 1990 and Naidu, 1992).

Sheath blight is one of the major biotic constraints that affects rice production in India and is considered economically important disease of rice in the world (Lee and Rush 1983 and Webster & Gunnell, 1992). The disease is caused by *Rhizoctonia solani* Kuhn (teleomorph: *Thanatophorus cucumeris* (Frank) Donk). The Sheath blight is becoming most destructive, being second only to rice blast disease among the rice diseases constraining rice productivity (Ou, 1985). The disease is endemic to areas where temperature and relative humidity are high and cultivation is intensive. The pathogen is polyphagous competitive saprophyte and has a wide host range. Continuous rice cropping, high density and heavy canopy associated with high nitrogen management favours disease build up from tillering to panicle initiation (Biswas, 2001).

The incidence of rice sheath blight disease has increased in recent years, because of the unavailability of resistant cultivars or any other suitable economic disease management measures. The yield losses due to this disease is reported to range from 5.2 to 50 per cent, depending on environmental conditions, crop stages at which the disease appears, cultivation practices and cultivars in India (Rajan, 1987; Sharma and Teng, 1996).

The management of sheath blight through fungicide application is the most common approach among the farmers. Because of the disadvantages of using the fungicides, it has become necessary to adopt eco-friendly approaches for enhancing crop yield and better crop health. The use of biological methods for the management of this disease is scarce. It is necessary to evaluate the biological methods including use of bioagents, bio fumigants, botanicals etc., to manage the disease effectively to avoid resistance development in pathogen and minimize the fungicidal residues for ecological sustainability. In view of the importance of the crop and seriousness of the sheath blight disease an investigation was undertaken under green house condition to evaluate bioagents and bio fumigants for its management.

MATERIAL AND METHODS

The investigations were conducted during 2017 in the Department of Plant Pathology, College of Agriculture, V.C. Farm, Mandya.

In-vivo Evaluation of Bioagents and Bio Fumigants Against Sheath Blight of Rice

The pot experiments were carried out for two seasons *kharif* and *rabi* 2017 with 13 treatments (Table 1). Three replications of each treatment were maintained including control. The inoculum of the pathogen was mixed in the soil @ 20 per cent of the soil weight. In case of T_7 to T_{10} the plant material was added one week after pathogen added to soil. Two weeks after treatment, 25 days old seedlings of variety Jyothi were transplanted in two hills per pot. The assessment of disease severity was made by following Standard Evaluation System (SES) scale (IRRI, 1996) on 45 and 75 DAT. Per cent chaffiness and yield was recorded at harvest and the yield was expressed per plant.

TABLE 1
Details of the treatment

T_1 :	Foliar application of *Trichoderma viride* (Tv) @ 5 g/L at 30 DAT
T_2 :	Foliar application of Tv @ 5 g/L at 30 DAT and 60 DAT
T_3 :	Foliar application of *Pseudomonas fluorescens* (Pf) @ 5 g/L at 30 DAT
T_4 :	Foliar application of Pf @ 5 g/L at 30 DAT and 60 DAT
T_5 :	Soil application of Pf (2 g) at the time of transplanting
T_6 :	Soil application of Pf (2 g) and foliar application of Pf (5 g/L) at 30 DAT
T_7 :	Soil application of mustard leaf @ 5 g/100 g soil before transplanting
T_8 :	Soil application of radish leaf @ 5 g/100 g soil before transplanting
T_9 :	Soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of Tv @ 5 g/L at 30 DAT
T_{10} :	Soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of Pf @ 5 g/L at 30 DAT
T_{11} :	Foliar application of propiconazole 25 % EC @ 0.1 % at 30 DAT
T_{12} :	Foliar application of propiconazole 25 % EC @ 0.1 % at 30 DAT and 60 DAT
T_{13} :	Untreated control

DAT = Days after transplanting

Statistical analysis

The data obtained in different experiments were statistically analysed by following Complete Randomized Design (CRD) as per the procedures suggested by Snedecor and Cochran (1967) and Panse and Sukhatme (1978). The data pertaining to percentage were transformed into arc sin transformation, as it is required before statistical analysis.

RESULTS AND DISCUSSION

In-vivo Evaluation of Bioagents and Bio Fumigants Against Sheath Blight of Rice

The bioagents and the bio fumigants found to be most effective during *in-vitro* studies were validated for their effect against sheath blight of rice by conducting pot studies. The experiments were carried during *kharif* and *rabi* 2017 with 13 treatments.

Effect of Different Treatments on Disease Severity

The bioagents and bio fumigants and their combination were evaluated for their effect on disease severity of rice sheath blight during *kharif* and *rabi* 2017. The effect of different treatments on disease severity is shown in Table 2 (Fig. 1) and Table 3 (Fig. 2). On the basis of mean disease severity and per cent reduction over control, foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT (T_{12}) was most effective (3.70 and 92.6 per cent) followed by (T_{10}) soil application of mustard leaf @5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (6.48 and 87.04 %). The least effective treatment was (T_1) foliar application of *Trichoderma viride* (Tv) @ 5 g/L at 30 DAT (41.66 and 16.68 %) followed by (T_8) soil application of radish leaf @5 g/100 g soil before transplanting (38.89 and 22.22 %) whereas, in T_{13} (control) the mean disease severity was observed to be 50 per cent. The remaining treatments showed the mean disease severity ranging from 7.41 to 32.40 per cent and 35.20 to 85.18 per cent reduction over control. The same trend was also observed during *rabi* 2017 wherein treatment (T_{12}) foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT was the most effective with mean disease severity and percent reduction over control (4.17 and 90.31 %) followed by (T_{10}) soil application of mustard leaf @5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (5.56 and 87.08 %). Among the treatments, (T_1) foliar application of *Trichoderma*

TABLE 2

In-vivo evaluation of bioagents and bio fumigants on disease severity of rice sheath blight during *kharif* 2017

Treatments	Disease Severity (%)			
	45 DAT	75 DAT	Mean	% reduction over control
T_1	24.07 (29.15)	59.25 (50.61)	41.66 (40.15)	16.68
T_2	12.96 (21.01)	24.07 (29.15)	18.52 (25.32)	62.96
T_3	20.37 (26.78)	44.44 (41.75)	32.40 (34.61)	35.20
T_4	12.96 (21.01)	20.37 (26.78)	16.66 (24.04)	66.68
T_5	16.66 (24.09)	37.03 (37.44)	26.85 (31.18)	46.30
T_6	11.11 (19.47)	18.51 (25.43)	14.81 (22.61)	70.38
T_7	14.81 (22.55)	29.63 (32.88)	22.22 (28.03)	55.56
T_8	22.22 (28.12)	55.55 (48.24)	38.89 (38.54)	22.22
T_9	5.55 (13.62)	11.11 (19.06)	8.33 (16.62)	83.34
T_{10}	3.70 (9.08)	9.26 (17.52)	6.48 (14.68)	87.04
T_{11}	0.00 (0.00)	14.81 (22.55)	7.41 (15.73)	85.18
T_{12}	0.00 (0.00)	7.40 (15.57)	3.70 (10.94)	92.60
T_{13}	29.63 (32.88)	70.36 (57.30)	50.00 (44.98)	0.00
S. Em±	1.93	3.11	1.90	
C.D. (0.05)	5.63	9.06	5.54	
C.V. %	15.54	16.36	11.93	

DAT = Days After Transplanting; Figures in parenthesis are arcsine transformed values

TABLE 3

In-vivo evaluation of bioagents and bio fumigants on disease severity of rice sheath blight during *rabi* 2017

Treatments	Disease Severity (%)			
	45 DAT	75 DAT	Mean	% reduction over control
T1	25.92 (30.57)	48.14 (43.93)	38.88 (38.56)	9.69
T2	12.96 (21.01)	25.92 (30.50)	16.67 (24.09)	61.28
T3	20.37 (26.78)	40.74 (39.62)	29.16 (32.64)	32.26
T4	11.11 (19.47)	20.37 (26.78)	15.28 (22.99)	64.51
T5	18.51 (25.43)	37.03 (37.44)	29.16 (32.64)	32.26
T6	9.26 (17.52)	18.51 (25.43)	13.89 (21.81)	67.74
T7	14.81 (22.55)	33.33 (35.26)	25.00 (29.99)	41.93
T8	22.22 (28.12)	44.44 (41.80)	33.33 (35.26)	22.58
T9	3.70 (9.08)	14.81 (22.55)	9.72 (18.13)	77.42
T10	0.00 (0.00)	12.96 (21.01)	5.56 (13.63)	87.08
T11	1.85 (4.54)	16.66 (23.89)	6.94 (15.23)	83.88
T12	0.00 (0.00)	9.26 (17.52)	4.17 (11.66)	90.31
T13	31.48 (34.10)	53.70 (47.12)	43.05 (41.00)	0.00
S.Em±	2.11	1.76	0.94	
C.D. (0.05)	6.17	5.15	2.75	
C.V. %	18.25	9.42	6.05	

DAT = Days after After transplanting; Figures in parenthesis are arcsine transformed values

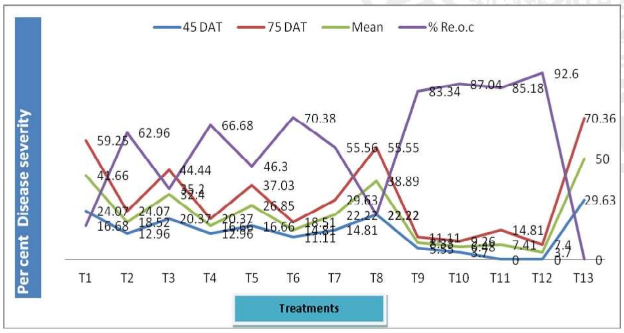

Fig. 1: *In-vivo* evaluation of bio agents and bio fumigants on disease severity of rice sheath blight during *kharif* 2017

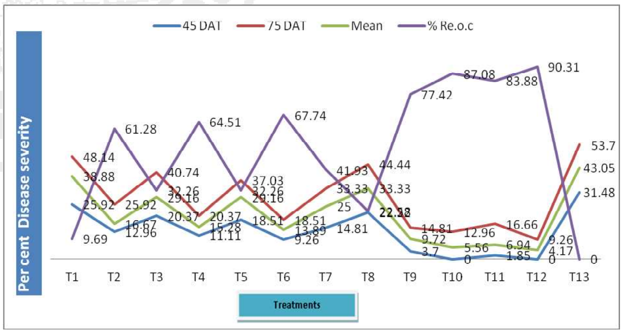

Fig. 2: In vivo evaluation of bio agents and bio fumigants on disease severity of rice sheath blight during *rabi* 2017

viride @ 5 g/L at 30 DAT was least effective with mean disease severity of 38.88 per cent and per cent reduction over control 9.69%.

Effect on Plant Height

The plant height was significantly influenced by the treatments during *kharif* and *rabi* 2017. The mean plant height in different treatments ranged from 52.8 cm to 81.3 cm (Table 4). The treatment foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT (T_{12}) had a significant effect on plant height which recorded highest mean plant height (81.3 cm) and mean percent increase over control (53.9 %) compared to other treatments. It was followed by

TABLE 4

In vivo effect of bioagents and bio-fumigants against sheath blight of rice / plant height

Treatments	*Kharif* 2017		*Rabi* 2017		Mean	
	Plant height (cm)	% increase over control	Plant height (cm)	% increase over control	Plant height (cm)	% increase over control
T_1	53.2	2.3	55.3	3.4	54.3	2.8
T_2	62.7	20.6	66.5	24.3	64.6	22.3
T_3	56.5	8.7	61.3	14.6	58.9	11.6
T_4	64.5	24.0	68.5	28.0	66.5	25.9
T_5	58.5	12.5	63.5	18.7	61.0	15.5
T_6	66.2	27.3	70.2	31.2	68.2	29.2
T_7	59.7	14.8	63.8	19.3	61.8	17.0
T_8	55.8	7.3	58.8	9.9	57.3	8.5
T_9	73.7	41.7	78.2	46.2	75.9	43.8
T_{10}	74.9	44.0	81.8	52.9	78.4	48.7
T_{11}	70.0	34.6	74.2	38.7	72.1	36.6
T_{12}	78.0	50.0	84.7	58.3	81.3	53.9
T_{13}	52.0	0.0	53.5	0.0	52.8	0.0
S.Em±	0.91		0.84		0.70	
C.D. (0.05)	2.66		2.47		2.04	
C.V. %	2.53		2.19		1.87	

(T_{10}) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (78.4 cm and 48.7 %), (T_9) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *T. viride* @ 5 g/L at 30 DAT (75.9 cm and 43.8 %) and (T_{11}) foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT (72.1 and 36.6 %). (T_{10}) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT was on par with (T_{12}) foliar application of propiconazole 25 per cent EC @ 0.1 per cent at 30 DAT and 60 DAT and the least mean plant height and mean per cent increase over control was observed in (T_1) foliar application of *T. viride* @ 5 g/L at 30 DAT (54.3 cm and 2.8 %) which was followed by (T_8) soil application of radish leaf @ 5 g/ 100 g soil before transplanting (57.3 cm and 8.5 %) and (T_3) foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (58.9 cm and 11.6 %).

Effect on Grain Chaffiness

The per cent of grain chaffiness was significantly influenced by different treatments (Table 5). The mean chaffiness percentage observed in different treatments ranged from 7.33 to 38 per cent. The treatment foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT (T_{12}) was superior to all other treatment which recorded the lowest per cent of chaffiness and highest per cent decrease over control (7.33 and 80.7 %) followed by (T_{10}) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (10 and 73.7 %), (T_9) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *T. viride* @ 5 g/L at 30 DAT (11 and 71.1 %) and (T_{11}) foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT (12.67 and 66.7 %). The highest per cent of chaffiness and lowest per cent decrease over control was observed in (T_1) foliar application of *T. viride* @ 5 g/L at 30 DAT (34 and

TABLE 5

In vivo effect of bioagents and bio-fumigants against sheath blight of rice/chaffiness

Treatments	*Kharif* 2017		*Rabi* 2017		Mean	
	Chaffiness (%)	% decrease over control	Chaffiness (%)	% decrease over control	Chaffiness (%)	% decrease over control
T1	35.67(36.65)	10.1	32.33 (34.65)	11.0	34.00 (35.66)	10.5
T2	24.00 (29.28)	39.5	24.67 (29.77)	32.1	24.33 (29.54)	36.0
T3	31.00 (33.82)	21.9	30.00 (33.20)	17.4	30.50 (33.51)	19.7
T4	21.67 (27.71)	45.4	20.00 (26.54)	44.9	20.83 (27.15)	45.2
T5	29.67 (32.99)	25.2	28.33 (32.13)	22.0	29.00 (32.58)	23.7
T6	19.67 (26.30)	50.4	19.00 (25.83)	47.7	19.33 (26.07)	49.1
T7	26.67 (31.08)	32.8	26.33 (30.86)	27.5	26.50 (30.97)	30.3
T8	34.33 (35.86)	13.5	32.00 (34.44)	11.9	33.17 (35.15)	12.7
T9	10.33 (18.66)	74.0	11.67 (19.90)	67.9	11.00 (19.34)	71.1
T10	9.00 (17.44)	77.3	11.00 (19.27)	69.2	10.00 (18.39)	73.7
T11	12.33 (20.49)	68.9	13.00 (21.01)	64.2	12.67 (20.82)	66.7
T12	7.00 (15.31)	82.4	7.67 (16.02)	78.9	7.33 (15.71)	80.7
T13	39.67 (39.02)	0.0	36.33 (37.04)	0.0	38.00 (38.05)	0.0
S.Em±	0.91		1.08		0.60	
C.D. (0.05)	2.65		3.14		1.74	
C.V. %	5.42		6.51		3.58	

Figures in parenthesis are aresine transformed values

10.5 %), which was followed by (T_8) soil application of radish leaf @ 5 g/100 g soil before transplanting (33.17 and 12.7 %) and (T_3) foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (30.5 and 19.7%).

Effect on Grain Yield Per Plant

The grain yield per plant was significantly influenced by the treatments and the data is presented in the Table 6. The highest mean grain yield per plant and average per cent increase over control was recorded in (T_{12}) foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT (13.4 g and 94.2 %), followed by (T_{10}) soil application of mustard leaf @ 5 g/100 g soil before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (11.7 g and 69.6 %), (T_9) soil application of mustard leaf @5 g/100 g soil before transplanting and foliar application of *T. viride* @ 5 g/L at 30 DAT (11.2 g and 62.3 %) and (T_{11}) foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT (10.6 g and 53.6 %). The lowest mean grain yield per plant and average per cent increase over control among the treatments other than T_{13} (control) was observed in (T_1) foliar application of *T. viride* @ 5 g/L at 30 DAT (7.5 g and 8.7 %) which was followed by (T_8) soil application of radish leaf @ 5 g/100 g soil before transplanting (8.1 g and 17.4 %) and (T_3) foliar application of *P. fluorescens* @ 5 g/L at 30 DAT (8.7 g and 26.1 %).

The present study showed significant result in the treatment foliar application of propiconazole 25 EC @ 0.1 per cent at 30 DAT and 60 DAT (T_{12}) followed by soil application of mustard leaf @ 5 g/100 g soil (T_{10}) before transplanting and foliar application of *P. fluorescens* @ 5 g/L at 30 DAT with significant reduction in disease severity and increase in yield. It was in accordance with the results of Das and Hazarika (2000). The seeds treated with *T. viride* and

TABLE 6

In-vivo effect of bioagents and bio-fumigants against sheath blight of rice/grain yield

Treatments	Yield / plant (g)					
	Kharif 2017		*Rabi* 2017		Mean	
	Grain yield (g)	% increase over control	Grain yield (g)	% increase over control	Grain yield (g)	% increase over control
T_1	7.2	5.9	7.9	12.9	7.5	8.7
T_2	9.7	42.6	9.5	35.7	9.6	39.1
T_3	8.7	27.9	8.6	22.9	8.7	26.1
T_4	9.9	45.6	9.6	37.1	9.8	42.0
T_5	9.0	32.4	9.2	31.4	9.1	31.9
T_6	10.2	50.0	10.0	42.9	10.1	46.4
T_7	9.7	42.6	9.4	34.3	9.6	39.1
T_8	7.9	16.2	8.3	18.6	8.1	17.4
T_9	11.2	64.7	11.1	58.6	11.2	62.3
T_{10}	11.9	75.0	11.6	65.7	11.7	69.6
T_{11}	10.6	55.9	10.5	50.0	10.6	53.6
T_{12}	13.6	100.0	13.2	88.6	13.4	94.2
T_{13}	6.8	0.0	7.0	0.0	6.9	0.0
S.Em±	0.25		0.22		0.19	
C.D. (0.05)	0.72		0.65		0.54	
C.V. %	4.48		4.09		3.36	

T. harzianum showed significant reduction in the sheath infection and reduction in yield. Khan and Sinha (2007) used cultured filtrate of *T. harzianum* and *T. virens* and found that *T. harzianum* was most effective showing 38.8 and 24.6 per cent reduction in disease severity with highest grain yield per plant (21%). Ashraf *et al*. (2011) observed that *T. harzianum* (rice leaf sheath isolate) was best in managing sheath blight compared to some commercial formulations of bioagents with 48 per cent reduction in disease severity. Higher rates of *T. harzianum* (4 or 8 g/l) was found highly effective in reducing disease severity (70 %) and increasing grain yield (27.3 %) over control. Under pot culture conditions, the combined application of *P. fluorescens* as seed treatment @ 10 ml/kg of seeds + seedling root dip @ 3 l/ha significantly reduced the incidence of sheath blight in rice and increased the plant growth and yield of rice to maximum.

Manibhusam Rao and Baby (1991) studied the effect of organic manures (glyricidia and neem cake) alone and combined with *T. longibrachiatum* and *Gliocladium virens* against *R. solani* causing rice sheath blight and found the combined treatments to be more effective in suppressing the disease. The current study also revealed that the combined treatment of bio-fumigant plant and bioagent was more effective than the individual treatments and on par with the fungicide treatment in decreasing the disease severity and increasing the yield over control.

Currently, there is no resistance rice cultivars against sheath blight disease, which warrants the use of chemical fungicides for the management of the disease. Development of alternative eco-friendly strategies like identifying suitable strain of bio agent and employing them and using bio fumigants needs to be explored and adopted for sustainable management of the disease. Hence, the combination of chemical fungicides, plant products and bio control agents identified in the present study can be used for the integrated management of rice sheath blight disease.

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