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INTEGRATED MANAGEMENT OF SIGATOKA LEAFSPOT OF BANANA

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ABSTRACT
A field experiment was conducted to manage banana sigatoka leafspot disease at Uttara Kannada district of Karnataka for consecutive two seasons (2008-09 and 2009-10). The plots sprayed thrice with Hexaconazole @0.1% has significantly reduced the disease incidence to the extent of 13.74% which is on par with three sprays of propiconazole (16.07%) and spray with *Psuedomonas fluorescens* (*P*)+ *Bacillus subtilis (Bs)-P+Bs-P+Bs @ 0.1% and 0.5%* (15.21%) respectively. The effectiveness of the fungicides was judged on the basis of increased yield per unit along with reduced disease intensity. Experimental results proved the effectiveness of *P+Bs-P+Bs-P+Bs @ 0.1% and 0.5%* treatment by recording significantly highest banana yield (42.13t/ha) and reduced disease pressure (15.21%) and which was at par with consecutive three sprays of hexaconazole (42.0t/ha) and propiconazole (41.49t/ha). The cost economics indicated highest net return in hexaconazole (Rs.56350.00) treatment and which was followed by P+Bs-P+Bs-P+Bs *(Rs.54,220.00)*and propiconazole (Rs. 52,660.00) treatments. Thus, a new triazole molecule hexaconazole could be used as an alternate molecule to manage sigatoka leaf spot disease in banana

INTRODUCTION

Banana (*Musa spp*) is one of the most important tropical fruit crops of the world. It is very important and economically profitable plantation crops of India having high export potential and the forth important global commodity in terms of the gross value of the produce after rice, wheat and milk products compared with the production of other fruits. The production of banana at national level is 28,221.37thousand ton, while it is 2,469 thousand tons in karnataka state (Anon. 2012). Banana crop is affected by several diseases caused by fungi, bacteria, viruses and nematodes in India. Among these Sigatoka leafspot disease caused by the fungal pathogen *Mycosphaerella musicola*, *Leach ex mulder* is considered to be the most destructive. However, the degrees of damage and yield loss vary from region to region. Black sigatoka *Mycosphaerella fijiensis*, causes yield losses of 30-50 per cent in banana and plantain. The control of black sigatoka disease in bananas and plantains estimated to cost $200 million annually has been widely related to loss of biodiversity, increased health hazards and economic instability of many banana producing countries (Elango *et al.,* 999).

Generally sigatoka leafspot, bunchytop of banana and burrowing nematode are considered as serious in the major banana growing belts such as Belgaum and Bijapur districts, of Karnataka. Economic losses due to leafspot disease have been so heavy in some areas that, banana production has ceased altogether especially whenever susceptible varieties are under cultivation. The sigatoka disease has been reported in India from Kerala, Tamil Nadu, Andra Pradesh, Gujarath, Madhya Pradesh and West Bengal (Rangaswamy and Kolandaiswamy, 1962; Kar and Mandal, 1975; Mustaffa and Narayanappa, 1988; Saxena *et al.,* 994;). The studies also revealed that, yellow sigatoka is prevalent in most of the places surveyed and also most commonly found on exotic cultivars than on the highland bananas (Johanson *et. al,* 2000).

Sigatoka leaf spot caused by *Mycosphaerella musicola* is important because of its epiphytotic nature. It has become one of the major production constraints of banana in Karnataka. The disease was more severe in orchards, which are at harvesting stage than those at vegetative stage and particularly more in ratoon crop as compared to fresh planted crop (Thammiah, 2003). Considering the above facts and extent of loss, experiment on integrated management of sigatoka leaf spot of banana was conducted from 2008-2010 in farmers' field at Sirsi taluk of Uttara Kannada district to evaluate the most effective molecule and its integration for the management of the sigatoka leafspot disease of banana.

MATERIALS AND METHODS

The experiment was laid out in randomized block design (RBD) with three replications and ten treatments mentioned below. The experiment was conducted on susceptible cultivar G9

Sl. No.	Treatments
1	Propiconazole (P) @ 0.1%
2	Carbendazim (C) @ 0.1%
3	Hexaconazole (H)@ 0.1%
4	Raw Neem Oil (RNO) 1%
5	SL-56(Botaniclal) 1%
6	P- RNO-P @ 0.1% and 1%
7	C-RNO-C @ 0.1% and 1%
8	H-SL-56-H @ 0.1% and 1%
9	P+Bs*-P+Bs-P+Bs @ 0.1% and 0.5%
10	Untreated control

**Bacillus subtilis* a biological agent

which was grown with a row to row and plant spacing of 1.8mX1.8m. The spraying was taken when typical symptoms of sigatoka disease were observed in few plants during August months of 2008-09 and 2009-10. Totally three sprays were taken at 15 days interval. Observations with respect to percent disease index were recorded one week after each spray. The treatments consist of individual spray of fungicides, biological agent, botanicals and their integration. SL-56 was used as a botanical pesticide which had a constituents like pongamia, simaruba, azaderectin etc. and also had a property of sticking and adjuvant. A biological control agent *Bacillus subtilis* was used one day later after the spray with propiconazole.

Percent disease index was calculated from these observations by using 0-6 scale (Gauhl *et al*, 1993).

Where,

Disease score	Disease reaction
0	Immune
1	Highly resistant
2	Resistant
3	Moderately resistant
4	Susceptible
5 & 6	Highly Susceptible

0 = no symptoms

1 less than 1% of lamina with symptoms (only streaks and /or up to 10 spots)

2 = 1-5% lamina with symptoms

3 = 6-15 % lamina with symptoms

4 = 16-33% lamina with symptoms

5 = 34-50% lamina with symptoms

6 = 51-100%

Per cent disease index (PDI) was calculated by using the formula (Wheeler, 1969).

$$\text{Percent disease index} = \frac{\Sigma nb \times 100}{(N-1)T}$$

Where, n = number of leaves in each grade

b = grade

N = no. of grades used in the scale

T = Total no. of leaves scored

The percent disease index (PDI) was calculated before spray and after 30 days, 60 days and 90 days after spraying.

Yield parameters

Yield was recorded in Kg per treatment and later converted to tons per hectare. Yield attributing characters like number of leaves, leaf length (cm) and width (cm) was recorded from randomly selected three leaves from top, middle and lower portions of the plant immediately after harvest of the crop. The cost economics was calculated based on prevailing market prices.

RESULTS AND DISCUSSION

During 2008-09 the incidence of sigatoka leafspot of banana recorded before spray ranged from 9.67 to 15.19 percent across the treatments but no significant difference among the treatments indicates the uniformity of disease infection in the trial. The results were similar during 2009-10 also and where, the Per cent Disease Incidence (PDI) ranged from 9.17 to 12.80. The pooled data of both the years (Table 1) revealed the same trend of non significance between treatments indicating total uniformity of disease incidence level before imposition of treatments.

The pooled disease incidence 30 days after first spray was significantly different among the treatments. The lowest percent disease index 13.19 was recorded in T6 (P-RNO-P) was on par with T1 (14.17), T3 (15.23) and T9 (14.74)(Table-1). The highest percent disease index of 23.03 was recorded in untreated control. Similarly pooled analysis of disease index after II spray indicated significant differences among the treatments. The lowest PDI was recorded to be 15.85 in T9 which was on par with T1 (16.74) and T3 (16.50). These treatments are followed by T8 (19.86), T2 (20.37), T5 (21.13) and T6 (22.31). The disease index of 35.84 percent was recorded in untreated control plots. The similar trend of observation was recorded after III spray. The treatment T3 (13.74%) was considered to be statistically superior and found on par to T9 (15.21%) and T1 (16.07%) followed by T2 (26.96%), T4 (29.26%), T5 (25.78%), T6 (24.33%) and T8 (23.15%). However, maximum disease index of 49.9 percent was recorded in untreated control. Thammiah, 2003 reported the three sprays of propiconazole @ 0.05% effectively managed the sigatoka leafspot disease in the main as well as in the first ratoon crop. In the main crop three sprays of propiconazole @ 0.05%at 15 days interval effectively controlled the leafspot disease. Allen *et al.* (1992) and Saxena *et al.* (1994) reported that, disease reduction and higher yields were obtained in the propiconazole sprayed plots. Petrolium oils acts as spreading and sticking agents and aid the retention and movement of fungicides on the leaf surface. Oils also assist the penetration of the leaf by systemic fungicides, reduce conidium germination, germ tube growth and appressorium formation and increases the pathogens incubation period, finally they retard the growth and development of the pathogen within the host leaf. In this study on integration of fungicide (propoiconazole) followed by biological agent (*Bacillus subtilis*) has resulted in effective management of the disease and found to be the first report in Indian context. *Pseudomonas* possesses diverse mechanisms by which they can exert inhibitory activity towards phytopathogens and thereby mediate crop protection (Asha *et al.*, 2011) Similarly Hexaconazole 5%EC has been found to be the effective new molecule against this disease. The low cost of this new systemic fungicide could be used as an alternate to propiconazole when used alone. Hexaconazole and other sterol demethylation inhibitors (DMI's) now comprise the largest group of systemic fungicides that are used on banana (Romero and Sutton, 1997).

The maximum yield per hectare was recorded in the integrated treatment T9 (42.13t) was on par with T3 (42.0 t) and T1 (41.49t) which differed significantly with all the remaining treatments. Bacillus subtilis can be used as a potential bio control agent as many similar microorganisms are reported to produce non volatile compounds that suppress the growth of

Table 1: Integrated management of Sigatoka leaf spot of Banana

	Treatments	Before spray			3ODAS Ist spray			6ODAS IInd spray		
		2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
1	P-P-P @ 0.1% (Propiconazole)	12.22 (-20.44)	9.87 (-18.24)	11.04 (-19.46)	14.82 (-22.63)	13.52 (-21.56)	14.17 (-22.14)	16.49 (-23.89)	17 (-24.35)	16.74 (-24.12)
2	C-C-C @ 0.1% (Carbendazim)	13.33 (-21.39)	11.22 (-19.55)	12.27 (-20.53)	17.59 (24.80)	15.55 (-23.06)	16.57 (-24.04)	21.29 (27.42)	19.45 (-26.13)	20.37 (-26.83)
3	H-H-H @ 0.1%	13.97 (-21.85)	12.8 (-20.96)	13.38 (-21.47)	15.27 (-22.95)	15.2 (-22.95)	15.23 (-22.95)	17.09 (24.43)	16.65 (-24.04)	16.5 (-23.97)
4	RNO-RNO-RNO 1%	11.85 (20.09)	9.17 (-17.66)	10.51 (-18.91)	18.87 (25.70)	15.93 (-23.5)	17.4 (-24.65)	25.94 (30.59)	24.75 (-29.8)	25.34 (-30.2)
5	SL-56-SL-56-SL-56 1%	10.37 (18.72)	10 (-18.43)	10.18 (-18.63)	16.29 (-23.81)	17.13 (-24.43)	16.71 (-24.12)	20.02 (-26.56)	22.25 (-28.18)	21.13 (-27.35)
6	P- RNO-P @ 0.1% and 1%	11.52 (19.82)	10.9 (-19.28)	11.21 (-19.55)	13.64 (-22.46)	12.75 (-20.88)	13.19 (-21.3)	24.9 (29.93)	19.73 (-26.35)	22.31 (-28.18)
7	C-RNO-C @ 0.1% and 1%	14.85 (22.63)	12.4 (-20.62)	13.62 (-21.64)	18.87 (25.33)	16.5 (-23.97)	17.68 (-24.88)	26.12 (30.72)	25.15 (-30.13)	25.63 (-30.4)
8	H-SL-56-H @ 0.1% and 1%	9.67 (-18.05)	11.75 (-20.00)	10.71 (-19.09)	12.19 (-20.44)	14.65 (-22.46)	13.42 (-21.47)	20.67 (-27.06)	19.06 (-25.91)	19.86 (-26.49)
9	P + Bs-P + Bs-P + Bs @ 0.1% and 0.5%	10.37 (18.81)	11.33 (-19.54)	10.85 (-19.19)	14.61 (-22.46)	14.87 (-22.71)	14.74 (-22.55)	15.31 (23.03)	16.4 (-23.59)	15.85 (-23.5)
10	Untreated control	15.19 (-18.63)	12.25 (-20.53)	13.72 (-21.72)	24.56 (-29.67)	21.5 (-27.62)	23.03 (-28.66)	39.59 (-39.0)	32.09 (-34.52)	35.84 (-36.75)
	SEm +	NS	NS	NS	0.74	1.06	1.1	0.84	0.83	0.92
	CD	NS	NS	NS	2.2	3.07	2.83	2.5	2.41	2.19
	CV	17.67	18.45	18.16	12.21	15.62	14.65	18.39	17.35	16.65

Table 1: Cont....

	Treatments	9ODAS IIIrd spray			Yield t/ha		
		2008	2009	Pooled	2008	2009	Pooled
1	P-P-P @ 0.1% (Propiconazole)	15.6 (-23.26)	16.55 (-24.04)	16.07 (-23.66)	43.47	39.51	41.49
2	C-C-C @ 0.1% (Carbendazim)	27.48 (31.63)	26.45 (-30.98)	26.96 (-31.24)	35.54	32	33.77
3	H-H-H @ 0.1%	13.28 (-21.39)	14.21 (-22.34)	13.74 (-21.72)	43.95	40.05	42
4	RNO-RNO-RNO 1%	30.13 (-33.27)	28.4 (-32.2)	29.26 (-32.77)	33.67	31.94	32.8
5	SL-56-SL-56-SL-56 1%	25.21 (30.13)	26.35 (-30.92)	25.78 (-30.53)	32.7	28.67	30.68
6	P- RNO-P @ 0.1% and 1%	26.96 (-31.24)	21.7 (-27.76)	24.33 (-29.53)	39.6	35.23	37.41
7	C-RNO-C @ 0.1% and 1%	32.21 (-34.57)	30.94 (-33.77)	31.57 (-34.2)	34.43	31.4	32.91
8	H-SL-56-H @ 0.1% and 1%	23.67 (29.13)	22.63 (-28.3)	23.15 (-28.79)	39.73	35.92	37.82
9	P + Bs-P + Bs-P + Bs @ 0.1% and 0.5%	14.6 (-22.46)	15.82 (-23.42)	15.21 (-22.95)	44.4	39.86	42.13
10	Untreated control	52.87 (-46.61)	47.07 (-43.34)	49.97 (-44.94)	27.8	25.95	26.87
	SEm +	1.19	1.15	1.17	1.09	1.02	1.07
	CD	3.53	3.28	3.27	3.24	2.97	3.16
	CV	21.8	16.08	18.44	12.07	10.91	12.05

P- Propiconazole: H- Hexaconazole: C- Carbendazim: RNO- Raw neem oil: S L-5 6- a botanical: Bs- Bacillus subtilis

the soil borne plant pathogens (Lalfakawma *et al.,* 2014) Significantly lowest yields of 26.87t and highest disease index of 49.97 were recorded in untreated control plots (Table 1). Allen *et al.* (1992) reported significantly higher yields in propiconazole sprayed plots. The absence of unpublished report on hexaconazole efficacy against the banana sigatoka disease limits the further discussion.

During 2008-09 and 2009-10 the effect of leaf parameters due to the incidence of sigatoka disease of banana was recorded and presented in the Table 2. ýNumber of leaves varied between treatments and highest number of leaves were recorded in T9 (12.20) which was found on par with T3 (11.90), T1 (11.57) and differed significantly with rest of the treatments. This is followed by T8 (10.70), T2 (10.40) and T7 (10.07) and the least was in untreated control (8.73). Similarly the leaf length was maximum in T9 (184.17cm) was at par with T3 (176.33cm), T1 (173.69cm) and which was significantly superior to other treatments and untreated control (11.28cm). This is in agreement with the studies conducted by Meredith

Table 2: Effect of sigatoka leafspot incidence over plant character*

Sl.No.	Treatments	No. of leaves	Leaf length (cm)	Leaf width (cm)
1	P-P-P @ 0.1%	11.57	173.67	72.63
2	C-C-C @ 0.1%	10.40	165.67	70.06
3	H-H-H @ 0.1%	11.90	176.33	71.55
4	RNO-RNO-RNO @ 1%	9.73	127.33	72.45
5	SL-56-SL-56-SL-56 @ 1%	9.57	118.56	74.12
6	P- RNO-P @ 0.1% and 1%	10.57	136.00	70.87
7	C-RNO-C @ 0.1% and 1%	10.07	129.21	73.05
8	H-SL-56-H @ 0.1% and 1%	10.70	138.45	71.91
9	P+Bs-P+Bs-P+Bs @ 0.1% and 0.5%	12.20	184.17	73.16
10	Untreated control	8.73	110.28	70.75
	SEm +	0.47	5.41	NS
	CD @0.5%	1.38	16.06	NS
	CV	13.55	16.78	NS

*Pooled data of two years

Table 3: Cost Economics of Management of leaf spot of Banana

Sl.No.	Treatments	Yield t/ha	Gross return @ 4000/t	Net return (Rs.)
1	P-P-P @ 0.1%	*41.49*	165960	52660
2	C-C-C @ 0.1%	*33.77*	135080	23430
3	H-H-H @ 0.1%	*42.00*	168000	56350
4	RNO-RNO-RNO @ 1%	*32.80*	131200	17900
5	SL-56-SL-56-SL-56 @ 1%	*30.68*	122720	6720
6	P- RNO-P @ 0.1% and 1%	*37.41*	149640	36740
7	C-RNO-C @ 0.1% and 1%	*32.91*	131640	19840
8	H-SL-56-H @ 0.1% and 1%	*37.82*	151280	38180
9	P+Bs-P+Bs-P+Bs @ 0.1% and 0.5%	*42.13*	168520	54220
10	Untreated control	*26.87*	107480	17480
	SEm +	*1.07*		
	CD @ 5%	*3.16*		
	CV	*12.05*		

(1970), who reported that, the bunch length, width, finger length and finger girth was less in control and good quality bunch was obtained in plots which received fungicidal treatments. Thammiah, 2003 reported that, maximum plant height and psuedostem girth was recorded in propiconazole @0.05% sprayed plots.

The cost economics of all treatments in the trial over untreated control was calculated and presented in Table 3. The maximum gross returns were obtained in T9 (Rs168520/h) followed by T3 (Rs168000/h) and T1 (Rs165960/h). However, absence of unpublished literature on cost economics limits the further discussion in this regard.

REFERENCES

Allen, R. N., Akehurst, A. A. and Ireland, G. 1992. Surveys of spraying practices for banana leafspot disease control in New South Wales and assessment of disease control based on leaf retention at harvest in July. *Aust. J. Exp. Agric.* **32.** 211-216.

Anonymous 2012. Horticultural Crop Statistics of India in APEDA. Source: *National Horticulture Board*.

Asha, B. B., Chandra nayaka, S., Udaya shankar, A. C., Srinivas, C. And Niranjana,S. R. 2011, Selection of effective bio - antagonistic bacteria for biological control of tomato wilt caused by fusarium oxysporum f. sp. *Lycopersici. The Bioscan.* **6(2):** 239-244.

Lalfakawma, C., Bharat Chandra Nath, Bora, C., Seweta Srivastava and Jay prakash, S. 2014. Integrated disease management of zingiber officinale Rosc. Rhizome rot. *The Bioscan.* **9(1):** 265-269.

Elango, F., Taboral, P., Vega, J. M., Senanayake, Y. D. A. and Sangakkura, U. R. 1999. Fifth International Conference on Kyusci Nature Farming. : *Proceedings of the conference on Kyusci Nature Farming and effective microorganism for Agricultural and Environmental sustainability*, Bangkok, Thialand. 23-26 October, 1997, pp. 226-229.

Gauchl, F., Pasberg, Gauhl, C., Vuylsteke, D. and Ortiz, R. 1993. Multi location Evaluation of black sigatoka resistance in Banana and Plantain. International Institute of Tropical Agriculture (IITA), *Research Guide*, 47, Ibudan, Nigeria, p. 59.

Johanson, A., Tushemereirwe, W. K., Karamvra, E. B., Craenen, K., Ortiz, R. and Vuylsteke, D. R. 2000. First International Conference on Banana and plantain for Africa, Kampala, Uganda, 14-18 October 1996, *Acta Horti*. **540**: 319-324.

Meredith, D. S. 1970. Banana leafspot disease caused by Mycosphaerella musicola. *Phytopath*, 11, CMI, Kew.

Romero, R. A. and Sutton, T. B. 1977. Sensitivity of Mycosphaerella fijiensis , causal agent of black sigatoka of banana to propiconazole. *Phytopath*. **87:** 96-100.

Saxena, D. R., Molysaxena and Bhalla, P. L. 1994. Controlling Sigatoka disease of banana. *Ind. Hort*. **39**: 20-21.

Stover, R. H. 1974. Effect of measured levels of sigatoka disease of bananas on fruit quality and leaf senescence. *Trop. Agric*. **51**: 531-542.

Thammaih, N. 2003. Studies on the epidemiology and management of sigatoka leafspot of banana. *Ph.D.thesisi, submitted to the University of Agricultural Sciences, Dharwad.* pp. 1-231.

Wheeler, B. E. J. 1969. An Introduction to Plant Diseases, *J. Wiley and Sons Ltd. London.* p. 301.