Efficacy of application of *S. marcescens*, FYM and micronutrient mixture on the incidence of *Fusarium* wilt (*Fusarium oxysporum* f. sp. *cubense* (E.F.Smith) Snyder and Hansan) of main and ratoon crop of banana

K. Sanjeevkumar[1], A.Muthukumar[1], S.Kumar,[2] T.Sivakumar[1] and P.Balabaskar[1]

[1]Dept. of Plant Pathology, [2] Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar-608002, Tamil Nadu

Abstract

Banana (*Musa* spp.) is one of the earliest crops cultivated by man which still remains to be the world's most important fruit crop. Among the diseases affecting banana, Panama disease caused by *Fusarium oxysporum* f.sp *cubense* is considered as one of the major constraints to banana production worldwide. Several strategies have been adopted to manage the disease with limited success. Hence, an attempt was made to develop an integrated approach involving a new biocontrol agent *Serratia marcescens* along with FYM and micronutrient mixture for the management of the disease. The results revealed that, the combination treatment involving "Basal application of FYM plus sucker treatment plus soil application of *S. Marcescens* and micronutrient mixture" significantly reduced the panama wilt incidence of banana (7.95 %) to the minimum and increased the plant growth and yield parameters to the maximum in both plant and ratoon crops of banana CV. Monthan.

Key words: *Fusarium* wilt, *Serratia marcescens*, *F. oxysporum* f.sp. *cubense*, ratoon crop, Integrated management

1. Introduction

Banana (*Musa* spp.) is one of the earliest crops cultivated by man which still remains to be the world's most important fruit crop. At present it is grown in more than 120 countries throughout tropical and sub tropical regions. The demand for banana is increasing due to increase in population. But the main hurdle in increasing the productivity is the threat posed

by the pest and diseases. Among the various diseases, Panama disease of banana caused by *Fusarium oxysporum* f.sp *cubense* (E.F.Smith) Snyd. and Hans. is considered as one of the major constraints to banana production (Thangavelu *et al*., 2001). It is a classic vascular wilt disease in which the fungus gains entry to the water conducting xylem vessels, then proliferates within the vessels causing water blockage. The typical symptoms include wilting and death of the leaves, followed by death of the whole plant. Since the discovery of *Fusarium* wilt of banana, various control strategies like soil fumigation (Ploetz *et al.,* 1992); fungicides (Lakshmanan *et al.,* 1987); crop rotation, flood –fallowing and organic amendments (Hwang, 1985; Moore *et al.,*1999) have been attempted, yet the disease could not be controlled effectively. Planting of resistant varieties also cannot be implemented because of consumer preference (Viljoen, 2002). Therefore, under these circumstances, the present study was taken up to develop an integrated management strategy involving a new biocontrol agent *Serratia marcescens* along with FYM and micronutrient mixture for the management of the disease. Because, integration of several strategies could enhance the disease suppression through the synergistic action of various mechanism of actions under varied climates and also increase the yield of banana.

2. Materials and methods

A field experiment was conducted at Vadukkumangudi village in Cuddalore district of Tamilnadu. The field selected for this purpose was heavily infested with *F. oxysporum* f.sp. *cubense*. The highly susceptible cultivar 'Monthan' was used for this study. The banana suckers of cultivar Monthan without *Fusarium* wilt infection was obtained from the wilt free garden and planted with the spacing of 1.8 m x 1.8 m after paring and pralinage practices. Based on the *in vitro* and *in vivo* screening tests, talc based formulation of *S. marcescens*, farm yard manure and micronutrient mixture ($ZnSO_4$ + Boran + $CuSO_4$) were selected for this study besides, the fungicide treatment carbendazim @ 0.1 per cent as soil drench + carbofuran 3% G @ 20g/sucker was included in the treatment schedule for comparison. All the agronomical practices were strictly adopted during the cropping period as per the crop production manual for Horticultural crops published by the Department of Horticulture, Government of Tamil Nadu. Suitable control was also maintained.

2.1. Treatment schedule

T_1 - *S. marcescens* - Soil application (SA) @ 25 g/ plant + Sucker treatment (ST) @ 20 g/ sucker.

T_2 - FYM -Soil application (SA) @ 7 Kg/plant.

T_3 - Micronutrient mixture (SA) (@ each 100 g/plant) + ST (@ each 50 g/ sucker)

T_4 - FYM - (SA) + T_3

T_5 - FYM (SA) + T_1 + T_3

T_6 - Carbendazim @ 0.1% as soil drench + Carbofuran 3% G @ 20 g/ sucker.

T_7 - Control

The wilt incidence at the time of harvest was recorded based on the 1-5 scale (Ploetz *et al*., 1999) where,

1- Healthy

2- Slight chlorosis and wilting with no petiole buckling.

3- Moderate chlorosis and wilting with some petiole buckling and / (or) splitting of leaf bases

4- Severe chlorosis, wilting, petiole buckling and dwarfing of the newly emerged leaf.

5- Whole death of the plant.

The observation on the growth parameters viz., Plant height, Pseudostem girth, Total number of leaves, Leaf area and Yield at the time of harvest were recorded as per the 'International Network for the Improvement of Banana and Plantain' (INIBAP).

2.3. Ratoon crop

After the harvest of crop the fields were allowed for rationing and one tiller alone was allowed per hill. The crop was raised without giving any treatment. The other agronomical practices and fertilizer applications were done following standard procedures. The observations on per cent disease incidence and growth parameters were recorded similar to that of plant crop.

3. Results and Discussion

3.1. Integrated management of *Fusarium* wilt of banana

The data on the effect of various treatments on the *Fusarium* wilt incidence of banana was recorded (Table 1). Perusal of the data revealed that all the treatments significantly reduced the disease incidence when compared to control. The per cent disease reduction ranged from 53.72 to 83.97 per cent with difference in treatments. The maximum percent decrease in the incidence was recorded in FYM (SA) plus *S. marcescens* (SA + ST) plus micronutrient mixture (SA + ST) (T_5) (83.97 %) This was followed by the soil application and sucker treatment of carbendazim and carbofuran (T_6) and FYM plus *S. marcescens* (SA + ST) (T_2) (79.14 and 67.63 % respectively). The disease suppression observed in the present study might be due to the activity of the antibiotic red pigment prodigiosin (Okamato *et al.,* 1998) produced by *S. marcescens.* Zinc and other trace minerals stabilized regulatory genes critical for antibiotic production in fluorescent pseudomonads, stimulate the production of phenazine type antibiotics and improved the biocontrol activity (Duffy and Defago, 1997). Ezhilarasi, (2006) reported that basal application of FYM and soil application of *S. marcescens* reduced the root rot disease incidence of blackgram. Stefen Kurze *et al.* (2001) plant growth promoting *S. plymuthica* strain HRO-C48 was found to control *Verticillium* wilt and *Phytophthora* root rot in strawberry. Similarly, Krishna Kishore *et al.* (2005) reported that chitin supplemented application of *S. marcescens* and *B. circulans* resulted in reduced late leaf spot of peanut when compared with control. These earlier reports lend support to the present findings.

3.2. Effect of integrated treatments on plant growth parameters

The combined application of FYM plus *S. marcescens* (SA+ST) plus micronutrients mixture at different level of treatments also increased the growth and yield parameters significantly when compared to control (Table 2). The maximum increase in growth parameters *viz.*, plant height (250.71 cm), pseudostem girth (44.13 cm), leaf number (23.12), leaf area (4310.25 and 4350.8 cm^2) and yield (25.01 Kg) was observed in T_5 followed by T_6 and T_2. The results of the present study are in line with the observation made by Jaiganesh *et*

al. (2007) observed that rice seeds treated with talc based formulation of *S. marcescens* recorded higher plant growth and yield. Rhizobacteria that colonize roots show great potentials in plant growth promotion (Ezhilarasi, 2006; Nandakumar *et al*., 2001). Similar to the present study, the IDM package comprising cultural, biological, physical and need based chemical treatment recorded significantly lesser incidence of diseases and increased the yield of tomato (Pandey *et al*., 2005). Organic amendment applied with $ZnSO_4$ proved superior and recorded significant improvement in plant growth and yield attributes of sesame (Aridoss *et al*., 2004). The dry matter from both shoots and roots of wheat showed a marked response to the addition of zinc (Sparrow and Graham, 1998). The enhanced biometrics observed in the present study might be attributed to the growth promotion substances produced by *S. marcescens* and also the enhanced vigour due to FYM and micronutrient mixture.

3.3. Integrated management of ratoon crop

The data in table 3 revealed that, the treatment with FYM (SA) plus *S. marcescens* (SA + ST) plus micronutrient mixture (SA + ST) (T_5) showed lesser disease incidence when compared to all other treatments. This was followed by the treatment with FYM (SA) + *S. marcescens* (ST+SA) (T_2) (15.01 %), *S. marcescens* (ST+SA) @ 25g/plant + 20g/sucker (T_1) (17.23 %) and carbendazim plus carbofuran(T_6) (18.61 %). The maximum disease incidence of 50.01 per cent was recorded in control. The treatment with FYM (SA) plus *S. marcescens* (SA + ST) plus micronutrient mixture (SA + ST) (T_5) recorded significant increase in plant height (261.38 cm), pseudostem girth (46.83 cm), leaf area(4500.30 cm^2), number of leaves(26.89) and yield(22.33 kg) in ratoon crop when compared to control (Table 4). These findings are in line with the observations made by Stefan Kurze *et al*. (2001) and Mohandas *et al*. (2004) who stated that, combination of VAM, *Trichoderma* sp. and *P. fluorescens* reduced the wilt incidence in ratoon crop of banana cv 'Rasthali' and 'Neipoovan'. Ploetz, (2004) stated that application of *Bacillus* and *Pseudomonas* resulted in reduced wilt incidence of banana in ratoon crop of banana cultivation. The high rhizosphere competence leading to improved root health might have protected banana roots against *Fusarium* disease.

References

1. Aridoss, G., Sasikumar, K. and Jeyadoss, T.(2004). Comparitive efficacy of oilcakes and NPK in combination with Azospirillum on growth ad yield enhancement of sesame. *Sesame and Safflower Newsletter*, **19:** 62-66

2. Davet, P.(1981). Effects de qualques pesticides sur ia colonization d'un substrat parle *Trichoderma harzianum* Rifai en presence de autres chamignons du sol. *Soil Biol. Biochem.*, **13**:513-517.

3. Duffy, B.K. and Defago, G. (1997). Zinc improves biocontrol of F*usarium* crown and root rot of tomato by *Pseudomonas fluorescens* and represses the production of pathogen metabolites inhibitory to bacterial antibiotic biosynthesis. *Phytopathology*, **87:** 1250-1257.

4.Ezhilarasi. A. (2006). Effect of *Serratia marcescens* on the management of dry root rot caused by *Macrophomina phaseolina* (Tassi.) Goid. of blackgram. *M.Sc (Ag.) Thesis*, Annamalai University, India.

5. Hwang, S.C. (1985). Ecology and control of *Fusarium* wilt of banana. *Plant Protection Bull., (Taiwan)*, 27: 233-245

6. Jaiganesh, V., Eswaran,A., Balabaskar., P. and Kanna,C. (2007). Antagonistic activity of *Serratia marcescens* against *Pyricularia oryzae, Not. Bot. Hort. Agrobat. Cluj.*, **35:** 48-54.

7. Krishna Kishore, G., Suresh Pande and Podile, (2005). Biological control of late leaf of peanut (*Archis hopogaea*) with chitinolytic bacteria. *Phytopathology*, **95:** 1157-1165.

8. Lakshmanan, P., Selvaraj, P., Mohan, S. (1987). Efficiency of different methods for the control of Panama disease. *Trop. Pest Manage.*, 33: 373–376.

9. Mohandas, S., Rawal, R.D., Manamohan, M., Lakshmikantha, H.C. and Manjula, R. (2004). Effect of *Fusarium* on plants procolonized with biocontrol agents.In: Interanational congress on musa: harnessing research to improve livelihoods, 6-9 July 2004, Penang, Malaysia.

10. Moore, N.Y., Pegg, K.G., Bentley, S., Smith, L.J. (1999). Fusarium wilt of banana: global problems and perspectives. In: Molina, A.B., Masdek, N.H.N. Liew, K.W, (eds). Banana Fusarium Wilt Management: Towards Sustainable Cultivation. *Proceedings of the International Workshop on Banana Fusarium Wilt Disease. Kuala Lumpur, Malaysia: INIBAP*, 11–30.

11.Nandakumar, R., Babu, S., Viswanathan, R., Sheela, J., Raguchander, T. and Samiyappan, R. (2001). A new bio-formulation containing plant growth promoting rhizobacterial mixture for the management of sheath blight and enhanced grain yield in rice. *Biocontrol*, **46:** 493-510.

12.Okamato, H., Sato, Z. and Isaka, M. (1998). Biocontrol of *Phytophthora capsici* by *Serratia marcescens* and analysis of biocontrol mechanism using transposon-in-sertion mutants *Ann. Rev. Phytopathol. Soc. Japan*, **64:** 287-298.

13.Pandey, K.K., Pandey, P.K. and Mishra, K.K. (2005). Development and testing of an integrated disease management package for multiple diseases of tomato. *Indian Phytopath.*, **58:** 294-297.

14.Ploetz, R.C. (2004). Biocontrol of *Fusarium* wilt: A review and Evaluation.In : International congress on Musa : harnessing research to improve livelihoods .6-9 July 2004, Penang, Malaysia.

15.Ploetz, R.C. Haynes, J.L. and Vazquez, A. (1999). Responses of new banana accessions in south Florida to Panama disease. *Crop prot.*, **18:** 445-449.

16.Ploetz, R.C., Channer, A.G., Chizala, C.T., Banda, D.L.N., Manika D.W. and Braunworth, W.S. (1992). A current appraisal of banana and plantain diseases in Malawi. *Trop. Pest Mgt.*, **38:** 36-42.

17.Sparrow, D.H. and Graham, R.D. (1988). Susceptibility of Zn deficient wheat plants to colonization by *Fusarium graminearum* schw Group I. *Plant and Soil***, 112:** 261-266.

18.Stefan Kurze, S., Bahl, H., Dahl, R. and Berg, G. (2001). Biological control of fungal strawberry disease by *Serratia plymuthica* HRO-C 48. *Plant. Dis.*, **85:** 529-534.

19.Thangavelu, R., Sundararaju, P., Sathiamoorthy, S., Raghuchandar, T., Velazhahan, *R.*, Nakkeeran, S. and Palaniswami, A. (2001). Status of *Fusarium* wilt of banana in India. In: Banana *Fusarium* wilt management: Towards sustainable cultivation. A.B. Molina, N.H. Nikmasdek, K.W. Liew (eds), INIBAP-ASPNET, Los Banos, Laguna, PhIlippines, pp. 58-63.

20.Viljoen, A. (2002). The status of Fusarium wilt (Panama disease) of banana in South Africa. *South African J. Sci.*, 98: 341–344.

Table 1. Efficacy of application of *S. marcescens*, FYM and micronutrient mixture on the incidence of *Fusarium* wilt of banana

Tr. No.	Treatment	Wilt incidence (%)	Per cent reduction
1	*S. marcescens* (ST + SA) @ 25 g/plant+ 20 g/sucker	16.75 (24.15)	62.15
2	FYM (SA) + *S. marcescens* (ST+SA)	14.32 (22.23)	67.63
3	Micronutrient mixture – (SA + ST)	20.48 (26.90)	53.72
4	FYM (SA) + Micronutrient mixture – (SA + ST)	18.33 (25.34)	58.58
5	FYM (SA) + T_1 + T_3	7.95 (63.07)	82.03
6	Carbendazim @ 0.1% as soil drench + Carbofuran 3% G @ 20 g/sucker	9.23 (73.88)	79.14
7	Control	44.25 (41.69)	-
	SEd CD (p=0.05)	0.63 1.56	-

Data in parentheses indicate angular transformed values.

Table 2. Efficacy of application of *S. marcescens*, FYM and micronutrient mixture on the biometrics of banana

Tr. No.	Treatments	Plant height(cm)	Pseudostem girth (cm)	No.of leaves /plant	Leaf area/ leaf(cm^2)	Yield/Plant (Kg)
1	*S. marcescens* (ST + SA) @ 25 g/plant + 20 g/sucker	245.46	40.02	20.07	3900.33	20.97
2	FYM (SA) + *S. marcescens* (ST+SA)	246.71	41.25	21.13	4000.72	22.12
3	Micronutrient mixture – (SA + ST)	242.14	38.12	18.23	3720.69	18.25
4	FYM (SA) + Micronutrient mixture – (SA + ST)	244.25	39.33	19.00	3850.63	19.82
5	FYM (SA) + T_1 + T_3	250.71	44.13	23.12	4310.25	25.01
6	Carbendazim @ 0.1% as soil drench + Carbofuran 3%g @ 20 g/sucker	249.25	43.23	22.82	4300.43	22.98
7	Control	199.37	35.46	15.38	3100.89	10.02
	SEd CD (p=0.05)	0.25 0.58	0.55 1.10	0.33 0.98	8.39 17.01	0.41 0.93

Table 3. Efficacy of application of *S. marcescens*, FYM and micronutrient mixture on the incidence of *Fusarium* wilt of banana ratoon crop

Tr. No.	Treatment	Wilt incidence (%)	Per cent reduction
1	*S. marcescens* (ST + SA) @ 25 g/plant+ 20 g/sucker	17.23(24.52)	65.55
2	FYM (SA) + *S. marcescens* (ST+SA)	15.01(22.79)	69.09
3	Micronutrient mixture – (SA + ST)	21.62(27.70)	56.77
4	FYM (SA) + Micronutrient mixture – (SA + ST)	19.12(25.92)	61.77
5	FYM (SA) + T_1 + T_3	9.21(73.67)	81.58
6	Carbendazim @ 0.1% as soil drench + Carbofuran 3% G @ 20 g/sucker	18.61(25.55)	62.79
7	Control	50.01(45.00)	-
	SEd CD (p=0.05)	0.58 1.24	-

Data in parentheses indicate angular transformed values.

Table 4. Efficacy of application of *S. marcescens*, FYM and micronutrient mixture on the biometrics of banana ratoon crop

Tr. No.	Treatments	Plant height(cm)	Pseudostem girth (cm)	No.of leaves /plant	Leaf area/ leaf (cm^2)	Yield / plant (Kg)
1	*S. marcescens* (ST + SA) @ 25 g/plant + 20 g/sucker	255.25	40.25	20.25	3960.38	19.13
2	FYM (SA) + *S. marcescens* (ST + SA)	256.71	44.69	22.75	4110.47	20.01
3	Micronutrient mixture – (SA + ST)	252.06	40.28	20.07	3800.93	17.98
4	FYM (SA) + Micronutrient mixture – (SA + ST)	254.25	43.32	21.50	3930.81	18.91
5	FYM (SA) + T_1 + T_3	261.38	46.83	26.89	4500.30	22.33
6	Carbendazim @ 0.1% as soil drench+ Carbofuran 3% G @ 20 g/sucker	241.45	40.13	21.65	3800.55	18.28
7	Control	197.35	35.21	15.38	3100.94	13.92
	SEd CD (p=0.05)	0.02 0.05	0.01 0.03	0.03 0.07	1.02 2.35	0.02 0.06