J. Mycopathol, Res, 51(1) : 125-130, 2013; (ISSN 0971-3719)

Biological control of Finger millet (*Elusine coracana* L.) leaf blast incited by *Magnaporthe grisea* (Cke) Sacc.

RAJESH RAMDAS WAGHUNDE[1] ,AMBALAL NATHABHAI SABALPARA[2] ,BANKIM B, NAIK[3] AND PATEL PRAVINBHAI P.[4]

[1]*N. M. College of Agriculture, Navsari Agricultural University,Navsari 396 450, Gujarat*
[2]*Directorate of Research, Navsari Agricultural University, Navsari 396 450, Gujarat*
[3]*Fruit Research Station, Navsari Agricultural University, Navsari 396 450, Gujarat*
[4]*Hill Millet Research Station, Navsari Agricultural University, Waghai,Dangs 394 730, Gujarat*

Received : 27.08.2012 Accepted : 12.02.2013 Published : 29.04.2013

An experiment was conducted in field condition from 2009-10 to 2011-12 at Hill Millet Research Station, Waghai to evaluate the efficacy of native strains of *Pseudomonas* spp. isolated from the rice, finger millet, castor, banana, farm pond and river soil/rhizosphere. Based on biochemical tests, they were identified as *Pseudomonas aeruginosa* and *P. fluorescens*. Bio-efficacy of the seven native strains of *Pseudomonas* spp. was compared along with local commercial available biopesticides and Hinosan. Three times spraying of *P. aeruginosa* Rambhas Strain @ 0.6% (2×10^9 cfu/ml) at 15 days interval, starting after 21 days of transplanting was found significantly effective for economical management of the leaf blast of Finger millet.

Key words : Biocontrol, Finger millet, *Magnaporthe grisea*

INTRODUCTION

Finger millet (*Elusine coracana* L.) locally known as *Nagli* or *Ragi* is rich source of sulphur containing amino acids. It ranks third in importance of area and production after sorghum and pearl millet. In India, finger millet is cultivated in about 1.74 Mha with 2.01 MT production during *Kharif* (Anon., 2008). It is mostly cultivated in Karnataka with higher production than other states such as Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Bihar and Utter Pradesh and more over about 40-45 per cent of total world production of *ragi* is cultivated in India (Singh and Rai, 2003). In Gujarat, 1,35,000 ha area is under millet cultivation, in which south, central and north Gujarat region is covering 35,000 ha area under finger millet cultivation (Waghunde *et al.*, 2011). In *Kharif*, due to continuous and heavy rainfall and high humidity, the crop is heavily infested by blast caused by *Magnaporthe grisea* (Anamorph: *Pyricularia grisea*) and is a major constraint to the production of finger millet, resulting in direct crop losses (Ramakrishnan, 1963). GN-4 is the most commonly cultivated variety in the tribal area of south Gujarat which is highly susceptible to blast. As tribal man is using negligible chemicals, biological control will be certainly a mainstay in commercial agriculture. Inconsistent performance of biocontrol agents in the field has been a bottleneck for biocontrol researchers to exploit them at commercial level. Therefore, there is a compelling need to identify efficient and dependable antagonists to be used singly or as mixtures to ensure consistent performance governing the success of biocontrol programs on a commercial basis (Mondal, 2006). Hence, an experiment has been undertaken to evaluate the efficacy of the native strains of *Pseudomonas* spp. isolated from south Gujarat in comparison with commercially available *P. fluorescens* products for the management of leaf blast of finger millet.

MATERIALS AND METHODS

The experiment was conducted for successive three years during *Kharif* 2009 to 2011 at Hill Millet Research Station, Navsari Agricultural University and Waghai- Gujarat. Seven *Pseudomonas* spp. were isolated from different locations and rhizosphere of various crops as per Table 1. Isolation and biochemical tests were done in the Biopesticide and Biofertilizer Unit, Department of Plant Pathology, N. M. College of Agriculture, N.A.U., Navsari. Based upon the biochemical tests, four isolates were confirmed as *P. aeruginosa* and three as *P. fluorescens*. The GN-4 (Red Nagli) cultivar was selected for experiment as it is mostly cultivated cultivar in south Gujarat region. The experiment was conducted in randomized block design with 12 treatments, replicated thrice with plot size of 2.25 x 1.5 m. Three sprays of *Pseudomonas* spp. (0.6% of 2 × 10^9cfu/ml) and Hinosan (0.1%) were given at 15 days interval and 1st spray was done at 21 days after sowing. The leaf infection was recorded after 7 days of each spray using a numerical scale from 0-5 by examining 20 selected plants in each treatment. Occurrence of leaf blast was recorded by visual observation following 0-5 scale as: 0= no symptoms on the leaves, 1= small brown specks of pin head size spot to slightly elongated, necrotic gray spots with brown margin less than 1% leaf area affected, 2= A typical blast lesion, elliptical 5-10 mm long, 1-5% of leaf area affected, 3=a typical blast lesion, elliptical 1-2 cm long, 5-25% of leaf area affected, 4=25-50% of leaf area affected and 5= more than 50% leaf area affected with coalescence of the lesions at the time of vegetative growth and per cent disease intensity (PDI) was calculated as suggested by Nagaraja *et al.* (2007) and yield (kg/ha) was recorded after harvest. The treatments were *P. aeruginosa* Waghai-1 PaWP (T_1), *P. fluorescence* Waghai-2 PfWN (T_2), *P. aeruginosa* Waghai-3 PaWS (T_3), *P. fluorescence* Rambhas-1 PfRB (T_4), *P. aeruginosa* Rambhas-2 PaRS (T_5), *P. aeruginosa* Navsari-1 PaNS (T_6), *P. fluorescence* Navsari-2 PfNC (T_7), Pf-1 (Commercial-1)(T_8), Pf-2 (Commercial-2) (T_9)and Pf-3 (Commercial-3) (T_{10}) Hinosan @ 0.1% (T_{11})and control (T_{12}).

Table 1: Location, habitat, crop and code of native strains of *Pseudomonas* spp.

Location	Habitat	Crop	Geographical location	Code
Hill Millet Research Station, NAU, Waghai	Rhizosphere	Paddy	20.77' N 73.50' E	PaWP
	Rhizosphere	Nagli	20.77' N 73.50' E	PfWN
	Soil	Nagli	20.77' N 73.50' E	PaWS
Hill Millet Research Station, NAU, Rambhas Farm, Rambhas.	Rhizosphere	Banana	20.80' N 73.62' E	PfRB
	Ambika River	----	20.80' N 73.62' E	PaRS
Krishi Vigyan Kendra and Livestock Research Station, NAU, Navsari.	Farm Pond	-----	20.95° N 72.93° E	PaNS
	Rhizosphere	Castor	20.95° N 72.93° E	PfNC

RESULTS

Leaf blast (PDI)

As per results presented in Table 2, significant reduction of finger millet leaf blast intensity based on percentage of disease index (PDI) in all the treatments was recorded as compared to the control. Significantly lower leaf blast intensity based on percentage of disease index (PDI) was recorded in PaRS (12.00) which was at par with Hinosan (14.00) and PaNS (15.67). Next best treatment in the order of merit was PfWN (24.33) followed by PaWS (24.67), PaWS (27.33), PaWP (27.67), Pf-2 (30.33), Pf-3 (32.00), PfRB (33.33) and Pf-1 (34.00).

There was significant reduction in the disease intensity of finger millet leaf blast in all the treatments during the second year also as compared to control. Significantly lower leaf blast intensity based on PDI was recorded in Hinosan (12.00) which was at par with PaRS (17.67), PaNS (18.00) and PaWS (18.67). The next best treatment in the order of merit was PfWN (24.67) followed by PfNC (24.67), PaWP (28.00), Pf-2 (32.00), Pf-3 (32.33), Pf-1 (34.33) and PfRB (35.33).

There was a significant reduction in disease intensity of finger millet leaf blast in all the treatments during the year 2011-12 as compared to control. The lowest disease intensity based on PDI was recorded in Hinosan (10.67) which was at par with PaRS (13.33) and PaNS (15.33). The next best treatment in order of merit was PaWS (19.33) followed by PfNC (20.67), PaWP (24.00), Pf-3 (24.67), PfWN (25.33), Pf-1 (26.00), Pf-2 (26.67) and PfRB (28.00).

The pooled results of application of *Pseudomonas* spp. against leaf blast of finger millet showed that all the treatments were significantly more effective in controlling the disease as compared to the control. The significantly lowest disease intensity (PDI) was recorded in Hinosan (12.22) which was statistically at par with PaRS (14.33) and PaWS (16.33). The next best treatment in the order of merit was PaWS (21.78) followed by PfNC (23.33), PfWN (24.78), PaWP (26.56), Pf-3 (29.67), Pf-2 (29.67), Pf-1 (31.44) and PfRB (32.22).

Significantly higher yield was recorded in all the treatments as compared to control as per mentioned in Table 3. Significantly maximum yield (kg/ha) was recorded in PaRS (3842.85) which was statistically at par with Hinosan (3789.73) and PaNS (3567.38). The next best treatment in order of merit was, PfRB (3231.54) followed by PfWN (3205.46), Pf-1 (3122.67), Pf-3 (3095.01), PaWS (3070.25), PfNC (3055.61), Pf-2 (3033.65) and PaWP (2614.13).

Significantly higher yield was recorded in all the treatments as compared to control during the second year also. The highest yield (kg/ha) was recorded in Hinosan (3883.18) which was statistically at par with PaRS (3863.40), PfWN (3607.71), PaWS (3438.54) and PfRB (3412.46). The next best treatment in order of merit was Pf-1 (3363.01) followed by Pf-2 (3273.98), Pf-3 (3135.51), PaWS (3110.58), PfNC (3095.95) and PaWP (2654.47).

The significantly highest yield (kg/ha) was recorded in the Hinosan (3926.80) during the year 2011-12 but was statistically at par with the PaRS (3630.07) and PaNS (3422.35). The next best treatment in order of merit was PaWS (3303.66) followed by PaWP (3282.79), Pf-1 (3242.14), PfWN (3234.42), PfNC (3224.42), Pf-2 (3135.51), PfRB (2977.25) and Pf-3 (2975.08).

Significantly higher yield was found in all the treatments in pooled as compared to the control. The maximum yield (kg/ha) was recorded in Hinosan (3859.98) which was statistically at par with PaRS (3785.37) and PaNS (3586.09) respectively. The

Table 2 : Effect of *Pseudomonas* spp. on yield of finger millet

Treatments		Per cent Disease Intensity (PDI)			
		2009 10	2010 11	2011 12	Pooled
	PaWP	31.58 (27.67)	31.83 (28.00)	29.14 (24.00)	30.85 (26.56)
	PfWN	29.47 (24.33)	29.67 (24.67)	30.18 (25.33)	29.77 (24.78)
	PaWS	31.42 (27.33)	25.54 (18.67)	25.99 (19.33)	27.65 (21.78)
	PfRB	34.99 (33.33)	36.41 (35.33)	31.74 (28.00)	34.38 (32.22)
	PaRS	19.90 (12.00)	24.77 (17.67)	21.26 (13.33)	21.97 (14.33)
	PaNS	26.06 (15.67)	24.86 (18.00)	22.92 (15.33)	23.31 (16.33)
	PfNC	29.64 (24.67)	29.75 (24.67)	26.92 (20.67)	27.77 (23.33)
	Pf-1	35.61 (34.00)	35.82 (34.33)	30.63 (26.00)	34.02 (31.44)
	Pf-2	33.36 (30.33)	34.42 (32.00)	31.05 (26.67)	32.95 (29.67)
	Pf-3	34.41 (32.00)	34.62 (32.33)	29.72 (24.67)	32.92 (29.67)
	Hinosan	21.93 (14.00)	20.02 (12.00)	18.93 (10.67)	20.29 (12.22)
	Control	39.15 (40.00)	39.36 (40.33)	37.97 (38.00)	38.82 (39.44)
Treatment	S.Em ±	2.23	1.98	1.94	1.12
	CD 5%	6.55	5.82	5.69	3.15
	CV (%)	12.64	11.25	11.98	11.98
	T x Y	NS	NS	NS	NS

Figures inside the parenthesis are the original value while those outside are arc sine transformed value

Table 3: Effect of the *Pseudomonas* spp. on finger millet leaf blast

	Treatment	Yield (Kg/ha)			
		2009-10	2010-11	2011-12	Pooled
	PaWP	2614.13	2654.47	3282.79	2850.46
	PfWN	3205.46	3607.71	3234.42	3349.20
	PaWS	3070.25	3110.58	3303.66	3161.50
	PfRB	3231.54	3412.46	2977.25	3207.09
	PaRS	3842.85	3863.40	3630.07	3785.37
	PaNS	3567.38	3438.54	3422.35	3586.09
	PfNC	3055.61	3095.95	3224.42	3128.66
	Pf-1	3122.67	3363.01	3242.14	3242.61
	Pf-2	3033.65	3273.98	3135.51	3147.71
	Pf-3	3095.01	3135.51	2975.08	3068.53
	Hinosan	3789.73	3883.18	3926.80	3859.98
	Control	1374.90	1415.23	1391.89	1394.01
Treatment	S.Em ±	181.88	167.89	174.37	99.40
	C.D. 5%	533.46	492.42	511.43	279.78
	CV (%)	10.22	9.12	9.60	9.64
	T x Y	NS	NS	NS	174.80
	Y	-	-	-	-
	T x Y	NS	NS	NS	NS

Table 4: Economics of Treatment

Treatment	Yield Kg/ha	Cost of Treatment (Rs.)			Gross Income	Net Income	Net Return	Net CBR
		Chemical	Labour	Total				
PaWP	2850.46	1080	600	1680	42756.95	41076.95	20166.86	12.00
PfWN	3349.20	1080	600	1680	50237.97	48557.97	27647.87	16.45
PaWS	3161.50	1080	600	1680	47422.44	45742.44	24832.35	14.78
PfRB	3207.09	1080	600	1680	48106.29	46426.29	25516.19	15.18
PaRS	3785.37	1080	600	1680	56780.50	55100.50	34190.41	20.35
PaNS	3586.09	1080	600	1680	53791.35	52111.35	31201.26	18.57
PfNC	3128.66	1080	600	1680	46929.89	45249.89	24339.80	14.48
Pf-1	3242.61	1800	600	2400	48639.08	46239.08	25328.99	10.55
Pf-2	3147.71	3375	600	3975	47215.72	43240.72	22330.63	5.617
Pf-3	3068.53	9000	600	9600	46027.97	36427.97	15517.87	1.616
Hinosan	3859.98	6000	600	6600	57899.69	51299.69	30389.60	4.604
Control	1394.01	0	0	0	20910.09	20910.09		

*Price of Nagli (Finger millet) @15/kg

Labour @100/day

T_1 to T_7: @120/L

T_8-Pf-1 @200/kg

T_9- Pf-2 @375/L

T_{10}-Pf-3 @300/100ml

T_{11}- Hinosan: @1000/L

next best treatment in the order of merit was PfWN (3349.20) followed by Pf-1 (3242.61), PfRB (3207.09), PaWS (3161.50), Pf-2 (3147.71), PfNC (3128.66), Pf-3 (3068.53) and PaWP (2850.46).

Maximum Net cost benefit ratio (CBR) was recorded in the treatment of PaRS (20.35) followed by PaNS (18.57), PfWN (16.45), PfRB (15.18), PaWS (14.78), PfNC (14.48), PaWP (12.00), Pf-1 (10.55), Pf-2 (5.61), Hinosan (4.60) and Pf-3 (1.61). Seed treatment of *P. fluorescence* (10 g/kg) with its broad casting (2.5 kg/ha) at 30 days after transplanting and foliar spray (1.25 kg/ha) at 45 to 60 days reduced the rice leaf and neck blast with higher yield production i.e. 14.5, 4.5 and 4625 kg/ha, respectively as compared to Ediphenphos (50 ml/ha) and carbendazim (250 g/ha) as foliar spray at 30, 45 and 60 days after transplanting as referred earlier by Muthaiyan, (2000). Two sprays of *P. fluorescence* @ 0.3 per cent i.e. first at 50 per cent flowering followed by second spray 10 days later were recommended for control of neck and finger blast. (Ramappa *et al.*, 2002). Kumar and Kumar (2011) revealed that seed treatment and two sprays of *P. fluorescence* Pf-2 @0.6 per cent recorded lowest neck and finger blast with maximum yield of 2312.34 kg/ha. Patro *et al.* (2008) found that *P. fluorescence* (0.6%) as a seed treatment with two foliar sprays at 10 days interval was best for the management of finger millet (27.8 PDI), leaf and neck blast with higher yield (3288 kg/ha) as compared to other treatments. Sitter *et al.* (1996) emphasized that six strains of *P. fluorescence* and *P. putida* showed fungal inhibition in dual plate assay in the laboratory and reduced *E. coracana* blast severity in the field. Ramanathan *et al.* (2002) found that the strains of *P. fluorescence* could promote growth in roll towel method and reduced blast of finger millet under glass house condition.

Strain PaRS was found better potent native isolate for controlling finger millet blast than rest of the isolates. PaRS may be inhibited pathogen by producing antibiotics, siderophores and plant growth stimulating substances. The reduction of disease by *Pseudomonas* may be due to (i) application of *Pseudomonas* isolates strengthen host cell wall structures resulting in restriction of pathogen invasion in plant tissue (ii) activation of enzymes of phenylpropanoid metabolism and accumulation of PR-proteins in finger millet leaves (Radjacommare *et al.,* 2004a) (iii) activate induced systemic resistance (iv) induction of defense proteins *viz.* chitinase, â-1,3 glucanase, peroxidase (PO) and polyphenol oxidase (PPO) (iv) increase amount of silicic acid in the leaves and (v) expression of defense gene against finger millet blast (Radjacommare *et al.,* 2004b).

The native *Pseudomonas* isolates were varying in their efficacies for controlling finger millet blast, it might be due to difference in ability to express the defense related gene.

Thus, minimum finger millet blast disease intensity was recorded in PaRS isolate, it might be due to strong synthesis and accumulation of chitinase, PO and PPO, expression of defense gene, production of silicic acid and strengthen cell wall and activate phenylpropanoid metabolism and PR-proteins activity in PaRS.

ACKNOWLEDGEMENTS

The authors are highly grateful to Principal, N. M. College of Agriculture, Navsari and all staff of Hill Millet Research Station-Waghai for providing necessary facilities during the present investigation.

REFERENCES

Anonymous. 2008. *Nagli- Major Kharif Hill Millet Crop in Hilly Region. Technical Bulletin* of Hill Millet Research Station, Waghai. p-1.

Kumar, B. and Kumar, J. 2011. Management of blast diseases of finger millet (*E. coracana*) through fungicides, bioagents and varietal mixture. *Indian Phytopathology*. **64**: 272-274.

Mondal, K. 2006. Bacterial Antagonists for bacterial diseases in plant. Daya Publication House, p: 256-289.

Muthaiyan, M. C. 2000. Biocontrol of rice blast disease with *Pseudomonas fluorescens. Pestology*. **24**: 20-22.

Nagaraja, A.; Kumar, J.; Jain, A. K.; Narasimhudu, Y.; Raghuchander, T.; Kumar, B. and Gowda, B. H. 2007. Compendium of small millets diseases. AICSMIP, Bangalluru. p-14

Patro, T. S. S. K; Rani, C and Vijay Kumar, G. 2008. *Pseudomonas fluorescens*, a potential bioagents for Management of Blast in finger millet (*Eleusine coracana*). *Journal of Mycology and Plant Pathology*. **38**: 298-300.

Radjacommare, R.; Ramanathan, A.; Kandan, A.; Harish, S.; Thambidurai, G.; Sible, G.V.; Ragupathi, N. and Samiyappan, R. 2004[a]. PGPR mediates induction of pathogenesis-related (PR) proteins against the infection of blast pathogen in resistant and susceptible ragi [*Eleusine coracana* (L.) Gaertner] cultivars. *Plant and Soil*. **266**: 165–176

Radjacommare, R.; Ramanathan, A.; Kandan, A.; Sible, G.V.; Harish, S. and Samiyappan, R. 2004[b]. Purification and antifungal activity of chitinase against *Pyricularia grisea* in finger millet. *World Journal of Microbiology and Biotechnology*. **20**: 251–256

Ramakrishnan, K.V. 1963. *Diseases of millets*. New Delhi, Indian

Council of Agricultural Research publication, p-152

Ramanathan A.; Shanmugam, V.; Raghuchander, T. and Samiyappan, R. 2002. Induction of systemic resistance in ragi against blast disease by *Pseudomonas fluorescens*. *Annals of Plant Protection Science*. **10**: 313-318

Ramappa, H. K., Ravishankar, C. R. and Prakash, P. 2002. Estimation of yield loss and management blast disease in finger millet (ragi). *Proc. Asian Cong. Mycol Pl. Path.* Oct. 1-4, 2002, University of Mysore p: 195

Singh, B. and Rai, R. S. 2003. Stability analysis for yield and components in ragi (*Eleusine coracana*. Gaertn). *RAU Journal of Research*. **13**:30-35

Sitter, V.; Gnanamanickam, S. S. and Sitther, V. 1996. Biological control of blast diseases of finger millet (*E. coracana* (L.) G.) and an analysis of fertility of *Magnaporthe grisea Current Science*. **71**: 144-147.

Waghunde R. R.; Sabalpara A. N.; Chaudhary, P. P. and Solanky, K. U. 2011. A new record of foot rot of finger millet in Gujarat. *Journal of Plant Disease Sciences*. **6**: 70.