J. Mycopathol. Res. ***52(2)*** *: 311-316, 2014;* (ISSN 0971-3719)

Occurrence and fungicidal management of Alternaria fruit rot [*Alternaria altarnata* (Fr.) Keissler] of Aonla

RAJESH RAMDAS WAGHUNDE*, RAVINDRANATH K. PATIL AND MANISHA SHANKAR SHINDE*****
**Hill Millet Research Station, Anand Agricultural University, Muvaliya Farm, Dahod 389 151*
***Department of Plant Pathology, B.A. College of Agriculture, Anand Agricultural University, Anand 388100 and*
****N.M. College of Agriculture, Navsari Agricultural University, Navsari 396 450 Gujarat*

Received : 09.12.2013 Accepted : 15.05.2014 Published : 27.10.2014

Alternaria alternata (Fr.) Keissler, the casual agent of Alternaria fruit rot of Aonla, is an important post harvest disease in Aonla fruits. The survey was carried out during 2007-08 at Vegetable Market, Station Road and Horticulture Farm Shop, Anand Agricultural University, Anand and found that the incidence of Penicillium rot was maximum (5.99 and 2.71%) at both the markets. Hexaconazole, thiophanate methyl and hexaconazole (5%) + captan (70%) recorded cent per cent inhibition of mycelial growth and sporulation at 1000 and 1500 ppm concentrations *in vitro*. The severity of Alternaria rot was significantly lowest in fruits treated with hexaconazole (5%) + captan(70%) at both the concentrations (1000 and 1500 ppm) (1.84 and 11.29% and 1.48 and 2.75%) followed by hexaconazole (1.88 and 13.51%) and (1.71 and 3.50%) and thiophanate methyl (1.95 and 14.45) and (1.79 and 5.37) in pre-and post-inoculation treatments after 4 and 7 days of inoculation, respectively.

Key words: *Alternaria alternata,* Aonla, fungicides, survey

INTRODUCTION

The Aonla (*Emblica officinalis* Gaertn.) is an important arid fruit crop. In India, the area under aonla cultivation is about 49,620 hectares in different states like Utter Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh, Tamil Nadu etc. with an annual production of 1,50,500 tonnes (Singh, 2006). *Alternaria alternata,* the causal agent of Alternaria fruit rot of aonla, is a post harvest disease and about 15 to 20 per cent of aonla fruits harvested are lost before they reach to consumers (Singh, 2006). Aonla fruits are highly perishable in nature, therefore it is very difficult to store fruits for longer period. Hence, an attempt has been done to know aonla fruit rot incidence in the markets of Anand and efficacy of market available fungicides for the management of Alternaria fruit rot *in vitro* and *in vivo*.

MATERIALS AND METHODS

Survey

Survey of fruit rots of aonla was conducted at Vegetable Market, Station Road and Horticultural Farm Shop, Anand Agricultural University, Anand. To study the incidence of fungal rots weekly survey was carried out at both the locations from first week of November to fourth week of January during 2007-2008. Five samples were selected randomly each containing 100 fruits from both the locations and were examined for the incidence of fungal rots caused due to different pathogens. The per cent fruit rot incidence was calculated by following standard formula

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits examined}} \times 100$$

Fungicides

In vitro

Efficacy of 9 fungicides were screened *in vitro* by following poisoned food technique method (Nene and Thapliyal, 1979) against Alternaria fruit rot pathogen at two different concentrations (1000 and 1500 ppm). Required quantity of the fungicides during experiment was mixed thoroughly in sterilized 100 ml potato dextrose agar media. The poisoned medium (20 ml) was then poured in sterilized Petri plates and allowed it to solidify. The plates were then inoculated with 5 mm diameter disc of 7 days old culture of test pathogen by placing in the centre of the plate along with control. Each treatment was repeated four times. Observations on the mycelial growth (mm), per cent growth inhibition and sporulation of test fungi were recorded after 7 days of incubation. The per cent growth inhibition of pathogen in each treatment was calculated by following formula (Asalmol *et al.*, 1990) and spore production by the method suggested by Pandey and Vishwakarma (1998). Following the scale given in Table 1.

$$I = \frac{C - T}{C} \times 100,$$

where I = Inhibition per cent,
C = Colony diameter (mm) in control plate, and
T = Colony diameter (mm) in treated plate

Table 1 : Scale used to record the number of spores of *Alternaria alternata*

Particulars	Conidia production (No. of conidia / microscopic field)	Sign indication
No spore production	Nil	-
Poor spore production	1-7	+
Moderate spore production	8-25	++
Good spore production	26-50	+++
Excellent spore production	>50	++++

In vivo

The fungicides studied *in vitro* were tested at two concentrations (1000 and 1500 ppm) by following both pre- and post-inoculation methods.

Pre- inoculation

The fresh, healthy, matured, uniform size aonla fruits of Gujarat Aonla-1 cultivar were surface sterilized by dipping in 0.1 per cent $HgCl_2$ solution for one minute followed by three washings with sterilized distilled water and inoculated separately by the pin prick method. The fruits were first dipped in the fungicidal solution for 5 minutes, air dried and then inoculated with fruit rot pathogen (10^6 spores/ml). The interval between fungicidal treatment and inoculation was 12 h. The severity of fruit rots was recorded on 4th and 7th day of inoculation.

Post- inoculation

The procedure detailed in pre-inoculation was same except that the fruits were first inoculated with test pathogen and then treated with fungicides.

RESULTS AND DISCUSSION

The weekly survey was carried out from first week of November to fourth week of January, 2007-08 and found the incidence of Penicillium, *Colletotrichum, Alternaria, Phomopsis, Aspergillus* rot, internal necrosis (boron deficiency) and other fruit rots (*Phoma* and *Cladosporium*) at Vegetable Market, Station Road and Horticulture Farm Shop, A.A.U., Anand.

Vegetable Market, Station Road, Anand, incidence of rot caused by Penicillium was pre dominant (5.99 %) followed by *Aspergillus* (3.34%) and *Colletotrichum* rots (3.18%). The incidence of *Alternaria, Phomopsis*, Internal necrosis and other fruit rots were 2.68, 1.95, 1.11 and 2.23 per cent, respectively. The highest incidence of Penicillium rot (12.6%) was recorded in 4th week of December followed by Aspergillus (7.5%), Colletotrichum (6.2%), Alternaria (5.3%) and Phomopsis *rots* (4.0%) (Table 2).

Horticulture Farm Shop, A.A.U., Anand recorded maximum incidence of Penicillium rot (2.71%) followed by *Aspergillus* (2.36%) and *Colletotrichum* (2.23%) during 2007-2008. The incidence of *Alternaria*, *Phomopsis*, Internal necrosis and other fruit rots were 1.78, 1.39, 0.86 and 0.66 per cent, respectively. The similar trend of observations which was recorded at Vegetable Market, pertaining to incidence of various rots was observed at Horticulture Farm Shop, in third week of January, i.e. *Penicillium* (5.2%), *Colletotrichum* (4.5%), *Aspergillus* (4.2%), *Alternaria* (3.5%), *Phomopsis* (2.6%), Internal necrosis (2.4%) and other fruit rots (1.8%) (Table 3).

Table 2 : Incidence of fruit rots at Vegetable Market, Station Road, Anand

Fruit Rot	Average Per cent Disease Incidence												Mean
	November				December				January				
	I week	II week	III week	IV week	I week	II week	III week	IV week	I week	II week	III week	IV week	
Penicillium rot	1.2	1.4	1.7	2.0	3.2	4.4	8.6	12.6	10.8	10	8.8	7.2	5.99
Colletotrichum rot	0.9	1.2	1.4	1.8	2.3	4.2	5.4	6.2	5.0	4.2	3.0	2.6	3.18
Alternaria rot	0.8	1.2	1.3	1.6	2.5	3.2	5.1	5.3	3	2.8	2.5	2.8	2.68
Phomopsis rot	0.3	0.5	0.8	1.2	1.6	2.2	3.9	4.0	2.8	2.5	2.0	1.6	1.95
Aspergillus rot	0.8	1.4	1.5	2.0	2.9	4.0	6.8	7.5	5.2	3.0	2.8	2.2	3.34
Internal necrosis	0.0	0.2	0.2	0.4	1.0	0.8	1.6	2.0	2.5	1.9	1.5	1.2	1.11
Other fruit rot	0.0	0.4	0.5	1.0	1.8	3.0	3.9	5.8	4.0	3.1	1.8	1.4	2.23
Weekly Av. Incidence (%)	0.57	0.90	1.57	1.42	2.18	3.01	5.42	6.20	4.75	3.92	3.20	2.71	

Table 3 : Incidence of aonla fruit rot at Horticulture Farm Shop, AAU, Anand

Fruit Rot	Average Per cent Disease Incidence												Mean
	November				December				January				
	I week	II week	III week	IV week	I week	II week	III Week	IV week	I week	II week	III week	IV week	
Penicillium rot	0.8	1.0	1.1	0.9	1.5	1.7	2.9	3.7	4.2	4.8	5.2	4.7	2.71
Colletotrichum rot	0.6	0.8	0.8	1.0	1.2	1.5	2.3	2.9	3.2	3.7	4.5	4.2	2.23
Alternaria rot	0.2	0.6	0.8	1.1	0.9	1.2	1.8	2.2	3	3.2	3.5	2.8	1.78
Phomopsis rot	0.1	0.4	0.6	0.9	1.1	1.2	1.4	1.8	2.2	2.4	2.6	2	1.39
Aspergillus rot	0.6	0.0	1.0	1.5	1.8	2.2	2.5	3.2	3.5	3.8	4.2	3.2	2.36
Internal necrosis	0.0	0.0	0.0	0.1	0.2	0.3	0.5	1.2	1.8	2.0	2.4	1.8	0.86
Other fruit rot	0.0	0.0	0.0	0.0	0.1	0.3	0.2	1.0	1.4	1.2	1.8	1.9	0.66
Weekly Av. Incidence (%)	0.32	0.51	0.61	0.78	0.97	1.20	1.65	2.28	2.75	3.14	3.45	2.94	

Table 4 : Bio-efficacy of fungicides against *Alternaria alternate in vitro*

Fungicides Common Name	1000 ppm			1500 ppm		
	Mycelial growth (mm)	PGI (%)	Sporulation	Mycelial growth (mm)	PGI (%)	Sporulation
Thiophanate methyl	0.00	100.0	-	0.00	100.0	-
Hexaconazole	0.00	100.0	-	0.00	100.0	-
Hexaconazole (5%) +captan (70%)	0.00	100.0	-	0.00	100.0	-
Cymoxanil(8%) + mancozeb (64%)	22.75	68.51	-	20.37	72.37	-
Metalaxyl (8%) +mancozeb (64%)	44.25	38.75	-	40.50	45.08	-
Mancozeb	14.75	79.58	-	13.50	81.69	-
Propineb	22.87	68.34	-	21.65	70.64	-
Carbendazim (12%) +mancozeb (63%)	23.50	67.47	-	21.75	70.50	-
Carbendazim	16.25	77.50	-	14.87	79.83	-
Control	72.25	0.00	++++	73.75	0.00	++++
S Em. ±	1.26			1.04		
C.D. at 5%	3.66			3.00		
CV. %	11.71			10.10		

Fungicides
In vitro

Nine fungicides at two concentrations (1000 and 1500 ppm) along with control were screened against the mycelial growth and sporulation of *A. alternata in vitro* following standard poisoned food technique (Nene and Thapliyal, 1979). The obser-

Table 5 : Bio-efficacy of fungicides on the severity of *Alternaria* fruit rot aonla

Fungicides	Pre inoculation				Post inoculation			
	1000 ppm		1500 ppm		1000 ppm		1500 ppm	
Common Name	4th Day*	7th Day**	4th Day	7th Day	4th Day	7th Day	4th Day	7th Day
Thiophanate methyl	1.95 (3.87)	14.45 (6. 25)	1.79 (3.25)	5.37	6.75	9.87	3.25	5.50
Hexaconazole	1.88 (3.62)	13.51 (5.50)	1.71 (3.00)	3.50	5.75	7.87	3.75	4.00
Hexaconazole (5%) + captan (70%)	1.84 (3.50)	11.29 (3.87)	1.48 (2.25)	2.75	4.25	6.00	2.87	3.62
Cymoxanil (8%) + mancozeb (64%)	3.99 (16.25)	27.76 (21.75)	3.51 (12.37)	15.00	17.75	18.50	13.25	16.87
Metalaxyl (8%) + Mancozeb (64%)	4.17 (17.50)	25.43 (18.50)	3.68 (13.32)	17.50	18.25	20.50	14.00	18.50
Mancozeb	3.09 (9.62)	22.14 (14.25)	2.58 (6.75)	8.37	10.62	12.37	7.62	9.12
Propineb	3.53 (12.50)	29.74 (25.00)	3.09 (9.62)	9.62	14.25	15.50	8.87	10.50
Carbendazim (12%) + mancozeb (63%)	3.25 (10.62)	22.97 (15.25)	1.73 (3.12)	4.75	11.87	12.25	9.12	9.00
Carbendazim	3.38 (11.50)	23.31 (15.75)	2.81 (8.00)	9.75	12.25	14.75	10.50	11.75
Control	4.81 (23.25)	40.08 (41.50)	4.26 (18.25)	39.00	25.75	42.25	20.50	40.75
S Em. ±	0.15	1.10	0.12	0.78	0.86	1.07	0.68	0.71
C.D. at 5%	0.45	3.19	0.36	2.26	2.48	3.10	1.98	2.06
CV %	9.86	9.60	9.47	13.57	13.50	13.45	14.64	11.01

*Figures in the parenthesis are retransformed values, those outside are square root transformed values.
**Figures in the parenthesis are retransformed values, those outside are arc sine transformed values.

vations on the mycelial growth, per cent growth inhibition (PGI) and sporulation were recorded after 7 days of incubation.(Table 4)

All the fungicides screened were found significantly superior in inhibiting the mycelial growth and sporulation of *A. alternata* over control. Thiophanate methyl, hexaconazole and hexaconazole (5%) + captan (70%) at both the concentrations recorded cent per cent inhibition of mycelial growth and proved significantly superior over the rest of the fungicides. The next best treatment in order of merit was mancozeb (14.75 and 13.50 mm) followed by carbendazim (16.25 and 14.87 mm) with 79.58 and 81.69 and 77.50 and 79.83 per cent growth inhibition at 1000 and 1500 ppm concentrations, respectively. Carbendazim (12%) + mancozeb (63%) (23.50 and 21.75 mm) (67.47 and 70.50 PGI), cymoxanil (8%) + mancozeb (64%) (22.75 and 20.37 mm) (68.51 and 72.37 PGI) and propineb (22.87 and 21.65 mm) (68.34 and 70.64 PGI) showed moderate growth inhibition while metalaxyl (8%) + mancozeb (64%) (44.25 and 40.50 mm) (38.75 and 45.08 PGI) found least effective in restricting the mycelial growth and per cent growth inhibition of the *A. alternata* at 1000 and 1500 ppm concentrations, respectively (Table 4).

In vivo

All the fungicides screened were found significantly superior in reducing the Alternaria fruit rot severity over control at 4th and 7th days after inoculation both in pre and post- inoculation treatments at 1000 and 1500 ppm concentrations.

Pre-inoculation

The results revealed that on 4th day of inoculation, significantly lowest disease severity was re-

corded in hexaconazole (5%) + captan (70%) (1.84 and 1.48%) but it was at par with hexaconazole (1.88 and 1.71%) and thiophanate methyl (1.95 and 1.79%) followed by mancozeb (3.09 and 2.58%), carbendazim (12%) + mancozeb (63%) (3.25 and 1.73%) and carbendazim (3.38 and 2.81%) at 1000 and 1500 ppm concentrations, respectively. Where as metalaxyl (8%) + mancozeb (64%) at both the concentrations (1000 and 1500 ppm) was found to be least effective in controlling the rot (4.17 and 3.68%) (Table 5).

A similar trend of result was observed on 7th day of inoculation. Hexaconazole (5%) + captan (70%) (11.29 and 2.75%) was found most effective in controlling the rot and it was at par with hexaconazole (13.51 and 3.50%) and thiophanate methyl (14.45 and 5.37%) followed by mancozeb (22.14 and 8.37%), while metalaxyl (8%) + mancozeb (64%) at 1000 and 1500 ppm was found to be least effective (27.76 and 15.00%) in controlling the rot (Table 5).

Post-inoculation

Significantly lowest Alternaria rot severity at 4th day was recorded in fruits treated with hexaconazole (5%) + captan (70%) (4.25 and 2.87%) but it was at par with hexaconazole (5.75 and 3.75%). The next best treatment in reducing fruit rot was thiophanate methyl (6.75 and 3.25%) followed by mancozeb (10.62 and 7.62%) at both the concentrations. Metalaxyl (8%) + mancozeb (64%) (18.25 and 14.00%) proved least effective in controlling Alternaria fruit rot.

On 7th day of inoculation, trend similar to that observed at 4th day. Higher dose of compound fungicides i.e. hexaconazole (5%) + captan (70%) (1500 ppm) found better for reducing the Alternaria rot severity as compared to lower doses (1000 ppm) in pre and post– inoculation. The pre–inoculation treatment was found better in controlling the fruit rot than post- inoculation treatments at both the concentrations (Table 5).

The results similar to the present findings have been reported by Kumar *et al.* (2005) showing complete inhibition of mycelial growth and conidial germination of *A. alternata* infecting leaf spot of apple by hexaconazole (0.05%), difenconazole (0.02%) and iprodione (0.15%) and Vadivel and Ebenezar (2006) reported that hexaconazole at 50, 100, 200, 500 and 1000 ppm gave complete inhibition of mycelial growth of *A. alternata* causing tomato blight. Tridemorph, propiconazole, hexaconazole and difenconazole (50, 100, 250 and 500 ppm) and thiram and mancozeb (500, 1000, 1500 and 2000 ppm) found most effective against Alternaria blight of sesame (Akbari and Parakhia, 2007).

The findings of *in vivo* management are quite confirmative with the results obtained by Singh and Sharma (1986) indicating that thiophanate methyl (1000 ppm) was most effective in managing Alternaria fruit rot of tomato, where as Navale *et al.* (1998) reported that mancozeb (0.3%) effective in controlling fruit spot of pomegranate caused by *A. alternata*. Further Kumar *et al.* (2005) noted chlorothalonil, carbendazim and penconazole at 1000 ppm found effective in controlling fruit rot of ber (*Alternaria alternata*). The Alternaria rot severity in tomato was significantly lowest in fruits treated with carbendazim (12%) + mancozeb (63%) at 1000 ppm concentration both in pre and post inoculation treatments. Pre- inoculation treatment found better in controlling the rot than post –inoculation treatments (Panchal, 2008).

It is clear from weekly survey that incidence of rot caused by *Penicillium* is more followed by *Aspergillus* and *Colletotrichum* at both the markets and hexaconazole (5%) + captan (70%), hexaconazole and thiophanate methyl at both the concentrations (1000 and 1500 ppm) were effective for the management of Alternaria fruit rot *in vitro* and *in vivo*.

ACKNOWLEDGEMENT

The authors are highly grateful to Principal, B. A. College of Agriculture, Anand Agricultural University, Anand for providing necessary facilities during the present investigation.

REFERENCES

Akbari, L. F. and Parakhia, A. M. 2007. Management of *Alternaria alternata* causing blight of sesame with fungicides. *Journal of Mycology and Plant Pathology,* **37**: 426-430.

Asalmol, M. N.; Sen, B. and Awasthi, J. 1990. Role of temperature and pH in antagonism of *Aspergillus niger* and *Trichoderma viride* against *Fusarium solani.* Proceeding of Indian Phytopathology Society (Western Zone) M.P.A.U., Pune, p-11-13.

Kumar, R.; Sharma, J. N. and Bharadwaj, L. N. 2005. Studies on epidemiology and management of Alternaria leaf spot of apple caused by *Alternaria alternata*. Abstract in "Second Global Conference, Plant Health-Global Wealth", Nov. 25-29, Udaipur, India. p-386.

Navale, A. M.; Padule, D. N. and Kaulgad, S. N. 1998. Efficacy of

different fungicides against leaf and fruit spots of pomegranate in mrig bahar. *Journal of Maharashtra Agricultural University*, **23**: 251-253.

Nene, Y. L. and Thapliyal, R. N. 1979. *Fungicides in Plant Disease Control*. Oxford and IBH Publishing House, New Delhi, p-7-10.

Panchal, D. G. 2008. *Alternaria fruit rot of tomato (Lycopersicon esculentum Mill.)* and its management. M. Sc. thesis submitted to Anand Agricultural University, Anand.

Pandey, K. K. and Vishwakarma, S. N. 1998. Studies on growth, sporulation and colony characters of *Alternaria alternata* on different vegetable-based media. *Journal of Mycology Plant Pathology*, **28**: 346-347.

Singh, J. P. and Sharma, S. 1986. Field evaluation of fungicides for controlling Alternaria fruit rot in tomato Haryana Agricultural University. *Journal of Research*. **16**: 294-295.

Singh, B. P. 2006. Scientific storage of nutritious aonla. *Phal-Phool*, ICAR publication, p-8-10.

Vadivel, S. and Ebenezar, E. G. 2006. Eco-friendly management of leaf blight of tomato caused by *Alternaria solani*. *Journal of Mycology Plant Pathology*, **36**:79-83.