Seed treatment and foliar application of fungicides for the management of sunflower leaf blight

M Santha Lakshmi Prasad, K Sujatha, N Naresh, S V Ramana Rao, S Chander Rao and P Madhuri

Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, India.
E mail: santha_1991@yahoo.com

Abstract

Field experiments were carried out during Kharif *seasons of 2008 to 2010 at Indian Institute of Oilseeds Research, Hyderabad, India for the management of sunflower leaf blight caused by* Alternariaster helianthi *(Hansf.) Tubaki and Nishihara. Different fungicides,* viz., *iprodione, carbendazim, iprodione + carbendazim, mancozeb, propiconazole and difenoconazole were evaluated in different combinations as seed treatment and foliar sprays. Seed treatment with iprodione +carbendazim 2g kg $^{-1}$ followed by two sprays of propiconazole 0.1% at 15 days interval recorded low leaf blight (27.9%) and higher seed yield of 975kg/ha. Seed treatment with iprodione + carbendazim 2g kg $^{-1}$ followed by two sprays of difenoconazole 0.1% at fortnightly interval also recorded leaf blight severity of 32.9% with seed yield of 878 kg/ha during three years of testing. However, seed treatment with iprodione 2g kg $^{-1}$ seed recorded high incremental benefit-to-cost ratio (8.88) followed by seed treatment with carbendazim 1g kg $^{-1}$ (8.43) and iprodione + carbendazim 2g kg $^{-1}$ seed (7.18). For the management of leaf blight of sunflower seed treatment with iprodione + carbendazim followed by two sprays of propiconazole was effective in terms of reduction of disease severity and increasing the seed yield, however, seed treatment with iprodione as well as with carbendazim was an effective treatment in terms of incremental benefit-to-cost-ratio.*

Keywords: Alternariaster leaf blight, disease severity, foliar spray, fungicides, management, seed treatment, sunflower and yield

Introduction

Sunflower (*Helianthus annuus* L.) is the most preferred oilseed crop for farmers in India due to its wider adaptability, high yield potential, shorter duration and profitability. Sunflower crop is affected by many fungal, viral and bacterial diseases, among which, leaf blight is a major constraint for the production of sunflower in India, as well as in tropical and sub-tropical regions of the world (Narain and Saksena, 1973; Tosi and Zazzerini, 1991). The disease has considerable effect on plant height, stem girth, head diameter, seed production, seed weight and hull percentage (Mathur *et al.* 1978) and was reported to reduce the seed yield by 27 - 80 % and oil yield by 17 - 33 % (Balasubrahmanyam and Kolte, 1980; Allen *et al.,* 1981; Carson, 1985). The disease also affects seed germination and seedling vigor and the loss in the germination varies from 23-32 % (Kolte *et al*., 1979). The causal organism, previously known as *Alternaria helianthi* (Hansf.) Tubaki & Nishihara, is now called *Alternariaster helianthi* Simmonds, a new genus erected by Simmons (2007) and recent evidence confirms that it belongs to the Leptosphaeriaceae (Alves *et al.,* 2013). The fungus is borne internally as well as externally on the seed with 22.9% seed transmission. Seedling blight may develop as the sunflower plants emerge on infested lands during the rainy season (Raut, 1985). Extended leaf wetness periods of 3-4 days duration can cause serious loss as the spots become larger and coalesce with each other (Mayee, 1992) and eventually the disease spreads rapidly due to the dampness of the rainy season.

Seed treatment with fungicides protects the seeds from seed borne infections and improve seed germination. Spraying of fungicides at appropriate intervals reduces the probability of airborne infection. Mesta *et al.,* (2011) reported that propiconazole 0.1% and hexaconazole 0.1% are effective fungicides against the Alternariaster blight of sunflower (ALB); however, application of hexaconazole and mancozeb gave the highest cost- benefit ratio. Many commonly used fungicides such as dithane M-45, vitavax, captan, dithane Z-78, fytolan, thiride and benlate failed to provide satisfactory control of severe incidence of leaf blight under field conditions, especially during the rainy season (Mukewar and Gera, 1980). The main aim of this study was to evaluate the efficacy of fungicides applied as a seed treatment alone or in the combination with foliar sprays applied at different intervals for the management of leaf blight in reducing the yield loss.

Materials and methods

Field trials were conducted at the Indian Institute of Oilseeds Research, Hyderabad (170.31'N; 780 39' E), India by using a randomized block design with three replications during *Kharif* seasons of 2008, 2009 and 2010. Sunflower hybrid, DRSH-1, moderately resistant to leaf blight, was sown on 30th July 2008, 7th July 2009 and 9th July 2010. Each plot consisted of 6 rows (3m long x 60 cm wide) (plot area 10.8 m^2). Plants were spaced 30cm apart within the rows. Weeds and insects were controlled as per standard recommended practices. Morden, a susceptible sunflower variety, was sown in five rows, 45cm apart, surrounding the experimental plot 15 days prior to sowing DRSH-1 in the main plots. These rows served as infector rows for initiation of the infection and spread of the leaf blight disease in the main plot.

Leaf blight appeared naturally and was severe during the 2008 and 2010 field trials. However, during the 2009 trial, leaf blight severity was lower, hence the crop at 35 days after sowing was artificially inoculated with *A. helianthi*. The pathogen was isolated from leaf blight infected sunflower leaves onto a sunflower leaf extract medium and a pure culture was maintained on the medium at 25 ± 2^0 C for 9 days. Spores in the culture were dislodged by adding distilled water to the culture plates, the suspension was filtered through muslin cloth and the spore concentration was adjusted to 10^6 conidia / ml. Two liters of inoculum was sufficient and the crop was inoculated with a knap sack sprayer in the evening hours. The field was irrigated prior to inoculation to maintain humidity in the micro-environment. Minute specks were observed on leaves of sprayed plants three days after inoculation. Fungicides were applied as seed treatment and foliar sprays in different combinations (Table 1). The combination of iprodione + carbendazim was used for seed treatment @ 2g kg^{-1} seed and iprodione and carbendazim were also evaluated individually as seed treatments. The fungicides including propiconazole, difenoconazole, iprodione + carbendazim, iprodione and carbendazim were sprayed on the plants after the visual appearance of small specks of leaf blight on the leaves with a scale of 1 or 3. The whole plots were sprayed with fungicides using a knapsack sprayer and spray drift was avoided by using a plastic sheet between the treatment plots. During 2008, small specks appeared 40 days after sowing (DAS) and fungicides were sprayed two times at 50 and 65 DAS. In 2009, fungicides were sprayed two times at 42 and 57 DAS. During 2010, the disease started appearing from 45 DAS, hence the fungicides were sprayed twice at 55 and 70 DAS. Mancozeb 0.25% was sprayed twice at 15 day intervals, which is a regular agricultural practice and water was sprayed in the control plots.

Leaf blight was assessed using a 0-9 point scale on leaves (Mayee and Datar, 1986). where 0 = no symptoms on leaf; 1 = small, circular, scattered, brown specks on leaves covering 1% or less of the leaf area infected ; 3 = spots enlarging, dark brown in colour, covering 1-10% of the leaf area infected; 5 = spots enlarging, dark brown in colour, target like appearance covering 11-25% of leaf area infected; 7 = spots dark brown, coalescing with target like appearance covering 26-50% of leaf area infected; 9 = spots uniformly

Table 1. Details of the treatments employed

Treatment	Name of active ingredient	Application dose of fungicide
Seed treatment (ST) only		
ST 1	Iprodione + Carbendazim (50%WP)	2g/kg seed
ST 2	Iprodione (50% WP)	2g/kg seed
ST 3	Carbendazim (50% WP)	1g/kg seed
Seed treatment + foliar spray (STF)		
STF 1	ST 1 + Propiconazole (25% EC)	0.1% (200ml/ha)
STF 2	ST 1 + Difenoconazole(25% EC)	0.1% (200ml/ha)
STF 3	ST 1 + Iprodione + Carbendazim (50%WP)	0.2% (200g /ha)
STF 4	ST 2 + Iprodione (50%WP)	0.2% (200g/ha)
STF 5	ST 3 + Carbendazim (50%WP)	0.1% (200g/ha)
Foliar sprays (F) only		
F1	Mancozeb (70% WP)	0.25% (200g/ha)
C	Control	-

Table 2. Efficacy of fungicides on leaf blight and yield of sunflower under field conditions (2008 to 2010)

Treatment	Leaf blight (%) 2008 I*	2008 II	2009 I	2009 II	2010 I	2010 II	Yield (kg/ha) 2008	2009	2010
STF1	14.2(22.1)	21.7 (27.8)	29.9(33.1)	31.8 (34.3)	23.1(28.7)	30.4 (33.5)	916	1222	787
STF2	22.9(28.6)	32.5 (34.8)	27.5(31.6)	30.3 (33.4)	27.8(31.8)	35.6 (36.6)	860	1081	692
STF3	16.8(24.2)	24.2 (29.5)	34.4(35.9)	40.7 (39.6)	30.9(33.8)	39.7 (39.1)	880	1016	671
STF4	28.7(32.4)	33.8 (35.6)	35.5(36.6)	38.5 (38.4)	35.3(36.5)	43.7 (41.4)	815	1129	618
STF5	30.7(33.7)	35.1 (36.3)	36.3(37.1)	54.6 (47.6)	35.6(36.6)	44.5(41.8)	782	960	562
ST3	34.2(35.8)	52.6 (46.5)	33.8(35.6)	38.8 (38.5)	43.8(41.4)	51.7 (45.9)	692	962	522
ST2	38.0(38.1)	57.4 (49.3)	32.6(34.8)	39.2 (38.8)	39.8(39.1)	48.6 (44.2)	663	1035	535
ST1	34.4(35.9)	54.7(47.7)	32.1(34.5)	40.7(39.6)	37.9(38.0)	46.2(42.8)	682	889	539
F1	29.6(32.9)	38.1 (38.1)	40.0(39.2)	53.3(46.9)	48.1(43.9)	57.8 (49.5)	798	897	447
C	51.9(46.1)	69.4(56.4)	44.1(41.6)	66.6(54.7)	52.3(46.3)	65.4(53.9)	510	684	412
LSD (p=0.05)	2.7	3.7	1.96	6.3	1.8	3.2	96.3	108.9	112.6
LSD (p=0.01)	3.8	5.1	2.7	8.7	2.4	4.4	131.9	149.4	152.0
CV%	4.8	5.4	3.2	8.9	2.8	4.4	7.1	6.4	15.7

STF 1 = Seed treatment (ST) with iprodione + carbendazim + foliar sprays (Fs) of propiconazole; STF 2 = ST 1 + difenoconazole Fs; STF 3 = ST 1 + iprodione + carbendazim Fs; STF 4 = ST 2 + iprodione Fs; STF 5 = ST 3 + carbendazim; ST 3 = ST with carbendazim; ST 2 = ST with iprodione; ST 1 = ST with iprodione + carbendazim; F1= Mancozeb Fs; C = control. Note: The values in columns are the mean of 3 years (2008 to 2010) in single factor analysis. Figures in parentheses are transformed angular values. The values within a column with different letters are significantly difference at 0.5% level by using Fisher's least significance difference test. *I : Disease severity 10 days after first spray of fungicides; II: Disease severity 15 days after second spray of fungicides

dark brown covering 51% or more of leaf area infected. Twenty plants from each plot were randomly selected and tagged for grading the disease severity. Disease intensity was assessed prior to the spray of fungicide and 10 days after the first and second fungicidal sprays. The disease index (%) was calculated as per standard formula. The tagged plants were graded based upon the amount of leaf area damaged. The mature heads were harvested upon maturity and the seed yield recorded. The data on ALB severity and seed yield were statistically analyzed by ANOVA (Gomez and Gomez, 1984). Prior to statistical analysis, the per cent disease severity data was transformed into angular values. Pooled analysis was also conducted on three years data.

The gross return on each treatment was measured by quantum of seed yield of each treatment multiplied by the sale price of sunflower seeds. The gross revenue was calculated by subtracting the input cost (pesticide and its application cost) incurred in the respective treatment from the gross income. The gross revenue over control for each treatment was calculated by subtracting the gross revenue of control from the gross revenue obtained in each individual treatment. The incremental cost-to-benefit ratio was calculated using the following formula.

Incremental Cost-to-benefit ratio = Gross revenue (individual treatment)-Gross revenue (control)

Input cost of individual treatment

Results and discussion

Generally, leaf blight severity was high during September and October months of the crop season. The leaf blight severity was more during 2008 and 2010 as compared to 2009. The weather conditions congenial for blight development were 21 -23^0 C low temperature with 88-95 % relative humidity during both years. The rainfall was 154 mm in the span of 15 days during 2008 and 265 mm in the duration of 13 days during September 2010 month (Fig.1).

The blight disease increased after 1st spray of fungicides and also due to congenial weather conditions like low temperature, high rainfall and more rainy days during the study periods. It is evident that the effect of seed treatment with fungicides in reducing the leaf blight severity was significant during all three years of the experimentation. During 2009, seed treatment with carbendazim (38.8%) and also iprodione (39.2%) reduced leaf blight as compared to control (66.6%). In 2010, the leaf blight intensity was comparatively low in seed treatment with iprodione + carbendazim (46.2%) than other seed treatments, however, during 2008, seed treatments with fungicides recorded moderate leaf blight severity of 52.6 to 57.4% (Table 2).

Among the combination of seed treatment followed by foliar application of fungicides, seed treatment with iprodione + carbendazim 2g/kg along with foliar application of propiconazole 0.1% twice at 15 days interval showed more reduction in leaf blight during 2008 (21.7%), 2009 (31.8%) and 2010 (30.4%). This treatment reduced the spread of the disease further after first spray of fungicides compared to other treatments. Seed treatment with iprodione + carbendazim 2g/kg in combination of two sprays of difenoconazole 0.1% reduced leaf blight during 2009 (30.3%) and 2008 (32.5%). In this treatment, leaf blight lesions kept expanding for 2-3 days then stopped from developing further which indicated that difenoconazole provided a long lasting protective and excellent curative disease control activity. Investigation of Dahmen and Staub (1992) revealed that difenoconazole is the sterol inhibitor compound with excellent protective and curative activity acting against *Alternaria solani*, leaf blight of tomato.

Seed treatment with iprodione + carbendazim 2g/kg combined with foliar application of same fungicide 0.2% two times at 15 days interval reduced leaf blight (24.2%) during 2008 and 2009 & 2010 (39.7 -40.7%). The efficacy of iprodione + carbendazim against leaf blight of sunflower was in agreement with findings of Srinivas *et al.,* (1997), Mondal *et al*., (1999) with respect to sunflower and Singh *et al.,* (1995) in linseed against leaf blight.

In seed treatment with iprodione followed by foliar spraying of same fungicide STF 4, the leaf blight incidence was comparatively lower, which indicates that iprodione either alone as a seed treatment (ST 2) or in a combination of seed treatment and foliar sprays reduced intensity of leaf blight or increased the seed yield. The treatment comprising of seed dressing with carbendazim along with sprays of the same fungicide (STF 5) showed a lower leaf blight severity during 2008 and 2010 in comparison to control.

During the three years, the seed yield was lowest in 2010 and highest in 2009 in all the treatments. Seed treatment with fungicides recorded significantly higher yield than that of control. Among the fungicides, seed treatment with iprodione was significantly on par with carbendazim, however, it was significantly higher as compared to seed treatment with iprodione + carbendazim during 2009-10. But during 2008 and 2010, the seed yield was at par with each other in seed treatments with carbendazim, iprodione and combination of both fungicides (Table 2).

A combination of seed dressing with fungicides together with foliar sprays of fungicides gave a significant seed yield compared to the control. A combination of iprodione + carbendazim seed treatment along with foliar sprays of propiconazole (STF 1) produced a significantly higher seed yield than other treatments irrespective of the year of testing and the seed yield ranged from 787 kg/h (2010) to 1222 kg/h (2009). Mesta *et al.* (2009) reported that among fungicides and plant extracts, iprodione + carbendazim , hexaconazole, propiconazole and neem leaf extract were most effective in inhibiting the spore germination and mycelial growth of the *Alternaria helianthi* in *in vitro*. Mesta *et al.* (2011) noticed that hexaconazole and propiconazole 0.1% recorded significantly low leaf blight and highest seed yield in sunflower under field conditions.

A combination of seed treatment with iprodione + carbendazim followed by two foliar sprays with difenoconazole and iprodione + carbendazim was at par with each other in seed yield. Seed treatment with iprodione along with foliar sprays of the same fungicide also recorded higher yield than control.

Table 3. Incremental cost benefit ratio of fungicides evaluated against leaf blight under field conditions

Treatment	Leaf blight Severity(%)	Yield (kg/ha)	Gross income (Rs.)	Gross expenditure (Rs/ha)	Gross revenue (Rs/ha)	Gross revenue over control (Rs/ha)	Incremental cost benefit ratio
ST 1	47.1 (43.3)	703	16942	9492	16450	3532	7.18
ST 2	48.5 (44.1)	745	17955	9510	17445	4527	8.88
ST 3	47.6 (43.6)	725	17473	9483	16990	4072	8.43
STF 1	27.9 (31.9)	975	23498	11182	21316	8398	3.85
STF 2	32.9 (35.0)	878	21160	11484	18677	5759	2.32
STF 3	34.4 (35.9)	856	20630	11162	18468	5550	2.57
STF 4	38.4 (38.3)	854	20581	11545	18036	5118	2.01
STF 5	44.8 (42.0)	768	18509	11049	16460	3542	1.73
F1	49.7 (44.8)	714	17207	10490	15717	2799	1.88
C	67.1 (55.0)	536	12918	9000	-	-	-
CD	1.66	39.4	-		-	-	-

ST 1 = ST with iprodione + carbendazim; ST 2 = ST with iprodione ; ST 3= ST with carbendazim ; STF 1 =Seed treatment (ST) with iprodione + carbendazim + foliar sprays (Fs) of propiconazole; STF 2= ST 1 + difeconazole Fs; STF 3= ST 1 + iprodione + carbendazim Fs; STF 4 = ST 2 + iprodione Fs; STF 5 = ST 3 + carbendazim Fs; F1= mancozeb Fs; C=control.

Note: The values in columns are the mean of 3 years (2008 to 2010) in single factor analysis. Figures in parentheses are transformed values. Labor wages for seed treatment and spraying: 4 and 12 man days respectively at Rs. 120 /man / day; Selling price of crop produce -: 2410 Rs/- Quintal; Seed rate: 5kg/ha.

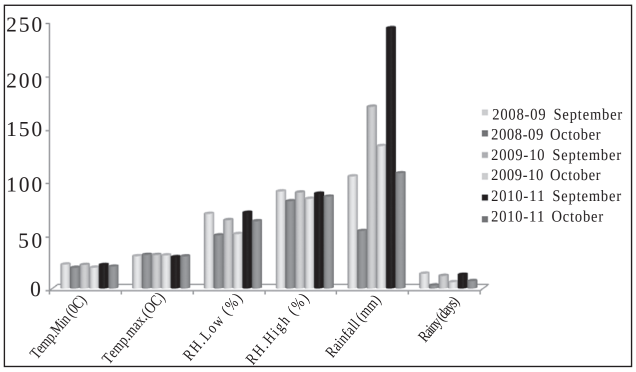

Figure1. Weather parameters prevailed during peak leaf blight severity period.

In a pooled analysis of the three years, leaf blight severity and seed yield were statistically at par with each other in seed treatments with carbendazim, iprodione and combination of iprodione + carbendazim (Table 3). Seed treatment with fungicide combined with a foliar application of fungicide gave greater disease control than seed treatment alone especially with foliar application of azole fungicides ie propiconazole (27.9%) and difenoconazole (32.9%). These fungicides also increased the seed yield to 975 kg/ha with propiconazole and 878 kg/ha with difenoconazole. Rao *et al.*, (2009) also reported that seed treatment with carbendazim + iprodione at 0.3% along with foliar sprays of hexaconazole 0.1% was most effective in reducing the sunflower leaf blight and recorded highest seed yield. But in this study, propiconazole was effective than other fungicides as propiconazole is considered to be fungistatic or growth inhibiting rather than fungicidal or killing the fungus (Water field and Sisler, 1989). This pronounced antisporulent activity may be contributed to control the secondary disease cycles and further disease development.

Seed treatment with iprodione + carbendazim followed by foliar application of same fungicide two times at 15 days interval reduced leaf blight (34.4%) with high seed yield (856 kg/ha). Seed treatment along with foliar application of iprodione also reduced leaf blight (38.4%) and increased the seed yield (854 kg/h). Amaresh and Nargund (2004) reported that ALB of sunflower was effectively managed by mancozeb and iprodione. Seed treatment and foliar application of carbendazim also reduced leaf blight (44.8%) and increased the seed yield (768 kg/h). Chattopadhyay (1999) showed that foliar application of carbendazim 0.1% at 30, 45 and 60 DAS significantly reduced leaf blight severity and increased yield in sunflower. Similar results were reported by Meena *et al.*, (2010) in sunflower and Deshmukh and Karve (1983) in safflower with carbendazim fungicide. Carbendazim showed both curative and protective activities, which inhibit mitosis and cell division. The fungicide also induces resistance in the sprayed plants.

Spraying of mancozeb alone was found to reduce the leaf blight severity (49.7%) and increased the seed yield. This is a traditional fungicide retained on the leaf surface with excellent protectant and significant antisporulent activity. Mahalinga *et al.*, (2003) reported effective management of Alternaria blight of sunflower using two foliar sprays of Mancozeb 0.2%.

Among all treatments, the highest incremental cost-benefit ratio was obtained in seed treatment with iprodione (8.88). The next best treatment was carbendazim seed treatment (8.43) followed by iprodione + carbendazim (7.18). In the combination of seed treatment with foliar application, the economically effective combination consisted of seed treatment with iprodione + carbendazim followed by sprays of propiconazole (3.85). The incremental cost-benefit ratio was lower in this treatment due to higher cost of the fungicides. The incremental cost-benefit ratio was 2.01 to 2.57 in STF 2, STF3, STF4 where difenoconazole, iprodione + carbendazim, iprodione alone sprayed. Incremental cost benefit ratio of seed treatment and foliar application of carbendazim is at par with farmers' practice i.e. F1 in which sprays of mancozeb was applied. Amaresh and Nargund (2002) reported that propiconazole, hexaconazole and mancozeb gave good results in controlling the Alternaria leaf blight of sunflower and recorded maximum grain yield, test weight and oil content. In conclusion, the highest incremental cost benefit ratio was obtained by seed treatment with iprodione followed by seed treatment with carbendazim and iprodione + carbendazim. However, the seed treatment with iprodione + carbendazim along with two foliar sprays of propiconazole and also difenoconazole at 15 days interval gave effective management of leaf blight of sunflower with highest seed yield, but the incremental cost benefit ratio was less than seed treatment with iprodione.

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Received : 18-10-2014 Accepted : 01-03-2015