Chemical control of major diseases of chilli by new fungicide molecule SAAF

[1]Ahila Devi P., [2]Prakasam V. and [3]kavitha P.G
[1]Plant Pathology Unit, Tamil Nadu Rice Research institute, Authorial – 612 101
[2]Centre for plant Protection studies, Tamil Nadu Agricultural university, Coimbatore-3
[3]Department of Tree Breeding, Forest College and Research Institute
Mettupalayam 641 301 TN, India

Abstract
The field trial conducted during October 2011 to January 2012 at TNAU indicated that SAAF @ 562.5 g a.i./ha (or 750 g/ha) dose can effectively control Leaf spot, powdery mildew and anthracnose or fruit rots diseases of chillies. This dose was at par with higher dose and resulted better yield than other treatments. No phytotoxicity was observed up to the dosage of SAAF @ 1125 g a.i./ha (1500 g/ha) *i.e.* double of the effective dose

Keywords: Chilli-SAAF-Leaf spot-Anthracnose- Powdery mildew

Introduction

Chilli (*Capsicum annum*) is the fourth most important vegetable crops in the world and first in Asia, with world production approximately 122.34 million tonnes of fresh chilli and 2.8 tonnes of dry chilli in 2010 (Indian Horticultural Database). The most important producers and exporters of chilli include China, India, Mexico, Morocco, Pakistan, Thailand and Turkey. Demand for chilli in the world is increasing every year (FAO, 2004). Chilli is a very remunerative spice crop of the Indian subcontinent (Sharma *et al.,* 2005) and occupies an area of about 0.81 million ha (Suthin Raj and Christopher, 2009) which accounts for 25% of the world production (Chandra Nayaka *et al*., 2009). In Tamil Nadu, chilli is cultivated on 49.0 thousand hectares with 31.8 thousand tonnes of production.

Chilli not only meets domestic consumption but also helps in earning foreign exchange. One of the great challenge facing the world is to produce adequate food for the growing population. Under these circumstances, one third of the global food production is estimated to be destroyed annually by over 20,000 species of insects, diseases, weeds, mites, nematodes, rodents and other field storage fungi and pests (McEven,1978). Besides insect and weeds, plant diseases caused by fungi lead to yield loss to most the crops in the field as well as under storage. Unlike other chilli-producing countries, about 90 per cent of the production (estimated over 10 lakh tonnes of chilli) in India is absorbed by the huge domestic market. India exports only about 1.5 lakh tonnes of chilli out of the total production of 7.5 lakh tonnes (Anon, 2008).

Chilli is attacked by several fungal, bacterial and viral diseases among them, anthracnose and powdery mildew are found to be the major diseases incurring heavy losses, if not cared. Anthracnose (fruit rot and die back) caused by *Colletotrichum capsici* (Syd. Butler and Bisby) is prevalent throughout the chilli growing areas of India. (Jeyalakshmi, 1996).

The leaf spot in chilli caused by *Colletotrichum capsici* Circular spots appear with a light gray center and a reddish-brown margin, growing up to 1 cm in diameter. Spots later become tan with a dark ring and a yellowish halo around the ring, resulting in a “frog-eye” appearance. The fungus survives in or on seed, and as tiny black fungal tissue known as stromata in old affected leaves in the soil. Spores will survive in infected debris for at least one season

The powdery mildew caused by *Leveillula taurica* (Lev.) Arn. is also one of the major constraint in chilli production in India causing heavy yield loss ranging from 14 to 20 per

cent, due to severe defoliation and reduction in size and number of fruits per plant (Mathur *et al.,* 1972).

Carbendazim (methyl benzimidazol-2-ylcarbamate) (MBC) is a broad-spectrum systemic fungicide, which has been commercially available since 1972. MBC is a chemically stable and relatively persistent fungicide, which only metabolises to a limited extent in plants and soil. Moreover, MBC is also the principal metabolite of two other systemic benzimidazole fungicides, benomyl [methyl 1-(butylcarbamoyl) benzimidazol-2-ylcarbamate] and thiophanate-methyl [dimethyl 4,4'-(ophenylene) bis(3-thioallophanate)]. They are used, pre- or post-harvest, for the protection of several crops including grapes, lettuce, citrus fruits, potatoes, and cereals.

Mancozeb is a coordination product of Zinc ion and Manganese ethylene bis-dithio-carbamate. This compound has a negligible vapour pressure; therefore it has a low potential to volatilize into the air. It is a multi-site protective fungicide for the control of a wide range of fungal diseases in horticulture, floriculture, and field crops as it sticks on leaves so that rain does not affect. It is bio-degradable and does not accumulate in the environment. It is used against Peronosporal diseases such as early and late blights, downy mildew, leaf spot, Rhizoctonia, scab, Puccinia and Septoria on fruit trees, vegetable (potatoes, tomatoes, onion, garlic, cucurbits etc), tobacco and ornamentals

In the quest for find newer and more efficacious molecules, the present investigation was carried out using a new formulation SAAF of United Phosphorus, Limited, Mumbai

But unfortunately, preliminary observations revealed that no single molecule is more effective against both the disease at a time. Thus, there is a need to evaluate new molecules that can be effective for the control of both the diseases at the low costs.

Materials and Methods

The field trial was conducted during October 2011 to January 2012 at Tamil Nadu Agricultural University (TNAU) to evaluate the bio-efficacy of SAAF against major diseases of Chillies. All the standard agronomic practices were followed as per the recommendations of the University. The evaluation of the test fungicide was done along with standard checks and untreated control against the incidences of Leaf spot, powdery mildew and fruits rots or anthracnose diseases of chillies both on leaves and fruits. Three rounds of sprays were given at 10-days intervals to control the diseases starting from the appearance of

diseases, 33-days after sowing. The observations were recorded on 10th day after each spray. After 10 days of 3rd spray the final scoring of the disease incidence was recorded as terminal disease index (TDI). 15-leaves randomly selected on 5-chilli plants/plot were assessed for scoring the incidence of diseases. The disease severities on fruits were recorded at random on 10-fruits/plots at the first harvest/plucking and scoring was done. The data were computed to percent diseases index (PDI) using following formula:

$$PDI = \frac{\text{Sum of numerical values}}{\text{Number of leaves/fruits observed}} \times \frac{100}{\text{Maximum disease rating value}}$$

The PDIs were suitably transformed into arcsine values, analyzed and presented with DMRT symbols. For phytotoxicity evaluations, the leaves and fruits of all the treatments including higher dose treatment of SAAF @ 1500 g/ha were visually examined and assessed for any sign or symptoms. The weights of chillies-fruits harvested/plucked at each interval were summed up for calculating total yield-plot-wise and converted into t/ha and statistically analyzed.

Cost Benefit (C: B) ratio

The cost benefit ratio was calculated for each treatment by computing with the prevailing local market price for the various inputs used in the experiment.

Table -1: Effect of SAAF on Leaf spot of chilli – Season I and II

Treatments	Product Dose (g or ml ha)	First season		Second season	
		3rd Spray	Percent reduction over control	3rd Spray	Percent reduction over control
SAAF	500	7.61 (16.00)[b]	61.95	8.67 (17.12)[b]	53.56
SAAF	750	4.82 (12.66)[a]	75.90	4.69 (12.38)[a]	74.88
SAAF	1000	4.70 (12.52)[a]	76.50	4.61 (12.38)[a]	75.31
Mancozeb 75% WP	2000	7.20 (15.56)[b]	64.00	8.00 (16.43)[b]	57.15
Carbendazim 50%Wp	300	6.75 (15.06)[b]	66.25	7.64 (16.00[b]	59.08
Hexaconazole 2% SC	3000	10.67 (19.07)[c]	46.65	11.33 (19.65)[c]	39.31
Untreated control	-	20.00 (26.57)[d]	-	18.67 (25.58)[d]	-
CD value (At		**1.37**		**2.01**	

5%P)

Values are means of three replications Figures in the parentheses represent arcsine transformed values PDI; Percent disease index
The common letters show non- significant differences among the treatments based on DMRT TDI; Terminal disease intensity

Table -2: Effect of SAAF on powdery mildew of chilli – Season I and II

Treatments	Product Dose (g or ml/ha)	First season				Second season			
		3rd Spray	Percent reduction over control	PDI on Fruits	Percent control	3rd Spray	Percent reduction over control	PDI on Fruits	Percent control
SAAF	500	7.93 (16.34)[b]	58.98	6.00 (14.15)[b]	50.66	9.68 (18.05)[b]	68.75	7.33 (15.71)[b]	48.23
SAAF	750	2.73 (9.51)[a]	85.88	3.63 (10.94)[a]	70.15	4.26 (11.83)[a]	86.25	4.25 (11.83)[a]	69.98
SAAF	1000	2.70 (9.45)[a]	86.03	3.22 (10.30)[a]	73.52	4.00 (11.54)[a]	87.09	4.20 (11.83)[a]	70.34

Mancozeb 75% WP	2000	12.00 (20.27)[c]	37.92	8.22 (16.64)[c]	32.40	21.51 (27.62)[c]	30.57	10.79 (19.09)[c]	23.80
Carbendazim 50%WP	300	8.67 (17.10)[b]	55.15	6.69 (14.89)[b]	44.98	10.01 (18.43)[b]	67.69	8.73 (17.15)[b]	38.35
Hexaconazole 2% SC	3000	3.85 (11.32)[a]	80.08	4.00 (11.52)[a]	67.11	5.33 (13.35)[a]	82.80	5.25 (13.25)[a]	62.92
Untreated control	-	19.33 (26.08)[d]	-	12.16 (20.36)[d]	-	30.98 (33.74)[d]	-	14.16 (22.06)[d]	-
CD value (At 5%P)		**2.01**		**1.71**		**2.30**		**1.50**	

Values are means of three replications **Figures in the parentheses represent arcsine transformed values PDI; Percent disease index**

The common letters show non- significant differences among the treatments based on DMRT **TDI; Terminal disease intensity**

Table -3: Effect of SAAF on anthracnose or fruit rots of chilli – Season I and II

Treatments	First Season					Second Season				
	Product Dose (g or ml /ha)	3rd Spray	Percent reduction over control	PDI on Fruits	Percent control	3rd Spray	Percent reduction over control	PDI on Fruits	Percent control

SAAF	500	6.57 (14.77)[b]	58.94	6.47 (14.65)[b]	51.86	6.00 (14.15)[b]	59.10	5.47 (13.44)[b]	58.60
SAAF	750	4.31 (11.97)[a]	73.06	4.67 (12.38)[a]	65.25	3.44 (10.62)[a]	76.55	3.76 (11.09)[a]	71.54
SAAF	1000	4.30 (11.97)[a]	73.13	4.60 (12.38)[a]	65.77	3.39 (10.47)[a]	76.89	3.70 (11.09)[a]	71.99
Mancozeb 75% WP	2000	7.18 (15.45)[b]	55.13	7.47 (15.86)[b]	44.42	7.33 (15.69)[b]	50.03	5.76 (13.81)[b]	56.40
Carbendazim 50%WP	300	7.39 (15.68)[b]	53.81	7.92 (16.32)[b]	41.07	7.50 (15.84)[b]	48.87	6.16 (14.30)[b]	53.37
Hexaconazole 2% SC	3000	10.61 (19.00)[c]	33.69	9.85 (18.27)[c]	26.71	10.67 (19.05)[c]	27.27	9.67 (18.05)[c]	26.80
Untreated control	-	16.00 (23.58)[d]	-	13.44 (21.47)[-d]	-	14.67 (22.50)[d]	-	13.21 (21.30)[d]	-
CD value (At 5%P)		**1.73**		**1.87**		**1.83**		**1.10**	

Values are means of three replications **Figures in the parentheses represent arcsine transformed values PDI; Percent disease index**

The common letters show non- significant differences among the treatments based on DMRT **TDI; Terminal disease intensity**

Table-5: Effect of SAAF on yield of chillies – Season I and II

Treatments	Product Dose (g or ml/ha)	Yield (t/ha)	Increased Yield over Control
SAAF	500	12.08[b]	51.38
SAAF	750	14.85[a]	86.10
SAAF	1000	15.00[a]	87.96
Mancozeb 75% WP	2000	12.33[b]	54.51
Carbendazim 50%Wp	300	9.67[c]	21.18
Hexaconazole 2% SC	3000	11.97[b]	50.00
Untreated control	-	7.98[d]	-
CD value (At 5%P)		**2.15**	

Values are means of three replications

the common letters show non- significant differences among the treatments based on DMRT

Table - 6: Benefit cost ratio

Treatment	Dose (g or ml/ha)	Yield (kg/ha)	Gross returns (Rs./ha)	Total cost of cultivation (Rs./ha)	Net Returns (Rs./ha)	Benefit : cost ratio
SAAF	500	12080	181200	36575	144625	3.95
SAAF	750	14850	222750	36913	185838	5.03
SAAF	1000	15000	225000	37250	187750	5.04
Mancozeb 75% WP	2000	12330	184950	37400	147550	3.95
Carbendazim 50% WP	300	9670	145050	36215	108835	3.01
Hexaconazole 2% SC	3000	11970	179550	38600	140950	3.65
Untreated Control	-	8980	134700	35000	99700	2.84

- **Price of chilli : Rs. 15/kg**
- **Basic cost of cultivation: Rs. 35000/ha**
- **Cost of insecticide spray: Rs. 900/ha :**
- **Cost of insecticide:**

(i) SAAF : Rs. 450/kg

(ii) Mancozeb 75% WP: Rs. 250/kg

(iii) Carbendazim 50% WP: 350/kg

(iv) Hexaconazole 2% SC : Rs. 300/l

Results and Discussion:

Effect on Leaf spot of chilli *(Cercospora capsici):*

All the treatments were more effective in comparison to untreated control. However, after 10th day of 2nd application the foliar spraying of SAAF @ 1000 g /ha provided the maximum control (PDI 3.52) of the leaf spot disease which was on par with SAAF at the rate of 750 g/ha (PDI 3.87). Both these treatments were significantly superior as compared to rest. The four fungicides viz., hexaconazole (0.1%), propiconazole (0.1%), tricyclazole (0.1%) and carbendazim + mancozeb (0.1%) for the management of leaf spot disease of turmeric through rhizome treatment + foliar spray and foliar spray alone at 45 and 90 days after planting (DAP).(Mishra,2015). Foliar spray of carbendazim, mancozeb and metalaxyl MZ significantly reduced the disease incidence and increased the yield.

Carbendazim spray recorded the higher yield of 4506 and 4350 kg/ha. (Rajappan,2005). The results of integrated disease management revealed that the seed treatment with carbendazim @ 2g/kg + foliar spry with SAAF @ 0.05% + second foliar spray with SAAF @ 0.05% fifteen days after first spray has shown less percent disease index (11.55%) and more disease reduction over control (Varaprasada Rao,2010)

Effect on Powdery mildew of chilli *(Leviellula taurica):*

Spraying of different chemical was found more effective in comparison to untreated control. However, at 10th day of 2nd application the foliar spraying of SAAF @ 1000 g /ha provided the maximum control (PDI 2.69) of the powdery mildew disease which was on par with SAAF at the rate of 750 g /ha (PDI 2.69) and std. check Hexaconazole 2% SC @ 3000 ml/ha (PDI 3.30). Spraying of these chemicals proved significantly superior to rest.

The disease incidence on fruits revealed that, maximum control of powdery mildew by the treatment of SAAF @ 1000 g /ha (PDI 3.22) which was on par with SAAF @ 750 g/ha (PDI 3.63) and the treatment of Hexaconazole 2% SC @ 3000 ml/ha (PDI 4.00). Mahajan *et al*. (1991) reported that triforine at 0.2 per cent was more effective than a conventional fungicide Sulphur WP (0.25%) in controlling the powdery mildew (*L. taurica*) on chilli and gave the highest yield. Jharia *et al*. (1978) reported that systemic fungicides like Calixin and Bavistin or nonsystemic fungicide like sulfer were effective in controlling powdery mildew of chilli and resulted in higher yields.

Effect on anthracnose or fruit rot disease of chilli (*Colletotrichum capsici*):

Disease data obtained after 10th day of 2nd application indicated that foliar spraying of SAAF @ 1000 g /ha (PDI 3.69) recorded the minimum severity of the anthracnose disease which was on par with SAAF @ 750 g /ha (PDI 3.73) but significantly superior to rest. The spraying of the same chemical SAAF @ 500 g /ha, Mancozeb 75% WP @ 2000 g/ha and Carbendazim 50% WP @ 300 g /ha recorded at par PDI of 5.33, 5.53 and 6.67 and proved the next best effective treatments which were however found superior to the treatments of Hexaconazole 2 % SC @ 3000 ml/ha (PDI 10.60). The data on terminal disease severity index (TDI) also gave the same trend and controlled the disease up to the extent of 73.13 – 73.06% by two superior dosages of SAAF @ 1000 and 750 g/ha.The data on fruits revealed the similar results with maximum control of disease by the treatment of SAAF @ 1000 g /ha (PDI 4.60) which was on par with SAAF @ 750 g /ha (PDI 4.67).

Suryawanshi and Deokar 2001 reported that carbendazim could inhibit growth of *Fusarium oxysporum* followed by Thiophonate methyl . Das and Mohanty (1988) and Biswas(1992) found the carbendazim as the best fungicide to control the fruit rot of chilli under field condition. Earlier studies also reported superior efficacy of combined formulation of carbendazim + mancozeb in controlling collar and root rot diseases of strawberry and chilli caused by *Sclerotium* rolfsii [Roy, 2010 and Raj,2005] In the present study, Companion showed additive effect, combining the advantage of both mancozeb and carbendazim. There have been many reports on the uses of mixtures of synthetic fungicides for the control of plant pathogenic fungi. When utilized in two-way mixtures, such fungicides maintain or enhance the level of control of a pathogen at reduced rates for both components utilized in combinations, compared to solo applied at higher rates [Pappas,1997 and Beever,1989]

Phytotoxicity:

SAAF treatments @ 500, 750, 1000 and 1500 g /ha doses were assessed for the phyto-toxicity along with std. checks. The observation on different parameters revealed that all the doses of SAAF didn't show any phytotoxicity sign or symptoms in comparison to other treatments. The crop stand and the crop growth were normal at every stage of observations (3, 7 and 10 days after each spray) (Table 4).

Yield:

SAAF at the rate of 1000 g /ha dose treatment recorded the maximum yield of 15.00 t/ha which was on par with the spray treatment of SAAF @ 750 g /ha dose (14.85 t/ha). These treatments recorded yield increase of 87.96 and 86.10 per cent, which was significantly superior to rest. Mancozeb 75% WP @ 2000 g/ha (12.33 t/ha), SAAF @ 500 g /ha (12.08 t/ha) and Hexaconazole 2 % SC @ 3000 ml/ha (11.97 t/ha) dose proved the next best treatments exhibiting insignificant variations among themselves. Carbendazim 50% WP @ 300 g/ha provided minimum yield (9.67 t/ha) among the treatments. Untreated control yielded only 7.98 t/ha during the 1st season.

Cost benefit ratio:

The highest Cost benefit ratio of 1:5.04 and 1:5.03 was obtained in the treatments of SAAF@ 1000g/ha and SAAF @ 750 g/ha, respectively. In untreated control the ratio of 1: 2.84 was observed. (Table 6)

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