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Eggplant diseases and its management through bio pesticides and fungicides in Kymore plateau zone of Madhya Pradesh

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Abstract
Eggplant (*Solanum melongena* L.) is an important Solanaceous crop widely grown in different parts of the country. Diseases were investigated at nursery stages, field and experimental field in the crop of two season basically during September-October 2016 and January-February 2017. Effect of seed treatment with bio pesticides and chemical fungicides indicate that higher emergence was recorded as compared to untreated seed. No infection of *Fusarium oxysporum*, *Rhizoctonia solani* and *Phomopsis vexans* was recorded is seed treated with Carboxin+ Thiram @ 0.2% and copper oxychloride @ 0.25%. Three application of Azoxystrobin (1g/L) recorded the minimum fruit rot incidence (5.4%) after 40 days as compared to untreated and unsprayed plants with 28% fruit infection. Efficacy of fungicides indicate that application of Tebuconazole @ 0.15% resulted in 5.9% fruit infection followed by 6.2% infection in plants with Propioconazole @ 0.1% and 6.5% fruit infection in Tricyclazole @ 0.1%. Application of fungicides also enhanced the fruit yield.

Keywords: Eggplant diseases, bio pesticides, fungicides, disease management

Introduction
Brinjal or eggplant (*Solanum melongena* L.) is an important Solanaceous crop of sub tropics and tropics. The bringal, eggplant or Aubergine (French name) has originated in Indian sub-continent and China (Thompson and Kelly, 1957) [8]. A number of cultivars are being cultivated in India. Common preference is largely dependent upon fruit color, size and shape. The varieties of eggplant display a wide range of fruit shape, ranging from oval to egg shaped to longclub shaped and from white, yellow green through degree of purple pigmentation to almost back. Eggplant fruit (unripe) is primarily consumed as cooked vegetable in various ways whereas dried stem and roots are used as fuel in rural areas.

Eggplant contains 92.7 g moisture, 1.4 g of proteins and 4.0 g of carbohydrates, 0.3 g minerals, 124 I.U. vitamins and 12.0 mg vitamin C per 100 g of edible portion (Kalra *et al.*, 1988) [6]. It is low in calories and fat, contain mostly water, little protein, fibre and carbohydrate, water soluble sugars, and vitamins (Bajaj *et al.*, 1979) [2]. High anthocyanin content and low glycoalkaloid content are considered essential component. For processing purposes, the fruit should have high dry matter content and a low level of phenolics. Bitterness in eggplant is due to the presence of glycoalkaloids. The glycoalkaloid contents in the Indian commercial cultivars of eggplant vary from 0.37 to 4.83 mg/100 g fresh weight (Bajaj *et al.*, 1981) [3]. In addition it also contains trace elements and alkaloid called solanin which has medicinal properties (Ayokroyd, 1963) [1].

The eggplant crop is affected by several plant pathogens at different growth stages. Important diseases are Phomopsis blight *(Phomopsis vexans),* leaf spot *(Cercospora melongenae),* leaf spot *(Alternaria melongenae),* little leaf *(Phytoplasma)* and collor rot *(Sclerotium rolfsii)* (Bhupendra *et al.*, 2014) [4]. Symptoms of leaf blight, fruit rot, leaf spot, stem canker and damping off of eggplant caused by *Phomopsis vexans* has been studied (Edgerton and Moreland, 1921 and Vishunavat, 1992) [5, 9]. Martin (1930) [7] reported the seed borne nature of *Phomopsis vexans* that occurred under the seed coat.

Material and Methods
The present studies were undertaken to investigate the prevalence and management of major eggplant diseases through a combination of bio agent and fungicides treatment. The material used and methods followed are described here with.

Location of the site

The field experiments were conducted at Seed Technology Research Experimental Area, Department of Plant Breeding & Genetics, JNKW, Jabalpur. The investigations were conducted on the crop grown during 2016-17 at Jabalpur. The location site lies between 22°49' and 22°80' North latitude and 78°2′ and 80°58' East longitude at an altitude of 411.78 meter above the mean sea level.

Incidence of Diseases

The incidence of major diseases was recorded on randomly selected 100 plants in a particular field and experimental plot. The diseases were identified initially on the basis of typical field symptoms. During the study, total and infected plants were counted to calculate the disease incidence as per the formula (Datar and Mayee, 1991)

$$PDI = \frac{TIP}{TPO} X100$$

Where,

PDI = Percent disease incidence i.e. per cent plant exhibiting symptoms

TIP = Total number of infected plants

TPO = Total number of plants observed

Detection of mycoflora associated with eggplant seed

Detection of mycoflora associated with eggplant seed was made using standard blotter and standard paper towel method. Eggplant seed were obtained from local farmer and Mandi. In standard blotter method 25 seed were placed on to of the top of blotter in a plate. In all 400 seed were tested. Observations were recorded on the mycoflora on 7th day after incubation. The mycoflora were identified on the basis of habit character and later confirmed through slide preparation for fungal structure and spore.

Standard blotter method

In this method, three circular blotter papers of the size of the Petri dish were cut and dipped in sterilized water. Excess water was dripped-off and soaked sheets were placed in each Petri dish. Twenty-five eggplant seeds were placed in each Petri dish with the help of sterilized forceps under aseptic conditions of inoculation chamber. In the outer circle, 16 seeds were placed, 8 in the inner circle and one in the center so as to allow the equal distance between the seeds. Seeded plates were kept for the incubation in the chamber. Fungi were identified by making slides and observing under microscope on eight day of incubation with the help of identification manuals.

Standard Ragdoll Method

Standard Ragdoll method (ISTA, 2006) was used for testing germination of seeds and associated mycoflora.

The towel (blotters) papers were moistened with sterile water. Excess of water was removed. The papers were stretched over the flat and clean surface of the table. Fifty seeds were arranged on the half portion of the wet towel paper. Seed were covered with the other half portion of the paper and rolled over.

A piece of wax paper was wrapped on the rolled paper towel and both ends were tightened with rubber bands. It prevented the run off of water as well it helped in the maintenance of humidity required for germination. The rolled towel papers were kept in a slant position. The seeded towels were placed in seed germination chamber at 25°C with relative humidity (RH) of about 5%.

The seedlings were examined on 10th day of incubation for *germination.* Association of mycoflora was determined with the help of making slides of growing fungi.

Development of diseases under field condition

The progressive development of *Phomopsis* blight, bacterial wilt, Alternaria leaf spot, Cercospora leaf spot was determined on crop grown under natural field condition at Seed Technology Research Experiment field, JNKVV Jabalpur during 2016-2017. The development of disease was correlated with weather parameters such as temperature, relative humidity, rainfall during growth period with standard weeks. The plants were pre- tagged and observations on the progressive development was determined.

Management

Seed associated mycoflora

Table 1: Bio pesticides and fungicides used for seed treatment

Treatment	Bio pesticide and fungicides	Dose
T_1	*Trichoderma viride*	10g/Kg seed
T_2	*Trichoderma harzianum*	10g/Kg seed
T_3	*Pseudomonas flurescence*	10g/Kg seed
T_4	Carboxin+Thiride	2.5g/kg seed
T_5	Carbendazim+Mancozeb	3.0g/Kg seed
T_6	Copper oxy chloride	3.0g/Kg seed
T_7	Carbendazim	1.0/Kg seed
T_8	Mancozeb	2.5g/Kg seed
T_9	Thiride	3.0g/Kg seed
T_{10}	Control (untreated) check	00

The required quantity of fungicides was measured and sprinkled over the seeds kept in polythene bags. The fungicide and seeds were gently shaked for uniform coating. The fungicides treated seeds were spread over a butter paper and later air dried eggplant seeds, were placed on the top of the blotter (Standard Blotter method) and sown in the sterile sand (Grow Out Test).

The seeds of pre tested local farmer variety having maximum natural infection of seed associated mycoflora was used. The seeds were treated with individual fungicides and observations were recorded on the associated mycoflora adopting Standard Blotter method (ISTA, 1996).

Seedling Disease

Management of seedling diseases at nursery stage was attempted by seed treatment and foliar application of Carbendazim + Mancozeb (0.25%) and Copper oxychloride (0.25%). Basic seed treatment was done with different bio

pesticides as listed.

Fruit and plant diseases through foliar application

Management of diseases was attempted under field conditions at experimental farm, JNKVV, Jabalpur. The fungicides and their combination were employed for the management studies under lab condition.

Table 2: Fungicides used for management of leaf and fruit diseases

Treatment	Fungicide	Dose
T_1	Mancozeb	0.25%
T_2	Propiconazole	0.10%
T_3	Tricyclazole	0.10%
T_4	Copper oxychloride	0.25%
T_5	Tebuconazole	0.10%
T_6	Carbendazim+Mancozeb	0.25%
T_7	Carboxin+Thirum	0.20%
T_8	Control	No spray

Result and Discursion

The status of eggplant diseases was determined at farmer's field and commercial nursery. Various diseases were recorded by random plot monitoring technique. Seed associated pathogens responsible for seedling abnormalities, leaf and fruit rot were managed using bio pesticides and fungicides. The results of various studies so obtained are presented herewith.

Management

Seed Associated Mycoflora

Use of bio pesticides and fungicides

Effect of seed treatment on mycoflora associated with eggplant seed was determined using the pre-tested seed sample having maximum natural infection of *Fusarium oxysporum, Rhizoctonia solani* and *Phomopsis vexans.*

No association of *Fusarium oxysporum* was observed in the seeds treated with Carboxin + Thirum (2.0%) Carbendazim + Mancozeb (0.25%) and copper oxychloride (0.25%) bio pesticide exihibited lesser impact and association of *Fusarium osysporum* was 12.0% in seed treated with *Trichoderma viride* (12.0%), *Trichoderma harzianun* (10.0%) and *Pseudomonas fluorescence* (18.0%) as compared to untreated naturally infected seed (21.0%). Seed treatment by bio pesticides and chemical fungicides reduced associated mycoflora and exhibited higher germination in the range of 53-58% on chemical fungicides as compared to control (42%). It was also observed that bio pesticides had comparatively lesser effect.

Table 3: Effect of seed treatment on mycoflora associated with eggplant seeds

Bio-pesticide / Fungicide	Dose /Kg Seed	Percent association	Percent seed Germination
Trichoderma viride	10.0	12.0	47.0
Trichoderma harzianum	10.0	10.0	47.0
Pseudomonas fluorescence	10.0	18.0	45.0
Carboxin + Thiram	2.0	0.0	58.0
Carbendazim + Mancozeb	2.5	0.0	56.0
Copper oxychloride	2.5	0.0	53.0
Tebuconazole	1.5	2.0	53.0
Control	0.0	21.0	42.0
Seed sample with infecting of *Fusarium oxysporum*	-	23.0	-

Seed sample with natural infection of *Rhizoctonia solani* was used. Seed treated with *Trichoderma harzianum* followed by *Trichoderma viride* (10.0%), *Pseudomonas fluorescence* (25.0%) as compared to 25% in control (untreated) were recorded.

Seed treatment with bio pesticides and chemical fungicides enhanced seed germination. Seed treated with fungicides exhibited the germination in the range of 53-61% as compared to 46% in untreated (control). Among the bio pesticides tested maximum (52%) seed germination was observed where seed were treated with *Trichoderma harzianum.*

Table 4: Effect of seed treatment on mycoflora associated with eggplant seeds

Bio-pesticide / Fungicide	Dose /Kg seed	Percent association	Percent seed Germination
Trichoderma viride	10.0	10.0	51.0
Trichoderma harzianum	10.0	9.0	52.0
Pseudomonas flurescence	10.0	13.0	49.0
Carboxin + Thiram	2.0	0.0	60.0
Carbendazim + Mancozeb	2.5	0.0	61.0
Copper oxychloride	2.5	0.0	58.0
Tebuconazole	1.5	2.0	53.0
Control	0.0	25.0	46.0
Seed sample with *Rhizoctonia solani*	-	26.0	-

Association of *Phomopsis vexans* was completely eliminated in seed treated with Carboxin + Thiram, Carbendazim + Mancozeb and Copper oxychloride. Bio pesticides were not effective as the association of *Phomopsis vexans* ranged between 6.0-12.0%. Association of *Phomopsis vexans was* 12.0% in seed treated with *Pseudomonas fluorescence* (Table. 4.19).

Table 5: Effect of seed treatment on mycoflora associated with eggplant seeds

Bio-pesticide / Fungicide	Dose /Kg seed	Percent association	Percent seed Germination
Trichoderma viride	10.0	8.0	59.0
Trichoderma harzianum	10.0	6.0	59.0
Pseudomonas fulorescence	10.0	12.0	57.0
Carboxin + Thiram	2.0	0.0	61.0
Carbendazim + Mancozeb	2.5	0.0	60.0
Copper oxychloride	2.5	0.0	63.0
Tebuconazole	1.5	2.0	62.0
Control	0.0	12.0	56.0
Seed sample with infecting of *Phompsis vexans*	-	14.0	-

Effect of seed treatment on emergence

Effect of seed treatment with bio pesticides and chemical fungicides was determined on seed emergence. Naturally infected seed sample with *Fusarium osysporum, Rhizoctonia solani and Phomopsis vexans* were treated and seed were sown in sterile soil and kept in pots.

When seed sample having natural seed infection of *Fusarium oxysporum* were sown in sterile soil those exhibited 3.0-7.0% disease in bio pesticides treated seed as compared to 20.0% in control. Naturally infected seed with *Fusarium osysporum* resulted in abnormal seedling, shriveling, discoloration on developing root and stem. No disease were observed in seeds treated with Carboxin + Thiram, Carbendazim + Mancozeb and Copper oxychloride.

It was also observed that seed treated with bio pesticides and chemical fungicides exhibited higher emergence as compared to untreated seed. Chemical fungicides treated seed resulted in seed emergence in the range of 60-62% while seed treated with bio-pesticides resulted in 60-61% emergence of seed. Seed treated with *Pseudomonas fluorescence* had lower emergence (52%) as compared to others in untreated naturally infected seed with *Fusarium osysporum* seed emergence after 10 days was 40%.

Table 6: Effect of seed treatment on eggplant seed emergence

Bio-pesticide / Fungicide	Dose /Kg seed	Seeds sown in sterile soil in pots	
		% Disease incidence after 21 days	Percent seed Emergence after 10 days
Trichoderma viride	10.0	3.0	61.0
Trichoderma harzianum	10.0	4.0	60.0
Pseudomonas fluorescence	10.0	7.0	52.0
Carboxin + Thiram	2.0	0.0	62.0
Carbendazim + Mancozeb	2.5	0.0	61.0
Copper oxychloride	2.5	0.0	60.0
Tebuconazole	1.5	5.0	61.0
Control	0.0	20.0	40.0
Seed sample with infection of *Fusarium oxysporum*	-	23.0	-

The influence of seed treatment of biopesticides and chemical fungicides. Seed sample with natural infection of *Rhizoctonia solani* was used. Seed treatment with Carboxin + Thiram and Copper oxychloride exhibited no disease after 21 days of sowing.

Seed treated with Carboxin + Mancozeb and Tebuconazole exhibited seedling decay in the range of 3.0-5.0% whereas disease incidence was 1.0-4.0% in bio pesticide treated seed as compared to 23% in untreated seed. Seed germination was 52-62% in treated seeds as compared to 48% untreated seed.

Table 7: Effect of seed treatment on eggplant seed emergence

Bio-pesticide / Fungicide	Dose /Kg seed	Seeds sown in sterile soil in pots	
		%Disease incidence after 21 days	Percent seed Emergence after 10 days
Trichoderma viride	10.0	2.0	58.0
Trichoderma harzianum	10.0	1.0	58.0
Pseudomonas fluorescence	10.0	4.0	52.0
Carboxin + Thiram	2.0	0.0	61.0
Carbendazim + Mancozeb	2.5	3.0	60.0
Copper oxychloride	2.5	0.0	62.0
Tebuconazole	1.5	5.0	59.0
Control	0.0	23.0	48.0
Seed sample with *Rhizoctonia solani*	-	26.0	-

No incidence of infection by *Phomopsis vexans* was recorded in seed treated with Carboxin + Thiram, Copper oxychloride and Tebuconazole.

Trichoderma viride and *Trichoderma harzianum* were also effective and no disease was observed after 21 days where seed were sown in sterile soil as compared to control (14.0%). Seed treatment increased the seed emergence in the range of 62-64% as compared to 57% in control.

Table 8: Effect of seed treatment on eggplant seed emergence

Bio-pesticide / Fungicide	Dose /Kg seed	Seeds sown in sterile soil in pots	
		% Disease incidence after 21 days	Percent seed Emergence after 10 days
Trichoderma viride	10.0	0.0	63.0
Trichoderma harzianum	10.0	0.0	62.0
Pseudomonas fluorescence	10.0	3.0	57.0
Carboxin + Thiram	2.0	0.0	63.0
Carbendazim + Mancozeb	2.5	1.0	60.0
Copper oxychloride	2.5	0.0	64.0
Tebuconazole	1.5	2.0	60.0
Control	0.0	14.0	57.0
Seed sample with *Phompsis vexans*	-	14.0	-

Management of *Phomopsis vexans* by foliar application

Chemical fungicides

Decrease in disease incidence was recorded in fungicides treated plots. Indicate that after three applications of fungicides, minimum fruit rot (5.4%) was noticed in plants sprayed with Azoxystrobin (1gram per liter.) as compared to untreated plants (28%). In plot where Tebuconazole was sprayed the fruit rot was 5.9%, followed by Propioconazole (6.2%).

Table 9: Effect of foliar application of fungicides on the incidence of fruit-rot (*Phomopsis vexans*)

Fungicide	Dose g/L	Fruit rot incidence (%)							Yield q/ha
		Before I spray	I spray (3days)	12 days	Before II spray	22 days	Before III spray	40 days	
Mancozeb	2.5	2.0	2.0	1.8	9.3	10.0	10.6	10.9	8.50
Carbendazim	2.0	2.0	2.0	1.6	8.3	8.5	9.9	11.0	9.00
Carbendazim + Mancozeb	1.5+1.5	2.0	2.0	1.5	5.9	7.9	9.0	9.2	13.50
Propioconazole	1.0	2.0	2.0	1.2	5.6	5.9	6.0	6.2	8.00
Tricyclazole	1.0	2.0	2.0	1.2	5.3	5.6	5.9	6.5	7.00
Azoxystrobin	1.0	2.0	2.0	1.0	3.3	4.6	5.1	5.4	8.00
Tebuconazole	1.5	2.0	2.0	1.3	3.5	4.9	5.4	5.9	5.50
Copper oxychloride	2.5	2.0	2.0	1.6	8.9	10.2	10.3	11.5	8.50
Copper hydroxide	1.0	2.0	2.0	1.7	11.0	11.0	11.2	12.0	6.00
Control	0.0	2.0	2.0	6.0	20.0	22.0	26.0	28.0	3.50
S Em	-	-	-	0.39	-	0.84	-	2.27	-
CD at 5%	-	-	-	1.19	-	1.57	-	4.18	-

Conclusion

Among the three bio pesticides and chemical fungicides carboxin+ thiram @ 0.2%, carbendazim+ mancozeb @ 0.25% and copper oxychloride @ 0.25% were the most effective fungicides whereas among the bio pesticides *Trichoderma harzianum* @ 10g/kg of seed was the most effective against three fungi associated with the eggplant seed.

Effect of seed treatment with bio pesticides and chemical fungicides indicate that higher emergence was recorded as compared to untreated seed. No infection of *Fusarium oxysporum*, *Rhizoctonia solani* and *Phomopsis vexans* was recorded in seed treated with carboxin+ thiram @ 0.2% and copper oxychloride @ 0.25%.

Three applications of Azoxystrobin (1g/L) recorded the minimum fruit rot incidence (5.4%) after 40 days as compared to untreated and unsprayed plants with 28% fruit infection. Efficacy of fungicides indicate that application of Tebuconazole @ 0.15% resulted in 5.9% fruit infection followed by 6.2% infection in plants with Propioconazole @ 0.1% and 6.5% fruit infection in Tricyclazole @ 0.1%. Application of fungicides also enhanced the fruit yield.

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