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In vitro efficacy of different fungicides against spore germination inhibition of *Erysiphe polygoni* DC. In Mung bean

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Abstract
Mung bean powdery mildew caused by *Erysiphe polygoni* DC. affects all the stages of the plant growth by causing premature defoliation, the plants become stunted and fail to grow properly and resulting 21 to 40 per cent yield loss in mung bean. Looking into significance of disease various non- systemic, systemic and combi product fungicides were evaluated *in vitro* for their efficacy against *Erysiphe polygoni* DC. by spore germination inhibition technique. Results revealed, among non-systemic fungicides evaluated, Wettable sulphur 80 WP, Dinocap 48 EC recorded maximum mean spore germination inhibition of 76.06, 73.68 per cent, respectively and least spore germination inhibition (65.67 %) was noticed in Copper oxychloride 50 WP. Among systemic fungicides evaluated, Azoxystrobin 23 SC, Tebuconazole 25.9 EC recorded maximum mean spore germination inhibition of 95.50, 94.20 per cent, respectively and least spore germination inhibition (76.08 %) was notice in Carbendazim 50 WP. Among combi fungicides evaluated, Tebuconazole 50 % + Trifloxystrobin 25 % WG, Azoxystrobin 11% + Tebuconazole 18.3% SC recorded maximum mean per cent inhibition of spore germination 86.22, 84.00 per cent and least mean per cent spore germination inhibition (67.90 %) was recorded in Carbendazim 12% + Mancozeb 63% WP.

Keywords: Mung bean, powdery mildew, *Erysiphe polygoni* DC, *in vitro*, spore germination inhibition technique, non- systemic, systemic and combi product fungicides

Introduction

Mung bean (*Vigna radiata* (L.) Wilczek) belongs to the *Leguminosae* family is a vital pulse crop predominantly cultivated in Asia, especially in India. It is originated from India and Central Asia. Among the thirteen edible legumes grown in India, mung bean ranks as the third most important pulse crop after chickpea and pigeon pea. It is widely cultivated in tropical and subtropical regions as a short-duration food legume, making it a suitable cash crop between major cropping cycles. Mung bean serves as a vital source of easily digestible protein in the cereal-based diet of people in India (Singh *et al.*, 2008) [10]. Pulses contain twice the amount of protein found in cereals and are a rich source of the essential amino acid lysine, which is deficient in most food grain crops. Nutritionally, mung bean seeds contain approximately 20% protein, 55-60% carbohydrates, 1% fat and 3.2% fiber. In addition to their nutritional value, pulses play a crucial role in maintaining soil fertility by fixing nitrogen and contributing organic matter to the soil (Islam *et al.*, 2008) [3]. Additionally, mung bean farming is economically viable, as it requires lower investment, water and energy compared to many other crops (Shanmugasundaram *et al.*, 2004) [10]. India Contributes more than 70% world's mung bean production. Mung bean was cultivated over 35.58 lakh hectare in India during 2024-25. (Anonymous, 2024) [1]. Mung bean is susceptible to various diseases caused by fungi, bacteria, viruses, nematodes and abiotic stresses (Khaire *et al.*, 2018) [4]. Several fungal diseases affect mung bean, including powdery mildew (*Erysiphe polygoni* DC), Cercospora leaf spot (*Cercospora canescens*, *C. cruenta*), root disease complex (*Pythium spp.*, *Macrophomina phaseolina*, *Fusarium spp.*), Anthracnose (*Colletotrichum lindemuthianum*) and Bacterial leaf blight caused (*Xanthomonas phaseoli)*. Among these diseases, powdery mildew (PM), caused by the obligate biotrophic fungus *Erysiphe polygoni* DC, is considered one of the most destructive diseases affecting mung bean. This fungus is ectoparasitic, extracting nutrients from the host plant through specialized structures called haustoria. The fungus produces oidia/conidia in chains, which are ovate, hyaline and thin-walled, measuring approximately 20-25 × 10-15 µm (Linnaeus, 1767; Salmon, 1900) [5, 9]. The fungus *Erysiphe polygoni* produces cleistothecia, which are sexual fruiting bodies, typically forming late in the season under adverse climatic conditions. Each cleistothecium contains 2 to 8 asci, measuring 46-72 × 30-45 µm in size, with each ascus housing 4 to 8 ascospores that measure approximately 19-25 × 9-14 µm (Yarwood, 1936, 1954, 1957) [14, 15, 16]. The optimal conditions for conidial germination include a temperature of 20°C and a relative humidity of 80% (Divya *et al.*, 2014) [2]. Powdery mildew (PM) affects all green, aerial parts of the mung bean plant, including leaves, stems, branches, pods and flowers. The disease typically begins on the older leaves, particularly at the collar region of the plant. Initially, small, scattered, circular or irregular white powdery spots appear on the upper surface of the leaves. Under favourable conditions, the white powdery growth of the fungus expands, coalescing to cover the entire leaf surface and spreading to the lower surface. Plants heavily infested with PM display a talcum powder-like appearance, with small, pale-yellow leaves. As the disease progresses, the plants become stunted and fail to grow properly. Hence experiment to find out effective fungicides against *powdery mildew* was conducted under field condition.

Material and Methods / Experimental Details / Methodology

Systemic, non-systemic and combi product fungicides were evaluated under *in vitro* by spore germination technique against *Erysiphe polygoni* DC during *Kharif* 2024-25 at department of Plant Pathology, College of Agriculture, Latur. Required concentrations of fungicides were prepared by dissolving known quantity of fungicides in sterile water separately under aseptic conditions. The conidial suspension was prepared separately in sterile water and adjusted to 4 $\times 10^3$ conidia /ml using haemocytometer. Then a drop of conidial suspension was mixed with one drop of fungicidal solution in a cavity slide to achieve the required concentration of systemic fungicides (1000 ppm), non-systemic and combi product fungicides (2000 ppm). In each treatment three replications were maintained. Treated cavity slides were kept in moist chamber and incubated at room temperature (25 ± 1°C) for 24 hours. Effect of fungicides and their concentrations on the germination of conidia was observed after 24 hours, under microscope at 40 X magnification. A control treatment was maintained with distilled water. Per cent conidial germination was calculated by the following formula.

$$\text{Per cent germination} = \frac{A}{B} \times 100$$

Where,
A = Number of conidia germinated
B = Number of conidia observed

Per cent inhibition over the control was calculated by using the formula given by Vincent (1947) [13].

$$\text{Per cent inhibition of spore germination (I)} = \frac{C-T}{C} \times 100$$

Where,
I = Per cent inhibition of spore germination
C = Germination of conidia in control.
T = Germination of conidia in treatment.

Table 1: List of non-systemic fungicides

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Mancozeb 75 WP	T_5	Copper oxychloride 50 WP
T_2	Wettable Sulphur 80 WP	T_6	Dinocap 48 EC
T_3	Chlorothalonil 75 WP	T_7	Propineb 76 WP
T_4	Zineb 75 WP	T_8	Control (Untreated)

Table 2: List of systemic fungicides

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Azoxystrobin 23 SC	T_5	Propiconazole 25 EC
T_2	Carbendazim 50 WP	T_6	Tebuconazole 250 EC
T_3	Difenconazole 25 EC	T_7	Myclobutanil 10 WP
T_4	Hexaconazole 5 EC	T_8	Control (Untreated)

Table 3: List of combi product fungicides

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Carbendazim 12 % + Mancozeb 63 %	T_5	Azoxystrobin 11 % + Tebuconazole 18.3 %
T_2	Tebuconazole 50 % + Trifloxystrobin 25 %	T_6	Carboxin 37.5 % + Thiram 37.5 %
T_3	Hexaconazole 5 % + Captan 70 %	T_7	Azoxystrobin 18.2 % + Difenoconazole 11.4 %
T_4	Hexaconazole 4 % + Zineb 68 %	T_8	Control (Untreated)

Results and discussion

In vitro efficacy of non-systemic fungicides against *Erysiphe polygoni* DC

Results reveled that all the fungicides evaluated were found significantly superior over the control with respect to spore germination inhibition technique.

Seven different non-systemic fungicides were evaluated for their efficacy against Erysiphe polygoni DC at 2000 ppm concentrations through spore germination inhibition technique under laboratory conditions. The per cent inhibition of spore germination over control was calculated. The results are presented in (Table 3.1 & Fig. 3.1)

Among the various non systemic evaluated, Wettable sulphur 80 WP was found to be most effective with highest spore germination inhibition of 75.06 per cent, which was significantly superior over other treatments because it creates a plant protective coating on the surface of the plant that prevents the spore germination. The next best fungicides were Dinocap 48 EC with mean spore germination inhibition of 73.68 per cent, which acts as uncoupler of oxidative phosphorylation, upsetting the electrochemical balance of the fungi cell and preventing the formation of energy rich ATP, affects the respiration and cell wall formation of fungi, Propineb 76 WP with mean spore germination inhibition of 72.76 per cent which interferes at different locations in the metabolism of the fungi on several points of the respiration chain, in the metabolism of carbohydrates and proteins, in the cell membranes. This multi-site mode of action of propineb prevents development of resistance in the fungi followed by Chlorothalonil 75 WP and Zineb 75 WP with mean spore germination inhibition of 71.39 and 68.98 per cent. Lowest spore germination inhibition was noticed in fungicides Copper oxychloride 50 WP followed by Mancozeb 75 WP with the mean spore germination inhibition of 65.67 and 68.01 per cent, respectively.

Table 4: *In vitro* efficacy of non-systemic fungicides against *Erysiphe polygoni* DC

Tr. No.	Fungicides	Conc. (ppm)	Germination (%)	Inhibition (%)
T_1	Mancozeb 75 WP	2000	29.32* (32.79) **	68.01
T_2	Wettable Sulphur 80 WP	2000	22.85 (28.56)	75.06
T_3	Chlorothalonil 75 WP	2000	26.23 (30.80)	71.39
T_4	Zineb 75 WP	2000	27.51 (31.63)	68.98
T_5	Copper oxychloride 50 WP	2000	31.47 (34.12)	65.67
T_6	Dinocap 48 EC	2000	24.13 (29.42)	73.68
T_7	Propineb 76 WP	2000	24.99 (29.99)	72.76
T_8	Control (Untreated)	-	91.67 (73.22)	-
S.Em. ±			0.70	
C.D. at 5%			2.93	

*: Mean of three replications, **: Values in parenthesis are arcsin transformed values.

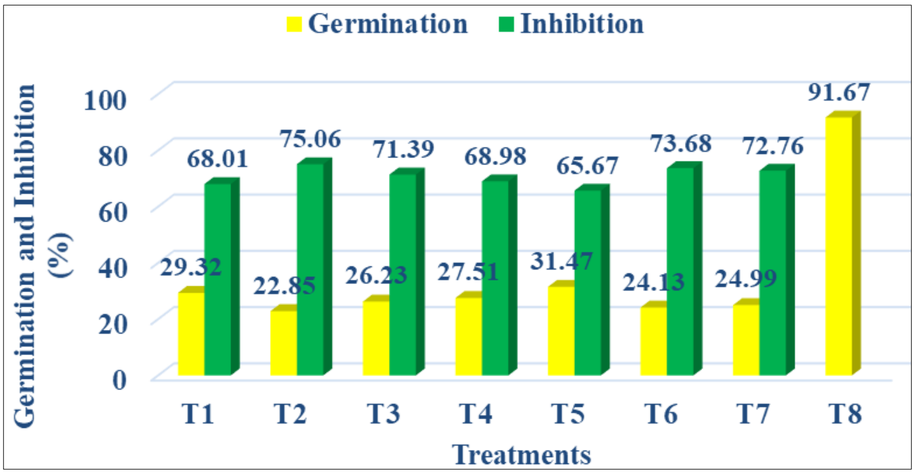

Fig 1: *In vitro* efficacy of non-systemic fungicides against *Erysiphe polygoni* DC

In vitro efficacy of systemic fungicides against *Erysiphe polygoni* DC

Seven different systemic fungicides were evaluated for their efficacy against *Erysiphe polygoni* DC at 1000 ppm concentrations through spore germination inhibition technique under laboratory conditions. The per cent inhibition of spore germination over control was calculated. The results are presented in (Table 3.2 & Fig. 3.2). All the seven systemic fungicides evaluated were found effective over control in inhibition of the conidial germination. Azoxystrobin 23 SC (95.50%) inhibited maximum conidial germination and it was followed by Tebuconazole 25.9 EC (94.20%), Hexaconazole 5 EC (91.90) and Difenconazole 25 EC (90.61). Least inhibiton of conidial germination was observed with Carbendazim 50 WP (76.08%), Propiconazole 25 EC (87.64%) and Myclobutanil 10 WP (88.97%).

Table 5: *In vitro* efficacy of systemic fungicides against *Erysiphe polygoni* DC

Tr. No.	Fungicides	Conc. (ppm)	Germination (%)	Inhibition (%)
T_1	Azoxystrobin 23 SC	1000	4.13* (11.72) **	95.50
T_2	Carbendazim 50 WP	1000	21.93 (27.92)	76.08
T_3	Difenconazole 25 EC	1000	8.61 (17.06)	90.61

T_4	Hexaconazole 5 EC	1000	7.43 (15.81)	91.90
T_5	Propiconazole 25 EC	1000	11.33 (19.67)	87.64
T_6	Tebuconazole 250 EC	1000	5.32 (13.33)	94.20
T_7	Myclobutanil 10 WP	1000	10.11 (18.54)	88.97
T_8	Control (Untreated)	-	91.67 (73.22)	-
S.Em. ±			0.49	
C.D. at 1%			2.02	

*: Mean of three replications. **: Values in parenthesis are arcsin transformed values.

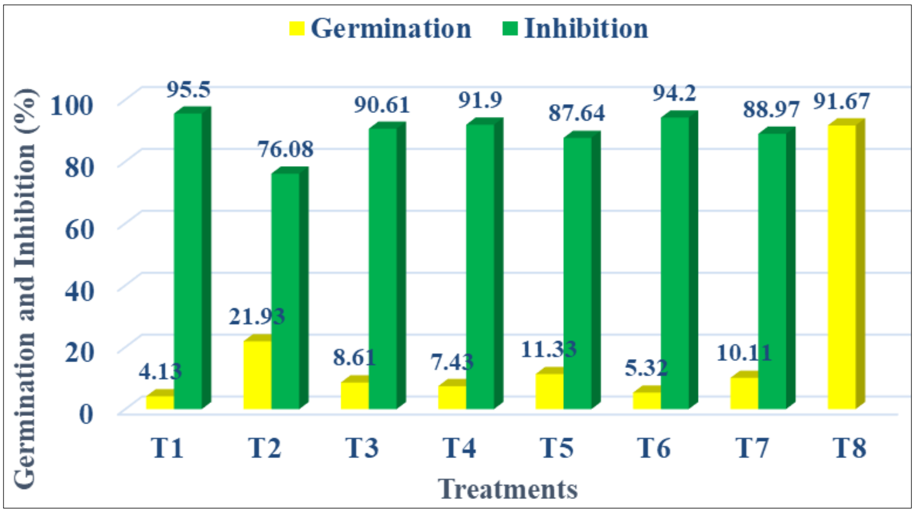

Fig 2: *In vitro* efficacy of systemic fungicides against *Erysiphe polygoni* DC

***In vitro* efficacy of combi-product fungicides *Erysiphe polygoni* DC**

Seven different combi fungicides were evaluated for their efficacy against *Erysiphe polygoni* DC at 2000 ppm concentrations through spore germination technique under laboratory. The per cent inhibition of spore germination over control was calculated. The results are presented in (Table 3.3 & Fig. 3.3). All the seven combi-product fungicides evaluated were found effective over control in inhibiting the conidial germination. Tebuconazole 50% + Trifloxystrobin 25% (86.22 %) inhibited maximum conidial germination and it was followed by Azoxystrobin 11% + Tebuconazole 18.3% (84.00 %), Azoxystrobin 18.2 % + Difenoconazole 11.4 % (83.24 %) and Hexaconazole 5 % + Captan 70 % (79.63 %). Least inhibition of conidial germination was observed with Carbendazim 12% + Mancozeb 63% (67.90%), Carboxin 37.5% + Thirum 37.5% (70.39%) and Hexaconazole 5% + Zineb 68% (79.06%) at 2000 ppm.

Similar, results were obtained by Venkatrao (1997) who reported the efficacy of Penconazole (0.1%) and Difenconazole (0.1%) in inhibiting conidial germination of *E. polygoni*. Meena *et al.* (2019) [7] tested fungicides against powdery mildew of black gram caused by *Erysiphe polygoni* DC. Among all the fungicides tested, the new combi-fungicide Taspa 300 SC (containing Propiconazole and Difenconazole) caused the maximum inhibition of spore germination (93.05%, 92.1% and 89.23%) at concentrations of 0.2%, 0.1% and 0.05%, respectively, followed by Hexaconazole. Mansukhbhai *et al.* (2020) [6] evaluated various fungicides against *E. polygoni* by following spore germination inhibition technique and revealed that, among the non-systemic fungicides evaluated, significantly highest (78.80%) mean spore germination inhibition was obtained in Wettable sulphur and least effective (33.14%) fungicide was Zineb.

Table 6: *In vitro* efficacy of combi-product fungicides against *Erysiphe polygoni* DC

Tr. No.	Fungicides	Conc. (ppm)	Germination (%)	Inhibition (%)
T_1	Carbendazim 12 % + Mancozeb 63 %	2000	29.43* (32.85) **	67.90
T_2	Tebuconazole 50 % + Trifloxystrobin 25 %	2000	12.63 (20.82)	86.22
T_3	Hexaconazole 5 % + Captan 70 %	2000	18.67 (25.60)	79.63
T_4	Hexaconazole 4 % + Zineb 68 %	2000	19.19 (25.98)	79.06
T_5	Azoxystrobin 11 % + Tebuconazole	2000	14.68	84.00

	18.3 %		(22.53)	
T_6	Carboxin 37.5 % + Thiram 37.5 %	2000	27.14 (31.40)	70.39
T_7	Azoxystrobin 18.2 % + Difenoconazole 11.4 %	2000	15.36 (23.07)	83.24
T_8	Control (Untreated)	-	91.67 (73.22)	-
S.Em. ±			0.42	
C.D. at 1%			1.74	

*: Mean of three replications. **: Values in parenthesis are arcsin transformed values.

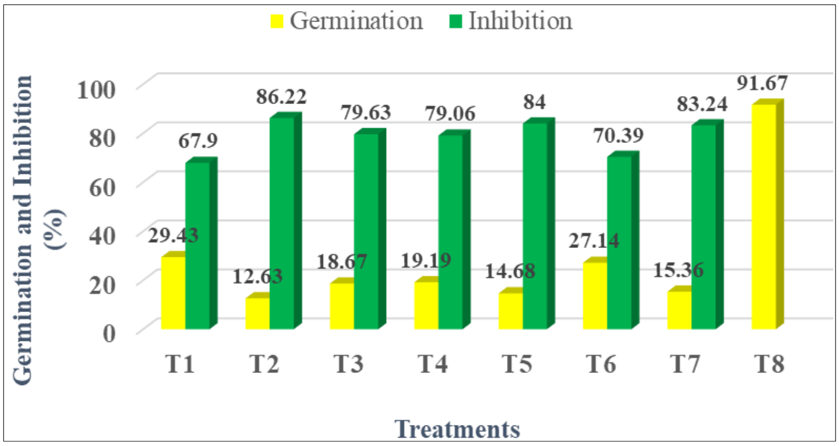

Fig 3: *In vitro* efficacy of combi-product fungicides *Erysiphe polygoni* DC

Conclusion

Inhibition of conidial germination was observed with non-systemic fungicide. Among various non systemic fungicide Wettable sulphur 80 WP inhibited conidial germination most effectively followed by Dinocap 48 EC. The least per cent inhibition was recorded in Copper oxychloride 50 WP at 2000 ppm. Maximum inhibition of conidial germination was observed with systemic fungicide Azoxystrobin 23% SC followed by Tebuconazole 25.9 EC. The least per cent inhibition was recorded in Carbendazim 50 WP at 1000 ppm. *In vitro* evaluation of combi-product fungicides revealed that maximum inhibition of conidial germination was observed with Tebuconazole 50% + Trifloxystrobin 25% WG followed by Azoxystrobin 11% + Tebuconazole 18.3% SC. The least per cent inhibition was recorded in Carbendazim 12% + Mancozeb 63% WP at 2000 ppm

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