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Compatibility of bio-control agent *Trichoderma harzianum* and *Aspergillus niger* with pesticides

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Abstract
New generation pesticides are most frequently used as seed treatment, soil drenching and foliar sprays. These pesticides have not been tested so far against *Trichoderma harzianum* and *Aspergillus niger*. Therefore, information is still lacking about the toxicity of these pesticides against different antagonists and plant pathogens. Ten pesticides were screened in *in vitro* at different concentrations to determine their reaction on radial growth and spore germination of the biocontrol agent *T. harzianum* and *A. niger*. Among them, the fungicides viz., carbendazim (12%) + mancozeb (63%), propiconazole and captan (70%) + hexaconazole (5%); insecticide viz., chlorpyphos were toxic to the *T. harzianum* as well as *A. niger*. Whereas, cymoxanil (8%) + mancozeb (64%), metalaxyl (8%) + mancozeb (64%), propineb and imidachloprid were safer to the *T. harzianum* and *A. niger*. However, Thiamethoxam and carbofuran compatible with *T. harzianum* and incompatible with *A. niger*.

Keywords: Compatibility, pesticide, *Trichoderma harzianum, Aspergillus niger*

Introduction
Aspergillus niger Van Tieghem is an important pathogen attacking groundnut at seed and seedling stage and causing collar rot disease, it may cause losses to the tune of 40 to 50% in terms of mortality of plants (Chohan, 1969) [3]. Chemical control is one of the classical method of crop disease management but at same time it has now become controversial because of the rising cost involved and its polluting effect on the environment. Therefore, biocontrol method has been intensified in recent years to reduce the effect ecologically hazardous chemicals. *Trichoderma harzianum* Rifai a potential biocontrol agent that control several seed-soil borne plant pathogens (Papavizas, 1985; Bhuvaneswari and Rao, 2001; Subbiah and Indra, 2003 and Mane and Pal, 2008) [12, 1, 18, 8]. It may be even better if the biocontrol agent is effective as well as compatible with seed and soil dressing pesticide so that it can be used in integrated disease management system. Hence, in the present study different pesticides have been evaluated at various concentrations to know the compatibility of *T. harzianum* and pathogen *A. niger* with pesticides.

Materials and Methods
The pure culture of *T. harzianum* Rifai was collected from department of Plant Pathology, B. A. College of Agriculture, AAU, Anand. Sub-cultured and maintained on potato dextrose agar (PDA) slants aseptically. The pathogen *A. niger* was isolated from infected portion of groundnut. Ten pesticides i.e. six fungicides viz., propineb (Antracol 70% WP), metalaxyl (8%) + mancozeb (64%) (Ridomil MZ 72 WP), cymoxanil (8%) + mancozeb (64%) (Curzate M8 72% WP), captan (70%) + hexaconazole (5%) (Taqat 75% WP), carbendazim (12%) + mancozeb (63%) (SAAF 75% WP), propiconazole (Result 25 EC); three insecticides viz., thiamethoxam (Actara 25 WG), imidachloprid (Confidor 200 SL), chlorpyriphos (Durmet 20 EC), and one nematicide viz., carbofuran (Furadan 3 G) were tested against *T. harzianum* and *A. niger* using “Poisoned Food Technique” described by Groover and Moore (1961) and spore germination study. The pesticides were used at different concentrations i.e. 25, 50, 125, 250, 500 and 1000 µg ml^{-1}.

Effect of pesticides on radial growth
A warm sterilized PDA of 60 ml was filled aseptically in sterilized Erlenmeyer flasks of 250 ml capacity. Chemicals were weighed as per the desired concentrations and mixed thoroughly in the flask aseptically.

To avoid bacterial contamination, 50 µg ml^{-1} of streptomycin sulphate was added. The PDA aliquots of 20 ml containing the chemical were pour aseptically in sterilized Petri plate and allowed to solidify. Medium without test chemical served as control. Mycelial disc of 6 mm diameter was cut from 7 days old culture of *T. harzianum* and *A. niger* were transferred aseptically in the centre of each plate having aliquots of test chemical. Simultaneously, plates with *T. harzianum* and *A. niger* on PDA were taken as control. Each treatment was replicated thrice. The inoculated Petri plates were incubated at 27 ± 1º C till the control plates with *T. harzianum* were full with the fungal growth. The linear mycelial growth of the bioagent in treatment and in control was measured in two directions at right angle to each other. Per cent inhibition of the mycelial growth was calculated by using the formula given by Bliss (1934) [2] i.e. I = 100 (C – T)/ C, where, I = per cent inhibition; C = Colony diameter in control (mm) and T = Colony diameter in treatment (mm).

Effect on spore germination

Standard spore suspension was prepared by harvesting the spore of 10 days old culture of *T. harzianum* and *A. niger* in 10 ml of sterilized distilled water and mixed thoroughly by shaking vigorously. Spore population of *T. harzianum* and *A. niger* in the spore suspension was counted (no. of spore ml^{-1}) with the help of haemocytometer and desired spore population i.e. 50 spore ml^{-1} was maintained by adding sterilized distilled water in standard spore suspension. Desired quantity of the pesticide was added in the spore suspension to maintain the desired concentration. One drop of the suspension containing test chemical of desired concentration and spore was placed in the centre of glass cover slip. Then the cover slip was kept inverted on to the cavity of the slide by which hanging position of the drop was maintained. The cavity slides with spore suspension without chemical were maintained as control. Three replications of each treatment were prepared. The cavity slides of each treatment were subjected to moist chamber. The moist chamber was prepared by keeping moist filter paper of Whatman No. 1 on each slide of Petri plate. The glass slides were elevated by placing them on glass rods so as to avoid the entry of water inside the cavity. The spore subjected to test chemicals in each cavity slides were incubated at 27 ± 1º C for 48 hrs. The observation of germinated and un- germinated spores in each treatment were recorded after 48 hrs. from three microscopic field of each slide. Inhibition of spore germination was calculated by using the formula of Bliss (1934) [2].

Results and Discussion

Sensitivity of *T. harzianum* against pesticides

Effect of fungicides on radial growth of *T. harzianum*:

The experimental results presented in Table 1 showed differences in the radial growth of *T. harzianum* due to different concentrations of fungicides. A combi product of cymoxanil (8%) + mancozeb (64%) showed a mean radial growth of 80.44 mm followed by metalaxyl (8%) + mancozeb (64%) (75.50 mm) and propineb (71.64 mm). Fungicidal mean revealed captan (70%) + hexaconazole (5%), propiconazole and carbendazim (12%) + mancozeb (63%) as toxic to the bioagent.

Among the fungicides, combi product of cymoxanil (8%) + mancozeb (64%) showed a little inhibition of radial growth of *T. harzianum* up to 500 µg ml^{-1} but the bioagent could grew up to 1000 µg ml^{-1} with radial growth of 68.67mm. However, there was increasing trend in inhibition of growth with increasing concentration. A similar trend was observed in case of combi product of metalaxyl (8%) and mancozeb (64%), but it was a little bit more inhibitory as compared to cymoxanil (8%) + mancozeb (64%). Propineb and combi product of captan (70%) + hexaconazole (5%) were next in order of toxicity to the bioagent as they showed 58.83 and 13.33 mm radial growth with 34.63 and 85.18 per cent growth inhibition at 1000 µg ml^{-1} respectively.

Besides, Carbendazim (12%) + mancozeb (63%) did not allowed to grow the bioagent and exerted complete inhibition over control even at 25 µg ml^{-1} concentrations. This was followed by propiconazole which showed 7.50 mm mycelial growth with 91.67 per cent growth inhibition at 25 and 50 µg ml^{-1}, respectively.

Different workers have also tested the sensitivity of *T. harzianum* to different fungicides. Combi product of metalaxyl (8%) + mancozeb (64%) was found least toxic to the bioagent (Sawant and Mukhopadhyay, 1990; Sushir, 2001; Tiwari and Singh, 2004) [15, 19, 20]. Contrary to this, the growth inhibition of *T. harzianum* with propineb was found to be similar to the present finding (Vijayraghavan and Abraham, 2004) [21]. The fungicides viz., Carbendazim (12%) + mancozeb (6%), captan and propiconazole have been reported as toxic to *T. harzianum*. (Sharma, 1992; Karpagavalli, 1997; Sushir, 2001; Mercy, 2004; Tiwari and Singh, 2004 and Khalko *et al.,* 2005) [16, 19, 9, 20, 6]. Effect of hexaconazole was extremely toxic to *T. harzianum* at lower concentrations (Pandey *et al*., 2006) [11].

The perusal of literature revealed no information of inhibitory effect of combi product viz. cymoxanil (8%) + mancozeb (64%) and captan (70%) + hexaconazole (5%) on the bioagent.

Effect of insecticides on radial growth of *T. harzianum*

Thiamethoxam was found to be safer for growth of the bioagent as it showed no inhibition at all concentrations tested (Table 1). It was followed by imidachloprid with 78.33 mm radial growth and 12.96 per cent growth inhibition at 1000 µg ml^{-1}. However, chlorpyriphos resulted to 89.67 and 44.33 mm growth with 0.37 and 50.74 per cent growth inhibition at 25 and 1000 µg ml^{-1}, respectively.

Thiamethoxam as showing no inhibition of mycelial growth of *T. harzianum* below 1.25 per cent concentration (Prasanna *et al.,* 2002) [13]. However, chlorpyriphos and imidachloprid at 500 µg ml^{-1} showed 21.4 and 23.3 per cent growth inhibition over control, respectively (Lal and Maharshi, 2007) [7].

Effect of nematicide on radial growth of *T. harzianum*

Significant differences in radial growth of *T. harzianum* (Table 1) were obtained due to different concentrations. Carbofuran up to 125 µg ml^{-1} concentration had no adverse effect on radial growth. However, at higher dose i.e. 1000 µg ml^{-1} it gave 48.33 per cent inhibition.

The results are in conformity with the reports of Sushir (2001) [19] and Mercy (2004) [9] who reported no adverse effect of carbofuran on radial growth of *T. harzianum* up to 125 µg ml^{-1} and even at higher concentrations (1000 µg ml^{-1}) it was least inhibitory.

Table 1: Effect of pesticides on radial growth of *T. harzianum*

S. No.	Name of Pesticides	*Average radial growth (mm) Concentration (µg ml-1)						Mean
		25	50	125	250	500	1000	
1	Propineb 70 WP (Antracol 70 WP)	87.67 (2.59)	86.67 (3.70)	69.00 (23.33)	68.33 (24.07)	59.33 (34.07)	58.83 (34.63)	71.64 (20.40)
2	Metalaxyl 8% + Mancozeb 64 % (Ridomil MZ 72 WP)	87.00 (3.33)	85.33 (5.18)	82.67 (8.15)	81.67 (9.26)	63.67 (29.26)	52.67 (41.48)	75.50 (16.11)
3	Cymoxanil 8 % Mancozeb 64% (Curzate M 8 72 % WP)	87.33 (2.96)	84.00 (6.67)	83.67 (7.04)	80.67 (10.37)	78.33 (12.96)	68.67 (23.70)	80.44 (10.62)
4	Captan 70% + Hexaconazole 5% (Taqat 75% WP)	59.50 (33.89)	39.00 (56.67)	37.83 (57.96)	30.00 (66.67)	16.00 (82.22)	13.33 (85.18)	32.61 (63.77)
5	Carbendazim12% + Mancozeb 63% (SAAF 75 % WP)	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)	0.00 (100.0)
6	Propiconazole (Result 25EC)	7.50 (91.67)	6.83 (92.41)	6.33 (92.96)	6.17 (93.15)	0.00 (100.0)	0.00 (100.0)	4.47 (95.03)
7	Thiamethoxam (Actara 25WG)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)
8	Imidachloprid (Confidor 200SL)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	89.67 (0.37)	82.33 (8.52)	78.33 (12.96)	86.72 (3.64)
9	Chlorpyriphos (Durmet 20EC)	89.67 (0.37)	87.00 (3.33)	80.67 (10.37)	74.67 (17.04)	52.33 (41.85)	44.33 (50.74)	71.44 (20.62)
10	Carbofuran (Furadan 3G)	90.00 (0.00)	90.00 (0.00)	90.00 (0.00)	83.67 (7.04)	66.00 (26.68)	46.50 (48.33)	77.69 (13.68)
	Concentrations mean	68.87 (23.4)	65.88 (26.8)	63.02 (29.98)	60.48 (32.8)	50.80 (43.56)	45.27 (49.70)	--
11	Control							90.00
		S. Em. ±		C. D. (0.05)		C. V. %		
Treatment (T)		0.54		1.51		3.87		
Concentration (C)		1.42		1.17				
Interaction (TxC)		1.32		3.69				

*Average of three replications.
Figures in parentheses are per cent growth inhibition over control.

Effect of fungicides on spore germination of *T. harzianum*

The results on effect of fungicides on inhibition of spore germination of *T. harzianum* are presented in Table 2. Fungicide mean for inhibition of spore germination revealed combi product of cymoxanil (8%) + mancozeb (64%) as least inhibitory (27.92%) for the spore germination. It was followed by combi product of metalaxyl (8%) + mancozeb (64%) (28.91%). Whereas, carbendazim (12%) + mancozeb (63%) showed higher inhibition for the spore germination (88.67%). It was followed by propiconazole (83.77%), captan (70%) + hexaconazole (5%) (78.86%) and propineb (38.04%). Many workers have tested the fungicides for their inhibition to spore germination, Metalaxyl was found less toxic in spore germination. (Sawant and Mukhopadhyay, 1990; Sharma, 1992 and Sushir, 2001) [15, 19]. Whereas, propiconazole showed higher inhibition to the spore germination in comparison to metalaxyl (Sushir, 2001) [19]. However, propiconazole has exerted 65.83 per cent spore inhibition at lower concentration (25 µg ml^{-1}) (Mercy, 2004) [9]. In a study, Sharma (1992) [16] found carbendazim as extremely toxic to the bioagent which completely inhibited the spore germination at 1000 µg ml^{-1}.

Effect of insecticides on spore germination of *T. harzianum*

The insecticides tested showed increased trend of inhibition of spore germination with increased concentration (Table 2). Thiamethoxam showed only 0.67 per cent inhibition in spore germination at lower concentration of 25 µg ml^{-1} which risen to only 24.00 per cent at 1000 µg ml^{-1}. It was followed by imidachloprid showing 38.66 per cent inhibition at 500 µg ml^{-1} whereas, chlorpyriphos showed 63.89 per cent inhibition of spore germination at 1000 µg ml^{-1}, respectively.

Results of present study showed more or less similar trend with the results reported by Mercy (2004) [9] with regard to chlorpyriphos. However, there are no reports on the effect of imidachloprid and thiamethoxam on the spore germination. It is evident with the result that the insecticides under test were less inhibitory to the germination of spore and growth of *T. harzianum*.

Effect of nematicide on spore germination of *T. harzianum*

Study on the inhibition of spore germination of *T. harzianum* indicated (Table 2) significant differences due to their concentrations. However, data revealed that at lower concentration (25 µg ml^{-1}) inhibition of spore germination was 17.69 per cent. Whereas, 48.30 per cent inhibition was found at higher concentration (1000 µg ml^{-1}).

Therefore, among different pesticides tested against *T. harzianum*, the fungicide i.e. cymoxanil (8%) + mancozeb (64%), metalaxyl (8%) + mancozeb (64%); insecticides i.e. thiamethoxam, imidachloprid and nematicide i.e. carbofuran were found comparatively safer for the growth as well as for spore germination of *T. harzianum.*

Table 2: Effect of pesticides on spore germination of *T. harzianum*

Sr. No.	Name of Pesticides	*Inhibition of spore germination (%) at different concentration (µg ml^{-1})						Mean
		25	50	125	250	500	1000	
1	Propineb 70 WP (Antracol 70 WP)	23.91	24.64	35.51	38.41	47.83	57.97	38.04^{e}
2	Metalaxyl 8% + Mancozeb 64 % (Ridomil MZ 72 WP)	15.65	21.09	26.53	27.89	37.42	44.90	28.91^{f}
3	Cymoxanil 8 % Mancozeb 64% (Curzate M 8 72 % WP)	15.54	22.29	24.32	26.34	35.80	43.25	27.92^{f}
4	Captan 70% + Hexaconazole 5% (Taqat 75% WP)	69.13	74.50	77.18	79.20	85.24	87.92	78.86^{c}
5	Carbendazim12% + Mancozeb 63% (SAAF 75 % WP)	84.66	86.66	88.00	89.33	90.00	93.33	88.67^{a}
6	Propiconazole (Result 25EC)	78.00	80.00	83.33	85.33	87.33	88.43	83.77^{b}
7	Thiamethoxam (Actara 25WG)	0.67	0.67	0.67	6.00	17.34	24.00	8.22^{h}
8	Imidachloprid (Confidor 200SL)	0.67	1.33	15.33	22.00	38.66	40.66	19.77^{g}
9	Chlorpyriphos (Durmet 20EC)	27.08	32.65	43.05	47.92	56.94	63.89	45.25^{d}
10	Carbofuran (Furadan 3G)	17.69	18.37	23.12	27.21	38.78	48.30	28.91^{f}
	Concentrations mean	33.30^{f}	36.21^{e}	41.71^{d}	44.96^{c}	53.53^{b}	59.29^{a}	--
		S. Em. ±		C. D. (0.05)		C. V. %		
Treatment (T)		0.491		1.375		4.65		
Concentration (C)		0.380		1.065				
Interaction (TxC)		1.203		3.369				

*Average of three replications.

Treatment means with the letters in common are not significant by DNMRT at 5% level of significance

Sensitivity of *A. niger* against pesticides

Effect on fungicides radial growth of *A. niger*

The results of present study showed differences in the radial growth of *A. niger* due to different concentrations of fungicides (Table 3). Among the fungicides, propiconazole showed significantly higher inhibition of mycelial growth of *A. niger*. It showed 15.33 mm radial growth and 82.96 per cent inhibition at 25 µg ml^{-1}. However, the per cent inhibition increased with increased concentration of fungicides. The next best fungicides was combi product of carbendazim (12%) + mancozeb (63%) which gave 45.56 per cent growth inhibition at 25 µg ml^{-1} whereas, complete growth inhibition was observed at 500 and 1000 µg ml^{-1}.

Table 3: Effect of pesticides on radial growth of *A. niger*

Sr. No.	Name of Pesticides	*Average radial growth (mm) Concentration (µg ml^{-1})						Mean
		25	50	125	250	500	1000	
1	Propineb 70 WP (Antracol 70 WP)	64.67 (28.15)	60.30 (32.96)	60.00 (33.33)	58.33 (35.18)	53.67 (40.37)	53.33 (40.74)	58.39 (35.12)
2	Metalaxyl 8% + Mancozeb 64 % (Ridomil MZ 72 WP)	84.33 (6.29)	81.67 (9.25)	79.67 (11.48)	74.67 (17.04)	66.67 (25.93)	64.00 (28.89)	75.17 (16.48)
3	Cymoxanil 8 % Mancozeb 64% (Curzate M 8 72 % WP)	78.50 (12.78)	70.33 (21.85)	68.33 (24.07)	65.00 (27.77)	50.50 (43.99)	36.67 (59.26)	61.56 (31.60)
4	Captan 70% + Hexaconazole 5% (Taqat 75% WP)	61.33 (31.85)	31.33 (65.19)	21.67 (75.93)	14.67 (83.77)	11.67 (87.03)	8.67 (90.37)	24.89 (72.34)
5	Carbendazim12% + Mancozeb 63% (SAAF 75 % WP)	49.00 (45.56)	43.33 (51.85)	32.33 (64.07)	21.00 (76.67)	0.00 (100.0)	0.00 (100.0)	24.28 (73.02)
6	Propiconazole (Result 25EC)	15.33 (82.96)	12.33 (86.29)	11.33 (87.41)	9.67 (89.26)	8.67 (90.37)	7.50 (91.67)	10.81 (87.99)
7	Thiamethoxam (Actara 25WG)	90.00 (0.00)	85.67 (4.41)	75.33 (16.30)	71.33 (20.74)	68.50 (23.89)	67.33 (25.18)	76.36 (15.16)
8	Imidachloprid (Confidor 200SL)	90.00 (0.00)	87.33 (2.96)	85.67 (4.18)	83.67 (7.03)	78.33 (12.96)	75.33 (16.30)	83.39 (7.34)
9	Chlorpyriphos (Durmet 20EC)	87.33 (2.96)	85.33 (5.18)	81.33 (9.63)	59.67 (33.70)	46.33 (48.52)	43.33 (51.85)	67.22 (25.31)
10	Carbofuran (Furadan 3G)	90.00 (0.00)	89.33 (0.74)	80.00 (11.11)	73.33 (18.52)	67.67 (24.81)	44.67 (50.37)	74.17 (17.59)
	Concentrations mean	71.05 (21.06)	64.70 (28.11)	59.57 (33.81)	53.13 (40.97)	45.20 (49.78)	40.08 (55.47)	--
11	Control							90.00
		S. Em. ±		C. D. (0.05)		C. V. %		
Treatment (T)		0.42		1.17		3.18		
Concentration (C)		0.32		0.90				
Interaction (TxC)		1.02		2.86				

* Average of three replications.

Figures in parentheses are per cent growth inhibition over control.

Besides, captan (70%) + hexaconazole (5%) at lower concentrations i.e. 25, and 50 µg ml^{-1} exerted 31.85 and 65.19 per cent inhibition, respectively. Similarly, propineb at 25 and 1000 µg ml^{-1} showed 28.15 and 53.33 per cent mycelial growth of *A. niger*. The least inhibition was recorded by combi product of cymoxanil (8%) + mancozeb (64%) (59.26%) and metalaxyl (8%) + mancozeb (64%) (28.89) at 1000 µg ml^{-1}.

It is reported that carbendazim and mancozeb completely inhibited the growth of *A. niger* and partially inhibited the growth of *T. harzianum* (Nagaraju and Urs, 1998) [10]. However, highest inhibition (100%) of growth of *A. niger* was observed in combi product of carbendazim (12%) + mancozeb (63%) (Raju and Naik, 2006) [14]. Whereas, cymoxanil (8%) + mancozeb (64%) gave 65.50 per cent inhibition. The fungicides viz., captan, hexaconazole and propineb were found to express higher inhibition to *A. niger* as compared to *T. harzianum* (Pandey *et al*., 2006) [11].
However, perusal of literature revealed no reports of inhibitory effect of propiconazole and metalaxyl (8%) + mancozeb (64%) on *A. niger*.

Effect of insecticides on radial growth of *A. niger*
In a study chlorpyriphos was found highly toxic to *A. niger* which gave 46.33 mm and 43.33 mm radial growth at 500 and 1000 µg ml^{-1}, respectively. The next best insecticide in order of merit was thiamethoxam which showed 68.55 mm and 67.33 mm mycelial growth at same concentrations, respectively. However, least toxicity to pathogen was found in case of imidachloprid i.e. 78.33 mm and 75.33 mm at 500 and 1000 µg ml^{-1}, respectively.
Thus, among three insecticides, chlorpyriphos was found as significantly superior over thiamethoxam and imidachloprid for reduction of mycelial growth of *A. niger*.

Effect of nematicide on radial growth of *A. niger*
The radial growth of *A. niger* differed significantly as influenced by different concentrations of nematicide. Mean of the concentration indicated carbofuran as least toxic as compared to fungicides wherein 17.59 per cent inhibition with 74.17 mm mycelial growth was obtained.
However, least inhibitory effect of carbofuran was found at lower concentration i.e. 0.00, and 0.74 per cent at 25 and 50 µg ml^{-1}, respectively. Whereas, higher concentration (1000 µg ml^{-1}) was found comparatively toxic to the pathogen (50.37%).

Effect of fungicides on spore germination of *A. niger*
The result on effect of fungicides on inhibition of spore germination of *A. niger* are presented in Table 4. Among the fungicides carbendazim (12%) + mancozeb (63%) at 500 and 1000 µg ml^{-1} showed 88.66 and 93.34 per cent inhibition, respectively. It was at par with propiconazole which gave 88.67 and 92.67 per cent inhibition at same concentrations, respectively. In other hand, captan (70%) + hexaconazole (5%), cymoxanil (8%) + mancozeb (64%), propineb and metalaxyl (8%) + mancozeb (64%) gave 85.24, 68.92, 67.39 and 48.30 per cent inhibition of spore germination at 1000 µg ml^{-1}, respectively. Thus, the data of the present study revealed that with in increased concentration of fungicides, there was an increase in the inhibition of spore germination.
However, perusal of literature revealed no reports on the effect of these fungicides on inhibition of spore germination of *A. niger*.

Effect of insecticides on spore germination of *A. niger*
The data presented in Table 4 indicated among three insecticides tested, inhibition of spore germination was maximum in chlorpyriphos with 59.72 per cent at 1000 µg ml^{-1}. It is clear from the results that chlorpyriphos highly toxic to *A. niger*. It was followed by thiamethoxam with (48.66%) and imidachloprid (42.66%). The insecticides tested showed increased inhibition of spore germination significantly with increasing concentrations.
From the present study on radial growth and spore germination, it is evident that the insecticides under test were less inhibitory to the spore germination and growth of *A. niger* as compared to fungicides.
There seems to be no reports of these insecticides on inhibition of spore germination of *A. niger*.

Effect of nematicide on spore germination of *A. niger*
The different concentrations (25 to 1000 µg ml^{-1}) of nematicide used for radial growth of pathogen were also tested for spore germination (Table 4).

Table 4: Effect of pesticides on spore germination of *A. niger*

Sr. No.	Name of Pesticides	Inhibition of spore germination (%) at different concentration (µg ml^{-1})						Mean
		25	50	125	250	500	1000	
1	Propineb 70 WP (Antracol 70 WP)	34.78	46.37	47.11	57.98	64.50	67.39	53.02^{c}
2	Metalaxyl 8% + Mancozeb 64 % (Ridomil MZ 72 WP)	19.04	26.53	37.41	40.14	42.86	48.30	35.71^{e}
3	Cymoxanil 8 % Mancozeb 64% (Curzate M 8 72 % WP)	39.19	45.94	50.68	60.81	64.19	68.92	54.95^{c}
4	Captan 70% + Hexaconazole 5% (Taqat 75% WP)	63.10	76.50	79.87	82.54	83.22	85.24	78.41^{b}
5	Carbendazim12% + Mancozeb 63% (SAAF 75 % WP)	66.00	77.34	83.34	86.00	88.66	93.34	82.45^{a}
6	Propiconazole (Result 25EC)	65.33	76.00	81.33	85.33	88.67	92.67	81.55^{a}
7	Thiamethoxam (Actara 25WG)	6.66	13.34	24.00	30.66	39.33	48.66	27.11^{f}
8	Imidachloprid (Confidor 200SL)	4.66	8.0	23.34	29.34	37.34	42.66	24.22^{g}
9	Chlorpyriphos (Durmet 20EC)	28.48	39.58	46.52	54.65	57.65	59.72	47.80^{d}
10	Carbofuran (Furadan 3G)	21.08	25.16	31.98	42.18	49.65	57.82	37.98^{e}
	Concentrations mean	34.83^{f}	43.48^{e}	50.55^{d}	56.98^{c}	61.61^{b}	66.47^{a}	--
		S. Em. ±		C. D. (0.05)		C. V. %		
Treatment (T)		0.84		2.341		6.78		
Concentration (C)		0.65		1.813				
Interaction (TxC)		2.05		5.733				

* Average of three replications.
Treatment means with the letters in common are not significant by DNMRT at 5% level of significance

The data of present study indicated a significant difference in relation to their concentrations. Carbofuran showed 21.08 per cent inhibition in spore germination at lower concentration (25 µg ml^{-1}) which risen to 49.65 and 57.82 per cent at 500 and 1000 µg ml^{-1}, respectively.

Thus, different pesticides were tested on *A. niger* to know the effect on radial growth as well as spore germination. Among them, the fungicides viz., carbendazim (12%) + mancozeb (63%) and propiconazole; insecticides viz., chlorpyriphos and thiamethoxam and nematicide i.e. carbofuran were found toxic to the pathogen.

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