Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 222-226
Received: 21-03-2019
Accepted: 24-04-2019

CS Azad
Department of Plant Pathology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Amarendra Kumar
Department of Plant Pathology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

G Chand
Department of Plant Pathology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

RD Ranjan
Department of Plant Breeding and Genetics, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Correspondence
Amarendra Kumar
Department of Plant Pathology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Evaluation of host defense inducing nanoparticles against *Alternaria tenuissima* (Kunze ex pers.) Wiltshire causing dieback disease of chilli

CS Azad, Amarendra Kumar, G Chand and RD Ranjan

Abstract
Dieback disease, caused by *Alternaria tenuissima*, (Kunze ex pers.) Wiltshire, is one of the most important disease that affecting all the plant parts of chilli. Among sixn nano compounds, all treatments significantly increased the enzymatic activities over control. Silver nanoparticles were found to best followed by Aluminum nano particles as lowest No. of spot/leaves as well as severity was recorded. The accumulation of enzymes i.e. polyphenol oxidase (PPO), peroxidase (PO) and total phenol significantly increased upto 72 hours. Among different nanoparticles highest significantly increase in PPO, PO and total phenol activity at 100 µgml^{-1} were recorded in Silver nano particles i.e. 0.039, 0.441 and 10.069 µmol/min/mg protein respectively. The average No. of spot/leaf (3.11), No. of infected leaves/plant (2.00) and disease severity after 60 DAI (days after inoculation) (8.00%) of dieback disease of chilli were minimum at 100µgml^{-1} as compare to control.

Keywords: *Alternaria tenuissima*, dieback, nanoparticles, polyphenol oxidase (PPO), peroxidase (PO) and total phenol

Introduction
Chilli (*Capsicum annum* L.) is considered as one of the most important commercial spice crop. Different varieties are cultivated for varied uses like vegetable, pickles, spice and condiments. It is cultivated over an area of 775 thousand hectares with an annual production of 1492 thousand tonnes and productivity of 1.9 metric tonnes per hectare in India (NHB, 2016). Chilli is affected by 750 pathogens of different origins, reported from different part of the world, but only few are responsible for considerable loss of production and productivity. Among the fungal diseases, dieback, leaf spot and fruit rot is caused by *Alternaria spp.*, damping off caused by *Pythium* spp., *Phytophthora* spp. and other fungi, seedling blight caused by *Rhizoctonia* spp., wilt caused by *Fusarium* spp., anthracnose and dieback caused by *Colletotrichum capsici* are major diseases. Among all these *Alternaria* spp. are responsible for dieback, leaf spot and fruit rot have been identified as major limiting factor in chilli cultivation is very common problem in fields and greenhouse. Use of host defence nano particles has been considered an alternate and effective approach for the control of pathogenic microbes. Plants can be sensitized for a more rapid and intense mobilization of defence responses leading to enhanced resistance to biotic stresses (Beckers and Conrath, 2007) [1]. Induction of systemic resistance is associated with gene induction, activation of a wide range of resistance mechanisms and the production of variety of defence compounds. It is a race non-specific and is often effective against a broad spectrum pathogenic agents (Walters and Fountaine, 2009) [14, 15]. Thus, study on induction of host defence through nano compounds can be considered as one of the effective sustainable approaches in disease management.

Materials and Methods
Soil was collected from the upper 0-15 cm layer from Vegetable Research Centre (VRC), GBPUA&T Pantnagar and was sterilized by autoclaving at 20 lb psi (121.6°C) for one hour on three consecutive days. The sterilized soil was filled in 1.5 kg capacity plastic pots and kept in glasshouse. Thirty days old seedlings of chilli cultivar Pant C1 grown in portrays under polyhouse was used in this experiment. Pots were watered regularly as and when required to maintain optimum moisture. Six nano compounds viz. Silver Nanoparticle, Aluminium Nanoparticle, Silicon carbide, Silicon dioxide, Titanium dioxide and Zinc oxide were tested at three concentrations (25, 50 and 100 µgml^{-1}) were applied under glass house these six nano compounds were prepared and applied at three different concentrations through atomizer to the point of runoff. Experiment was laid out in a completely randomized block design with five replications.

After 30 days of transplanting plants were inoculated by spraying with spore suspension of $1x10^6$ spores/ml by sterilized atomizer of the *Alternaria tenuissima* (Kunze ex Pers.) Wiltshire.

Effect of Nanoparticles on enzymatic activity after post inoculation of *Alternaria tenuissima* on chilli

Top five leaves per treatments were harvested at 0, 24, 48, 72, 96 and 120 hours after inoculation and brought to the laboratory in an ice box for analysis of the enzymes as mentioned below.

Polyphenol oxidase (PPO) activity

PPO activity was determined as per the procedure given by Mayer *et al*. (1965) [6]. Leaf samples (1 g) were homogenized in 2 ml of 0.1 M sodium phosphate buffer (pH 6.5) and centrifuged at 10,000 rpm for 20 minutes at 4°C. The supernatant was used as the enzyme source. The reaction mixture consisted of 200 µl of the enzyme extract and 1.5 ml of 0.1 M sodium phosphate buffer (pH 6.5). To start the reaction, 200 µl of 0.01M catechol was added and the activity was expressed as µmol/min/mg protein.

Peroxidase (PO) activity

Assay of Peroxidase (PO) activity was carried by Hammerschmidt *et al*. (1982) [3] method. Enzymes extract was prepared by homogenizing one gram of leaf samples in 0.1M sodium phosphate buffer (pH 6.0). It was centrifuged at 10,000 rpm for 20 minutes. The reaction mixture consisted of 2.5 ml of a mixture containing 0.25 per cent (v/v) guaiacol in 0.01 M sodium phosphate buffer (pH 6.0) and 0.1 M hydrogen peroxide. Enzyme extract (0.1 ml) was added to initiate the reaction, which was followed colorimetrically at 480 nm. The boiled enzyme preparation served as blank. Activity was expressed as µmol/min/mg protein.

Total phenolics

Total phenolics content was determined as per methodology given by Swain and Hills (1959). One gram leaves were homogenized in 10 ml of 80 per cent methanol and agitated for 15 minute at 70°C. One milliliter of methanolic extract was added to 5 ml of distilled water and 250 µl of Folin-ciocalteu reagent, after this the solution was kept at 25°C. After 3 minutes, 1 ml of a saturated solution of Na_2CO_3 and 1 ml of distilled water were added, and the reaction mixture was incubated for 1 hr at 25°C. The absorbance of the developed color was measured using spectrophotometer at 725 nm. The total soluble phenolic content was calculated by comparison with a standard curve obtained from Folin-Ciocalteu reaction with catechol.

Effect of Nanoparticles on dieback disease of chilli

The effect of nano compounds on No. of spots/leaf and disease severity of dieback disease of chilli was observed. Observations on number of spots/leaf, number of infected leaves/plant were recorded 15 days after inoculation. Disease severity was also recorded 15, 30, 45 and 60 days after inoculation on 0-5 scale suggested by Vishwakarma and Sitaramaiah (1986) [12, 13] and percent disease index (PDI) was calculated as described by McKiney (1923).

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total number of plants observed x maximum rating value}} \times 100$$

Results and Discussion

Effect of Nanoparticles on Polyphenol oxidase (PPO) activity in chilli

The results of the experiment presented in Table 5 revealed that a significant increased in polyphenol activity was recorded in chilli plants treated with abiotic elicitor as compared to control. An increased in PPO activity was recorded at 24 hour interval and reached its higher value at 72 hours after inoculation of *Alternaria tenuissima* while after 72 hrs PPO activity decreased significantly in all the treatments and their concentrations. Among three different concentration of nanoparticles application, 100 μgml^{-1} was found significantly superior over 50 μgml^{-1} followed by 25 μgml^{-1} at every 24 hrs interval. The interaction between treatments, concentrations and time interval was found none significant. This trend was observed at all time durations at its peak *i.e.* 72 hours after treatment. At 100 μgml^{-1} concentration of silicon carbide nano particles the increased PPO activity was (61.11%) which was followed by Titanium dioxide (56.52%), Silver nanoparticles (54.84%), silicon dioxide (53.85%), Aluminium nanoparticles (50.00%) and Zinc oxide (41.67%) respectively higher than initial value (0 hour). Among nanoparticles highest mean increase in PPO activity was recorded in *Silver Nanoparticles* followed by *Aluminium Nanoparticles*, *Titanium dioxide*, *Silicon carbide*, and *Silicon dioxide and Zinc oxide i.e.* 0.039, 0.035, 0.029, 0.023, 0.016 and 0.015 µmol/min/mg protein respectively at 100 μgml^{-1} concentration.

Effect of nanoparticles on Peroxidase (PO) activity in chilli

The peroxidase activity was increased significantly as compared to control in chilli plants treated with abiotic elicitor *Alternaria tenuissima*. An increased in PO activity was recorded at 24 hour and reached its higher value at 72 hours after inoculation of *Alternaria tenuissima* in all the treatments. However after 72 hrs, there has been decrease in polyphenol activity in all the different methods of application. Data pertaining to effect of different nanoparticles on peroxidase activity in chilli presented in Table 2 revealed that all the nanoparticles increased the peroxidase accumulation as compared to control.

Among nanocompounds highest increase in PO activity was recorded in *Zinc oxide* followed by *Silicon dioxide*, Aluminium Nanoparticles, Titanium dioxide, Silver Nanoparticles and Silicon carbide. Among three concentration, 100 μgml^{-1} concentration proved to be the best as compared to 50 μgml^{-1} and 25 μgml^{-1}. In case of 100 μgml^{-1} concentration of nanocompunds *Zinc oxide*, PO activity was 54.31% followed by *Silicon dioxide* (54.01%) and Aluminium Nanoparticles (54.01%) respectively higher than initial value after 72 hours after treatment.

Effect of nanoparticles on total phenol accumulation in chilli

The effect of nanoparticles on total phenol accumulation in chilli after 120 hours of inoculation of *Alternaria tenuissima* was recorded at every 24 hours interval. Among three different concentration of nanoparticles 50 μgml^{-1} concentration was found superior over 25 μgml^{-1} concentration but 100 μgml^{-1} concentrations proved to be the best. The data revealed in Table 3 showed that the total phenol accumulation increases upto 72 hours but later on total phenol activity decreases in all the three concentrations.

Among different nanoparticles highest increase in total phenol content was recorded in *Titanium dioxide* followed by Zinc oxide, Silver Nanoparticles, Aluminium Nanoparticles, Silicon dioxide and Silicon carbide. At 100 µgml^{-1} concentrations of *Titanium dioxide*, total phenol content was 53.41% higher than initial value (0 hour). In case of Zinc oxide, Silver Nanoparticles, Aluminium Nanoparticles and Silicon dioxide it was 53.38, 53.36, 53.35 and 53.34 per cent, respectively.

Effect of nanoparticles on leaf infection of dieback disease of chilli

The nanoparticles reduced the No. of spot/leaf and No. of infected leaves/plant significantly as compared to control. The results of the experiment presented in Table 4 revealed that among three different concentrations 25 µgml^{-1}, 50 µgml^{-1} and 100 µgml^{-1} the highest concentration of nanoparticles showed significantly minimum No. of spot/leaf and No. of infected leaves/plant as compared to other concentrations. The minimum No. of leaf spots/ leaf and No. of infected leaves/plant was recorded 3.11 and 2.00 respectively at 100 µgml^{-1} concentration of Silver Nanoparticles which was followed by Aluminium Nanoparticles *i.e.* 4.11 and 2.56 respectively.

Effect of nanoparticles on severity of dieback disease of chilli

The results of the experiment presented in Table 5 revealed that 15, 30, 45 and 60 days after inoculation (DAI), all the nanoparticles reduced the disease severity of *Alternaria tenuissima* as compared to control. Among treatments having various nanoparticles, at 100 µgml^{-1} Silver Nanoparticles was found best followed by Aluminium Nanoparticles while least effective was in case of Zinc oxide after control. The percent disease severity was found minimum in Silver Nanoparticles *i.e.* 0.00, 0.00, 4.00, 8.00 and 8.00 followed by Aluminium Nanoparticles *i.e.* 4.00, 4.00, 08.00 and 12.00 at 100 µgml^{-1} concentration at 15, 30, 45 and 60 DAI respectively.

The fungus causing leaf spot, fruit rot and early dieback of chilli under *tarai* conditions of Uttarakhand was established as *Alternaria tenuissima* (Kunze ex Pers.) Wiltshire which is probably the first report from India so very few works were done with the same crop.

The present study clearly showed increased activity of PO, PPO and Phenol in treated plants as compared to control. These finding are in accordance of Hasanuzzaman and Fujita (2013) who reported that application of silver nano particles enhanced the activity of different antioxidant enzymes like poly phenol oxidase, peroxidase and total phenol. Chandra *et al*. (2015) [2] and Zhao (2007) [17] have reported that exogenous application of chitosan nanoparticles on tea leaves elevated the defense response in the tea plant and observed higher accumulation of PO, PPO, β-,3 glucanase, and PAL in the CNP treated leaves. Park *et al.* (2006) [9] observed the efficacy of silica–silver nanoparticles in the control of plant pathogenic fungi viz. *Botrytis cinerea*, *Rhizoctonia solani*, *Colletotrichum gloeosporioides*, *Magnaporthe grisea* and *Pythium ultimum*. Wani and Shah (2012) [16] observed release of extracellular enzymes and metabolites by application of Magnesium oxide and Zinc oxide nanoparticles against *Alternaria alternata*, *Fusarium oxysporum*, *Rhizipus stolonifer* and *Mucor plumbeus*. Imada *et al*. (2015) [5] have found that Magnesium oxide nanoparticles induce systemic resistance in tomato plants against *Ralstonia solanacearum*. Exogenous application of chitosan nanoparticles on tea leaves elevated the defense response in the tea plant and promoted higher accumulation of Peroxidase, Polyphenol oxidase, β -1,3-glucanase, Phenylalanine lyase in the chitosan nanoparticles treated leaves.

Table 1: Effect of Nanoparticles on Polyphenol oxidase (PPO) activity in chilli

Treatments	POLYPHENOL OXIDASE (µmol/min/mg protein)																				
	0 Hr			24 Hrs			48 Hrs			72Hrs			96 Hrs			120 Hrs			Mean		
	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}
Silver Nanoparticles	0.023	0.026	0.031	0.026	0.030	0.035	0.030	0.035	0.041	0.036	0.041	0.048	0.031	0.036	0.041	0.028	0.033	0.038	0.029	0.034	0.039
Aluminium Nanoparticles	0.020	0.024	0.028	0.023	0.027	0.031	0.027	0.031	0.036	0.032	0.035	0.042	0.027	0.032	0.037	0.025	0.031	0.035	0.026	0.030	0.035
Silicon carbide	0.013	0.016	0.018	0.016	0.018	0.021	0.018	0.021	0.024	0.022	0.025	0.029	0.018	0.022	0.024	0.018	0.020	0.023	0.017	0.021	0.023
Silicon dioxide	0.011	0.012	0.013	0.012	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.020	0.014	0.015	0.017	0.013	0.014	0.015	0.013	0.014	0.016
Titanium dioxide	0.016	0.021	0.023	0.019	0.023	0.027	0.022	0.026	0.030	0.026	0.032	0.036	0.022	0.027	0.031	0.021	0.025	0.028	0.021	0.026	0.029
Zinc oxide	0.011	0.012	0.012	0.012	0.013	0.013	0.014	0.015	0.015	0.016	0.017	0.017	0.014	0.015	0.016	0.013	0.014	0.014	0.013	0.014	0.015
Control	0.010	0.010	0.010	0.011	0.011	0.011	0.013	0.013	0.013	0.015	0.015	0.015	0.013	0.013	0.013	0.012	0.012	0.012	0.012	0.012	0.012
Mean	0.015	0.017	0.019	0.017	0.019	0.022	0.020	0.022	0.025	0.023	0.026	0.030	0.020	0.023	0.026	0.019	0.021	0.024	0.019	0.021	0.024
CD at 1 %	a=0.0003 b=0.0002 c=0.0003 a x b= 0.0006 b x c=0.0009 c x a =0.0005 a x b x c=0.0011																				
CV	4.5951																				

a = Treatments b =Concentrationc = Hours

Table 2: Effect of Nanoparticles on Peroxidase (PO) activity in chilli

Treatments	Peroxidase (µmol/min/mg protein)																				
	0 Hr			24 Hrs			48 Hrs			72Hrs			96 Hrs			120 Hrs			Mean		
	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}
Silver Nanoparticles	0.254	0.297	0.349	0.287	0.335	0.395	0.330	0.386	0.454	0.389	0.455	0.535	0.342	0.400	0.472	0.318	0.372	0.438	0.320	0.374	0.441
Aluminium Nanoparticles	0.230	0.279	0.303	0.261	0.315	0.343	0.300	0.363	0.395	0.354	0.428	0.466	0.311	0.377	0.410	0.290	0.351	0.381	0.291	0.352	0.383
Silicon carbide	0.154	0.176	0.202	0.175	0.198	0.228	0.201	0.228	0.262	0.237	0.270	0.309	0.209	0.238	0.272	0.194	0.221	0.253	0.195	0.222	0.254
Silicon dioxide	0.078	0.124	0.137	0.088	0.140	0.155	0.101	0.162	0.178	0.120	0.191	0.211	0.105	0.167	0.185	0.098	0.156	0.172	0.098	0.157	0.173
Titanium dioxide	0.186	0.220	0.253	0.211	0.248	0.286	0.243	0.286	0.330	0.286	0.337	0.389	0.252	0.297	0.342	0.234	0.276	0.318	0.235	0.277	0.320
Zinc oxide	0.068	0.106	0.116	0.076	0.120	0.132	0.088	0.137	0.152	0.104	0.162	0.179	0.092	0.142	0.157	0.086	0.132	0.146	0.086	0.133	0.147
Control	0.067	0.067	0.067	0.075	0.075	0.075	0.087	0.087	0.087	0.103	0.103	0.103	0.091	0.091	0.091	0.084	0.084	0.084	0.084	0.084	0.084
Mean	0.148	0.181	0.204	0.167	0.205	0.231	0.193	0.236	0.265	0.228	0.278	0.313	0.200	0.244	0.276	0.186	0.227	0.256	0.187	0.229	0.257
CD at 1 %	a=0.002 b=0.001 c=0.002 a x b= 0.003 b x c=0.005 c x a =0.003 a x b x c=0.009																				
CV	2.634																				

a = Treatments b =Concentration c = Hours

Table 3: Effect of Nanoparticles on total phenol accumulation in chilli

Treatments	Total Phenols (mg/gm of fresh leaf)																				
	0 Hr			24 Hrs			48 Hrs			72Hrs			96 Hrs			120 Hrs				Mean	
	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	10 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}
Silver Nanoparticles	5.836	6.829	8.029	6.595	7.717	9.073	7.584	8.875	10.434	8.950	10.472	12.313	7.786	9.111	10.711	7.163	8.382	9.854	7.319	8.564	10.069
Aluminium Nanoparticles	5.302	6.414	6.976	5.991	7.248	7.883	6.890	8.335	9.066	8.130	9.835	10.698	7.074	8.557	9.307	6.507	7.872	8.564	6.649	8.044	8.749
Silicon carbide	3.569	4.043	4.651	4.033	4.569	5.256	4.638	5.255	6.044	5.473	6.201	7.132	4.762	5.395	6.205	4.381	4.963	5.708	4.476	5.071	5.832
Silicon dioxide	1.807	2.858	3.155	2.042	3.230	3.565	2.348	3.714	4.100	2.771	4.382	4.838	2.410	3.813	4.209	2.217	3.508	3.872	2.266	3.584	3.956
Titanium dioxide	4.296	5.065	5.834	4.854	5.724	6.595	5.582	6.582	7.585	6.586	7.767	8.950	5.731	6.757	7.786	5.272	6.217	7.163	5.387	6.352	7.319
Zinc oxide	1.536	2.429	2.681	1.732	2.745	3.030	1.996	3.157	3.485	2.355	3.725	4.112	2.049	3.241	3.577	1.885	2.982	3.291	1.925	3.046	3.363
Control	0.755	0.755	0.755	0.854	0.854	0.854	0.982	0.982	0.982	1.159	1.159	1.159	1.008	1.008	1.008	0.927	0.927	0.927	0.948	0.948	0.948
Mean	3.300	4.056	4.583	3.729	4.584	5.179	4.289	5.271	5.956	5.061	6.220	7.029	4.403	5.412	6.115	4.050	4.979	5.626	4.139	5.087	5.748
CD at 1 %	a=0.056 b=0.036 c=0.052 a x b= 0.097 b x c=0.138 c x a =0.090 a x b x c=0.239																				
CV	2.978																				

a = Treatments b =Concentration c = Hours

Table 4: Effect of Nanoparticles on leaf infection of chilli by *Alternaria tenuissima* (Kunze ex Pers.) Wiltshire.

Treatments	No. of spots/leaf			No. of infected leaves/plant		
	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}
Silver Nanoparticles	5.56	4.89	3.11	3.56	3.00	2.00
Aluminium Nanoparticles	6.33	5.67	4.11	4.00	3.67	2.56
Silicon carbide	9.22	8.56	6.22	6.00	5.56	4.00
Silicon dioxide	10.89	10.11	7.67	7.11	6.56	4.89
Titanium dioxide	8.00	7.33	5.33	5.11	4.67	3.33
Zinc oxide	12.22	10.67	8.44	8.00	6.89	5.44
Control	14.11	14.11	14.11	9.22	9.22	9.22
CD at 1 %	a=0.65 b= 0.42 axb=1.13			a=0.43 b= 0.28 axb=0.75		
CV	10.95			11.31		

Table 5: Effect of Nanoparticles on severity of *Alternaria tenuissima* (Kunze ex Pers.) Wiltshire.

Treatments	PDI at 15 DAI*			PDI at 15 DAI*30 DAI			PDI at 15 DAI*45 DAI		PDI at 15 DAI*60 DAI			
	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}	25 µgml^{-1}	50 µgml^{-1}	100 µgml^{-1}
Silver Nanoparticles	5.33	4.00	0.00	9.33	4.00	0.00	13.33	8.00	4.00	17.33	12.00	8.00
Aluminium Nanoparticles	9.33	4.00	4.00	13.33	8.00	4.00	17.33	12.00	8.00	21.33	16.00	12.00
Silicon carbide	9.33	8.00	8.00	17.33	12.00	12.00	25.33	20.00	16.00	33.33	28.00	24.00
Silicon dioxide	13.33	12.00	8.00	21.33	16.00	12.00	29.33	24.00	20.00	36.00	32.00	28.00
Titanium dioxide	9.33	8.00	4.00	17.33	12.00	8.00	21.33	16.00	12.00	29.33	24.00	20.00
Zinc oxide	17.33	16.00	12.00	25.33	20.00	12.00	33.33	28.00	24.00	41.33	36.00	32.00
Control	21.33	21.33	21.33	29.33	29.33	29.33	36.00	36.00	36.00	60.00	60.00	60.00
CD at 1 %	a= 1.43 b=0.94 axb=2.49			a=1.43 b=0.94 axb=2.49			a=1.17 b=0.76 axb=2.03		a=1.17 b=0.76 axb=2.03			
CV	14.70			10.18			5.89		4.10			

DAI* = Days after inoculation a= Treatments b= Concentrations

References

1. Beckers GJM, Conrath U. Priming for stress resistance: from the lab to the field. Current Opinion in Plant Biology. 2007; 10:425-431.
2. Chandra S, Chakraborty N, Dasgupta A, Sarkar J, Panda K, Acharya K. scientific reports, www.nature.com. 2015, 1-14.
3. Hammerschmidt R, Nuckles EM, Kuc J. Association of enhanced peroxidise activity with induced systemic resistance of cucumber to Colletotrichum lagenarium. Physiological Plant Pathology. 1982; 20:73-82.
4. Hasanuzzaman M, Fujita M. Exogenous sodium nitroprusside alleviates arsenic-induced oxidative stress in wheat (*Triticum aestivum* L.) seedlings by enhancing antioxidant defense and glyoxalase system. Ecotoxicology. 22, 584–596.
5. Imada K, Sarkar S, Kajihara S Tanaka, Ito S. Magnesium oxide nanoparticles induce systemic resistance in tomato against bacterial wilt disease. Plant Pathology. 2015; 65:551-560.
6. Mayer AM, Harel E, Shaul RB. Assay of catechol oxidase: a critical comparison of methods. Phytochemistry. 2015; 1965; 5:783-789.
7. Mc-Kinney HH. Influence of soil temperature and moisture on infection of wheat seedlings by Helminthosporium sativum. Journal of Agricultural Research. 1923; 26:195-217.
8. NHB. Indian Horticulture Database. National Horticulture Board. India: Ministry of Agriculture, Government of India, 2016.
9. Park HJ, Kim SH, Kim HJ, Choi SH. A new composition of nanosized silica-silver for control of various plant diseases. Plant Pathology Journal. 2006; 22:295–302.
10. Swain T, Hills WE. Phenolic constituents of *Prunus domestica*. I. Quantitative analysis of phenolics constituents. Journal of Science Food and Agriculture. 1959; 10:63-68.
11. Swain T, Hills WE. Phenolic constituents of *Prunus domestica*. I. Quantitative analysis of phenolics constituents. Journal of Science Food and Agriculture. 1959; 10:63-68.
12. Vishwakarama SN, Sitaramaiah K. Relative efficacy of fungicides in field for the control of die-back and fruit rot of chilli (*Capsicum annum* L.), Advances in Biological Research.1986; 4:128-137.
13. Vishwakarama SN, Sitaramaiah K. Relative efficacy of fungicides in field for the control of die-back and fruit rot of chilli (*Capsicum annum* L.), Advances in Biological Research. 1986; 4:128-137.
14. Walters DR, Fountaine JM. Practical application of induced resistance to plant diseases: an appraisal of effectiveness under conditions. Journal of Agricultural Sciences. 2009; 147:523-535.
15. Walters DR, Fountaine JM. Practical application of induced resistance to plant diseases: an appraisal of effectiveness under conditions. Journal of Agricultural. Sciences. 2009; 147:523-535.
16. Wani AH, Shah MA. A unique and profound effect of MgO and ZnO nanoparticles on some plant pathogenic fungi. Journal of Applied Pharmaceutical Science. 2012; 02(03):40-44.
17. Zhao XM, She XP, Yu W, Liang XM, Du YG. Effects of oligochitosans on tobacco cells and role of endogenous nitric oxide burst in the resistance of tobacco to Tobacco mosaic virus. Journal of Plant Pathology. 2007; 89:55–65.