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Alterations in Defense Enzymes by Azoxystrobin and Chaetoglobosin Biomolecules in Chilli

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A B S T R A C T

The activity of defense enzymes *viz*., peroxidase, polyphenol oxidase, catalase and superoxide dismutase up on treatment with azoxystrobin and chaetoglobosin was studied in this experiment. The chilli plants inoculated with *C.capsici* showed various levels of peroxidase activity with respect to the treatments. The combined application of azoxystrobin with chaetoglobosin at 0.2 per cent concentration showed the highest level of peroxidase activity (1.130). The next highest level (0.872) was observed in azoxystrobin with tebuconazole combination. In the case of chilli plants inoculated with *L. taurica*, the maximum peroxidase activity was recorded in the same combination (0.817). The highest polyphenol oxidase activity in chilli plants inoculated with *C.capsici* recorded in azoxystrobin and chaetoglobosin combination (0.883). The next best increase (0.721) of PPO was noted in combined application of azoxystrobin with tebuconazole at 0.2 per cent concentration. The same trend was noticed when chilli plant inoculated with *L. taurica*. In the case of catalase and superoxide dismutase, azoxystrobin and chaetoglobosin combination, followed by azoxystrobin (Willowood) and tebuconazole combination showed the highest level of activity in chilli plants inoculated with *C. capsici* and *L.taurica.*

Introduction

The activity of defense enzymes *viz*., peroxidase (PO), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), β-1,3 glucanase, chitinase, catalase and defense inducing chemicals (total phenols) was found to be increased in azoxystrobin and *P. fluorescens* treated chilli plants (Amrita *et al.*, 2016). Increased expression of specific isoforms of PO and PPO was observed due to Induced Systemic Resistance (ISR) induction (Zahidi *et al.*, 2018). Peroxidase polymorphism could be used as a biochemical marker related to different levels of field resistance (Lebeda *et al.*, 1999). Peroxidases also participate in synthesis of phenolic compounds and in the building of intermolecular bonds during the organization of the cell wall at the sites of infection by the pathogens (Repka and Slovakova, 1994). Many studies have shown that PPO is induced in response to mechanical wounding; fungal and bacterial infection; treatment with

signaling molecules such as jasmonic acid / methyl jasmonate (MeJA); system in and salicylic acid (Yadav *et al.,* 2017). Sundravadana (2008) reported that, azoxystrobin had efficiently activated the defense enzymes *viz.,* PO, PPO, and PAL which are increased the lignin content in *P. grisea* inoculated rice seedlings. Systemic induction of PPO in response to wounding and pathogen infection might provide an additional line of defense to protect the plants against further attack by pathogen and insects (Thipyapong *et al.,* 1995).

Application of salicylic acid on bluegrass plants increased the activity of catalase and super oxide dismutase (Mckersie *et al.,* 1996). Babitha (2002) reported the higher SOD activity in resistant pearl millet seedlings than the susceptible seedlings upon inoculation with *Sclerospora graminicola.* The fungicides such as ketoconazole, propiconazole and azoxystrobin increased the production of antioxidant enzymes *viz.,* superoxide dismutase, catalase, and peroxidases in plants (Abdul *et al.,* 2008; Gonias *et al.,* 2008).

Materials and Methods

Induction of defense related enzymes in chilli up on treatment with azoxystrobin and chaetoglobosin was assayed by using the methodologies given below. In all the experiments, tebuconazole was included for comparison purpose.

Assay of defense related enzymes

The fungicide azoxystrobin at 0.2 per cent concentration were compared with 0.2 per cent of chaetoglobosin and tebuconazole for the induction of defense related enzymes. Chilli plants sprayed with above treatments and where inoculated with *Colletotrichum capsici, Leveilulla taurica*. The leaf samples were collected at 0, 1, 3, 5, 7, 9 d after inoculation of the pathogen and used for enzyme assay.

One g of chilli leaf sample was homogenized with one ml of 0.1M Sodium phosphate buffer (pH 7.0) at 4 ^{0}C. The homogenate was centrifuged for 20 min at 10000 rpm. The supernatant was used as enzyme extract for assaying of Peroxidase (PO) and Poly Phenol Oxidase (PPO). For Catalase and Super oxide Dismutase (SOD) the sample was extracted in 5 ml of 0.05 M sodium acetate buffer (pH 5.0). The homogenate was centrifuged at 20,000 rpm for 10 min at 4°C and the supernatant was used as enzyme source.

Assay of peroxidase (PO)

Assay of PO activity was carried out as per the procedure described by Hammerschmidt *et al.,* (1995). The reaction mixture consisted of 2.5 ml of the mixture containing 0.25% (v/v) guaiacol in 0.01 M sodium phosphate buffer, pH 6.0 and 0.1 M hydrogen peroxide. Enzyme extract (0.1ml) was added to initiate the reaction, which was followed calorimetrically at 470 nm. Crude enzyme preparations were diluted to give changes in absorbance at 470 nm of 0.1 to 0.2 absorbance units / min. The boiled enzyme was used as blank. Activity was expressed as the increase in absorbance at 420 nm min^{-1} mg^{-1} of protein.

Assay of polyphenoloxidase (PPO)

The polyphenoloxidase activity was determined as per the procedure given by Mayer *et al.,* (1965). The reaction mixture consisted of 1.5 ml of 0.1 M sodium phosphate buffer (pH 6.5) and 200 µl of the enzyme extract. To start the reaction, 200 µl of 0.01 M catechol was added and the activity was expressed as change in absorbance at 495 $min^{-1}mg^{-1}$ of protein.

Assay of catalase (CAT)

CAT activity was assayed spectrophotometrically as described by Chaparro-Giraldo *et al.,* (2000) using 3 ml assay mixture containing 100 mM potassium phosphate buffer (pH 7.5) and 2.5 mM H_2O_2 prepared immediately before use and 100 µl enzyme extract. The activity was measured by monitoring the degradation of H_2O_2 using UV-Visible Spectrophotometer (Varian Cary 50) at 240 nm over 1 min, against a plant extract-free blank. The decrease in H_2O_2 was followed as the decline in optical density at 240 nm, activity was calculated using the extinction coefficient (ε_{240nm} = 40 mM^{-1} cm^{-1}) for H_2O_2 and expressed in µmol min^{-1} mg^{-1} of sample.

Assay of superoxide dismutase (SOD)

The enzyme extract was prepared by homogenizing 1 g of chilli tissue in 2 ml of 0.2 M citrate phosphate buffer (pH 6.5) at 4°C. The homogenate was centrifuged at 15,000 g at 4°C for 30 min. The supernatant served as enzyme source and SOD activity (EC 1.15.1.1) was determined as its ability to inhibit the photochemical reduction of NBT. The assay mixture (3 ml) contained 50 mM sodium phosphate buffer (pH 7.8), 13 mM methionine, 75 µM NBT, 2 µM riboflavin. 0.1 mM EDTA and 100 µl of the enzyme extract and the riboflavin was added at the end. Tubes were shaken and placed under a 40-W fluorescent lamp at 25°C.

The reaction was initiated and terminated by turning the light on and off respectively. The absorbance at 560 nm was measured against identical non-illuminated in parallel to the sample tubes for blank. Each extract was subtracted from the blank and mathematical difference was then divided by blank and multiplied by 100 to obtain the percentage inhibition of NBT photo-reduction. The SOD activity was expressed in SOD units mg^{-1} tissue (50% NBT inhibition = 1 unit) (El-Moshaty *et al.,* 1993).

Results and Discussion

Changes in peroxidase (PO)

The chilli plants inoculated with *C.capsici* showed various levels of peroxidase activity with respect to the treatments. The combined application of azoxystrobin with chaetoglobosin at 0.2 per cent concentration showed the highest level of peroxidase activity (1.130). The next highest level (0.872) was observed in azoxystrobin with tebuconazole combination. The lowest peroxidase activity (0.157) was observed in uninoculated control.

In the case of chilli plants inoculated with *L. taurica,* the maximum peroxidase activity was recorded in combined application of azoxystrobin (Willowood) with chaetoglobosin (0.817). The next highest (0.725) peroxidase activity observed in individual application of azoxystrobin; azoxystrobin and tebuconazole combination (0.702) also showed significant increase of peroxidase activity than the inoculated (0.231) and uninoculated (0.158) control (Table 1 and 2; Fig. 1 and 2).

Changes in polyphenoloxidase (PPO)

The experimental results revealed that the activity of polyphenol oxidase was progressively increased in all the treatments when compared to both inoculated (0.183) and uninoculated (0.152) control. Among the different treatments, combination of azoxystrobin with chaetoglobosin recorded the highest polyphenol oxidase activity in chilli plants inoculated with *C.capsici* (0.883). The next best increase (0.721) of PPO was noted in combined application of

azoxystrobin with tebuconazole at 0.2 per cent concentration. The same trend was noticed when chilli plant inoculated with *L. taurica*. The highest PPO (1.016) activity was noticed when both biomolecules were combined. The next best increase of PPO activity was noticed in combination of azoxystrobin with tebuconazole (0.936) which is onpar with tebuconazole and chaetoglobosin (0.901) combination and individual application of azoxystrobin (0.917) and chaetoglobosin (0.889) (Table 2 and 3; Fig. 3 and 4).

Changes in catalase (CAT)

Azoxystrobin (Willowood) and chaetoglobosin combination (0.942), followed by azoxystrobin (Willowood) and tebuconazole combination (0.761) showed the highest level of catalase activity in chilli plants inoculated with *C. capsici.* The lowest catalase activity was noticed in uninoculated (0.364) control.In the case of chilli plants inoculated with *L.taurica*, the same combination showed the highest (0.895) level of catalase activity (Table 5 and 6; Fig. 5 and 6).

Changes in superoxide dismutase (SOD)

The combined application of azoxystrobin (Willowood) with chaetoglobosin at 0.2 per cent concentration on chilli showed the highest SOD activity against *C.capsici* and *L.taurica* (9.32 and 8.84).Which is followed by, the combination of azoxystrobin with tebuconazole showed the second maximum increase of SOD activity against both the pathogens (9.00 and 8.06). The minimum SOD activity was recorded in uninoculated control (Table 7 and 8; Fig. 7 and 8).

Table.1 Effect of azoxystrobin, chaetoglobosin and tebuconazole on peroxidase activity in chilli plants inoculated with *C. capsici*

Treatment	Absorbance at 420 ηm min^{-1} g^{-1} at different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2%	0.364^{a}	0.542^{a}	0.613^{b}	0.736^{cd}	0.802^{cd}	**0.721^{cd}**
Chaetoglobosin 0.2 %	0.329^{b}	0.531^{a}	0.604^{b}	0.765^{cd}	0.739^{de}	**0.718^{cd}**
Tebuconazole 0.2%	0.290^{c}	0.484^{b}	0.620^{b}	0.701^{d}	0.728^{e}	**0.692^{d}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.336^{b}	0.542^{a}	0.802^{a}	1.158^{a}	1.134^{a}	**1.13 0^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.278^{cd}	0.322^{cd}	0.532^{c}	0.792b^{c}	0.840^{c}	**0.762^{c}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.298^{c}	0.336^{c}	0.571^{bc}	0.847^{b}	0.918^{b}	**0.872^{b}**
Inoculated Control	0.263^{d}	0.287^{d}	0.349^{d}	0.368^{e}	0.305^{f}	**0.276^{e}**
Un inoculated control	**0.143^{e}**	**0.175^{e}**	**0.218^{e}**	**0.226^{f}**	**0.191^{g}**	**0.157^{f}**

Mean of three replications

In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.2 Effect of azoxystrobin, chaetoglobosin and tebuconazole on peroxidase activity in chilli plants inoculated with *L. taurica*

Treatment	Absorbance at 420 ηm min^{-1} g^{-1} at different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2 %	0.298^{a}	0.486^{b}	0.627^{b}	0.741^{bc}	0.739^{b}	**0.725^{b}**
Chaetoglobosin 0.2 %	0.315^{a}	0.493^{b}	0.574^{cd}	0.726^{c}	0.696^{b}	**0.684^{b}**
Tebuconazole 0.2%	0.267^{b}	0.407^{c}	0.562^{d}	0.698^{c}	0.679^{b}	**0.622^{c}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.306^{a}	0.592^{a}	0.708^{a}	0.958^{a}	0.925^{a}	**0.817^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.218^{c}	0.322^{d}	0.532^{d}	0.792^{b}	0.710^{b}	**0.693^{b}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.290^{a}	0.484^{b}	0.620^{bc}	0.736^{bc}	0.714^{b}	**0.702^{b}**
Inoculated Control	0.261^{b}	0.284^{e}	0.316^{e}	0.286^{d}	0.273^{c}	**0.231^{d}**
Un inoculated control	**0.136^{d}**	**0.159^{f}**	**0.207^{f}**	**0.226^{e}**	**0.197^{d}**	**0.158^{e}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.3 Effect of azoxystrobin, chaetoglobosin and tebuconazole on polyphenol oxidase (PPO) activity in chilli plants inoculated with *C. capsici*

Treatment	Absorbance at 495ηm min^{-1} g^{-1} at different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2 %	0.283^{abc}	0.394^{d}	0.551^{d}	0.856^{b}	0.748^{c}	**0.673b**
Chaetoglobosin 0.2 %	0.294^{a}	0.425^{c}	0.676^{b}	0.896^{b}	0.751^{c}	**0.607^{c}**
Tebuconazole 0.2%	0.260^{bcd}	0.367^{e}	0.644^{bc}	0.74 0^{c}	0.680^{d}	**0.413^{e}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.288^{a}	0.462^{b}	0.794^{a}	0.995^{a}	0.927^{a}	**0.883^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.253^{d}	0.346^{f}	0.594^{cd}	0.829^{b}	0.795^{b}	**0.501^{d}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.259^{cd}	0.536^{a}	0.678^{b}	0.890^{b}	0.743^{c}	**0.721^{b}**
Inoculated Control	0.284^{ab}	0.289^{g}	0.297^{e}	0.212^{d}	0.206^{e}	**0.183^{f}**
Un inoculated control	**0.200^{e}**	**0.230^{h}**	**0.260^{e}**	**0.200^{d}**	**0.190^{e}**	**0.152^{f}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per centlevelby DMRT

Table.4 Effect of azoxystrobin, chaetoglobosin and tebuconazole on polyphenol oxidase (PPO) activity in chilli plants inoculated with *L. taurica*

Treatment	Absorbance at 495ηm min^{-1} g^{-1} at different intervals (d)					
	0	1	3	5	7	9
Azoxystrobin 0.2 %	0.313^{c}	0.629^{bc}	0.847^{a}	0.971^{bc}	0.944^{b}	**0.917^{bc}**
Chaetoglobosin 0.2 %	0.394^{b}	0.643^{b}	0.796^{ab}	0.923^{bc}	0.901^{b}	**0.889^{bc}**
Tebuconazole 0.2%	0.278^{e}	0.464^{de}	0.685^{d}	0.892^{c}	0.879^{b}	**0.853^{c}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.337^{c}	0.698^{a}	0.847^{a}	1.274^{a}	1.112^{a}	**1.016^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.311^{cd}	0.583^{c}	0.729^{cd}	0.984^{b}	0.916^{b}	**0.901^{bc}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.434^{a}	0.496^{d}	0.752^{bc}	0.956^{bc}	0.944^{b}	**0.936^{b}**
Inoculated Control	0.282^{de}	0.437^{e}	0.579^{e}	0.703^{d}	0.688^{c}	**0.659^{d}**
Un inoculated control	**0.264^{e}**	**0.379^{f}**	**0.485^{f}**	**0.691^{d}**	**0.653^{c}**	**0.614^{d}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.5 Effect of azoxystrobin, chaetoglobosin and tebuconazole on catalase activity in chilli plants inoculated with *C. capsici*

Treatment	changes in absorbance at 240 nm min^{-1} g^{-1} at different intervals (d)					
	0	1	3	5	7	9
Azoxystrobin 0.2%	0.448^{ab}	0.653^{a}	0.774^{ab}	0.859^{cd}	0.792^{bc}	**0.718^{b}**
Chaetoglobosin 0.2 %	0.397^{c}	0.510c	0.760^{ab}	0.844^{cd}	0.738^{c}	**0.701^{bc}**
Tebuconazole 0.2%	0.402^{c}	0.629^{ab}	0.731^{bc}	0.824^{d}	0.769^{bc}	**0.652^{cd}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.472^{a}	0.643^{a}	0.814^{a}	1.106^{a}	0.983^{a}	**0.942^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.324^{d}	0.590^{b}	0.684^{c}	0.912^{bc}	0.812^{b}	**0.624^{d}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.423^{bc}	0.612^{ab}	0.763^{ab}	0.960^{b}	0.818^{b}	**0.761^{b}**
Inoculated Control	0.337^{d}	0.339^{e}	0.427^{e}	0.518^{e}	0.483^{d}	**0.497^{e}**
Un inoculated control	**0.323^{d}**	**0.394^{d}**	**0.516^{d}**	**0.430^{f}**	**0.356^{e}**	**0.364^{f}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.6 Effect of azoxystrobin, chaetoglobosin and tebuconazole on catalase activity in chilli plants inoculated with *L. taurica*

Treatment	changes in absorbance at 240 nm min-^{1}g-^{1}at different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2%	0.323^{c}	0.475^{cd}	0.691^{b}	0.862^{bc}	0.799^{b}	**0.747^{b}**
Chaetoglobosin 0.2 %	0.307^{cd}	0.618^{a}	0.688^{b}	0.749^{d}	0.701^{c}	**0.695^{bc}**
Tebuconazole 0.2%	0.397a	0.443^{d}	0.617^{c}	0.798^{cd}	0.593^{d}	**0.574^{d}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	0.301^{d}	0.558^{b}	0.827^{a}	0.974^{a}	0.912^{a}	**0.895^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	0.385^{a}	0.476^{cd}	0.589^{cd}	0.798^{cd}	0.683^{c}	**0.641^{c}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	0.324^{c}	0.497^{c}	0.686^{b}	0.907^{ab}	0.896^{a}	**0.874^{a}**
Inoculated Control	0.360^{b}	0.389^{e}	0.571^{cd}	0.594^{f}	0.567^{de}	**0.496^{e}**
Un inoculated control	**0.301^{d}**	**0.469^{cd}**	**0.543^{d}**	**0.677^{e}**	**0.522^{e}**	**0.470^{e}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.7 Effect of azoxystrobin, chaetoglobosin and tebuconazole on superoxide dismutase (SOD) activity in chilli plants inoculated with *C. capsici*

Treatment	Unit / min / g of sample at 560 nm in different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2%	3.651^{ab}	4.89^{a}	6.12^{c}	8.87^{a}	9.34^{b}	**9.00^{a}**
Chaetoglobosin 0.2 %	3.293^{cd}	3.57^{c}	5.84^{c}	7.94^{b}	7.18^{c}	**6.62^{c}**
Tebuconazole 0.2%	3.562^{bc}	4.21^{b}	4.56^{d}	5.22^{d}	5.42^{d}	**4.96^{d}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	3.368^{bc}	5.24^{a}	7.49^{a}	9.21^{a}	10.33^{a}	**9.32^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	3.016^{de}	4.45^{b}	5.73^{c}	6.49^{c}	5.91^{d}	**5.48^{d}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	3.941^{a}	4.29^{b}	6.73^{b}	8.71^{a}	7.78^{c}	**7.32^{b}**
Inoculated Control	3.393^{bc}	3.74^{c}	3.84^{e}	3.96^{e}	3.94^{e}	**3.55^{e}**
Un inoculated control	**2.980^{e}**	**2.67^{d}**	**3.24^{f}**	**2.34^{f}**	**2.68^{f}**	**2.12^{f}**

Mean of three replications
In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Table.8 Effect of azoxystrobin, chaetoglobosin and tebuconazole on superoxide dismutase (SOD) activity in chilli plants inoculated with *L. taurica*

Treatment	Unit / min / g of sample at 560 nm in different intervals (d)					
	0	**1**	**3**	**5**	**7**	**9**
Azoxystrobin 0.2%	2.76^{ab}	4.23^{a}	6.24^{b}	8.31a^{bc}	8.04^{bc}	**7.79^{bc}**
Chaetoglobosin 0.2 %	2.84^{ab}	3.99^{ab}	6.01^{b}	7.99b^{cd}	7.64^{cd}	**7.15^{d}**
Tebuconazole 0.2%	2.68^{b}	3.61^{cd}	5.83^{b}	7.45^{d}	7.21^{d}	**6.99^{d}**
Azoxystrobin 0.2% + Chaetoglobosin 0.2 %	2.58^{b}	3.87^{bc}	6.87^{a}	8.94^{a}	8.86^{a}	**8.84^{a}**
Tebuconazol 0.2% + Chaetoglobosin 0.2 %	2.79^{ab}	3.44^{d}	4.99^{c}	7.69^{cd}	7.42^{cd}	**7.42^{cd}**
Azoxystrobin 0.2% + Tebuconazol 0.2 %	2.98^{a}	4.03^{ab}	6.19^{b}	8.64^{ab}	8.33^{ab}	**8.06^{b}**
Inoculated Control	2.65^{b}	3.01^{e}	3.17^{d}	2.99^{e}	2.99^{e}	**2.98^{e}**
Un inoculated control	**2.26^{c}**	**2.87^{e}**	**2.94^{d}**	**2.85^{e}**	**2.84^{e}**	2.43^{e}

Mean of three replications

In a column, means followed by same letter are not significantly different at the 5 per cent level by DMRT

Fig.1

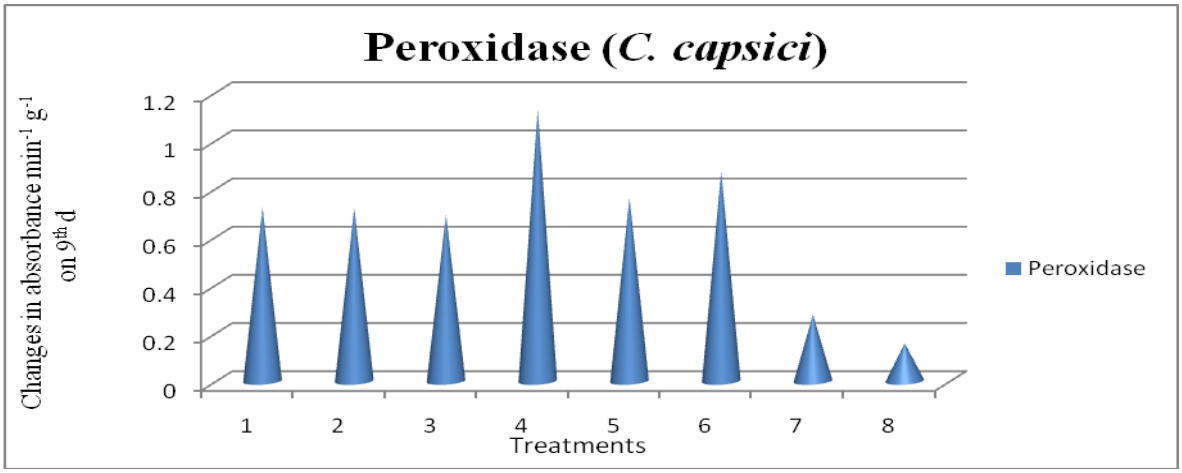


Fig.2

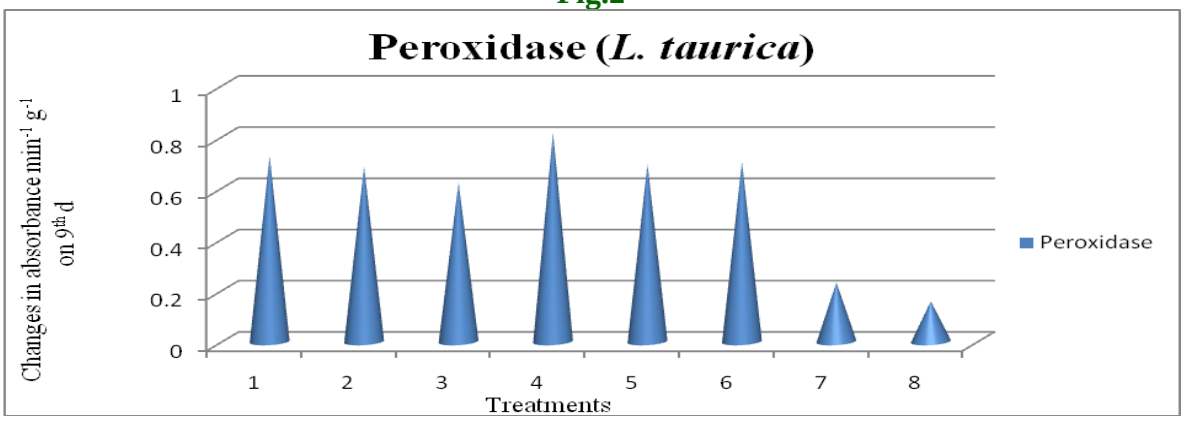


Fig.3

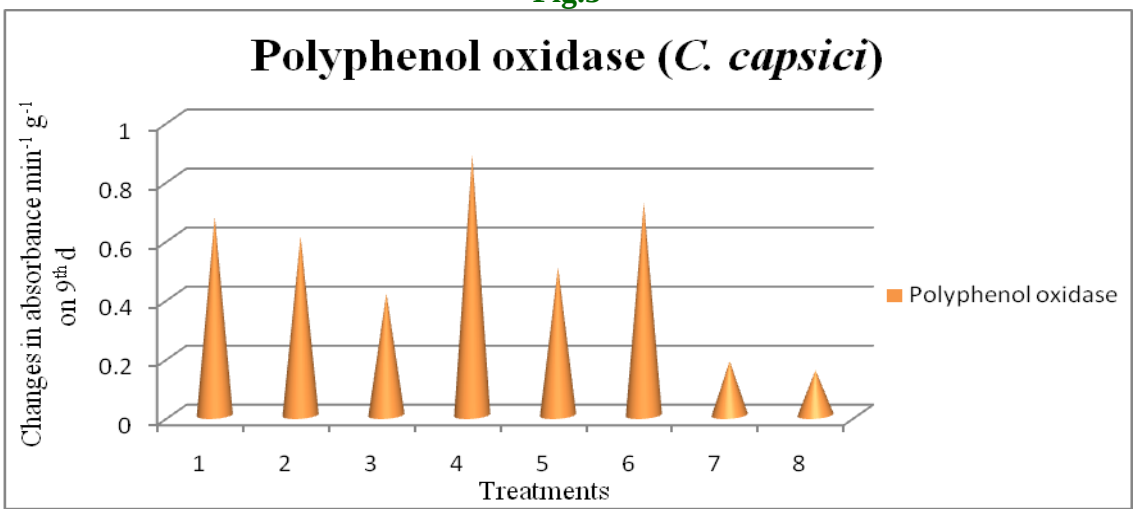


Fig.4

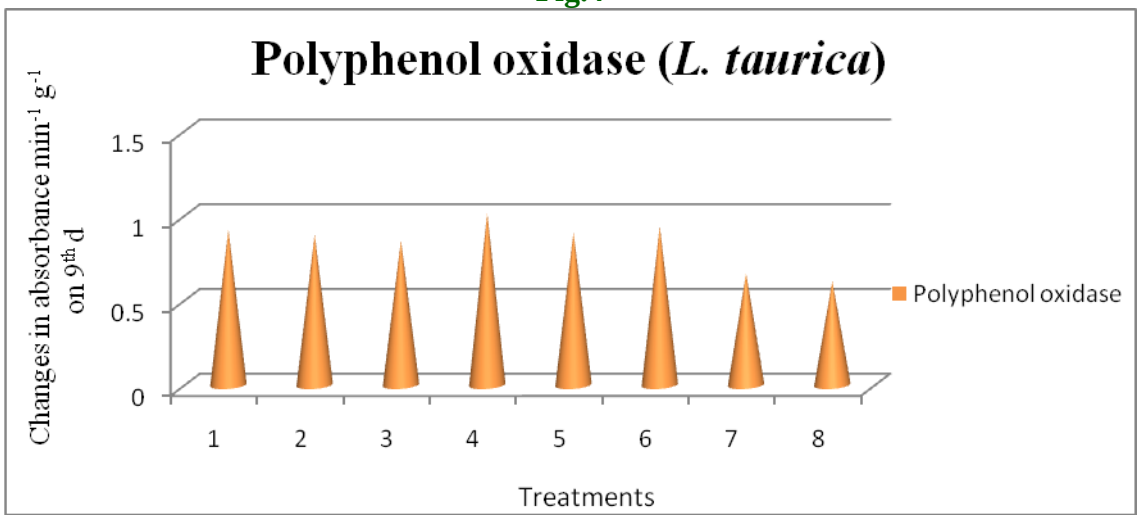


Fig.5

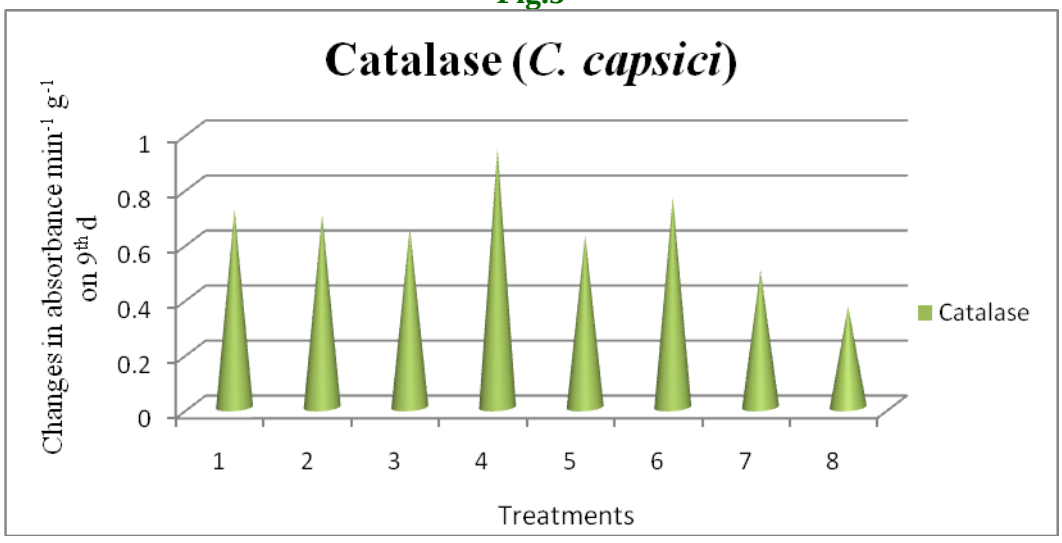


Fig.6

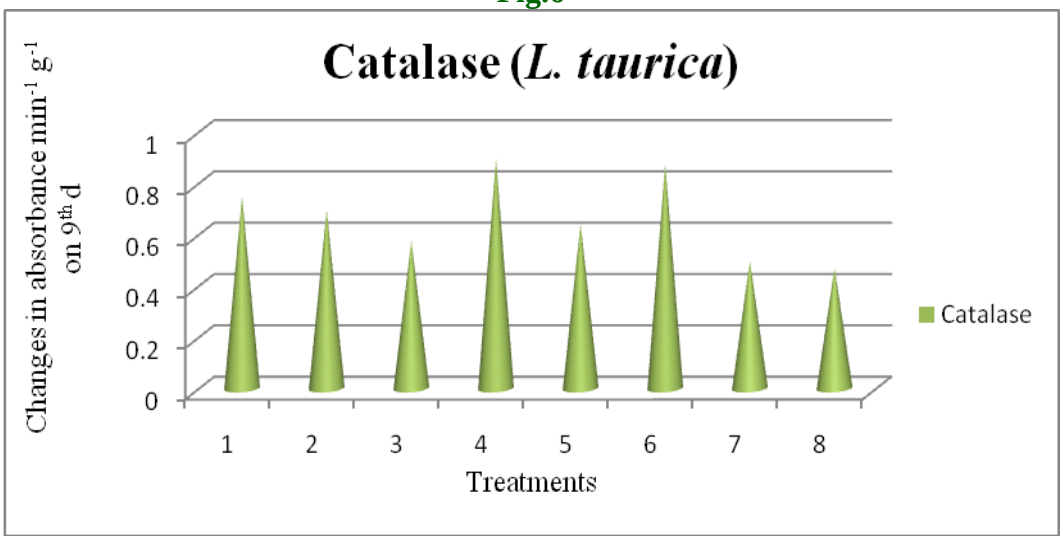


Fig.7

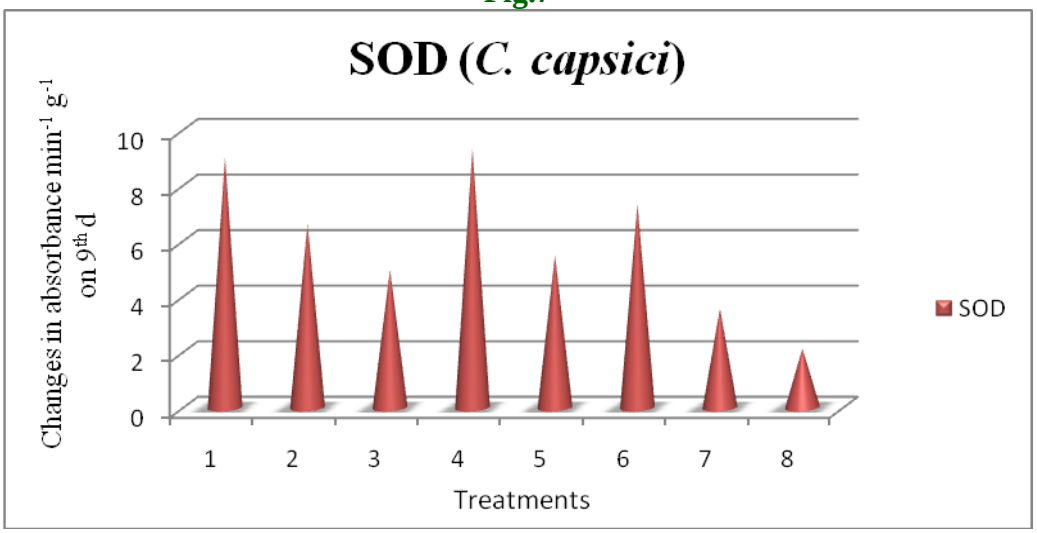
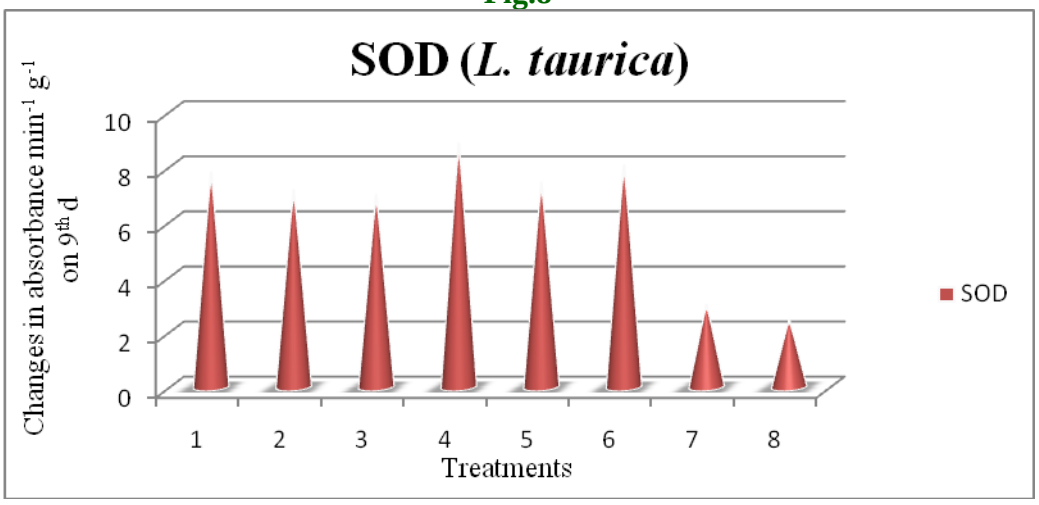


Fig.8



Exposing plants to abiotic or biotic stresses lead to improved resistance to subsequent pathogen attack both locally and systemically (Walter *et al.,* 2005). Applying fungicides on plants was also found to induce the resistance against the pathogens. For example, pyraclostrobin (strobilurin class fungicide) enhanced resistance of tobacco plants by activation of pathogenesis related protein (PR 1) against Tobacco Mosaic Virus and *Pseudomonas syringae* pv *tabaci* (Herms *et al.,* 2002). The defense enzymes such as superoxide dismutase, catalase and ascorbate peroxidase activities increased after the application of metalaxyl on *Solanum nigrum* (Alexandra *et al.,* 2013). In the present study also, triggering of defense related enzymes *viz*., peroxidase (PO), polyphenol oxidase (PPO), catalase and super oxide dismutase (SOD) was recorded in chilli plant upon spraying with azoxystrobin, chaetoglobosin and other fungicides. The individual application of fungicides showed lesser increase in defense enzymes as compared to combination treatments. Among the combinations, azoxystrobin with chaetoglobosin showed the maximum induction of defense enzymes in chilli. Similar reports have already been made by Nuchadomrong *et al.,* 2004.They reported that the activity of the defense enzymes such as peroxidase (PO), polyphenol oxidase (PPO), phenyl alanine ammonia lyase (PAL) and chitinase increased in the azoxystrobin treated cucumber plants.

The bioactive compounds, trichotoxin A50 extracted from *Trichoderma harzianum* PC01 and chaetoglobosin C extracted from *Chaetomium globosum* have also been reported to elicit resistance or immunity in plants by inducing oxidative burst in plant cells (Reihana *et al.,* 2018). Hence, apart from various modes of action, inducing resistance in plants is an additional advantage for azoxystrobin as well as for chaetoglobosin application, which will be most helpful in managing the plant diseases effectively.

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