COMPARATIVE PERFORMANCE OF TWO VEGETABLES CROPS IN THE PHOTOSYNTHETIC ACTIVITY AMELIORATION BY FOUR DIFFERENT ANTIDOTES

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Abstract- India is a country whose economy rests on agriculture and is confronted with an ever growing demand for agricultural production, while needing to sustain their already fragile resource base It has long been recognized that pollutant gases cause significant impact on crops in the country. Reduction in crop yield and quality has been attributed to air pollutants. The greatest impacts occur in areas close to the source of pollution, with high pollution concentrations in the atmosphere and high deposition rate. Increases in atmospheric Ozone, SO2, NO2 concentration have demonstrable effect on crop growth, and yield. There is significant concern about the possible effect of these gases on agricultural production and practices. The atmospheric pollutants have been reported to affect the yield of crops and its quality by degrading the levels of proteins, oil, sugars, carbohydrates, fibres, calorific value, photosynthetic activity etc. The plant injury due to air pollution could be visible as well as latent. Protection of plants from oxidative damage can be achieved through various means and one of the possible ways is to provide exogenously certain effective protectants that can scavenge/ mitigate the toxic free radicals generated within the plant system, under stressed condition. With this objective in the present study, following antidotes i.e. Sodium Erythrobate (SE), N, N'-Dimethylurea (DMU), Tetramethylene diamine (Putrescine), and 6-Benzylaminpurine were exogenously supplied as foliar spray.

Keywords: Mitigation, Antidotes, Lycopersicon esculentum, Solanum melongena. Sodium Erythrobate (SE), N, N'-Dimethylurea (DMU), Tetramethylene diamine (Putrescine), and 6-Benzylaminpurine.

Introduction: Air pollution is not a new problem in agriculture. For decades, farmers in congested or in industrialized area have experienced air pollution damage to their crops, often without realizing it. Important physiological processes such as photosynthesis, respiration, carbon allocation and stomatal function are adversely affected by air pollutants. Estimates of yield loss in major crop plants, resulting from ambient oxidative gas stress generally range from up to 45% Pearson and Percy, 1997.

Oxidative atmospheric pollutant, including Ozone, SO_2, NO_2 and particulates represent a significant source of stress to both terrestrial plants and animals (Cross et al., 2002). The crop effect database clearly show that air pollutants are capable of impairing physiological function causing foliar injury, reducing growth and yield of crop at ambient concentration. Ozone is one of the most ubiquitous and damaging air pollutants to which plants are exposed (Heath et al., 1997). There is arguably more evidence that present - day ozone levels cause greater damage to the vitality of plants than animals (Agrawal et al., 1999).

The studies of the potential for protection of vegetation from the oxidative gases (SO_2, NO_2 and O_3) using chemical application have been performed over the last three to four decades. A diverse group of chemical compounds, such as antisenescence agents, antioxidants, antitranspirants, dust, growth regulators, growth retardants, and pesticides, will provide varying degree of short-term protection for plant from O_3 injury. Most of these chemicals were used in short-term single application studies designed to identify those that were effective in preventing acute O_3 injury Manning (2000).

Material and Methods: Experiments were conducted at the Institute of Environment Management and Plant Sciences,
Vikram University Ujjain (M.P.). N, N'-Dimethylurea (DMU) was selected as Antidotes and ***Lycopersicon esculentum*** **Mill** (Tomato) (cv. Pusa samrat, Family Solanaceae) crop was selected to Experiments. .

Experimental Set Up: Ten healthy seeds of both the crops were sown in earthen pots separately containing 3 kg. Black Cotton Soil. After 10 days of germination and plant growth, thinning was carried out and 4-5 plantlets were allowed to grow further in each pot. Total number of pots was 64 for both the crop i.e. 32 number of pots for each crop was sown for spray treatment. After one month of normal growth plants were subjected to different combination and concentration of gaseous pollutant at the rate of 6hrs/ day. O_3 (60 µg/m^3), O_3 + NO_2 (60 + 100 µg/m^3), O_3 + SO_2 (60 + 300 µg/m^3) and O_3 + NO_2 + SO_2 (60 + 100 + 300 µg/m^3), in fabricated open top polythene chambers (1x1x1x1m) till the maturing of crop. A control set was also run simultaneously. Each set was run with three replicates.

Mode of application of Antidotes: A solution of concentration of 20 ppm and 100 ppm referred as low dose and high dose respectively was prepared of the four antidotes (SE, DMU, Putrescine and BA) with acetone and distilled water. 100 ml of each solution were sprayed with the calibrated spray gun on plants at the age of 51 and 83 days.

Instruments employed in study: Open Top Chamber (OTC) type of study has been carried out for treatment of different combinations of gaseous pollutant in this investigation

Exposure Chamber (OTC): The crop plants were exposed to gaseous pollutant in chamber 1m^3 a cubical frame of above size was made by welding iron rods. It was covered with transparent polythene. The top of the chamber was left open. All the crop plants to be exposed and considered to be control were placed in the chamber to obtain similar environmental condition with or without fumigation. The gas generated pass in the open top chamber through inner side Teflon tube in which holes of 1mm at 30 cm apart done.

Sulphur dioxide (SO_2) Generation: The gaseous pollutant sulphur dioxide was generated by bubbling the air through 0.1% aqueous sodium metabisulphite solution at a fixed rate. The airflow rate was standardized in 1m^3 open top chamber. The generated gas was then measured with TGM-555.The average value obtained was considered as the concentration of the gas to which the crop plants were exposed. The amount of gas generated was depended on the airflow rate and temperature.

Nitrogen dioxide (NO_2) Generation: The gaseous pollutant NO_2 was generated by bubbling SO_2 gas through dilute HNO_3 at a fixed rate. SO_2 was generated with above method was passed through dilute HNO_3. Gas concentration in open top chamber was initially standardized then measured with TGM-555. The average value obtained was considered as the concentration of the gas to which the crop plants were exposed. The amount of gas generated was depended on the airflow and temperature.

Ozone (O_3) Generation: Through UV- B exposure of air: Ozone was generated by flowing the air through UV-Tubes at fixed rate of flow rate. The amount of gas generated was monitored by standard method Byers & Saltzman, 1958, with the help of Portable gas sampler by using the 1% potassium buffer solution and absorbance was read at 352nm at UV-VIS spectrophotometer. Concentration of ozone in the air was calculated with the help of a standard graph prepared by diluting a stock solution of 0.025 M iodine.

Photosynthetic Rate Estimation (LICOR - 6200, USA Portable Photosynthetic system): The instrument contains an infrared gas analyzer (IRGA), a mass flow meter and a pump. The analyzer is a differential non-dispensive, infrared type. IRGA can be used for absolute as well as differential measurement of CO_2.

Toxic Gas Monitor- 555 (CEA, USA): The toxic gas monitor 555 measures the concentration of a particular gas in the air by monitoring the amount of colour change produced in the analyzer reagent systems. Air to be analyzed is continuously drawn into the instrument via an internal vacuum pump via series of tubing and the colorimetric estimation of the gas is displayed as the digital read out.

Amelioration study of Photosynthetic Activity Ozone+ Nitrogen dioxide+ Sulphur dioxide (60 +100+300 g/m^3)- : As these gases have been regarded as the most important pollutants affecting terrestrial ecosystem for the past decades. Some works have been conducted on the response of nitrate reductase (NR) activity, peroxidase (POD) activity, and superoxide dismutase (SOD) activity in needles of spruce saplings (*Picea abies*) to SO_2+NO_2+O_3 (Klumpp et al., 1989b). All of the enzyme activities responded in a different manner.

Plant age 51 days: In this case the photosynthetic activity decreased as compared to pollutant mixtures i.e. (O_3 +NO_2 and O_3 +SO_2) because of increase in pollution concentration, (160 and 360 to 460 g/m^3) but surprisingly at this concentration loss in the photosynthetic activity was lesser **44.60 %**, which is **19.48 %** and **05.46 %** less with O_3+SO_2 and O_3+NO_2 respectively.

In Brinjal plant loss in the photosynthetic activity was **45.69 %,** which is only **02.38 %** higher as compared to tomato plant but as compared to O_3 +SO_2 and O_3 +NO_2 the difference was **14.30 %**and **03.95 %** respectively. As referred in same cases the O_3+NO_2 has counteracted the mutual effects inducing the damage and it has been reported with O_3+SO_2 too. This also will of course depend on plant species and the growth stage of the plant.

Plant age 62 days: Increased in photosynthetic activity at this age is suggesting an induction of tolerance through consumption of antidotes and thus the result of percentage recovery was also more as compared to other two concentrations.

At 20- ppm maximum increase was **70.76 %** through SE treatment, **64.11 %** with DMU, while **56.96 %** and **51.55 %** with the application of Putrescine and 6-Benzylaminpurine respectively. (Table- 5).

While with 100- ppm maximum increase was **75.71 %** with SE, **73.33 %** with DMU treatment, **71.52 %** with Putrescine and **65.57 %** with 6-Benzylaminpurinerespectively. (Table- 5)

In Brinjal plant at 20- ppm maximum increase was **58.46 %** through SE treatment, **52.35 %** with DMU, while **41.97 %** and **31.48 %** with the application of Putrescine and 6-Benzylaminpurine respectively. (Table- 9).

While at 100- ppm maximum increase was **69.68 %** with the application SE, **65.84 %** with DMU treatment, **60.78 %** with the application of Putrescine and **57.64 %** with 6-Benzylaminpurine (Table- 9) **.**

Plant age 83 days: Oxidative stress such as O_3, SO_2, NO_2 damage plant tissue, at least in part, because they generates active oxygen and other free radicals (Smironoff, 1995). Free radicals, such as superoxides (O^-_2) and hydroxyl (OH) are very reactive chemical species and can readily lead to uncontrolled reaction, which may result cross-linking of DNA, proteins, lipids to each other or one another, or oxidatively damage functional group of these important biological compounds causing molecular damage and cellular injury that lead to accelerated aging and senescence (Packer, 1994; Lee, 2002). In tomato plant at 20-ppm maximum loss was 53.61 % through 6-Benzylaminpurine treatments, 41.93 % with Putrescine, while 34.68 % and 31.40 % with the application of DMU and SE respectively.

While at 100-ppm maximum loss was **34.28** % with 6-Benzylaminpurine, **31.38 %** with Putrescine, **21.86 %** with DMU application and **16.19 %** with SE treatment (Table- 5).

In Brinjal plant at this plant age the observation was at 20-ppm maximum loss was **45.87 %** through 6-Benzylaminpurine treatments, **43.64 %** with Putrescine, while **43.92 %** and **42.39 %** with the application of DMU and SE respectively.

While at 100-ppm maximum loss was **42.28** % with 6-Benzylaminpurine, **38.57 %** with Putrescine, **26.94 %** with DMU and **24.05 %** through SE treatment (Table-9).

Plant age 94 days: Antioxidant like DMU and Putrescine is capable to ameliorate the quantitative and qualitative damage up to 12 %-14% to 7 %-9% respectively in various studied crop which suggest that antioxidant can protect the plant from, pollutant injury and bring significant recovery (Dubey.2002). Same observation was noted in the present study in Tomato plant at 20-ppm maximum increase was **72.44 %** through 6-Benzylaminpurine, **65.65** % with the application of Putrescine while **58.48 %** with DMU and **49.59 %** SE treatment (Table-5).

While at 100-ppm maximum recovery was **58.30 %** with 6-Benzylaminpurine, **51.45 %** with Putrescine treated **46.96 %** with DMU application, **40.85 %** through SE (Table- 5).

In Brinjal plant at 20-ppm maximum increase was **72.37 %** through DMU **69.03 %** with 6-Benzylaminpurine, **65.46** % with the application of Putrescine while and **62.02 %** SE treatment r (Table-9).

While at 100-ppm maximum recovery was **63.41 %** with 6-Benzylaminpurine, **61.69 %** with Putrescine treated **51.08 %** with DMU application, **49.39 %** through SE (Table- 9).

The overall study trend suggests that all the four antidotes used could induce a considerable tolerance for various stress in the crop species studied and crops shows remarkable recovery potential against the oxidative stress of different concentration.

The results of antidotes treatment against different gaseous concentration suggest that minimum loss in total chlorophyll will show minimum recovery, while maximum loss will show maximum recovery in the photosynthetic activity

With O_3+ NO_2+SO_2 the trend at R_1 stage is same and the difference between Tomato and Brinjal exists so also the response of antidotes specially PUT and BA. At R_2 stage as seen with other combinations the recovery does not corresponds to dose of antidotes. Also with this combination it appears that crop has been damaged much more because of three pollutants acting cumulatively and hence poor recovery is there. Again Tomato and Brinjal responses differ at R_1 and R_2 stage and with antidotes.

It is apparent that at R_2 stages under higher stress of pollutants the recovery responses may become poor as the plant is at the juncture of the stabilized metabolic activity and starting of the senescence stage. Since the metabolic activity at early growth stages are very high. Recovery is very high irrespective of crop or antidote however the differential response will always exist as is visible in this study too between Tomato and Brinjal.

For any practical application by the farmers the recommendation is simpler i.e. apply low dose of antidote at early stage of crops growth. Ofcourse screening of the antidotes is required since varied response with different crops exists.

The next set of observations, which have been obtained through this study, is again relevant. It is related to the quantity of the photosynthetic pigments. it is an established fact that the pollutant specially the oxidative once like O_3 NO_2 and SO_2 reacts with the chloroplast structure SO_2 significantly reacts with the chlorophyll too .

Hence it is very relevant not determine the PR but even the contents since both are linked parameters. A look at the results reveals that trend / patterns of the chlorophyll contents to follows similar trend as PR function with O_3 and O_3 interaction with NO_2 or SO_2. The results again confirm that with higher dose application with anti dotes i.e. 100 ppm no appreciable change in recovery appear as against 20 ppm i.e. the recovery is not proportionate to concentrations.

Table: 1: Experimental Conditions

S. No.	Plant age	Fumigation Protocol	Antidotes Treatment	Sampling order
1	01 to 30 days	No treatment	No treatment	-
2	30 days	-	-	First sampling
3	31 to 51 days	I treatment	No treatment	-
4	51 days	-	-	Second sampling
5	51 to 61 days	No treatment	I treatment	-
6	62 days	-	-	Third sampling
7	62 to 82 days	II treatment	No treatment	-
8	83 days	-	-	Fourth sampling
9	83 to 93 days	No treatment	II treatment	-
10	94 days	-	-	Fifth sampling

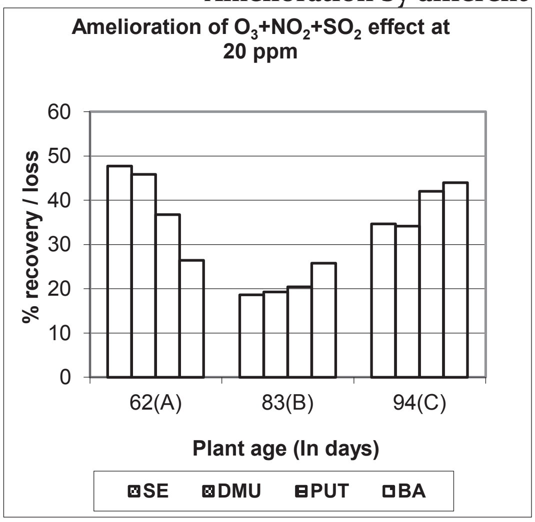
Effect of $O_3 + NO_2 + SO_2$ (60 +100+ 300 μg/m^3) on Photosynthetic rate (μmol m^{-2}s^{-1}) in Tomato plant and their amelioration by different antidotes

Plant age (In days)	Dose	Antidotes (ppm)			
		SE	DMU	PUT	BA
30 days	Control	08.34± 0.26			
51 days Gaseous treatment for 20 days	Control	10.11± 0.89			
	Treatment	05.60± 0.08			
Loss$_{-1}$ at 1st stage (%)		**44.60**			
62 days Antidote treatment and 10 days for recovery	Control	16.38 ±1.30			
	20 ppm	34.58 ±0.12	28.17 ±0.97	23.49 ±0.26	20.87 ±0.08
	100 ppm	41.63 ±2.85	37.91 ±0.16	35.50 ±1.23	29.37 ±0.91
Recovery$_{-1}$ at 1st stage (%)	20 ppm	**70.76**	**64.11**	**56.96**	**51.55**
	100 ppm	**75.71**	**73.33**	**71.52**	**65.57**
83 days Gaseous treatment for 20 days	Control	24.58 ±0.08			
	20 ppm	23.72 ±0.17	18.40 ±0.92	13.64 ±0.05	09.68 ±1.36
	100 ppm	34.89 ±2.58	29.62 ±0.11	24.36 ±0.85	19.30 ±0.10
Loss$_{-2}$ at 2nd stage (%)	20 ppm	**31.40**	**34.68**	**41.93**	**53.61**
	100 ppm	**16.19**	**21.86**	**31.38**	**34.28**
94 days Antidote treatment and 10 days for recovery	Control	31.53 ±3.87			
	20 ppm	47.06 ±0.32	44.32 ±0.54	39.71 ±0.12	35.13 ±0.89
	100 ppm	58.99 ±0.17	55.85 ±1.58	50.18 ±1.93	46.29 ±3.68
Recovery$_{-2}$ at 2nd stage (%)	20 ppm	**49.59**	**58.48**	**65.65**	**72.44**
	100 ppm	**40.85**	**46.96**	**51.45**	**58.30**

Effect of $O_3 + NO_2 + SO_2$ (60 +100+ 300 μg/m^3) on Photosynthetic rate (μmol $m^{-2}s^{-1}$) in Brinjal plant and their amelioration by different antidotes.

Plant age (In days)	Dose	Antidotes (ppm)			
		SE	DMU	PUT	BA
30 days	Control	09.20± 0.19			
51 days Gaseous treatment for 20 days	Control	11.14± 0.09			
	Treatment	06.05± 1.93			
Loss-1 at 1st stage (%)		**45.69**			
62 days Antidote treatment and 10 days for recovery	Control	18.76 ±0.73			
	20 ppm	26.82 ±1.55	23.38 ±0.23	19.20 ±0.08	16.26 ±2.14
	100 ppm	36.75 ±0.96	32.62 ±0.31	28.41 ±0.10	26.30 ±0.75
Recovery-1 at 1st stage (%)	20 ppm	**58.46**	**52.35**	**41.97**	**31.48**
	100 ppm	**69.68**	**65.84**	**60.78**	**57.64**
83 days Gaseous treatment for 20 days	Control	25.30 ±0.15			
	20 ppm	15.45 ±1.95	12.11 ±0.11	09.15 ±2.42	07.20 ±0.09
	100 ppm	27.91 ±0.66	23.83 ±0.91	17.45 ±0.16	15.18 ±0.07
Loss-2 at 2nd stage (%)	20 ppm	**42.39**	**43.92**	**43.64**	**45.87**
	100 ppm	**24.05**	**26.94**	**38.57**	**42.28**
94 days Antidote treatment and 10 days for recovery	Control	33.18 ±0.58			
	20 ppm	40.69 ±0.62	37.45 ±0.18	32.73 ±1.12	29.42 ±0.41
	100 ppm	55.15 ±0.66	48.72 ±0.13	45.55 ±0.09	41.49 ±0.88
Recovery-2 at 2nd stage (%)	20 ppm	**62.02**	**72.37**	**65.46**	**69.03**
	100 ppm	**49.39**	**51.08**	**61.69**	**63.41**

Fig : % Change (recovery / loss) in the Photosynthetic Activity after Amelioration by different antidotes in Tomato Plant



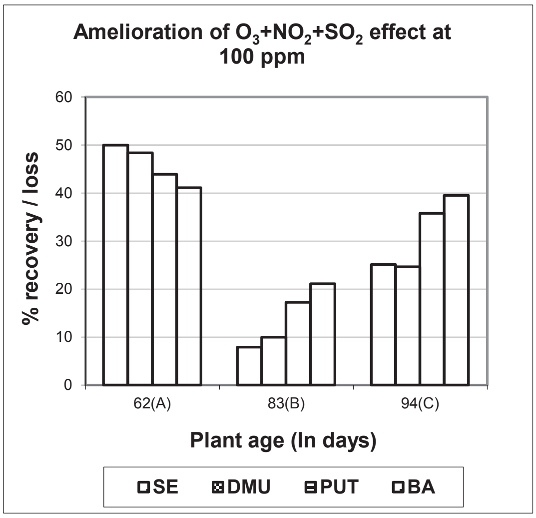
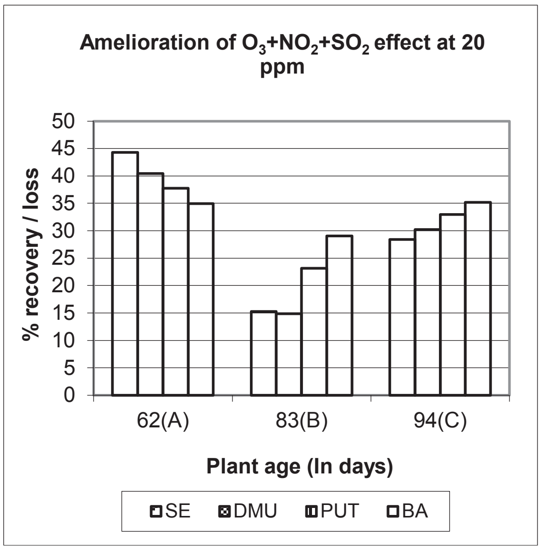
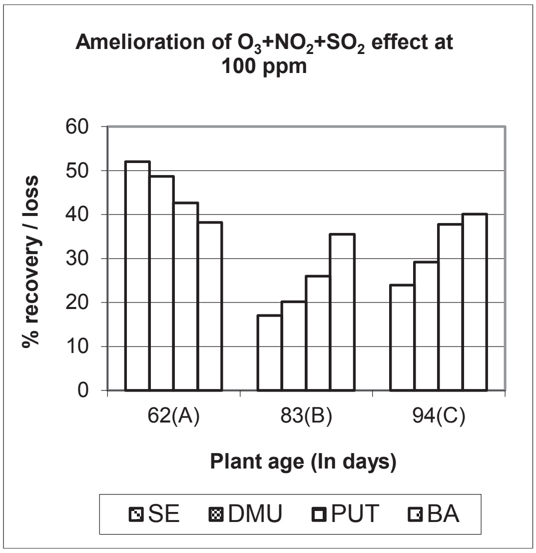


Fig : % Change (recovery / loss) in the Photosynthetic Activity after Amelioration by different antidotes in Brinjal plant





A :It shows % recovery between antidote treatment and gaseous treatment at the plant age of 62 days
B :It shows % loss with gaseous treatment inspite of antidote treatment at the plant age of 83 days
C : It shows again % recovery against the effect of gaseous treatment at the plant age of 94 days
SE: Sodium Erythorbate, DMU: N,- N' Dimethyl Urea , PUT: Putrescine, BA: 6-Benzylaminpurine

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