NUMERICAL DATA

Effects of carbon monoxide, nitrogen dioxide, and fine particulate matter on insect abundance and diversity in urban green spaces 2024

Table 1 Primers used for gene expression analysis

From: Carbon monoxide is involved in melatonin-enhanced drought resistance in tomato seedlings by enhancing chlorophyll synthesis pathway

Gene name	Accession number	Forward primer sequence	Reverse primer sequence
SlCAO	LOC101261422	GCAGCCTAGAAGATCCCTCAATGTG	ATCAGCGGAGAAAGCAACAGGATAC
SlChlS	LOC101246752	TGTTATAGGCAGGGCATGACTTTCC	TGGTGGAGCTGAGTAGATGTAGGAG
SlFECH	LOC101248153	ATGCCTGCTTGCCATTCCTCAC	GACAATCCTCCACCTACACTGCTTC
SlMGMT	LOC101267302	TCCGCCGCTACCGACATCTC	CCGACCTCCTCCGCCTGAAG
SlPOR	LOC101244717	TGGACCTCGCCTCTCTTGACAG	AAACAGCAGCATTAGCAACCAACAC
SlPPOX	LOC101259974	CGCCGTCCTCCTCCTCATCC	ACCGTGTTCTCCAGCCATTGC
SlUROD	LOC101260578	AGAAAGTGCCCACAAACACCTCTTG	GCCGCCTTCCATCTGCCATATC
Actin	NC_015447	AATGAACTTCGTGTGGCTCCAGAG	ATGGCAGGGGTGTTGAAGGTTTC

Carbon monoxide/heme oxygenase system in plant: Roles in abiotic stress response and crosstalk with other signals molecules2023

Table 1. Role of CO response to abiotic stress in plant.

Stress Species	Sources/Concentration of Stress	Sources and Concentration of CO	Plant Species	CO-induced effect	Reference
Salt stress	100 mM NaCl	1.0 µM hematin,5% CO-saturated aqueous solution	*Cassia obtusifolia* L.	Enhanced activity of SOD, POD, CAT, APX and GR; Improved F_v/F_m, ΦPSII and qP; Enhanced chlorophyll concentration, total soluble sugars, free proline and soluble protein	[29]
	150 mM NaCl	1.1 µM β-CDH, 10 µM hemin	*Nicotiana tabacum* L.	Reduced lipid peroxidation; Enhanced activity of SOD and POD	[30]
	100 mM NaCl	10 µM hemin,10% CO-saturated aqueous solution	*Medicago sativa* L.	Increased K/Na ratio; Up-regulated POD, SOD and APX	[34]
	200 mM NaCl	5 µM hemin, 50% CO aqueous solution	*Triticum aestivum* L.	Up-regulated POD, SOD and APX; Down-regulated NADPH oxidase	[39]
	Saline soil	0, 50, 75 and 100 µM hemin	*Hordeum vulgare* L.	Reduced Ca, Na, Mn and Zn element content	[40]
	1.8, 3.6, 5.4 or 7.2 dsm ^{1} Seawater salinity	75 µM hemin	*Abelmoschus*	Enhanced activity of CAT and α-amylase; Reduced lipid peroxidation	[41]
	100 mM NaCl	1.0 mM hematin,5% CO-saturated aqueous solution	*Oryza sativa* L.	Up-regulated SOD; Enhanced activity of CAT; Regulated glucose metabolism	[42]
	200 mM NaCl	50% CO aqueous solution	*Triticum aestivum* L.	Up-regulated SOD and down-regulated NADPH oxidase to decrease $O_2^{\bullet -}$ overproduction	[43]
	150 mM NaCl	10 µM hemin	*Triticum aestivum* L.	Increased K/Na ratio; Up-regulated SOD; Enhanced activity of POD, APX and CAT	[44]
	50 mM NaCl	5 µM hemin	*Oryza sativa* L.	Increased photosynthetic pigment content and photosynthetic parameters (Pn, Tr, Gs, Ci); promoted carbon metabolism	[45]
	150 mM NaCl	50% CO aqueous solution	*Triticum aestivum* L.	Increased K/Na ratio; Up-regulated H^+-pump and APX, GR, SOD, MDHAR and DHAR	[74]
	300 mM NaCl	0.01 µM hematin	*Triticum aestivum* L.	Relieved lipid peroxidation; Enhanced activity of POD, SOD, APX and CAT	[75]

Heavy metal stress	20 µM $CdCl_2$	10 µM hemin	*Brassica chinensis* L.	Decreased MDA level; Enhanced activity of SOD, POD, CAT; Increased concentrations of AsA and GSH; Scavenged superfluous ROS;	**[31]**
	100 µM $ZnSO_4$ 100 µM Pb $(NO_3)_2$ 80 µM $K_2Cr_2O_7$	1 µM hemin	*Oryza Sativa* L.	Enhanced activity of SOD, APX, GR; Increased concentration of AsA and GSH; Reduced ROS level	[33]
	85 mg L^{-1} $CdCl_2$	100 µM hemin	*Zea may* L.	Increased photosynthetic pigment content and photosynthetic parameters (Pn, Tr, Gs, qP, F_v/F_m, ETR); Decreased ROS and MDA content; Enhanced activity of SOD, CAT and POD; promoted GSH-ASA cycle; Regulated polyamine metabolism	[48]
	200 µM $CdCl_2$	0.01 µM CDH, 10 µM hemin	*Medicago sativa* L.	Regulated APX and SOD; Reestablished GSH and ROS homeostasis	[50]
	464 µM $CdCl_2$	100 µM hemin	*Zea may* L.	Increased DIMBOA, total phenolic content, and PAL activity; Reduced TF and BCF	[51]
	100 mg kg^{-1} $CdCl_2$	150 µM hemin	*Zea may* L.	Enhanced photosynthesis; Delayed leaf senescence; Improved dry matter accumulation and distribution	[52]
	85 mg L^{-1} $CdCl_2$	100 µM hemin	*Zea may* L.	Enhanced the metabolism of sucrose and nitrogen; Regulated endogenous hormone level	[53]
	5 µM $CuSO_4$	5 µM CO	*Chlamydomonas reinhardtii*	Reduced lipid peroxidation; Increased chlorophyll accumulation; Enhanced activity of CAT	[54]
	10 µM Hg	0.2 mM CO	*Brassica juncea* L.	Decreased ROS level; Enhanced activity of SOD, CAT, APX and POD; Increase proline content	[55]
	100 µM $CdCl_2$	50% CO-saturated aqueous solution	*Medicago sativa* L.	Enhanced activity of SOD, POD, GST, and PAL	[76]
	100 µM $ZnSO_4$	1 µM hemin, 1 µM CORM3	*Oryza Sativa* L.	Down-regulated the relative expression of OsZIP1, OsZIP3, OsZIP7, and OsZIP8 to reduce zinc accumulation	[77]
	20 µM $CdCl_2$	10 µM hemin	*Brassica chinensis* L.	Inhibited expression of Fe^{2+}/Cd^{2+} transporter BcIRT1	[78]
	50 µM $CdCl_2$	0.5 mM hemin	*Vigna radiata* L.	Enhanced photosynthetic pigments; Increased activity of SOD, APX and POD, and proline content; Enhances the uptake and translocation of Cd	[79]
	4 mM $HgCl_2$	40 mM CO	*Chlamydomonas reinhardtii*	Inhibited ROS production; Reduced Hg accumulation	[80]
	100 µM $HgCl_2$	50% CO-saturated aqueous solution	*Medicago sativa* L.	Reduced the lipid peroxidation; Enhanced activity of GR, MDHAR and SOD; Decreased LOX activity	[81]

Temperature stress	4 °C cold-stress	10 µM hemin, 10 µM CORM3	*Conyza blinii*	Increased activity of CAT, POD, SOD and saponin content; Increased photosynthetic pigment content and photosynthetic parameters (Pn, Tr, Gs, Ci)	**[56]**
	2 °C Chilling	10 mM hematin solution 50% CO-saturated solution	*Baccaurea ramiflora*	Accelerate GSH-ASA cycle; Enhanced the activity of APX, MDHAR and GSNOR; Decreased content of H_2O_2 and RNS	[58]
	damaging heating (45 °C, 10 min).	5 µM hemin	*Triticum aestivum* L.	Enhanced activity of SOD, CAT and POD	[59]
	damaging heating (45 °C, 10 min)	5 µM hemin	*Triticum aestivum* L.	Enhanced activity of SOD, CAT and POD; Decreased H_2O_2 content	[60]
	damaging heating (45 °C, 10 min)	5 µM Heme, 10 µM hemoglobin	*Triticum aestivum* L.	Decreased ROS level; Enhanced activity of POD	[61]
	42 °C heat-stress	50 µM CORM-2	*Ganoderma lucidum*	Improved ganoderic acid biosynthesis; Protected cell-wall integrity	[82]
	damaging heating (45 °C, 10 min)	5 µM hemin	*Triticum aestivum* L.	Increased content of NO and H_2O_2; Enhanced activity of POD and NR; Reduced MOD content	[83]

Drought stress	25% PEG	1.0 µM hematin	*Triticum aestivum* L.	Enhanced activity of CAT, DHAR, SOD and APX; Increased amylase activity and reducing sugar content	**[63]**
	0.3% (w/v) PEG	500 µM Hemin, 30% (w/v) CO aqueous solution	*Cucumis Sativus* L.	Increased chlorophyll content and chlorophyll fluorescence parameters (Fv/Fm, ΦPSII, qP); Enhanced activity of CAT, POD, SOD and APX	[65]
	10% PEG6000	10 µM hemin, 10 µM CORM3	*Conyza blinii*	Increased activity of CAT, POD, SOD and saponin content; Increased photosynthetic pigment content and photosynthetic parameters (Pn, Tr, Gs, Ci)	[56]
	PEG-8000	10 µM Hemin, 50% CO-saturated aqueous solution	*Medicago sativa* L.	Enhanced activity of POD, SOD and APX	[84]
Iron deficiency	50 µM Fe-EDTA	50 µM CO	*Arabidopsis thaliana*	Improve chlorophyll accumulation; Up-regulated expression of AtIRT1, AtFRO2, AtFIT1 and AtFER1	[71]
Paraquat stress	10 mg L^{-1} Paraquat	0.1 µM hematin	*Triticum aestivum* L.	Reduced level of H_2O_2 and lipid peroxidation; Enhanced content of chlorophyll and activity of CAT, SOD and APX	[67]
	5 µM Paraquat	50 µM hemin, 50% CO-saturated aqueous solution	*Medicago sativa* L.	Reduced lipid peroxidation; Decreased ROS level; Up-regulated POD, SOD and APX	[68]
Chiral herbicide stress	0.2 µM dichlorprop	20 µM hemin	*Arabidopsis thaliana*	Increased Fe^{2+} and MDA content; Relieve oxidative damage	[85]

Key: SOD, superoxide dismutase; $O_2^{\bullet -}$, superoxide anion; NADPH, nicotinamide adenine dinucleotide phosphate; APX, ascorbate peroxidase; DHAR, dehydroascorbate reductase; MDHAR, monodehydroascorbate reductase; GR, glutathione reductase; CAT, catalase; POD, guaiacol peroxidase; APX, ascorbate peroxidase; Pn, net photosynthetic rate; Gs, stomatal conductance; Tr, transpiration rate; Ci, intercellular CO_2 concentration; qP, photochemical quenching coefficient; Fv/Fm, PSII maximum photochemical efficiency; ETR, electron transfer rate; ΦPSII, actual photochemical efficiency of PSII; ROS, reactive oxygen species; MDA, malondialdehyde; ASA, ascorbic acid; GSH, glutathione; GST, glutathione S-transferase; PAL, phenylalanine ammonium lyase; DIMBOA, 2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one; TF, transport factor; BCF, bioconcentration factor; LOX, Lipoxygenase; GSNOR, S-nitrosoglutathione reductase; RNS, reactive nitrogen species; H_2O_2, hydrogen peroxide; NO, nitric oxide; NR, nitrate reductase; β-CDH: β-Cyclodextrin–hemin; CORM: carbon monoxide releasing molecule; PEG: polyethylene glycol.

Table 2. Characterization of HO and its response to abiotic stresses and stimuli in plant.

Plant Species	Identified HO gene	Inducer	Plant Tissue	Reference
Arabidopsis thaliana	AtHO-1,2,3,4	osmotic stress, GSH depletion, $CoCl_2$, ABA, NO, and H_2O_2	roots, rosettes, stems, flowers	[109,128]
***Medicago sativa* L.**	MsHO-1	Hemin, NO	**stems**, **young leaves**, roots, germinating seeds	[129]
	MsHO-2	NO, H_2O_2	stems, young leaves, roots, **germinating seeds**	[110]
***Oryza sativa* L.**	OsHO-1	Hemin, Paraquat, NaCl	**stems**, **leaves**, roots, germinating seeds	[130]
	OsHO-2			[111]
***Triticum aestivum* L.**	TaHO-1	NO, GA, ABA, H_2O_2, NaCl	leaves, **stems**, roots, **buds**	[112]
Zea mays	ZmHO-1	NAA, hemin, CO	**leaves**, roots, seeds, stems	[113]
Brassica rapa subsp. pekinensis	BrHO-1	Hemin, H_2O_2, Osmosis and salinity stress, cadmium exposure	roots, **stems**, young leaves, germinating seeds	[114]
Sorghum bicolor	SbHO-1,2,3,4	Osmotic and oxidative stress	leaves, roots, **stems**	[115]
***Nicotiana tabacum* L.**	NtHO-1	osmotic and salinity stresses, cadmium exposure, hemin, H_2O_2	roots, stems, **young leaves**, germinating seeds	[116]
Brassica napus	BnHO-1	NaCl, PEG, NAA, hemin, CO	seeds, roots, stems, **seedling leaves**, **stem leaves**, buds, flowers and siliques	[75,117]
***Cucumis sativus* L.**	CsHO-1	auxin, ABA, hemin, NO, $CaCl_2$, NaHS	germinating seeds, roots, stems, **leaves**	[118]

Key: GSH, glutathione; $CoCl_2$, cobalt chloride; ABA, abscisic acid; NO, nitric oxide; H_2O_2, hydrogen peroxide; GA, gibberellin; NAA, N-1-naphthylacetic acid. Tissues are marked in italics and bold format indicates plant tissues with high expression tissues.

Effects of carbon monoxide, nitrogen dioxide, and fine particulate matter on insect abundance and diversity in urban green spaces 2022

Table 1 Insect species associated with the Chinese thuja trees, *Platycladus orientalis* (L.) in Lashkar (La), Sadaf (Sf), and Sajjad (Sj), urban green spaces in Mashhad, Iran.

From: Effects of carbon monoxide, nitrogen dioxide, and fine particulate matter on insect abundance and diversity in urban green spaces

Order	Family	Species	Abundance		
			La	Sj	Sf
Coleoptera	Coccinellidae	*Chilocorus bipustulatus* Linnaeus, 1758	2	–	1
		Clitostethus arcuatus Rossi, 1794	4	–	29
		Coccinella septempunctata Linnaeus, 1758	62	10	86
		Coccinella undesempunctata Linnaeus, 1758	1	8	8
		Exochomus nigromaculatus Goeze, 1777	1	6	11
		Hippodamia variegata Goeze, 1777	2	2	2
		Oenopia conglobata Linnaeus, 1758	17	28	18
		Oenopia oncina Olivier, 1808	4	1	1
		Scymnus nubilus Mulsant 1850	–	1	–
		Scymnus syriacus Marseul,1868	4	–	2
	Curculionidae	*Aspidapion radiolus* Marsham 1802	–	2	–
		Malvapion malvae Fabricius, 1775	2	6	8
		Smicronyx syriacus Faust, 1887	3	9	5
Diptera	Sciaridae	*Lycoriella sativae* Johannsen, 1912	19	2	13
		Scatopsciara atomaria Zetterstedt, 1851	6	7	10

Hemiptera	Cicadellidae	*Asymmetrasca decedens* Paoli, 1932	**–**	**19**	**–**
		Zyginella pulchra Löw, 1885	32	35	138
	Aphididae	*Cinara tujafilina* Del Guercio, 1909	1092	1942	1487
	Anthocoridae	*Orius albidipennis* Reuter, 1884	–	8	24
		Orius niger Wolff, 1811	–	13	–
	Geocoridae	*Geocoris luridus* Fieber, 1844	–	14	12
		Geocoris megacephalus Rossi, 1790	–	9	2
	Miridae	*Deraeocoris lutescens* Schilling, 1837	–	18	6
		Deraeocoris punctulatus Fallen, 1807	–	14	7
	Aleyrodidae	*Aleyrodes* sp.	–	13	40
Hymenoptera	Aphelinidae	*Encarsia formosa* Gahan, 1924	–	5	34
	Braconidae	*Pauesia hazratbalensis* Bhagat, 1981	2	–	3
Thysanoptera	Phlaeothripidae	*Haplothrips tritici* Kurdjumov, 1912	8	–	7
		Haplothrips subtilissimus Haliday, 1852	–	–	17

1. Abundance and guilds are provided.
2. ^{H}herbivores, ^{P}natural enemies that include predators + parasitoids.

Table 2 Standard levels of air pollutants given by American (USA), Australian, the European Union (EU), and the World Health Organization (WHO) including the permitted in Mashhad (Iran).

From: Effects of carbon monoxide, nitrogen dioxide, and fine particulate matter on insect abundance and diversity in urban green spaces

Pollutant	WHO	EU	Australia	USA	Canada	Mashhad
Ozone (8-h, ppb)	50	60	80	80	65	80
PM_{10} (24-h, μg/m^3)	25	50	25	65	30	150
Sulphur dioxide (24-h, ppb)	8	48	80	140	115	140
Nitrogen dioxide (annual, ppb)	21	21	30	53	53	53
Carbon monoxide (8-h, ppm)	9	9	9	9	13	9
Lead (μg/m^3)	–	0.5	0.5	1.5	–	–
$PM_{2.5}$ (24-h, μg/m^3)	25	–	–	–	–	35

1. *μg/m^3* micrograms per cubic meter, *ppb* part per billion, *ppm* part per million.

Mitigation of indoor air pollutants using Areca palm potted plants in real-life settings 2021

Table 1 Specifications of the monitoring sites

From: Mitigation of indoor air pollutants using Areca palm potted plants in real-life settings

Experimental sites	Area (m^3)	Doors (no.)	Windows (no.)	Exhaust fan (no.)	Ceiling fans (no.)	Estimated number of visits (daily basis)
Site I	122.1	1	4	-	2	35
Site II	256.5	2	4	5	4	12
Site III	153.4	2	4	2	-	500
Site IV	197.2	1	2	-	-	40

Table 2 Characteristics of the experimental sites

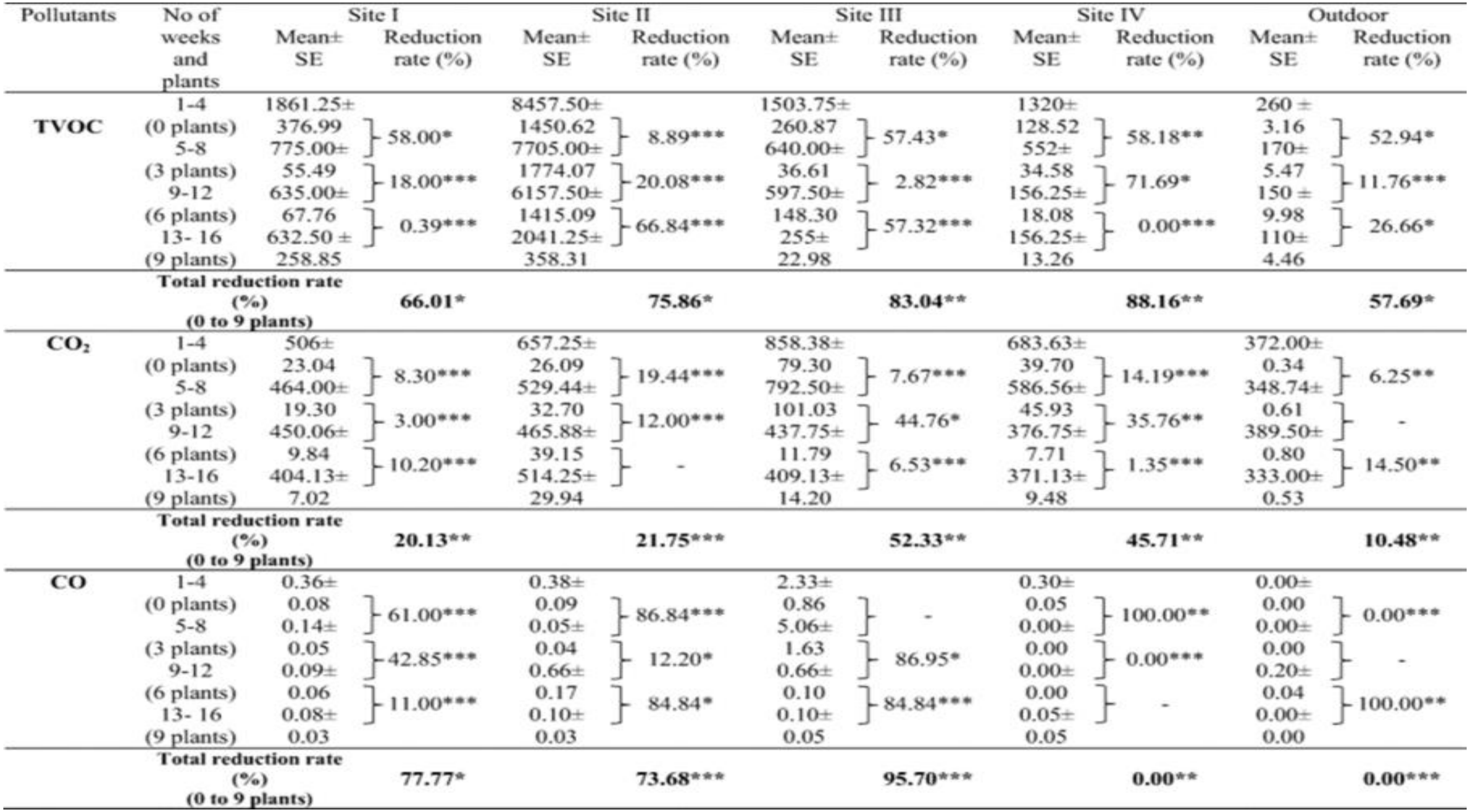
From: Mitigation of indoor air pollutants using Areca palm potted plants in real-life settings

Experimental sites	Ventilation system		Research equipment	Generator within 10 m	Other activities
	Natural	Air conditioner			
Site I	✓	-	✓	-	Media preparation, refrigerators, weighing, oven drying
Site II	✓	-	✓	-	Rotary evaporators, spectrophotometry, laboratory centrifuges, ultra-sonicators, electrophoresis equipments
Site III	✓	-	-	-	Cooking (gas stoves and electricity) and dining
Site IV	✓	-	-	✓	Reading

1. √ used to describe the presence of ventilation system, research equipment's and generator

Table 3 Reduction rate (%) of TVOC, CO_2, and CO in outdoor and indoor experimental sites over 16-week experiment period

From: Mitigation of indoor air pollutants using Areca palm potted plants in real-life settings



Pollutants	No of weeks and plants	Site I Mean± SE	Site I Reduction rate (%)	Site II Mean± SE	Site II Reduction rate (%)	Site III Mean± SE	Site III Reduction rate (%)	Site IV Mean± SE	Site IV Reduction rate (%)	Outdoor Mean± SE	Outdoor Reduction rate (%)
TVOC	1-4 (0 plants)	1861.25± 376.99		8457.50± 1450.62		1503.75± 260.87		1320± 128.52		260 ± 3.16	
	5-8 (3 plants)	775.00± 55.49	58.00*	7705.00± 1774.07	8.89***	640.00± 36.61	57.43*	552± 34.58	58.18**	170± 5.47	52.94*
	9-12 (6 plants)	635.00± 67.76	18.00***	6157.50± 1415.09	20.08***	597.50± 148.30	2.82***	156.25± 18.08	71.69*	150 ± 9.98	11.76***
	13- 16 (9 plants)	632.50 ± 258.85	0.39***	2041.25± 358.31	66.84***	255± 22.98	57.32***	156.25± 13.26	0.00***	110± 4.46	26.66*
	Total reduction rate (%) (0 to 9 plants)		**66.01***		**75.86***		**83.04****		**88.16****		**57.69***
CO_2	1-4 (0 plants)	506± 23.04		657.25± 26.09		858.38± 79.30		683.63± 39.70		372.00± 0.34	
	5-8 (3 plants)	464.00± 19.30	8.30***	529.44± 32.70	19.44***	792.50± 101.03	7.67***	586.56± 45.93	14.19***	348.74± 0.61	6.25**
	9-12 (6 plants)	450.06± 9.84	3.00***	465.88± 39.15	12.00***	437.75± 11.79	44.76*	376.75± 7.71	35.76**	389.50± 0.80	-
	13-16 (9 plants)	404.13± 7.02	10.20***	514.25± 29.94	-	409.13± 14.20	6.53***	371.13± 9.48	1.35***	333.00± 0.53	14.50**
	Total reduction rate (%) (0 to 9 plants)		**20.13****		**21.75*****		**52.33****		**45.71****		**10.48****
CO	1-4 (0 plants)	0.36± 0.08		0.38± 0.09		2.33± 0.86		0.30± 0.05		0.00± 0.00	
	5-8 (3 plants)	0.14± 0.05	61.00***	0.05± 0.04	86.84***	5.06± 1.63	-	0.00± 0.00	100.00**	0.00± 0.00	0.00***
	9-12 (6 plants)	0.09± 0.06	42.85***	0.66± 0.17	12.20*	0.66± 0.10	86.95*	0.00± 0.00	0.00***	0.20± 0.04	-
	13- 16 (9 plants)	0.08± 0.03	11.00***	0.10± 0.03	84.84*	0.10± 0.05	84.84***	0.05± 0.05	-	0.00± 0.00	100.00**
	Total reduction rate (%) (0 to 9 plants)		**77.77***		**73.68*****		**95.70*****		**0.00****		**0.00*****

1. ******Values are means ± SE; ($p < 0.05$); ($p < 0.01$); ($p > 0.05$)

30 years of free-air carbon dioxide enrichment (FACE): What have we learned about future crop productivity and its potential for adaptation? 2020

Site	Years of experiment	Crops studied	Elevated [CO_2] ppm	Additional treatments	Proportionate increase in yield	Source
Maricopa, AZ, USA	1989–1991	Cotton	550	Water	D 0.35 I 0.38	Ainsworth and Long (2005)
	1993–1994	Wheat	550	Water	D 0.20 I 0.08	Ainsworth and Long (2005)
	1996–1997	Wheat	+200	Nitrogen	L 0.11 H 0.14	Ainsworth and Long (2005)
	1998–1999	Sorghum	+200	Water	D 0.23 W −0.05	Ainsworth and Long (2005)
Rapolano, Italy	1995, 1998, 1999	Potato	+200		0.31	Miglietta et al. (1998) and Magliulo et al. (2003)
	1996–1997	Grape	550		0.46	Bindi et al. (2001)
Shizukuishi, Japan	1998–2000	Rice	+200	Nitrogen	L 0.08 H 0.13	Ainsworth and Long (2005)
	2003–2004	Rice	+200	4 Cultivars averaged	0.11	Shimono et al. (2009)
	2007–2008	Rice	+200	4 Cultivars averaged	0.17	Hasegawa et al. (2013)
Braunschweig, Germany	2000–2003 2001–2004 2002–2005 2007–2008 2014–2015	Winter Barley Sugar beet Winter Wheat Maize Winter Wheat	550 550 550 550 600	Nitrogen Nitrogen Nitrogen Water Nitrogen	L 0.12 H 0.11 L 0.15 H 0.09 L 0.12 H 0.16 D 0.18 I −0.01 L 0.09 H 0.17	Weigel and Manderscheid (2012) Weigel and Manderscheid (2012) Manderscheid et al. (2014) Dier et al. (2018)

Champaign, IL, USA	2001–2003	Soybean	550	Elevated Ozone	0.14	Morgan et al. (2005)
	2004–2006	Soybean	550	9 Cultivars averaged	A 0.14 E 0.15	He et al. (2014)
	2004–2007	Soybean	550	Nitrogen	0.12	Bishop et al. (2015)
	2006	Maize	550	Warming	0.01	Leakey et al. (2006)
	2008	Maize	550	Warming	L 0.04 H 0.01	Markelz et al. (2011)
	2009–2011	Soybean	585	8 Cultivars	C 0.11 W 0.06	Ruiz-Vera et al. (2013)
	2010	Maize	585		C −0.10 W 0.00	Ruiz-Vera et al. (2015)
	2010	Cassava	585		0.88	Rosenthal et al. (2012)
	2012–2014	Soybean	600		0.20	Sanz-Saez et al. (2017)
	2017	Cassava	600		0.25	Ruiz-Vera et al. (2020)
Wuxi, Jiangsu, China	2001–2003	Rice	+200	Nitrogen	L 0.11 H 0.16	Yang et al. (2006)
Changshu, Jiangsu, China	2013–2014	Rice	500	Warming	C 0.06 W 0.08	Cai et al. (2016)
	2013–2014	Wheat	500	Warming	C 0.06 W 0.10	
Stuttgart, Germany	2004–2006	Wheat	+150		0.01	Högy et al. (2009)
	2007	Oilseed Rape	500		0.14	Högy et al. (2010)
	2008	Wheat	+150		0.10	Högy et al. (2013)
Yangzhou, Jiangsu, China	2004–2006	Rice	+200	Nitrogen	L 0.33 H 0.34	Yang et al. (2006)
	2007–2008	Wheat	+200		0.15	Zhu et al. (2009)

New Dehli, India	2006–2008	Mung bean	550		0.20	Singh et al. (2013)
	2006–2008	Mustard	550		0.20	
	2006–2008	Potato	550		0.20	
	2008–2010	Peanut	550		0.21	
	2008–2010	Chickpea	550		0.23	
	2009–2011	Rice	550		0.15	
	2010–2012	Wheat	550		0.15	
Horsham, VA, Australia	2007–2009 2013–2014 2010–2012 2016 2015–2016	Wheat Wheat Field pea Faba bean Lentil	550 550 550 550 550	Water 2 cultivars avg Heat waves 5 cultivars avg Water Heat waves 2 cultivars	D 0.12 I 0.37 C 0.39 HW 0.35 0.28 D 0.24 I 0.59 C 0.64 HW 0.88	Fitzgerald et al. (2016) Macabuhay et al. (2018) Bourgault et al. (2016) Parvin et al. (2019) Bourgault et al. (2018)
Walpeup, VA, Australia	2008–2009	Wheat	550		0.56	Fitzgerald et al. (2016)
Tsukubamirai City, Japan	2010–2011	Rice	+200	5 cultivars averaged	0.17	Sakai et al. (2019)
	2010–2012	Rice	+200	Warming	C 0.15 H 0.13	Usui et al. (2016)
	2012–2014	Rice	+200	Nitrogen (2 cultivars)	L 0.05 H 0.09	Hasegawa et al. (2019)
Jaguariúna, Brazil	2011–2015	Coffee	+200	2 cultivars averaged	0.13	Ghini et al. (2015)

Table 1 Tree species gradation based on air pollution tolerance index, morphological parameters and socio-economic importance

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Grading character	Parameters	Pattern of assessment	Grade allotment (point)
Tolerance	Air Pollution Tolerance Index	Less than 12	1
		Between 10 and 16	2
		Above 17	3 (Maximum)
Morphological	Type of tree	Deciduous, Semideciduous	0
		Evergreen	1 (Maximum)
	Tree size (height)	Small: less than 30 ft (< 9.14 m)	0
		Medium: 30–70 ft (9.17–21.34 m)	1
		Large: above 70 ft (21.36 m)	2 (Maximum)
	Canopy structure	Sparse, irregular, globular	0
		Spreading crown, open, semi dense	1
		Spreading dense	2 (Maximum)
	Laminar structure		
	(a) Leaf size	Less than 225 mm^2	1
		225–2025 mm^2	2
		2025–4500 mm^2	3
		4500–18,225 mm^2	4 (Maximum)
	(b) Texture	Smooth	0
		Rough, coriaceous, leathery	1 (Maximum)
	(c) Hardness	Soft, delicate, fragile	0
		Hardy, robust, sturdy	1 (Maximum)
Socio-economic value	Food, fodder, timber, medicinal, raw material, erosion control, shade/shelter, ornamental, reclamation	Less than three uses	0
		Three or more uses	1
		Five or more uses	2 (Maximum)

1. Modified from Tiwari et al. (1993)

Table 2 Anticipated Performance Index (API) of Tree species

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Grade	Score (%)	Assessment category
0	Up to 30	Not recommended
1	31–40	Very poor
2	41–50	Poor
3	51–60	Moderate
4	61–70	Good
5	71–80	Very good
6	81–90	Excellent
7	91–100	Best

Table 3 Ambient air quality of Kumasi Metropolis during the study period

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Parameter/sampling sites	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)	VOC (ppm)
Arterial road I	7.96 ± 1.62^b	0.15 ± 0.01^b	0.08 ± 0.00^a	0.12 ± 0.29^a
Arterial road II	6.81 ± 0.16^b	0.21 ± 0.02^b	0.08 ± 0.01^a	0.07 ± 0.02^a
Arterial road III	5.26 ± 0.06^b	0.21 ± 0.01^b	0.10 ± 0.00^a	0.08 ± 0.00^a
Control site	0.85 ± 0.24^a	0.07 ± 0.02^a	0.06 ± 0.01^a	0.01 ± 0.00^a

1. Mean + SE in the same column with different letters in superscript are significantly different ($P < 0.05$)

Table 4 Effect of vehicular air pollution on relative water content (%) of four street tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Sampling site	Tree species			
	Terminalia catappa	*Mangifera indica*	*Ficus platyphylla*	*Polyalthia longifolia*
Control	68.17 ± 7.76^{a}	64.42 ± 4.94^{a}	77.84 ± 2.77^{a}	79.94 ± 7.16^{a}
Arterial road I	86.11 ± 6.24^{a}	80.08 ± 4.90^{a}	85.42 ± 8.54^{a}	85.97 ± 1.89^{a}
Arterial road II	83.80 ± 4.61^{a}	68.39 ± 7.27^{a}	82.75 ± 3.53^{a}	84.49 ± 3.16^{a}
Arterial road III	92.81 ± 1.33^{a}	83.63 ± 3.04^{a}	92.19 ± 1.88^{a}	93.86 ± 3.01^{a}

1. Mean ± SE in the same column with different letters in superscript is significantly different ($P < 0.05$)

Table 5 The effect of vehicular air pollution on leaf extracts pH of selected tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Sampling site	Tree species			
	Terminalia catappa	*Mangifera indica*	*Ficus platyphylla*	*Polyalthia longifolia*
Control	6.15 ± 0.03^{c}	6.11 ± 0.01^{d}	6.13 ± 0.04^{d}	6.75 ± 0.02^{d}
Arterial road I	5.48 ± 0.01^{b}	5.08 ± 0.04^{a}	5.73 ± 0.01^{c}	5.73 ± 0.02^{a}
Arterial road II	5.09 ± 0.06^{a}	5.60 ± 0.01^{c}	5.13 ± 0.02^{a}	5.85 ± 0.02^{b}
Arterial road III	5.10 ± 0.01^{a}	5.47 ± 0.01^{b}	5.42 ± 0.01^{b}	5.95 ± 0.02^{c}

1. Mean ± SE in the same column with different letters in superscript is significantly different ($P < 0.05$)

Table 6 The effect of vehicular air pollution on ascorbic acid contents (mg/g) of selected tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Sampling site	**Tree species**			
	Terminalia catappa	***Mangifera indica***	***Ficus platyphylla***	***Polyalthia longifolia***
Control	12.05 ± 0.01^{a}	14.38 ± 0.03^{a}	13.46 ± 0.10^{a}	10.91 ± 0.02^{a}
Arterial road I	19.81 ± 0.05^{c}	18.53 ± 0.04^{d}	15.97 ± 0.04^{b}	13.61 ± 0.05^{c}
Arterial road II	19.68 ± 0.19^{c}	17.18 ± 0.02^{c}	18.92 ± 0.04^{c}	12.09 ± 0.06^{b}
Arterial road III	15.41 ± 0.02^{b}	16.86 ± 0.05^{b}	16.03 ± 0.03^{b}	14.32 ± 0.15^{d}

1. Mean ± SE in the same column with different letters in superscript is significantly different ($P < 0.05$)

Table 7 The effect of vehicular pollution on total chlorophyll (mg/g) contents of selected tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Sampling site	**Tree species**			
	Terminalia catappa	***Mangifera indica***	***Ficus platyphylla***	***Polyalthia longifolia***
Control	1.21 ± 0.01^{d}	1.53 ± 0.02^{d}	1.52 ± 0.01^{d}	1.41 ± 0.03^{d}
Arterial road I	0.53 ± 0.01^{a}	0.67 ± 0.03^{a}	0.97 ± 0.01^{c}	0.93 ± 0.01^{c}
Arterial road II	0.84 ± 0.01^{b}	1.01 ± 0.03^{b}	0.65 ± 0.01^{a}	0.58 ± 0.03^{a}
Arterial road III	1.02 ± 0.01^{c}	1.13 ± 0.01^{c}	0.70 ± 0.03^{b}	0.74 ± 0.01^{b}

1. Mean ± SE in the same column with different letters in superscript is significantly different ($P < 0.05$)

Table 8 The effect of vehicular air pollution on of carotenoids (mg/g) contents of selected tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Sampling site	**Tree species**			
	Terminalia catappa	***Mangifera indica***	***Ficus platyphylla***	***Polyalthia longifolia***
Control	0.19 ± 0.01^{b}	0.17 ± 0.02^{b}	0.19 ± 0.01^{b}	0.18 ± 0.02^{a}
Arterial road I	0.12 ± 0.03^{a}	0.14 ± 0.03^{ab}	0.16 ± 0.01^{ab}	0.17 ± 0.01^{a}
Arterial road II	0.16 ± 0.03^{b}	0.12 ± 0.01^{a}	0.14 ± 0.01^{a}	0.14 ± 0.01^{a}
Arterial road III	0.11 ± 0.02^{a}	0.13 ± 0.01^{ab}	0.14 ± 0.01^{a}	0.15 ± 0.02^{a}

1. Mean ± SE in the same column with different letters in superscript is significantly different ($P < 0.05$)

Table 9 Air pollution tolerance index (APTI) and classification for selected tree species in the Kumasi Metropolis

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Tree species	**Ascorbic acid (mg/g)**	**Total chlorophyll (mg/g)**	**pH**	**Relative water content (%)**	**APTI**	**Classification**	
						Thakar and Mishra's approach	**Padmavathi's approach**
Control site							
Terminalia catappa	12.05	1.21	6.15	68.17	15.69	Sensitive	Intermediate
Mangiferaindica	14.38	1.53	6.11	64.42	17.43	Intermediate	Tolerant
Ficusplatyphylla	13.46	1.52	6.13	77.84	18.08	Intermediate	Tolerant
Polyalthialongifolia	10.91	1.41	6.75	79.94	16.89	Sensitive	Intermediate
Arterial road I							
Terminalia catappa	19.81	0.53	5.48	86.11	20.52	Tolerant	Tolerant
Mangifera indica	18.53	0.67	5.08	80.08	18.66	Moderately tolerant	Tolerant
Ficus platyphylla	15.97	0.97	5.73	85.42	19.24	Moderately tolerant	Tolerant
Polyalthia longifolia	13.61	0.93	5.73	85.97	17.66	Intermediate	Tolerant
Arterial road II							
Terminalia catappa	19.68	0.84	5.09	83.8	20.05	Tolerant	Tolerant
Mangiferaindica	17.18	1.01	5.60	68.39	18.19	Intermediate	Tolerant
Ficusplatyphylla	18.92	0.65	5.13	82.75	19.21	Moderately tolerant	Tolerant
Polyalthialongifolia	12.09	0.58	5.85	84.49	16.22	Sensitive	Intermediate
Arterial road III							
Terminalia catappa	15.41	1.02	5.10	92.81	18.71	Moderately tolerant	Tolerant
Mangiferaindica	16.86	1.13	5.47	83.63	19.49	Moderately tolerant	Tolerant
Ficusplatyphylla	16.03	0.70	5.42	92.19	19.02	Moderately tolerant	Tolerant
Polyalthialongifolia	14.32	0.74	5.92	93.86	18.92	Moderately tolerant	Tolerant

Table 10 Correlation matrix between the APTI values and some studied parameters

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

Biochemical parameters	Arterial road I	Arterial road II	Arterial road III	Control site
	APTI	**APTI**	**APTI**	**APTI**
AA	0.807	0.250	0.684	0.552
TCHL	− 0.597	0.907	0.377	0.953*
pH	− 0.140	0.125	0.276	− 0.121
RWC	0.157	− 0.986*	− 0.896	0.322

1. *Correlation significant at 0.05 level
2. ** Correlation significant at 0.01 level

Table 11 Evaluation of tree species gradation based on APTI, morphological parameters and socio-economic importance

From: Roadside air pollution in a tropical city: physiological and biochemical response from trees

S/no	**Grading character**	***Terminalia catappa***	***Mangifera indica***	***Ficus platyphylla***	***Polyalthia longifolia***
1	Air Pollution Tolerance Index	3	3	3	3
2	Type of plant	0	1	1	1
3	Plant size	1	1	1	1
4	Canopy structure	1	2	2	0
5	Laminar structure				
	(a) Leaf size	1	1	1	1
	(b) Texture	1	1	1	0
	(c) Hardiness	1	1	1	0
6	Socio-economic value	2	2	2	0
	Total (+)	10	12	12	6
	API (%)	62.50	75	75	37.50
	API Grade	4	5	5	2
	Assessment	Good	Very good	Very good	Poor