IMPACT OF AMBIENT OZONE POLLUTION ON GROWTH AND PRODUCTIVITY OF TWO CULTIVARS OF MUNGBEAN BY USING ETHYLENEDIUREA AT SUBURBAN AREA OF LAHORE-PAKISTAN

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Abstract

An experiment was conducted at Institute of Agricultural Sciences (IAGS), University of the Punjab, Lahore, Pakistan during March-June 2011-12 to determine the effect of ambient ozone pollution on growth and yield of mungbean. Soil drench method of application of Ethylenediurea (EDU) on two cultivars of mungbean (Vigna radiata L. cv. NIAB-2006 and AZRI-2006) and its improving results against ambient ozone stress was checked on growth and productivity features of crop. Monthly mean O3 concentration changed between 79.4 ppb and 105.2 ppb during the experimental period. Mungbean plants were treated with EDU by making concentrations such as 0, 200, 300, 400 and 500 ppm after 10-daysbreak as soil drench during the whole growth period. EDU treatments affected plant growth and productivity with varying effects on cultivar, age, and EDU concentration. In this study growth and productivity was improved for NIAB-2006 and AZRI-2006 at 400 ppm EDU. Overall results on mungbean crop by applying EDU looks like a very useful to evaluating the ambient ozone consequences in Pakistan.

Key Words: ***Mungbean, Ethylenediurea, productivity, Ambient, Yield***

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INTRODUCTION:

Mungbean (Vigna radiate (L.) Wilczek) also known as mungbean, mung, green gram, golden gram. In ancient times production of mungbean has been proved by the discovery of carbonized grains in a Madhya Pradesh state of India at Chalcolithic site dated 1660 to 1440 B.C. Since early times, mungbean has been grown in Burma, China, India, Iran, Pakistan, Sri Lanka and eastern regions of the former Soviet Union. In Asian countries like Pakistan, mungbean (Green gram) is an important pulse crop, where the diet is mostly cereal based. Nationwide, in 2010-11 mungbean was grown on about 137.4 hectares with approximately 76.2 tonnes production (Anonymous, 2010-11). In Pakistan mungbean is grown all over but its cultivation is focused mostly in the Punjab. Punjab is the major mungbean growing province that alone accounted for 85% of the total mungbean production. Cultivation is concentrated in the districts of Layyah, Bhakkar, Mianwali and Rawalpindi (Anonymous, 2010-11). In recent times, urbanization, industrialization, and transportation (particularly motor traffic) have increased at arecord scale in Pakistan with subsequent increase in phytotoxic atmospheric pollutants viz., O3, SO2, NO2, lead and PAN. In developed world, phytotoxic air pollutant has recognized as tropospheric ozone (Paoletti and Manning, 2007; Serengil et al., 2011). Various studies in the past few years have revealed that the pollutants absorbed through exposed surfaces can lead to a number of physiological disorders with consequent depressions in plant vigor and lowered crop yields. While for the developing and highly populated countries like Pakistan, such yield losses alone may pose a big problems, it is likely to be compounded further if the target crop is a legume.

In developing world tropospheric ozone O3 is most wide spread phytotoxic air pollutant. Ambient ozone injury of plantshave been checked for protection against different chemical compounds (Manning and Krupa, 1992; Manning, 2000). Different methods like soil or foliar applied fungicides, growth regulators, retardants, inert dusts and pesticides. Due to various success levels by using these compounds, but most of them were not followed up by further research. Different types of chemical compounds have been assessedon plants to check their potential against ambient O3 (Manning and Krupa, 1992; Manning, 2000). Due to unnecessary use for a longer period of time result in EDU phytotoxicity, rough or random release in media or field soils from organic matter treated with EDU. EDU availability depends on level of soil moisture during different applications. Due to dryness of soils, EDU can begin to build-up and cause phytotoxicity when released later.

To know the physiological basis of differences in yield among the genotypes of mungbean, growth components are essentialand the variation in crop development. Pandey et al., 1978were studies five different varieties of black gram to analyzed the physiological causes of yield differences and observed in CGR, RSR, RGR, LWR, SLW, NAR and LA among the varieties. Egli et al., 1991were determined that plant photosynthesis during pod formation was related to seeds per unit area. If LAI attains its maximum value,the dry matter increase may be the highest within the possible short time period (Sarwar et al., 2004; Pawar et al., 1980; Khan et al., 2010). Meteorological conditions in Pakistan, likelight andtemperature intensity with long light duration are encouragingthe formation of O3 due to long distance travel of precursor. The present investigation was assumedto assess ambient O3 injury in mungbean (Vigna radiate (L.) Wilczek) using ethylenediurea with reference to growth and productivitydifferences in EDU treated and untreated plants.

MATERIALS AND METHODS

Description of experimental site: The experiment was arranged at the Institute of Agricultural Sciences, University of the Punjab, Quaid-e-Azam Campus, Lahore (31o29-00-N, 74o17-00-E), Pakistan, on a suburban site 20x14 m next to agricultural fields. The main road was 800 m away from experimental site, industrial area was 7 km and main city center was about 3.5 km. (Figure 1)

Metrological Data: To study the effects of metrological parameters on ozone formation and their concentration, data collected from Pakistan Metrological Department, Lahore. Different parameters like temperature, precipitation, relative humidity and sunshine. (Table 1)

Months / Year	No. of days	Temperature (°C)			Relative humidity (%)			Rainfall (mm)	Sunshine (h)
		Mean	Max*	Min*	Mean	Max*	Min*		
Mungbean Season – 2011									
Mar. 2011	31	22.98	28.80	17.17	54.87	69.29	40.45	0.26	8.60
Apr. 2011	30	26.94	33.04	20.58	43.58	55.81	31.35	1.19	9.10
May. 2011	31	33.17	39.15	27.19	38.01	47.09	28.94	1.93	10.5
Jun. 2011	30	31.88	36.99	26.78	56.60	66.52	46.68	3.85	9.50
Seasonal	**122**	**28.74**	**34.49**	**22.93**	**48.27**	**59.68**	**36.85**	**1.81**	**9.42**
Mungbean Season – 2012									
Mar. 2012	31	21.21	27.75	14.68	47.71	60.03	35.39	0.69	8.10
Apr. 2012	30	27.19	33.66	20.73	47.64	58.77	36.52	1.53	8.80
May. 2012	31	31.97	38.83	25.12	32.06	41.58	22.55	0.07	10.2
Jun. 2012	30	34.77	41.31	28.23	37.13	45.61	28.65	0.49	10.5
Seasonal	**122**	**28.79**	**35.39**	**22.19**	**41.14**	**51.49**	**30.78**	**0.69**	**9.40**

Ambient ozone monitoring: The 400E model ozone monitor was used for ozone concentrations measurements between 9.00 to 17.00 h during the whole growth period of the plant at different stages.

Exposure index for O3, i.e. AOT40 (stored O3 over a threshold concentration of 40 ppb during daylight hours) by using the formula given by (Mills et al., 2007):

$$AOT\ 40 = \sum_{i=1}^{n} [CO_3 - 40]\ i$$

For CO3>40 ppb; (AOT40 ppb h), where, CO3is the hourly O3 concentration in parts per billion (ppb), i is the index, n is the number of hours with CO3>40 ppb over the 3–month growing period that has been set as the period of evaluation for mungbean crop.

Procurement of Plant materials: Certified seed of mungbean [Vigna radiata (L.) Wilczek var. NIAB-2006 & AZRI-2006] were obtained through the help of Mutation &Breeding Division of Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan and Arid Zone Research Institute (AZRI), Bhakkar, Pakistan.

Raising of Plants: In this study pots of size 36 cm diameter were used. The field soil used as potting medium was an unsterilized (fine-loamy) mixed with sand (medium-to-coarse, mined, sieved) in 3:1 ratio. The mixture of soil was air-dried and sieved (passed through 2mm screen). This soil was mixed with thoroughly sieved composted farmyard manure with good quality in 6:1 ratio by volume. The suitable moisture (18%) was maintained for germination of plants in these pots.

One week old seedling emergence pots of mungbean were treated with EDU (200, 300, 400 & 500 ppm) solution at weekly interval up to 90 days by Randomized Complete Block Design (RCBD). Deionized water was used for fresh preparation of EDU solution and 100 ml plant_1of mungbean was applied as a soil drench at 7:30 AM. Control plants received only deionized water (100 ml plant_1). Plants were subjected to same water supply both for EDU-treated and N - EDU-treated ones.

Plant sampling and analysis: Five mungbean plants were selected at random per treatment from each replicate pot for biomass determination and growth analysis at 30 and 60 days after germination (DAG). Plant samples were analyzed for shoot and root lengths, number of leaves and leaf area.

Different growth parameters and growth indices of mungbean plants: Three harvests were taken during the entire duration of experiment at experimental site. First harvest (initial harvest or Harvest - I) was carried out at seedling stage of plants after 30 days of germination (DAS) and the second harvest (mid-season harvest or Harvest - II) was taken at vegetative stage of plants after 60 days of germination (DAS) while third harvest (final harvest or Harvest – III) was taken at the end of growing season of 90 days.

Random samples of plants were taken in triplicate at 30, 60 and 90 days after sowing (DAS) for various growth and yield analyses.

Different growth parameters such as Net Assimilation Rate (NAR), Relative Growth Rate (RGR), Root Shoot Ratio (RSR), Specific Leaf Weight (SLW), Specific Leaf Area (SLA), Leaf Area Ratio (LAR) and Leaf Weight Ratio (LWR) were calculated by using formulae modified by Hunt (1982).

$$\text{Specific Leaf Weight (SLW) (g cm}^{-2}\text{)} = \frac{L_W}{L_A}$$

$$\text{Specific Leaf Area (SLA) (cm}^{2}\text{ g}^{-1}\text{)} = \frac{L_A}{L_W}$$

$$\text{Leaf Area Ratio (LAR) (cm}^{-2}\text{ g}^{-1}\text{)} = \frac{L_A}{W}$$

$$\text{Leaf Weight Ratio (LWR) (g g}^{-1}\text{)} = \frac{L_w}{W}$$

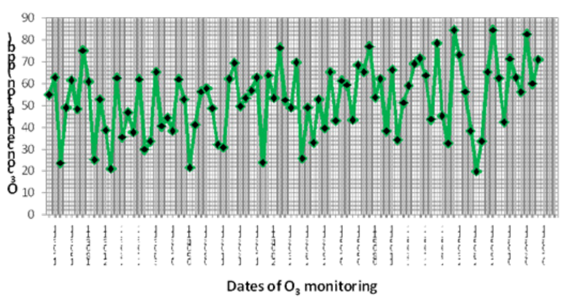
$$\text{Root Shoot Ratio (RSR) (g g}^{-1}\text{)} = \frac{R_w}{S_W}$$

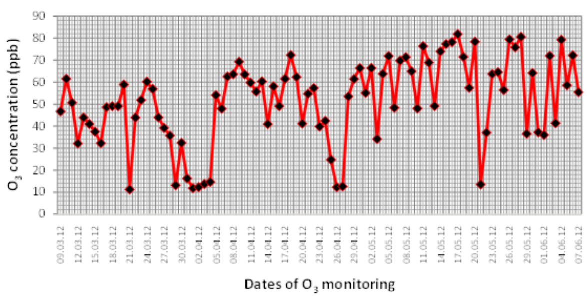
Where, W -- total plant dry weight, SW -- total shoot dry weight, RW -- total root dry weight, LW -- total leaf dry weight, LA -- leaf area.

Statistical analysis: Statistical analysis was done by using the statistical package SPSS software (SPSS Inc., Version 10.0). Mean and standard error was calculated according to treatments.

RESULTS

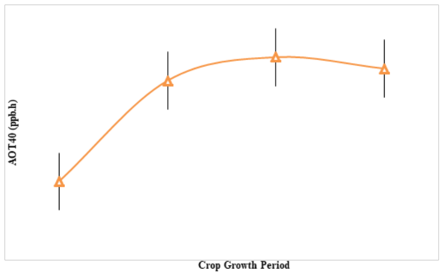
Ambient ozone monitoring and AOT40: Monthly mean O3 concentration values on every day of a particular month for both the mungbean seasons are concised in Fig 2 & 3.

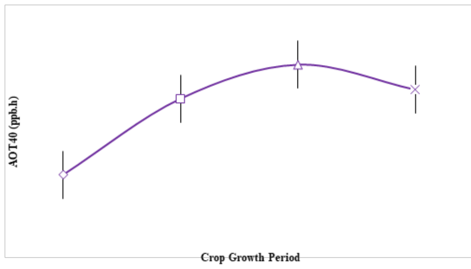




During 2011 mungbean growth season, monthly mean O3 concentration in ambient air was much higher i.e., 101.3 ppb, 93.81 ppb and 79.4 ppb for the months of May, June and July respectively, while O3 levels decreased for the months of March, 54.0 ppb and August, 65.5 ppb. Almost similar pattern of ozone behavior was noted in the second mungbean experimental season. Mean 8 h O3 concentration during 2012 mungbean season 105.2 ppb, 95.5 ppb and 93.5 ppb for the months of May, June and July was relatively higher than that of March, 64.3 ppb and August 65.3 ppb respectively.

Ozone concentrations that contributed to AOT40 were calculated in a six months period, from 9.00 am to 7.00 pm. AOT40 values from May to July 2011 was the highest when compared to other period with 9539 ppb.h, 9003 ppb.h and 7249 ppb.h respectively. In the months of March, April and August 2011 lowest values of AOT40 with 3701ppb.h, 8437 ppb.h and 6015 ppb.h was calculated (Fig. 4). During 2012 mungbean season monthly AOT40 concentration in ambient air was much higher in the months of May, June and July 2012 with values 10684 ppb.h, 9302 ppb.h and 8918 ppb.h, respectively. In the months of March, April and August 2012 lowest values of AOT40 was calculated, 4608 ppb.h, 8810 ppb.h and 6403 ppb.h respectively (Fig. 4).





Early growth of two mungbean cultivars (NIAB-06 & AZRI-06) at harvest - 1 (30-days-old) during two successive mungbean growth seasons showed positive influence on growth parameters due to different EDU concentrations applied as showed by increases in plant height, leaf area and biomass of plants over non-EDU treated. An increase of mungbean plant leaf fresh and dry weight by applying 400 ppm EDU as compared to different other concentration like 200, 300, 500 ppm and N-EDU. Mungbean plant fresh and dry shoot- root weights different significantly ($p = 0.05$) due to treatment with EDU showed on mungbean cultivar NIAB-06>AZARI-06>N-EDU (Table 2). Fresh and dry biomass of shoot-root were lower in N-EDU as compared to EDU-treated plants. Leaf area 50% was increased in line for EDU-treatment of 400 ppm in NIAB-06 as compared to N-EDU. Leaves number, branches, nodules, flowers and pods decreased in N-EDU as compared to EDU-treated plants. Number of leaves was recorded 21 in NIAB-06 and AZRI-06 as associated to N-EDU plants at 30 days after sowing (DAS). Highly significant ($p = 0.05$) two-way analysis of variance test showed variations in leaf area and their number due to plant age, EDU and N-EDU treated and their interactions (Table 2).

Cultivar	Treatment	Fresh weight (g)				Oven dry weight (g)				Leaf area / plant (cm^2)	Leaf Number/ Plant
		Leaf	Stem	Root	Total	Leaf	Stem	Root	Total		
Growth Season 2011											
NIAB -2006	NEDU	1.42a	0.16a	0.50b	1.97f	0.46a	0.05a	0.51cd	0.69ab	31.01a	9.00b
	EDU-200 ppm	1.65a	0.41a	0.44a	2.23f	0.56ab	0.13ab	0.14abc	0.84b	33.02a	13.00cd
	EDU-300 ppm	2.37cd	0.74b	0.62c	2.61d	0.79cd	0.24b	0.17cd	1.20c	49.54b	14.00d
	EDU-400 ppm	3.60e	2.56e	0.79e	5.23b	1.18e	0.84d	0.25e	2.27d	65.31c	20.00e
	EDU-500 ppm	2.05b	1.21c	0.83e	3.28d	0.68c	0.39c	0.23e	1.30c	53.62b	13.00cd
	L.S.D.	0.29	0.28	4.61	0.37	0.10	0.12	0.03	0.17	6.41	2.01
AZRI -2006	NEDU	1.43a	0.17a	0.52b	2.11f	0.47ab	0.05a	0.11a	0.63a	31.19a	6.00a
	EDU-200 ppm	1.62a	0.42a	0.64c	1.94e	0.58b	0.14ab	0.12a	0.83b	32.28a	7.00ab
	EDU-300 ppm	2.48d	0.75d	0.73d	3.97c	0.79d	0.23b	0.13ab	1.16c	51.91b	13.00cd
	EDU-400 ppm	3.60e	2.14d	1.51f	7.25a	1.19e	0.85d	0.19d	2.23d	65.37c	14.00d
	EDU-500 ppm	2.07bc	1.22c	0.66c	3.95c	0.72cd	0.40c	0.16bc	1.28c	54.03b	11.33c
	L.S.D.	0.29	0.28	4.61	0.37	0.10	0.12	0.03	0.17	6.41	2.01
Growth Season 2012											
NIAB – 2006	NEDU	1.50d	0.36e	0.53e	2.39e	0.45e	0.08e	0.18c	0.71d	32.76de	10.00c
	EDU-200 ppm	1.79c	0.51d	0.63d	2.92d	0.54d	0.16d	0.20bc	0.91c	35.68d	13.00b
	EDU-300 ppm	2.35b	0.81c	0.69bc	3.85c	0.79b	0.28c	0.23b	1.30b	49.19c	14.00b
	EDU-400 ppm	3.56a	2.05a	0.86a	6.46a	1.17a	0.78a	0.28a	2.22a	64.52a	21.00a
	EDU-500 ppm	2.28b	1.34b	0.73b	4.36b	0.70c	0.40b	0.23b	1.33b	59.54b	13.00b
	L.S.D.	0.14	0.11	5.53	0.16	7.12	6.64	3.93	0.13	2.80	2.27
AZRI – 2006	NEDU	1.48d	0.34e	0.51e	2.33e	0.43e	0.09e	0.17c	0.69d	32.25e	10.00c
	EDU-200 ppm	1.78c	0.50d	0.61d	2.89d	0.57d	0.17d	0.19bc	0.93c	35.48d	13.00b
	EDU-300 ppm	2.34b	0.80c	0.67cd	3.80c	0.80b	0.29c	0.22b	1.32b	48.96c	14.00b
	EDU-400 ppm	3.54a	2.03a	0.84a	6.41a	1.15a	0.78a	0.30a	2.23a	64.22a	22.00a
	EDU-500 ppm	2.27b	1.33b	0.72bc	4.33b	0.73bc	0.42b	0.23b	1.37b	59.28b	14.00b

Two mungbean cultivars (NIAB-06 & AZRI-06) at harvest - II (60-days-old) during two consecutive mungbean growth seasons showed almost similar enlightened influence on growth parameters due to different EDU concentrations application as exhibited by increases in plant biomass and leaf number and plants area over non-EDU treated. Plant dry and fresh stem and root weights diverse considerably ($p = 0.05$) due to treatment with EDU showed on mungbean cultivar NIAB-06>AZARI-06>N-EDU (Table 3). Dry and fresh biomass of shoot and toot of plants were lower in N-EDU treated plants than EDU-treated ones. Plant leaf area was increased as 200<300<400>500 ppm EDU as associated to N-EDU. Significantly, increase in plant leaf number and area compared to N-EDU. In AZRI-06 number of leafs was 25.5 compared to N-EDU plants was 15.0 at 60 days after sowing (DAS). (Table 3)

Cultivar	Treatment	Fresh weight (g)				Oven dry weight (g)				Leaf area / plant (cm^2)	Leaf Number/ Plant
		Leaf	Stem	Root	Total	Leaf	Stem	Root	Total		
Growth Season 2011											
NIAB -2006	NEDU	2.65d	3.86g	1.13f	7.64h	1.50ef	0.90e	0.46c	2.86e	58.13de	17.00de
	EDU-200 ppm	2.96bc	7.20e	1.46de	11.62f	1.80cd	2.09d	0.43c	4.32d	60.30d	21.00bc
	EDU-300 ppm	3.17b	10.47c	1.70a-d	15.34c	2.03bc	3.02b	0.56bc	5.61b	75.46b	22.00b
	EDU-400 ppm	5.07a	12.79a	1.90a	19.75a	3.38a	3.76a	0.73a	7.87a	97.50a	25.00a
	EDU-500 ppm	3.22b	9.46d	1.81abc	14.49d	2.14b	2.31c	0.44c	4.89c	71.60bc	18.00cde
	L.S.D.	0.29	0.65	0.24	0.47	0.22	0.13	0.12	0.27	4.17	2.88
AZRI -2006	NEDU	2.48d	3.69g	1.15f	7.32h	1.42f	0.88e	0.47c	2.77e	55.30e	15.00e
	EDU-200 ppm	2.79cd	5.60f	1.33ef	10.10g	1.72de	2.06d	0.43c	4.21d	59.76de	17.00de
	EDU-300 ppm	3.05bc	9.01d	1.55cde	13.62e	1.97bc	2.95b	0.53c	5.44b	74.70b	20.00bcd
	EDU-400 ppm	5.08a	11.38b	1.84ab	18.30b	3.29a	3.74a	0.67ab	7.70a	94.44a	25.67a
	EDU-500 ppm	3.27b	8.87d	1.62bcd	13.75e	1.97bc	2.37c	0.43c	4.77c	70.20c	19.00bcd
	L.S.D.	0.29	0.65	0.24	0.47	0.22	0.13	0.12	0.27	4.17	2.88
Growth Season 2012											
NIAB -2006	NEDU	2.55d	3.84e	1.11e	7.50d	1.47d	1.39d	0.40d	3.26e	54.80c	16.00de
	EDU-200 ppm	2.99c	7.17d	1.39d	11.55c	1.77c	2.06c	0.46d	4.29d	58.63c	21.00b
	EDU-300 ppm	3.14c	9.99b	1.66c	14.79b	2.00b	3.09b	0.63c	5.72b	73.46b	21.00b
	EDU-400 ppm	4.97a	12.79a	2.01a	19.77a	3.32a	3.83a	0.79a	7.94a	96.84a	25.00a
	EDU-500 ppm	3.33b	9.39c	1.78b	14.50b	2.10b	2.25c	0.48d	4.83c	69.94b	18.00cd
	L.S.D.	0.15	0.39	7.50	0.41	0.15	0.24	0.13	0.26	4.78	2.50
AZRI- 2006	NEDU	2.56d	3.81e	1.13e	7.49d	1.44d	1.39d	0.38d	3.21e	54.13c	15.00e

Higher root shoot ratio (RSR) was obtained in EDU-treated plants at different growth periods with higher increase in 300 ppm EDU plants after 30 & 60 days of sowing (DAS). Leaf weight ratio (LWR) was higher during first sampling in EDU-treated plants and thereafter dropped over treatment with N-EDU. Specific leaf area (SLA) & leaf area ratio (LAR) showed a tendency opposite of LWR. LWR and SLA varied significantly due to plant age (Table 4, 5).

Cultivar	Treatment	Growth Parameters				
		(RSR) --- (g g-1) RW/SW	(LWR) - (g g-1)	(SLA) --- (cm2 g-1) LA/LW	Leaf area Ratio (LAR) (cm-2) LA/W	Specific leaf weight (SLW) (g cm) LW/LA
Growth Season 2011						
NIAB -2006	NEDU	9.57c	0.67bc	66.92abc	45.16bc	0.01a
	EDU-200 ppm	1.05ab	0.67b	58.53ab	39.39ab	0.02a
	EDU-300 ppm	0.73a	0.66b	62.78abc	41.40bc	0.02a
	EDU-400 ppm	0.29a	0.52a	55.22a	28.75a	0.02a
	EDU-500 ppm	0.58a	0.52a	78.33c	41.11bc	0.01a
	L.S.D.	1.49	5.81	16.23	10.42	4.80
AZRI -2006	NEDU	2.54bc	0.74c	72.03abc	51.64c	0.02a
	EDU-200 ppm	0.87a	0.69bc	55.80a	38.78ab	0.02a
	EDU-300 ppm	0.59a	0.68bc	66.01abc	45.17bc	0.02a
	EDU-400 ppm	0.24a	0.54a	55.04a	29.39a	0.02a
	EDU-500 ppm	0.40a	0.56a	75.18bc	42.33bc	0.01a
	L.S.D.	1.49	5.81	16.23	10.42	4.80
Growth Season 2012						
NIAB - 2006	NEDU	2.27a	0.64a	72.25bc	45.97a	0.01cd
	EDU-200 ppm	1.22c	0.60a	65.97cd	39.56bc	0.02bc

Cultivar	Treatment	Growth Parameters				
		(RSR) --- (g g-1) RW/SW	(LWR) - (g g-1)	(SLA) --- (cm2 g-1) LA/LW	Leaf area Ratio (LAR) (cm-2) LA/W	Specific leaf weight (SLW) (g cm) LW/LA
Growth Season 2011						
NIAB -2006	NEDU	0.52a	0.52a	38.76a	20.33a	0.03ab
	EDU-200 ppm	0.21b	0.42b	33.46bc	13.95b	0.03ab
	EDU-300 ppm	0.19b	0.36c	37.20ab	13.45bc	0.03ab
	EDU-400 ppm	0.19b	0.43b	28.88c	12.39c	0.03a
	EDU-500 ppm	0.19b	0.44b	33.54bc	14.63b	0.02b
	L.S.D.	8.63	0.03	4.40	1.25	8.11
AZRI -2006	NEDU	0.54a	0.51a	38.86a	19.94a	0.03ab
	EDU-200 ppm	0.21b	0.41b	34.75ab	14.19b	0.03ab
	EDU-300 ppm	0.18b	0.36c	38.21ab	13.75b	0.03ab
	EDU-400 ppm	0.18b	0.43b	28.83c	12.28c	0.03a
	EDU-500 ppm	0.18b	0.41b	35.71ab	14.72b	0.02b

DISSCUSSION

Study site location in the locality of Lahore (Pakistan) where ambient O3 concentrations high due to its existence in the downwind of the city and their precursors are transported. High temperature, long time period of sunshine hours and more O3 precursors are causes for its high concentrations due to increase in number of vehicles cause impact on crop in the experimental period. However, in the experimental site low concentration of O3were observed in March and April as related to June and July. It would happened due to the low sun shine availability and heavy rain washout precursors along with utilization of O3 by HOx radicals. Rai and Agrawal (2008) informed in the year 2005 and 2006 that mean monthly concentration of O3 (12 h time period) varied from 23.4 to 44 and 30.5 to 45.4 ppb from July to October. Similarly, Sarkar and Agrawal (2010) also reported a similar type of tendency during 2007 in the rice season. During the rainy season from 2002 to 2006 in a dry tropical area, twelve hourly O3 showed difference of 24.1–43.8 ppb (Tiwari et al., 2008).

EDU effect on growth and productivity features eventually affects the mungbean plants in a positive way. By applying EDU, root length, shoot length, leaves number and area of leaf were found to be higher in both mungbean verities. Antioxidant also controls cell division, cell cycle progression from G1 to S phase, this might be happened due to increased ascorbic acid(Smirnoff 1996) and elongation of cell (De Tullio et al., 1999). In N-EDU treated plants these parameters reduced may be due to senescence and deficiency of photosynthetic activity caused by O3. Soybean plant facing O3 concentrations of 63–75 ppb in particular area, increases plant height, leaves number and leaf area of EDU-treated as compared to N-EDU-treated ones(Wahid et al.,2001). In Beta vulgaris plants 28% number of leaves plant-1 increased in EDU-treated (300 ppm) as compared to non-EDU-treated plants (Tiwari and Agrawal 2009).When wheat appeared to O3 concentrations of 27.7–59.1 ppb, number of leaves and leaf area increased treated with different concentrations of EDU (Singh and Agrawal 2010). In the present study, shoot and root biomass was affected by EDU treatment as compared to N-EDU. Singh and Agrawal (2009)also reported similar observation in five cultivars of wheat.EDU treated plants were found to have more shoot-root length, increased leaf numbers and total biomass in both the cultivars of mungbean.

CONCLUSION

During this study EDU can be successfully used for eradicate the problems caused by O3 in mungbean crop under ambient conditions in experimental site of Lahore (Pakistan). However, it is important that dose of EDU needs to be standardized and species sensitivity needs to be determined. By applying 400 ppm EDU, was effective in measuring the ambient ozone pollution impact on growth and yield of a mungbean cultivars. Level of ambient ozone increasing in Pakistan, significantly more research needs to be done on assessing ambient ozone effects on crops, trees and vegetation in natural and urban areas.

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