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IMPACTS OF ELEVATED OZONE CONCENTRATION ON SOME PHYSIOLOGICAL AND MORPHOLOGICAL CHARACTERISTICS OF TWO WHEAT PLANT VARIETIES

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ABSTRACT

Tropospheric ozone is the most important atmospheric pollutant affecting agricultural crops due to its phytotoxicity. Wheat plant, as an important and dominant cereal crop has been found to be sensitive to elevated ozone levels leading to adverse effects on growth and productivity. The objective of this study is to assess the impact of the ambient air concentration and the future increase in tropospheric ozone concentration on some physiological and morphological traits of two wheat plant (*Triticum durum*) varieties, Semito and Creso. Open- top chamber (OTC) field experiments were conducted during two consecutive years 2016-2017 and 2017-2018 under environmental conditions of Kurdistan region of Iraq, accumulated exposure over threshold of 40 ppb (AOT40) was tested, the treatment were i) ambient air concentration (32-37) ppb, ii) 50 ppb and iii) 60 ppb. Elevated Ozone concentration show a significant negative effect on total chlorophyll content (SPAD), relative water content, leaf area, plant height and consequently reducing above ground biomass, while in the same time induced increase in proline content in flag leaves. The present study demonstrate that the elevated tropospheric Ozone concentration significantly affect a range of important physiological and morphological characteristics of both varieties of wheat plant (*T. durum*).

***KEYWORDS*:** Tropospheric Ozone, *Triticum durum*, physiological traits, morphological traits

INTRODUCTION

Tropospheric ozone (O_3) is recognized as one of the most effective regional and global atmospheric pollutant due to its phytotoxicity, causing threat to food security to feed the growing population across the globe (Sarkar et al, 2010). And acting as the most powerful greenhouse gases after CO2 and CH4, in opposite to stratospheric ozone which protect the earth biosphere living components from harmful ultraviolet radiation emitted from the sun (Solomon et al. 2007).

Recently it's identified as the most dominant countryside air pollutant, affecting vegetation, crops productivity and human health. As a result of huge anthropogenic emissions of O3 precursors e.g nitrogen oxide (NOx) and volatile organic compounds (VOC) during the last decade levels of tropospheric ozone has been increased in northern hemisphere by approximately five times from 10 ppb pre-industrial concentration to 50-60 ppb current concentration (Gauss et al. 2006).

Approximately 25 % of earth surface is suffering from elevated ozone concentration to above 60 ppb particularly during summer time, when high light intensity and atmospheric pressure is prevailing, and this is above the standards of accumulated exposure over a threshold of 40 ppb (AOT40) which is crucial for injury to sensitive plant species (Monks et al., 2015).

In addition the global climate change can force more pressure on tropospheric ozone emission e.g. by modifying emissions of ozone precursors particularly biogenic volatile organic compounds (e.g. isoprene) that may be very effective to climate change in the same time (Nakicenovic and Swart, R., 2000).

In Asia mean monthly tropospheric O3 concentrations usually exceeding 50 ppb during crops growing season (Lu et al, 2010). And furthermore various simulating modeling projects indicate that globally might have more increase in ozone concentration throughout the 21^{st}, by 20–25% between 2015 and 2050, and by 40–60% by

2100, consequently more damage to agricultural crops and food production (Meehl et al., 2006, 2007).

Chronic exposure to elevated tropospheric O3 concentration it will causes a scope of negative effects on many morphological, physiological and productivity traits of plants including effects at the cellular level, visible leaf injury, reduced photosynthetic activity, accelerated senescence and consequently reducing yield (Booker et al., 2009).

Durum wheat plant (*T. durum)* is the second most cultivated wheat plant species in the world after the common wheat plant species (FAO, 2007). And it's also considered one of the most sensitive crops to elevated tropospheric O3 concentration, therefore it's estimated that the global wheat plant yield loss percentage is about 5-15% due to ambient O3 concentrations (Mauzerall&Wang, 2001; Reitze et al 2015).

Under Mediterranean environmental conditions wheat plant is very well adapted with productivity up to 6 tons/hectare in rain-fed cultivation and its considered as a fundamental crop supporting food security and economic development for rural people (Gonzalez et al., 2013).

In northern of Iraq as a part of Mediterranean environmental conditions wheat plant is considered as the most important crop with average production up to 3.4 million tons in 2016-2017 (The International Grains Council (IGC) 2016).

Regardless of its importance for food security and local economic development there are no studies in best of our knowledge concerning the sensitivity of (*T. durum)* and other agriculture crops to elevated O3 concentration under environmental conditions prevailing in Kurdistan region and whole Iraq,

Therefore this study will be the first one in whole Iraq to i) estimate the effects of elevated O3 concentration in comparison with the current ambient atmospheric concentration of tropospheric O3 on some physiological and morphological traits of two wheat plant cultivars; ii) to screening if different cultivars of *T. durum* show a different tolerance/sensitivity to tropospheric O3 in terms of growth and productivity; iii) to provide new information for improving risk assessments of the impact of tropospheric O3 on food security in the future, under environmental conditions of Kurdistan region.

MATERIAL AND METHODS

Field preparation and experimental design:

The experiment had been performed during the growing season of 2016-2017 and 2017-2018 for two consecutive years, at the research field of college of Agriculture, University of Duhok, Kurdistan Region at (36.86003 N, 42.869440). The experiment was planned to estimate the impact of tropospheric ozone on some qualitative and quantitative characteristics of two wheat plant varieties (*T. durum* Var. Semito and Var. Creso) under environmental conditions of Duhok province. The field experiment was carried out under rainfed environmental conditions. The experiment were designed as randomize complete block design (RCBD) with two factors, i.e. cultivars and Ozone concentrations with three replications. The plot size was 1 m^2. Each plot was divided to five rows with 20 cm distance between them. The sowing rate was 30 kg/dunum which is equal to 13 gm/m2, and the density was adjusted taking into account their actual purity and germination percentage determined according to the Omer and Ahmed (2015).Seed sowing was performed manually at November 2016 and 2017.

Ozone fumigation:

The target for elevated (O3) was (16-26 ppb approximately) above current ambient air concentrations which is about (32-37 ppb), during growing season daylight hours, based on the future prediction of tropospheric O3 concentration for 2050(Jagard et al, 2010).

Ozone fumigation began at anthesis growing stage when more than 50 % main-stem ears flowered on April 2017 and 2018, and continued daily during daylight hours for 30 days. The maximum 3-hours average of O3 exposure was ambient O3 concentration, 50 ppb and 60 ppb. Ozone is produced by ozone generator (QJ-002, multi -functional ozone generator, China).

Studied parameters: Many parameters concerning the physiological and morphological aspects e.g. total chlorophyll content (SPAD), relative water content (RWC), proline content, flag leaf area, plant height and total biomass, were measured during the two year of study, as explained bellow:

1- Total Chlorophyll content (SPAD) total chlorophyll was determined after about 30 days of ozone fumigation at dough development growing stage during both year of study, by taking the average of 10 flag leaves randomly for each plot by using chlorophyll meter SPAD – 502 (Konica Minolta Sensing, INC, made in Japan).

2- Relative water content (RWC %) of flag leaf was measured at dough development growing stage. Were 10 fresh flag leaves taken randomly from each plot, immediately placed in plastic bag, taken to the lab and weighted fresh weight (FW) then placed in distilled water for 24 h for hydration under ambient room temperature (25 C) and weighted again to calculate the turgid weight (TW). Afterward the leaves were oven dried at 75 C for 72 h and the dry weight was taken. Relative water content (RWC) was calculated according to the following equation by (Muranaka et al, 2002).

$$RWC (\%) = \frac{FW - DW}{TW - DW} * 100$$

Where *FW* is the fresh weight, *DW* is the dry weight and *TW* is turgid weight.

3- Proline content (mg/g): Proline content of the flag leaf at dough development growing stage was measured in accordance with Alaei et al (2012). Accordingly, 0.5gm of the fresh flag leaf was grated in 10 ml of 0.5% aqueous toluene and shacked for 60 minute for a homogenous mixture. Then the extract was filtered by using No. 2 Wattman paper and then 2 ml of acid ninhydrin reagent and 2 ml of glacial acetic acid was added to the mixture. The mixture was stirred and left in water bath at 100 C for an hour. After placing the tubes in ice water for cooling, 4 ml of tolouene was added to the tubes. Subsequent to stirring the mixture, two distinct layers were formed after about 20 seconds. The stained upper layer was taken by a micropipette and placed in spectrophotometer at 520 nm and using toluene as blank.

4- Flag leaf area $(cm)^2$ was calculated at the dough development growing stage by using the following equation,

Flag leaf area (cm^2) = $W * L * 0.75$

Where *W* is the flag leaf width and *L* is the flag leaf length (Kandic *et al*., 2009).

5- Plant height (cm) the plant height were measured at maturity stage by taking the average of 10 plants height randomly from the earth surface to the top of the plant excluding spike length for each plot.

6- Total biomass (above ground biomass Kg/dunum) air dried total biomass was determined after harvesting during June for each plot by weighting of (Straw + Grain) before threshing by using digital balance.

Statistical analysis

The data were statistically analyzed using SAS 9.4 software (SAS Institute, Inc., Cary, NC). Analysis of variance was carried out using ANOVA, and the difference between various treatments means were tested with Duncan's Multiple Range test at 5% level. Correlation analyses were carried out in SAS 9.4 software using the CORR.

RESULTS

Physiological traits

1- Effects of elevated Ozone concentration, seasonal variation and varieties on total chlorophyll content (SPAD): The results of the effects of elevated ozone concentration, seasonal variation and varieties on total chlorophyll content of the two wheat plant varieties are presented in (Table 1). It was clear from the combinational effect (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the highest values 56.7 in comparison to Creso with (60 ppb) taking the lowest values 22.5. The result of elevated ozone concentration during first and second season on chlorophyll content loss was ranged between 38-53% for Semito and 39-57% for Creso.

Table (1): Effect of elevated Ozone concentrations, seasonal variation and Varieties on total chlorophyll content (SPAD) of two wheat plant varieties

Season	Varieties	Ozone (O3) concentration ppb			V effect	
		32-37	**50**	**60**		**Season effect**
S1	**Semito**	**58.7 a**	**35.7 c**	**28.7 e**	**41.1 a**	**39.5 a**
	Creso	**56.3 b**	**33.1 d**	**24.7 f**	**38.1 b**	
	C effect	**57.5 a**	**34.3 b**	**26.7 c**		
S2	**Semito**	**54.7 a**	**33.1 c**	**23.3 d**	**37.1 a**	**35.6 b**
	Creso	**50.7 b**	**31.3 c**	**20.3 e**	**34.1 b**	

	C effect	52.7 a	32.17 b	21.8 c	
S1 + S2	Semito	56.7 a	34.3 c	26.1 d	39.1 a
	Creso	53.5 b	32.2 c	22.5 e	36.1 b
	C effect	55.1 a	33.3 b	24.3 c	

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect. Means following with the same letters are not significantly different according to Duncan Multiple at 0.05 levels.

2- Effects of elevated Ozone concentration, seasonal variation and varieties on relative water content (RWC %): The results of the effects of elevated ozone concentration, seasonal variation and varieties on the relative water content of the two wheat plant varieties are presented in (Table 2). It was clear from the combinational effect of (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the highest values 73.26% in comparison to Creso with (60 ppb) taking the lowest values 40.22%. The result of elevated ozone concentration during first and second season on relative water content loss was ranged between 28-40% for Semito and 26-38% for Creso.

Table (2): Effect of elevated Ozone concentrations, seasonal variation and Varieties on relative water content % (RWC) of two wheat plant varieties

Season	Varieties	Ozone (O3) concentration ppb			V effect	
		32-37	50	60		Season effect
S1	Semito	74.76 a	53.98 c	44.53 e	57.76 a	55.43 a
	Creso	66.89 b	50.84 d	41.56 f	53.11 b	
	C effect	70.83 a	52.41 b	43.04 c		
S2	Semito	71.76 a	50.98 c	42.53 d	55.09 a	52.21 b
	Creso	63.89 b	45.18 d	38.89 e	49.32 b	
	C effect	67.83 a	48.08 b	40.71 c		
S1 + S2	Semito	73.26 a	52.48 c	43.53 e	56.42 a	
	Creso	65.39 b	48.01 d	40.22 f	51.21 b	
	C effect	69.33 a	50.25 b	41.88 c		

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect. Means following with the same letters are not significantly different according to Duncan Multiple range at 0.05 levels.

3- Effects of elevated Ozone concentration, seasonal variation and varieties on proline content (mg/g) in flag leaves: The results of the effects of elevated ozone concentration, seasonal variation and varieties on the proline content of the two wheat plant varieties are presented in (Table 3). It was clear from the combinational effect of (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the lowest values 0.80 mg/g in comparison to Creso with (60 ppb) taking the highest values 1.50 mg/g. The result of elevated ozone concentration during first and second season on proline content increase was ranged between 40-75 mg/g for Semito and 49-76 mg/g for Creso.

Table (3): Effect of elevated Ozone concentrations, seasonal variation and Varieties on proline content (mg/g) of two wheat plant varieties

Season	Varieties	Ozone (O3) concentrations ppb			V effect	Season effect
		32-37	50	60		
S1	Semito	0.77 d	1.10 c	1.33 ab	1.07 b	1.12 b
	Creso	0.83 d	1.23 b	1.43 a	1.17 a	
	C effect	0.80 c	1.17 b	1.38 a		
S2	Semito	0.83 d	1.13 c	1.47 a	1.14 b	1.19 a
	Creso	0.87 d	1.30 b	1.57 a	1.24 a	
	C effect	0.85 c	1.22 b	1.52 a		
S1 + S2	Semito	0.80 e	1.12 d	1.40 b	1.11 b	
	Creso	0.85 e	1.27 c	1.50 a	1.21 a	
	C effect	0.83 c	1.19 b	1.45 a		

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect Means following with the same letters are not significantly different according to Duncan Multiple at 0.05 level.

Morphological traits

1 - Effects of elevated Ozone concentration, seasonal variation and varieties on flag leaf area (cm^2): The results of the effects of elevated ozone concentration, seasonal variation and varieties on the flag leaf area of the two wheat plant varieties are presented in (Table 4). It was clear from the combinational effect of (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the highest values 44.24 cm^2 in comparison to Creso with (60 ppb) taking the lowest values 18.87 cm^2. The result of elevated ozone concentration during first and second season on leaf area loss was ranged between 38-56 cm^2 for Semito and 39-52 cm^2 for Creso.

Table (4): Effect of elevated Ozone concentrations, seasonal variation and Varieties on flag leaf area (cm^2) of two wheat plant varieties

Season	Varieties	Ozone (O3) concentration ppb			V effect	Season effect
		32-37	50	60		
S1	Semito	46.41 a	28.57 c	20.17 e	31.71 a	30.43 a
	Creso	43.13 b	24.01 d	20.37 e	29.19 b	
	C effect	44.77 a	26.29 b	20.27 c		
S2	Semito	42.08 a	27.91 c	19.17 e	29.72 a	28.51 b
	Creso	39.13 b	24.33 d	18.37 e	27.28 b	
	C effect	40.61 a	26.12 b	18.77 c		
S1 + S2	Semito	44.24 a	27.24 c	19.17 e	30.22 a	
	Creso	40.13 b	24.17 d	18.87 e	27.72 b	
	C effect	42.68 a	26.20 b	19.52 c		

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect Means following with the same letters are not significantly different according to Duncan Multiple range at 0.05 level.

2 - Effects of elevated Ozone concentration, seasonal variation and varieties on plant height (cm): The results of the effects of elevated ozone concentration, seasonal variation and varieties on plant height of the two wheat plant varieties are presented in (Table 5). It was clear from the combinational effect (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the highest values 97.81 cm in comparison to Creso with (60 ppb) taking the lowest values 71.81 cm. The result of elevated ozone concentration during first and second season on plant height loss was ranged between 12-22 cm for Semito and 7-21 cm for Creso.

Table (5): Effect of elevated Ozone concentrations, seasonal variation and Varieties on plant height (cm) of two wheat plant varieties

Season	Varieties	Ozone (O3) concentration ppb			V effect	
		32-37	**50**	**60**		**Season effect**
S1	**Semito**	**100.13 a**	**85.03 c**	**76.33 d**	**87.17 a**	**85.79 a**
	Creso	**92.91 b**	**86.57 c**	**73.81 d**	**84.42 b**	
	C effect	**96.52 a**	**85.81 b**	**75.07 c**		
S2	**Semito**	**95.47 a**	**86.71 b-c**	**75.33 d**	**85.83 a**	**83.13 b**
	Creso	**89.23 b**	**82.23 c**	**69.81 e**	**80.42 b**	
	C effect	**92.35 a**	**84.47 b**	**72.57 c**		
S1 + S2	**Semito**	**97.81 a**	**85.87 c**	**75.83 d**	**86.51 a**	
	Creso	**91.07 b**	**84.41 c**	**71.81 e**	**82.42 b**	
	C effect	**94.43 a**	**85.13 b**	**73.82 c**		

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect Means following with the same letters are not significantly different according to Duncan Multiple range at 0.05 level.

3 - Effects of elevated Ozone concentration, seasonal variation and varieties on total aboveground biomass: The results of the effects of elevated ozone concentration, seasonal variation and varieties on the total aboveground biomass of the two wheat plant varieties are presented in table (6). It was clear from the combinational effect of (S1+S2) that Semito with ambient air concentration (32-37 ppb) exhibit the highest values 3714 kg/dunum in comparison to Creso with (60 ppb) taking the lowest values 1911 kg/dunum. As a result of elevated ozone concentration during first and second season on total biomass loss was ranged between 26-41% for Semito and 22-44% for Creso.

Table (6): Effect of elevated Ozone concentrations, seasonal variation and Varieties on total above ground biomass yield Kg/ Dunum of two wheat plant varieties

Season	Varieties	Ozone (O3) concentration ppb			V effect	
		32-37	**50**	**60**		**Season effect**
S1	**Semito**	3956 a	3050 c	2278 e	3094 a	2965 a
	Creso	3672 b	2894 d	1939 f	2835 b	
	C effect	3814 a	2972 b	2108 c		
S2	**Semito**	3472 a	2439 c	2061 d	2657 a	2573 b
	Creso	3156 b	2428 c	1883 e	2489 b	
	C effect	3314 a	2433 b	1972 c		
S1+S2	**Semito**	3714 a	2744 c	2169 d	2876 a	
	Creso	3414 b	2661 c	1911 d	2662 b	
	C effect	3564 a	2703 b	2040 c		

Where S1= first season, S2= second season, S1+S2= combinational effect of season, C effect= concentration effect, V effect= varieties effect, Means following with the same letters are not significantly different according to Duncan Multiple range at 0.05 level.

DISCUSSION

1- Total chlorophyll content (SPAD)

In this study, elevated ozone concentration decreased total chlorophyll content (SPAD) of the flag leaves, which is act as an active assimilate source during the anthesis stage of the plant and caused accelerated senescence in both durum wheat plant cultivars (Semito and Creso). Both cultivars responded to the elevated O3 exposure by reducing total chlorophyll content, via an accelerated senescence and resulting in a loss in grain yield. Several studies have suggested chlorophyll content of flag leaves as an indicator of stress under elevated O3 concentration exposure like (Rai et al, 2008; Sarkar et al, 2010).

The elevated ozone concentration-induced decrease in total chlorophyll content suggests a generalized negative impact of the pollutant on photosynthetic pigments (Fiscus et al, 2005). In addition it is well documented that when absorbed light exceeds plant photochemical requirement in the presence of environmental restrictions, this excess energy may be transferred to the formation of reactive oxygen species ROS, which lead to destruction of photosynthetic pigments and ultimately damage chloroplast by changing membrane permeability (Demmig-Adams and Adams 2006). In a study conducted by Burkart et al (2013), they found that elevated ozone concentration severely affects photosynthetic process by influencing photosynthetic pigments (chlorophyll, carotenoids), chlorophyll fluorescence kinetics and as well as carbon fixation.

Furthermore as a result of increasing ozone concentration to 82 ppb for 7 h day-1 over 21 days in open top chamber OTCs with 20 wheat plant cultivars, a mean reductions in total chlorophyll content was 13 % which lead to early senescence, shortening the grain filling period and result in lower grain yield (Biswas et al, 2008),

Consequently yield loss induce by elevated O3 concentration has often been attributed to reduction in photosynthetic activity as a results of reduction in stomatal conductance (gs) and photosynthetic pigments and the second reason is the lower supply of assimilates from the source to the sink that support reproductive development and seed growth (Fiscus et al, 2005).

2- Relative water content

The relative water content of flag leaves (relative turgidity) of a leaf is a measurement of its hydration status (actual water content) to its maximal water holding capacity at full turgidity (Avenson et al, 2005). RWC gives a strong indication of the plant's response to different environmental conditions, and its control the leaf tissue turgor pressure which ultimately maintains the activities of leaf resulting to high rate of photosynthesis (Sade et al., 2009). Increasing ozone concentration induces relative water content loss and severely limits plant physiological metabolism and growth parameters (Feng et al., 2008). Furthermore in another study conducted by Schreuder et al (2001), they observed that elevated ozone concentration to 45 ppb during growing season increased foliar water loss and minimal conductance to water vapour of two poplar species trees. In addition plant exposure to elevated ozone concentration lead to change in leaf cuticles and accelerated wax layer erosion (Mankovska et al., 1999). And possibly leading to decreased photosynthetic gas exchange, increased pollutant deposition and increased susceptibility of foliage to infection by fungal plant pathogens (Grantz et al. , 1997).

3- Proline content

Accumulation of proline in response to adverse effects of environmental stresses like atmospheric pollution seems to be widespread among different plant species. And it's considered to be very important osmotic regulation substance in stressful environmental conditions (Chen and Murata, 2002). It has been observed that proline accumulates under stresses of water shortage, nutrient deficiency, high salinity, low temperature, heat and heavy metal exposure as a part of general adaptation to adverse environment conditions (Dencic et al, 2000; Maggio et al, 2002). In a study conducted by Zhou et al (2014), they found that elevated ozone concentration above 85 ppb significantly increased proline content in two cultivars of winter wheat, which make the plants more resistance to oxidative damages caused by elevated ozone concentration. And this is in line with our results particularly with Semito cultivar. Furthermore wheat plant resists different stresses forms during their growth that each stress could leave various effects on the growth of the plant, metabolism and yield, based on sensitivity level and plant species growth stage (Alaei et al, 2012).

4- Leaf area, plant height and total biomass:

Recently levels of Ozone concentration in different agricultural area are known to be high enough to decrease carbon assimilation and to suppress growth and biomass accumulation in many agricultural crops and wild plant species around the world (Pleijel 2011). The adverse effects of elevated Ozone concentration on agricultural crops is highly variable depending on the cultivars, genotypic of the plant, Ozone concentration, stomatal conductance and the growth stage (Rai et al, 2010).

When Ozone enters into the plant leaves through the stomata which is exist on the underside of the leaves, it's directly react with the molecules in the cell wall that resulted in production of reactive oxygen species (ROS) molecules which lead to change cell wall permeability and destroying it gradually (Bhatia et al, 2012) and inhibiting photosynthesis, reducing carbon assimilation, visible leaf injury (Zhou et al., 2014), and accelerating leaf senescence, reducing plant height, plant growth and consequently reducing plant biomass (Biswas et al, 2008).

In a meta-analysis conducted by Pleijel et al, (2018) which is a conclusion of 33 published studies they found that non-filtered air (NF) had significant negative effects compared to charcoal filtered air (CF) on total above ground biomass (−5.4%). In another study conducted by Tomer et al, (2015) they found that as a result of elevated Ozone concentration at flowering stage, impacted plant growth by reducing the stomatal conductance (gs) which inhibited the photosynthesis rate, reducing in carbon fixation, plant height, and leaf area and consequently leading to reduction in dry matter accumulation. Also it's observed that under elevated Ozone concentration leaf senescence is accelerated, formation of new leaves will be decreased by shortage of supply of assimilates, resulted in decreasing the number of leaves per plant, leaf area, total aboveground biomass and grain yield were decreased (Fiscus et al, 2005; wahid et al, 2006).

CONCLUSSION

The present study demonstrate that the elevated tropospheric Ozone concentration significantly affect a range of important physiological and morphological characteristics of both varieties of (*T. durum* var. Semito) and (*T. durum* var. Creso).

A significant negative relationship between elevated ozone concentrations and total chlorophyll content SPAD, relative water content, plant height, leaf area and total biomass were observed in comparison with ambient air concentration, on the other hand a significant positive relationship were observed between elevated Ozone concentration and proline content in flag leaves. The sensitivity of growth, total chlorophyll content SPAD, relative water content, plant height, leaf area, total biomass and proline content was significantly difference between the two varieties and significantly difference were observed in all variables between the two growing season.

With continuously urban sprawling, increasing petrol and other industries in the region, more atmospheric pollution by different pollutants is expected, consequently there will be need for further studies on the sensitivity of a wide range of economic crops to ambient air concentration of air pollutant like tropospheric ozone, and also place extra emphasizes on appropriate varieties selection to moderate the impact of air pollutant like tropospheric Ozone on crops production in Kurdistan Region of Iraq.

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پوختە

گازا ئوزون یا ترووپوسفری دهێتە هژمارتن ئێك ژگرنگترین پیسکەرێن هەوایی کو کارتێکرنێ لسەر دەرامەتێن چاندنێ دکەت ژئەگەرێ رێژا ژەهراوییونا بەرز . رووەکێ گەنمی دهێتە هژمارتن ژ رووەکێن ئابوری یێن گرنگ وهاتییە دەستنیشانکرن وەك رووەکەکێ هەستیار بو تیراتیا زێدەیا ئوزونی دهەوایدا کو کارتێکەرە لسەر گەشەکرنێ و بەرهەمئینانێ. ئارمانج ژڤێ ڤەکولینێ هەلسەنگاندنا کارتێکرنا وێ خەستیا ئوزونێ ترووپوسفری یە کو دهەوایدا هەی ل دەمێ نوکە و پاشەروژێ لسەر هندەك سەخلەتێن فیزیولوجی و بەرچاڤ یێن دوو توخمێن گەنمی (**Triticum durum**) سمیتو و کریسو. ئەڤ ڤەکولینە هاتییە ئەنجامدان ل زەڤیێ ب بکارئینانا سیستەمێ خانیکێن بان ڤەکری **(OTC)** بو ماوێ دوو سالان ل دیڤ ئێك **2016-2017** و **2017-2018** لژێر کاودانێن ژینگەهێ یێن هەرێما کوردستانا عێراقێ. کارتێکرنا کومکری زێدەتر لسەر ئاستێ **ppb40** هاتییە تاقیکرن. فاکتەرێن هاتینە دارێتن بڤی رەنگی **i)** خەستیا ئوزونێ هەیی دهەوایدا کو دبیتە **32-37 ppb , ii)** خەستیا **50 ppb iii)** خەستیا **60 ppb.** زێدەکرنا خەستیا ئوزونی کارتێکرنەکا نەرێنی لسەر کلوروفیلێ تێکرا, پێکهاتا ئاڤێ یا رێژەیی, روپیڤا بەلگی, بلنداهیا رووەکی و هەروەسا لسەر کێمبونا کومەکا زیندی لسەر رویێ زەڤیێ دیارکر. ل هەمان دەمدا زێدەکرنا خەستیا ئوزونی بو ئەگەرێ زێدەبونا پێکهاتا ئەنزیمێ پرولین دبەلگێ ئالایدا. ڤەکولینا نوکە خویادکەت کو زێدەبونا خەستیا ئوزونێ ترووپوسفری کارتێکرنەکا بەرچاڤ لسەر هندەك سەخلەتێن فیزیولوجی و بەر چاڤ یێن هەردوو توخمێن گەنمی هەبوون.

الخلاصة

الأوزون التروبوسفيري يعتبر من اهم الملوثات الهوائية التي تؤثر في المحاصيل الزراعية بسبب سميته العالية. نبات الحنطة يعتبر من النباتات القتصادية المهمة والسائدة التي وجدت بانها حساسة الى زيادة تركيز الأوزون في الهواء الذي يؤثر في نموه و انتاجه. الهدف من هذا البحث هو تقييم تاثير تركيز الأوزون التروبوسفيري الموجود في الهواء في الوقت الحاضر والمستقبل على بعض الصفات الفسيولوجية و الظاهرية لصنفين من نبات الحنطة (***Triticum durum***) سميتو و كريسو. تم تنفيذ هذا البحث في الحقل باستخدام نظام الحجرة ذات السقف المفتوح (**OTC**) خلال سنتين متتاليتين **2016-2017** و **2017-2018** تحت الظروف البيئية لاقليم كوردستان العراق. تم اختبار التاثير التراكمي فوق مستوى ال **40 ppb**. المعاملات كانت **i)** تركيز الأوزون الموجود في الهواء و الذي يتراوح ما بين **32-37 ppb**. **ii)** تركيز **50 ppb**. **iii)** تركيز **60 ppb**. زيادة تركيز الأوزون أظهرت تأثيرا سلبيا على الكلوروفيل الكلي, المحتوى المائي النسبي, المساحة الورقية, ارتفاع النبات و بالتالي نقص الكتلة الحية فوق الأرض. في ذات الوقت أدت زيادة تركيز الأوزون الى زيادة محتوى انزيم البرولين في ورقة العلم. الدراسة الحالية توضح بان زيادة تركيز الأوزون التروبوسفيري قد أثرت بصورة معنوية على عدد من الصفات الفسيولوجية و الظاهرية لكلا صنفي الحنطة قيد الدراسة .