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EFFECT OF ELEVATED CO_2 AND TEMPERATURE ON ROOT LENGTH AND ROOT DIAMETER OF CUTTINGS OF GRAPE VARIETIES UNDER FACE AND FATE FACILITIES

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Abstract

The experiment was carried out to study the effect of eCO_2 (550ppm), eT (+3^0C) and interaction (eCO_2+eT) on rooting (fine root production) of cuttings of three grape varieties (Thompson Seedless, Bangalore Blue, and Dogridge). The objective of this study was to investigate the proportion of production of fine roots of grape varieties under high CO_2 and temperature. Destructive sampling was done and the data on root diameter and length was recorded by scanning and analysis of roots using win RHIZO software. Analysis of data revealed that there was a significant difference between varieties and treatments for the characters under study. Root diameter is one of the important factors in terms of root growth for better water absorption. It is known that lower the root diameter higher will be the water absorption. The average root diameter was lowest (*i.e.* production of fine roots were higher) in cuttings grown under eCO_2 alone or in combination with eT (eCO_2+eT). Increase in atmospheric CO_2 concentration and temperatures associated with future climate are expected to affect positively on root diameter of grape cuttings.

Key words: Elevated CO_2, Elevated temperature, Root diameter, Fine roots, win RHIZO

Introduction

Climate change is an important issue which take place on global scale, and climate change directly or indirectly affects agriculture. The rising atmospheric carbon dioxide concentration (CO_2) is one of the documented global atmospheric changes of the past half century (Prentice, 2001). The effect of climate change on agriculture may be related to unpredictable weather conditions. Atmospheric concentrations of CO_2 have steadily increased from approximately 315 ppm in 1959 to a current atmospheric concentration of approximately 404.31ppm this year. At this rate of increase, concentrations are projected to reach levels between 500 and 1000 ppm by 2100 (IPCC 2014). Rising concentrations of carbon dioxide will potentially increase global average near surface temperatures by 1.4-5.8^{0}C. Therefore, it is important to quantify the interactive effects of increasing CO_2 and temperature on crop production. Analyses of plant responses to elevated atmospheric CO_2 have focused largely on aboveground processes but production of fine roots helps in producing sustainable highly productive crops with a ability to cope up with climate changes, however, the effect of increasing CO_2 on root growth and development is poorly understood.

Grape is sensitive to different environmental factors, including temperature, water availability and CO_2. Any increase of atmospheric CO_2 concentration could increase grapevine growth rate and yield resulting in a higher accumulation of vegetative biomass and fruits (Bowes 1993; Rogers *et al*., 1994). As grape is propagated by hardwood cuttings, better root production helps in better establishment in field. Root diameter is one of the important factors for better water absorption; better water absorption helps in better nutrient uptake. Keeping this in

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view the present research work was carried with the objective of to study the effect of elevated carbon dioxide and temperatures on rooting of grape cuttings under elevated carbon dioxide and temperatures. The present study involved the observation of fine roots and root length of grape varieties exposed to elevated CO_2 and temperature.

Materials and methods

Plant materials

Hard wood stem Cuttings of three grape varieties *i.e.* Thompson Seedless, Bangalore Blue, Dogridge of 25-30 cm length having 5-6 nodes were collected from the winter pruning of grape plants. Hard wood stem cuttings treated with standard solution of 1500 ppm IBA and cuttings were planted in poly bags of size 23×12×12 cm^3 filled with potting mixture of FYM+ red soil in 1:1 proportion. The planted cuttings were kept under specially designed Open Top Chambers (OTC), Free Air Carbon dioxide Enrichment (FACE) and Free Air Temperature Enrichment (FATE) facilities.

Treatments and Experimental conditions

To study the rooting pattern, the cuttings planted in polybags were exposed to elevated carbon dioxide of 550ppm, elevated temperature (ambient+3^0C), elevated carbon dioxide (550 ppm)+ elevated temperature (+3^0C) and ambient condition which were imposed in OTC, FATE and FACE facilities.

In OTC the desired levels of CO_2 (550ppm) concentration was maintained by continuous injection of CO_2 into the plenum of OTCs was done where it was mixed with air from air compressor before entering into chamber and the set level of CO_2 concentration was maintained with the help of solenoid valves, rota meters, programme Logic Control (PLC) and Supervisory Control and Data Acquisition (SCADA) software.

Both horizontal & Vertical GI pipes (C class) are used in hexagonal structure for CO_2 release in FACE Ring. CO_2 sampling tube is placed at three different locations in FACE ring to pull air sample through air pump to CO_2 analyser to determine and control of CO_2 level/ concentration in each ring on real time basis. Wind direction, wind velocity, and CO_2 are measured and this information is used by a computer-controlled system to adjust CO_2 flow rate to maintain the target elevated CO_2. Powerful and efficient infrared heaters with quartz heating element are used in hexagonal ring to achieve temperature up to ambient +3^0C across the open plot area. Signals from each sensor are obtained to control room through four core shielded cable for data logging and control option.

WinRHIZO is an image analysis system specifically designed for root measurement in different forms. The root system and shoot system was separated and the roots were washed. Scanning and image analysis for root characteristics was carried out using Root Scanner (LA-1600) and the root morphology and architecture measurements (total root length and root diameter) were done by win- RHIZO program.

Results and discussion

Total Root length (cm/pl):

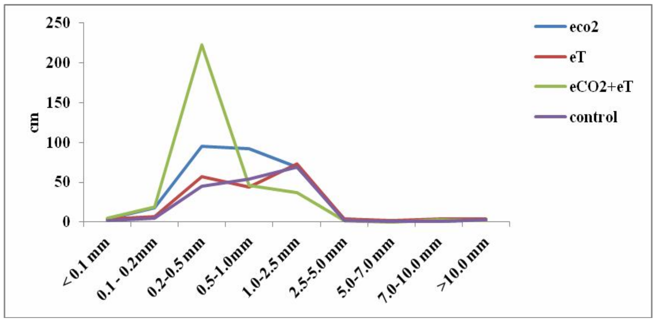
At 50DAP, Thompson Seedless and Bangalore Blue have shown higher root length under eCO_2+eT while Dogridge has shown higher root length under eT. At 80 DAP Thompson Seedless and Dogridge has shown highest root length under eCO_2+eT, while Bangalore Blue under eCO_2 Total root length was higher in eCO_2 in all the varieties.

Total root length was higher in eCO_2 in all the varieties. At 50 DAP Thompson Seedless has shown an increase in root length under eCO_2 and eCO_2+eT and there was a decrease under eT while at 80 DAP the improvement in root length was increased by eCO_2. In Bangalore Blue there was an increase in root length under eCO_2, eT and eCO_2+eT continued at 80 DAP also, however the increase was higher under eCO_2 and eCO_2+eT than eT. In Dogridge the root length was higher under eCO_2+eT at 80 DAP. At 80DAP, the response of cuttings to eT was decreased in Thompson Seedless and Bangalore Blue, however increased in Dogridge. Hence it was presumed that there might be a requirement of higher temperature at early stages for better root growth, and continuous exposure of cuttings to eCO_2 alone or in combination with eT results in higher root length.

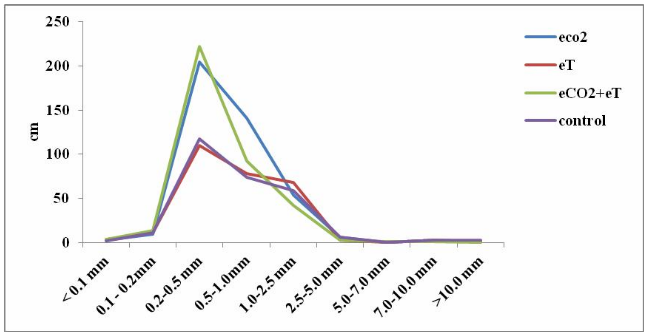
The results are in accordance with Rogers *et al.* (1992) demonstrated that increased CO_2 level resulted in enhanced root growth in soybean when compared to ambient CO_2 concentration. According to Wang *et al.* (2013), there was an increase in root length under eCO_2 than ambient CO_2 conditions in tomato. Davis and Potter (1983) reported that under elevated CO_2 an increase in root length and dry weights was observed for several ornamentals. The eCO_2 increases the carbon flow to the rhizosphere by increasing photosynthetic activity which in turn improves root production in plants (Mani Rajkumar *et al.*, 2012).

Average root diameter (mm)

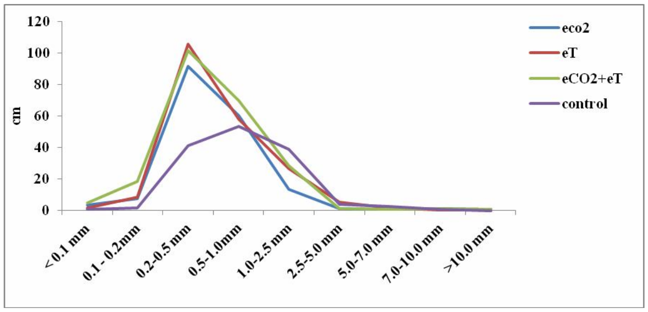
At 50 DAP, average root diameter of Thompson Seedless was 1.2mm at both eCO_2 and eT, while under



Length wise root diameter of Thompson Seedless at 80 DAP



Length wise root diameter of Bangalore Blue at 80DAP



Length wise root diameter of Dogridge at 80DAP

eCO_2+eT the diameter was 1.1mm, however under control the average diameter was 2.1mm. In Bangalore Blue the average diameter was 0.9mm under eCO_2, 1.4mm under eT, 0.6mm under eCO_2+eT and 1.7mm under control treated plants. In Dogridge the average diameter was 0.9mm under eT, 1.4mm under eCO_2+eT and 1.5mm under control.

At 80 DAP, the average root diameter of Thompson Seedless was 0.8mm under eCO_2, 1.5mm under eT, 0.9mm under eCO_2+eT and 1.2mm under control. In Bangalore Blue the average diameter was 0.7 mm under eCO_2, 1.1mm under eT, 0.8mm under eCO_2+eT and 1.0 mm under control treated plants. In Dogridge the average diameter was 0.7mm under eCO_2, 0.9mm under eT, 1.4mm under eCO_2+eT and 1.5mm under control.

Mean (±SE) performance of root length and root diameter of grape varieties under eCO_2, eT, and interaction (eCO_2+eT) at 50 and 80 DAP:

Treatments	Varieties	Total root length (cm)		Average root diameter (mm)	
		50 DAP	80 DAP	50 DAP	80 DAP
eCO_2	**TS**	179.8 ±32.8	287.1 ±29.4	1.2 ±0.1	0.8 ±0.0
	BB	297.3 ±24.6	420.5 ±63.1	0.89 ±0.0	0.71 ±0.1
	DR	0±0	179.2 ±16.5	0 ±0.0	0.67 ±0.1
eT	**TS**	195.6 ±26.2	198.2 ±23.0	1.2 ±0.2	1.5 ±0.1
	BB	179.1 ±12.4	278.3 ±19.3	1.41 ±0.1	1.13 ±0.1
	DR	165.0 ±9.2	208.4 ±11.2	0.88 ±0.0	0.87 ±0.1
eCO_2+eT	**TS**	309.0 ±30.4	336.6 ±27.8	1.1± 0.1	0.8 ±0.0
	BB	365.4 ±24.5	380.0 ±34.2	0.62 ±0.1	0.76 ±0.0
	DR	120.4 ±9.9	227.2 ±12.1	1.36 ±0.2	0.72 ±0.1
Control	**TS**	59.9 ±2.1	180.8 ±2.7	2.0 ±0.1	1.2 ±0.1
	BB	104.2 ±3.4	275.1 ±21.5	275.1 ±0.2	1.0 ±0.0
	DR	123.8 ±19.5	142.5 ±2.9	1.54 ±0.2	1.54 ±0.1

* **eCO_2-** Elevated CO_2 (550ppm), **eT-** Elevated Temperature (+3^0C), **DAP:** Days after planting, **TS-** Thompson Seedless, **BB-** Bangalore Blue, **DR-**Dogridge

ANOVA of root length and root diameter of grape varieties under eCO_2, eT, and interaction (eCO_2+eT) at 50 and 80 DAP:

Factors	Total root length		Average root diameter	
	50 DAP	80 DAP	50 DAP	80 DAP
V	110296.17 **	134849.75 **	1.285**	0.510**
T	87711.952**	53503.306**	3.603**	0.989**
V*T	43618.615**	9780.032*	0.940 **	0.116**
LSD (V)	33.979	44.315	0.227	0.140
LSD (T)	39.236	51.171	0.262	0.161
LSD (V*T)	67.959	66.619	0.453	0.279

It is known that lower the diameter of root, higher will be the water absorption. Thompson Seedless and Bangalore Blue has shown lowest root diameter (*i.e* higher number of fine roots) under eCO_2+eT at 50 DAP and under eCO_2 at 80 DAP. Here we can conclude that the diameter of the root was lowest at high CO_2 (eCO_2) alone or in the presence of high temperature (eCO_2+eT). In case of Dogridge the diameter was low under eT at first sampling, whereas at 80 DAP the diameter of the roots became lower under eCO_2 and eCO_2+eT. This may be due to initiation of fine roots under eCO_2 during early stage of growth for Dogridge.

The root diameter tend to be lowered from 50 to 80 DAP in all varieties at all treatments, the diameter of roots were highest under eT than eCO_2 and eCO_2 +eT this indicates that there would be involvement between eCO_2 and formation of fine roots in plants that were grown under eCO_2.

Length wise root diameter:

The roots having less than 1mm diameter is known as finest roots. In the total root length of Thompson Seedless the fine roots were higher under eCO_2+eT at both 50 (198.9 cm) and 80 DAP (293.2 cm). In Bangalore Blue, the finest roots were higher under eCO_2 +eT (322.2 cm) out of total root length at 50DAP, and under eCO_2 (357.2 cm) at 80DAP, while in Dogridge the finest roots were highest under eT (124.5 cm) at 50DAP but by 80 DAP there was an increase in finest roots under eCO_2+eT (194.3 cm).

Overall at final sampling all the three varieties has shown higher root length and more fine roots under eCO_2, eT, eCO_2+eT treated cuttings than control. Here it may be concluded that the fine roots may increase when grape cuttings were exposed to eCO_2 alone or in combination with eT (eCO_2+eT).

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