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The effect of CO_2 and temperature combinations on *Chenopodium album* L. early growth

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Abstract. Vegetative pots experiments were carried out at the Phytotron of the Lithuanian Institute of Horticulture in the period between January and September 2005. Four levels of CO_2 concentration: 350 ppm (control treatment), 700 ppm, 1500 ppm, 3000 ppm and two levels of temperature regimes: 21°C/17°C (control treatment) and 25°C/21°C, photoperiod of 16/8 h, and their combinations were used in testing *Chenopodium album* L. early growth. The level of radiation (PAR) was 170 micro-mol m^{-2} s^{-1}.

Experimental data proved that the concentration of CO_2, which had been gradually increasing and reached 1500 ppm, added to the length of *Chenopodium album* L. sprouts and increased the biomass of sprouts and roots. *Chenopodium album* L. was not able to adapt to further increase of CO_2 concentration and had a tendency to retard the early growth. Increase of the environment temperature to 25°C/21°C initiated more intensive early growth of *Chenopodium album* L. increasing sprout length and quantity of the accumulated biomass. However, under the conditions of 25°C/21°C, the 700 ppm concentration of CO_2 already had a negative impact on the early growth of *Chenopodium album* L.

Key words: *Chenopodium album* L., CO_2, temperature, early growth

INTRODUCTION

Climate change and environmental pollution have become the significant factors determining plant growth, development and productivity (Hoffmann & Persons, 1997; Duchovskis, 1998). These factors generate plant stress affecting physiological processes according to plant species, variety, duration of influence time and its intensity (Larcher, 1995; Vassilev, 2002; Alexieva et al., 2003). Anthropogenic factors are continuously changing our environment. Exhaust of CO_2 gases is increasing the temperature of the environment which is likely to have reached 5,5°C by the end of this century (Houghton et al., 2001). This could result in global climate change. Plants react to the increased concentration of CO_2, therefore, this can trigger the processes of plant biomass accumulation (Rogers et al., 1994). Such a change could have an impact on microbiological variation of the rizosphere as well (Niklaus, 1996).

Various plant species differ in their sensitivity and adaptation with reference to intensified anthropogenic factors that may determine their distribution and interrelation in agro-ecosystems. Therefore, it is purposeful to investigate the ability of not only cultural plants but also weeds to adapt to and grow under the influence of various environmental factors. The ability of plants to survive under unfavourable conditions depends on the intensity and character of the unfavourable factors (Bluzmanas et al., 1991). The investigated weed species – *Chenopodium album* L. – is widely spread in Europe and Asia; it even belongs to the cosmopolitan group of plants. *Chenopodium album* L. is spread in agricultural lands and set–aside all over the world (Aleksandraviciute et al., 1961; Holm et al., 1979). However, there is a lack of data about the abilities of *Chenopodium album* L. seedling growth under the conditions of different CO_2 concentrations and temperature levels.

The aim of this work was to evaluate the influence of CO_2 concentrations and temperature level combinations on the early growth stage of *Chenopodium album* L.

MATERIALS AND METHODS

The experiment was conducted at the Lithuanian Institute of Horticulture. The seeds of the investigated weed species white goosefoot *Chenopodium album* L. were collected at the Research Station of the Lithuanian University of Agriculture in the summer and autumn of 2004. The seeds were cleaned and stored in darkness at room temperature until use. Research-- was carried out in two stages at the Phytotron of the Lithuanian Institute of Horticulture during 2005.

The experimental factor was the environment of contrasting carbon dioxide (CO_2) concentrations and temperature level combinations. Four levels of CO_2 concentration: 350 ppm (control treatment), 700 ppm, 1500 ppm, 3000 ppm and two levels of temperature regimes: 21°C/17°C (control treatment) and 25°C/21°C, photoperiod of 16/8 h, and their combinations were tested in the Phytotron vegetative pot experiments. The concentration of CO_2 was regulated using CO_2 cylinder-reservoir controlled by CO_2 measurer "CO_2RT-5" (produced by Regin, Sweden). Photoperiod was achieved using high-pressure sodium (HPS) lamps SON-T Agro (Philips). The level of background radiation (PAR) made 170 micro-mol m^{-2} s^{-1}. PAR was measured with RF-100 Radiometer-Fotometer with G.PAR-100 detector cell (produced by Sonopan, Poland).

Until the emergence of *Chenopodium album* L. and for one week following,, pots were kept in the greenhouse, and then moved to the phytotron for 2 weeks. Emerged weeds were thinned out to 25 seedlings per pot. Results were evaluated after 21 days from weed emergence. The lengths of sprouts were measured (mm) and biomass (g per pot) was established oven-dried at 65°C. The experiment was conducted in three replications.

The collected data of *Chenopodium album* L. early growth, temperature regime and CO_2 concentration during 2005 was analysed by means of ANOVA. The treatment effects and standard errors (SE) were tested for significance using the 'Sigma Stat' software (SPSS Science, 1997). Evaluating data of the experiments, correlation – regression analysis was also used. Dependence reliability was evaluated by the *P* test. The data was processed using 'SigmaPlot 8.0' software (SPSS Science, 2000).

RESULTS AND DISCUSSION

The early growth of *Chenopodium album* L. depending on CO_2 concentration during the vegetative pot experiment is given in Table 1. The concentration of CO_2, which had been gradually increasing and reached 1500 ppm, added to the length of *Chenopodium album* L. sprouts. Continual increase of CO_2 concentration, which topped 3000 ppm, retarded the growth of sprouts, however, sprouts were longer than in control treatment with standard CO_2 concentration (350 ppm) which is the same as the level in the atmosphere. Accumulation of green and air-dry biomass in sprouts and roots of *Chenopodium album* L. has a tendency to decrease by CO_2 concentration of 700 ppm. The biomass increases and reaches maximum by 1500 ppm whereas it starts gradually decreasing by 3000 ppm (Table 1). This showed that *Chenopodium album* L. was not able to adapt to further increase of CO_2 concentration and had a tendency to retard the early growth.

Table 1. *Chenopodium album* L. accumulated biomass from a pot (g) and seedlings length (mm) under different CO_2 concentrations.

CO_2 concentration	Above-ground plant part				Roots	
	Sprout length before treatment, mm	Sprout length after treatment, mm	Green biomass, g pot^{-1}	Air-dry biomass, g pot^{-1}	Green biomass, g pot^{-1}	Air-dry biomass, g pot^{-1}g
350 ppm (control treatment)	9,13	24,91	68,58	6,49	6,36	0,73
700 ppm	10,54	28,61	75,87	5,51	6,52	0,59
1500 ppm	9,41	28,64	93,89	8,33	9,20	1,00
3000 ppm	9,12	26,96	82,33	8,21	8,36	0,69
± SE	0,176	0,440	4,646	0,556	0,587	0,070
P	0,039	0,023	0,274	0,315	0,437	0,437

± SE – standard error

Increase of the environment temperature (Table 2) to 25°C/21°C initiated more intensive early growth of *Chenopodium album* L., increasing sprout length and quantity of the accumulated biomass. However, in 25°C/21°C conditions, the 700 ppm concentration of CO_2 already had a negative impact on the early growth of *Chenopodium album* L. It was established that the most favourable conditions for *Chenopodium album* L. early growth were at the higher temperature regime - 25°C/21°C - with both CO_2 concentrations. However, for initiating root growth, especially, optimal conditions were with lower – 350 ppm – CO_2 concentration (Table 2). Higher CO_2 concentration 700 ppm with lower temperature regime 21°C/17°C showed the negative influence on the early growth of *Chenopodium album* L. The increase of temperature and CO_2 concentration has a negative tendency for *Chenopodium album* L. above-ground green biomass as well as for the air-dry biomass of the above-ground part and roots (Table 2).

Table 2. *Chenopodium album* L. accumulated biomass from a pot (g) and seedlings length (mm) under different combinations of temperature regimes and CO_2 concentrations.

Temperature and CO_2 concentration	Above-ground plant part			Roots (air-dry biomass, g pot^{-1})
	Longevity, mm	Green biomass, g pot^{-1}	Air-dry biomass, g pot^{-1}	
$21^oC/17^oC$ + 350 ppm (control treatment)	30.40	61.50	6.51	1.10
$25^oC/21^oC$ + 350 ppm	41.04**	61.80	7.28	1.53*
$21^oC/17^oC$ + 700 ppm	34.44*	69.98	5.72	0.823
$25^oC/21^oC$ + 700 ppm	36.18**	56.17	6.70	0.867
± SE	± 0.597	± 3.116	± 0.333	± 0.093
P	0.001	0.534	0.480	0.002

± SE – standard error, * – significant differences in comparison with control treatment (350 ppm) at $P < 0.05$ and ** - at $P < 0.01$.

Therefore, conditions of higher temperature regime 25°C/21°C, compared with 21°C/17°C, were more favourable for this weed sprouts growth and biomass accumulation (Table 2).

Having evaluated *Chenopodium album* L. sprout length dependence on CO_2 concentration (Fig. 1) non-essential positive tendencies were identified. Weak positive correlative relationship between *Chenopodium album* L. above-ground green biomass and CO_2 concentration (Fig. 2) and between the above-ground air-dry biomass and CO_2 concentration was established (Fig. 3). The influence of CO_2 concentration on *Chenopodium album* L. root green (Fig. 4) and air-dry (Fig. 5) biomass accumulation has the analogous tendency of weak increase in the above ground plant part.

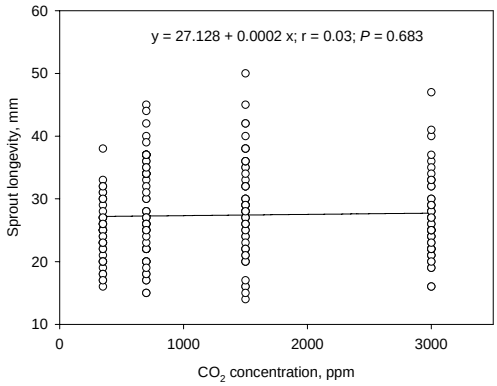

Fig. 1. *Chenopodium album* L. seedlings sprout length (mm) depending on CO_2 concentration (ppm).

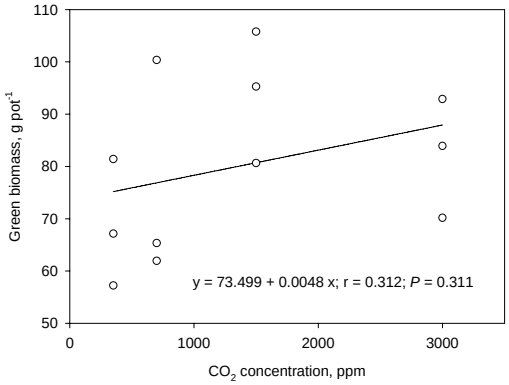

Fig. 2. *Chenopodium album* L. above-ground green biomass (g pot^{-1}) depending on CO_2 concentration (ppm).

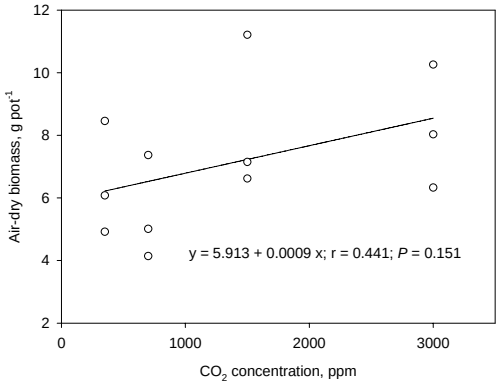

Fig. 3. *Chenopodium album* L. above-ground air-dry biomass (g pot^{-1}) depending on CO_2 concentration (ppm).

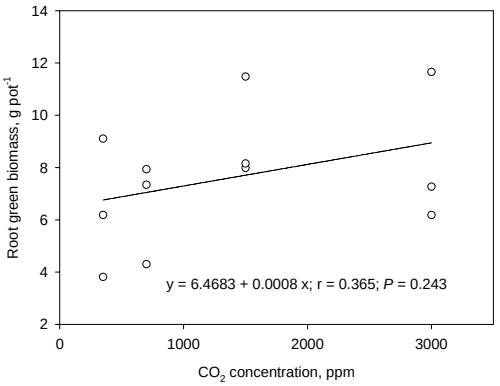

Fig. 4. *Chenopodium album* L. root green biomass (g pot^{-1}) depending on CO_2 concentration (ppm).

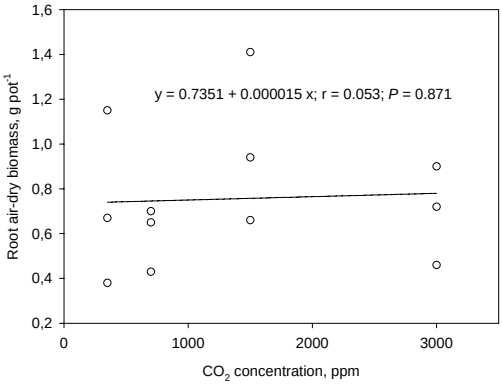

Fig. 5. *Chenopodium album* L. root air-dry biomass (g pot^{-1}) depending on CO_2 concentration (ppm).

CONCLUSIONS

An increase of CO_2 concentration positively affected the early growth of *Chenopodium album* L. and reached the optimum at 1500 ppm.

Correlation-regression analyses showed the stimulation effect of CO_2 concentration on *Chenopodium album* L. sprout length, above-ground, and root green and air-dry biomass accumulation at the stage of early growth.

A higher temperature regime - 25°C/21°C compared with 21°C/17°C - compounded more favourable conditions for *Chenopodium album* L. early growth at both – 350 ppm and 700 ppm – CO_2 concentrations.

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