

**Investigating the effects of CO₂ concentration and salinity on
the growth of *Phaseolus vulgaris***

Viksu

Biology

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Tutkimuksen tarkoituksena oli määrittää hiilidioksidi- ja suolapitoisuuden muutoksen vaikutusta tarhapavun (*Phaseolus vulgaris*) kasvuun. Nykyään tapahtuvassa ilmaston alituudessa muutoksessa hiilidioksiditasot (CO_2) nousevat samanaikaisesti veden ja maaperän suolapitoisuuden kanssa.

24 kappaletta kasveja kasvatettiin kuudessa samanlaisessa kasvihuoneessa, joissa jokaisessa oli tietty CO_2 - ja suolapitoisuus. Kolmessa kasvihuoneessa oli korotettu CO_2 -pitoisuus 0.00 mol dm^{-3} , 0.05 mol dm^{-3} ja 0.10 mol dm^{-3} suolarasituksen kanssa. Kasvihuoneet, joissa oli ilmakehän CO_2 -taso, olivat myös käsitelty 0.00 mol dm^{-3} , 0.05 mol dm^{-3} ja 0.10 mol dm^{-3} pitoisilla natriumkloridilla (NaCl). Tulokset osoittivat, että lisätty suolakuorma vähensi kasvien kasvua. Toisin kuin ennakoita odotettiin, tulos myös osoitti heikompa kasvua korkeammalla CO_2 -tasolla. CO_2 -taso ylitti kasvin optimaalisen määrän ja alkoi näin toimia rajoittavana tekijänä. Kasvi, jolla oli pisin varsi ja korkein kuivapaino, oli yksi neljästä näytteestä kasvihuoneesta, jossa oli ilmakehän CO_2 -pitoisuus suolattomassa kasvualustassa. Vertailun vuoksi heikoiten kasvanut kasvi oli yksi näytteistä, jossa oli korotettu CO_2 -pitoisuus ja 0.10 mol dm^{-3} NaCl -pitoisuus.

Tämän kokeen muutamia näkökohtia voidaan yleistää planeettamme bioversiteetin tulevaisuuteen, jos radikaaleja muutoksia ei pian tehdä sen suhteen, kuinka kohtelemme ympäristöä. Ihmisen toiminnalla on paljon seurauksia luonnolle. Tämä tutkimus ottaa selkoa yhdestä niistä.

Abstract

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The purpose of this investigation was to determine the impact of carbon dioxide concentration and various salinity levels on the growth of *Phaseolus vulgaris*. Due to the continual change in climate, especially in the present day, carbon dioxide (CO₂) levels in the atmosphere are increasing simultaneously with salinity levels in water and soil. 24 plants were grown in six identical greenhouses, each with its specific CO₂ and salinity conditions. Three greenhouses had elevated CO₂ levels, with salinity stresses of 0.00 mol dm⁻³, 0.05 mol dm⁻³, and 0.10 mol dm⁻³. The greenhouses exposed to atmospheric CO₂ levels were also treated with 0.00 mol dm⁻³, 0.05 mol dm⁻³, and 0.10 mol dm⁻³ sodium chloride (NaCl) concentrations. Results indicated that increased salinity stress stunted the growth of the plants. Contrary to prior predictions, the results also showed reduced growth in plants exposed to elevated CO₂. The level of CO₂ exceeded the plants' optimal quantity, and therefore behaved as a limiting factor. The plant with the highest stem length and dry mass peaks was one of the four samples from the atmospheric CO₂, salt stress-free greenhouse. In contrast, the plant with the least growth was one of the elevated CO₂, 0.10 mol dm⁻³ NaCl-stressed samples. A few aspects of this experiment can be generalized and predicted for the future of biodiversity on our planet if drastic changes are not made soon to the manner in which we treat the environment. There are so many consequences to nature as a result of human activity, all ultimately significant, and this study looks into one of them.

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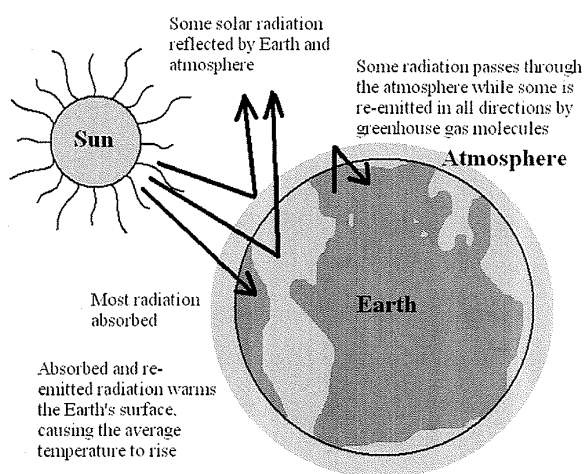
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1. Introduction

It is absolutely shocking how our day-to-day actions are causing biodiversity to change so radically. Whatever it is that we burn, we simultaneously release carbon dioxide into the atmosphere. The carbon dioxide in turn leads to warmer temperatures, melting the ice caps, and hence raising water levels, consequently lowering the pH of our soil. In addition, we irrigate land and cast salt onto highways for our own benefit. The question remains, is it essentially beneficial that the carbon dioxide concentration is increasing alongside salinity stress? How will nature respond to the extensive alterations in the environment, and how will this in effect influence humanity as we know it?

1.1. Global warming

A crucial issue currently facing our civilization is the concern of global warming. Not only is the average global temperature of our planet increasing, but potentially harmful levels of greenhouse gases are accumulating in the atmosphere (Figure 1). Human activities as well as natural events contribute to the increase in the concentrations of these gases which include water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) (Figure 2). Namely carbon dioxide is a major contributor to the problems associated with global warming. Its emissions from power stations, industrial processes, automobiles, and deforestation not only cause the Earth's temperature to rise, but significantly affect biodiversity as its concentration increases



(Figure 3).¹ Biodiversity, the diversity among plant and animal species within an environment, is essential to our survival and well-being, as it provides us with fresh air, food, and medicine.²

Figure 1. A diagram of the greenhouse effect causing global warming. 2007, Pauliina Korpela

¹ Ecobridge.org, 2001

² Dictionary.com

Annual greenhouse gas emissions by sector

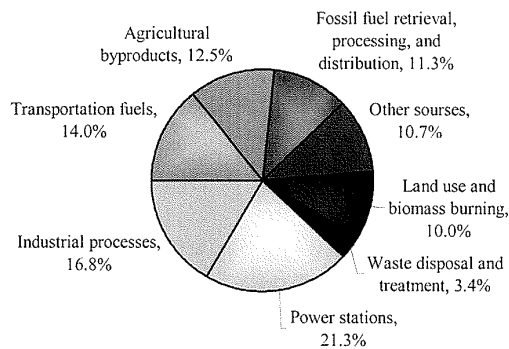


Figure 2. Annual greenhouse gas (CO₂, CH₄, and N₂O) emissions from different sources. 2007, Pauliina Korpela

Annual CO₂ emissions by sector

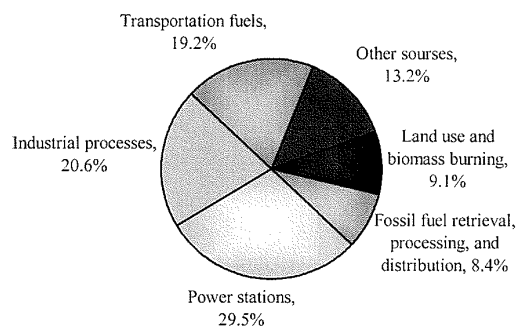


Figure 3. Annual CO₂ emissions from different sources. 2007, Pauliina Korpela

Air bubbles trapped in Antarctic ice have been measured for CO₂ concentrations. The results show that from approximately 1680 until 1880, the concentrations have remained comparatively stable, however, they have risen significantly since 1880. CO₂ levels have been monitored in Mauna Loa, Hawaii, continuously since 1958. Today the CO₂ concentration of our atmosphere is 100ppm higher than it was in 1880, when it was 270ppm.³ With increasing rates of CO₂ production, its ratio

³ Allot, 2001

in Earth's atmosphere will surely continue rising higher and faster toward a point at which its impact on our biodiversity will be inevitable. It is expected to double in the next century.⁴ Never has its concentration in Earth's atmosphere been as high as it is today.

1.2. Salinity

Salt is a compound formed by the replacement of one or more hydrogen atoms of an acid with elements or groups. Salts are usually ionized in water or another solution ($\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$). It is a constituent of seawater, a preservative, and used in the seasoning of foods.⁵ Salinity is the term used to describe the salt content in water or soil, and it is also a growing dilemma in today's world. Salt stunts the growth of plants; hence all plants die if the salt concentration is too high. If a plant tolerates an increase in salt over a narrow range, that is, a small fluctuation limit, without an instant productivity loss, it is considered salt tolerant.⁶ When the salt content is excessive it degrades water quality and land productivity, limiting availability to drinking water and the range of crops grown.⁷

There are two types of salinity; dryland and irrigation. Dryland salinity occurs when water tables (underground surfaces under which earth materials are saturated with water) bring natural occurring salts to the surface of the soil, while irrigation salinity occurs when irrigation water (artificial application of water to land to assist in the production of crops) soaks through the soil, bringing salt to the surface. As the area dries, the salt is left in the soil, thus causing the salinity concentration in the soil to rise.⁸

Though salt is naturally present in the ground, European farming practices have caused groundwater levels to rise, consequently causing a significant increase in the salinity of land and water sources. Also, areas with low rainfall commonly have a problem with soil salinization. A combination of low rainfall, irrigation, and inefficient drainage may lead to a permanent loss of soil fertility.⁹ Australia and California are two of these problematic areas.

⁴ McKee, 2003

⁵ Dictionary.com

⁶ Katterman, 1990

⁷ Napsqw.gov.au, 2001

⁸ Napsqw.gov.au, 2001

⁹ Fao.org, 2005

1.2.1. Salinity in Australia

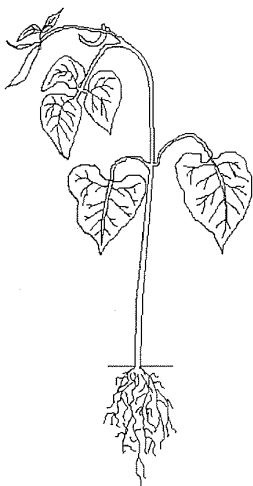
Currently, salinity increase is one of the largest environmental concerns in Australia. Australia is one of the most salt-affected countries in the world. Almost all of its soils are geologically old, infertile and underlain by salt. The National Land and Water Resources Audit estimates that 5.7 million hectares of land will potentially develop dryland salinity in Australia. By 2050, it is expected to rise to 17 million hectares.¹⁰ This in turn means drastic reduction in crop harvest and other plant growth.

1.2.2. Salinity in California

California is also faced with a serious problem with salinity threatening its agricultural industry. The San Joaquin valley has natural drainage problems, while simultaneously it has an extensive system of irrigated agriculture.¹¹ Collectively these two stress factors suppress agricultural yield.

2. Background Information

2.1. *Phaseolus vulgaris*



A well-known dicotyledon plant, the *Phaseolus vulgaris*, also known as the common bean, is grown worldwide for its edible bean. This annual plant is the most popularly cultivated bean in temperate regions and also widely cultivated in semitropical regions.¹² The leaves are occasionally used as a vegetable, and the straw for fodder.

This bean species is highly variable; its bushes growing up to 60cm tall, while its pole varieties form vines as long as 3m. All plants of the species bear green or purple leaves, small white or purple flowers, and pods growing 8-20cm in length, each containing 4-6 beans.¹³

Figure 4. A developing *Phaseolus vulgaris* plant.
2007, Pauliina Korpela

¹⁰ Environment.gov.au

¹¹ Ponce

¹² Duke, 1983

¹³ Leighcourtfarm.org

It is a C₃ plant, which means that its metabolic pathway for carbon fixation in photosynthesis involves RuDP carboxylase, the enzyme responsible for CO₂ fixation, producing compounds containing three carbon atoms. Unlike C₄ plants, C₃ plants are typically found in temperate climates, where sunlight intensity and temperatures are moderate, and groundwater plentiful.¹⁴ C₃ plants represent 95% of the world's biomass.

2.2.Sodium chloride

Sodium chloride (NaCl), also known as common salt, is a chemical compound made up of sodium and chlorine. NaCl is the salt contributing the most to the salinity of seawater and of the extracellular fluid of many multicellular organisms. Almost everywhere, its supply exceeds the demand and therefore it has a tendency to accumulate.¹⁵

The osmotic effect is the most extensively affected by salt in plants.¹⁶ In this process, water is taken up by the roots of a plant through the process of osmosis. This comprises of a movement of water through a gradient of low salt concentration to high salt concentration (e.g. soil to root cells). When salt concentrations in the soil are relatively high, the water flow will slow down. If salt concentrations in the soil exceed the salt concentration inside in the plant, the water will be drawn out of the plant causing the plant to wilt.¹⁷

2.2.1. Commercial use

Commercially, NaCl is produced by the evaporation of seawater, or by mining of halite (NaCl occurring in crystal-like structure) formations. The largest volume users include chemical production, and highway defrosting.¹⁸ As highway defrosting is a necessity during wintertime in many countries, various methods of defrosting are utilized, such as the application of chemical de-icers to ice and snow. NaCl is frequently used as a chemical de-icer due to its efficiency in melting ice, and its relatively light weight. It works by lowering the freezing point of water. A major concern in the usage of NaCl in melting roads is its impact on the environment. Studies show that most soil and vegetation damage occurs within 20m from the salt-induced pavement.¹⁹

¹⁴ Cancerweb.ncl.ac.uk, 1997

¹⁵ Ponce

¹⁶ Yiasoumi, Bill, 2003

¹⁷ Fao.org, 2005

¹⁸ Feldman, 2005

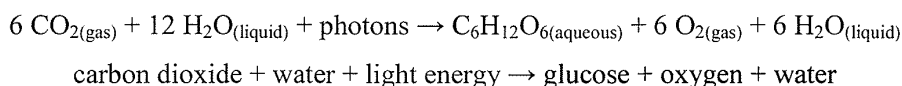
¹⁹ Usroads.com, 1996

2.3. Carbon dioxide

Most of the carbon dioxide in our global ecosystem is produced by human and animal respiration, and volcanic activity.²⁰ CO₂ is an odorless gas which makes up 370 parts per million (ppm) of the atmosphere. A plant photosynthesizing can use up to 1600ppm of CO₂. 40% of carbon in dead plant material comes entirely from CO₂. It is a vital plant nutrient, without which a plant cannot live.²¹ At 150ppm of CO₂, photosynthesis is restricted since plants are unable to obtain CO₂ from the atmosphere. At 100ppm, photosynthesis will have stopped completely. Photosynthesis is stable and consistent in an atmosphere of 350ppm as long as other factors are not limiting. A toxic level of 2000ppm of CO₂ in the atmosphere will result in a low photosynthetic rate for most plants, as the stomata closes.²²

2.3.1. Photosynthesis

Photosynthesis is the conversion of light energy into energy by living organisms such as plants. It is the reason for plant growth, development, and production. Photosynthetic reactions occur within plant leaves, requiring light as the energy source, water (H₂O), and CO₂. The first stage of this process is the light-dependant stage in which the chloroplasts capture light and use it to make high-energy molecules. Stage two does not require light, but uses the high-energy molecules to convert CO₂ and water into monosaccharide sugars, oxygen, and water.²³ If one of the resources required for photosynthesis is limited to the point where it inhibits growth, it is called a limiting factor. The equation below demonstrates the basic chemical reactions of photosynthesis.



2.4. Effects of CO₂ under salinity stress

Studies show that the enhancement percentage brought on by the elevation of CO₂ could be greater in plants under environmental stress than in plants without stress.²⁴ Due to the increases in global population, more demand is placed on the production yield of world agriculture. Estimations have been made suggesting that 20 to 30 million hectares are seriously salt-stressed, thus irrigation is

²⁰ Kent, 2000

²¹ Progressivegardens.com, 2005

²² Gov.mb.ca, 2006

²³ Progressivegardens.com, 2005

²⁴ Co2science.org, 2007

being limited on some agricultural land. Now with the increasing CO₂ levels, many people believe that this phenomenon will only benefit agricultural growth.²⁵

3. Experimental Method

3.1. Introduction

The main aim of the experimental procedure was to determine the effect of increased CO₂ levels together with varied salinity levels, including their individual effects, on C₃ plants in biodiversity. Environmental changes combined with biological stress factors can have different, even opposite consequences on biodiversity than what they may have solely. Sodium chloride, causing significant damage to plants and agriculture, and carbon dioxide, a major component of global warming were chosen as the main focus in this experiment precisely due to their relevancy in our progressively changing environmental situation. In the future we will undoubtedly have problems with both atmospheric CO₂ elevation and salinity stress.

The *Phaseolus vulgaris* was a suitable plant for the procedure as its bean is universally consumed, and its growth rate is relatively fast. As it is a C₃ plant, it represents the majority of the plant biomass in the world.

3.2. Hypothesis

In this experiment, it was estimated that the plants that were subjected to more NaCl would have increasingly stunted growth, both in stem length and dry mass. In a research experiment on *Phaseolus vulgaris* conducted by Shirley Bray and David M. Reid, salinity increased the volume density of the palisade mesophyll (the upper layer of the leaf), while the intercellular spaces (in the spongy mesophyll) and epidermis densities were reduced. Cell volumes, relative leaf expansion rate, and leaf dry weight were all decreased. Elevated CO₂ on the other hand increased leaf volume, and reduced the density of epidermal and palisade cells. The effects of salt were moderately reduced. Under high CO₂, epidermal and intercellular space volume densities were reduced, and the palisade mesophyll volume density increased. In their experiment, Bray and Reid concluded that high CO₂ had more effect on salt-stressed plants than unstressed ones.²⁶

²⁵ Wilson. Liu. Linghe, 2005

²⁶ Bray. Reid, 2002

CO₂ supplementation was expected to enhance the dry mass increment of the *Phaseolus vulgaris* species because elevation of CO₂ to a certain extent increases plant tolerance to salinity.²⁷

Another experiment conducted by Enrico Brugnoli and Marco Lauteri suggests that salinity decreases stomatal conductance (rate of passage CO₂ through the stomata²⁸).²⁹ A particular elevation in the concentration of CO₂ in the air provides a more efficient diffusion of CO₂ through the stomata of the plant. In cases of decreased stomatal conductance, CO₂ elevation would be relatively more effective than in cases without reduced stomatal conductance, since the stomata acts as the limiting factor instead of the CO₂ supply.

3.3. Overview

In this experiment, *Phaseolus vulgaris* seeds were planted in six identical airtight greenhouses. The greenhouses were each divided into four sections so that each greenhouse fit four plants. Under the soil, a bottom layer of gravel served as drainage. Three of the greenhouses contained a smaller container with a vinegar and baking soda mixture (20ml of vinegar and a slight excess of baking soda) providing a supply of CO₂ to elevate the CO₂ level in the greenhouses (Figure 6). The mixtures of vinegar and baking soda were replaced daily. The other plants were planted in greenhouses without the CO₂ source (Figure 5). The seeds/plants were given 15ml of water daily, each with its specific concentration of sodium chloride. Greenhouses A₁, A₂, A₃, B₁, B₂ and B₃ (B₁, B₂ and B₃ being the greenhouses with elevated CO₂) were given 0.00 mol dm⁻³, 0.05 mol dm⁻³, 0.10 mol dm⁻³, 0.00 mol dm⁻³, 0.05 mol dm⁻³, and 0.10 mol dm⁻³ of NaCl respectively. There were six different growing conditions, with four plants in each environment in order to get reliable results. The plants were monitored for a period of nine days, after which their stem lengths, and dry weights were measured.

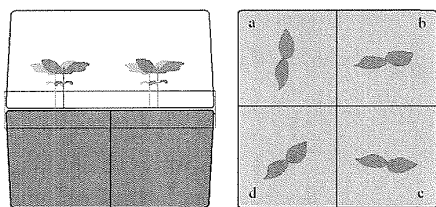


Figure 5. The diagram illustrates the layout

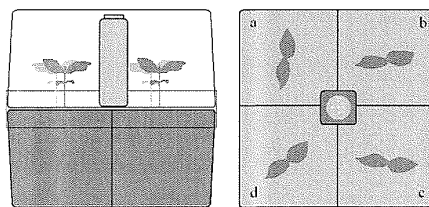


Figure 6. This diagram illustrates the layout

²⁷ Schwarz. Gale, 1984

²⁸ Uni-giessen.de

²⁹ Brugnoli. Lauteri, 1991

of the greenhouses without a CO₂ supply from front view and top view. 2007, Pauliina Korpela

of the greenhouses with a CO₂ supply from front view and top view. 2007, Pauliina Korpela

3.4. Conditions

The positions of the greenhouses were alternated systematically each day, keeping the sunlight exposure to the greenhouses relatively similar. The exterior environment of the greenhouses was the same, while the interiors were kept fairly similar aside from the salinities and CO₂ concentrations. The greenhouses were identical in all shape, size, lucidity and material. The same soil was used in all of the greenhouses in order to keep mineral quantities equal. The plants were grown for a period of nine days because one plant reached the height of the greenhouse roof on the ninth day.

4. Results

Table 1. Stem lengths of plants after nine days

Greenhouse	Total stem lengths				Average
	Plant a	Plant b	Plant c	Plant d	
	<i>l/m</i>				
	$\Delta l \pm 0.01m$				
A ₁	0.21	0.18	0.21	0.24	0.21
A ₂	0.20	0.16	0.19	0.17	0.18
A ₃	0.18	0.15	0.12	0.18	0.16
E ₁	0.12	0.16	0.15	0.13	0.14
E ₂	0.18	0.18	0.13	0.11	0.15
E ₃	0.12	0.11	0.12	0.10	0.11

Table 2. Dry masses of plants after nine days

Greenhouse	Dry masses				Average
	Plant a	Plant b	Plant c	Plant d	
	<i>m/g</i>				
	$\Delta m \pm 0.001g$				
A ₁	0.136	0.181	0.271	0.204	0.198

A₂	0.238	0.147	0.190	0.153	0.182
A₃	0.146	0.207	0.117	0.202	0.168
E₁	0.130	0.150	0.191	0.095	0.142
E₂	0.174	0.171	0.186	0.150	0.170
E₃	0.118	0.137	0.160	0.101	0.129

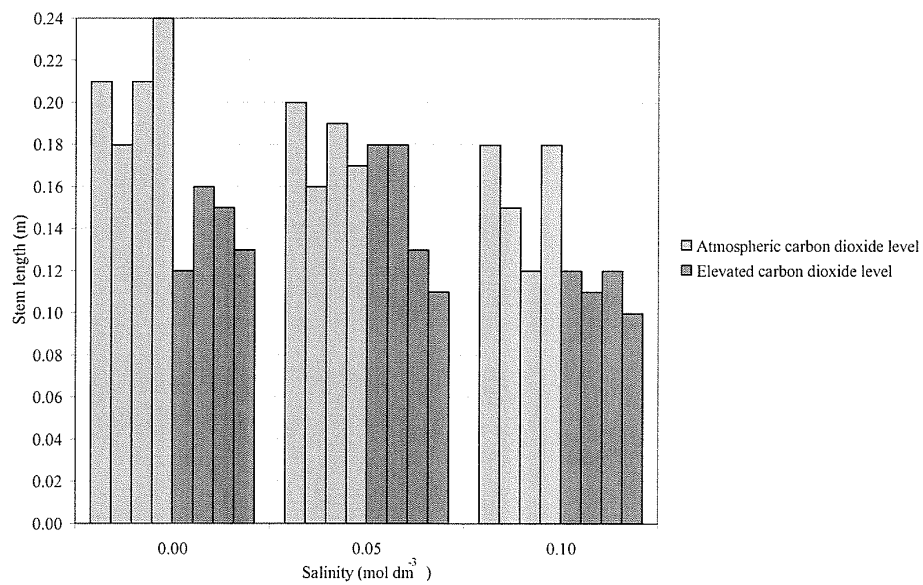
Stem lengths of *Phaseolus vulgaris*

Figure 7. Graph displaying the stem lengths of a, b, c, and d plants under salinity stresses ranging from 0.00 mol dm⁻³ to 0.10 mol dm⁻³, exposed to atmospheric and elevated carbon dioxide levels.

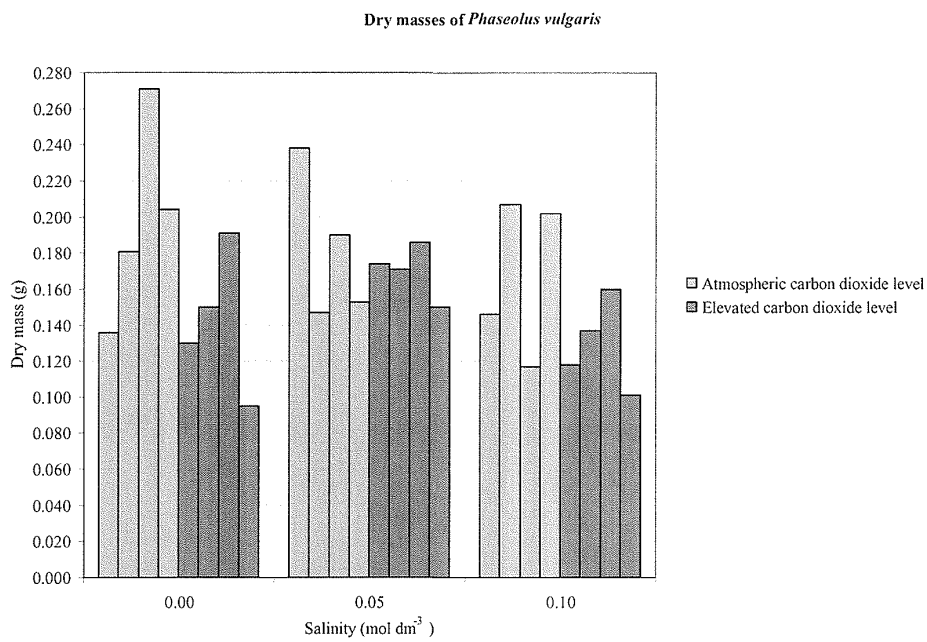


Figure 8. Graph displaying the dry masses of a, b, c, and d plants under salinity stresses ranging from 0.00 mol dm⁻³ to 0.10 mol dm⁻³, exposed to atmospheric and elevated carbon dioxide levels.

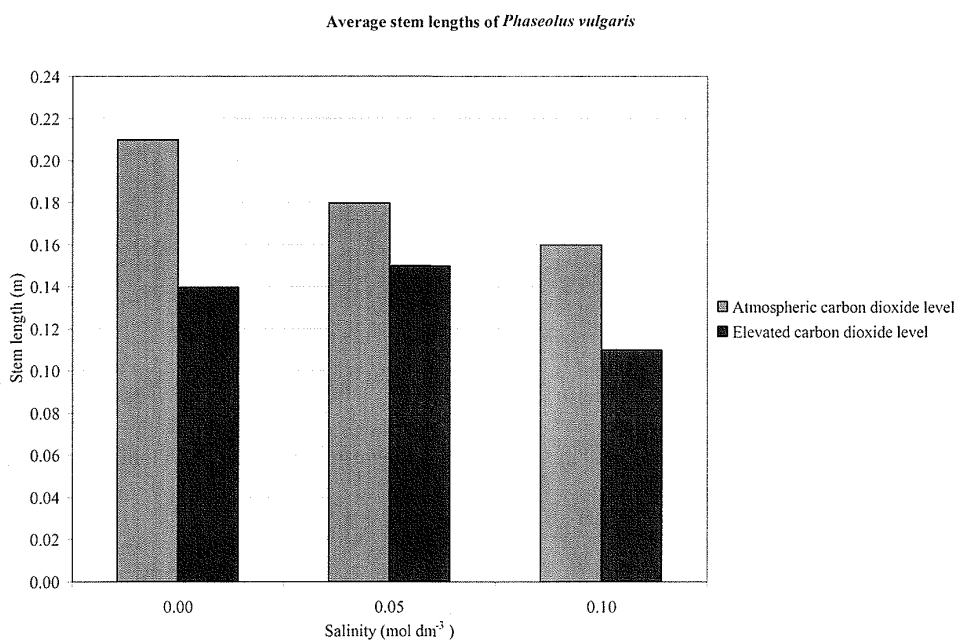


Figure 9. Graph showing the average stem lengths of the *Phaseolus vulgaris* under three different salinity stresses, and exposed to atmospheric and under elevated carbon dioxide levels.

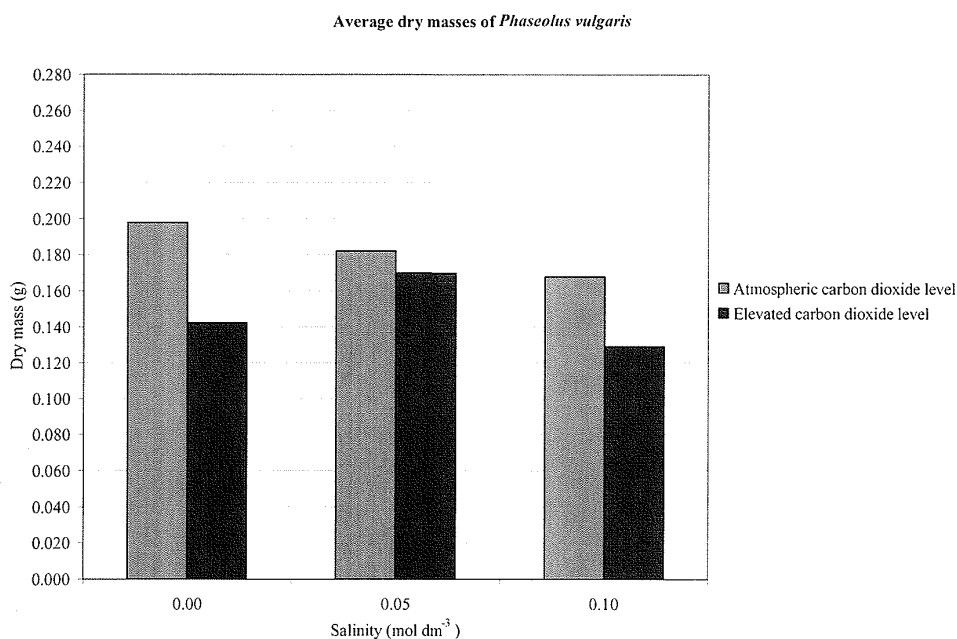


Figure 10. Graph showing the dry masses lengths of the *Phaseolus vulgaris* under three different salinity stresses, and exposed to atmospheric and under elevated carbon dioxide levels.

5. Analysis of experiment

5.1. Effect of salinity stress

The plants in the experiment showed clear response to the NaCl. Figure 9 and Figure 10 illustrate the plant size and dry mass reduction as the salinity increased. The osmotic effect was definitely altered, slowing down the water flow, hence indicating that salt limited the uptake of water in the *Phaseolus vulgaris*. Since water is a vital component of photosynthesis, one which plants cannot grow or function without, the growth was limited. The gradients between the plants and soils of the systems with no salinity stress, compared to the systems with salinities of 0.05mol dm⁻³ and 0.10mol dm⁻³, were greater, thus resulting in a greater water flow into the plant. Similarly, the systems with 0.05mol dm⁻³ salinity had a larger salinity gradient than the 0.10mol dm⁻³ systems.

Ions can interfere with plant growth processes if their concentration within the plant is excessive.³⁰ Toxic levels of sodium cause high pH values resulting in micronutrient deficiencies.³¹ This may have also been a cause to the smaller stem lengths and dry masses of the salt-stressed plants.

A few signs of salinity effect are poor germination, stunted growth, smaller leaves, slight yellowing of leaves, and burnt appearance on tips of leaves. Stunted growth was definitely noticeable at the increase in salt concentration. Two of the plants receiving 0.10 mol dm^{-3} of NaCl had slight burnt appearances on the tips of their leaves. The overall leaf areas of the plants receiving 0.05 mol dm^{-3} of NaCl had tendency to be lesser in size compared with the plants without salinity stress. The effect was more so in the plants receiving 0.10 mol dm^{-3} .

5.2. Effect of CO₂

Despite prior anticipations, the plants grown under atmospheric CO₂ levels grew significantly larger than the plants grown under elevated CO₂ levels, as indicated by both the stem lengths and the dry masses. The elevated CO₂ levels reached toxic levels (supposedly close to 2000ppm as this is the concentration at which most plants begin to slow down their photosynthetic rate) in the three greenhouses; B₁, B₂, and B₃, causing slower photosynthetic rate due to the closing of stomata. While the collected data from the plants growing under atmospheric CO₂ levels showed a fairly steady increase in growth (from 0.10 mol dm^{-3} to 0.00 mol dm^{-3}), the measurements of the high CO₂-induced plants did less so. This is because the CO₂ levels in greenhouses B₁, B₂, and B₃ were not as steady as the levels in the other three greenhouses. Comparing the 0.00 mol dm^{-3} and 0.10 mol dm^{-3} values in Figure 9 and Figure 10, the difference between the atmospheric CO₂ plants is greater than the difference between the elevated CO₂ plants. This could indicate that the elevation of CO₂ enhanced the percentage growth of the salt stressed plants; however, this is not certain do to the uncertainty of the gas levels.

5.3. Errors in the method

Plants given the same conditioning were grown in the same greenhouse. This was problematic because CO₂ levels in the greenhouses naturally differed to some extent. The CO₂ imbalance may have been a significant cause to some inaccuracy in the results, particularly in one of the elevated

³⁰ Yiasoumi, Bill, 2003

³¹ Fao.org, 2005

CO₂ greenhouses. Growing plants of different salinities in one greenhouse would have ensured the same CO₂ level, humidity and temperature for each plant. However, the sunlight exposure would have differed slightly as two plants in each greenhouse were always further and partially blocked from sunlight. Due to this reason, plants of same salinity and CO₂ condition were grown in one greenhouse, so that plant samples a, b, c, and d from each greenhouse had fairly equal exposure to sunlight as the plants a, b, c, and d from the other greenhouses respectively. This explains why the measurements varied within the individual greenhouses (Figure 7 and Figure 8).

5.4. Limitations to the experiment

Despite various conclusions and observations can be made from the experiment, only a fraction of the entirety of the environmental impact of salinity and CO₂ can be studied, and cannot therefore be generalized. Only three different salinity concentrations were applied, none of which prevented any of the plants from sprouting. Furthermore, the two CO₂ concentrations do not depict how the plants will react to different concentrations, especially since the elevated concentration reached a toxic degree. The plants were grown inside greenhouses, in mineral-abundant soil, in optimal temperature, and with sufficient water supply. In nature, plants do not necessarily grow in optimal conditions.

5.5. Improvements

In order to obtain more accurate results, the range of salinity should be increased to the point at which the plant does not grow, so as to get information for the whole spectrum of salinity effect. In addition to this, with the use of a CO₂ concentration meter different measured concentrations of CO₂ would increase the possibility of conclusions to be made from the experiment. The time period given for the growth could be lengthened to give results of the long term consequences of salinity stress and CO₂ concentration on the plants. A separate investigation on the two variables, CO₂ and salt, would give more perspective to this experiment in which their effects are largely combined. Investigation of several different plants would also broaden the general perspective.

6. Conclusion and Evaluation

6.1. Effect of salinity and CO₂ elevation on biodiversity

Early effects of salinity stress are often barely noticeable, however, when posterior signs become more obvious, it may be too late for a particular plant. More advanced salinity problems include new wet patches or boggy areas in paddocks, yellow and bronzed plants, legumes dying out, increasing numbers of salt-tolerant plants, increase in number and size of bare areas, greasy black patches and salt crusts on the soil surface, and trees dying in low areas and along drainage lines.³² Salt sensitivity varies in different plants, some with low tolerance including tomatoes, and others with high tolerances, such as halophytes. Therefore, some plants will not be drastically affected by the increasing salinity, while others will quickly wither and die.

Even if the accumulation of CO₂ in the atmosphere enhances plant growth and the partially reverse growth reduction brought about by salt stress, it may ultimately backfire, stunting crops and other plants. A decrease in plants also indicates a decrease in the conversion of CO₂ to oxygen, leading to a continuously increasing CO₂ buildup, and so the cycle continues.

6.2. Alternative methods for road defrosting

There are four basic methods utilized in highway maintenance during winter time. These methods include the use of chlorides, organic and inorganic chemicals, and abrasives. Much like NaCl, chlorides are environmentally harmful, since they tend to accumulate and change natural chemical balance in soils, increase concentrations of ions in water, and repress vegetation growth.³³ Abrasives like sand are relevant sources of dust in the air, they form deposits in soil, exacerbate air quality, yet practically they do not have an effect on roadside vegetation. The problem with salinity is far too critical to be left not dealt with. In consideration of plants, the negative aspects of the utilization of abrasives lessen in view of the fact they are chemically nontoxic, and hardly disturb vegetation if at all. They are a good alternative to salt in the process of road defrosting.

³² Yiasoumi, Bill, 2003

³³ Jelisejevs

6.3. CO₂ emission reduction

Countries and cities need to take action in reducing CO₂ emissions. Transportation fuels, for instance, contribute immensely to the atmospheric CO₂ accumulation. Therefore upgrading public transportation is an effective method in which to reduce gas output. Finland has a relatively efficient transportation system, whereas the United States releases more than twice the amount of emissions per capita than Finland in transportation alone.³⁴

Most emissions from homes are from the fossil fuels burned to generate electricity and heat. These emissions can be reduced without considerable effort. Simply by regulating thermostats, up by two degrees in the summer and down two degrees in the winter, or cleaning the filters on furnaces and air conditioners (this alone can save 260kg of CO₂ each year), cities would help in CO₂ reduction significantly.³⁵

The Kyoto Protocol to the United Nations Framework Convention on Climate Change is an amendment to the international treaty on climate change, allocating necessary emission limitations for the reduction of greenhouse gas emissions to the signatory nations.³⁶ As of 2007, the Kyoto Protocol has been ratified by all other countries except for Australia, the United States, and Kazakhstan.

There are countless ways in which CO₂ gas emissions can be limited and regulated; all we have to do is make the effort to do so. Biodiversity is fragile and should be looked after for future generations. The concern with global warming is not simply a political or environmental issue discussed in newspapers and scientific studies; it is reality. As the results of this experiment indicate, we will see a difference in nature and agriculture as the CO₂ in the atmosphere continues to accumulate.

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³⁴ Schipper. Ting, 1997

³⁵ Climatecrisis.net

³⁶ unfccc.int

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