Climate change: risks and opportunities in nursery production©

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INTRODUCTION

The purpose of my presentation is to bring some of the latest information to you about the predicted impacts of climate change on South Africa, with a particular focus on how it may affect the nursery industry. Plant growth is driven by environmental factors, and so any change to the environment will impact on production and therefore our livelihood as growers of living products.

Everyone here has heard of climate change and you will all have your own opinions about the issue and possible solutions. After a while, hearing about climate change can become like background noise; too big a problem to be able to directly relate to your own life and business decisions. So while most people acknowledge that climate change is happening, it's difficult to prioritise time to plan how to handle these impacts.

There's no doubt that many of the predicted changes are worrying but I also want to talk about some of the opportunities that are unique to our involvement in nursery production. We all need to engage with climate issues and I believe there are many opportunities for growers to increase their production while also taking a leading role providing green solutions in their communities.

DISCUSSION

Understanding the atmosphere

Sunlight passes through the atmosphere and warms the earth's surface. That heat is then radiated back towards space but fortunately our lower atmosphere has a blanket of gases—we call these greenhouse gases—whose chemical structure reacts to absorb this heat. These gases then re-emit the heat in all directions, some of which radiates back to warm the surface of the earth and the surrounding lower atmosphere. This is a natural effect and thanks to its existence, our average global earth surface temperature is a comfortable 15°C, which enables us to grow crops and exist.

About 1% of the earth's lower atmosphere is composed of these greenhouse gases: mainly water vapour, carbon dioxide, methane, and nitrous oxide. Without them our world would be cold and uninhabitable but…the proportion of these gases in our atmosphere is changing.

The most significant of these gases is carbon dioxide because it lasts for a long time in the atmosphere, and it is therefore considered to have a greater long-term warming effect. A recent report by Stevens et al. (2015), notes that the concentration of atmospheric carbon dioxide is higher than it has been for the past 800,000 years. Scientists have been able to unravel some of the history of our earth's atmosphere by sampling the air trapped inside frozen bubbles of ice from Antarctica. In more modern times, our atmospheric CO_2 measurements are recorded at the Mauna Loa Observatory in Hawaii. At the time of writing, the level of atmospheric CO_2 for January 2016 was 402.52 ppm as displayed at http://co2now.org/Current-CO2/CO2-Now/. When the Mauna Loa Observatory first started recording in 1959, CO_2 levels were below 320 ppm.

Some people might pine for the good old days when things seemed more certain and we believed we had little effect on the environment. As levels of CO_2 from burning fossil fuels, methane from intensive farming, and nitrous oxide from nitrogen fertiliser use increases; so does global warming. The Intergovernmental Panel on Climate Change (known as IPCC)

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produces public reports on climate change every 5 to 7 years, drawing together research from scientists around the world. This group has concluded in their latest Fifth Assessment Report, that it is highly likely that humans are the dominant cause of warming since the mid-20th century (IPCC, 2015). Copies of this report, including summaries of climate change effects on all regions of the world, are publicly available from their website: (https://www.ipcc.ch/ report/ar5/).

Global effects of climate change

Intergovernmental Panel on Climate Change (2014) reports that we are already experiencing some of the global effects of climate change: increasing air temperatures; longer periods of drought in some areas; longer, more intense heat waves, and increasing frequency of wildfires.

By warming the atmosphere, climate change is predicted to increase the number, duration, and frequency of tropical storms. Warmer oceans are leading to a loss of sea ice, and increasing sea levels. The global sea level has risen 10-25 cm in the last century (Stevens et al., 2015).

Of course we share this planet, and other living organisms are also affected. Some are moving to different habitats or ranges, particularly cooler ones, to survive climate change effects. Migration patterns and seasonal behaviors such as flowering have changed. According to the IPCC "most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change in most landscapes" (IPCC, 2014). This global redistribution of species is recognised by scientists as an identifying sign or "fingerprint" that climate change is taking place (Pecl and Williams, 2015).

Effects of climate change on South Africa

The earth's climate will not change uniformly across the globe. What may happen in South Africa, will be different from what may happen in my corner of the world, New Zealand. It's important to get the most accurate technical information you can for your area, as you can't manage the risks, if you don't know the risks.

The following section describes information about climate change trends in South Africa from recently published sources such as the Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) and others (Ziervogel et al., 2014; DEA, 2013). A report titled "Change Is in the Air" by Stevens, Bond, Hoffman, and Midgley is particularly interesting (Stevens et al., 2015).

CLIMATE CHANGE TRENDS IN SOUTH AFRICA

Effects of climate change on temperatures

The first two bullet points below describe changes that have taken place, whereas the last two describe what is predicted to happen in the future.

- Over the last 5 decades, mean annual temperatures have increased in South Africa by more than 1.5 times the observed global average of 0.65°C.
- Maximum and minimum temperatures have been increasing annually across the country, with the exception of the central interior.
- Temperature increases of more than 4°C are projected under scenarios, where emissions remain high, for the central and northern interior regions over 2080-2100.
- The coastal regions are expected to experience the least amount of warming.

Effects of climate change on rainfall

The first two bullet points below describe changes that have taken place, whereas the last two describe what is predicted to happen in the future.

- There is less autumn rainfall and fewer days with rain in the central and north-eastern parts of the country; overall annual rainfall has not reduced significantly but fewer rainy days means a tendency towards an increase in the intensity of rainfall

events with longer dry spells in between.
- Spring and summer rainfall has increased in southern Drakensberg region.
- Unlike temperature, there is more uncertainty about future rainfall trends.
- Current models project rainfall to reduce over Limpopo and south-western Cape while it will increase in the central interior extending to the southeast coast in the far future. Increases are projected to occur in spring and summer.

Work by MacKellar et al. (2014), illustrates the trends in annual mean daily maximum temperatures and trends in annual mean rainfall across South Africa, over a 50-year period (1960-2010).

Effects of climate change on biodiversity

South Africa has nearly 10% of the world's plant species—what an amazing natural heritage. We experience climate change and these ecological systems also show the effects of such change.

To understand the distribution of this plant diversity, ecologists have broadly characterised it into eight different vegetation types or biomes, plus the mixed Indian Ocean Coastal belt. Biomes have distinct plant growth forms and are often linked with particular climates.

Changes in the vegetation patterns of these biomes have been mapped and it shows that the Savanna biome is becoming woodier and these plants are expanding into the grassland biome. In turn, the grasslands tend to be expanding into the eastern Karoo biome. While the increase in trees may have some positives, researchers are concerned that in some wetter areas they shade out the grasses, reducing biodiversity and ultimately reducing grazing and the economic benefits of tourism (Stevens et al., 2015). While different land use practices such as burning and grazing are established factors in vegetation change, these researchers believe that it is the increase of CO_2 itself, rather than warming that is promoting growth in plants that are sensitive to it. Climate change is also causing changes in rainfall seasonality, and it may be this factor that accounts for shifts of grasslands into the eastern Karoo.

Future projected changes, until 2050, in the distribution of biomes under low, medium and high-risk climate scenarios, have also been developed (DEA and SANBI, 2013a). The most threatened biome under all climate scenarios is the grassland—replaced with savanna and potentially forest; second most threatened is Nama-Karoo with savannah and desert; third most threatened Indian Ocean Coastal Belt, fynbos and forest. Desert will expand under all climate scenarios especially the high risk one.

EFFECTS OF CLIMATE CHANGE ON NURSERY PRODUCTION

In IPPS we share a love of plants—complex living organisms that are responsive to their environment. I thought it was worth reviewing the environmental factors that drive plant growth and consider how climate change will affect our plant-based livelihoods. To be specific, what will increased temperatures, reduced water resources, and increased carbon dioxide, mean for nursery production in the future. Remember, for South Africa, climate change projections up to 2050 and beyond point to warming as high as 5-8°C over the South African interior, if we aren't able to decrease global emissions (DEA and SANBI, 2013b).

Effects of increasing temperatures

- Heat stress damages, and in extreme cases, kills plants. It is a function of intensity, duration and rate of increase in temperature.
- High day temperatures have direct damaging effects linked to hot tissue temperatures or indirect effects linked to plant water deficits.
- High soil temperatures can reduce plant emergence and also damage the reproductive development of many crop species, i.e., no flowers, or if flowering, poor fruit set/seeding.
- Plants take up an enormous amount of water—much more than an animal of a similar size and water is essential for photosynthesis and cell processes.

- Almost 99% of the water taken in by the roots is released from leaves in a process called transpiration through stomata openings.
- Increasing temperatures increases transpiration; the rate of water evaporation doubles for every 10°C rise which increases the risk of cell death.

The role of stomata

- Plants have the ability to control both the amount of water in their bodies and gas exchange by opening and closing the stomata in their leaves—there are thousands of these pores per square cm of leaf.
- Stomata need to be open in day light hours for plants to take in carbon dioxide and this allows water vapour to move out. When the plant senses it is too dry, it will shut the stomata rather than die through lack of water. Temperatures higher than 30 to 35°C can also lead to stomata closing. The result of this will be that the plant cannot make the food needed for growth processes as there is no carbon dioxide entering the leaf.
- Root initiation in cuttings depends on the temperature but root growth after that is strongly dependent on available carbohydrates (Hartmann et al., 1997). Low food reserves equals poor root growth and ultimately a poor quality plant.
- Some researchers are investigating genetically altering plants to increase the density of stomata per area of leaf. The idea is that this will increase the amount of CO_2 drawn in, increasing the photosynthetic efficiency of the plant and removing more CO_2 from the air to the benefit of our atmosphere.

Effects of increasing carbon dioxide

When CO_2 increases, trees will grow faster. Research by Bond and Midgley (2012) illustrated roots of the common acacia karoo (sweet thorn) exposed to different levels of CO_2. A plant grown at CO_2 levels typical of the pre-industrial age (i.e. 180 ppm) had a much smaller root system than a plant grown at 375 ppm CO_2 (the concentration representing the level of CO_2 in the late 1990s). The difference between these plants was a three-fold increase in their biomass.

As there is more carbon dioxide in the atmosphere to take in, it is easier for plants to absorb it and manufacture food. Trees store the extra carbon in their roots or woody stems. This produces much larger root systems with increased starch concentrations. The consequence of enlarged root systems is that this enables plants to re-sprout quickly after fire and browsing, and also increases the growth rate of tree seedlings, and so many trees are gaining a competitive advantage due to high carbon dioxide conditions (Bond and Midgley, 2012).

How might increasing CO_2 levels affect my nursery?

- Increased carbon dioxide levels increase plant growth there will be less need for artificial CO_2 enrichment.
- Increased carbon dioxide levels mean plants will use less water when growing. This is because plants don't have to open their stomata as much to gain carbon dioxide, and so less water vapour is lost from the plant. This means that for the same amount of water, plants will grow more; a useful benefit for plants growing in drier areas.
- In urban areas demand for plants may increase due to urban greening and carbon credit schemes. In Australia, the Nursery and Garden Industry have set a target of 20% more urban green space by 2020 (Horticulture Innovation Australia Ltd.).
- As increasing CO_2 is partly driving changes in indigenous vegetation, those nurseries growing for ecological restoration work need to ensure their plant mix is "future proofed." If the balance between grasses and woody plants in your local biome is changing, that means the type of stock plants or seed stock you hold, needs to reflect that changing pattern.

Instead of maintaining genetic purity by only collecting from local seed sources (known as ecosourcing), new ideas are being developed known as "climate adjusted

provenancing." Where landscapes remain largely fragmented, the idea is to collect genetically diverse material to use in revegetation to enhance a species' adaptive potential. For example if your local area is predicted to become drier in the future, by introducing a broader range of genetics to native plant populations, there is a greater chance that those plants will be able to adapt over time and survive into the future.

If you want to know more about climate change implications for those supplying the restoration sector, the Society for Ecological Restoration Australasia has a draft of national restoration standards out which you may find useful. I believe there will be increased demand for seed resources and restoration work as habitats to sustain biodiversity come under pressure.

How might increasing temperatures affect my nursery?

- Review the use of greenhouses—with temperatures already high, do you need to fully enclose plastic houses? This may allow cheaper structures to be built.
- Identify ways of cooling plants that are energy efficient. With the decrease in the price of solar cells and the abundant light in South Africa, this would seem to be a likely option for future energy efficiency.
- Increase shading by use of natural plantings/shade materials.
- Increase technical knowledge to deal with new pests and diseases that are likely to establish.
- Grow crops that fit your conditions.
- The shorter time to crop maturity may be an opportunity for increased crop rotations.

How might decreasing water availability affect my nursery?

- Have you thought about how you would deal with the possibility of reduced water resources?
- Now is the time to investigate ways of improving irrigation efficiency: increase water storage, water recycling, fittings and infrastructure.
- Grow more drought tolerant crops.
- Conserve soil moisture with mulches.
- The increased demand for drought tolerant garden plants is an opportunity.
- Give wise water advice to your customers; help them to adapt their gardening methods.

TOOLS AND INFORMATION RESOURCES

It is normal business practice to plan ahead to manage risk, and climate change will bring changes to markets, logistics, operational processes, finance, insurances, people, and premises. Although the exact impacts of climate change are uncertain, they can be managed like any other business risk. The point is to start the discussion now with your staff and identify a few key risks and develop an action plan to make your business more resilient to these risks. Use the issue as a catalyst to review and focus on what you can control, rather than worrying about all the things that you cannot.

I recommend having a look at the UK Climate Impacts Programme website (2010), now just called UKCIP, which is all about decision making for adaptation. They have a number of tools you can access for free such as Adaptation Wizard and Adapt Me toolkit. Their information is considered a model for other countries to use.

There are also numerous carbon footprint calculators available. Food & Trees for Africa developed the first South African calculator which can be found at: http://www.trees.co.za/carbon-offset/carbon-calculator.html The Australian nursery production industry has also developed one specifically for the nursery sector known as NurseryFootprint (NGIA).

There is also information on the Green Economy for Sustainable Development Project for businesses, including Green Economy resources and other climate change information on the DEA (Department of Environmental Affairs) website which can be found at

https://www.environment.gov.za/

Another source of information is the SANBI website (South African National Biodiversity Institute) particularly the LTAS Factsheet Series which are located at http://www.sanbi.org/biodiversity-science/state-biodiversity/climate-change-and-bioadaptation-division/ltas (DEA, 2013). South Africa has some of the best vegetation, geology, and soils data in the region (Ziervogel et al., 2014).

CONCLUSION

We can feed the world

The world population has now reached 7 billion and is expected to reach 9 billion by 2050. It is estimated that 70% more food will be needed to feed the world population by 2050 (Ministry for the Environment, 2015). Opportunities for both domestic and international food production will increase the market for starter plants for the vegetable and fruit production sectors.

Think of the potential advantage South Africa has in heat and drought tolerant plant genetic material for future breeding.

Green yourself

Investigate industry standards and policies on climate change and sustainability. Take the time to educate yourself and plan how to sustain your business into the future. Along the way share your knowledge with your customers and your community—consumer awareness of the value of plants is your best advantage. Take a future focused approach—you are not only there to sell plants, you're there to sell a solution; to help the customer feel they have taken a small active step towards creating a better environment or becoming more self-sufficient.

Lead the green

Carbon dioxide removing, food creating, life enhancing—plants are a huge part of the solution to global warming. Horticulturalists fundamentally understand that plants are the corner stone that sustain all other life. If any group can position themselves as having an answer to saving the planet, it's plant propagators! This puts us at the forefront of leadership, both professionally and personally, on the most significant global issue of our age! Whether we decide to embrace the risks and opportunities of this situation is up to us.

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