Plant & Food Research
Rangahau Ahumāra Kai

RESEARCH BRIEF 04

Climate change and growth of Poplar and Willow trees

Summary

We evaluated the response of *Populus* and *Salix* trees to elevated carbon dioxide (CO_2) and temperature, and the interaction of these factors with drought, in a controlled environment. Enhanced CO_2 **and** elevated temperature operating together increased shoot biomass significantly, but not root biomass. Shoot biomass was significantly reduced under drought stress, but there was no significant change in root biomass. Shoot biomass reduction was less severe under drought conditions when the trees were in enhanced CO_2 conditions **and** at elevated temperature. **Drought** will be a major deterrent of production in future and will probably overshadow the beneficial effects of enhanced CO_2 and temperature.

Introduction

Poplars and willows will continue to be the key species used to stabilise soil on pastoral hill country in New Zealand. Future climate scenarios depict a climate with elevated temperature (~2.5°C annual mean increase by 2090) and more atmospheric CO_2 (550 ppm). Such changes in temperature and CO_2 will create environmental stresses that are beyond our current experience. This report provides an insight into how poplars and willows will respond in such an environment.

Some poplar cultivars cope with drought better than others

Methods

We evaluated the response of *Populus* and *Salix* species to enhanced CO_2 and temperature, and the interaction of these factors with drought. We did this in an experiment at the Controlled Environment facility at Plant & Food Research, Palmerston North.

Two poplar clones, 'Fraser' (*P. deltoides* × *nigra*) and 'Geyles' (*P. maximowiczii* × *nigra*) were used as representative of *Populus* clones, and two willow clones 'Hiwinui' (*S. matsudana* × *alba*) and *S. matsudana* × *lasiandra* were used as representative of *Salix* clones.

We grew the trees from 25-cm, one-year-old cuttings planted into a mix of fertilised peat (35%), sand (30%) and bark fines (35%) in 20-L bags. We sprouted the cuttings in ambient conditions before moving them into the controlled environment rooms. The drought regime began after eight weeks of growth in the climate rooms, and ran for a further 8 weeks. We randomly selected the trees for the drought treatment.

Table 1 describes the controlled environment conditions (temperature, CO_2, water regime; normal, enhanced, drought).

Climate	CO_2 (ppm)	Temperature (°C)	Humidity (±5%RH)	PFD (µmol m^{-2} s^{-1})	Day length (h)	Water regime	
						Normal	Drought
Normal	370	23/14	70/72	700	11	90%	30%
Elevated	550	25.5/16.5	70/72	700	11	90%	30%

PFD = photon flux density
Table 1. Controlled environment conditions used in the poplar and willow trials

Immediately before the imposition of drought conditions, we measured production of both poplars and willow clones.

Findings

We did not treat temperature as a separate variable from CO_2. Primarily this was because future climate predictions assume increasing CO_2 (as cause) and increasing temperature (as effect) as occurring together, and it will be the combined scenario that plants will experience.

Responses differed between poplars and willows, and between the two poplar clones. However, these were not as significant as the differences due to the imposed environmental conditions.

The percentage reduction in tree dry matter (DM) due to the drought conditions was greater than the percentage DM increase due to the enhanced temperature and CO_2. Root biomass was least affected by the imposition of drought.

Enhanced temperature and CO_2

- Shoot dry matter (DM) and height increased significantly from that in normal climate conditions
- Root DM was not significantly different from that in normal climate conditions.

Drought

- Shoot DM decreased significantly from that in non-drought conditions.
- Root DM was not significantly different from that in non-drought conditions.
- Shoot DM reduction was less severe under elevated temperature and CO_2.

These findings warn that **drought** will be a major deterrent of production in future and will probably overshadow the beneficial effects of enhanced CO_2 and temperature.

Comments

The ability of willow and poplar trees to maintain production of new leaf material in contrast to pasture is due to access to water at greater depths. However, they will experience drought stress. **Pollarding** (reducing the trunk and large branch components of the canopy) reduces tree internal requirements for water, and hence stress.

We conclude from this and other published studies that both enhanced CO_2 and elevated temperature change the growth and resource allocation in a range of plant species, including poplars and willows.

In general, growth is enhanced, and for trees in their natural environment this increased flow of resources to roots may increase the contribution to soil organic matter, through exudates and higher fine root turnover. The greater limitation will be reduced water availability in those regions likely to experience increased drought risk, which will increase the difficulty of establishment of young trees and will stress older trees, increasing susceptibility to pests and diseases. Currently New Zealand is relatively free of significant insect pests of poplar and willow, while *Melampsora* spp. (rusts) are the main disease threat.

Drought is a significant factor challenging poplar and willow growth

Elevated atmospheric CO_2 should increase plant biomass, whereas **elevated mean temperatures** may have a greater impact on plant respiration than on photosynthesis. Root biomass was the least affected by the imposition of drought conditions, and the net reduction in growth in response to drought was less severe under the enhanced conditions than under the normal conditions.

The combined effect of increased atmospheric CO_2 and increased mean day/night temperature is expected to result in an increase in biomass production. Under future climate change, responses are likely to vary between clones in both poplar and willow, and the interim period should be used to evaluate the relative responses to drought stress of the range of commercial poplar and willow clones being currently used or in the developmental stage.

These responses can be monitored by including a range of clones and management practices in new farm and river plantings.

For more information

This is one in a series of research briefs about Poplars and Willows that can be found at poplarandwillow.org.nz

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