The Effects of the Tree Growth Regulator Paclobutrazol on Fast Growing Trees and Application to Utility Arboriculture

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Utility Vegetation Management (UVM)

Trees are a major cause of unplanned service interruptions (faults), and they can also provide access to live electricity lines with associated safety risks.

Electricity distribution network operators (DNOs) in Britain required, by law to maintain the supply free of unplanned service interruptions in so far as reasonably practicable.

Trees have to be pruned and/or removed to maintain nationally set clearance distances between trees and overhead power lines (OHPL) for reasons of safety and security of supply.

Utility Vegetation Management (UVM) Costs

In Britain, as in other countries, the cost of UVM is high.

Between 2004 and 2009 the UVM budget in Britain **GB£87 million (€100m)** per year across all the UK DNOs

between 2010 and 2015 this increased to **GB£134 million (€154m)** per year.

Anything that can reduce costs is desirable.

Most Common Tree Genera on the OHPL Networks

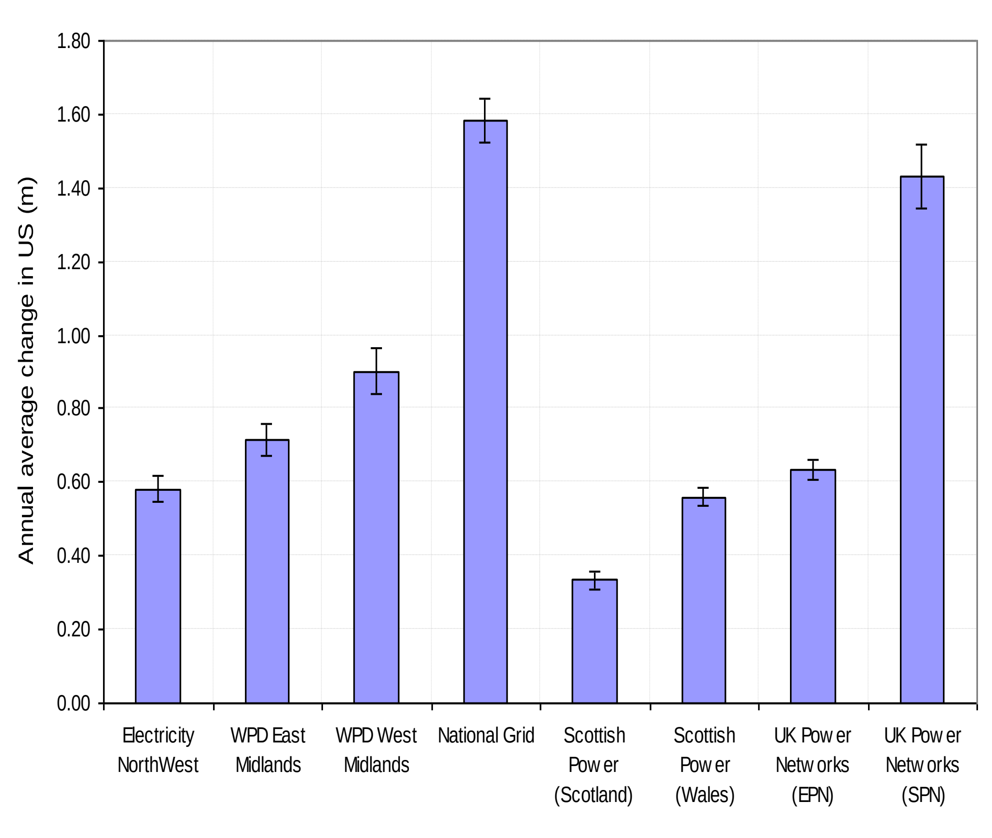
Wherever the utility is located, it is true to say that over 75% of the trees on the OHPL Network is represented by six to eight genera

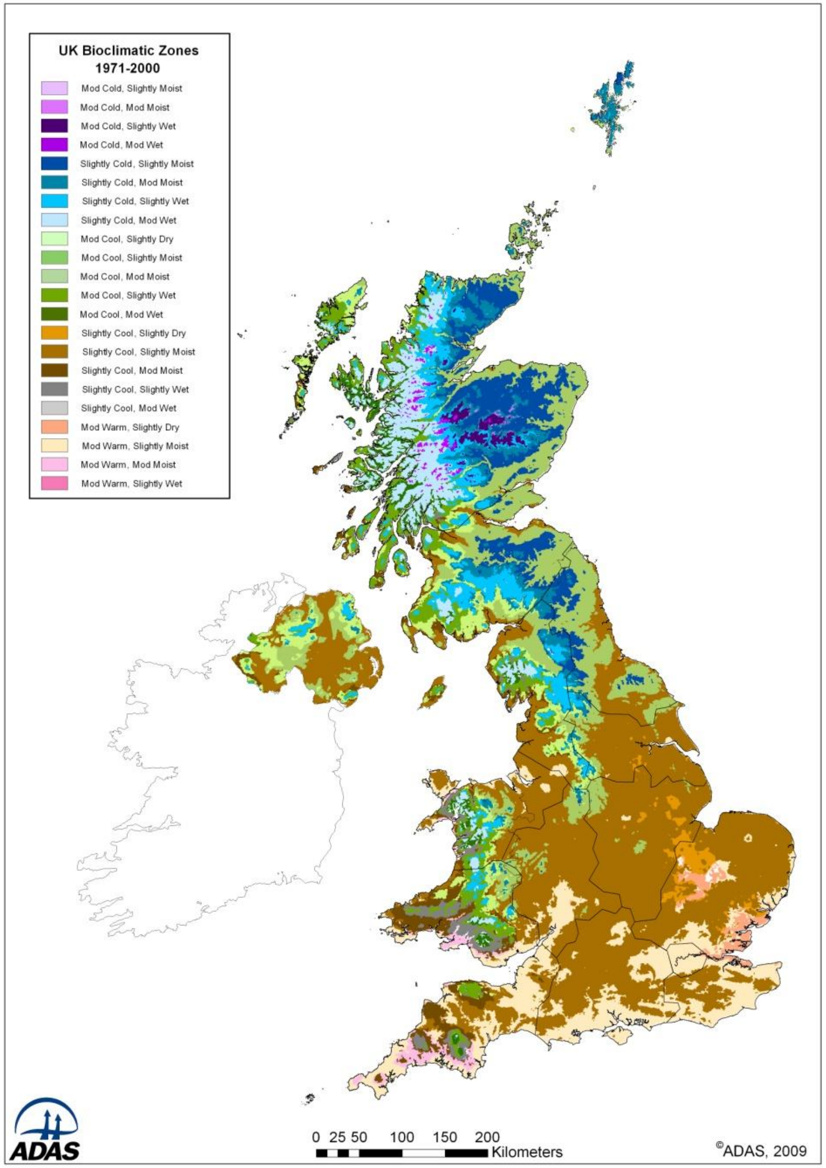
In Britain, 77% of the trees on the OHPL Networks is comprised of eight species / genera:

Common Alder	(*Alnus glutinosa*)
Common Ash	(*Fraxinus excelsior*)
Birch	(*Betula* spp)
Hawthorn	(*Crataegus* spp)
Hazel	(*Corylus* spp)
Oak	(*Quercus* spp)
Sycamore	(*Acer pseudoplatanus*)
Willow	(*Salix* spp)

Humphries, S (2011) *Utility Space Degradation*: Final Report on the IFI Project, ADAS UK Ltd, www.adas.co.uk

Rates of Re-growth vary cross the country by Region





Controlling Tree Growth

We now know that trees are growing faster than was thought and rates of growth are projected to increase significantly within the next 10 years.

DNOs encounter problems in pruning amenity trees in prominent locations such as village greens and conservation (historic) areas etc, AND

Sometimes landowners restrict cutting to the minimum necessary to obtain clearance at that point in time and the DNO has to return every year or other year to maintain clearances.

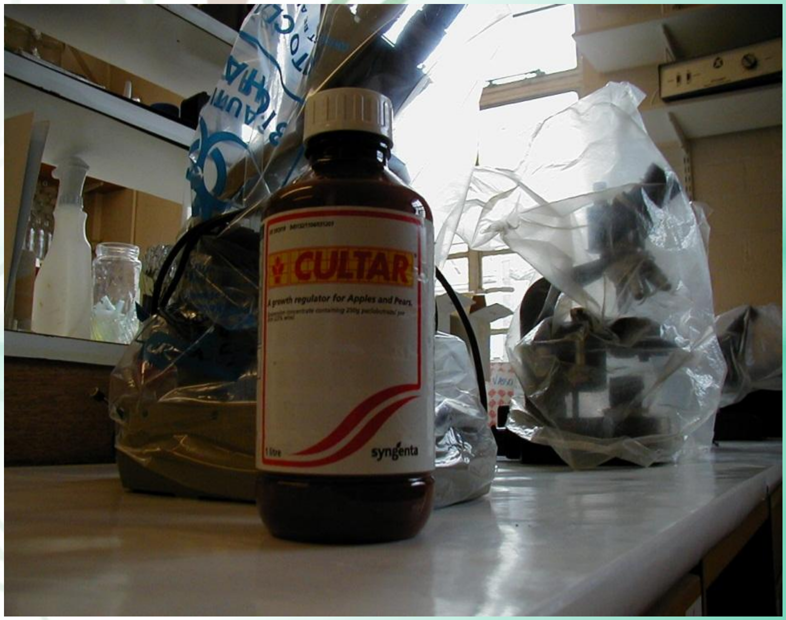
Controlling Tree Growth

Research has shown that compounds known as tree growth regulators (TGRs) can slow the regrowth rates of trees for 3 to 5 years dependant upon species;

The most effective compound currently available is Paclobutrazol (PBZ) and this has been shown to be effective in slowing regrowth rates of trees in England (Hotchkiss 2003);

PBZ is licensed for use in Britain on Apple, Cherry, Pear and Plum and for some container nursery container stock as ‘Cultar’

PBZ is commonly used in the USA & Canada in the utility sector where the trade name is ‘Cambistat’



What Is a Tree Growth Regulator?

A Tree Growth Regulator (TGR) is a specially developed compound applied to a tree to control crown (branch) growth by suppressing the production of gibberellin; the hormone that causes cell elongation.

This reduces a tree's growth and its biomass without significantly altering its appearance.

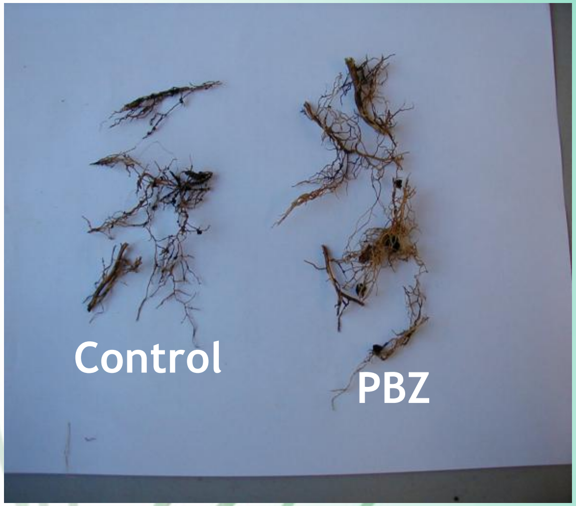
What Is a Tree Growth Regulator?

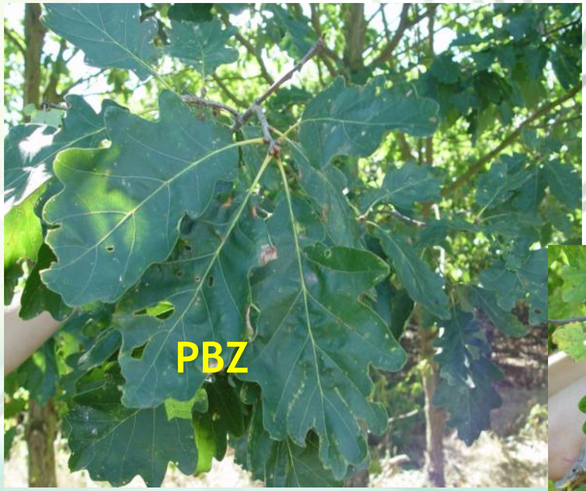
PBZ has been shown to have beneficial effects on treated trees;

it increases drought tolerance, and the production of fine roots;

It enhances chlorophyll production;

it has fungicidal properties that can combat vascular wilt diseases and tar spot on Sycamore for example





UK Trials of PBZ

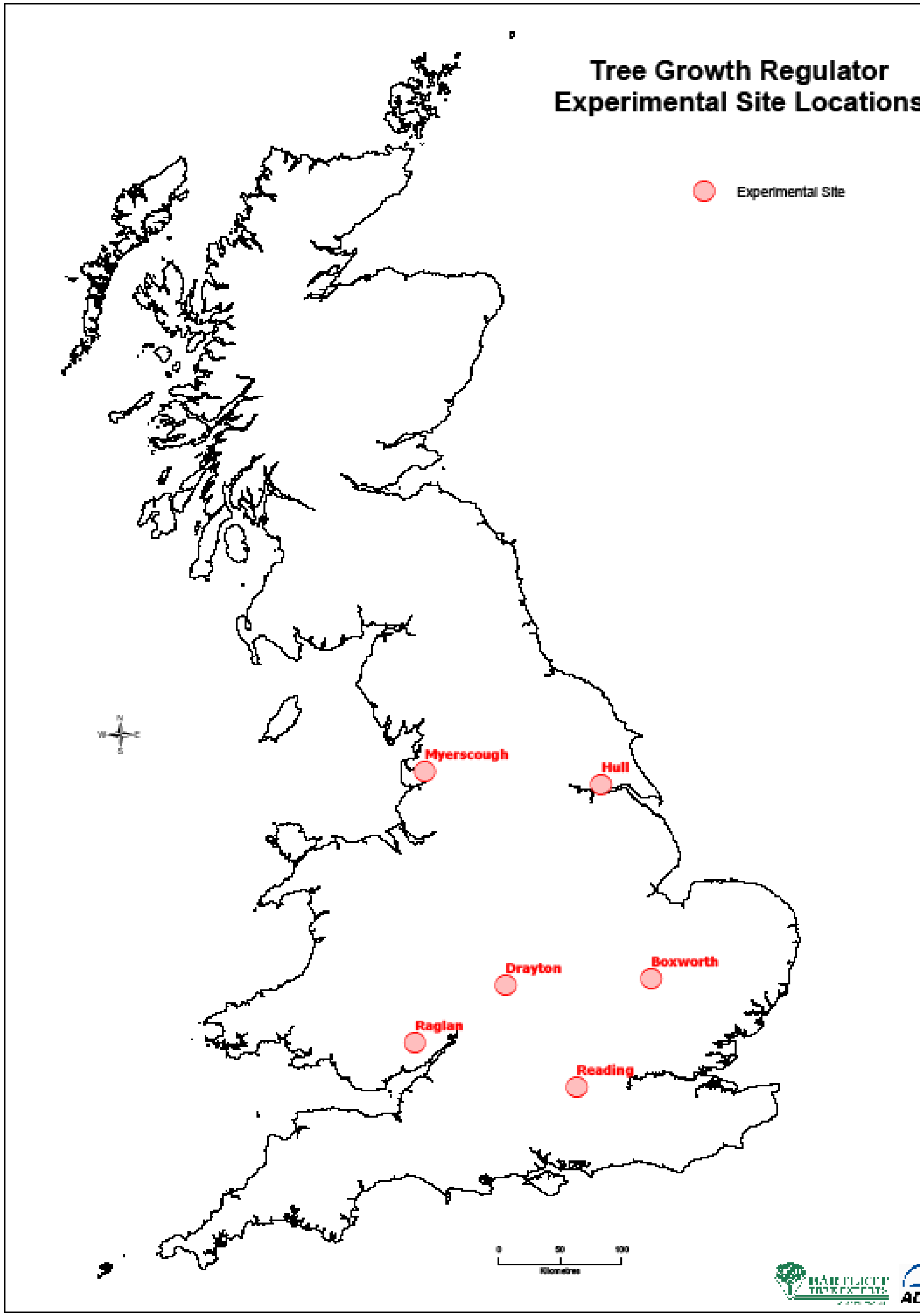
This five year study was financed through the Regulator (Ofgem) Innovation Fund Initiative (IFI); started in 2009 and completed in 2013

Four of the UK Electric Utilities participated, Northern Powergrid; Scottish & Southern Energy; UK Power Networks; and Western Power Distribution which between them control 11 of the 14 Licence Areas.

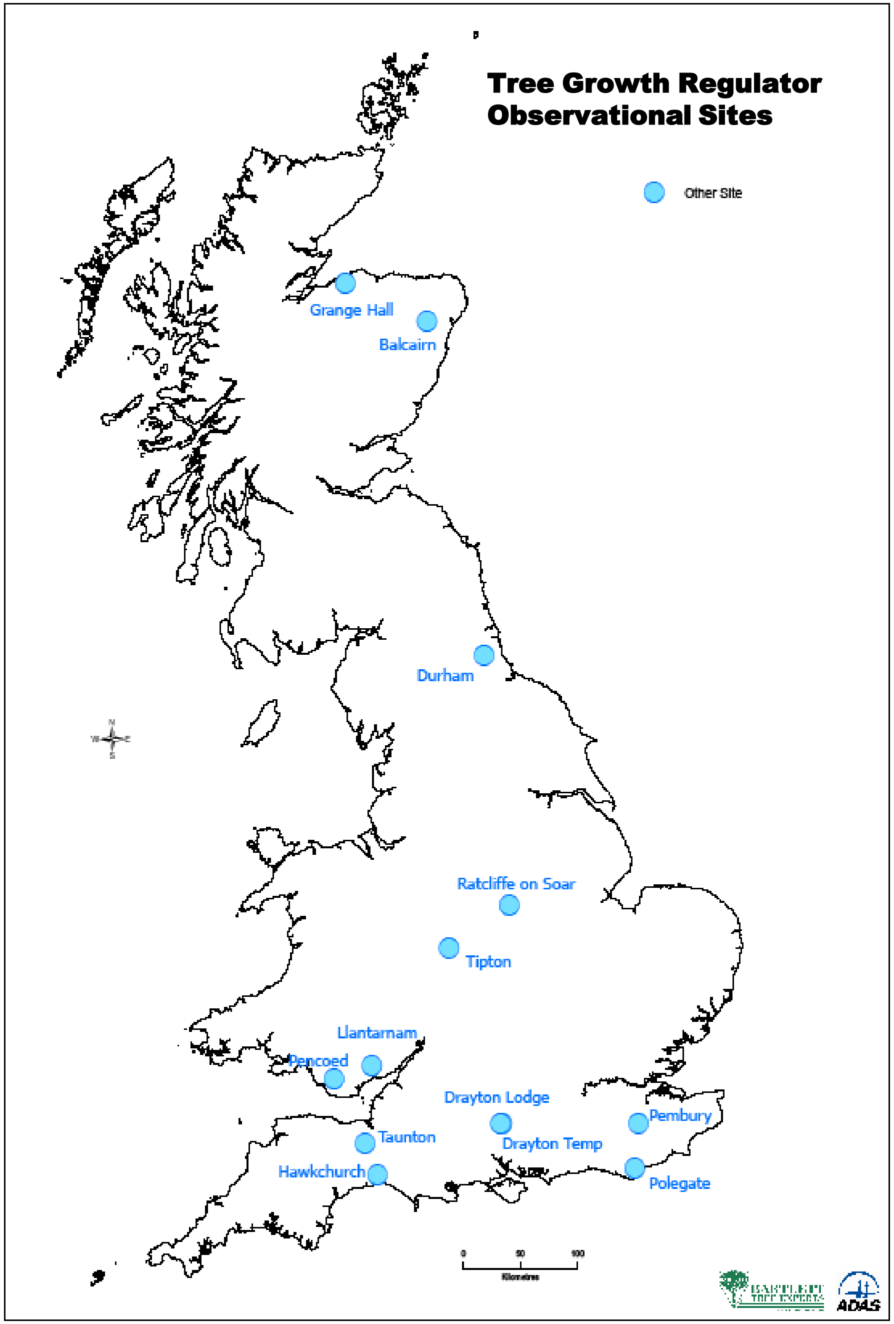
The Research Collaborators were the F A Bartlett Tree Research Lab at Reading University; and ADAS

Objectives of this study were to evaluate the feasibility of PBZ as a TGR for UK DNO purposes using a large number of tree species.

Six trial sites throughout the UK were used for experiments supported by **thirteen** (13) smaller observational sites.



Produced by the ADAS Environment Group, Wolverhampton, WV6 8TQ.



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UK Trials of PBZ - Methods

PBZ was applied using a Rainbow Treecare Soil Injection System based on a 1 x 1 metre spacing to an area three times the diameter of the trunk. One litre per hole was injected to a depth of 20-25cm at a pressure of 2 bar (30 psi).

The quantity of PBZ injected was based on manufacturers recommended rates as determined by tree species and diameter at breast height (DBH).

All experimental and observational sites were treated between late June to early August2009.

After PBZ application all trees were top and side pruned by 15%

Experimental Design

At each field site 30 trees per species were used; 15 PBZ treated and 15 water treated controls in 3 replicates of 5 pairs of trees.

This experimental design was adopted in line with ORETO guidelines for efficacy testing

The results were analysed as a three randomized complete block design.

In the observational site pairs of trees were identified with one treated and the other as a control.

PBZ	Control	PBZ	Control	PBZ	Control
T1	C	T1	C	T1	C
T1	C	T1	C	T1	C
T1	C	T1	C	T1	C
T1	C	T1	C	T1	C
T1	C	T1	C	T1	C

Analysis

The project assessed the effects of PBZ on two factors;

(1) The effects of PBZ on tree health and vitality; and
(2) The effects of PBZ on tree growth.

The effects on tree health were designed to investigate whether PB produced any phytotoxic in the treated trees when compared to controls.

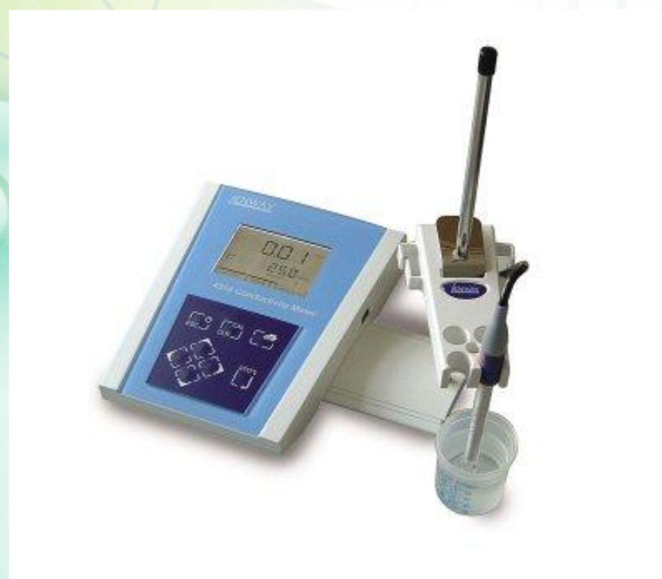
Tree Heath was assessed in three ways

(1) Chlorophyll Content – amount of chlorophyll present or 'greenness'
(2) Chlorophyll Fluorescence – the efficiency of the chlorophyll
(3) Electrolyte Leakage – a measure of the strength of the cell walls

Chlorophyll Content – Spad Meter

Chlorophyll Fluorescence

Electrolyte Leakage – measures the strength of the cell wall



Effects of PBZ on Tree Health - Results

No symptoms of leaf burn or reductions in leaf photosynthetic activity caused by PBZ application have been recorded to date. Close to 2000 trees have been treated.

A significant influence of PBZ on vitality was recorded from 2010-2013 i.e. four years after PBZ application. Analysis of individual tree species (PBZ treated Vs non-PBZ treated controls) at each field site shows that the influence of PBZ was manifest by:

* Increased leaf photosynthetic activity (higher CF values),
* Greener leaves (higher SPAD readings as a measure of leaf chlorophyll content)
* Reduced electrolyte leakage (higher plant cell wall strength).

Effects of PBZ on Tree Health - Results

The influence of PBZ on tree vitality of trees growing under field conditions 2010 -Reading Site

Species	Treatment	CF	SPAD	EL
Quercus robur	Control	8.27	46.60	2.93
	PBZ	8.08^{ns}	47.12^{ns}	3.06^{ns}
Betula pendula	Control	10.5	43.6	1.98
	PBZ	11.2^{ns}	42.8^{ns}	1.97^{ns}
Populus	Control	18.5	42.4	5.17
	PBZ	18.5^{ns}	43.5*	4.72*
Fagus sylvatica	Control	6.5	32.8	1.98
	PBZ	6.4^{ns}	33.7^{ns}	1.97^{ns}

ns = not significant from control, * = $P \leq 0.05$ using LSD. All values mean of fifteen trees, ten leaves per tree.

<u>Lack of significance between control and PBZ treated trees indicates no leaf phytotoxicity</u>

Effects of PBZ on Stem Extension - Results

Application of PBZ has resulted in reduced shoot extension growth over three years in the majority of tree species tested.

However, data trends indicate greater growth reduction in 2010 and 2011 compared to 2012 and 2013 indicating the effects of PBZ are starting to "wear off" in some, but not all species.

Species	Treatment	2010	2011	2012	2013
Quercus robur	Control	10.60	5.44	18.50	7.30
	PBZ	2.97* (71.9)	4.92^{ns} (9.6)	19.88^{ns} (+7.0)	6.50^{ns} (11.0)
Fagus sylvatica	Control	10.8	9.75	8.55	11.31
	PBZ	6.3* (41.6)	2.17* (77.7)	6.61^{ns} (22.6)	6.20* (45.2)
Malus spp.	Control	16.8	13.72	5.71	4.90
	PBZ	14.5^{ns} (13.7)	3.28* (76.1)	2.34* (59.0)	1.50* (69.8)
Populus spp.	Control	18.9	8.27	11.58	17.9
	PBZ	14.3^{ns} (24.3)	8.51^{ns} (+2.9)	12.64^{ns} (+8.4)	16.9^{ns} (5.4)

ns = not significant from control, * = $P \leq 0.05$ using LSD. Values in parenthesis are % reduction from controls. + = % increase from controls. ± = standard error of the mean.

Effects of PBZ on Stem Extension - Results

The influence of PBZ on stem extension (cm) of trees growing under field conditions (Reading Site)

Species	Treatment	Mean reduction in growth over four years
Quercus robur	Control	21.4%
	PBZ	
Fagus sylvatica	Control	46.8%
	PBZ	
Malus	Control	54.7%
	PBZ	
Populus	Control	4.6%
	PBZ	

Effects of PBZ on Stem Extension - Site Effect

Species	Location	Stem Extension Reduction (mean of three growing seasons)
Quercus Robur	Hull	34%
	Reading	25%
	Raglan	50%
Acer pseudoplatanus	Boxworth	9%
	Drayton	44%
Fagus sylvatica	Reading	47%
	Raglan	34%
	Myerscough	19%

All stem extension values mean of fifteen trees five stems per tree.

Results and Conclusions

The principal result of the research is that the tree growth regulator (TGR) Paclobutrazol (PBZ) is effective and fit for purpose.

Effects of PBZ on tree growth will vary between sites.

Growth of English oak was reduced by 50% averaged across four growing seasons at the Raglan site and by 25% at the Reading site when averaged across four growing seasons.

Stem extension of sycamore was reduced by 9% averaged across four growing seasons at the Boxworth site and by 44% at the Drayton site when averaged across four growing seasons.

Stem extension of beech was reduced by 47% at the Reading site; 34% at Raglan; and 19% at Myerscough.

Differences in soil conditions may account for these responses.

Effects of PBZ on Stem Extension - Species Effect

Sensitive	Intermediate	Tolerant
Tilia spp (46%)	*Quercus robur* (37%)	*Salix* spp (18%)
Quercus ilex (61%)	*Fagus sylvatica* (33%)	*Populus* spp (4%)
Crataegus monogyna (38%)	*Betula pendula* (26%)	*Picea sitchensis* (+3%)
Malus spp. (50%)	*Acer pseudoplatanus* (35%)	
Alnus glutinosa (41%)	*Pinus sylvestris* (29%)	
	Fraxinus excelsior (28%)	
	Cupressocyparis leylandii (28%)	

the numbers in parentheses represent the mean extension growth reduction over four growing seasons 2010 to 2013 inclusive

Effects of PBZ on Stem Extension – Species Effect

Sensitive: = A minimum of 3 years growth reduction ranging from 30%-60%

Intermediate: = A minimum of 2 years growth reduction ranging from 50%-75% with effects starting to wear off in year 3 i.e. *ca.* 25% growth reduction.

Tolerant: = Little effect of PBZ. Probably not cost effective to treat these trees.

Of the eight genera that make up 77% of trees on the OHPL Networks in Britain

two genera (*Alnus* & *Crataegus*) are **'sensitive'** to the effects of PBZ; and

four (*Acer*, *Betula*, *Fraxinus* & *Quercus* are in **'intermediate'** in their response to PBZ.

Of the remaining two genera (*Corylus* & *Salix*), *Corylus* was not tested and *Salix* is 'tolerant' to the effects of PBZ,

(*Populus* comprises <2% of the trees on the overhead line networks nationally).

Conclusions

1. The TGR Paclobutrazol is effective in controlling the growth of six of the eight genera of tree most commonly occurring on the OHPL networks.

2. Significantly it controls the growth of C. Leylandii s very common tree on the low voltage network.

3. The effects of PBZ vary between sites possibly due to differing soil conditions.

4. PBZ is ‘fit for purpose’ to control the growth of commonly occurring trees within UVM programmes.

5. Research is ongoing into the development of a formulation of PBZ that can be applied by trunk injection rather than into the soil and the results to date look promising

6. Further research is planned to investigate if higher doses of PBZ would result in control of the growth of ‘tolerant’ genera.

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