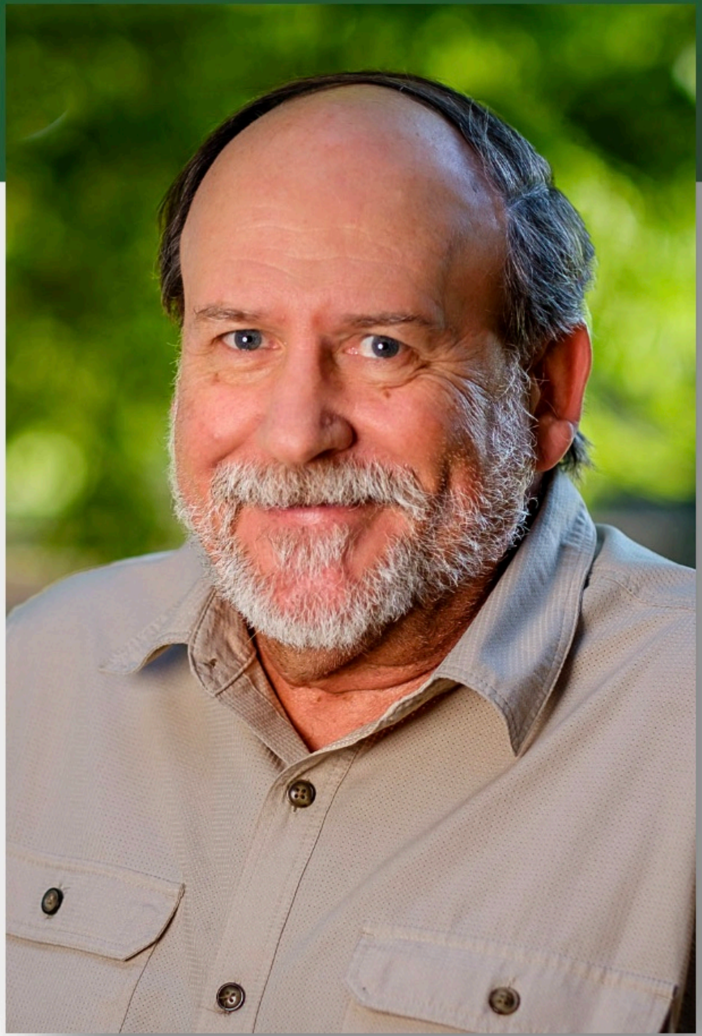
Dr Robert Geneve

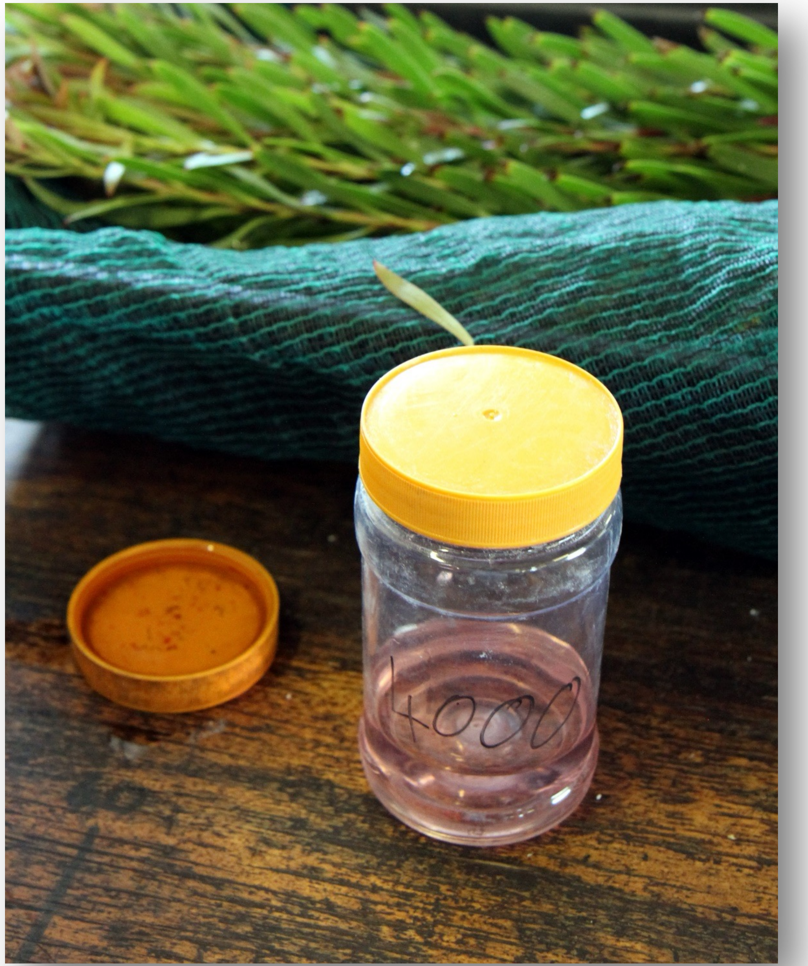
Auxin use in cutting propagation - Then and Now



Dr. Robert Geneve has been a faculty member of the University of Kentucky, Department of Horticulture for over 35 years performing teaching and research in seed biology and clonal plant propagation.

With over 100 journal, proceeding and industry publications, and having serviced as a Past – President for the International Plant Propagators' Society – Eastern region, he is currently the International Plant Propagators' Society Editor.

Auxin use in cutting propagation - then and now



Robert Geneve
University of Kentucky

Auxin use in cutting propagation - then and now

Brief history of auxin

Auxin delivery systems

Future directions

Auxin use in cutting propagation

The greenhouse and nursery industry have seen significant changes over the past twenty years.

Auxin use in cutting propagation

Colorful foliage annuals are in vogue.

Auxin use in cutting propagation

Interspecific hybrids

Interspecific hybrids in geranium between *Pelargonium xhortorum* and *Pelargonium peltatum*.

They are triploid and therefore do not produce seed – no need for deadheading.

Auxin use in cutting propagation

Interspecific hybrids

Hybrid spider flower (*Cleome*) are compact growing under two feet tall, are odorless, thornless and seedless.

Auxin use in cutting propagation

Intergeneric hybrids

x*Petchoa* is an Intergeneric hybrid betwen *Petunia* and *Calibrachoa.*

Auxin use in cutting propagation

Hormone theory and organ formation

Julius Sachs in 1880 postulated the existence of plant morphogens.

Root forming – Rhizocaline

Flower forming – Florigen

Stem forming - Caulocaline

Auxin use in cutting propagation

Brief history of auxin discovery

1933 – Kögl *et al*. isolated auxin from human urine.

1934 – Kögl *et al*. identified compound as indole-3-acetic acid.

Über ein neues Auxin („Hetero-auxin") aus Harn.

11. Mitteilung über pflanzliche Wachstumsstoffe[1].)

Von

Fritz Kögl, A. J. Haagen-Smit und **Hanni Erxleben.**

(Aus dem Organisch-chemischen Institut der Rijksuniversität Utrecht.)

(Der Schriftleitung zugegangen am 8. August 1934.)

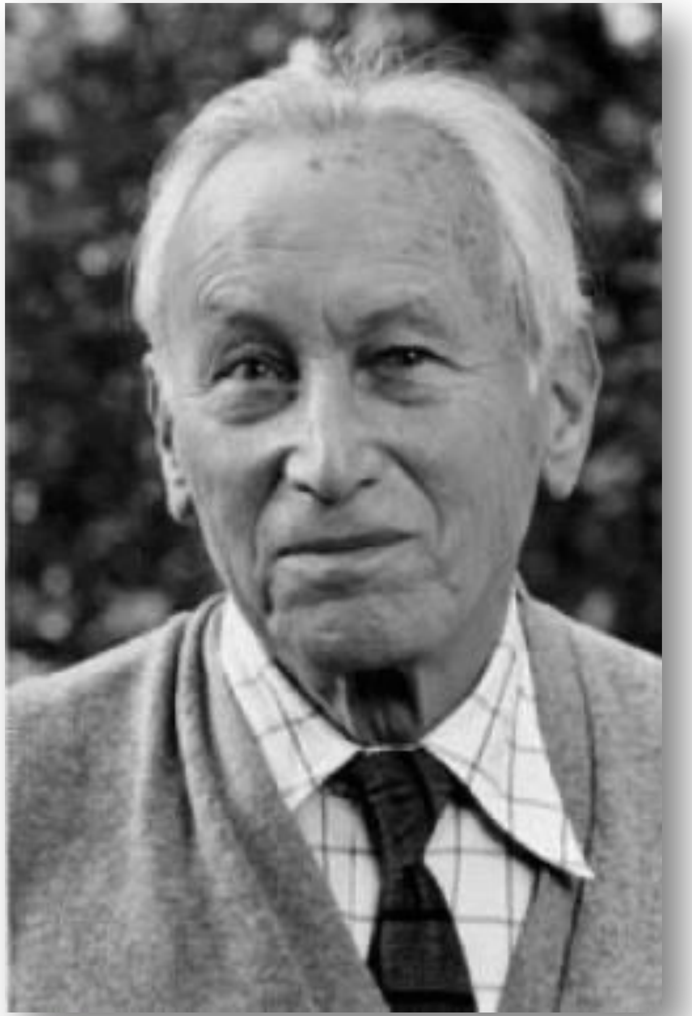
Auxin use in cutting propagation

Brief history of auxin discovery

1934 – Went developed a rooting bioassay using etiolated pea seedlings.

1934 – Went and Thimann test root forming capacity of various leaf extracts in pea bioassay.

Fritz Went



Kenneth Thimann

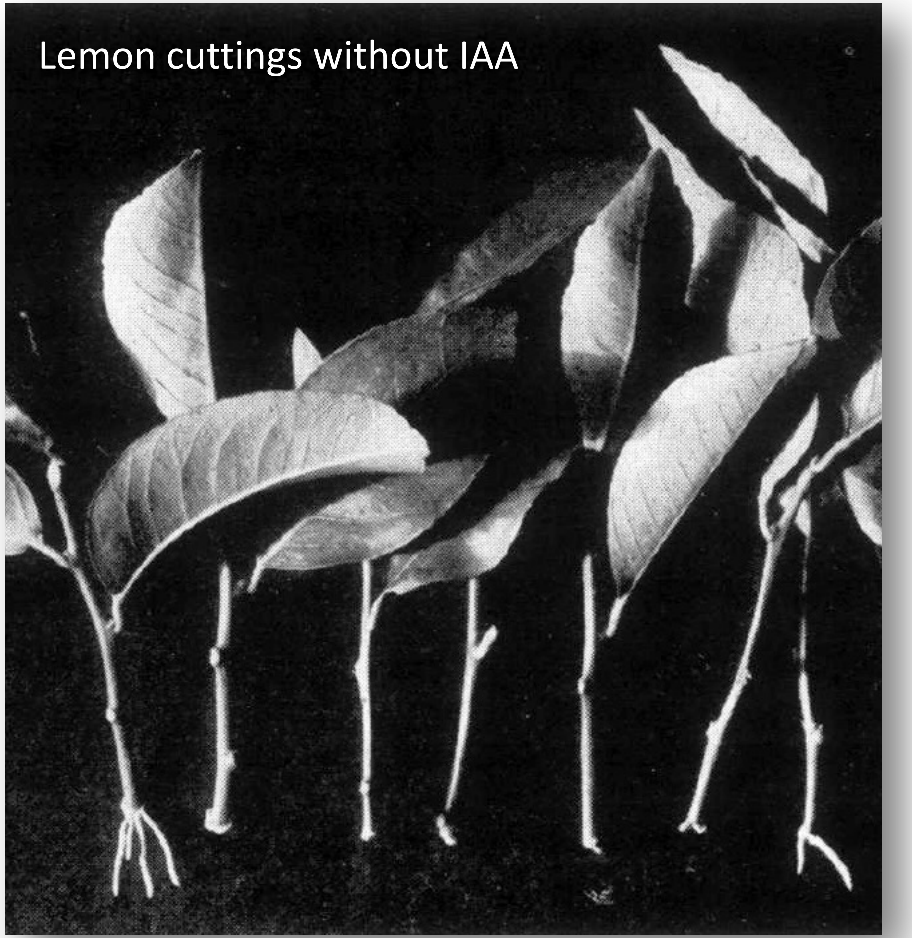
Auxin use in cutting propagation

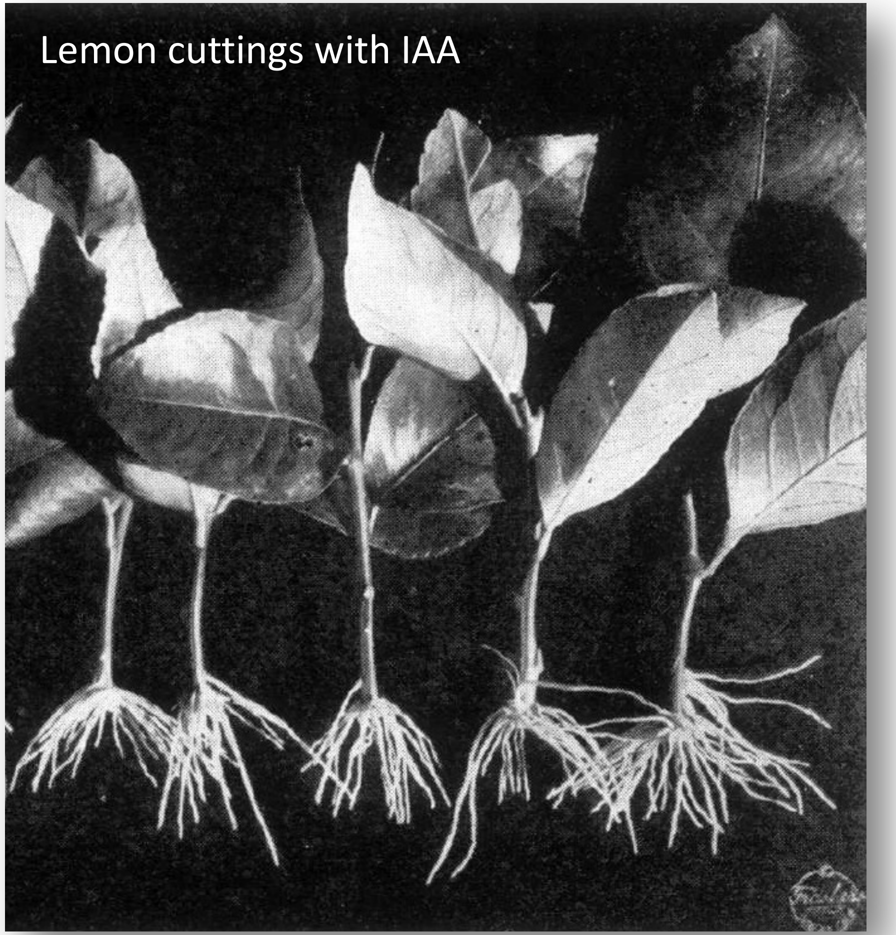
1935 - Researchers at the Boyce Thompson Institute become very active in auxin and rooting in cuttings.

William Cooper was first Superintendant for Boyce Thompson Institute

Auxin use in cutting propagation

The first report of IAA being used to stimulate rooting in cuttings was by William Cooper in 1935.
He treated cuttings with IAA in lanolin paste.





Cooper, W.A. 1935. Hormones in relation to root formation on stem cuttings. Plant Physiology 10:789-794.

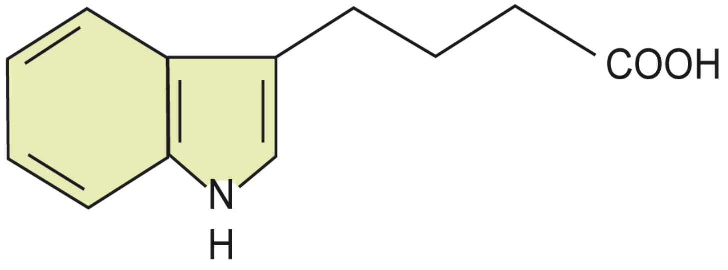
Auxin use in cutting propagation

1935 – Synthetic auxins are created at the Boyce Thompson's Institute.

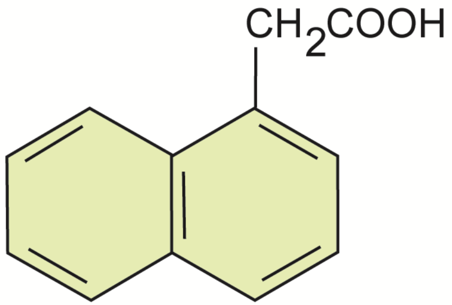
The synthetic auxins included the familiar indolebutyric acid (IBA) and α–naphthaleneacetic acid (NAA) compounds used by modern propagators.

Synthetic auxins showed root promotion in cuttings that was as good or better than IAA.

Indole-3-butyric acid



Naphthalene-1-acetic acid



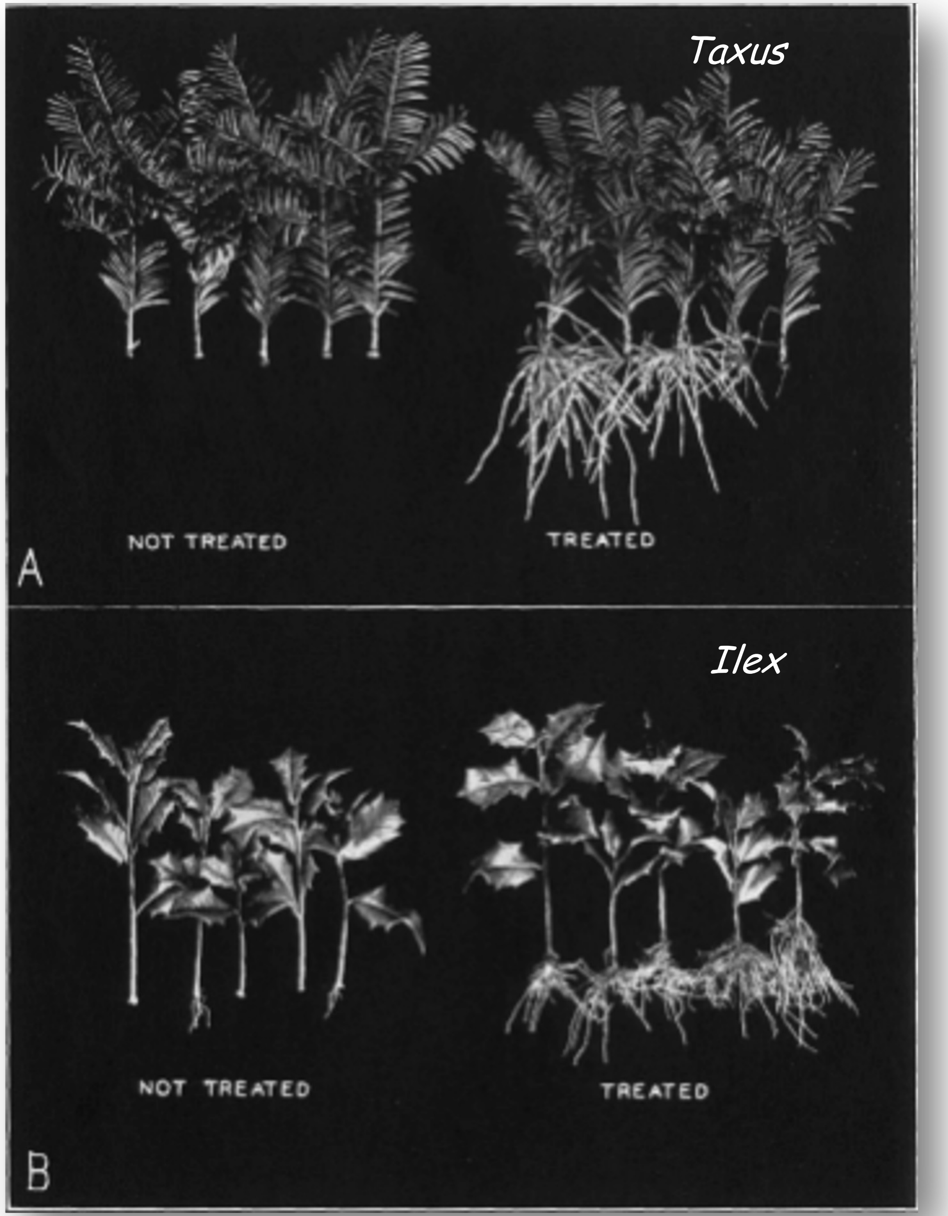
Zimmerman, P.W. and Hitchcock, A.E. 1935. Several chemical growth substances which cause initiation of roots and other responses in plants. Contr. Boyce Thompson Institute 7:209-229.

Auxin use in cutting propagation

In 1936, the soak method replaced lanolin paste for auxin delivery.

Auxin was made soluble in alcohol and diluted in water.

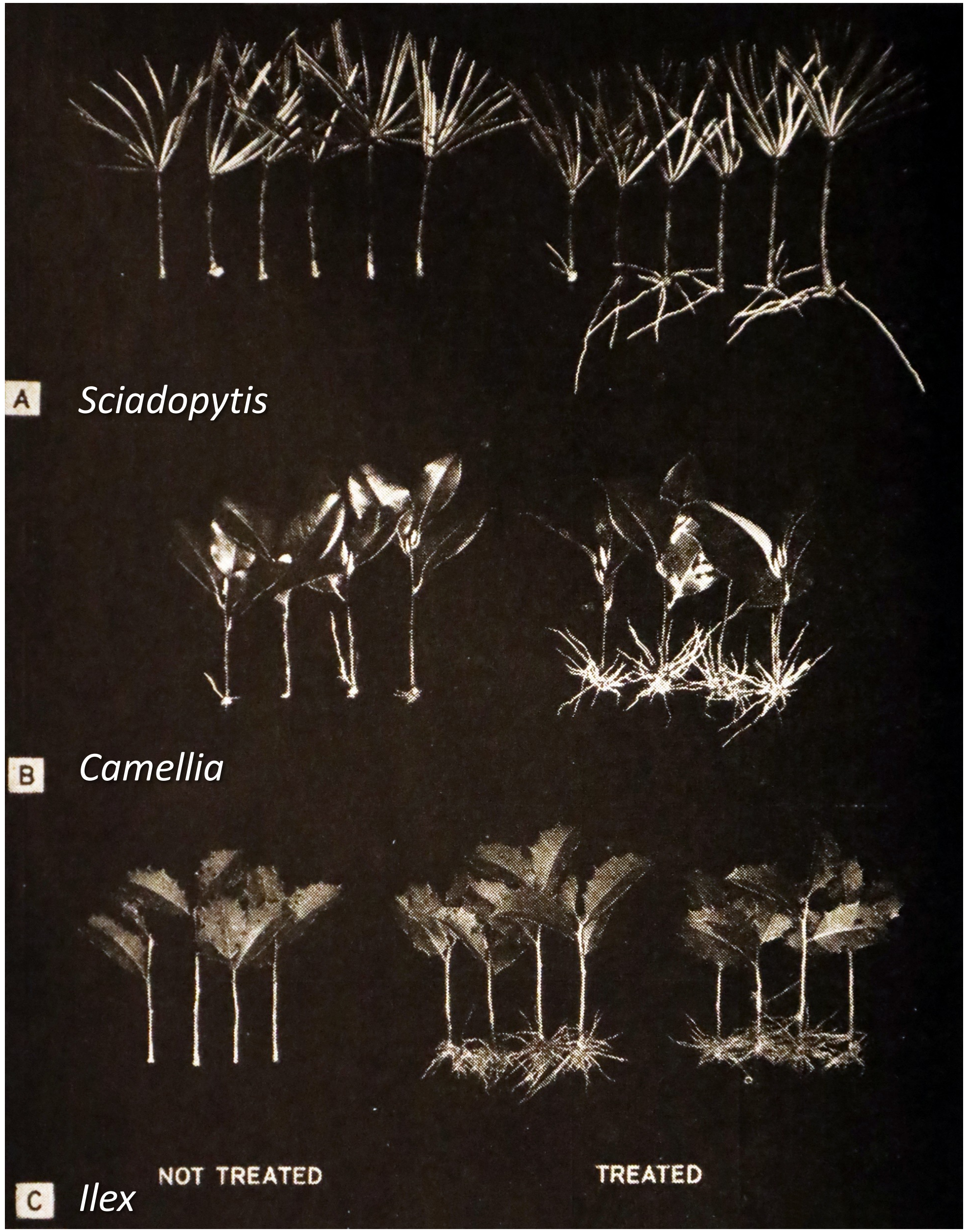
Typical soak durations were 10 to 24 hours.



Hitchcock, A.E. and P.W. Zimmerman. 1936. Effect of growth substances on the rooting response of cuttings. Contr. Boyce Thompson Institute 8:63-79.

Auxin use in cutting propagation

By 1937, researchers at the Boyce Thompson Institute showed that <u>auxin stimulated rooting in over 85 genera</u>, including woody plants that had proven too difficult-to-propagate in the past.



Auxin use in cutting propagation

Soon after, auxin "dust" formulations became available.

In 1938, Chadwick and Kiplinger treated a variety of cuttings with IBA in a soak solution or as commercially available dusts.

They treated over 100 types of woody cuttings.

Interestingly, they reported IBA sprays were not as effective as basal soaks.

Lewis Charles (L.C.) Chadwick

Chadwick, L.C. and D.C. Kiplinger, 1938. The effect of synthetic growth substances on the rooting and subsequent growth of ornamental plants. Proc. Amer. Soc. Hort. Sci. 36:809-816.

Auxin use in cutting propagation

The Boyce Thompson Institute was granted a patent for use of auxins in rooting and subsequently licensed Merck to distribute Hormodin A for commercial application.

By 1947, four commercial companies were offering synthetic auxin formulations in talc for application to cuttings.

Hormodin – Merck

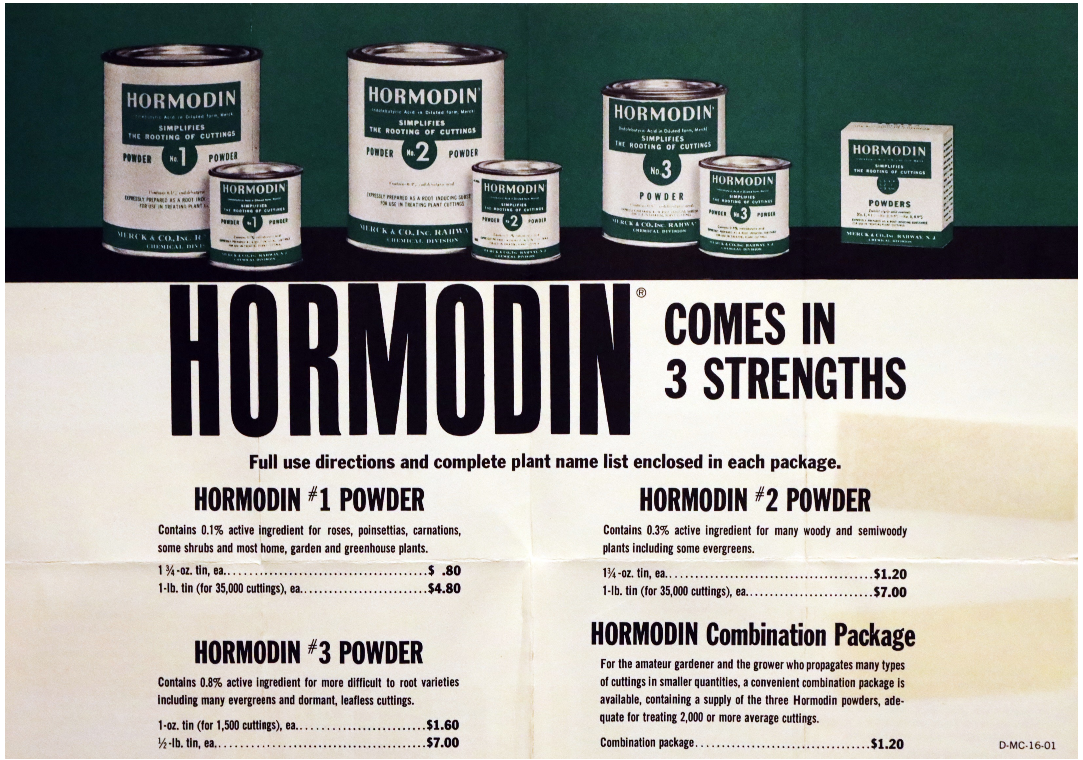
Rootone - American Chemical Paint Co.

StimRoot - Plant Products Co.

Quick-Root - Dow Chemical,

October, 1940 Research Bulletin 280

Effect of Hormodin A, a Growth Substance, on the Rooting of Cuttings



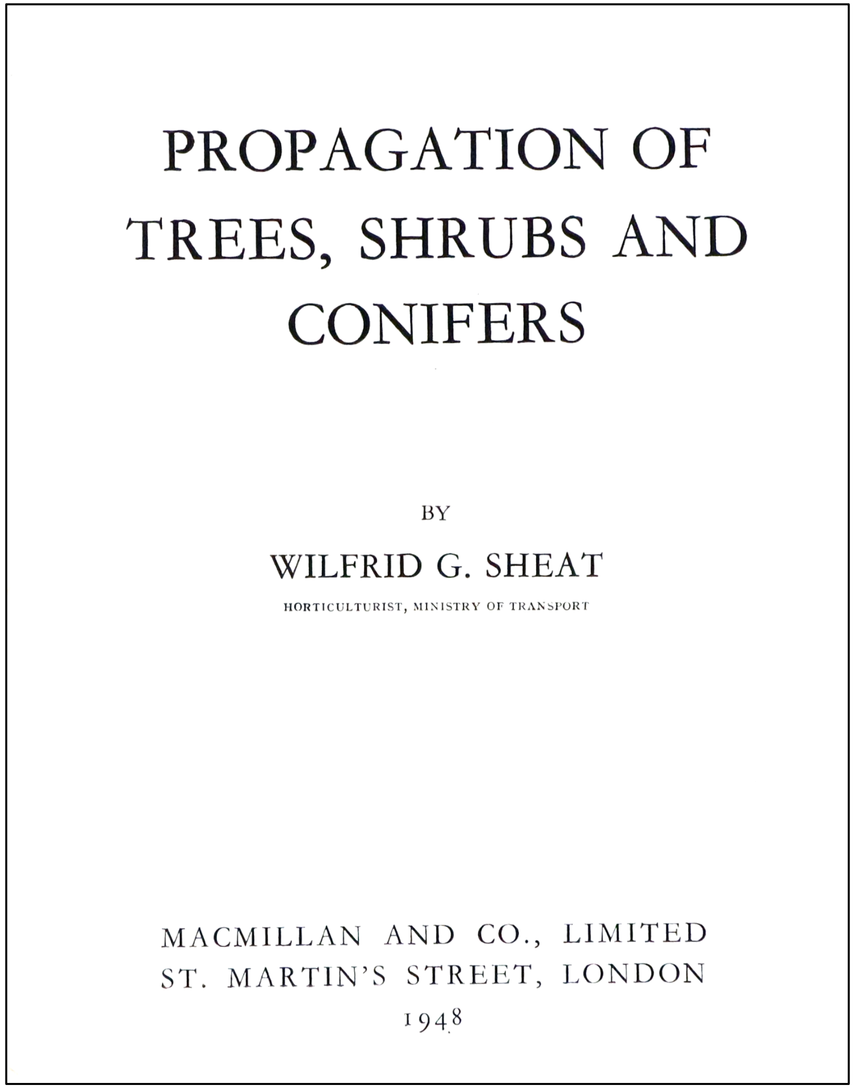
Auxin use in cutting propagation

Commercial auxin adoption

Propagation of Trees, Shrubs and Conifers
Wilfrid G. Sheat
London, 1948.

"I think it is true to say that to date no real commercial advantage has yet been gained by the use of the substance (auxin) for the production of plants by cuttings."

"As a practical propagator, I would add a word of warning. The use of chemical root-producing materials is no substitute for the exercise of intelligent practice in the art of propagation."


PROPAGATION OF TREES, SHRUBS AND CONIFERS

BY

WILFRID G. SHEAT

HORTICULTURIST, MINISTRY OF TRANSPORT

MACMILLAN AND CO., LIMITED
ST. MARTIN'S STREET, LONDON
1948

Auxin use in cutting propagation

Commercial auxin adoption

James Wells. 1951. Propagating Rhododendrons from stem cuttings. Proc. IPPS 1:12-14.

"HORMONE TREATMENTS – There are growers who say that there are no results obtained by the use of hormones which the skilled propagator cannot develop without them."

Auxin use in cutting propagation

Commercial auxin adoption

James Wells. 1951. Propagating Rhododendrons from stem cuttings. Proc. IPPS 1:12-14.

“This is an argument to which we do not subscribe. We believe that used intelligently the plant hormones have a most definite place in modern plant propagation and we use them extensively.”

“For our easily rooted varieties we use a powder containing 6 mg/g of indole butyric acid. This is the strongest commercially available powder in this country.”

Auxin use in cutting propagation

Commercial auxin adoption

Richard Fillmore. 1951. General review of woody plant propagation. Proc. IPPS 1:40-50.

"The use of synthetic hormones is a well established and often beneficial practice in rooting cuttings."

"Assuming that one is thoroughly familiar with the most suitable hormone and the optimum concentration for the species under consideration, hormone treatments will unquestionably promote improved results with a wide variety of plants."

Auxin use in cutting propagation

Commercial auxin adoption

Richard Fillmore. 1951. General review of woody plant propagation. Proc. IPPS 1:40-50.

"When the requirements of this assumption cannot be met, the indiscriminate use of hormones may do more to inhibit than to promote rooting."

"I do not wish to be misunderstood.
I am a pro-hormone man and I have successfully used hormones on dozens if not hundreds of species."

Auxin use in cutting propagation

Commercial auxin adoption

John Vermeulen. 1954. The propagation of *Taxus* by cuttings. Proc. IPPS 4:76-81.

"The use of hormones! You know, I never went to high school. I never went to college, and I am awfully dumb in chemicals."

"I am quite thick-headed as a Dutchman and I didn't want to try a lot of things."

"I probably should have, but we finally got to the point we are trying chemicals."

Auxin use in cutting propagation

Commercial auxin adoption

John Vermeulen. 1954. The propagation of *Taxus* by cuttings. Proc. IPPS 4:76-81.

"This year for the first time, we tried some indolebutyric acid, one and two percent. I don't know whether it will work out."

"I am not alone down there anymore, so they tell me I shouldn't be so old-fashioned, I should try some new things."

"We have to give in once in a while to the younger generation.

So we have!"

Auxin use in cutting propagation

Commercial auxin adoption

IPPS Proceedings Vol. 9 1959

Charles E. Hess

A COMPARISON BETWEEN THE QUICK DIP AND POWDER METHODS OF GROWTH SUBSTANCE APPLICATION TO CUTTINGS

CHARLES E. HESS
Purdue University
Lafayette, Indiana

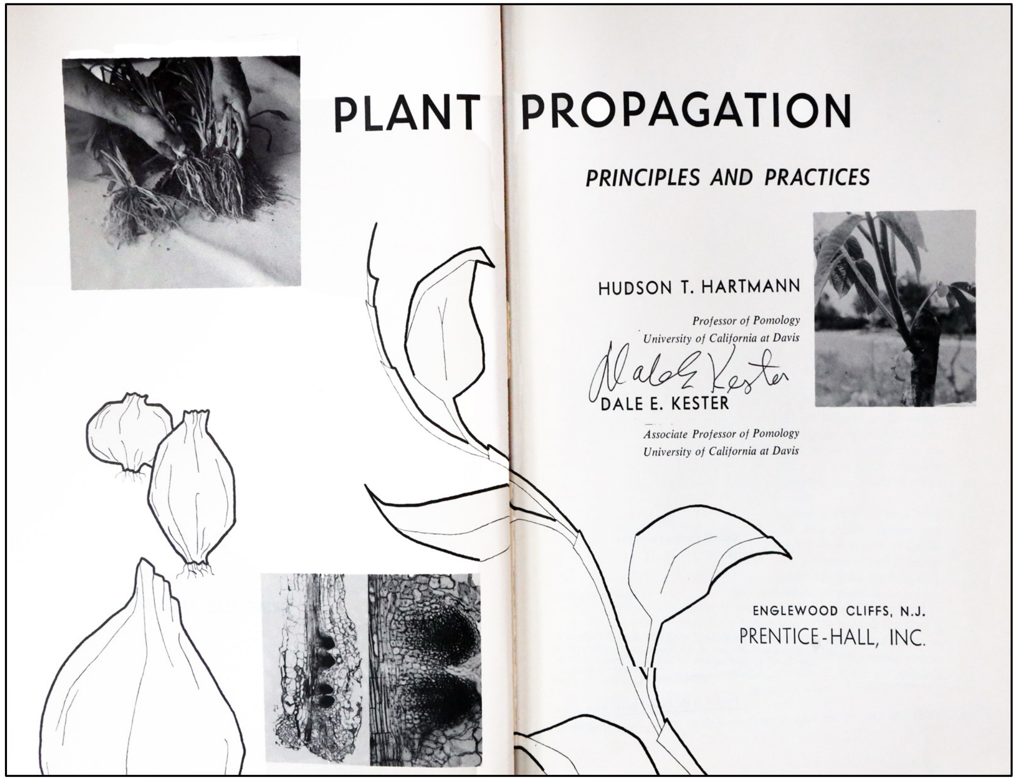
There were seven papers in Volume 9 about the "quick dip" method.

A STUDY OF PLANT GROWTH SUBSTANCES IN EASY AND DIFFICULT-TO-ROOT CUTTINGS

CHARLES E. HESS
Purdue University
Lafayette, Indiana

Auxin use in cutting propagation

Plant Propagation: Principles and Practices
Hartman and Kester 1959



There are several groups of substances considered plant hormones.

These are (a) auxin, (b) traumatic acid, (c) caulines, and (e) vitamins.

Auxin appears to act as a sort of "master hormone".

Hudson Hartman

Dale Kester

Auxin use in cutting propagation

Auxin application methods

- Dilute soak
- Quick dip
- Talc
- Foliar spray
- Total immersion

Auxin use in cutting propagation

The dilute soak method is an older procedure where the basal part of the cutting is placed in the auxin solution.

Timing – up to 24 hours.

Auxin use in cutting propagation

The dilute soak method is an older procedure where the basal part of the cutting is placed in the auxin solution.

Timing – up to 24 hours.

Concentration – 50 to 150 ppm.

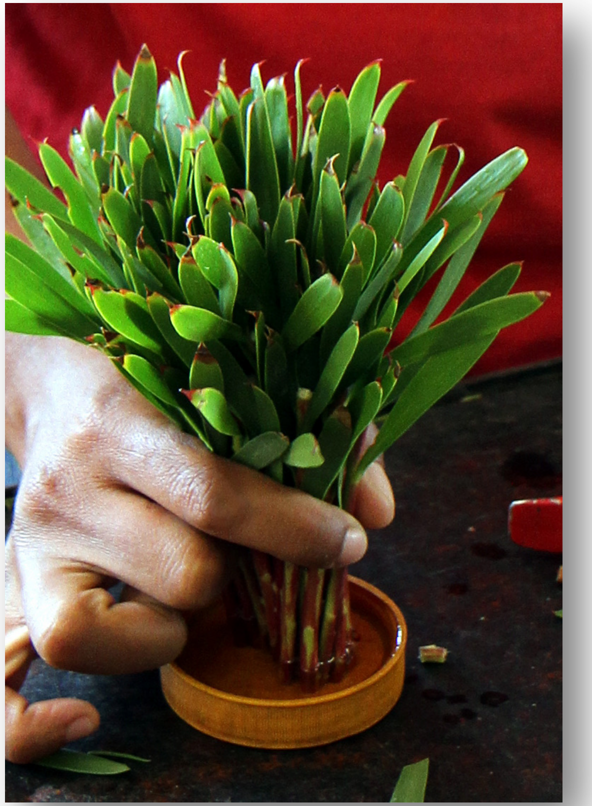
Solution type – must be in water.

Effectiveness – works well but is cumbersome because of timing.

Auxin use in cutting propagation

The <u>quick dip method</u> is a common treatment. The base of the cutting is immersed in the solution.

<u>Timing</u> – 3 to 5 seconds.



Auxin use in cutting propagation

The quick dip method is a common treatment. The base of the cutting is immersed in the solution.

Timing – 3 to 5 seconds.

Concentration – 500 to 10,000 ppm.

Solution type – up to 50% solvent (ethanol). Potassium salts in water.

Effectiveness – very effective and uniform way to treat cuttings. Some cuttings may be sensitive to solvent.

Auxin use in cutting propagation

The <u>talc (powder) method</u> is also a common treatment.

The base of the cutting is coated with the auxin talc.

Auxin use in cutting propagation

The talc (powder) method

Concentration – 0.1 to 8.0%.

Carrier – talc is the most common.

Effectiveness – an effective treatment, especially for herbaceous cuttings.

A pre-dip in a solvent (water or ethanol) may increase effectiveness.

Auxin use in cutting propagation

The foliar spray method uses an atomizer to spray the foliage.

Timing – until the solution drips from the leaves.

Auxin use in cutting propagation

The foliar spray method uses an atomizer to spray the foliage.

Timing – until the solution drips from the leaves. It is applied after sticking.

Concentration – 100 to 5,000 ppm.

Solution type – usually the potassium salt of IBA in water.

Effectiveness – varies by species, but when effective it reduces worker exposure and labor time.

Auxin use in cutting propagation

Auxin and rooting in mum cuttings

Treatment	Roots per cutting
Untreated	19.7

Auxin use in cutting propagation

Auxin and rooting in mum cuttings

Treatment	Roots per cutting
Untreated	19.7
Talc	29.5

Auxin use in cutting propagation

Auxin and rooting in mum cuttings

Treatment	Duration	Roots per cutting
Untreated		19.7
Talc		29.5
Quick dip	1 seconds	41.3
	3 seconds	40.5

Auxin use in cutting propagation

Auxin and rooting in mum cuttings

Treatment	Duration	Roots per cutting
Untreated		19.7
Talc		29.5
Quick dip	1 seconds	41.3
	3 seconds	40.5
Dilute soak	8 hours	40.4
	16 hours	42.0

Auxin use in cutting propagation

Auxin and rooting in mum cuttings

Treatment	Duration	Roots per cutting
Untreated		19.7
Talc		29.5
Quick dip	1 seconds	41.3
	3 seconds	40.5
Dilute soak	8 hours	40.4
	16 hours	42.0
Spray		38.2

Auxin use in cutting propagation

The total immersion method submerges cuttings in K-IBA solution.

Timing – several minutes.

Concentration – 100 to 5,000 ppm.

Solution type – usually the potassium salt of IBA in water.

Effectiveness – varies by species, but is time efficient (batch treatment).

Auxin use in cutting propagation

Total immersion method - background

Stock plant specialists and shipping unrooted cuttings.

Auxin use in cutting propagation

Total immersion method - background

Reinforced awareness of importance of hydrating cuttings.

Use of surfactants.

Auxin use in cutting propagation

Total immersion method - background

Sanitation including disinfectants in washing solution.

Auxin use in cutting propagation

Total immersion method - background

Biopesticides treatment of cuttings.

Auxin use in cutting propagation

Total immersion method

Stacking immersion solutions

UpTake = wetting agent

Suffoil-X = mineral oil

K-IBA at 1000 ppm

Auxin use in cutting propagation

Total immersion method

Auxin use in cutting propagation

Foliar spray

Effective foliar auxin may be impacted by:

Species type

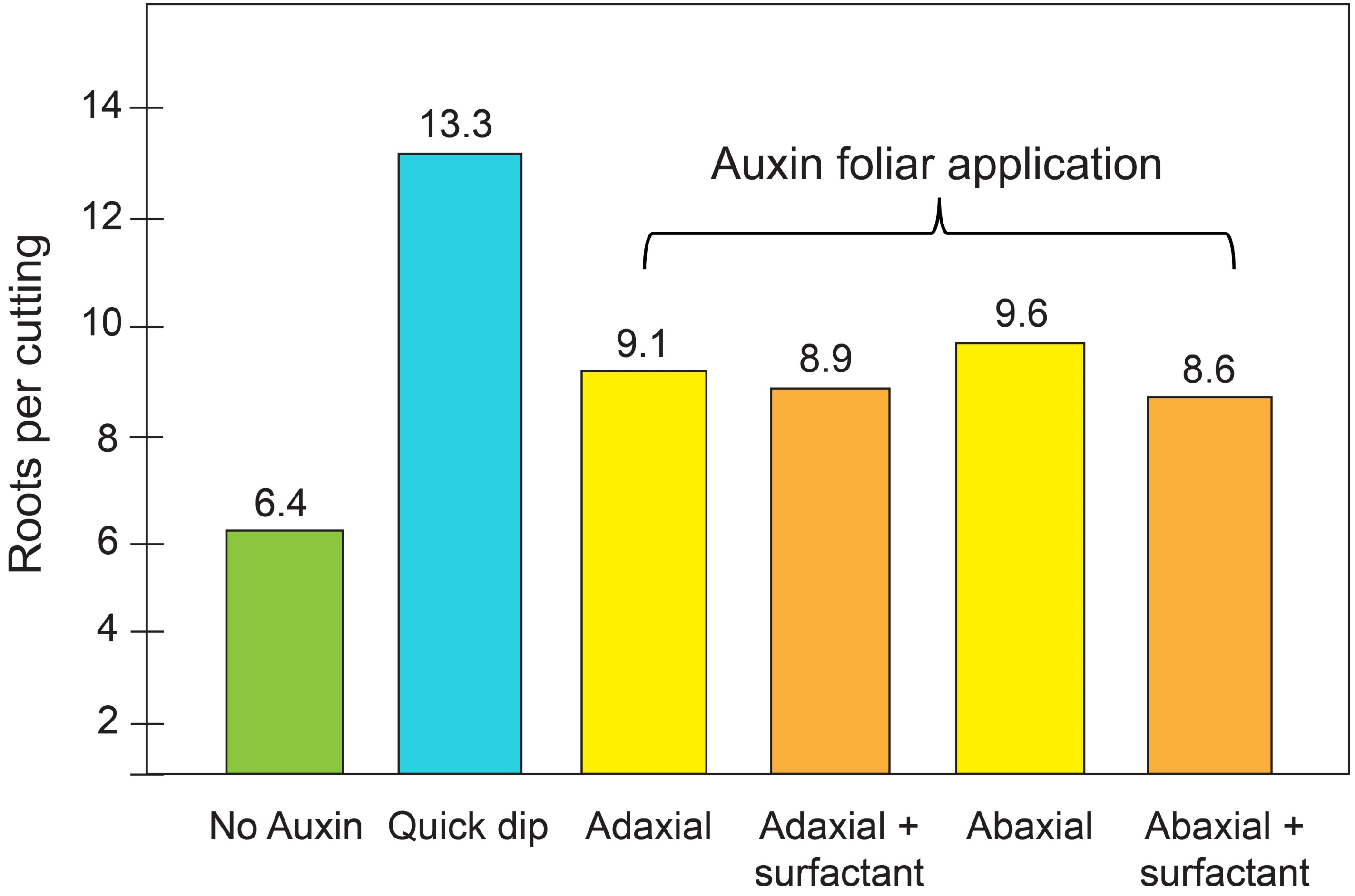
Auxin uptake, transport or metabolism

Timing of spray application

Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Euonymus alatus* cuttings with auxin applied as a quick dip or to the abaxial (upper) or adaxial (lower) leaf surfaces with or without a surfactant.

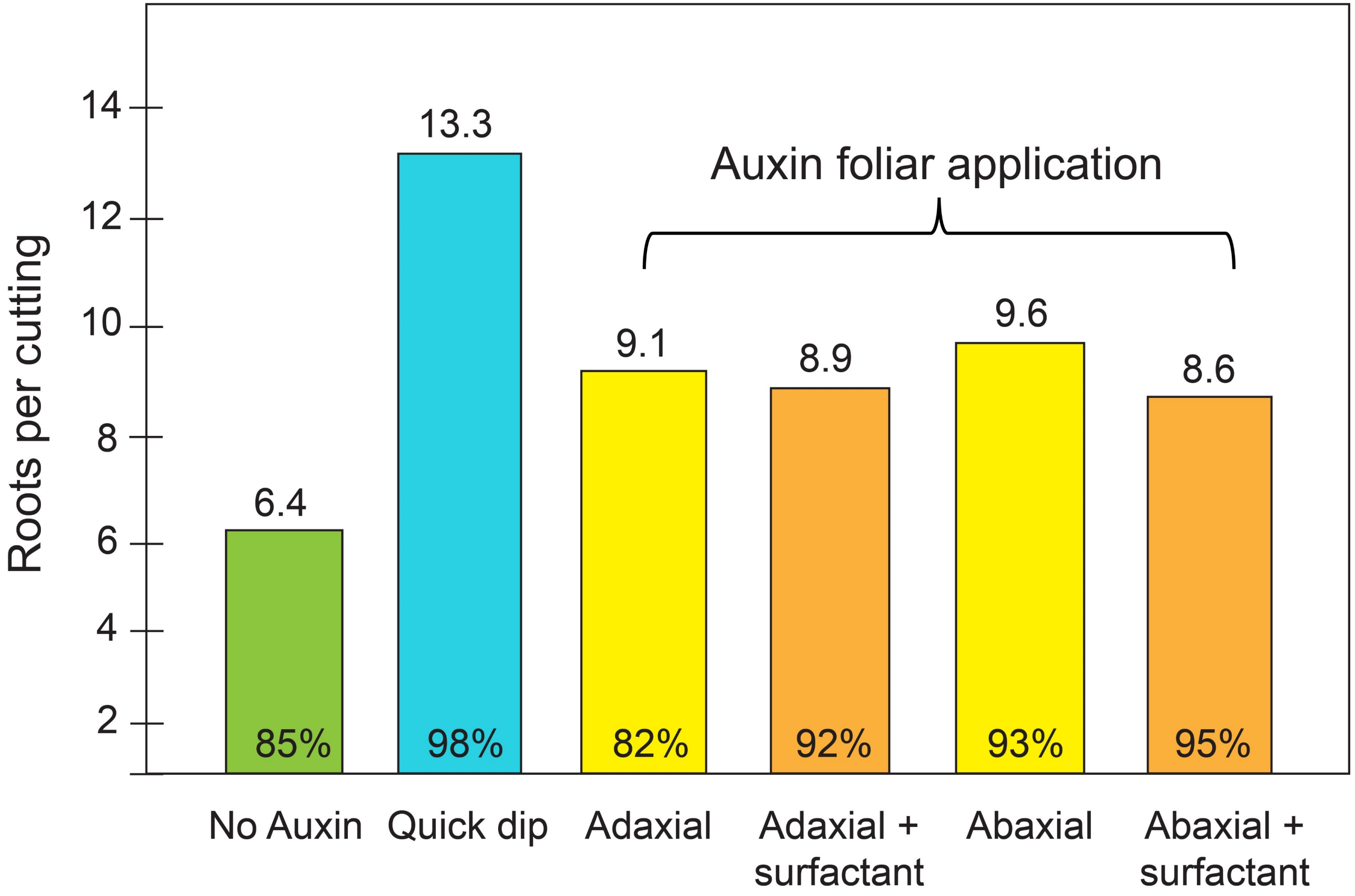


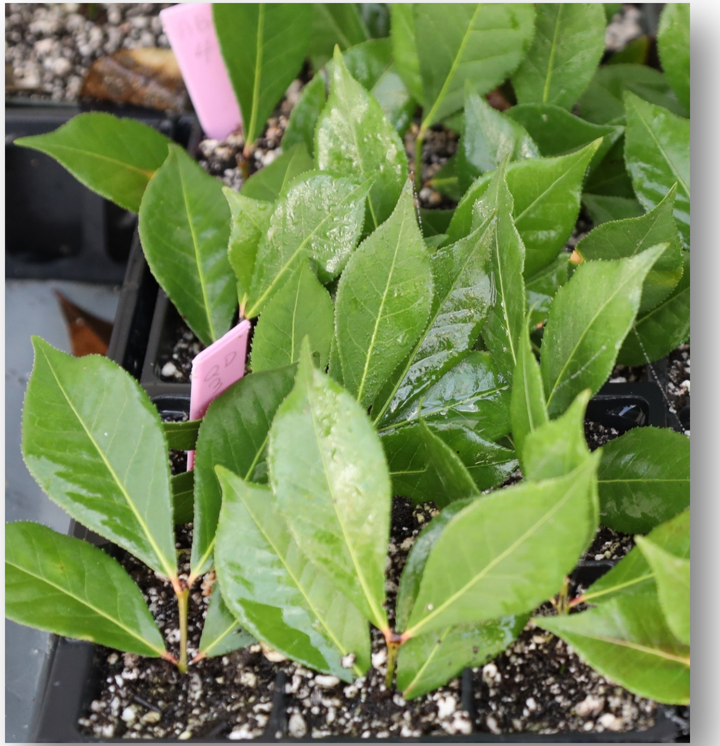
No difference in roots per cutting between adaxial vs. abaxial auxin application.

Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Euonymus alatus* cuttings with auxin applied as a quick dip or to the abaxial (upper) or adaxial (lower) leaf surfaces with or without a surfactant.





Rooting percentages were lower in adaxial treated cuttings and this was recovered using the surfactant.

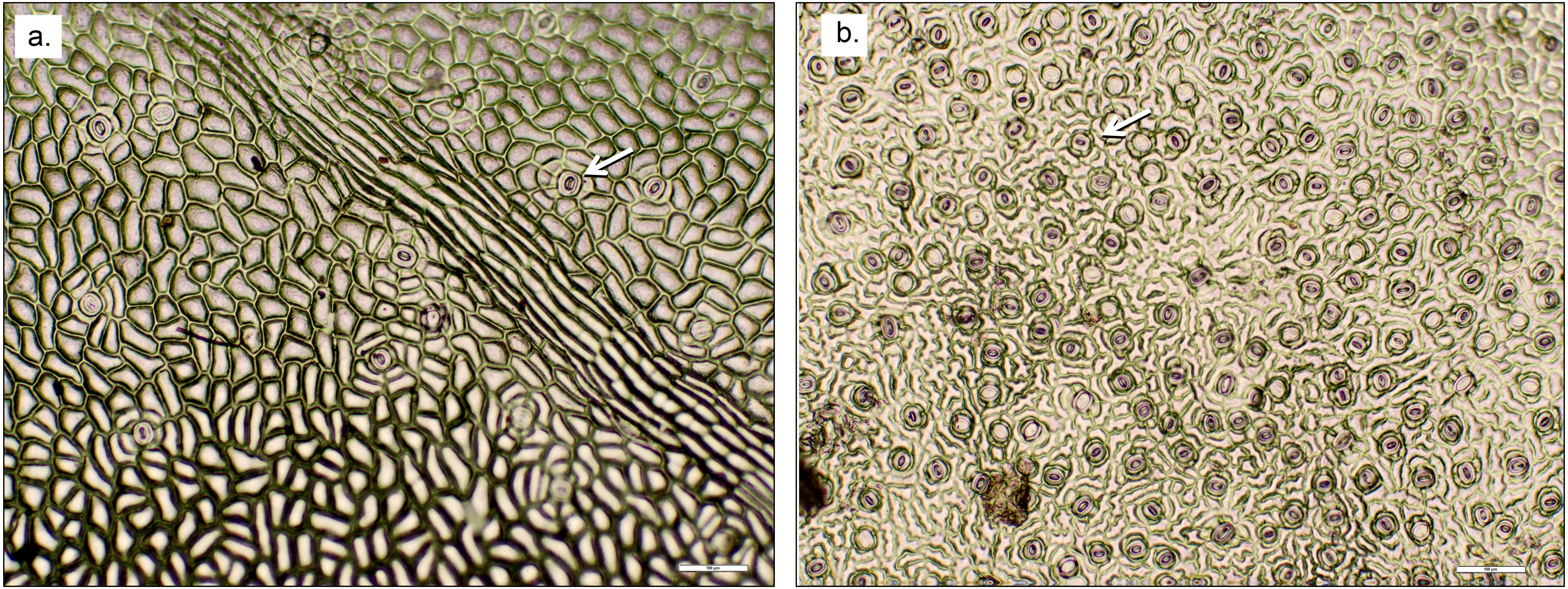
Auxin use in cutting propagation

Foliar spray

Comparison of stomatal density in (a) abaxial and (b) adaxial leaf surfaces in *Euonymus alatus*.

Adaxial (upper surface) ~ 15 stomata

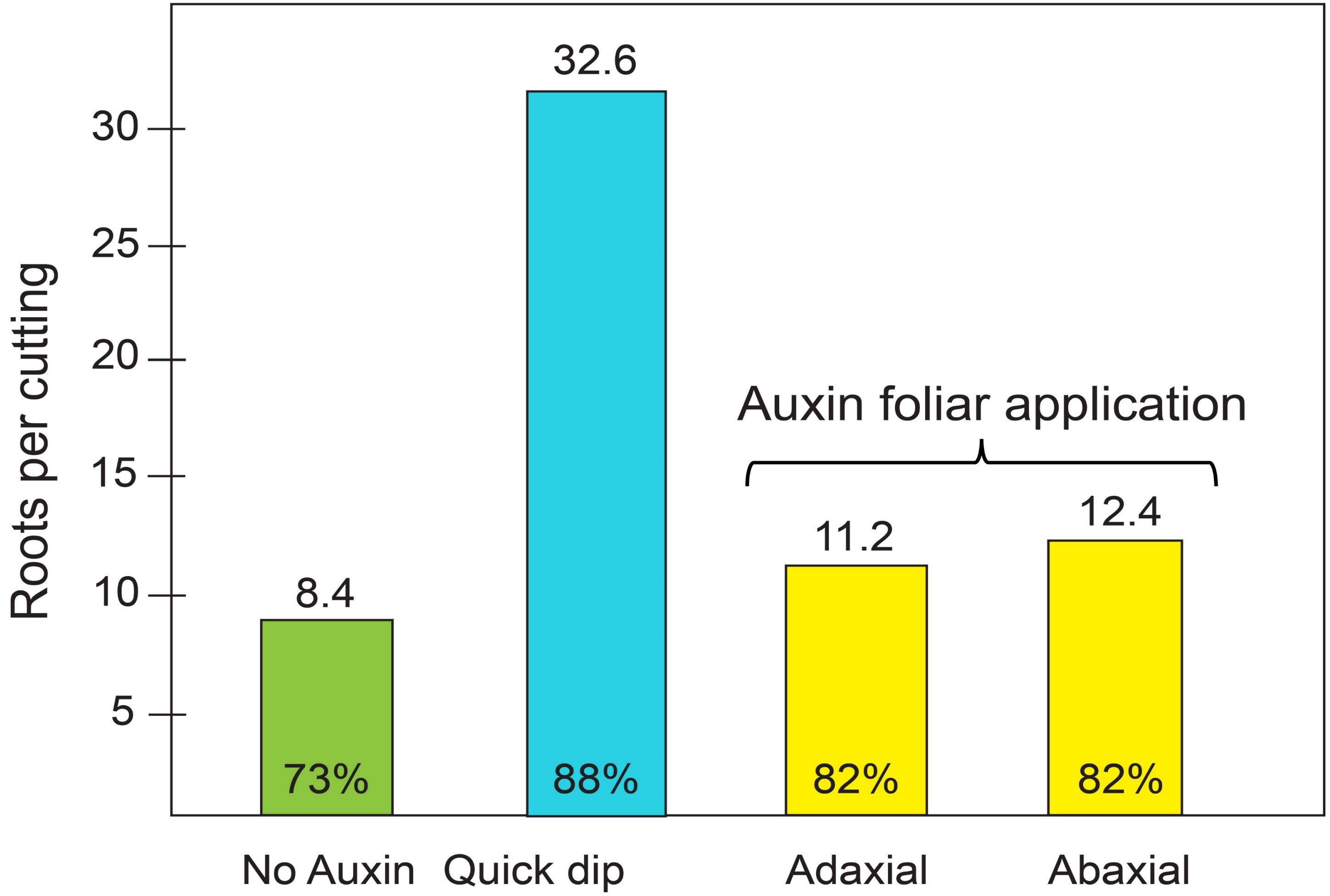
Abaxial (lower surface) >100 stomata



Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Cephlalanthus* cuttings with auxin applied as a quick dip or to the abaxial (upper) or adaxial (lower) leaf surfaces.



Auxin use in cutting propagation

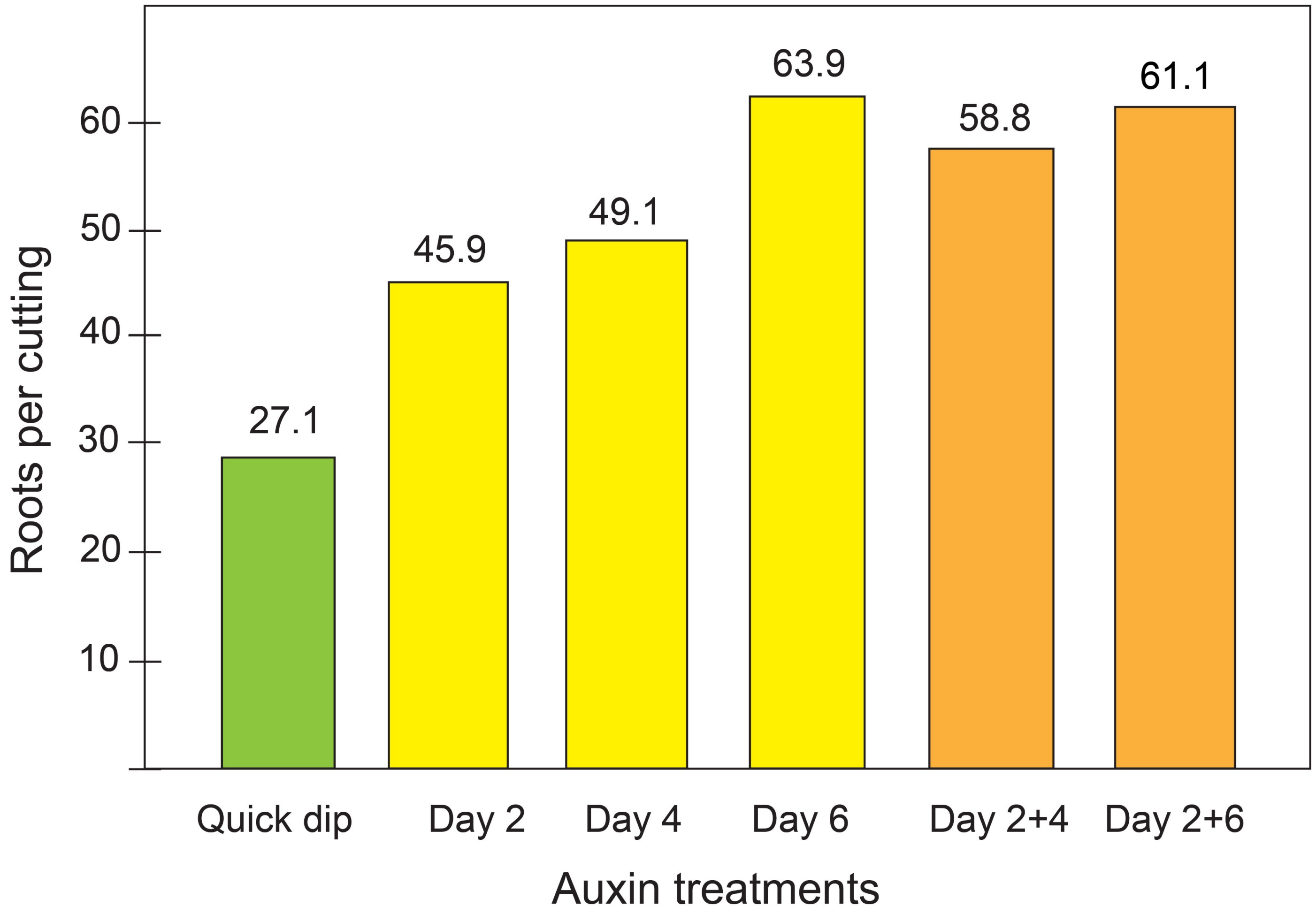
Foliar spray

Impact of application timing and multiple applications on rooting.

Auxin use in cutting propagation

Foliar spray

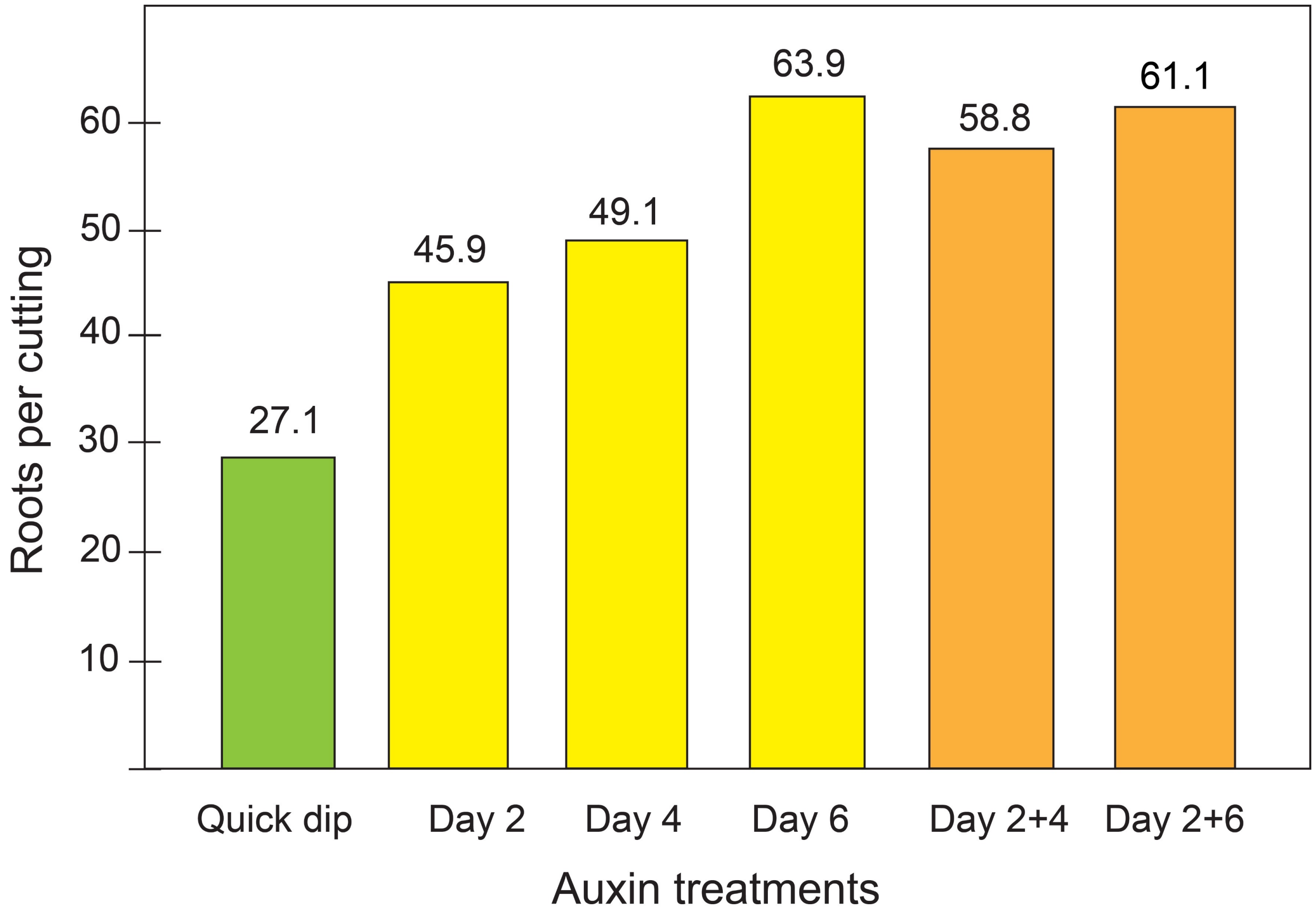
Roots per cutting in *Hydrangea paniculata* ‘Limelight’ cuttings with auxin applied as a quick dip or as single or multiple foliar sprays on 2, 4, or 6 days after sticking.



Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Hydrangea paniculata* ‘Limelight’ cuttings with auxin applied as a quick dip or as single or multiple foliar sprays on 2, 4, or 6 days after sticking.



Foliar spray was more effective than quick dip.

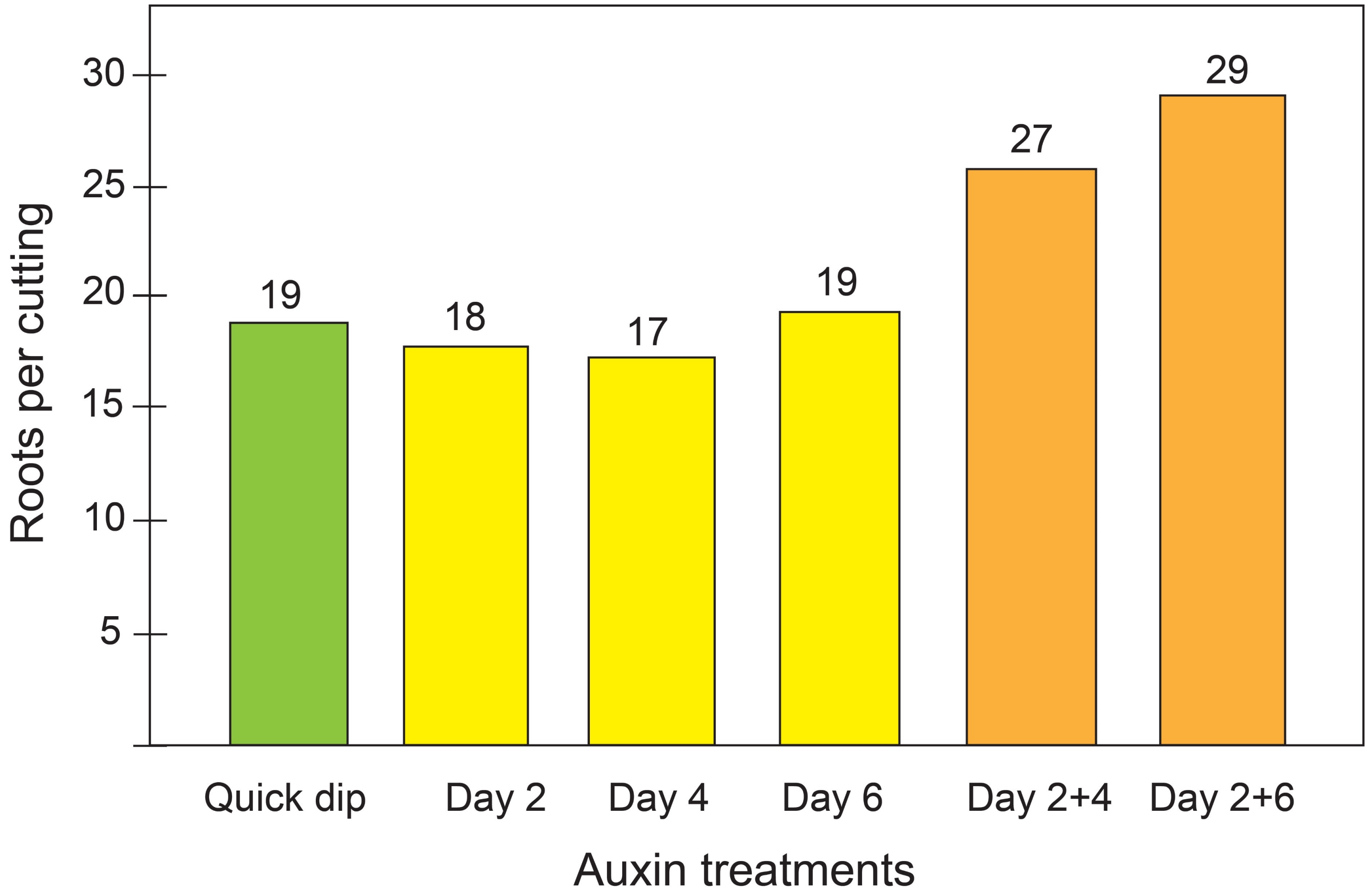
Roots per cutting for auxin increased when applied at six days after sticking.

Multiple sprays generally showed an increase in roots per cutting over single sprays.

Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Viburnum dentatum* cuttings with auxin applied as a quick dip or as single or multiple foliar sprays on 2, 4, or 6 days after sticking.



Auxin use in cutting propagation

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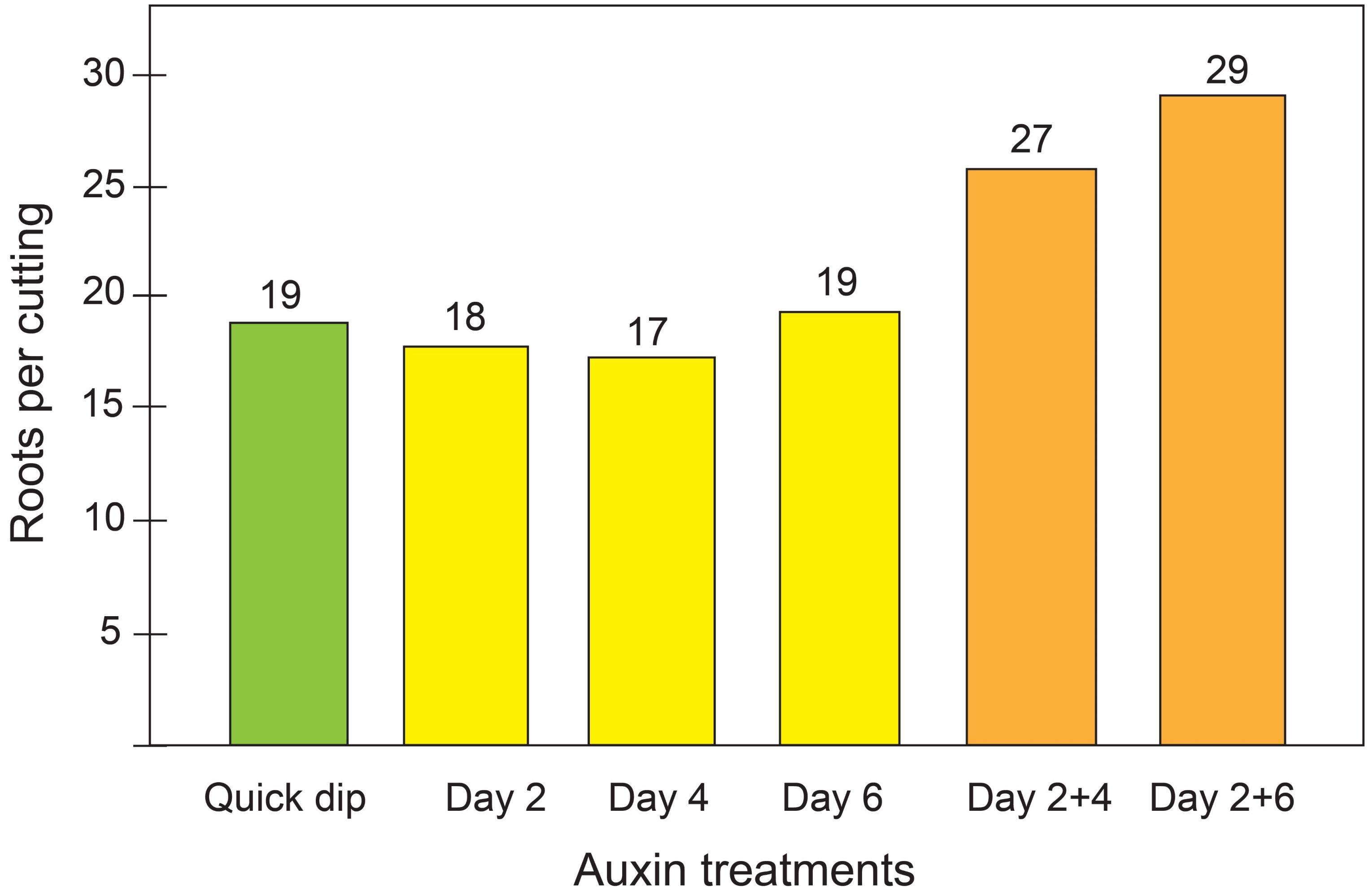
Roots per cutting in *Viburnum dentatum* cuttings with auxin applied as a quick dip or as single or multiple foliar sprays on 2, 4, or 6 days after sticking.



Foliar spray was as effective as quick dip.

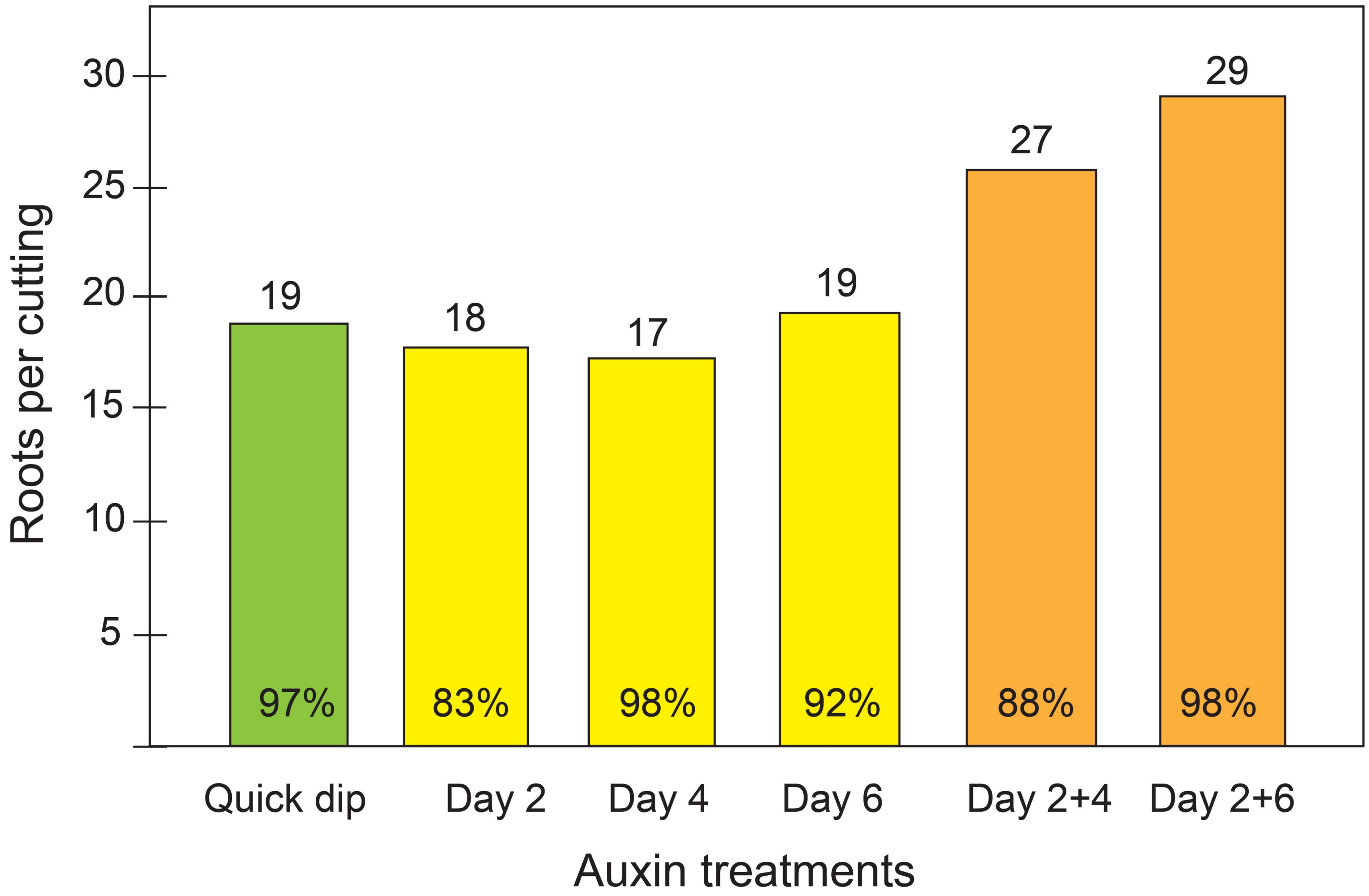
No difference in roots per cutting for auxin applied up to six days after sticking.

Multiple sprays showed an increase of about 10 roots per cutting.

Auxin use in cutting propagation

Foliar spray

Roots per cutting in *Viburnum dentatum* cuttings with auxin applied as a quick dip or as single or multiple foliar sprays on 2, 4, or 6 days after sticking.



Foliar spray was as effective as quick dip.

No difference in roots per cutting for auxin applied up to six days after sticking.

Multiple sprays showed an increase of about 10 roots per cutting.

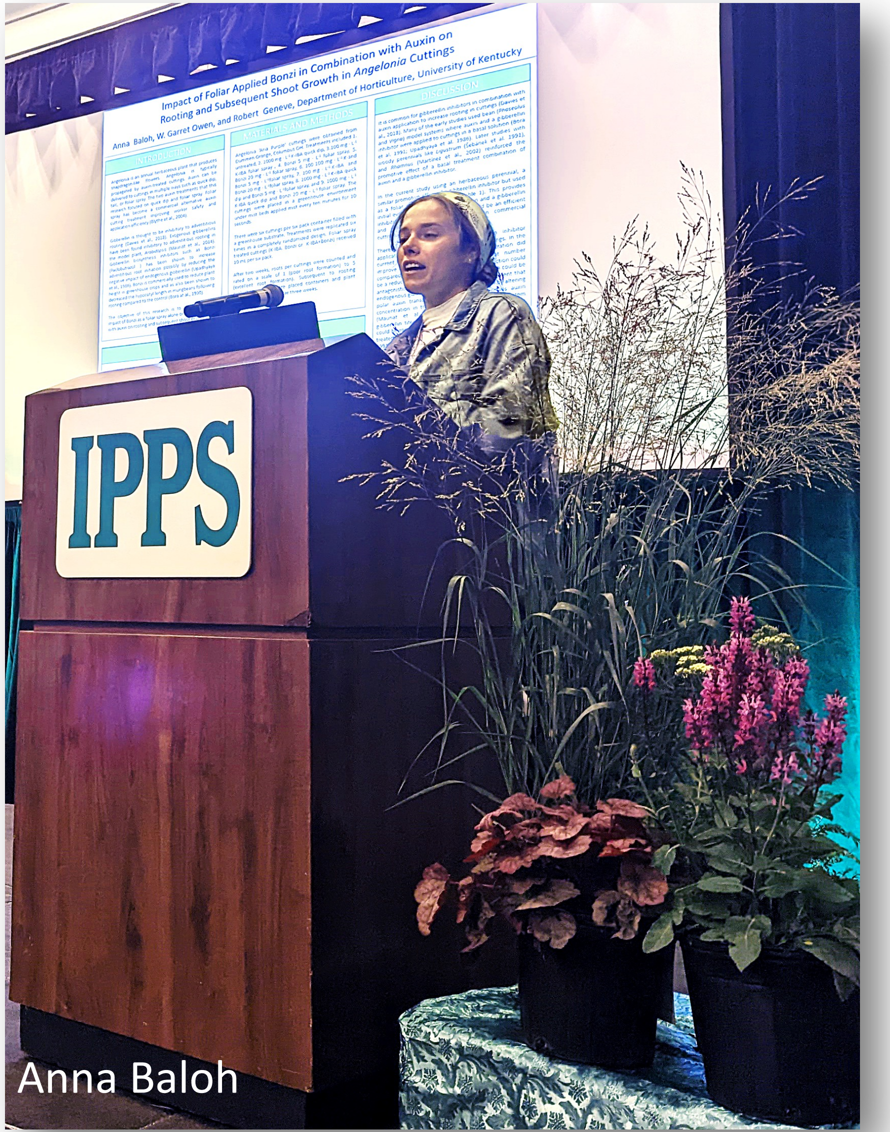
No difference in rooting percentage.

Auxin use in cutting propagation

Foliar spray

Including growth regulators
in the K-IBA foliar spray.

Angelonia



Anna Baloh

Auxin use in cutting propagation

Foliar spray

Root formation in *Angelonia* cuttings treated with K-IBA and Bonzi as a dip or foliar spray.

Application method	K-IBA ($mg \cdot L^{-1}$)	Bonzi ($mg \cdot L^{-1}$)	Rooting percentage	Roots per cutting
Untreated	0	0	79.7c	3.9d
Foliar spray	0	20	95.8b	6.1c
	100	0	100a	5.9c
	100	20	100a	7.1c

Auxin use in cutting propagation

Foliar spray

Root formation in *Angelonia* cuttings treated with K-IBA and Bonzi as a dip or foliar spray.

Application method	K-IBA ($mg \cdot L^{-1}$)	Bonzi ($mg \cdot L^{-1}$)	Height (cm)
Untreated	0	0	6.2
Quick dip	1000	0	7.5
	1000	20	7.7
Foliar spray	0	20	7.3
	100	0	7.5
	100	20	7.7

Auxin use in cutting propagation

Foliar spray

Root formation in *Angelonia* cuttings treated with K-IBA and Bonzi as a dip or foliar spray.

Auxin use in cutting propagation

Foliar spray

Some species do not have the same response to foliar auxin compared to basal dips.

Species	K-IBA	Rooting percentage	Roots per cutting
Euonymus	Untreated	85	6.4
	Quick dip	98	13.3
	Foliar spray	89	9.2

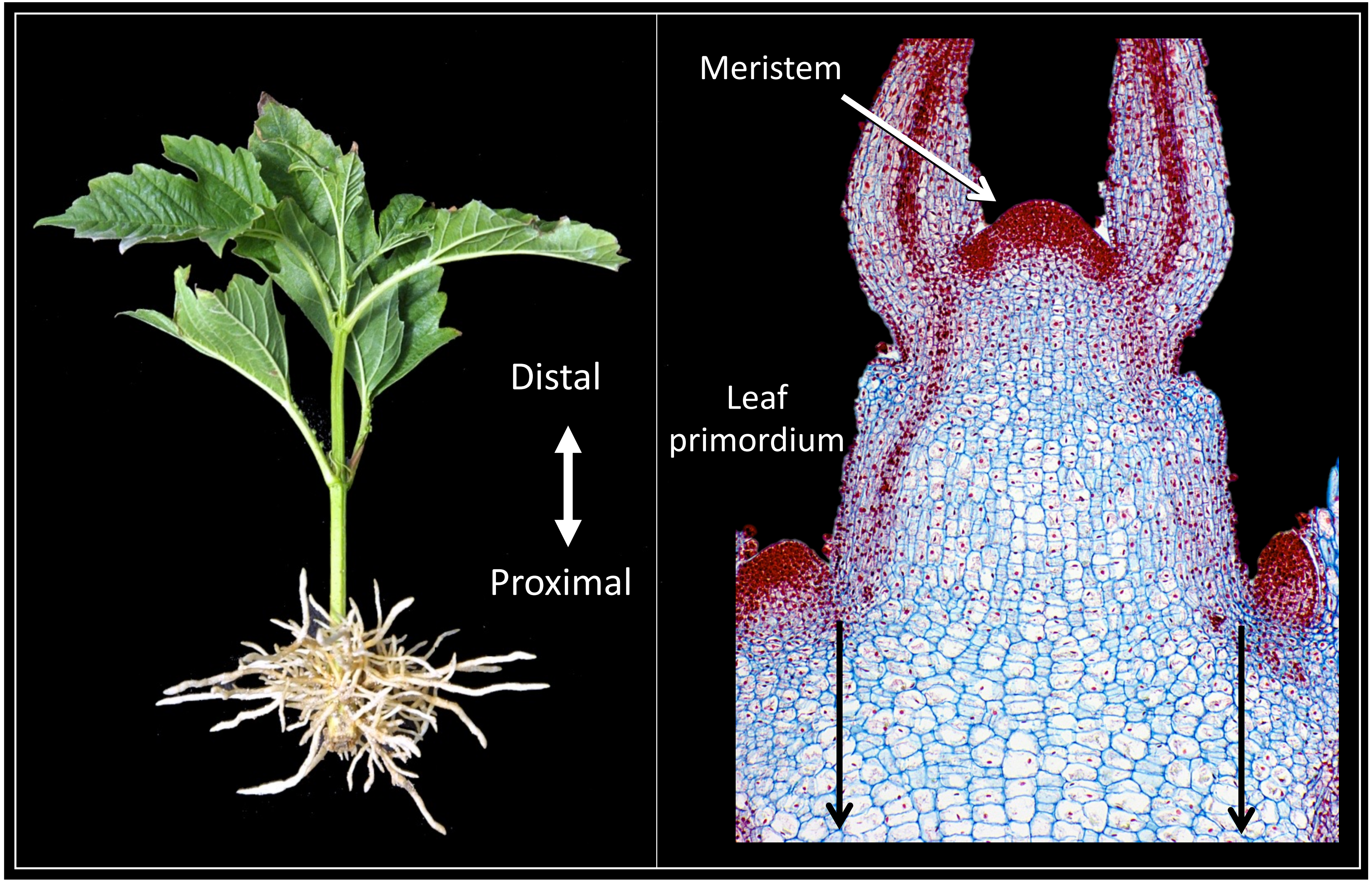
Auxin use in cutting propagation

Auxin transport

In *Arabidopsis* hypocotyls, applied IBA and IAA moved basipetally at different speeds.

Significant amounts of IBA were converted to IAA during transport.

Conjugated IBA accumulated at the base preferentially to active free IBA.

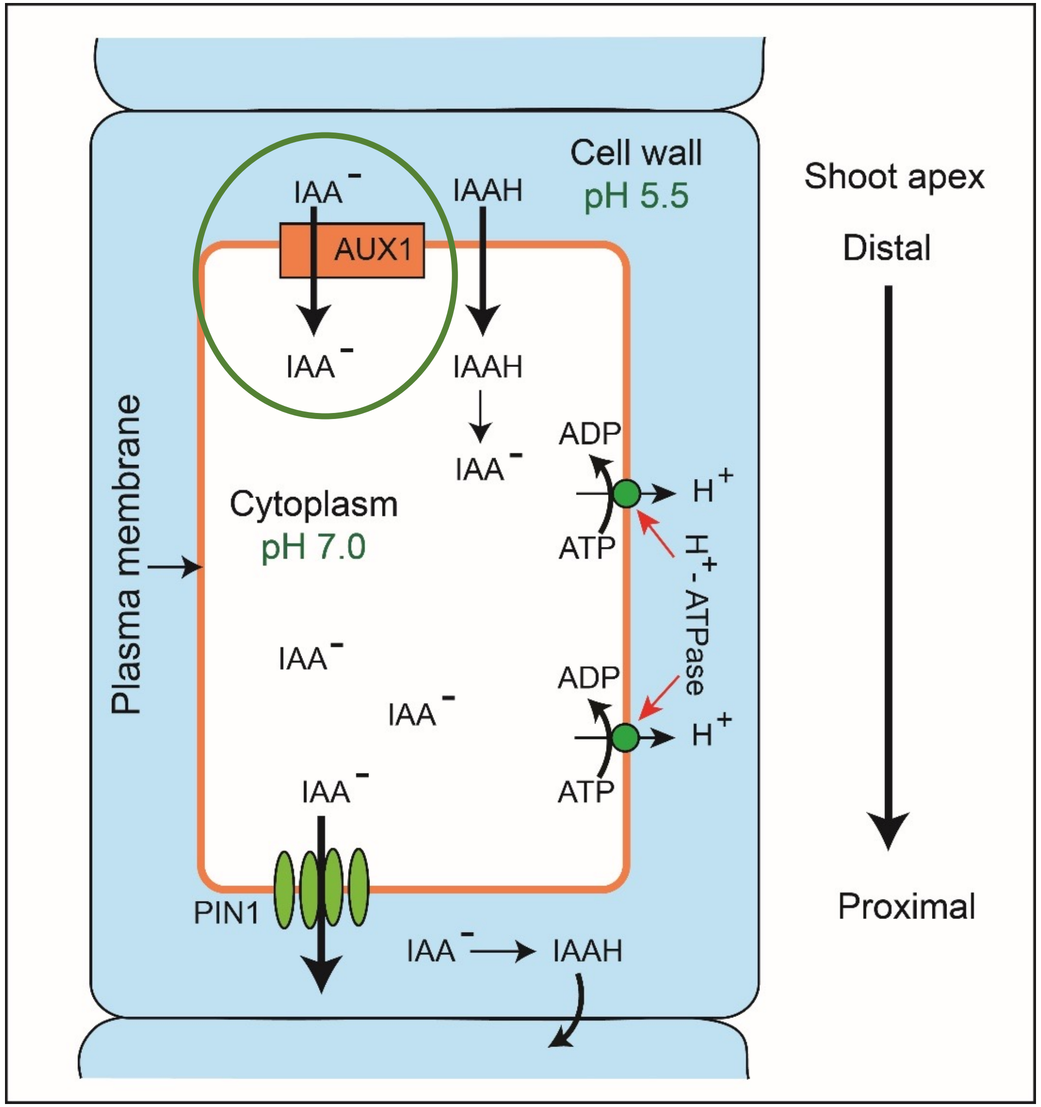


Auxin use in cutting propagation

Auxin transport

Can we manage polar auxin transport?

For example, dopamine inhibits oxidation of IAA and enhances auxin transport at AUX1.



Auxin use in cutting propagation

Combining auxin with other growth substances

Impact of foliar applied benzyladenine on shoot regrowth in Rudy Haag euonymus.

Auxin use in cutting propagation

Combining auxin with other growth substances

The influence of adenine and benzyladenine on rooting and development of *Fuchsia hybrida* cuttings.

Species	Rooting percentage	Roots per cutting
Untreated	65	5.0
NAA + BA	⇨ 64	⇨ 0.5
NAA + Adenine	⇨ 87	⇨ 9.0

K. Wróblewska. 2012. The influence of adenine and benzyladenine on rooting and development of *Fuchsia hybrida* cuttings. Acta Agrobotanica 65: 101–108.

Auxin use in cutting propagation

Combining auxin with other growth substances

The influence of adenine and benzyladenine on rooting and development of *Fuchsia hybrida* cuttings.

Species	Rooting percentage	Roots per cutting
Untreated	65	5.0
NAA + BA	64	0.5
NAA + Adenine	87	9.0

K. Wróblewska. 2012. The influence of adenine and benzyladenine on rooting and development of *Fuchsia hybrida* cuttings. Acta Agrobotanica 65: 101–108.

Auxin use in cutting propagation

Hormone theory and organ formation

Julius Sachs in 1880 postulated the existence of plant morphogens.

Root forming – Rhizocaline

Flower forming – Florigen

Stem forming - Caulocaline


Julius Sachs

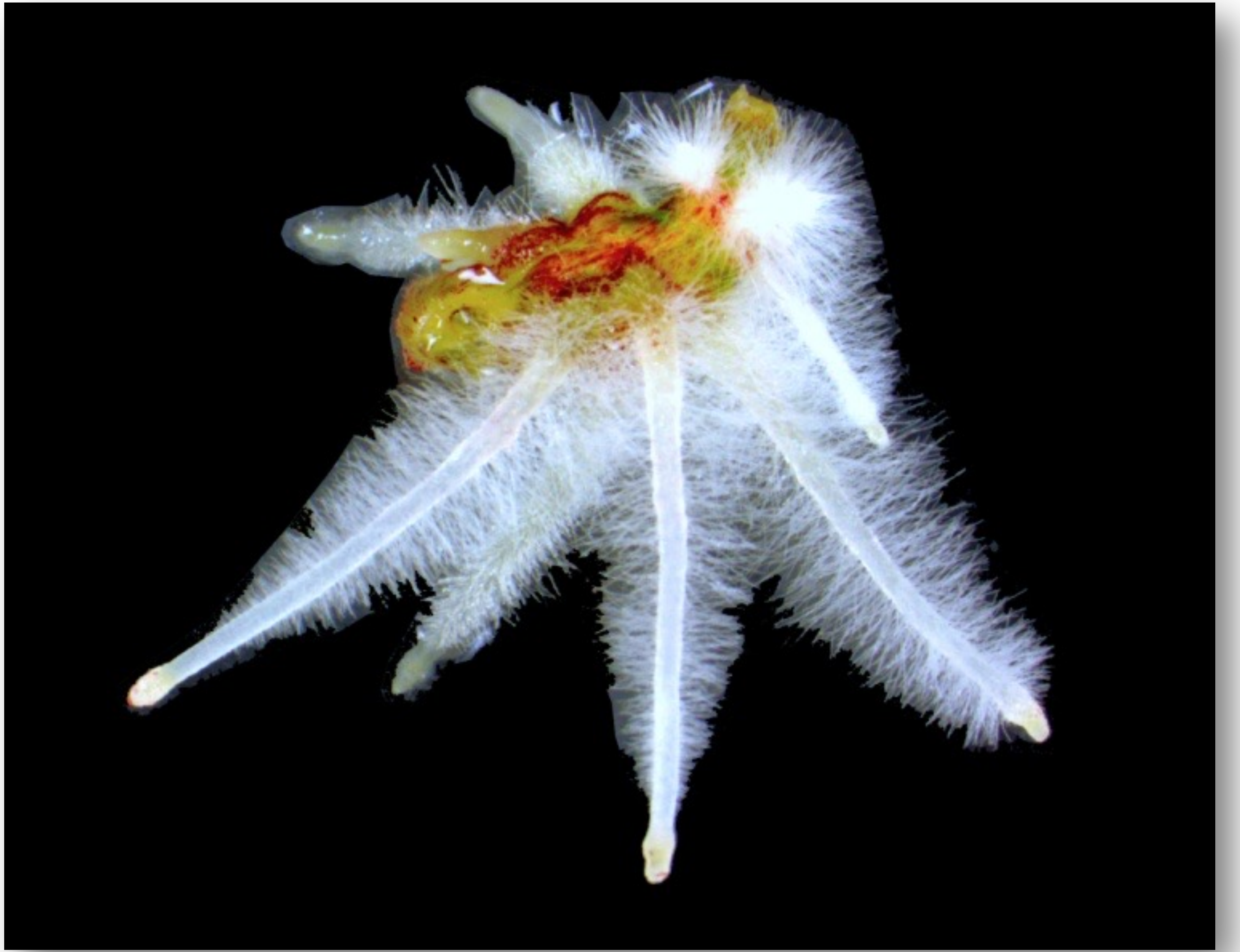
Auxin use in cutting propagation

Rhizocaline

Rhizocaline is a term related to plant biology. It refers to a hormone or hormonelike factor that is distinct from auxin (another plant hormone).

Rhizocaline is believed to play a role in the formation of plant roots. However, its exact mode of action remains somewhat mysterious.

In summary, rhizocaline is an intriguing component in the complex world of plant growth and rooting processes.



Auxin use in cutting propagation

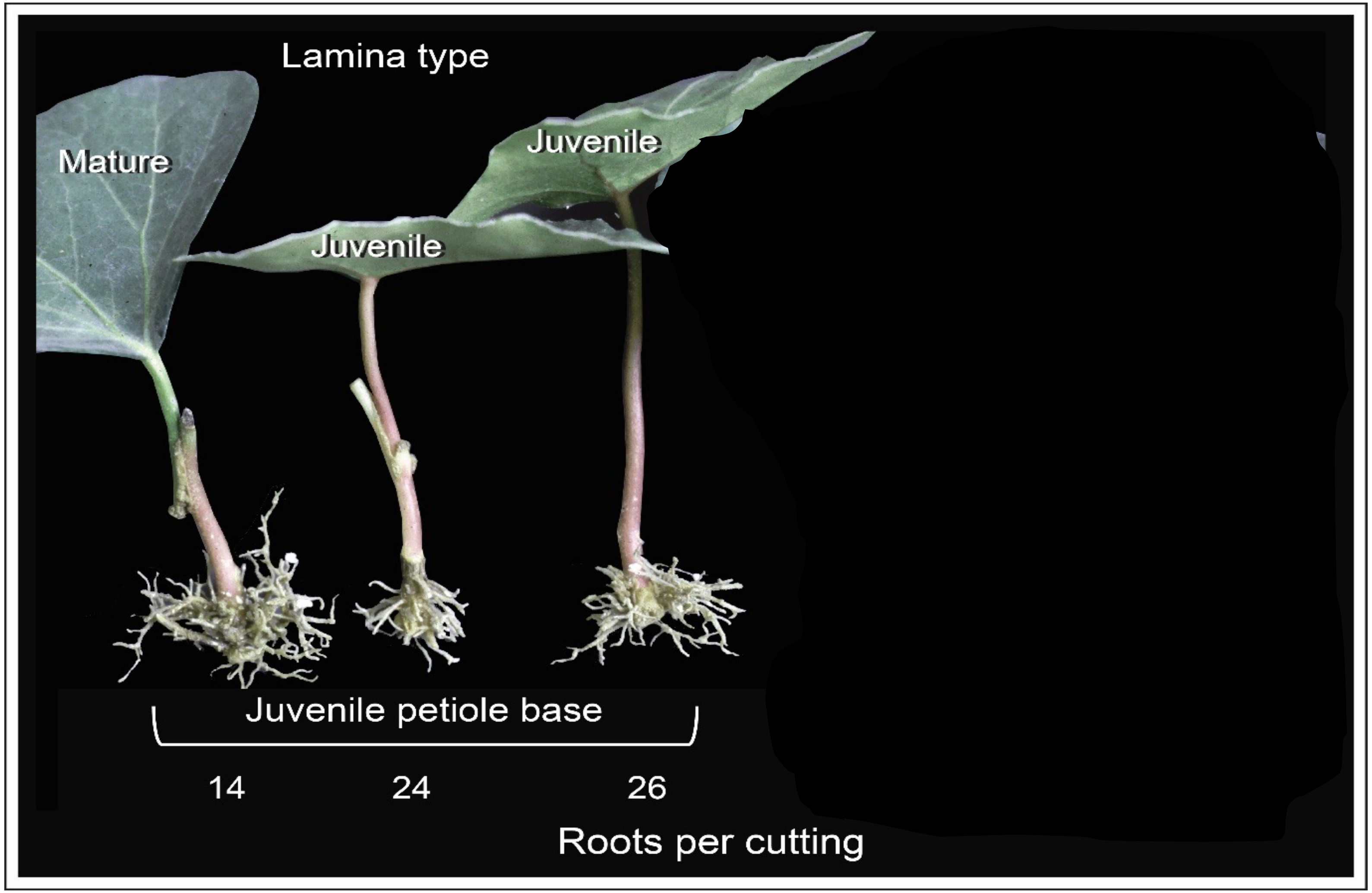
Graft transmissible substances (Rhizocaline)

There are graft transmissible substances that move from leaves to the base of a cutting that improve rooting.

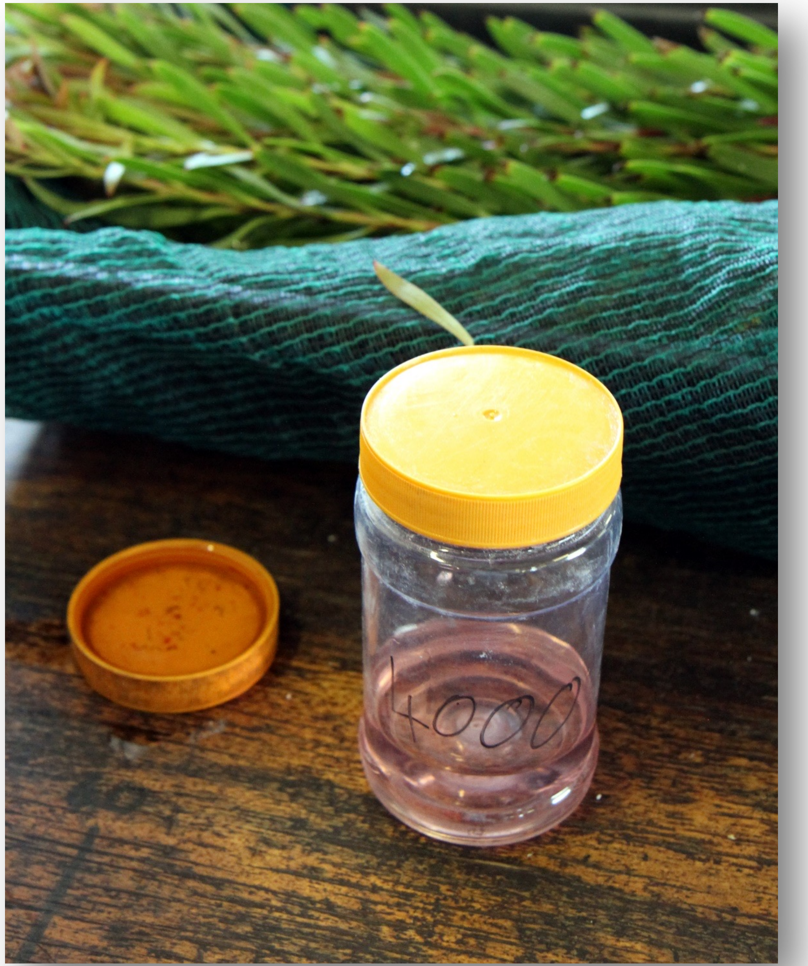
MicroRNAs including miR156 are found to control vegetative phase transition by regulating phase change genes.

miR156 is graft-transmissible.

Reciprocal grafts between juvenile and mature English ivy.



Auxin use in cutting propagation - then and now



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