



THE UNIVERSITY OF
WESTERN AUSTRALIA



**Two-way nitrogen transfer between
Dalbergia odorifera
and its hemiparasite *Santalum album*
is enhanced when the N₂-fixing host
effectively fixes nitrogen**

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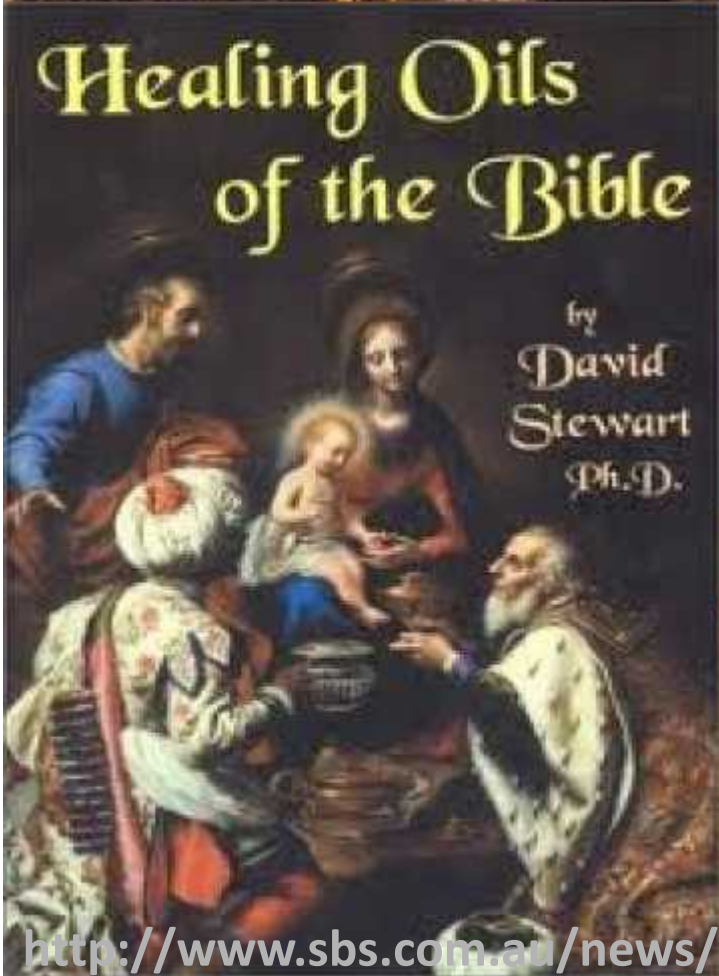
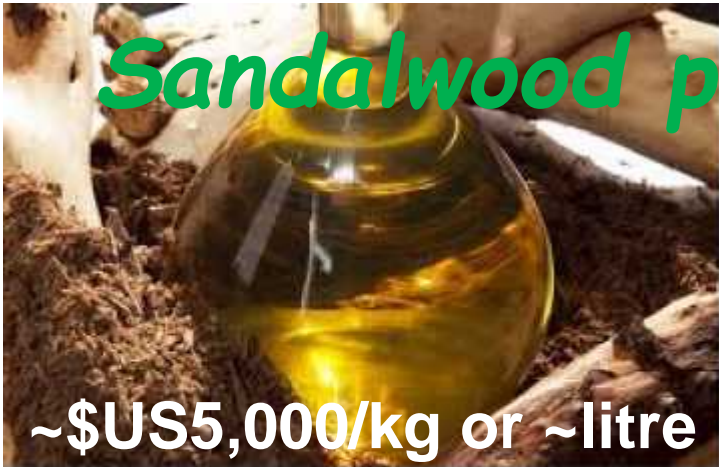
https://www.researchgate.net/profile/Xinhua_He3

Santalum: One of the most valuable timber tree

- ~15 years to mature
- ~8 m tall & 100 kg biomass (20 kg **heartwood**)/tree



Sandalwood products as good as gold



~5,000-15,000 US\$

Dalbergia: Another most valuable timber tree



Dalbergia nigra

Brazilian rosewood



- Traded for >300 years
- Over-exploited
- Banned in the Red List in 1992

More valuable *Dalbergia* rosewood



~20,000 US\$



<https://en.wikipedia.org/wiki/Rosewood>



Back side of a guitar
(4,000 US\$ for Brazilian rosewood)



~500,000 US\$!!!

**A 16th Chinese Ming
Dynasty compound
wardrobe made of Chinese
'huanghuali' rosewood**

The most expensive *Dalbergia odorifera*



- 600 years old
- 10 m length
- ~100 cm breast diameter
- ~3 tones
- **US\$ 30 million**
(1,000 US\$/kg
or 1.0 US\$/g)

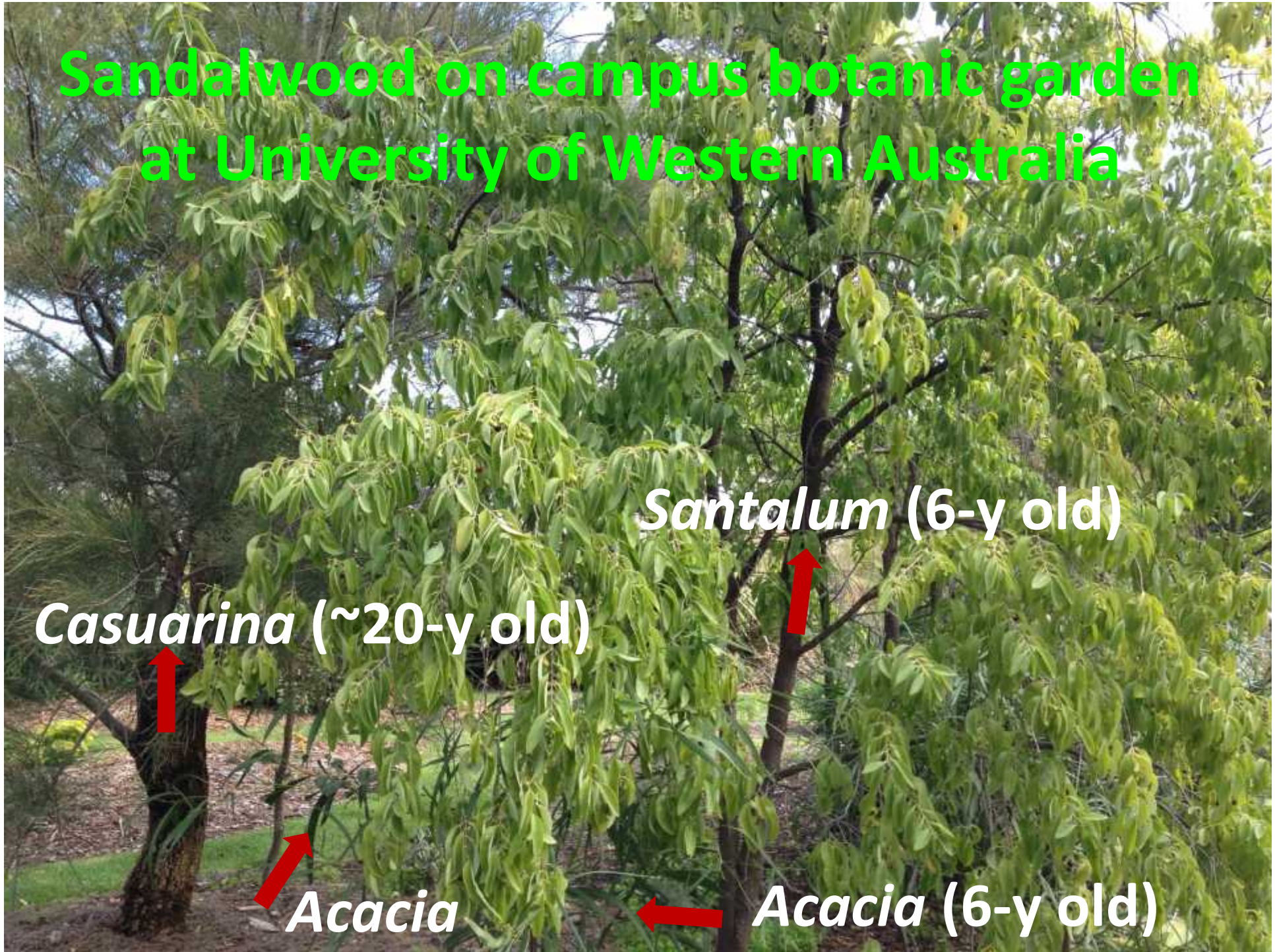
**Sandalwood on campus botanic garden
at University of Western Australia**

Santalum (6-y old)

Casuarina (~20-y old)

Acacia

Acacia (6-y old)



**A
reinforced
concrete
tree
shelter in
2015**

**A nightshift
shed**

**40-years-old
teak trees**



**Station
Office
(~150m
away)**

>1.0M RMB or ~0.2M US\$ per *Dalbergia odorifera*



Barb wire

A concrete prison
or blockhouse?

A tree name
label or an
epitaph?

Transpiration/respiration



Without a host



With non-N₂-fixing
Bischofia polycarpa



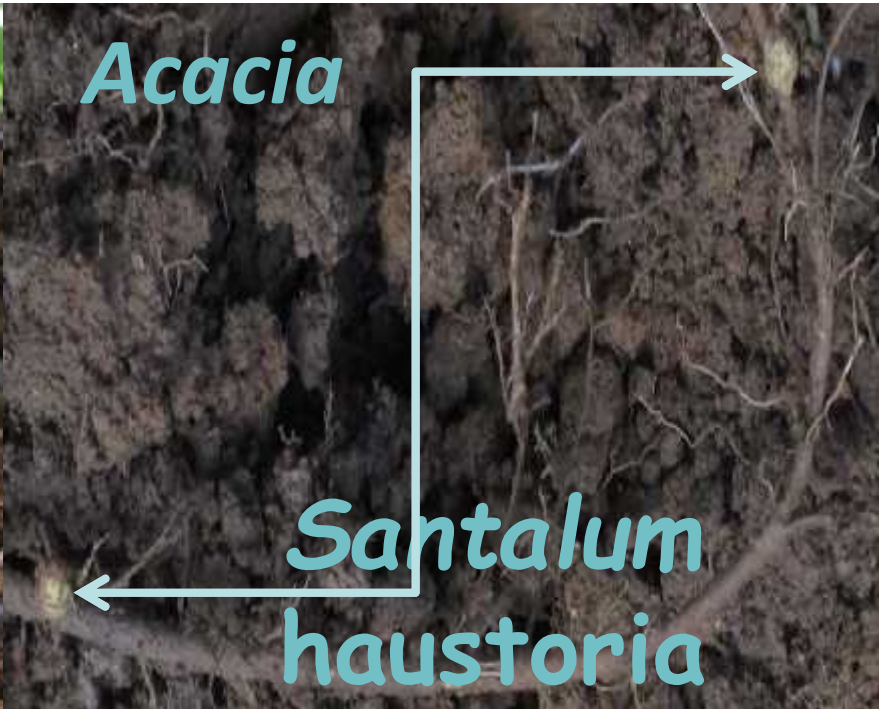
With non-N₂-fixing
*Dracontomelon
duperreranum*



With N₂-fixing *Acacia confusa*



With N₂-fixing *Dalbergia odorifera*



Dalbergia odorifera: the **best partner** for sandalwood growth comparing with other 3 paired plants and itself

Host species	Height m	Diameter mm	Shoot DW g	Root DW g	Total DW g
<i>A. confusa</i>	1.21±0.01 ab	8.17±0.34 a	28.71±6.86 ab	10.78±2.76 ab	39.49±9.55 ab
<i>D. odorifera</i>	1.36±0.13 a	8.70±1.08 a	32.80±9.21 a	14.59±0.92 a	47.39±9.34 a
<i>B. polycarpa</i>	0.82±0.03 c	5.47±0.49 c	7.02±0.88 c	2.10±0.41 c	9.11±1.25 d
<i>D. duperreranum</i>	0.84±0.05 c	5.15±0.50 c	17.95±6.94 bc	5.80±2.79 bc	23.74±9.08 c
No host	1.17±0.14 b	6.67±0.38 b	20.05±0.61 b	8.43±3.12 b	28.48±3.17 bc

- **N₂-fixation:**

Lu et al. 2014. Tree Physiol 34: 1006

~44% in *Acacia confusa* but ~50% in *Dalbergia odorifera*

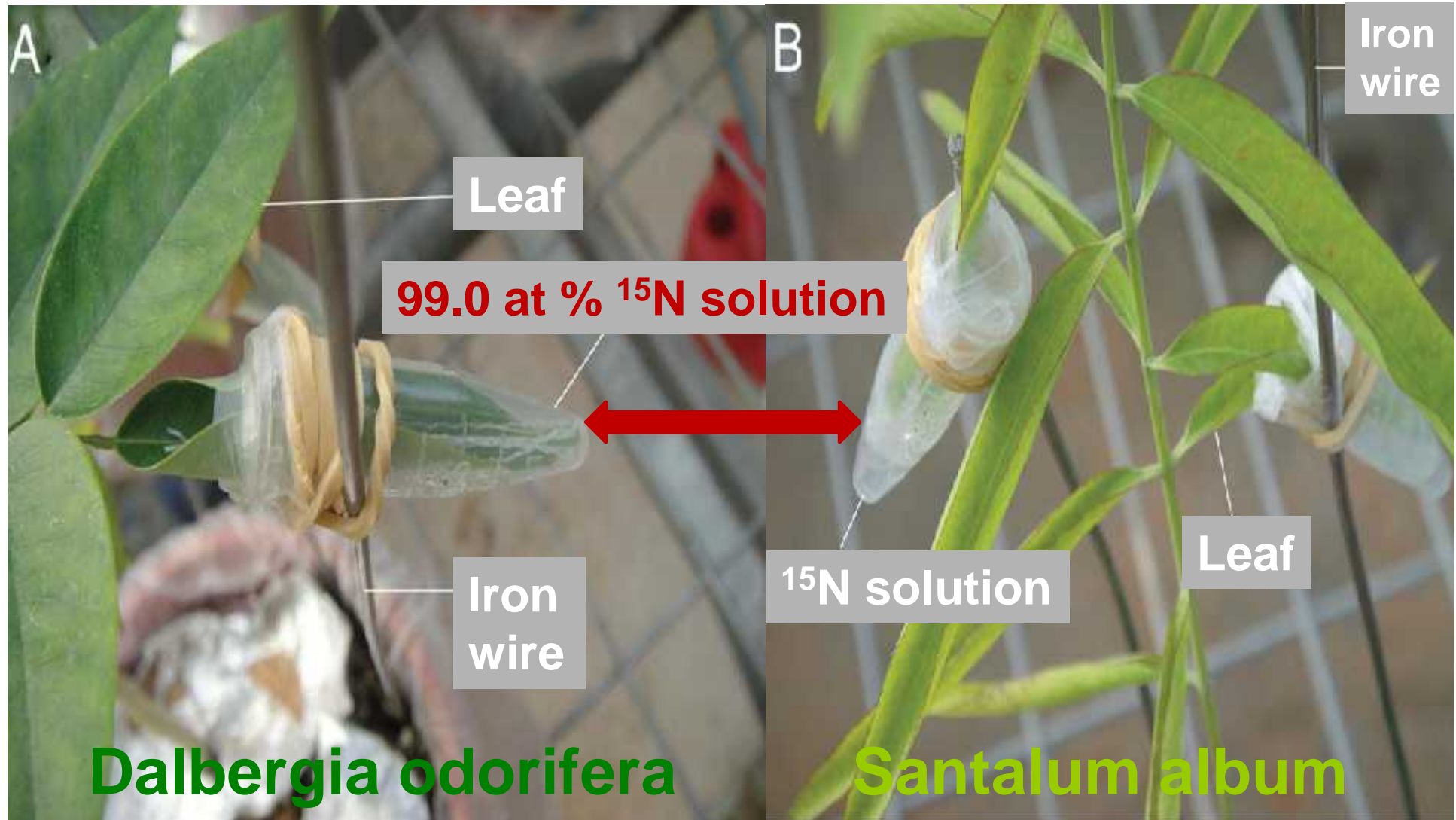
- Leaf & root **total N** were significantly **higher**, while **¹⁵N** were significantly **lower** in *Santalum album*

Experimental design for two-way N-transfer between *Dalbergia odorifera* and *Santalum album* seedlings

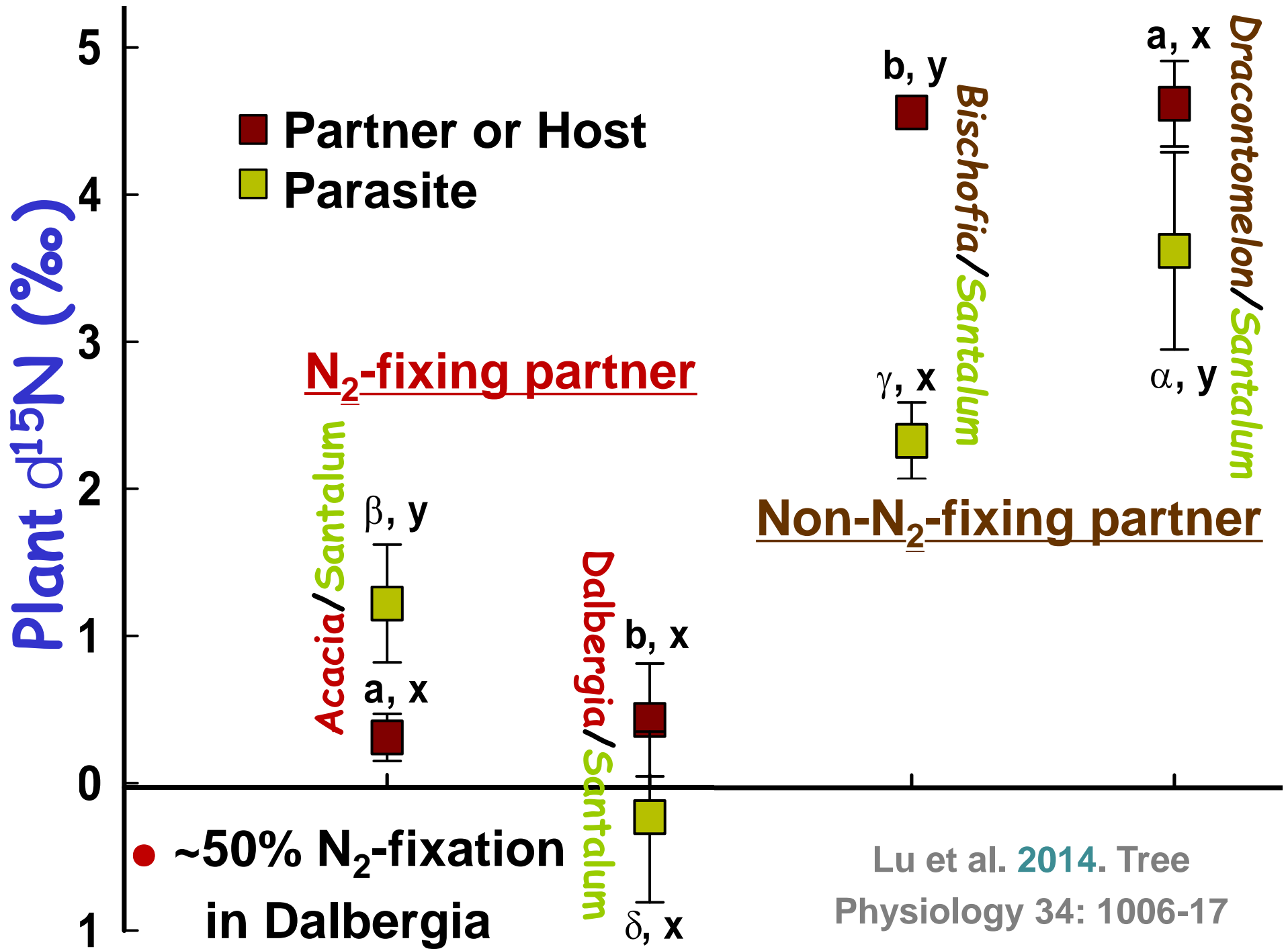
Pair name	N-donor	N-receiver	Nod	Code
Non-nodulated	<i>Dalbergia</i>	<i>Santalum</i>	-	$D^{nod-} \rightarrow S^{-}$
(D^{nod-}/S^{-} pair)	<i>Santalum</i>	<i>Dalbergia</i>	-	$S^{-} \rightarrow D^{nod-}$
Nodulated	<i>Dalbergia</i>	<i>Santalum</i>	+	$D^{nod+} \rightarrow S^{+}$
(D^{nod+}/S^{+} pair)	<i>Santalum</i>	<i>Dalbergia</i>	+	$S^{+} \rightarrow D^{nod+}$

^{14}N supplement to leaves of both N-donors and N-receivers was ceased when plants were 6-months-old, and then only ^{15}N was supplied to leaves of N-donor for another 1-month

0.15% N (99.0 atom% ^{15}N) leaf labeling

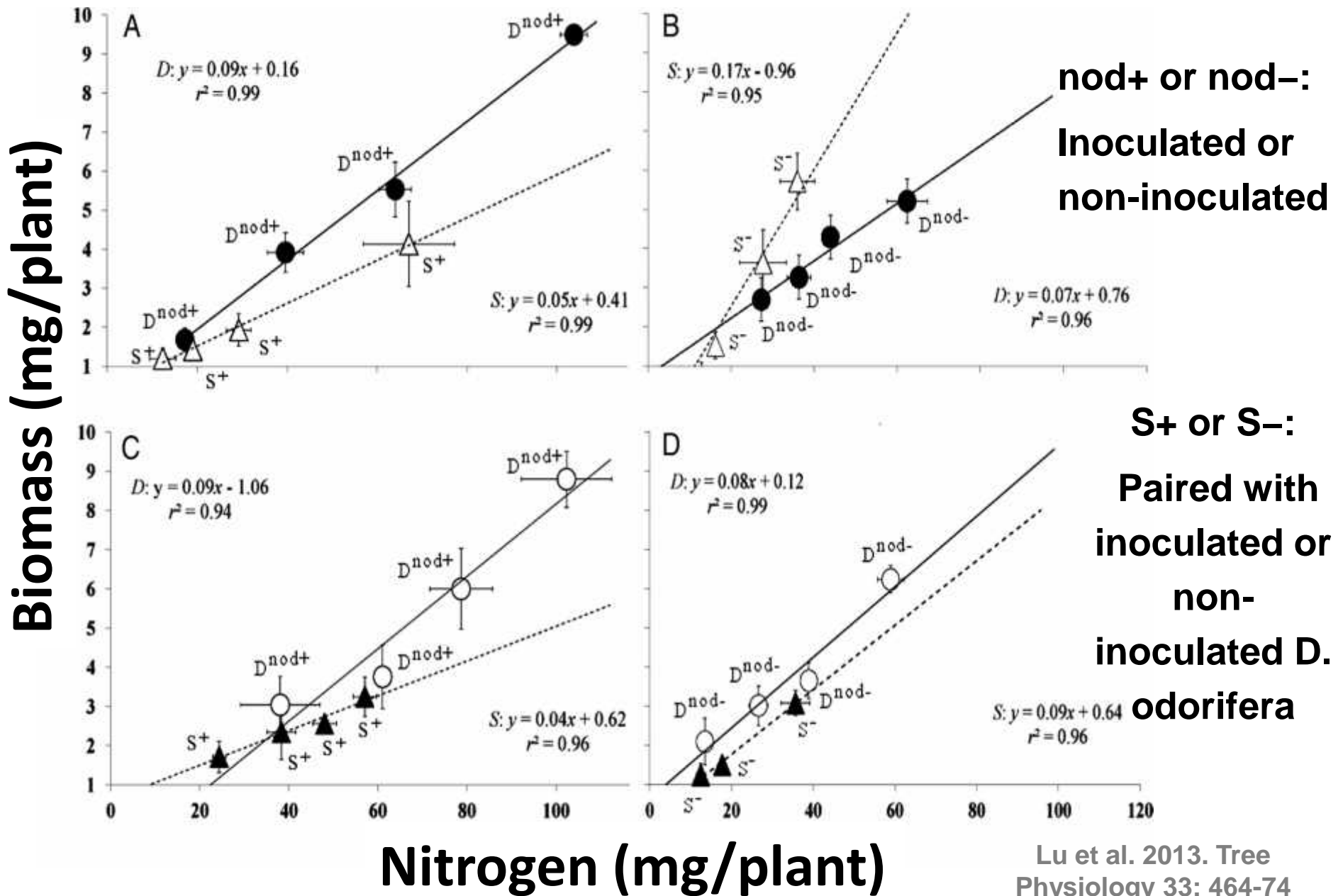


Lu et al. 2013. Tree Physiology 33: 464-74

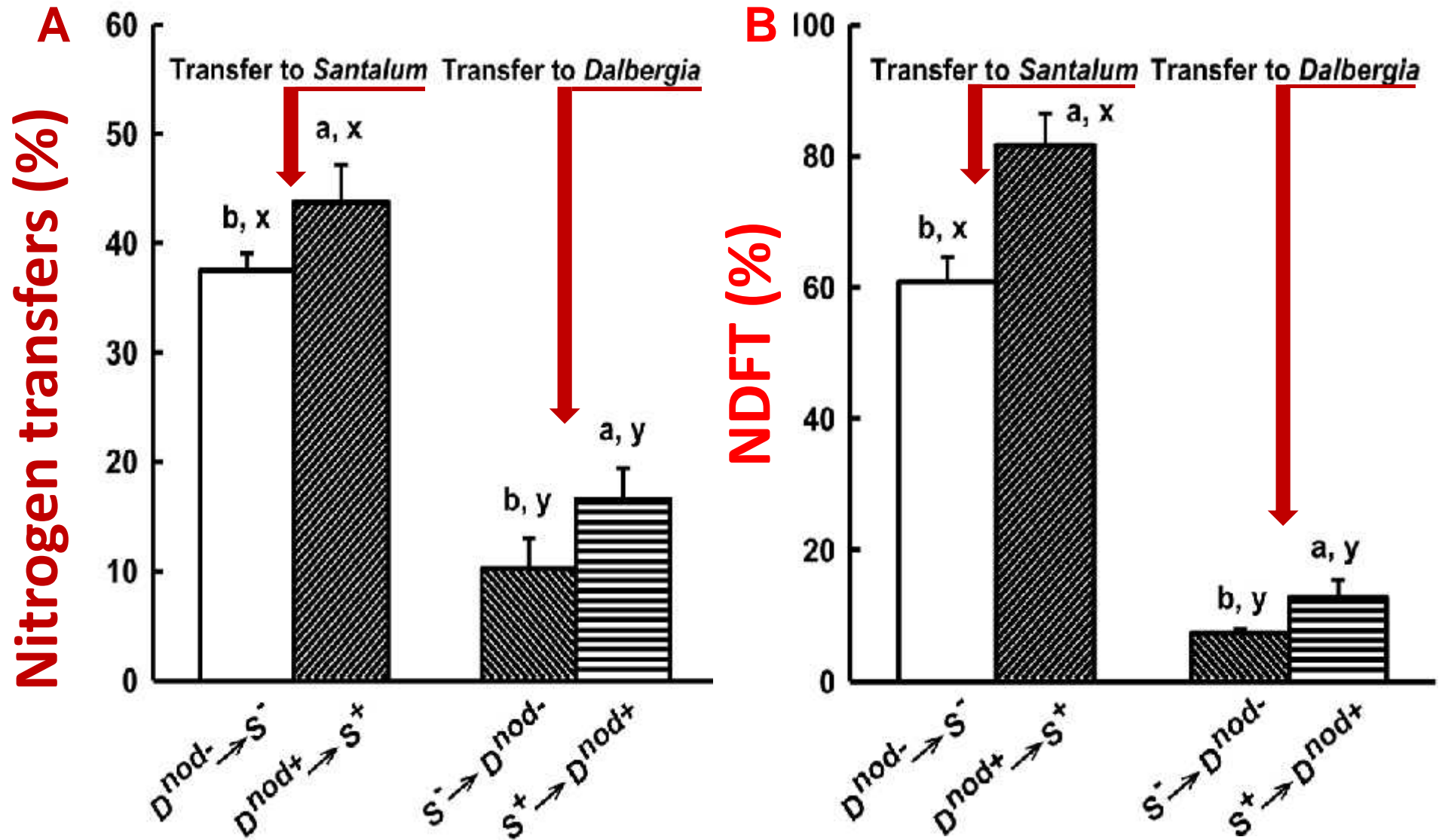


Lu et al. 2014. Tree Physiology 34: 1006-17

Relationships between biomass production and N content of 7-month-old *Dalbergia* (●) and *Santalum* (▲) seedlings



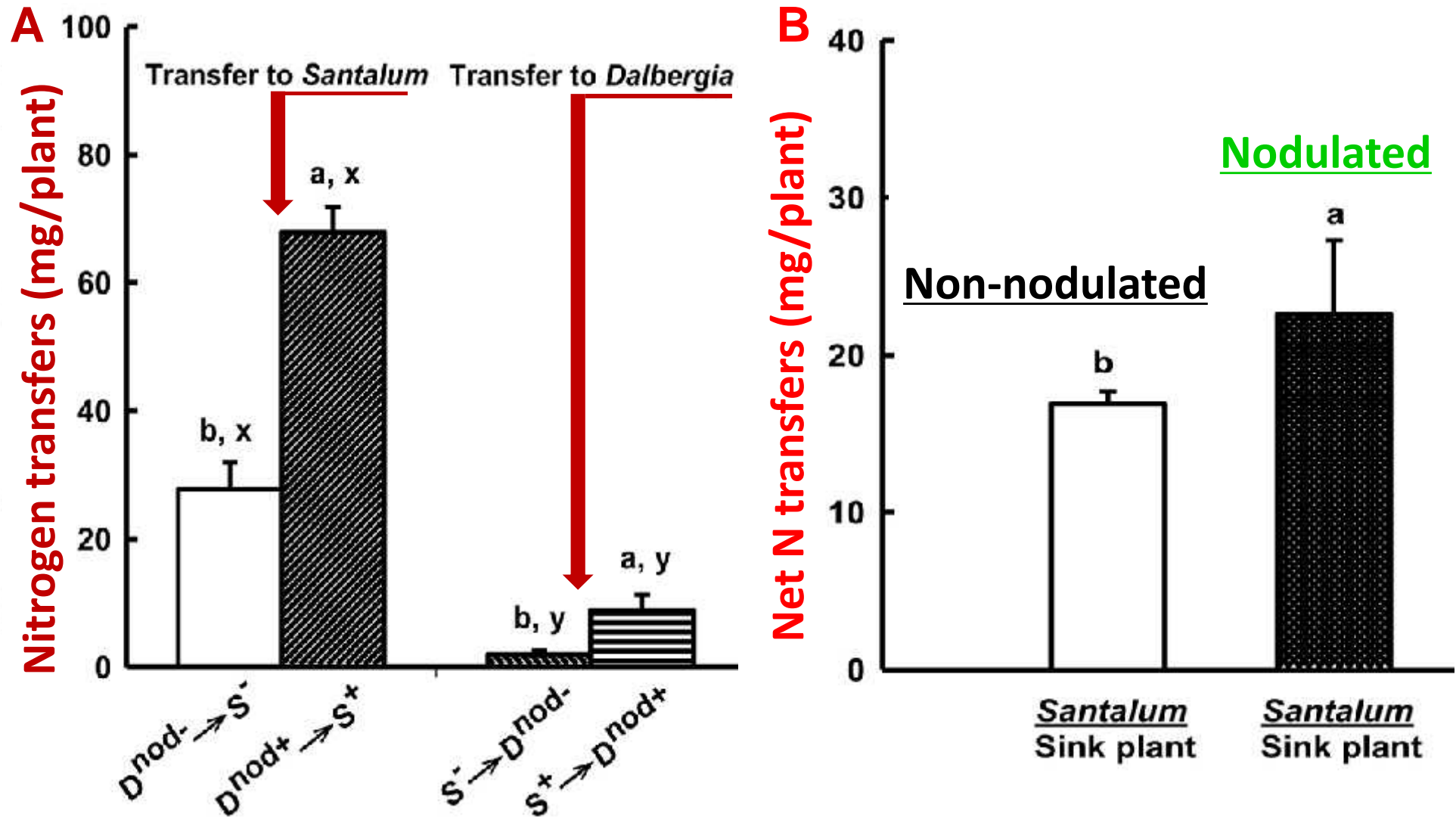
% of 2-way N transfer (A) & N in receivers derived from transfer (NDFT, B) in 7-m-old *D. odorifera*/*S. album* pairs



(a, b): between treatments for the same plant species

(x, y): between species for a given treatment Lu et al. 2013. Tree Physiology 33: 464-74

Amount of 2-way N transfer (A) and net N transfer (B) in 7-month-old *D. odorifera*/*S. album* pairs



(a, b): between treatments for the same plant species

(x, y): between species for a given treatment Lu et al. 2013. Tree Physiology 33: 464-74

7-year-old in south China



- Paired **rosewood** not only **improves** the growth of **sandalwood**, but also **offers, itself**, another high-value wood to the world market



Summary



Sandalwood

Fragrant
rosewood

7-Y-old in
south China

- ~50% N₂-fixation in **Dalbergia odorifera**
- **N₂-fixation plays an important role in N-translocation** either to non-N₂-fixation or to N₂-fixation partners
- Paired **rosewood** not only **improves** the growth of **sandalwood**, but also **offers, itself**, another high-value wood to the world market

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