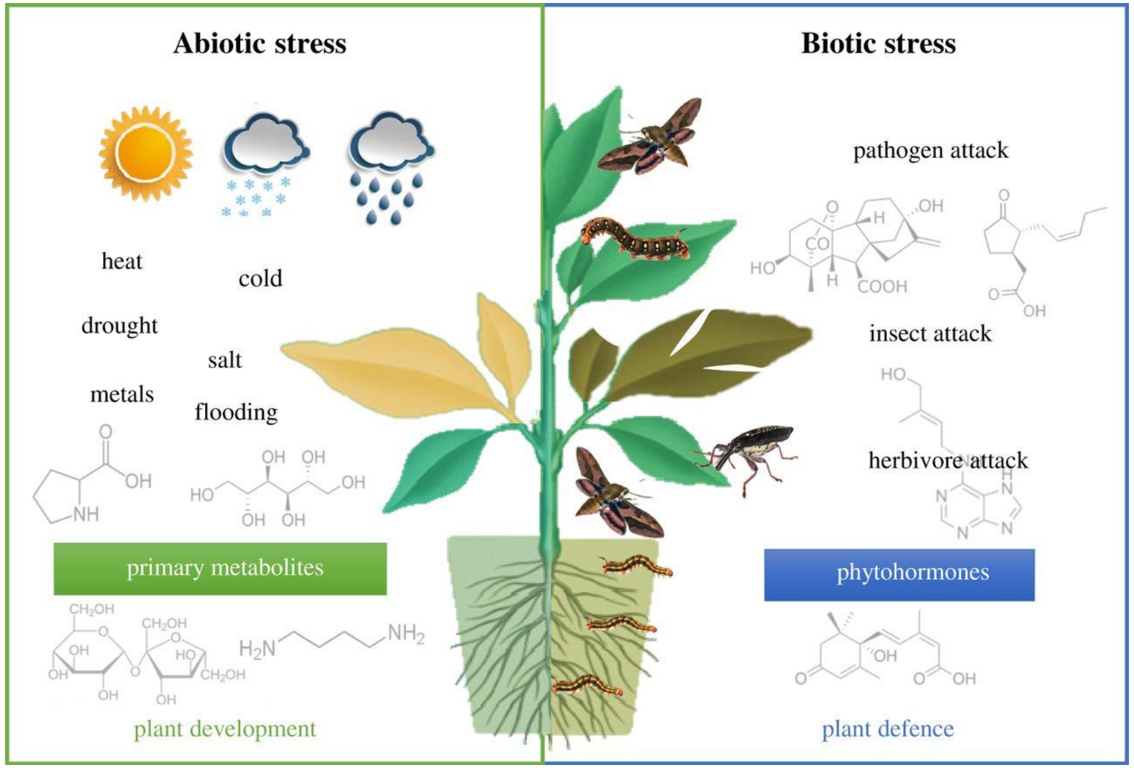
Strigolactones

(New plant hormone in action)

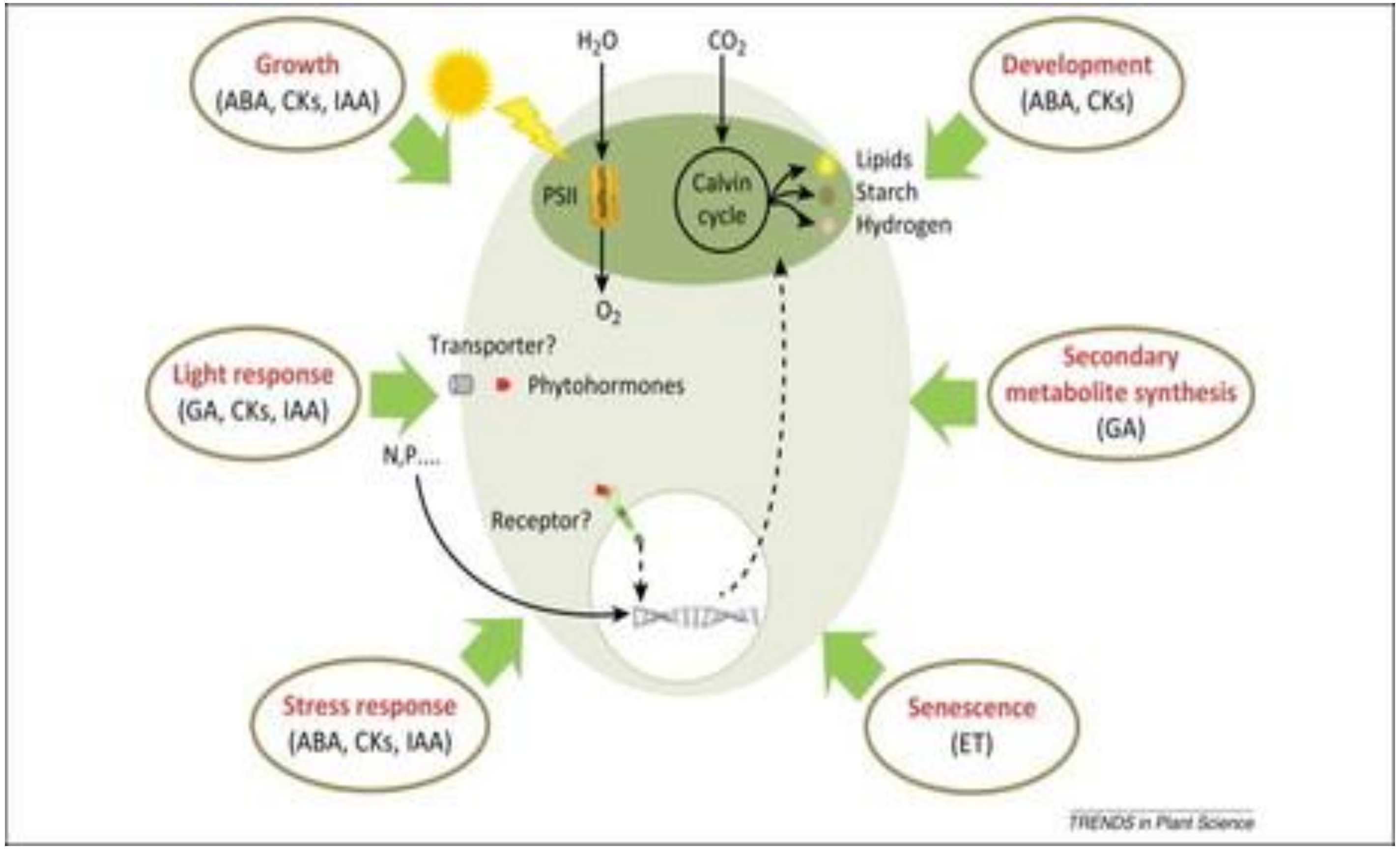
Sessile life style of plants



The sessile life style of plants largely depends on endogenous metabolites to fine-tune their growth and development against changing environmental conditions

Phytohormones

Generally, plant hormones (phytohormones) attributes adaptability to the ever-changing environmental conditions and to various biotic-abiotic constrains.

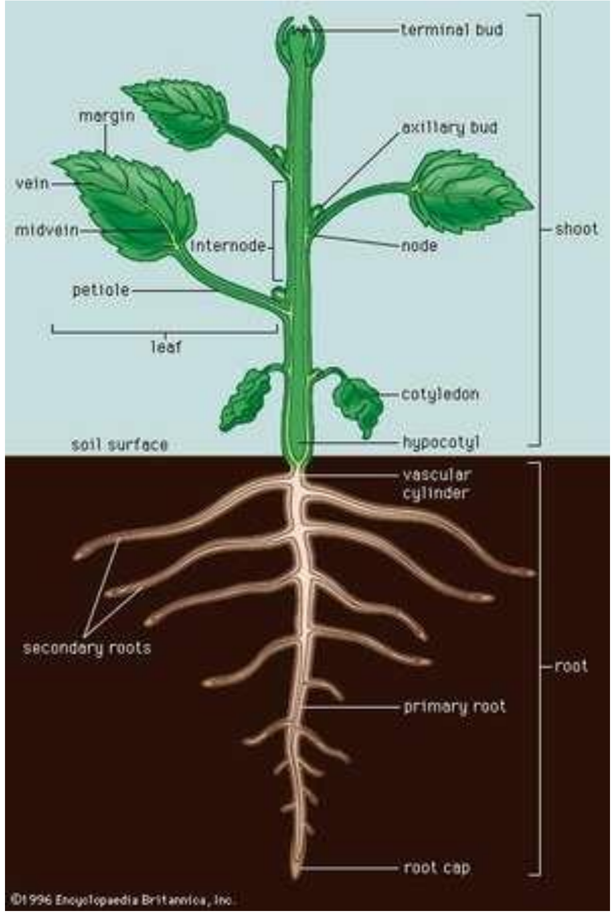


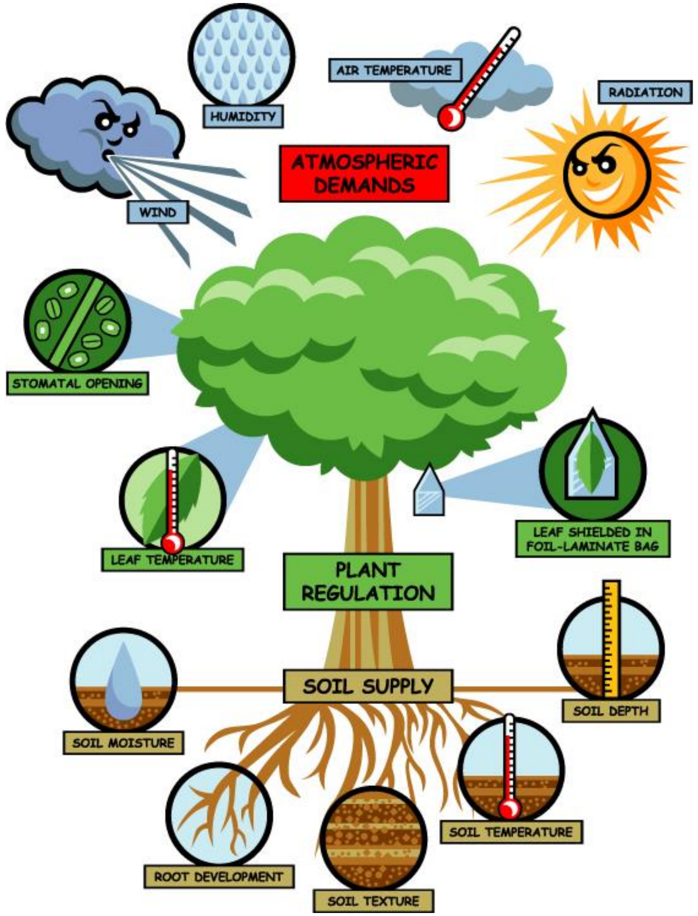
Mostly, different phytohormones have functional distinctions. In general, auxin, cytokinins (CK), gibberellins (GA), brassinosteroids (BR) and ethylene predominantly have their role in plant growth and developmental events,

Abscisic acid (ABA) and jasmonic acid (JA) act as the abiotic and biotic stress response molecules

New plant hormones

Considering the complexity of plant life, the existence more signalling molecules are anticipated and experimental biology occasionally comes up with new signalling molecules in plants.





The recent addition to the class of plant hormones are strigolactones (SLs)

Strigolactone inhibition of shoot branching

Victoria Gomez-Roldan[1], Soraya Fermas[2], Philip B. Brewer[3], Virginie Puech-Pagès[1], Elizabeth A. Dun[3], Jean-Paul Pillot[2], Fabien Letisse[4], Radoslava Matusova[5], Saida Danoun[1], Jean-Charles Portais[4], Harro Bouwmeester[5,6], Guillaume Bécard[1], Christine A. Beveridge[3,7]*, Catherine Rameau[2]* & Soizic F. Rochange[1]*

2008, Nature 455: 189-194

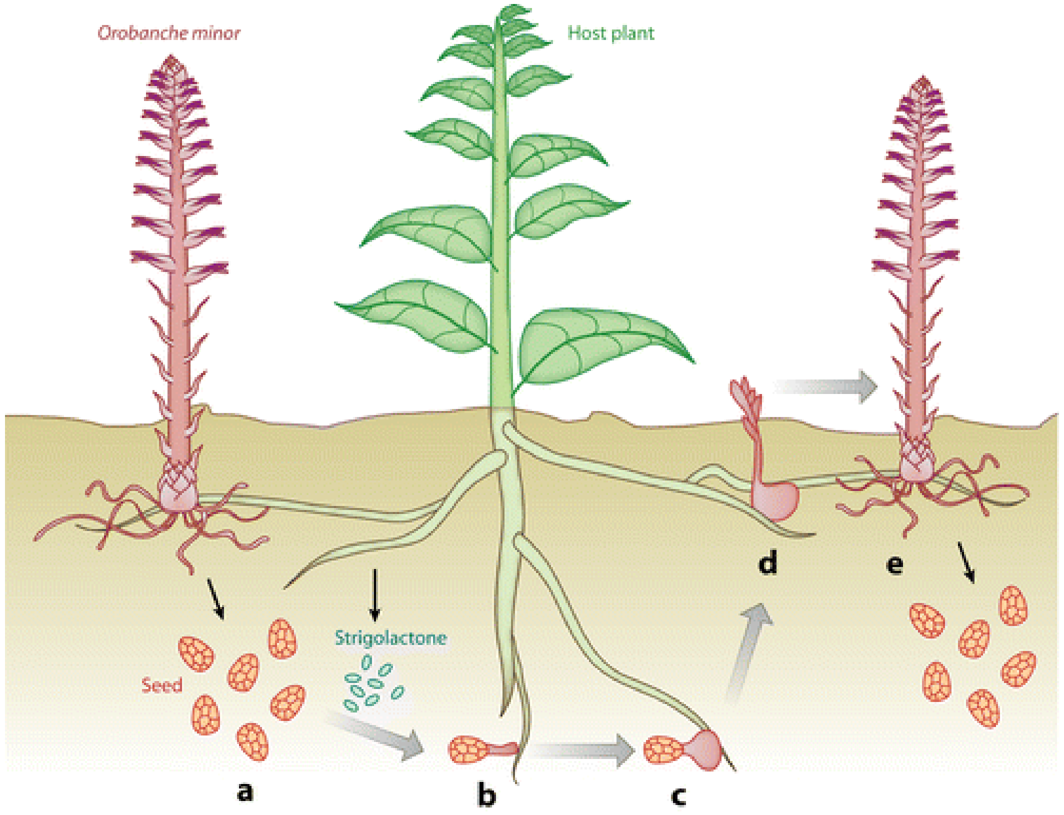
Inhibition of shoot branching by new terpenoid plant hormones

Mikihisa Umehara[1], Atsushi Hanada[1], Satoko Yoshida[1], Kohki Akiyama[2], Tomotsugu Arite[3], Noriko Takeda-Kamiya[1], Hiroshi Magome[1], Yuji Kamiya[1], Ken Shirasu[1], Koichi Yoneyama[4], Junko Kyozuka[3] & Shinjiro Yamaguchi[1]

2008, Nature 455: 195-202

Initially identified function

Strigolactones are initially identified as a seed germination stimulants of parasitic plants; Striga



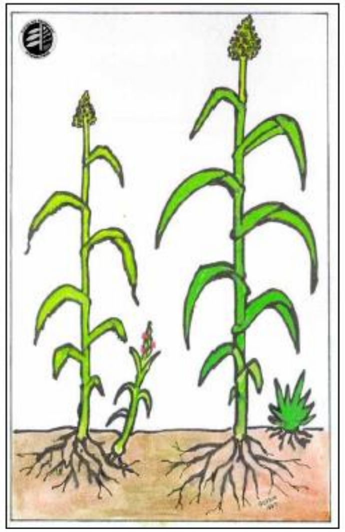
Xie X, et al. 2010.
Annu. Rev. Phytopathol. 48:93–117

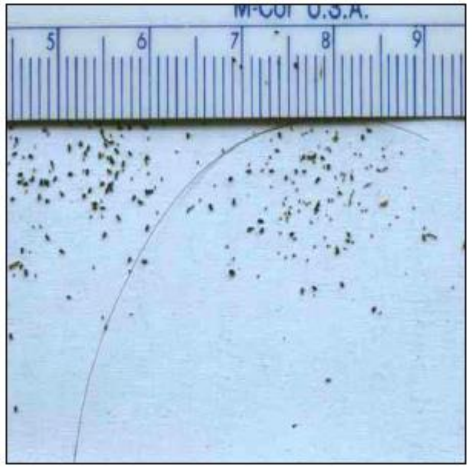
Cook et al., 1972

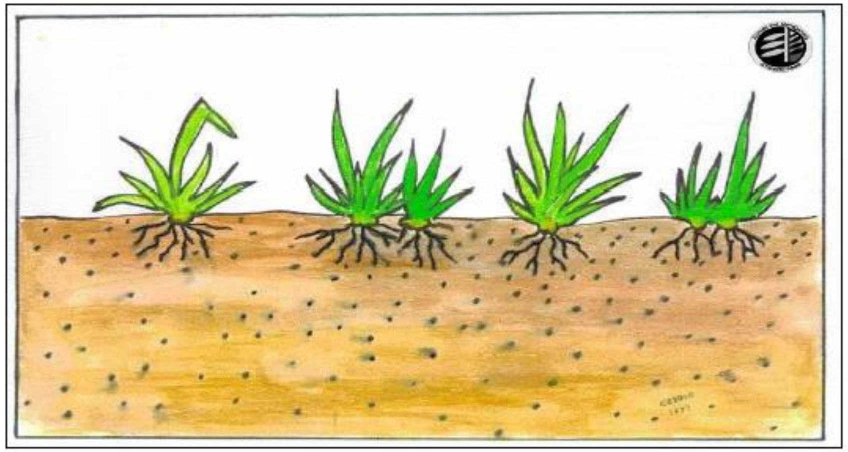
The most challenging biotic constrain in cereal production especially in African region is parasitic plants of Striga species.

Approximately 25 million people in Africa alone are affected by Striga and causing losses estimated to 1 billion USD per year.

Why Striga infestation is hard to control?



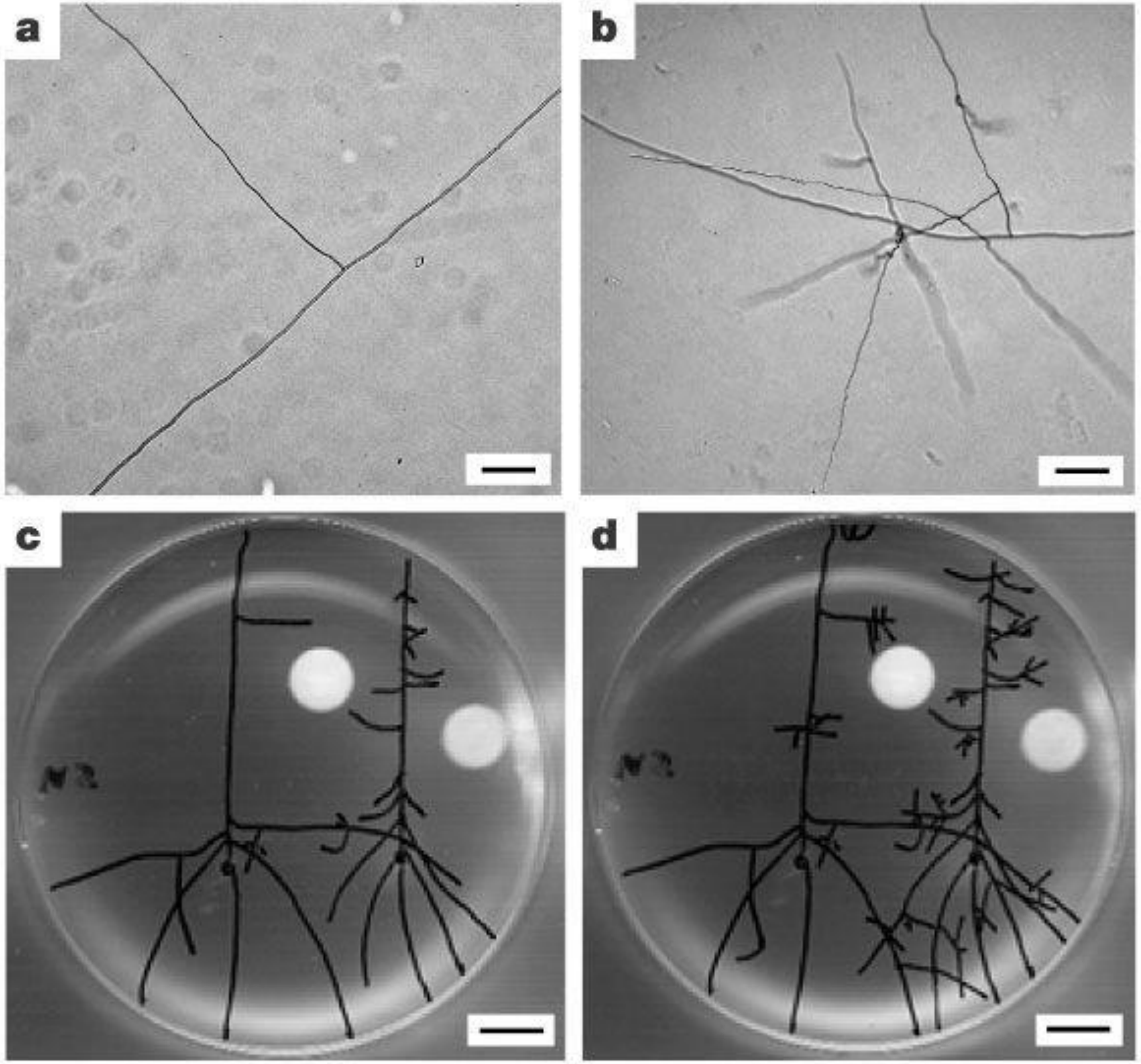




- After attachment to the host root, Striga seedlings grow underground and emerge already after causing severe damage to the host plant.
- Each Striga plant can produce up to 20,000-50,000 seeds.
- These seeds are dust like, can be easily dispersed by wind, water, contaminated crop seeds, and by people.
- They can survive over 15 years in dormancy stage until come in contact with germination stimulant.

Severity of Sriga infestation of maize fields

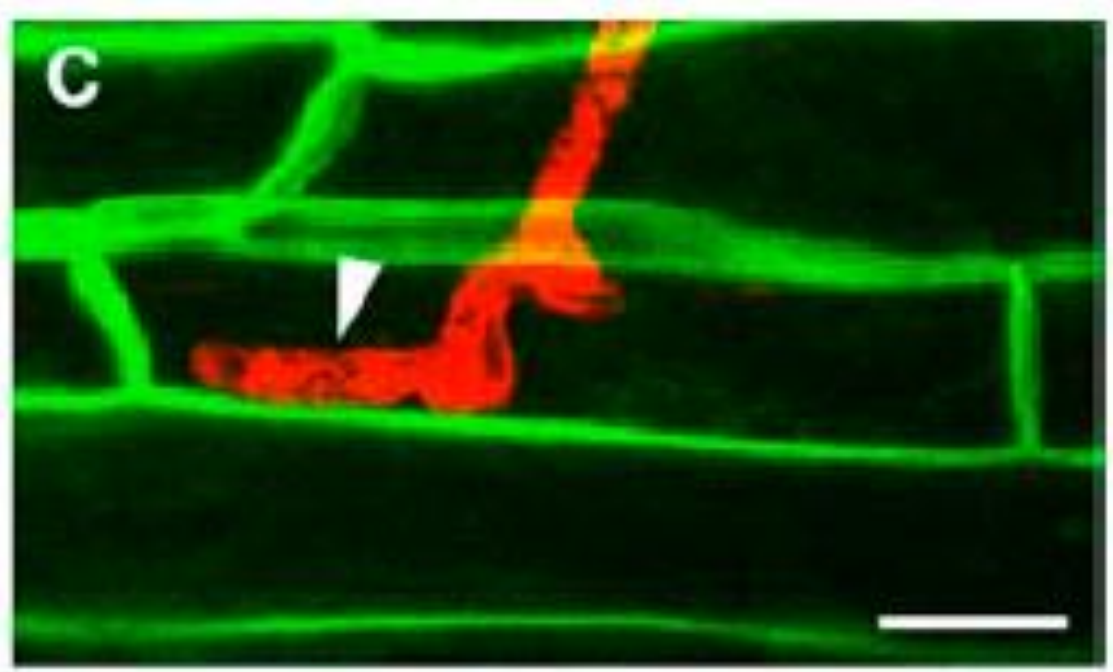
Promoting hyphal branching of symbiotic arbuscular mycorrhiza (AM) fungi



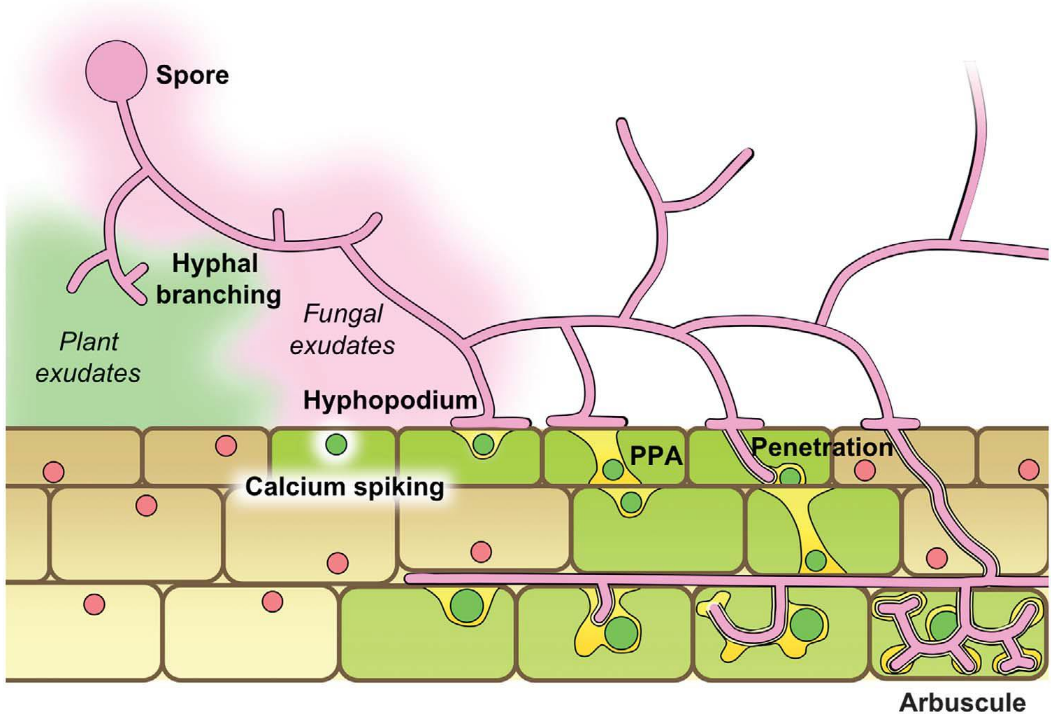
Akiyama et al., 2005

Facilitates beneficial symbiotic interaction with the host plant

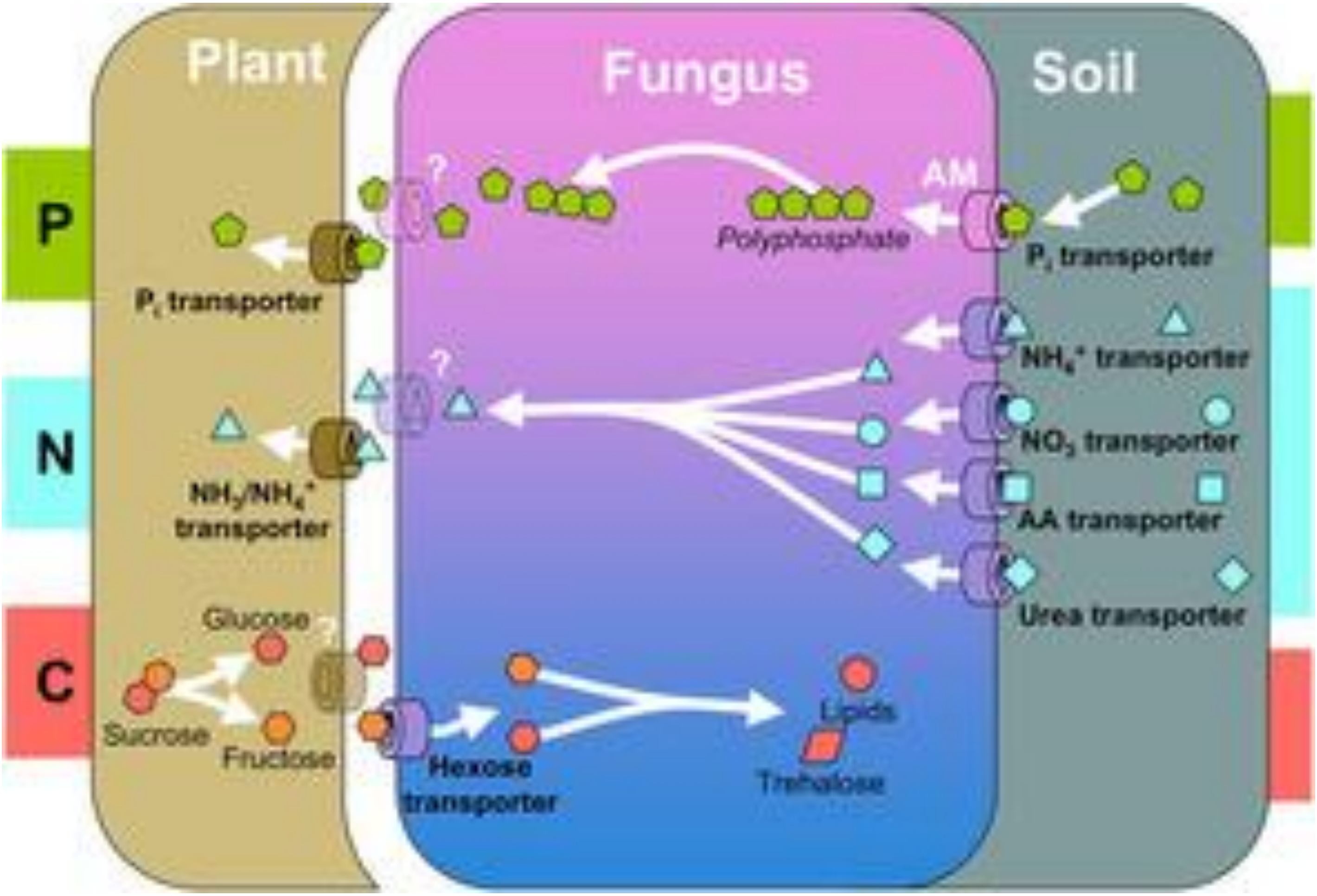
Host plant and AM fungi interaction



AM fungi penetration (red) through plant root epidermal cell



Host plant and AM fungi relationship



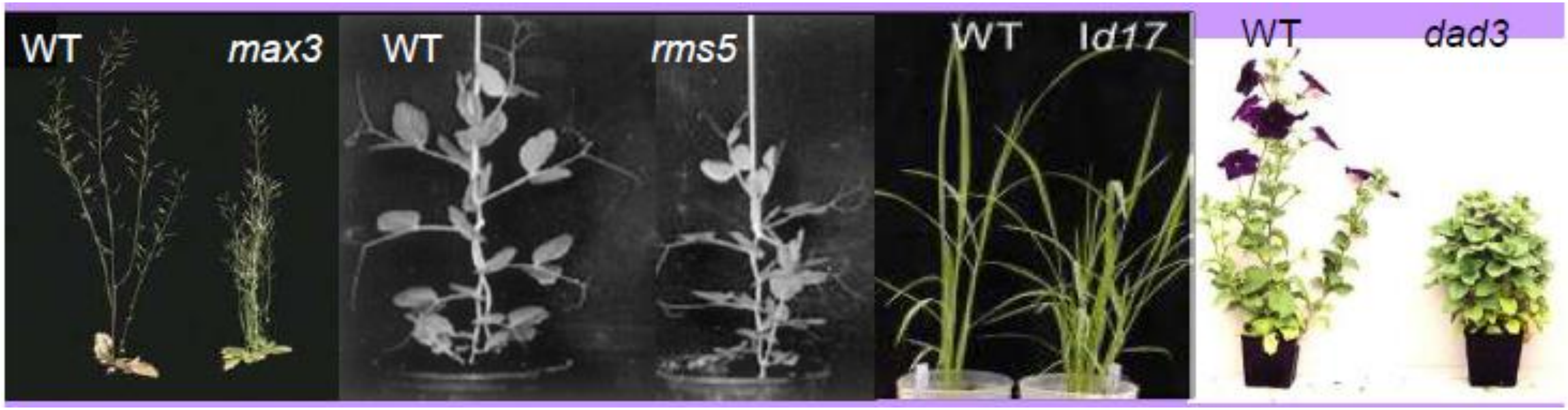
AM Fungi maintains a symbiotic relationship with host plant

AM Fungi absorbs nutrients such as nitrogen and phosphorus from soil and supplies to the plant.

The plant gives ten to twenty percent of the carbon they generated through photosynthesis to the fungus

Strigolactone inhibition of shoot branching

Victoria Gomez-Roldan[1], Soraya Fermas[2], Philip B. Brewer[3], Virginie Puech-Pagès[1], Elizabeth A. Dun[3], Jean-Paul Pillot[2], Fabien Letisse[4], Radoslava Matusova[5], Saida Danoun[1], Jean-Charles Portais[4], Harro Bouwmeester[5,6], Guillaume Bécard[1], Christine A. Beveridge[3,7]*, Catherine Rameau[2]* & Soizic F. Rochange[1]*



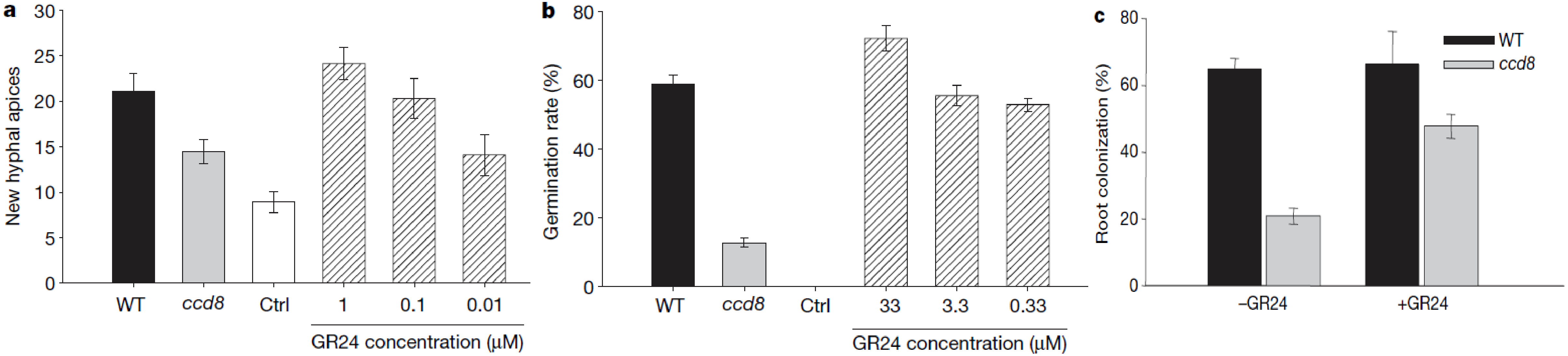
Arabidopsis Pea Rice Petunia

MAX- MORE AXILLARY GROWTH

RMS-RAMOUS

D-DWARF

DAD-DECREASED APICAL DOMINANCE



Glomus intraradices *Orobanche crenata*

2008, Nature 455: 189-194

Strigolactone inhibition of shoot branching

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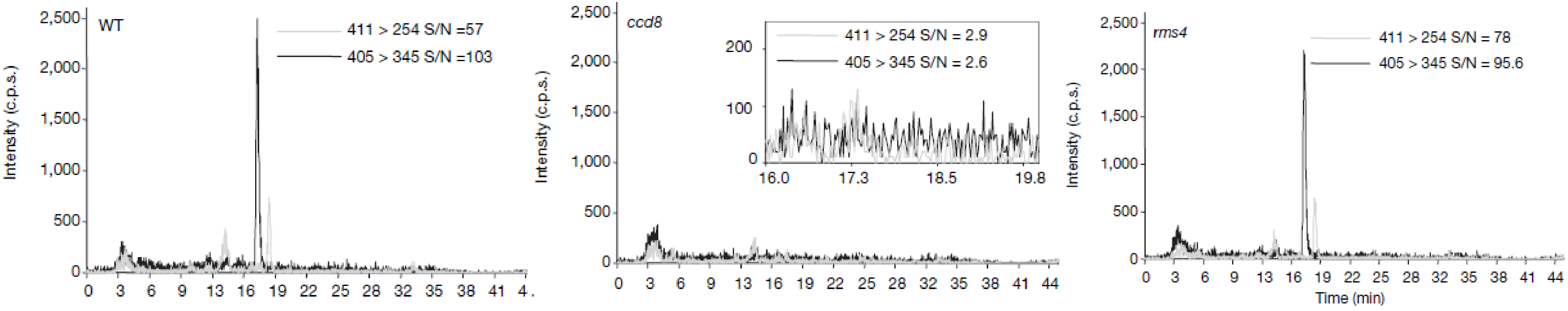
Strigolactone quantification



Measurement of orobanchyl acetate (grey) and the second strigolactone (black) in different genotypes

2008, Nature 455: 189-194

Strigolactone inhibition of shoot branching

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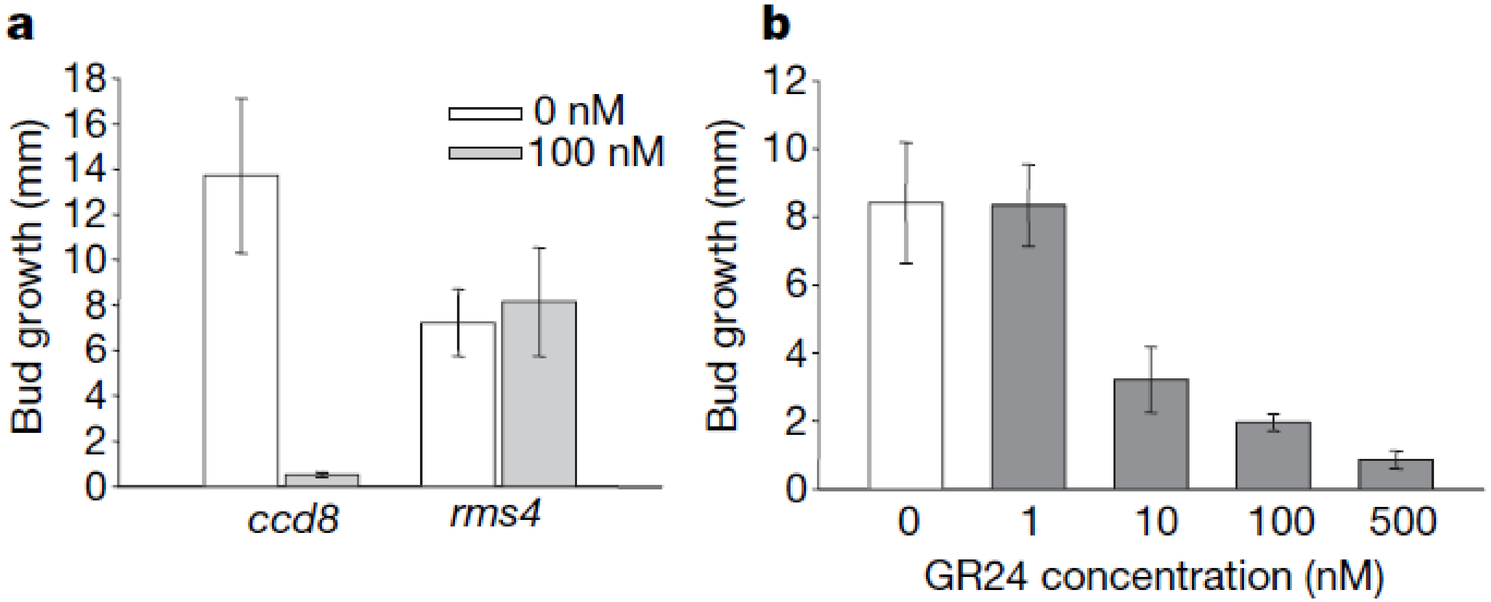
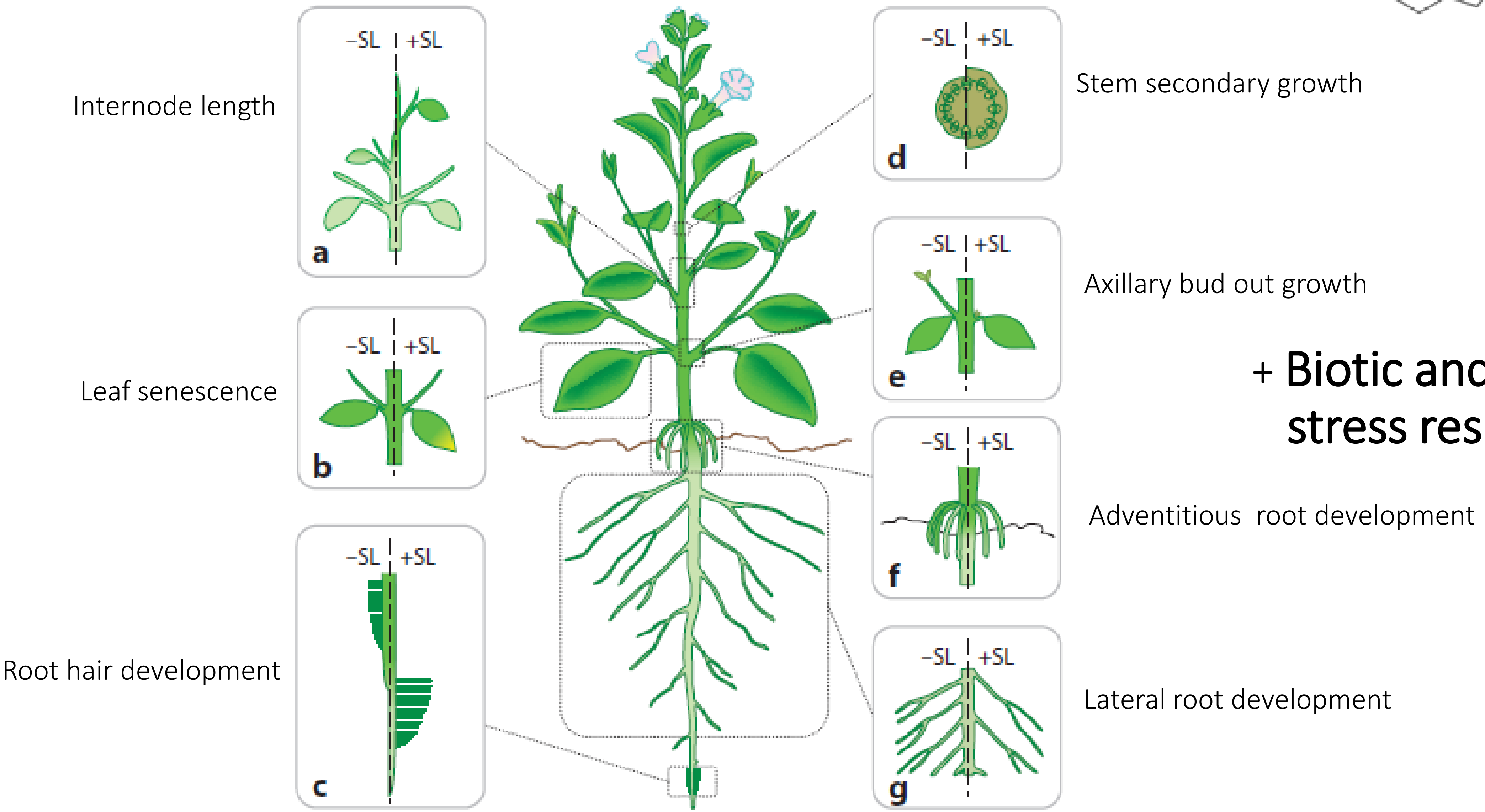
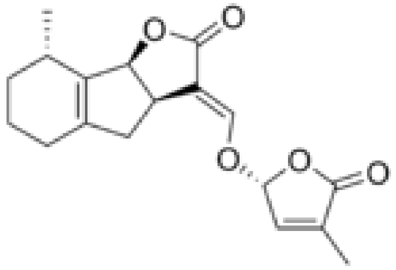


Role of Strigolactone in plant development



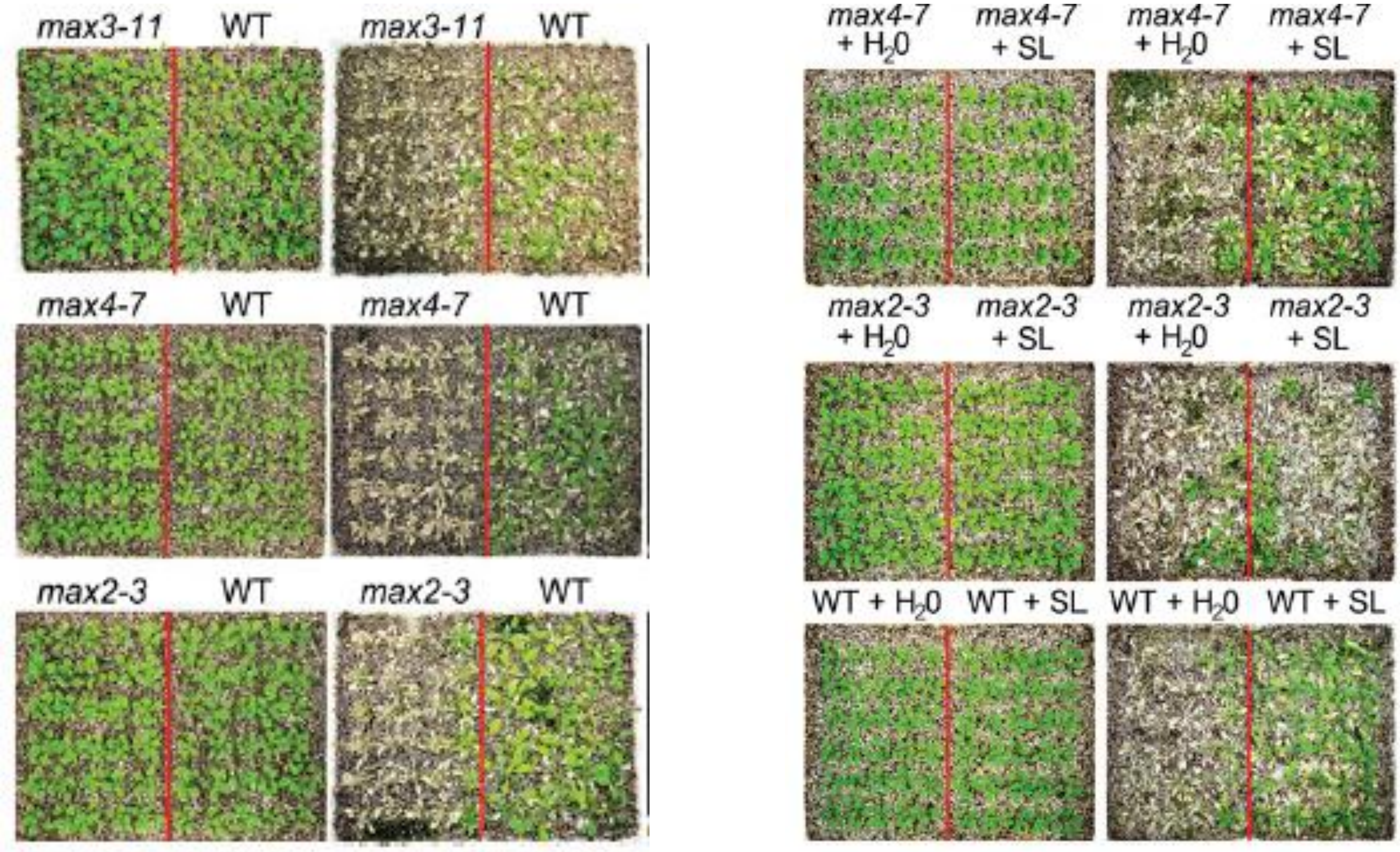


GR24

+ Biotic and abiotic stress responses

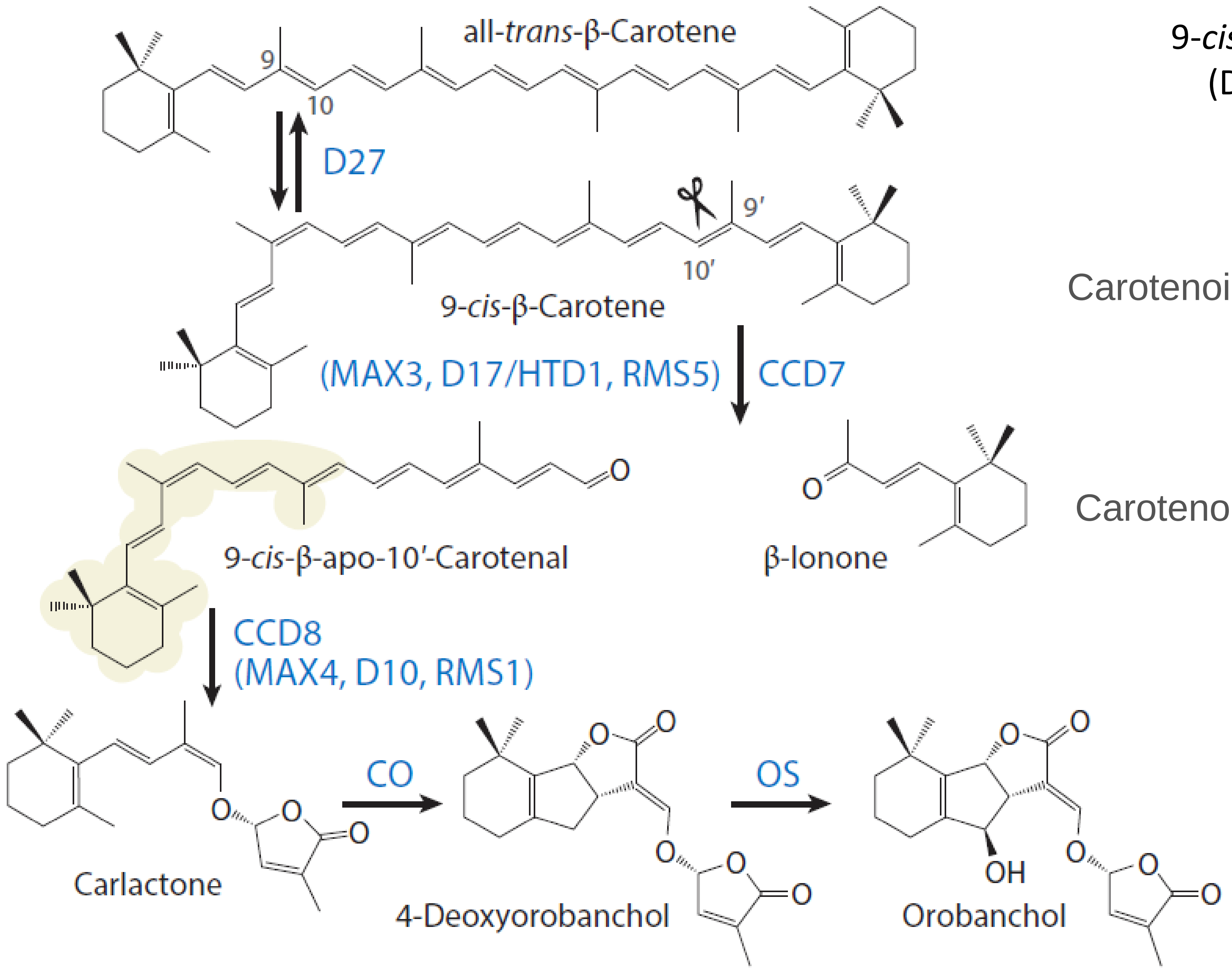
Al-Babili and Bouwmeester, Annu. Rev. Plant Biol. 2015

Role of Strigolactone in drought stress



Ha et al., 2013

Strigolactone biosynthesis



9-*cis*/all-*trans* isomerization
(DWARF 27-isomerase)

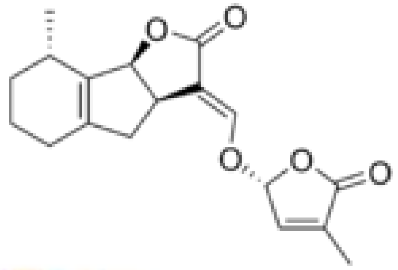
Carotenoid cleavage dioxygenases 7 (CCD7)

Carotenoid cleavage dioxygenases 8 (CCD8)

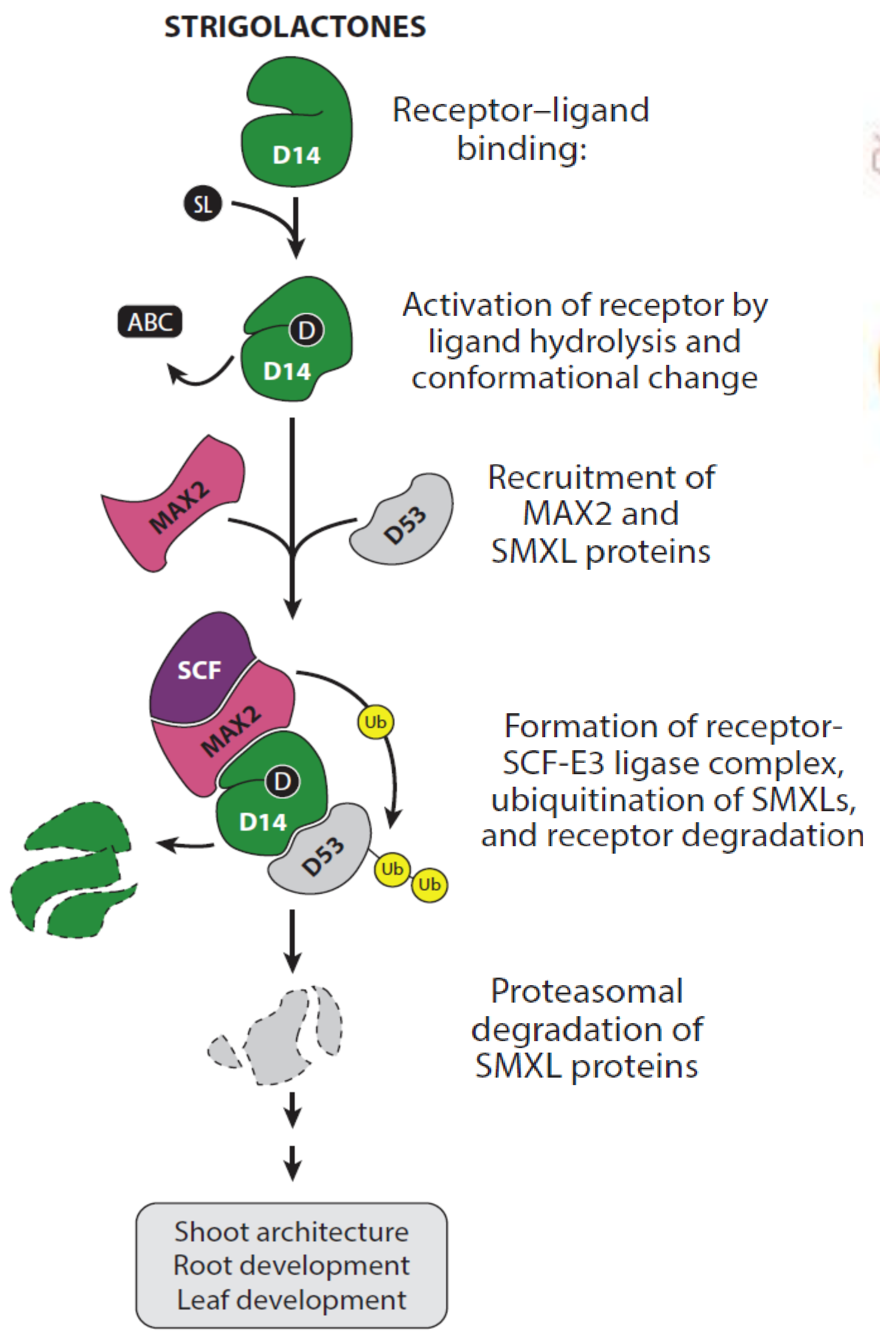
Carlactone oxidase (CO)

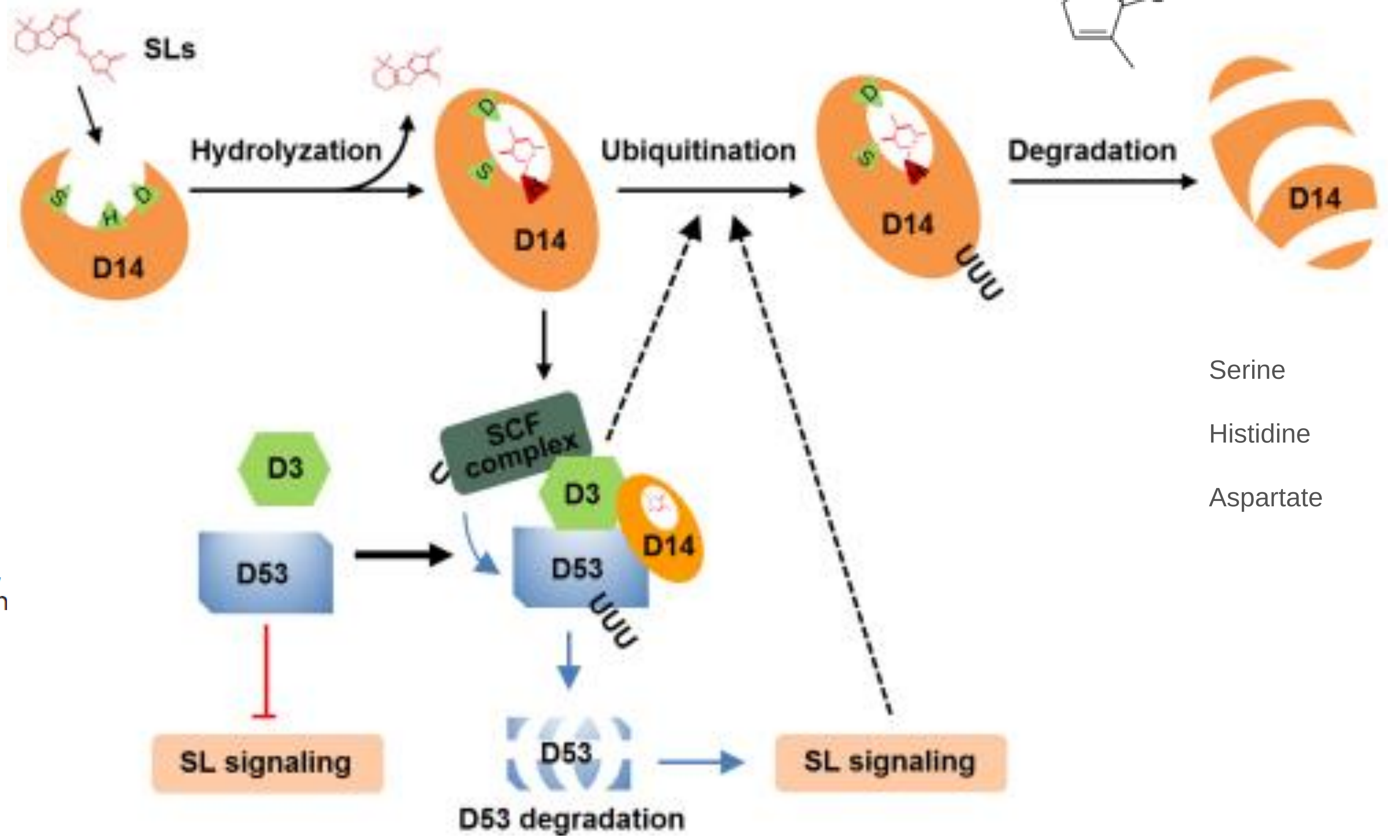
Orobanchol synthase (OS)

Strigolactone signalling



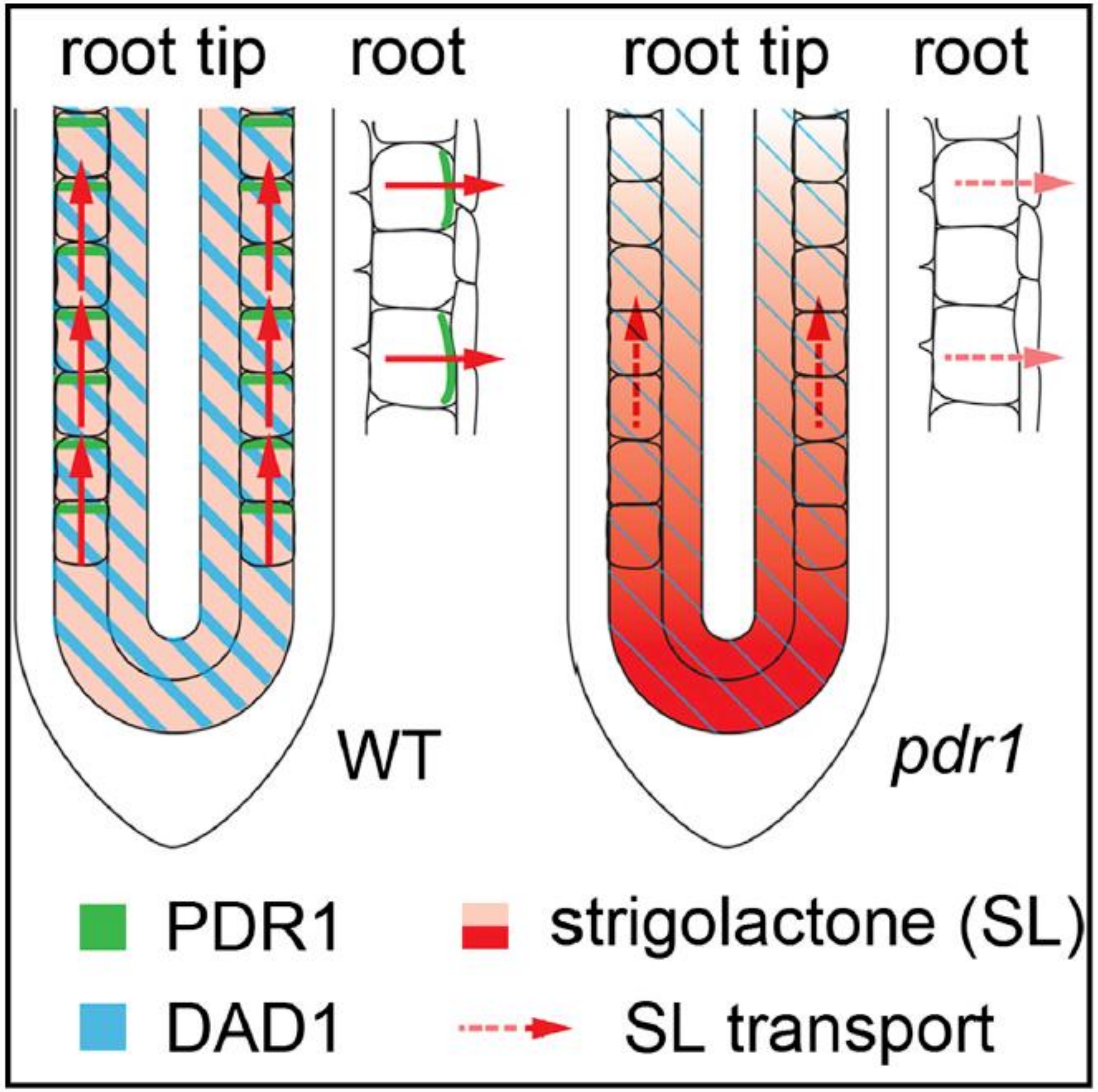
GR24





Unique step in plant signalling

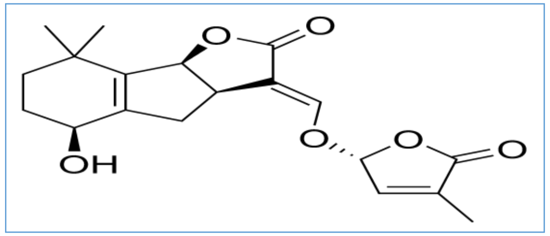
Strigolactone transport



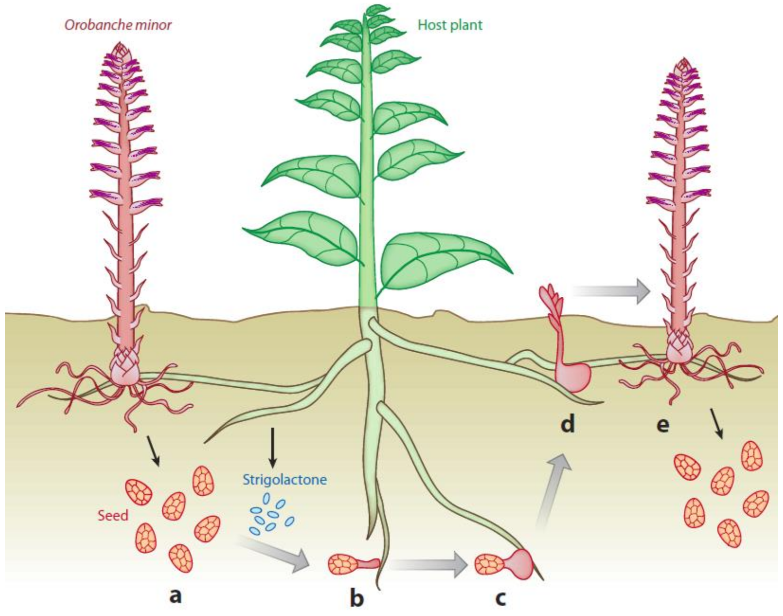
ABC protein PLEIOTROPIC DRUG RESISTANCE 1 (PaPDR1) is apically localized in root tip cortex cells and outer-laterally localized in the root hypodermis.

PaPDR1 plays a key role in regulating shootward and outward directional strigolactone transport.

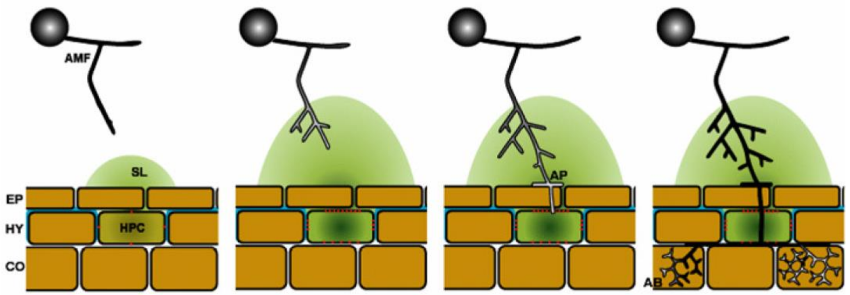
Sasse et al., 2015



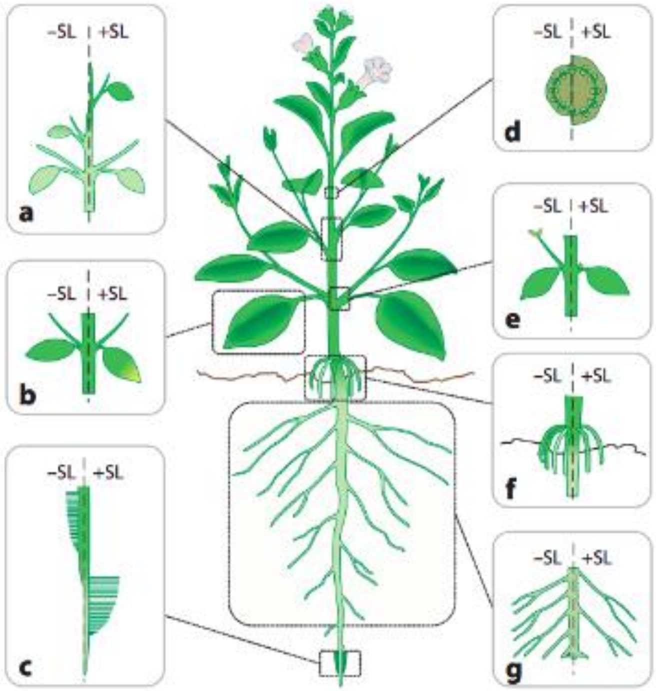
Strigol



C E cook et al.,1966



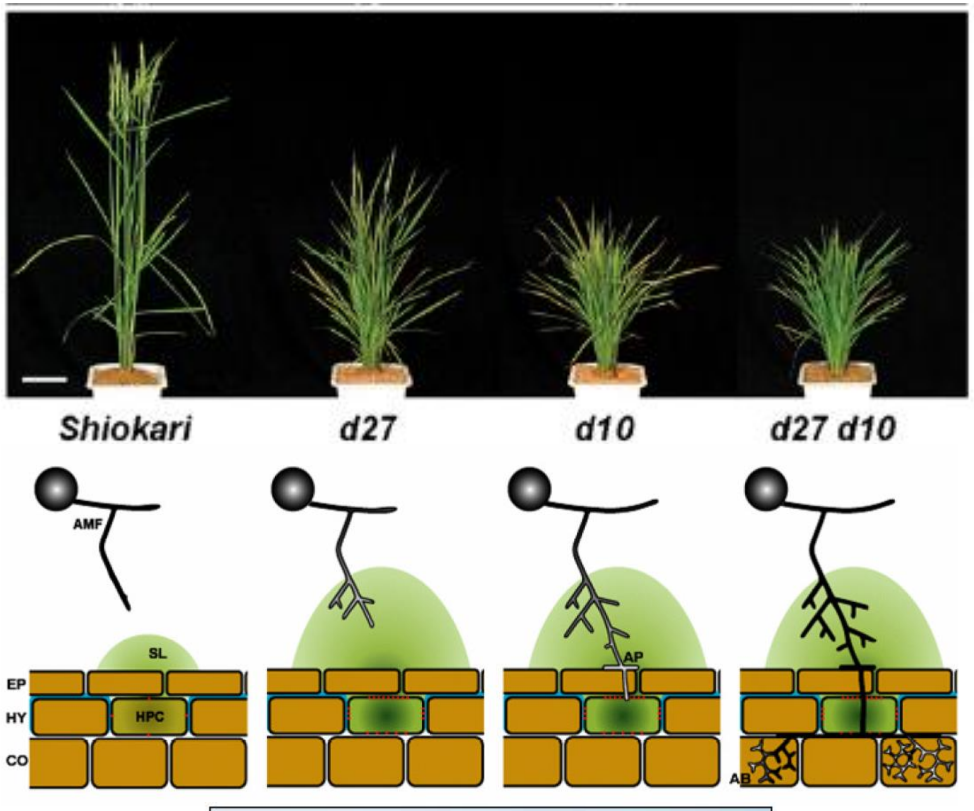
Akiyama, et al., 2005



Al-Babili and Bowmeester , 2015

THINK OF POSSIBLE APPLICATIONS

Possible applications of SL research



Regulates agronomically important traits

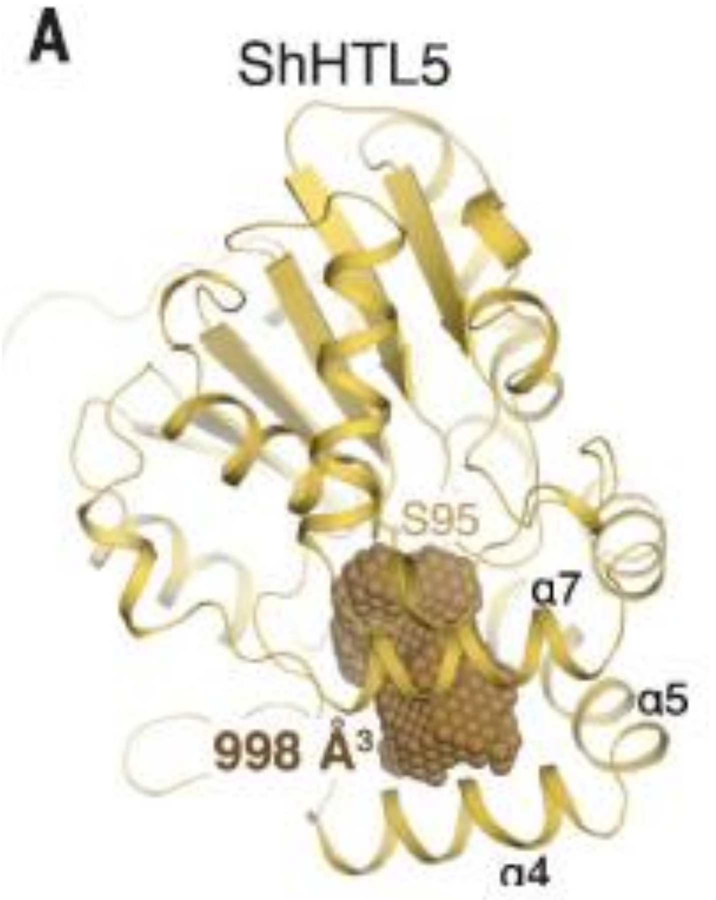
Better uptake of soil nutrients

Solution for Striga infestation

Solution for Striga infestation

Most commonly used control methods are **hand weeding**, **crop rotation**, **improving soil fertility**, **use of tolerant cultivars and inventing 'suicide' germination compounds.**

Inventing 'suicide' germination compounds



Toh et al., 2015

Offers opportunity to design and synthesize Striga specific SL antagonists and agonists.

Receptor-ligand binding affinity

Importance of strigolactone research

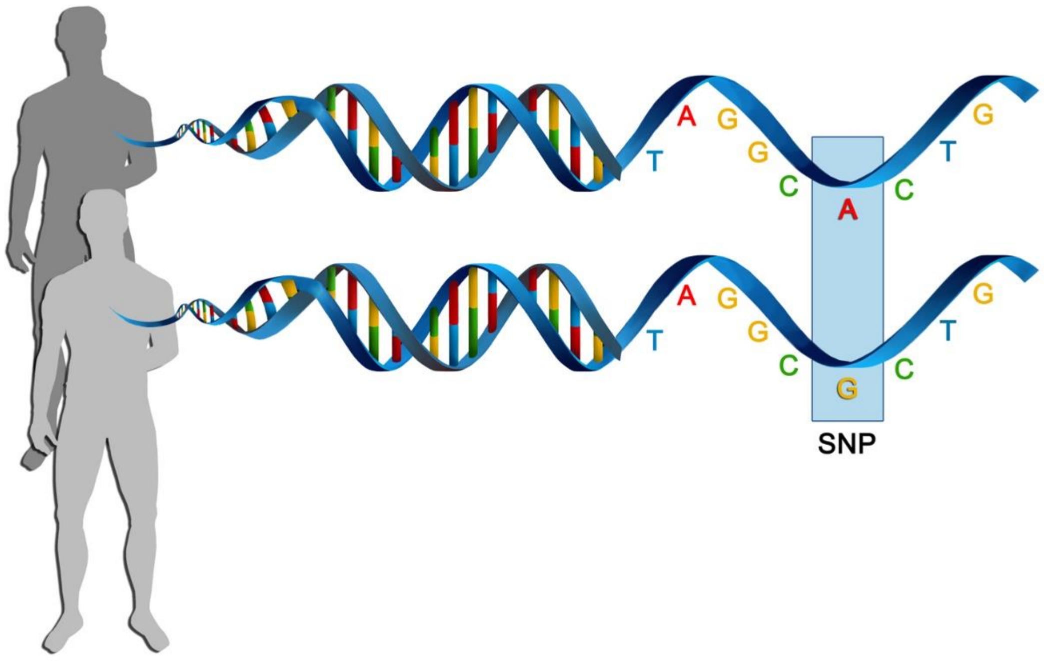
- Possible direct application in agriculture.
- Diverse role in plant development.
- Genetic tools generated and research going on different plant species in parallel.
- Very unique signalling mechanism.

Genome Wide Association Study (GWAS)

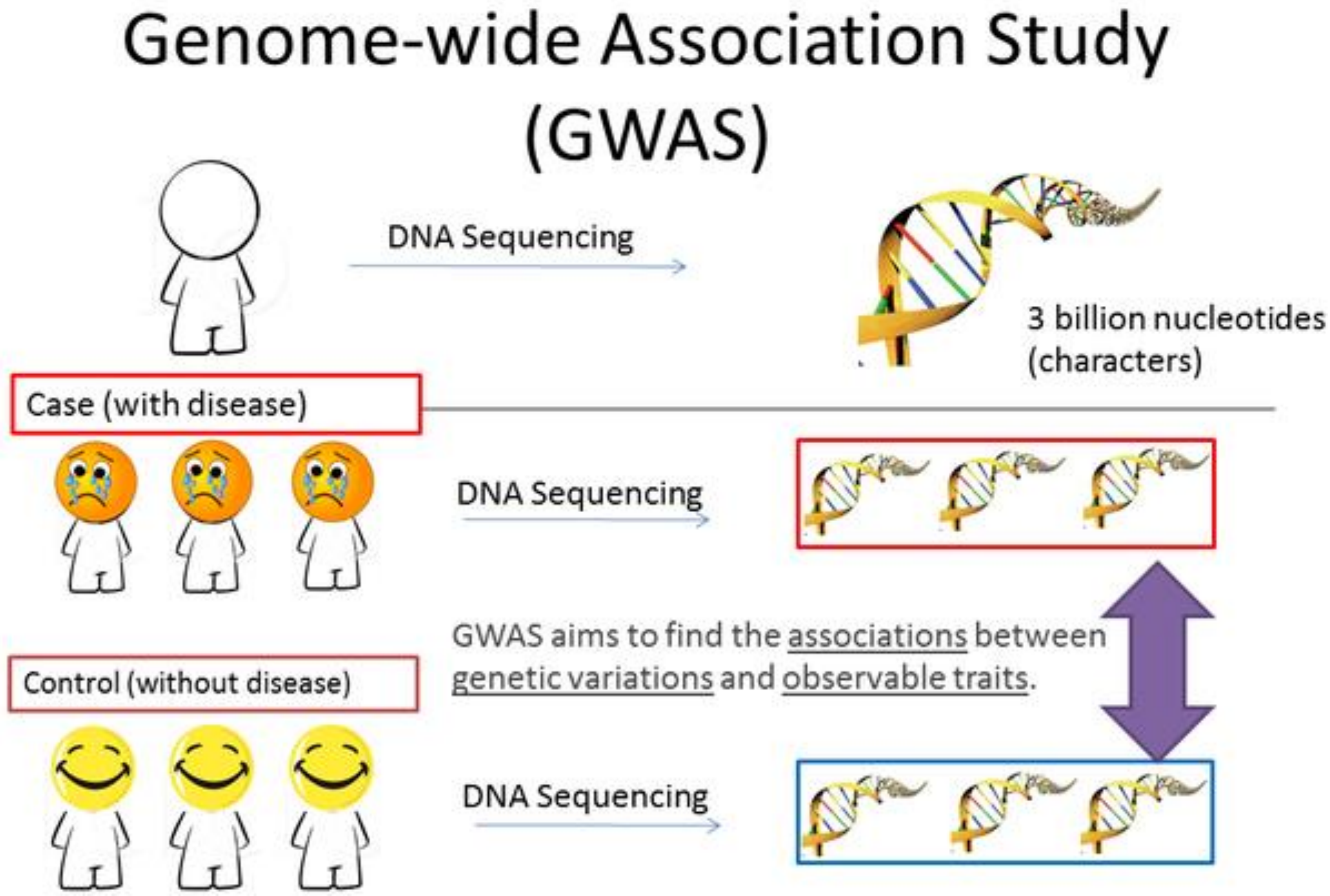
GWAS is an alternative to traditional QTL mapping

GWASs typically focus on associations between **single-nucleotide polymorphisms** (SNPs) and traits like major human diseases

These are positions in genome where some individuals have one nucleotide and others have different.



Around 325 million SNPs have been identified in the human genome,15 million of which are present at frequencies of 1% or higher across different populations worldwide.



The basic principle of GWAS is to correlate genetic variation with physical characteristics.

GWAS

Wide range of human diseases such as sickle-cell anemia, Osteoporosis, atherosclerosis, β-thalassemia and cystic fibrosis result from SNPs.

Microarray-based genome-wide association studies (GWAS) have been the most common approach for identifying disease associations across the whole genome

Identifying candidate genes of Strigolactone pathways using

Genome Wide Association Study

Arabidopsis thaliana

- unique collection
- 242 ecotypes - 28 countries

Col0 ctrl

Col0 GR24

Genome Wide Association Study (GWAS)

Various root traits were analyzed as readouts in 242 accessions

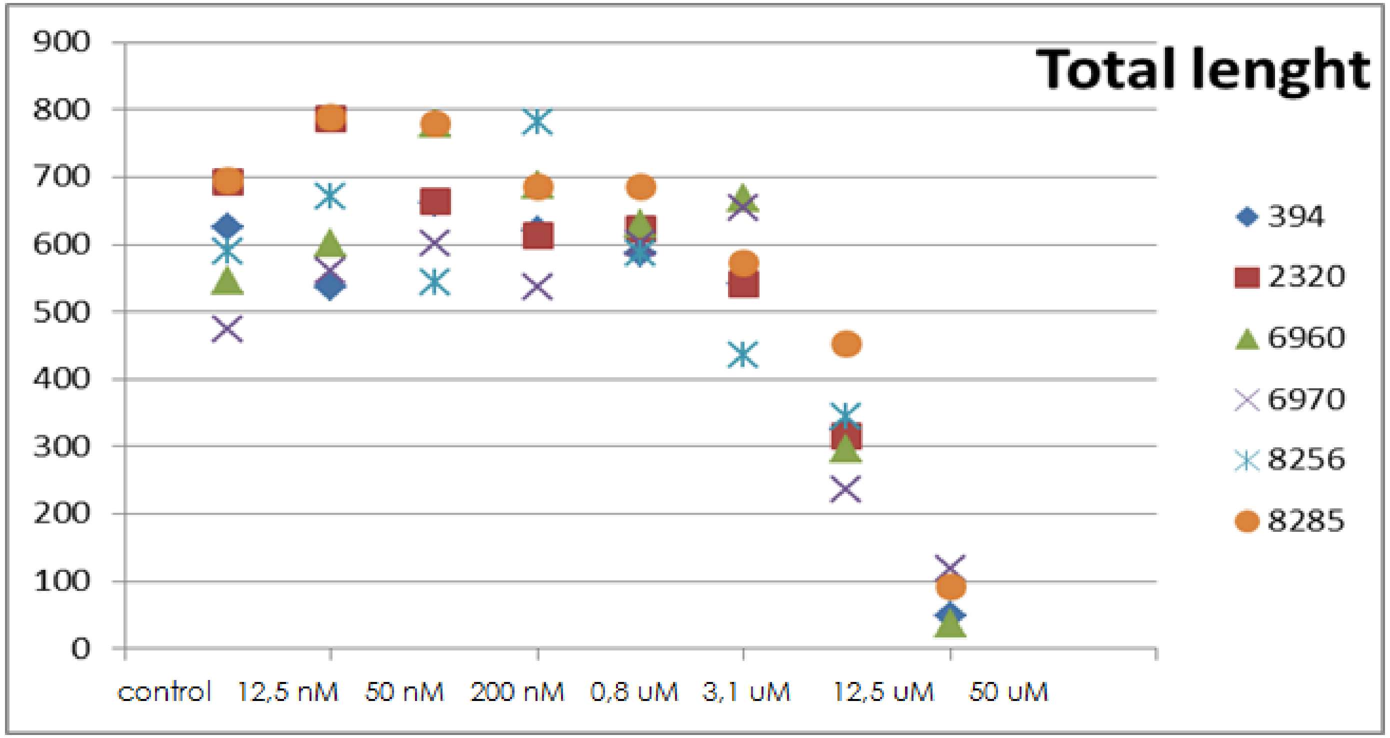
Total length,
Euclidian length,
Root tortuosity,
Root growth rate,
Relative root growth,
Root angle,
Root direction index,
Root horizontal index,
Root vertical index,
Root linearity,
Lateral root number
Root width in different height of the root

GMI
GREGOR MENDEL INSTITUTE
OF MOLECULAR PLANT BIOLOGY

Dr. Wolfgang Busch

Concentration of GR24

Pilot experiment



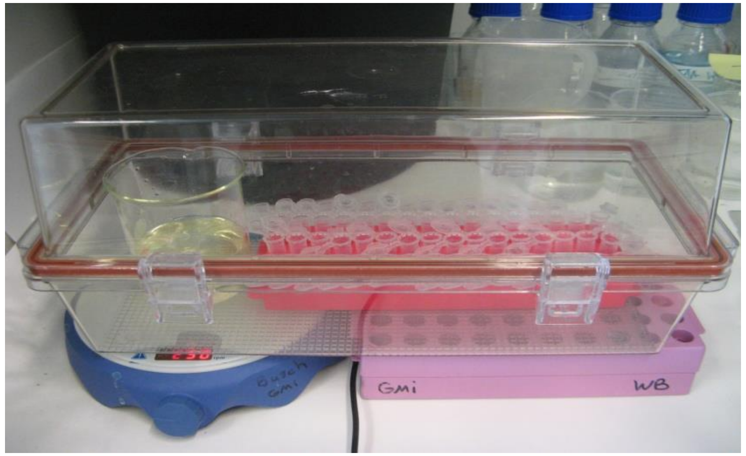
100 nM

Methodology

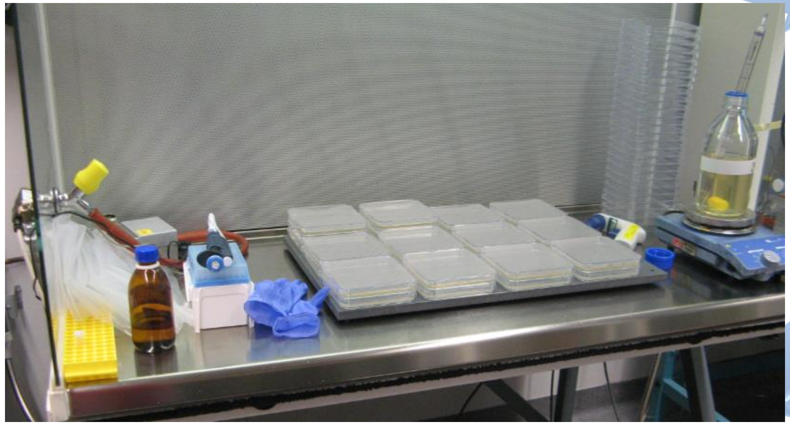
gas sterilization

stratification

(72 hod, 4ºC)



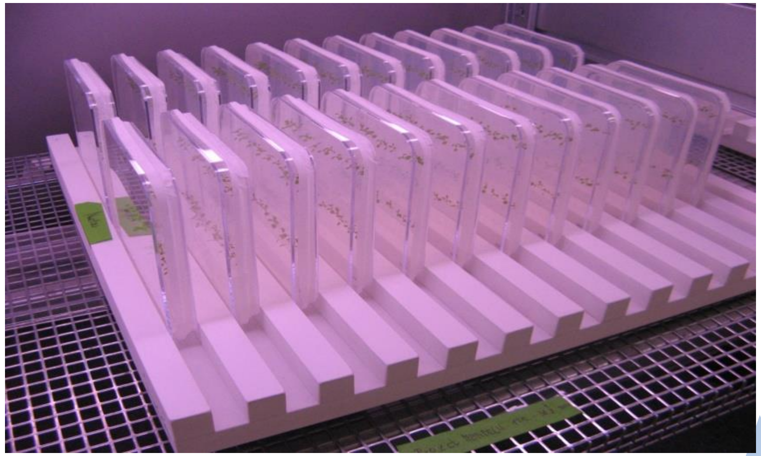
making media Control/Strigolactone (GR24 100 nM, DMSO)



plating seeds

(23 ecotypes + 1 Col-0)

Methodology



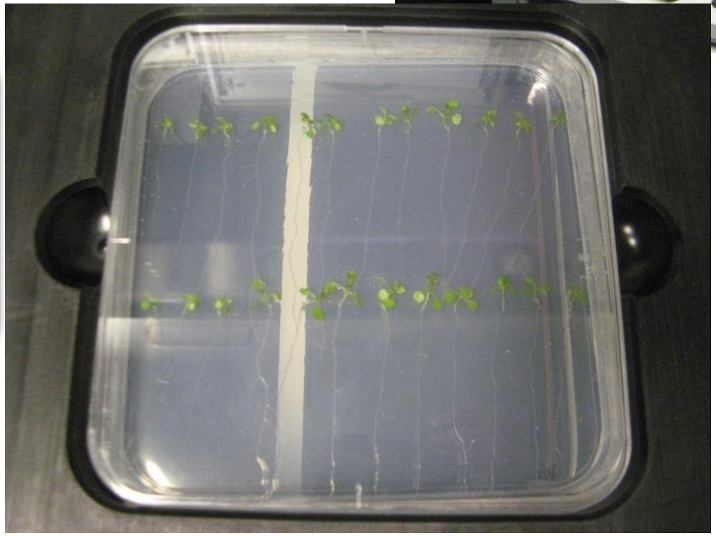
growing in culture room,

3 days (21ºC, 16/8)

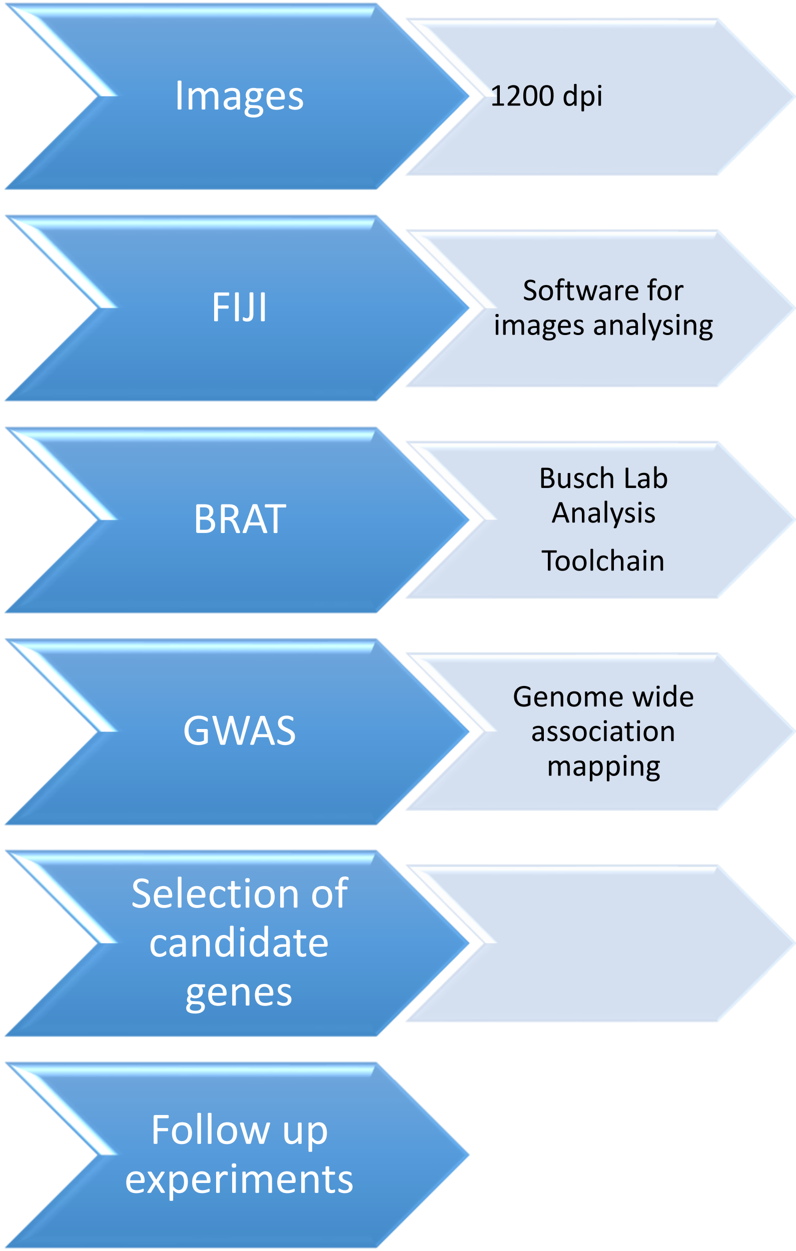
scanning

1-5, 8, 11, 15, 18 day

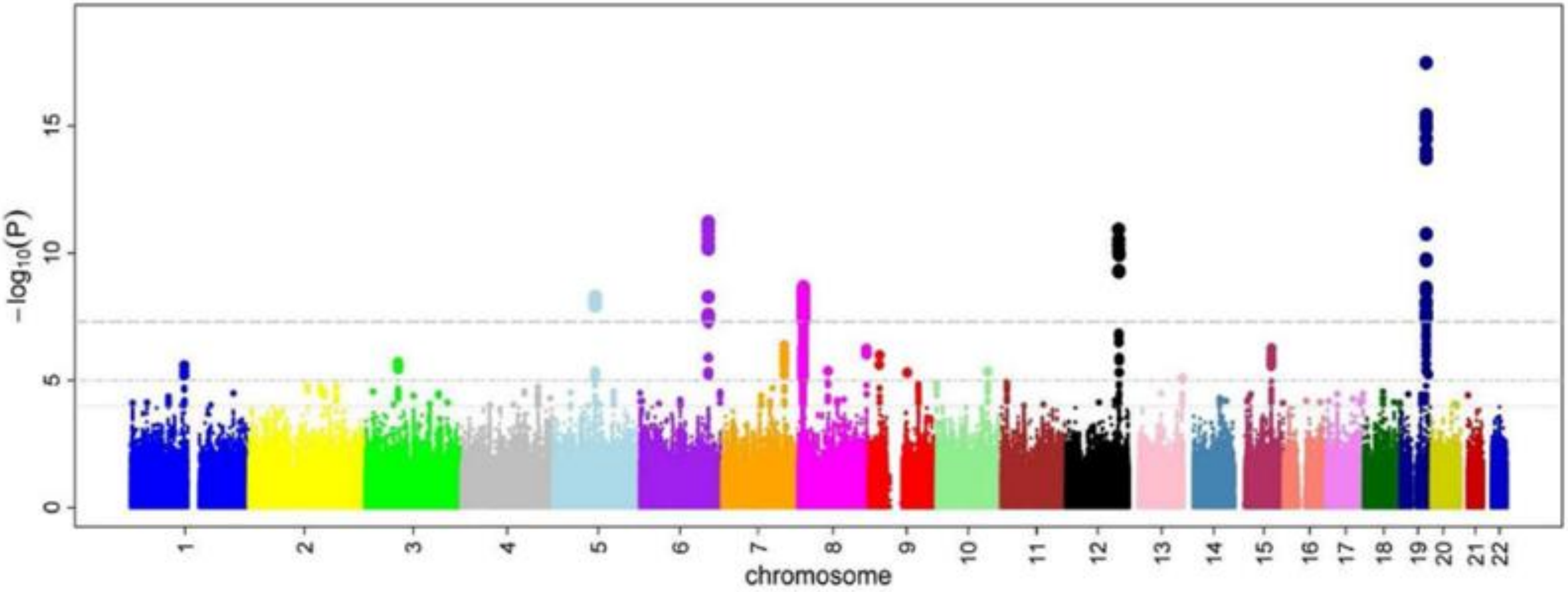
data processing



Data processing

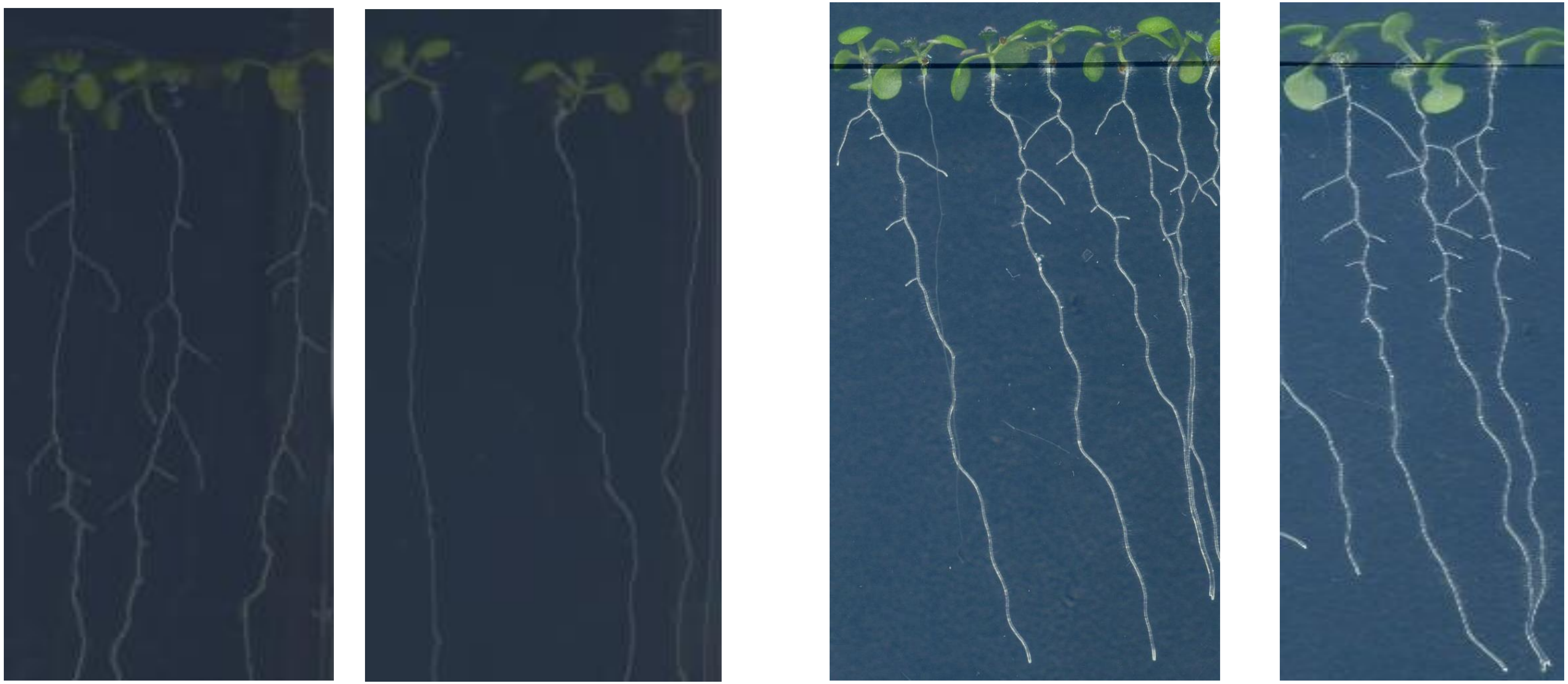


Manhattan plot depicting several strongly associated risk loci



GWAS parameters

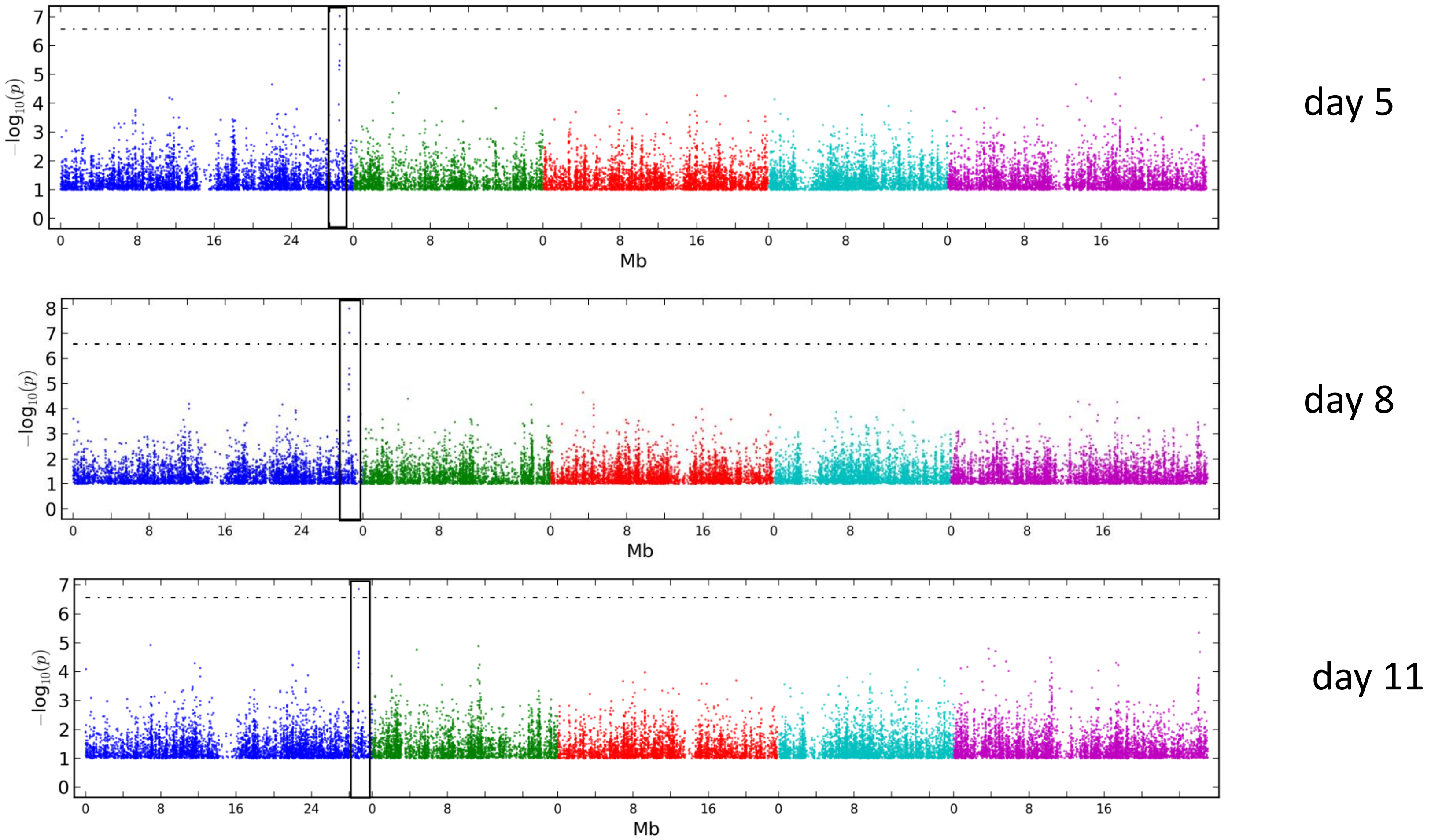
Control Is-1 GR24 Is-1 Control KAR-1 GR24 KAR-1



10 accessions from each extremes will be selected for running GWAS

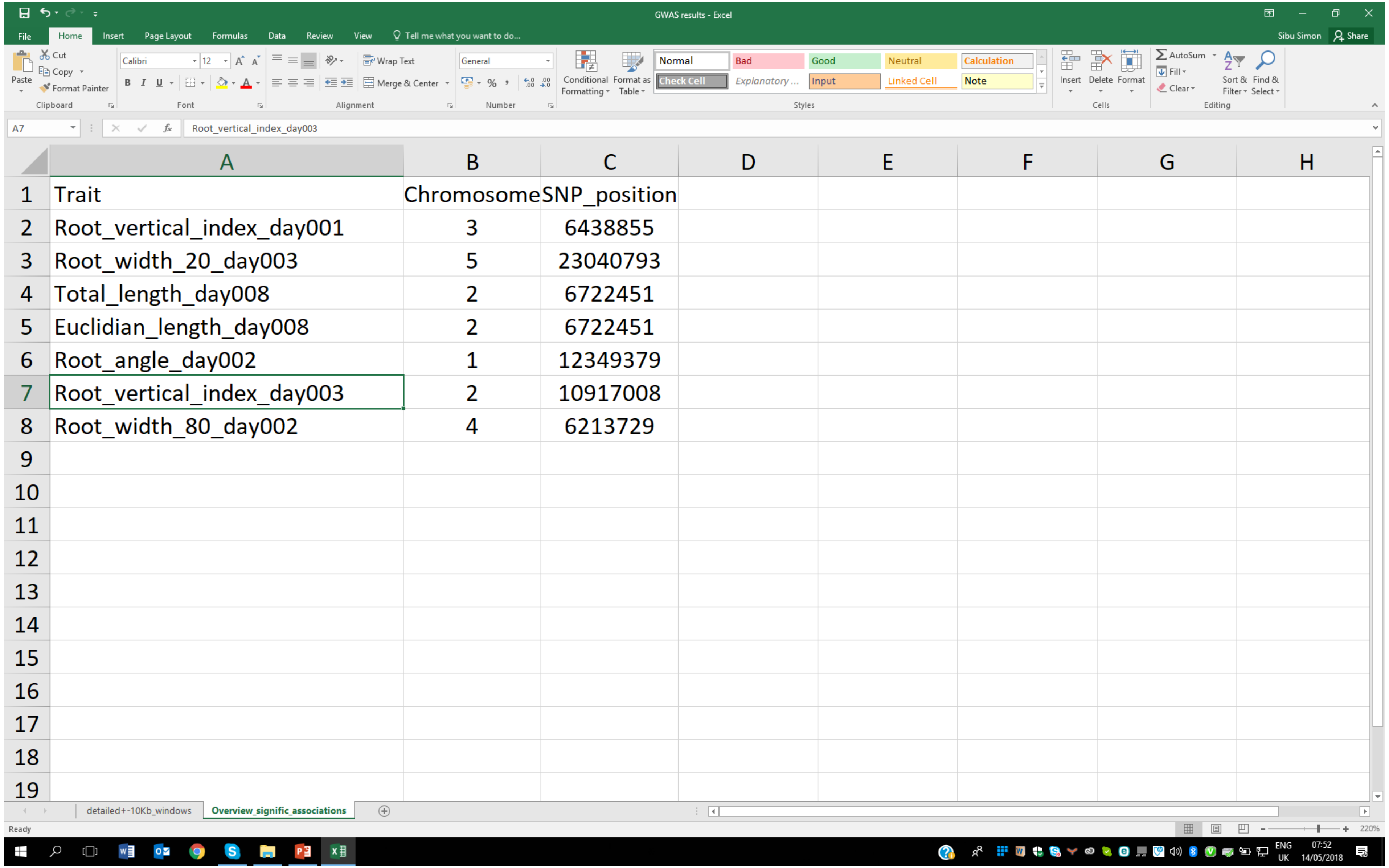
Preliminary Outcomes
KAR 1

Lateral root number



Genes - Protein of unknown function (DUF506)

GWAS results



Trait	Chromosome	SNP_position
Root_vertical_index_day001	3	6438855
Root_width_20_day003	5	23040793
Total_length_day008	2	6722451
Euclidian_length_day008	2	6722451
Root_angle_day002	1	12349379
Root_vertical_index_day003	2	10917008
Root_width_80_day002	4	6213729

GWAS results

http://signal.salk.edu/atg1001/3.0/gebrowser.php

Advantages and disadvantages of GWAS over QTL mapping

Advantages

- Higher mapping resolution
- Reduced research time (no creation of bi- or multi-parental populations)
- Larger number of detectable alleles

Disadvantages

- Low statistical power than QTL mapping can lead to false positive
- Hard to detect rare alleles
- Necessity of large sample volume