PAST TOPICS

- Mitigation and Susiba2 rice
- Floodings
- Snorkel, Sub1 and RAP2.12 ERF VII
- Epigenetics and flowering time
- Epigenetics and drought resistance

NEXT TOPICS:

- Seed biology and nitrogen nutrition

- About 10 minutes per episode
- https://www.audacityteam.org/

LIGHT

10 APRILE 2024

Mind(the)plant

di Redazione

CONDIVIDI

Avvicinamento alla psicologia.

La rassegna *Avvicinamenti Appassionati*, iniziativa nell'ambito delle **attività di terza missione dei Dipartimenti di Psicologia generale e Studi linguistici e letterari** dell'Università di Padova, propone per il 10 aprile l'incontro con **Umberto Castiello, Silvia Guerra e Bianca Bonato** (Dipartimento di Psicologia Generale – Università degli Studi di Padova)
L'evento è organizzato in collaborazione con il Festival Anime Verdi 2024 del Comune di Padova.

L'evento vuole consentire di aprire una finestra sul segreto e ancora poco conosciuto mondo vegetale, per proteggerlo dai cambiamenti climatici e l'inquinamento, a salvaguardia degli ecosistemi.

Ingresso libero fino ad esaurimento posti.

IL BO LIVE IN SERIE
IL CLIMA CHE VOGLIAMO
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NELLA STESSA CATEGORIA
LIGHT

9 SETTEMBRE 2022
Venezia '79: una Biennale all'insegna delle famiglie disfunzionali

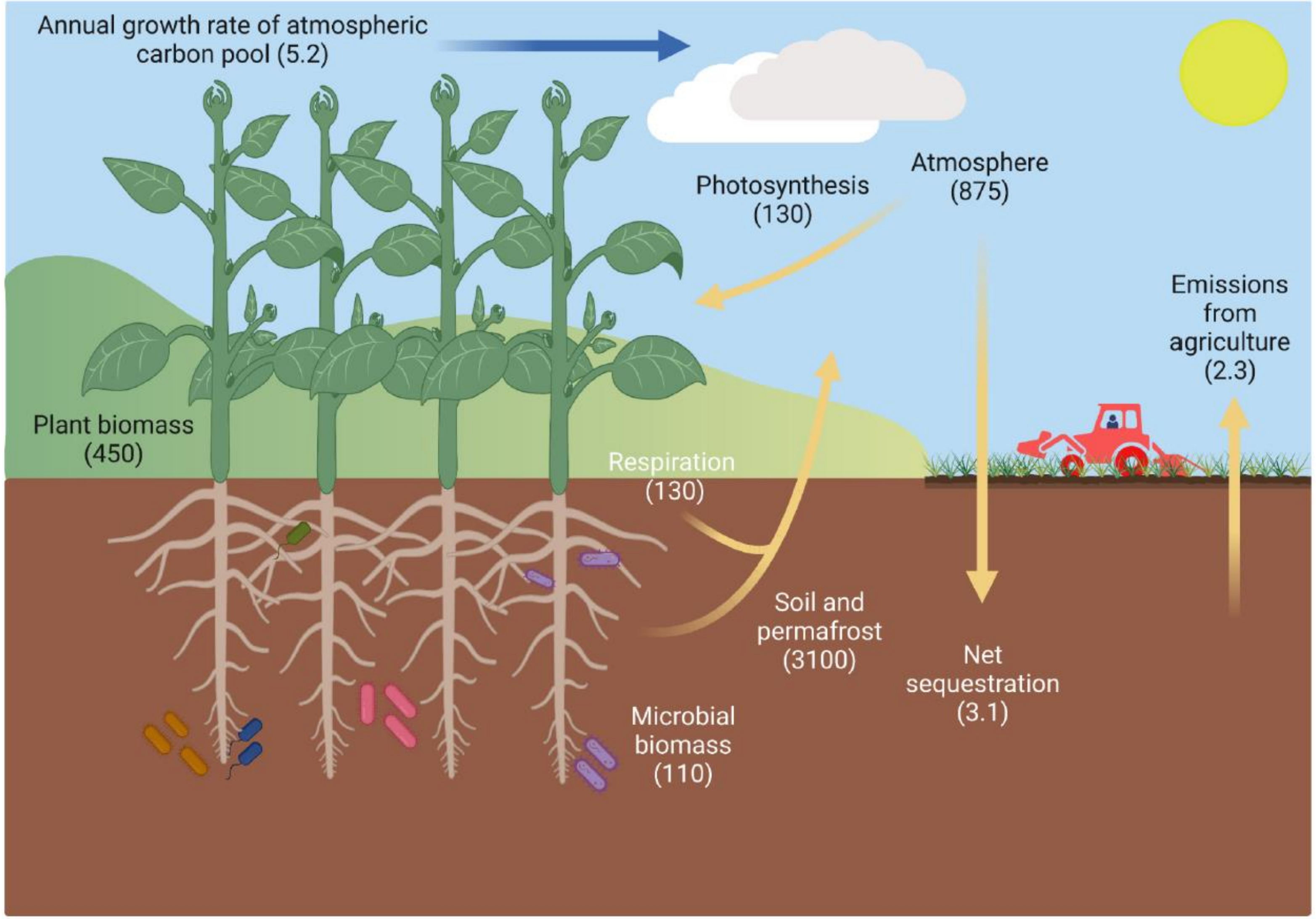
7 SETTEMBRE 2021
Venezia 78: si stava meglio quando si stava in coda

21 OTTOBRE 2020
Le "vedove" di PES ai tempi del Covid

TRENDING TOPICS
- storia della scienza
- fisica
- matematica
- lingua madre
- fMRI
- bilinguismo
- lingue
- sistema cognitivo
- linguistica
- neuroscienza

Trends in
Plant Science
CellPress
Special issue: Food security
Opinion

PlantACT! – how to tackle the climate crisis



- terrestrial and aquatic net primary production is in the range of 130 gigatons of carbon per year.
- The vast majority of this assimilated carbon is returned to the atmospheric CO2 pool via respiration. Hence, the natural global carbon cycle is nearly balanced.
- However, net anthropogenic annual carbon emissions are leading to an estimated 5.2 gigaton increase in atmospheric CO2 in 2022
- 20–25% of GHGs are released through agricultural activities
- Methane is produced by rice paddy fields, livestock (via enteric fermentation and manure), and organic waste in landfills. Nitrous oxide emissions are an indirect product of the use of organic and mineral nitrogen fertilizers.

Good practices and novel technologies

Table 1. Strategies to avoid adverse impact of agriculture on climate change, to adapt to the consequences of climate change, and to mitigate climate change

GHG source	Avoid		Adapt		Mitigate	
Estimated timeframes to implementation[a]	Short-term	Long-term	Mid-term	Long-term	Mid-term	Long-term
Methane	Rice paddy-filed management (Box 1)	Reduce dependence on ruminant livestock protein		Perennial crops Improve rice seedling early vigor (Box 1)		Capture methane emissions at source
Nitrous oxide	Reduce synthetic nitrogen (N) fertilizer use	N_2 fixation through legumes	Breeding for improved N-use efficiency Restore degraded soil fertility Novel crops			
Land use change	Replace soya-based animal feeds Sustainable intensification		Adopting plant-based diets Alternative plant-based protein sources		De-desertification	Reforestation Restoration of peat moss
Carbon dioxide		Reduce dependence on fossil fuels	Improved crop rotation schemes	Improved water use efficiency (Box 2) Enhanced temperature tolerance		Increased carbon capture through photosynthesis Enhanced storage of organic and inorganic carbon in soils (Box 3) Oxalogenic plants (Box 3)

[a]Short-term, within a decade; mid-term, one to several decades; long-term, centennial.

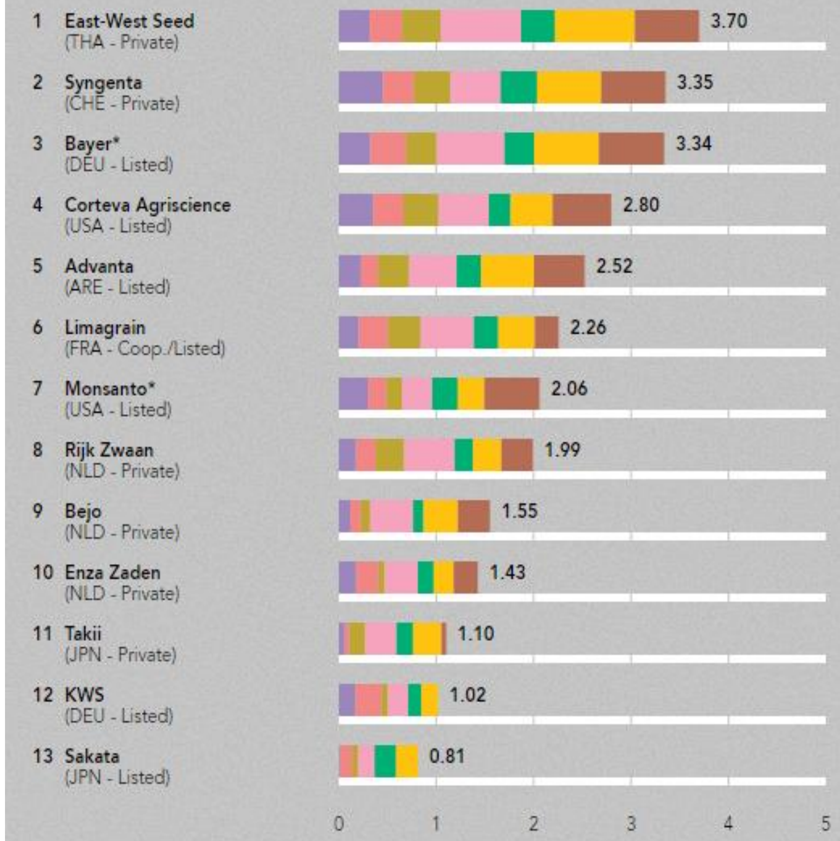
Seed physiology

- Seeds are the delivery systems for agricultural biotechnology. High quality seed leads to excellent seedling performance in the field.
- Companies breed crop plants for seed production.
- Seed quality is a complex trait
- Dormancy of crop and horticultural seeds is an unwanted trait for horticulture.
- Companies develop seed technologies for agricultural and consumer benefit.

https://www.accesstoseeds.org/index/global-seed-companies/ranking/

Learn more about the Global Seed Companies Index

The 2019 ranking explained



*In August 2018, Bayer completed the $66 billion takeover of Monsanto. The 2019 index reflects

- In contrast to the 2016 Index, which presented separate rankings for global field crop and vegetable seed companies, the 2019 Index combines these companies in one ranking. This overall ranking is the weighted sum of the scores in seven measurement areas. Looking at the absolute scores, all companies made progress compared to 2016.

- East-West Seed tops the 2019 Index, scoring slightly better than it did in the 2016 Global Index of Vegetable Seed Companies, which it also led. The company's unique smallholder-centric business model means it performs strongly across all measurement areas, particularly Intellectual Property, Research & Development and Marketing & Sales.

- Syngenta and Bayer are virtually tied for second place, with Syngenta just having the edge. Both companies improved their scores compared to 2016. Syngenta's second-place position is a result of robust SDG commitments that cut across all measurement areas and regions as well as a leading performance in Seed Production. Bayer owes its third-place position to marked progress in its commitments to improving access to seeds for

- Coming in fourth is Corteva Agriscience (DowDuPont's agricultural division), with a strong performance in Governance & Strategy and Intellectual Property. The company is a steady performer overall, without displaying or disclosing 'game-changing' approaches like its better performing peers do.

- Advanta debuts in the index in fifth place, thanks to consistent performance across measurement areas. However, it did not make it into the top three in any measurement area, indicating room for improvement.

- Limagrain has made significant progress compared to the 2016 Index, making it into the top three in Research & Development and earning recognition for its leading role in Genetic Resources.

- Monsanto, currently being integrated into Bayer after the 2018 takeover, once again ranks in the middle of the index.

- Among the specialized vegetable seed companies, Rijk Zwaan outranks its peers – with the exception of East-West Seed – with strong performance in Research & Development and consistent average performance in other areas. The other Dutch companies Bejo and Enza Zaden follow closely, also demonstrating progress compared to 2016.

- Takii, KWS and Sakata perform weakly across all areas, disclosing limited information about their activities and providing little or no clarity on whether improving access to seeds for smallholder farmers is part of their strategy.

https://www.isiacademy.org/internships

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Plant Cell Reports (2023) 42:657–688
https://doi.org/10.1007/s00299-023-02988-w

REVIEW

Molecular dynamics of seed priming at the crossroads between basic and applied research

Andrea Pagano[1] · Anca Macovei[1,2] · Alma Balestrazzi[1,2]

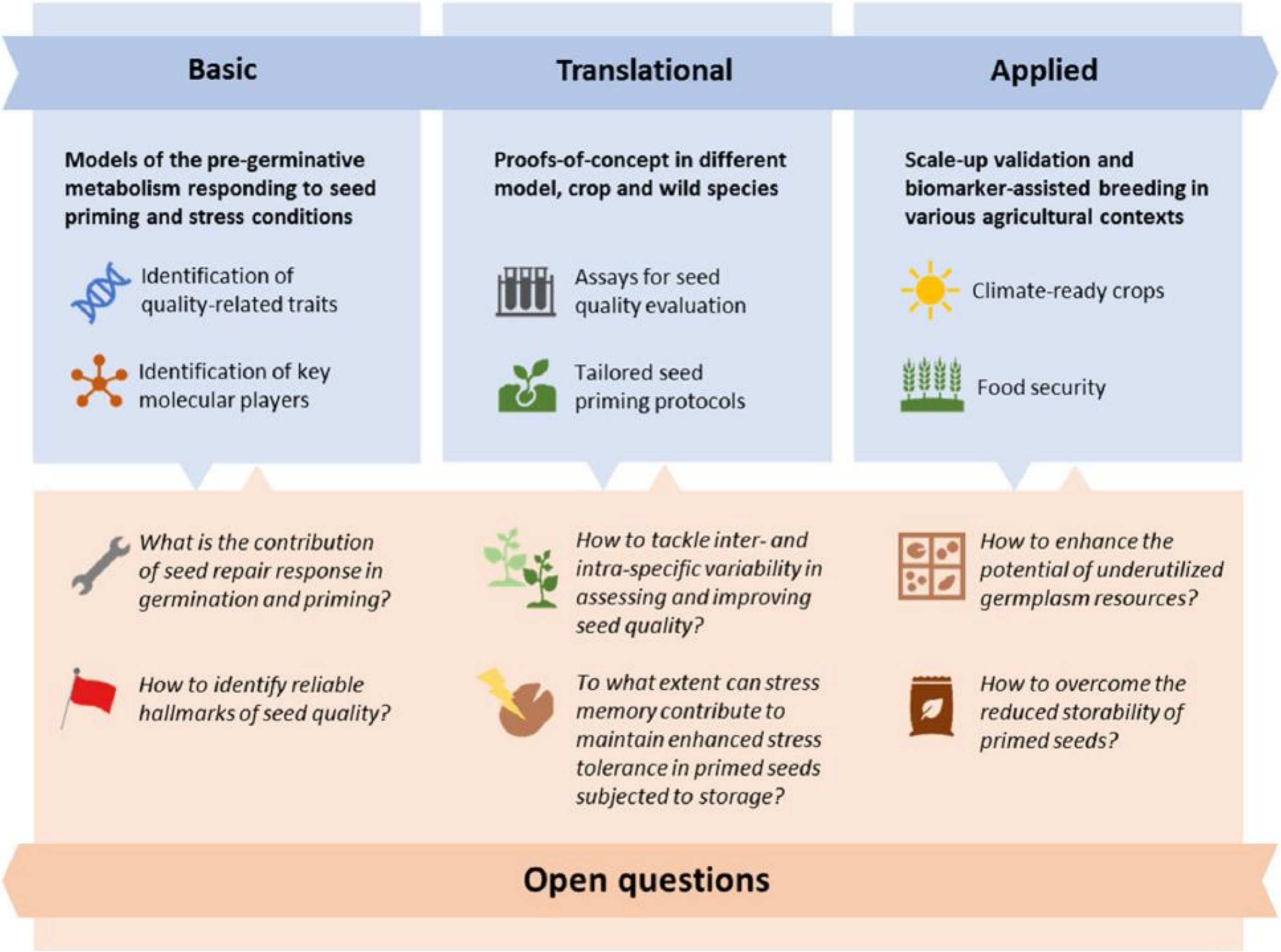

Fig. 1 Overview of the implications of seed priming technologies throughout basic, translational, and applied research, highlighting the most relevant deliverables of each phase and stating the main open questions driving future developments

Received: 14 June 2017 | Revised: 29 August 2017 | Accepted: 18 September 2017

DOI: 10.1111/pce.13082

WILEY Plant, Cell & Environment

ORIGINAL ARTICLE

Predicted global warming scenarios impact on the mother plant to alter seed dormancy and germination behaviour in *Arabidopsis*

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[1] School of Life Sciences, Wellesbourne Campus, University of Warwick, Warwickshire CV35 9EF, UK

[2] College of Life Sciences, Chongqing Normal University, Chongqing 401331, China

Abstract

Seed characteristics are key components of plant fitness that are influenced by temperature in their maternal environment, and temperature will change with global warming. To study the

Fitness can be considered as **the ability of species to survive and reproduce** in the environment in which they find themselves and therefore the probability of surviving to the next generation.

Adaptation depends on phenotypic plasticity and genetic variation within populations

TEMPERATURE
is a primary signal

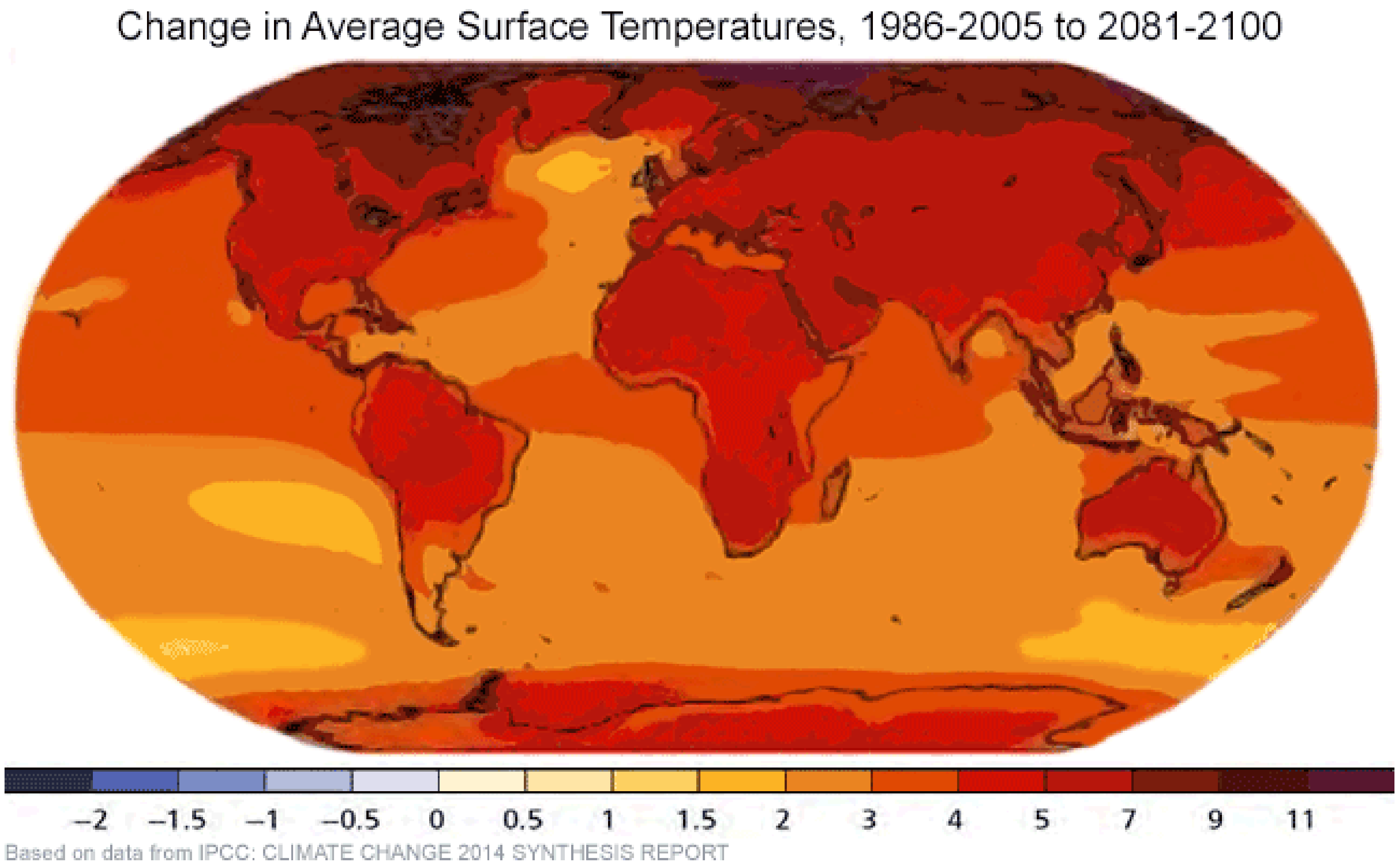
Germination*
(seed to plant transition)

Reproduction
(plant to seed transition)

PLANT FITNESS

* Temperature also affects depth of dormancy during seed maturation and during dormancy cycling in the soil following shedding

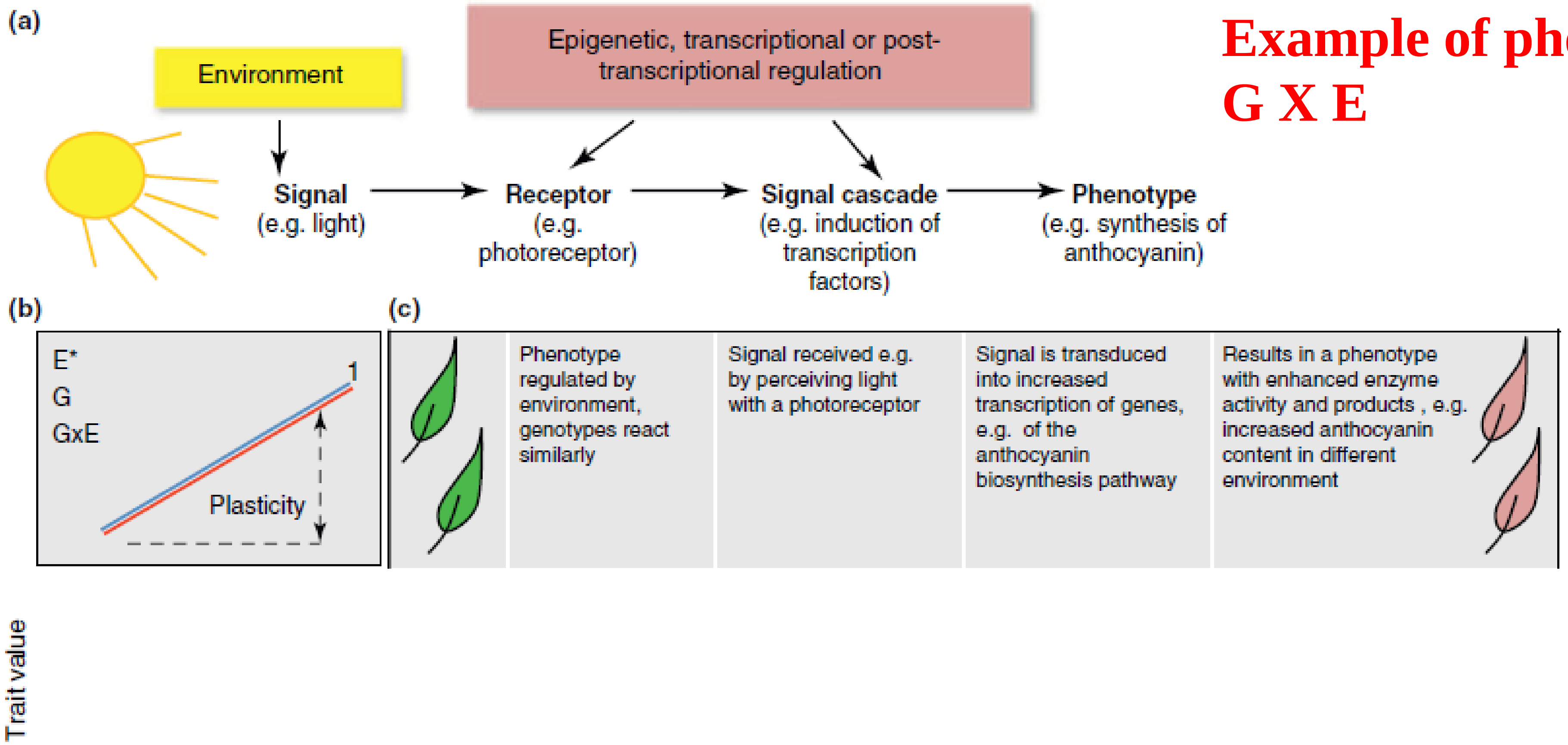
Evidence for warming of the climate system resulting from anthropomorphic greenhouse gas emissions is now unequivocal (IPCC, 2014)

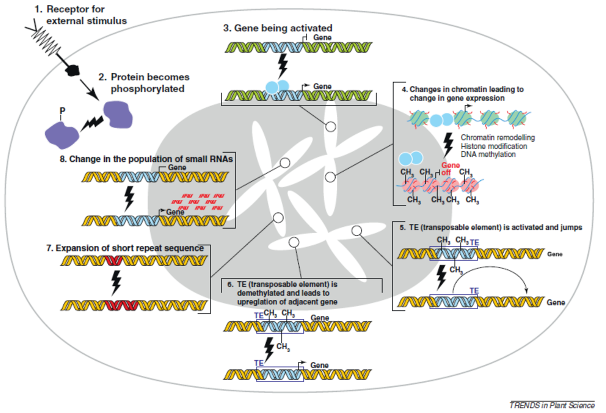


Non-homogeneous at the day scale (min T°has encreased more than max T°)

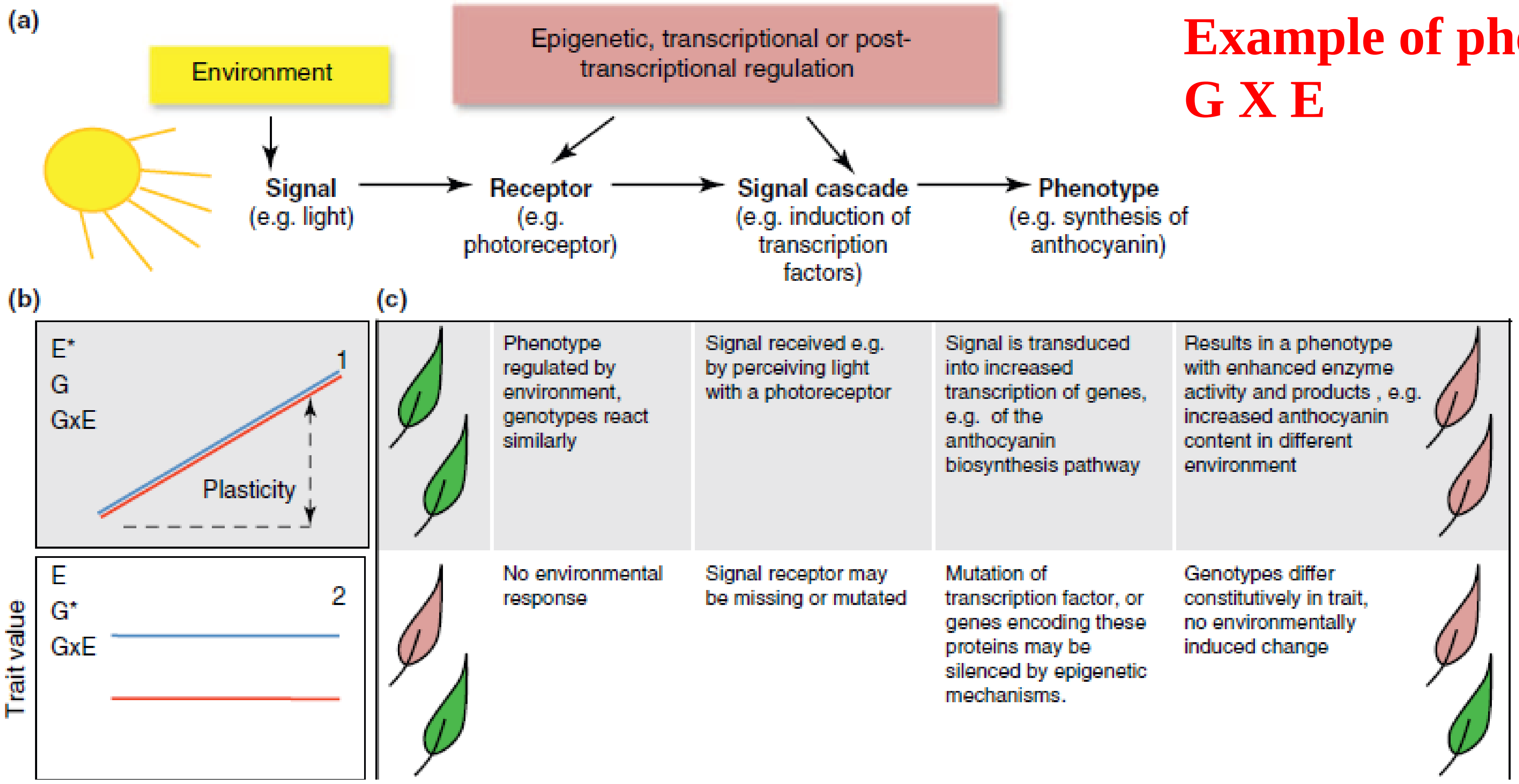
biological spring is now earlier and biological winter is later

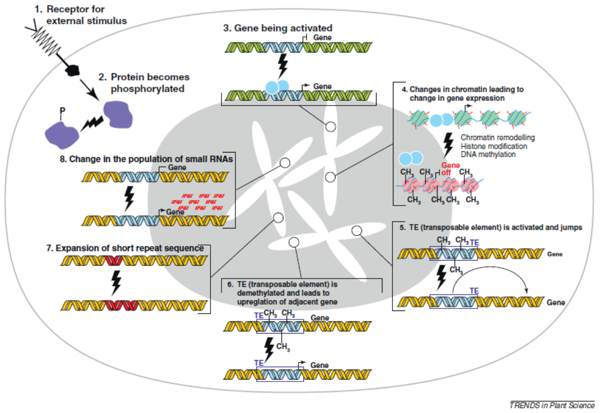
Example of phenotypic plasticity
G X E



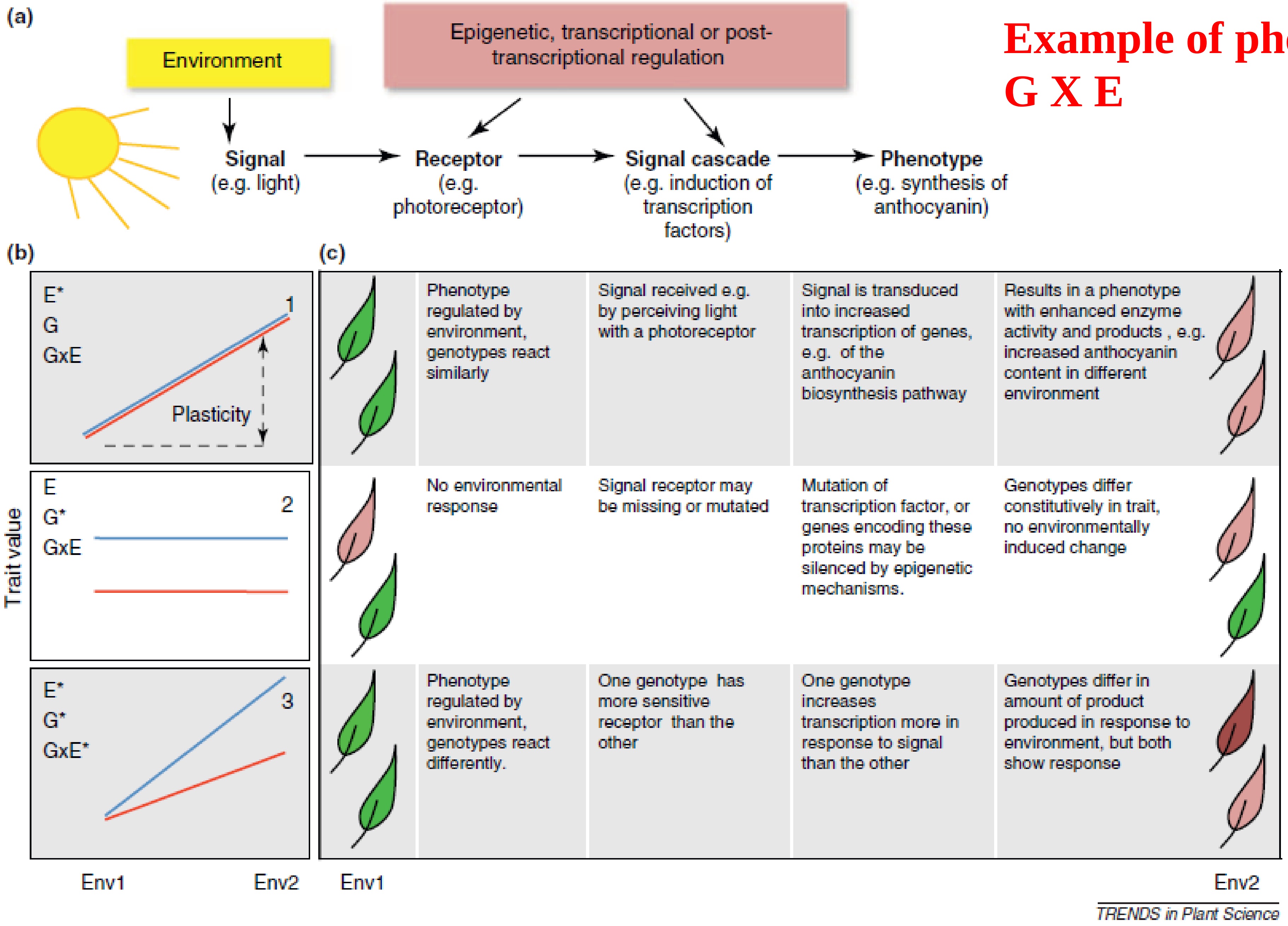


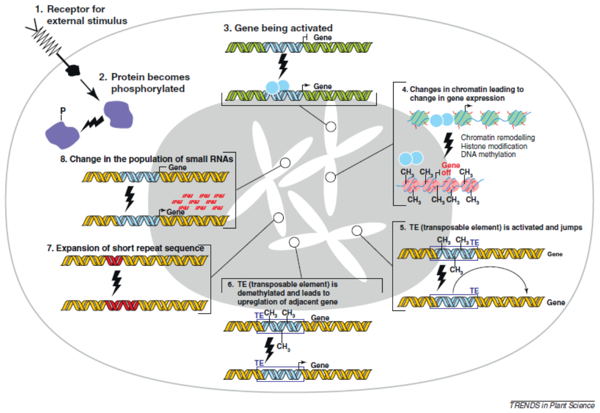
Example of phenotypic plasticity G X E





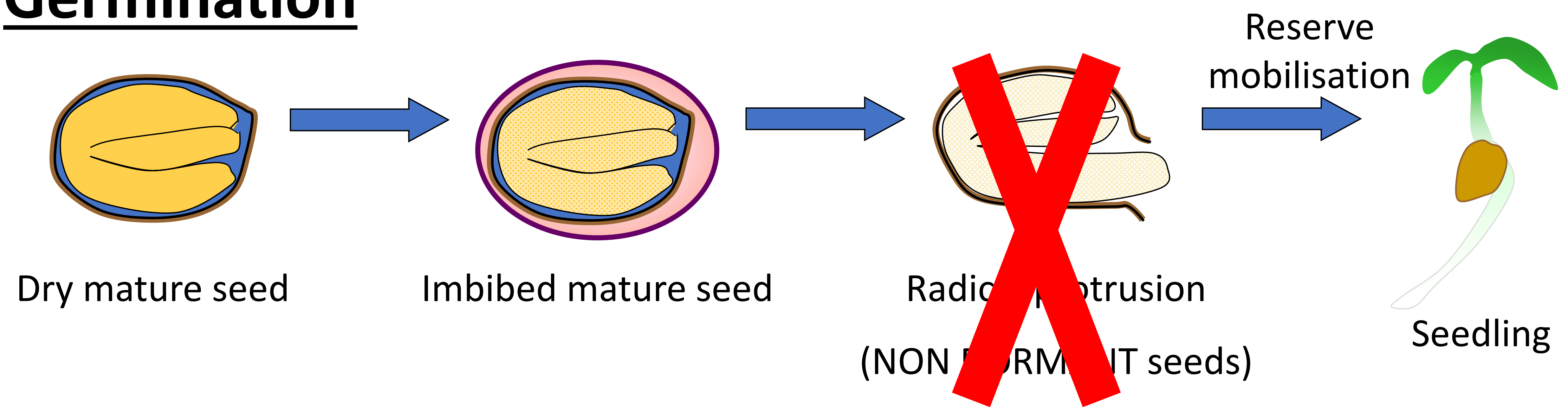
Example of phenotypic plasticity G X E





Seed dormancy: definition

Germination



"A **dormant seed** does not have the capacity to germinate under environmental conditions otherwise favorable for its germination"

Baskin and Baskin, 2004

Primary and secondary dormancy

frontiers in
PLANT SCIENCE

REVIEW ARTICLE
published: 15 September 2014
doi: 10.3389/fpls.2014.00458

Functional genomics of seed dormancy in wheat: advances and prospects

Feng Gao and Belay T. Ayele*

Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada

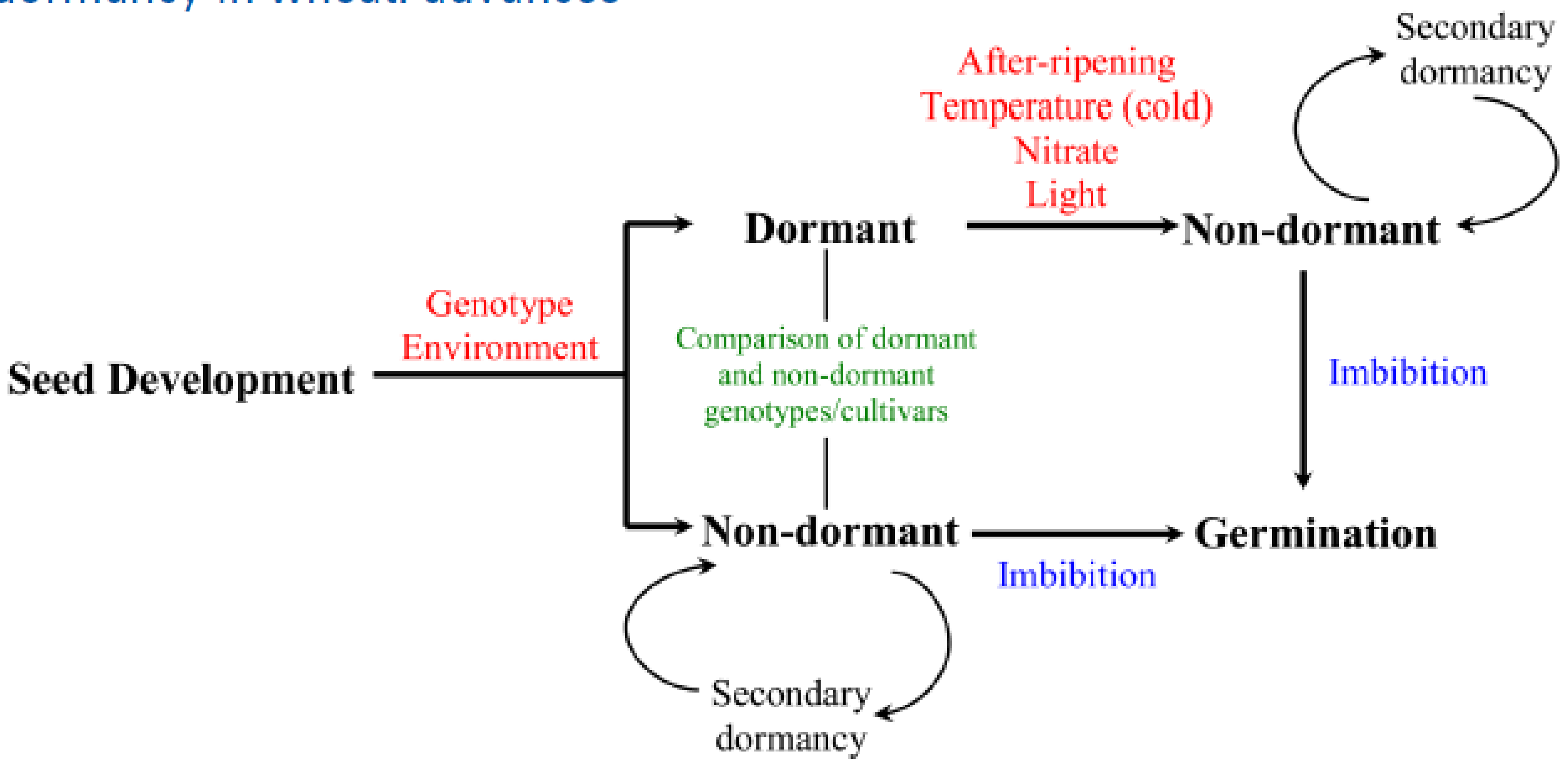
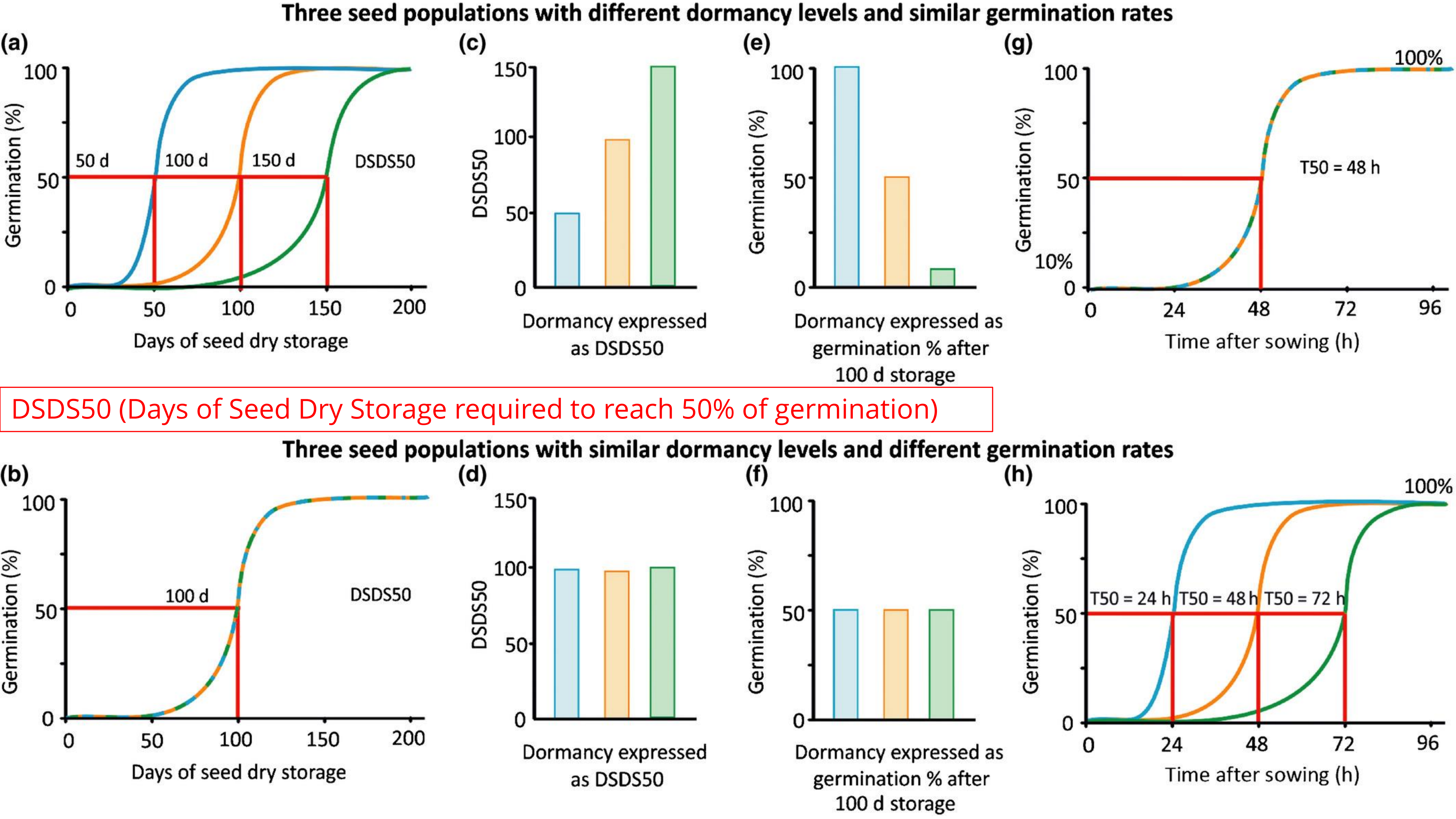


FIGURE 1 | Developmental timeline of dormancy induction and decay in seeds. Induction and maintenance of primary dormancy during seed development is influenced by both genetic and environmental factors. Transition of mature seeds from dormant to non-dormant state can be induced by environmental signals including temperature (cold), nitrate and light, and after-ripening, a period of dry storage during which dormancy breaks down. Non-dormant seeds complete germination once imbibed or may enter secondary dormancy if the environmental conditions are unfavorable for germination. The pathway for preharvest sprouting is represented by the seeds that go directly from development-maturation to non-dormancy to germination. Seed dormancy studies in wheat mainly involve after-ripening and comparative analysis of seeds from dormant and non-dormant cultivars.



Three seed populations with different dormancy levels and similar germination rates
(a)
(c)
(e)
(g)
Germination (%)
50 d
100 d
150 d
DSDS50
Days of seed dry storage
DSDS50
Dormancy expressed as DSDS50
Dormancy expressed as germination % after 100 d storage
100%
T50 = 48 h
10%
Time after sowing (h)
DSDS50 (Days of Seed Dry Storage required to reach 50% of germination)
Three seed populations with similar dormancy levels and different germination rates
(b)
(d)
(f)
(h)
100 d
T50 = 24 h
T50 = 48 h
T50 = 72 h

If seeds drop into an environment that simply isn’t suitable, for example, it’s too dry or the seed hasn’t been buried properly, then it makes no sense to germinate.

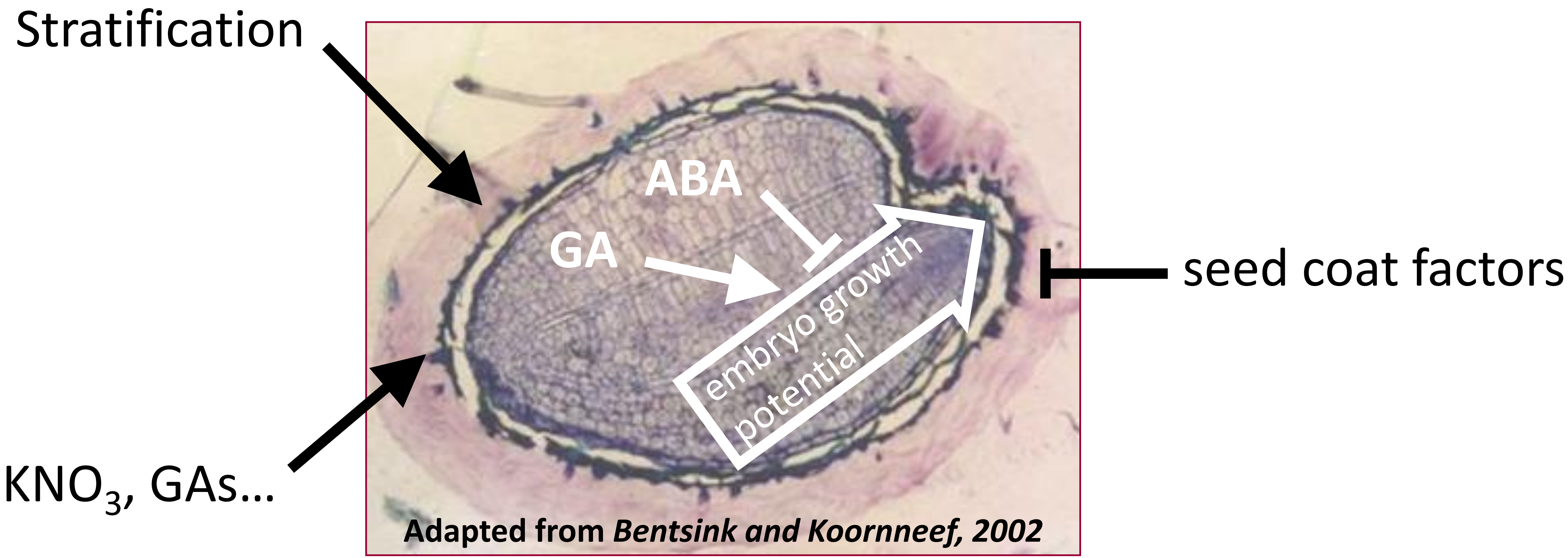
Thermal control both before and after shedding therefore determines when seeds germinate and the timing of seedling emergence in seasonal climates

This control is likely to be disrupted in the event of future climate change to impact upon plant regeneration from seeds

Compromised seedling emergence and vigor, and shifts in germination phenology are likely to influence population dynamics, and therefore, species composition and diversity of communities

When can we consider a seed germinated?

What are the main factors influencing seed dormancy and germination?



Adapted from *Bentsink and Koornneef, 2002*

Global Change Biology

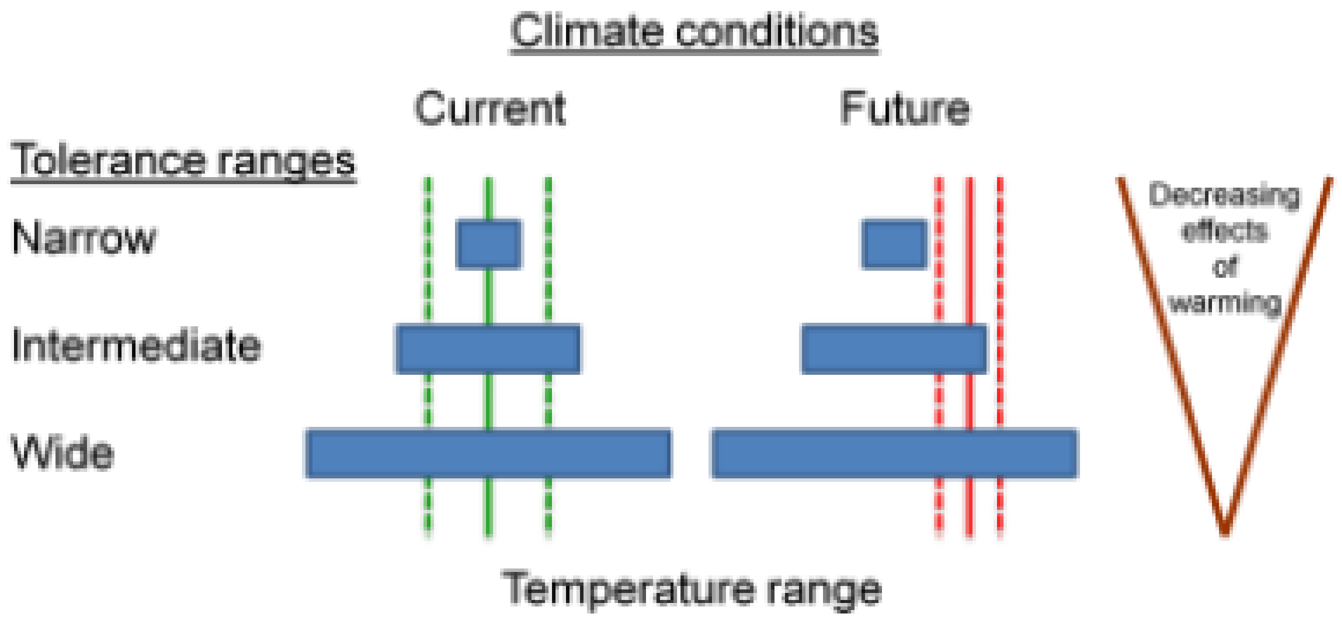
Global Change Biology (2011) 17, 2145–2161, doi: 10.1111/j.1365-2486.2010.02368.x

REVIEW

Climate change and plant regeneration from seed

JEFFREY L. WALCK*, SITI N. HIDAYATI*, KINGSLEY W. DIXON†‡, KEN THOMPSON§ and PETER POSCHLOD¶

*Department of Biology, Middle Tennessee State University, Murfreesboro, TN 37132, USA, †Kings Park and Botanic Garden, Fraser Avenue, West Perth, WA 6005, Australia, ‡School of Plant Biology, The University of Western Australia, Crawley, WA 6009, Australia, §Department of Animal and Plant Sciences, The University, Sheffield S10 2TN, UK, ¶Institute of Botany, University of Regensburg, Regensburg D-93040, Germany



The level (solid lines) and **duration (distance between dashed lines) of cold stratification** is changing currently and will likely continue to do so into the future (difference between green and red lines). The effects on stratification may vary among species dependent on their **tolerance ranges (blue boxes) for temperatures** required for dormancy loss. With a decrease in dormancy loss, seeds may be expected to remain dormant.

Directional selection may offset the effects from warming and shortening of winters. Since soil moisture is predicted to increase in winter, we would not expect a change in hydration levels of seeds to impact stratification.

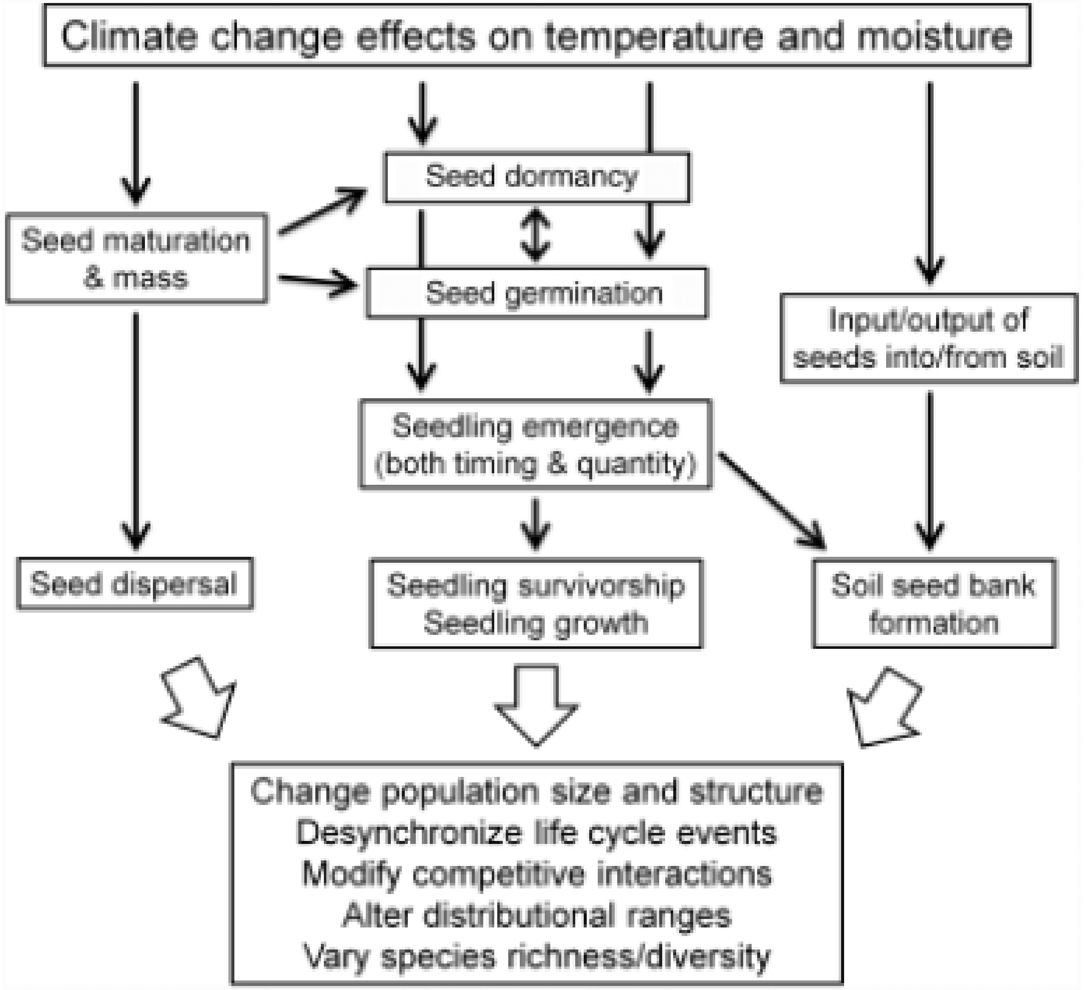
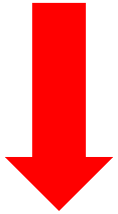
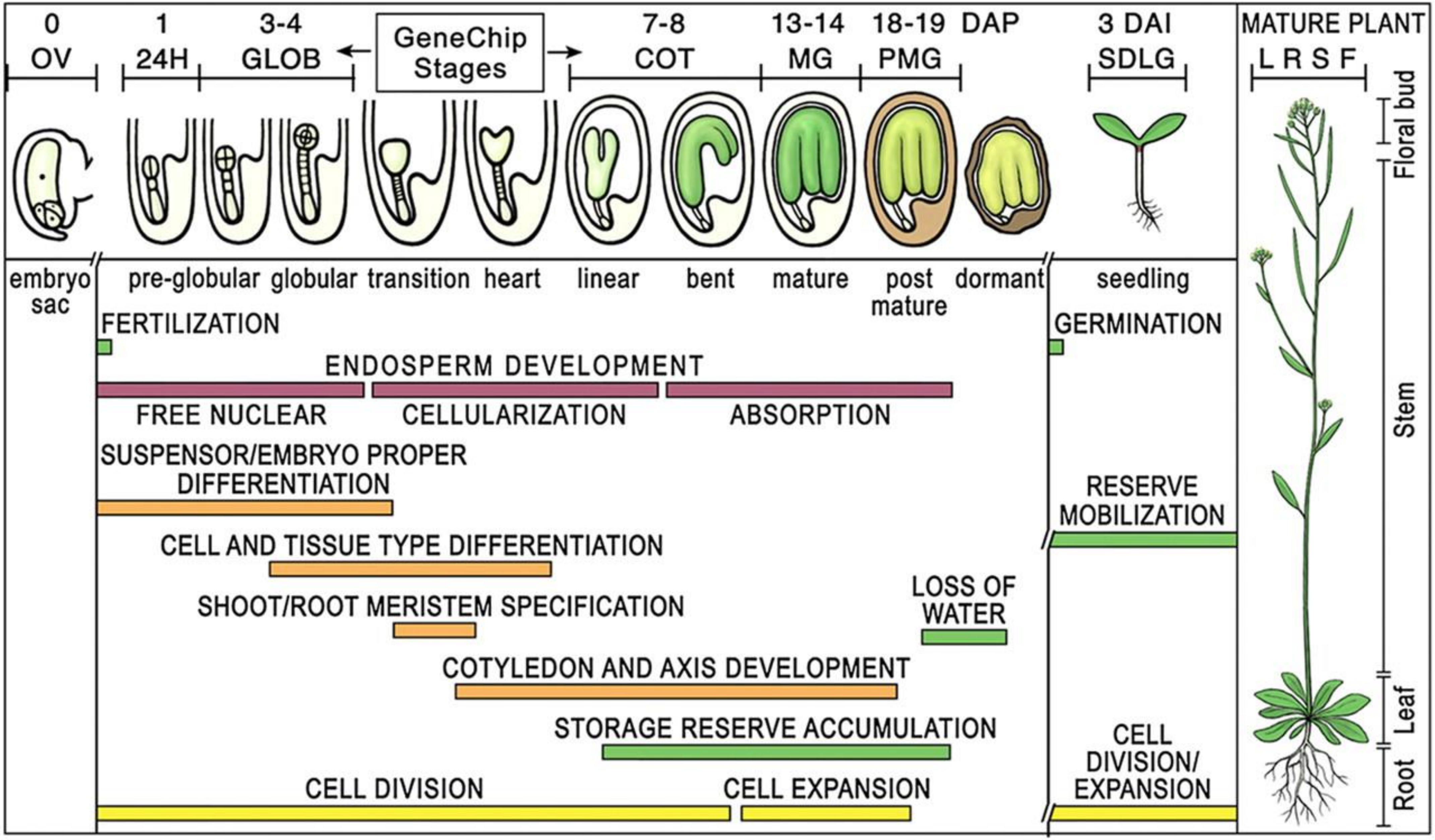


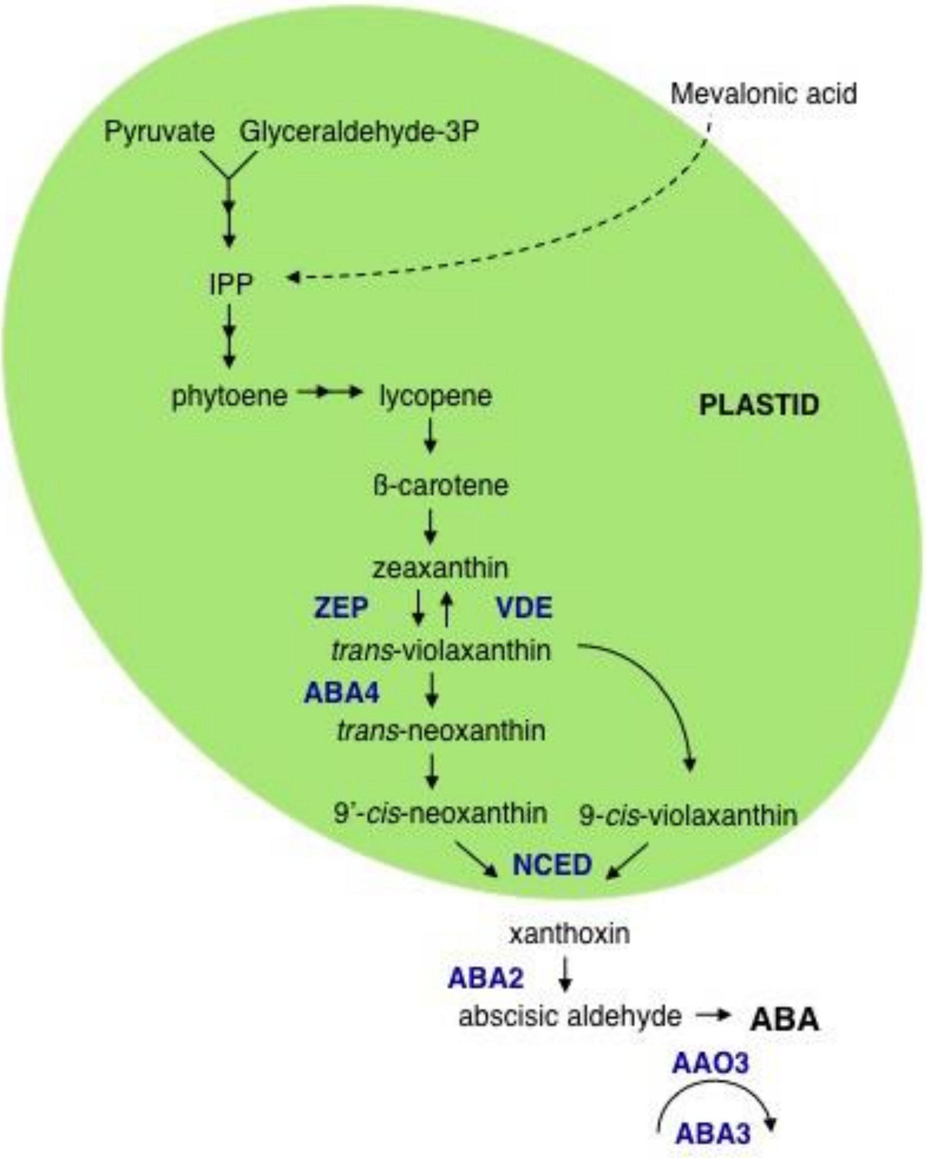
Fig. 7 Flow chart showing the effects of climate change on plant regeneration from seeds and repercussions on the early life history events of plants at the population and community levels.

Phenotipic plasticity



Adaptation


0
OV
1
24H
3-4
GLOB
GeneChip Stages
7-8
COT
13-14
MG
18-19
PMG
DAP
3 DAI
SDLG
MATURE PLANT
L R S F
Floral bud
Stem
Leaf
Root
embryo sac
pre-globular
globular
transition
heart
linear
bent
mature
post mature
dormant
seedling
FERTILIZATION
GERMINATION
ENDOSPERM DEVELOPMENT
FREE NUCLEAR
CELLULARIZATION
ABSORPTION
SUSPENSOR/EMBRYO PROPER DIFFERENTIATION
RESERVE MOBILIZATION
CELL AND TISSUE TYPE DIFFERENTIATION
LOSS OF WATER
SHOOT/ROOT MERISTEM SPECIFICATION
COTYLEDON AND AXIS DEVELOPMENT
STORAGE RESERVE ACCUMULATION
CELL DIVISION
CELL EXPANSION
CELL DIVISION/ EXPANSION

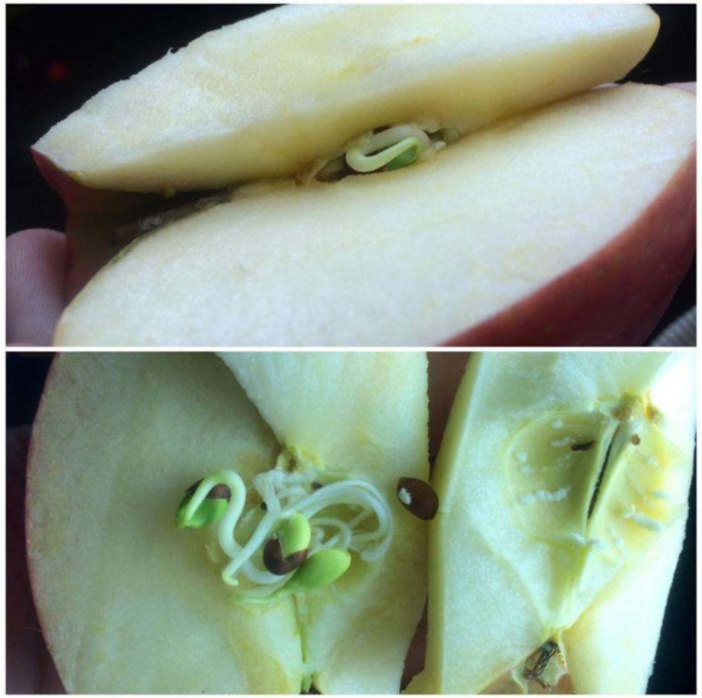


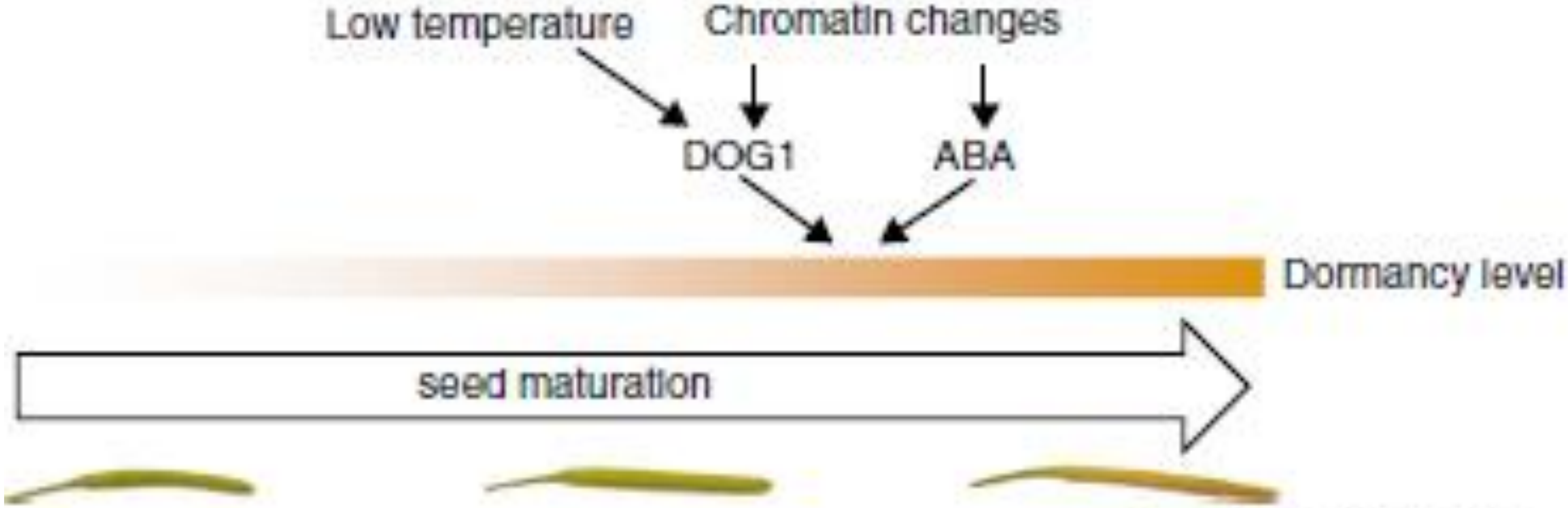
In corn (*Zea mays*) the viviparous mutants (*vp2, vp5, vp7, vp9, vp14*) are defective in abscisic acid production.

The mutants are called viviparous because the seeds germinate while still on the ear inside the husk.

Obviously abscisic acid is more accurately called dormin. Loss of dormin production causes these embryos to fail to go into seed dormancy and to germinate prematurely.



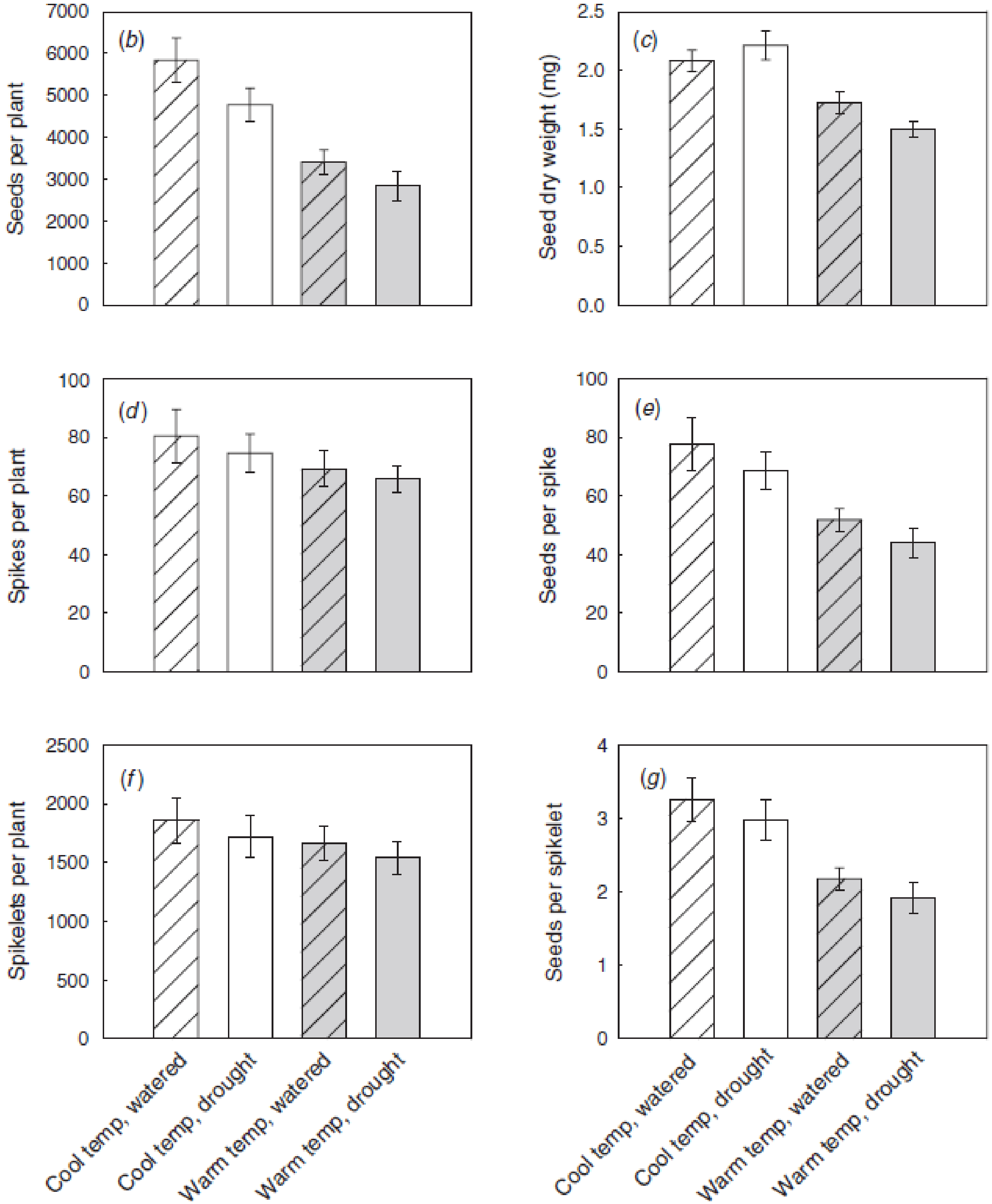




Current Opinion in Plant Biology

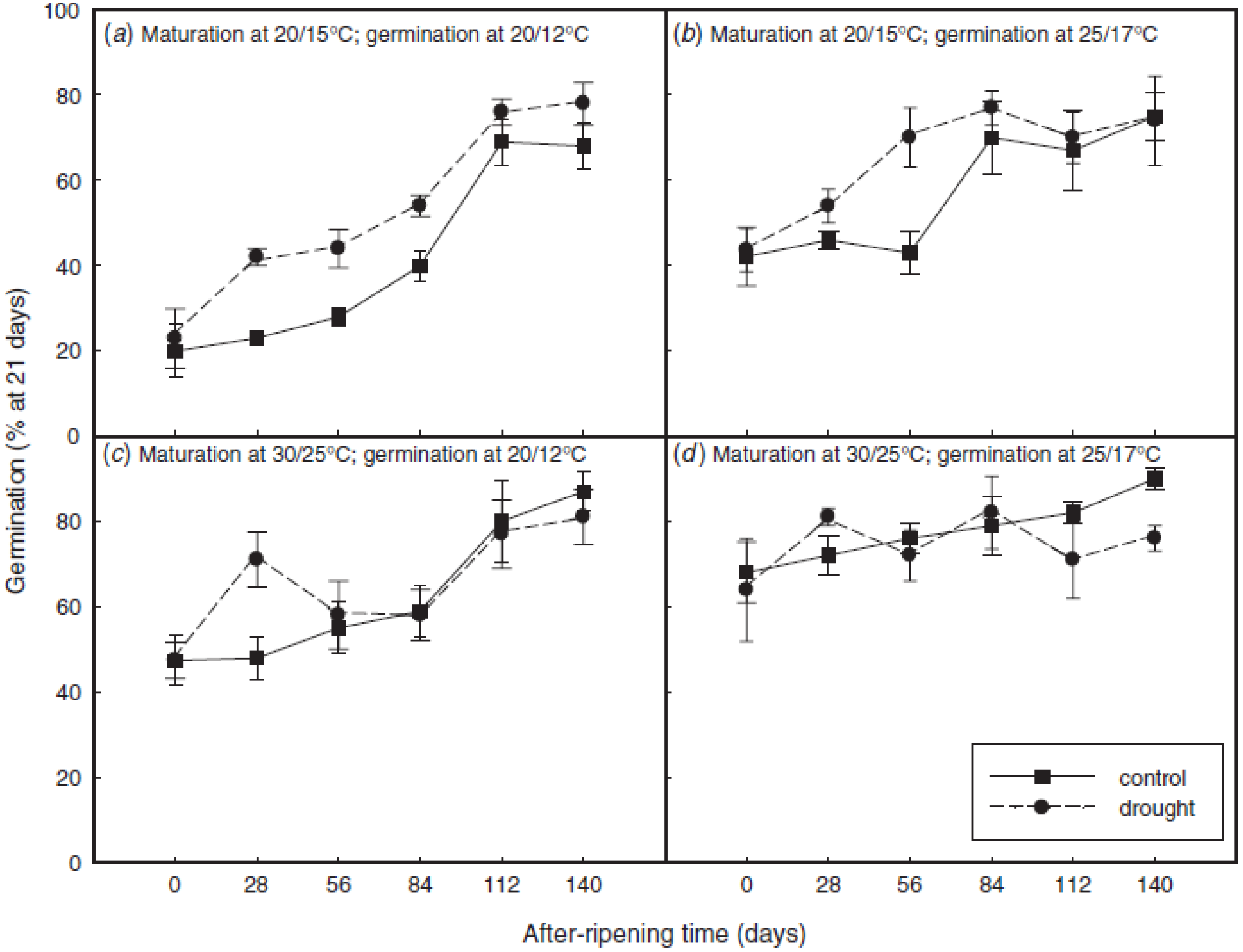
Maturation temperature and rainfall influence seed dormancy characteristics of annual ryegrass (*Lolium rigidum*)

Kathryn J. Steadman[A,D], Amanda J. Ellery[B], Ross Chapman[B], Andrew Moore[C], and Neil C. Turner[B]



Seeds were collected from plants subjected to cool (20/15◦C; a, b) or warm (30/25◦C; c, d) temperatures during flowering and seed development. Plants were also either well-watered (control) or subjected to a drought treatment during flowering and seed development.

There is an effect both during seed development and during seed maturation



Annals of Botany Page 1 of 11
doi:10.1093/aob/mcw125, available online at www.aob.oxfordjournals.org

ANNALS OF BOTANY Founded 1887

Seed dormancy and germination changes of snowbed species under climate warming: the role of pre- and post-dispersal temperatures

Giulietta Bernareggi[1,†], Michele Carbognani[1,†], Andrea Mondoni[2,*] and Alessandro Petraglia[1]

[1]Università di Parma, Dipartimento di Bioscienze, Parco Area delle Scienze 11/A, 43124 Parma, Italy and [2]Università di Pavia, Dipartimento di Scienze della Terra e dell'Ambiente, Via S. Epifanio 14, 27100 Pavia, Italy
**For correspondence. E-mail andrea.mondoni@unipv.it*
[†]These authors contributed equally to this work.

Parental plant growth environment could alter the state of seed dormancy, affecting the timing of emergence and seedling survival. In the context of climate warming, they evaluated the effects of pre- and post-dispersal temperatures on the seed dormancy release and germination requirements of alpine plants.

parental environments can therefore facilitate the evolutionary divergence of life history patterns among plant populations

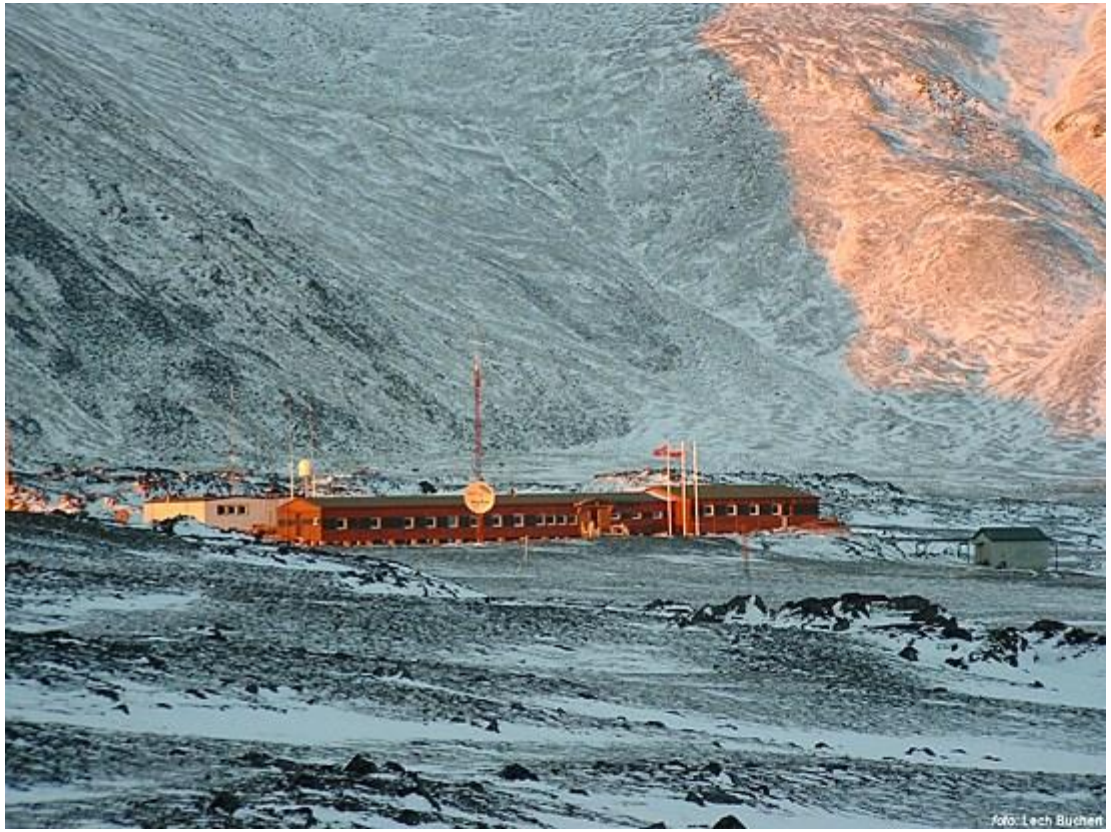
seed behavioral characteristics such as seed dormancy, germination phenology, longevity and persistence in the soil seed bank, which can also be influenced indirectly by seed mass. Temperature, water stress and nitrate in the maternal environment influence the phenotypic expression of all these seed characteristics

A degree of environmental buffering may also occur in the soil seed bank.

Fenner and Thompson (2005) concluded that most evidence suggests that direct effects of global warming on the soil seed bank will be limited, but there may be large indirect effects of climate change on seed banks.

Such indirect effects may result from changes in the dormancy level and seed mass of newly dispersed seeds; this may alter the balance between the short-term and persistent seed banks.


Seeds in Svalbard
©2008 MAPS.com
80°
Laptev Sea
ARCTIC OCEAN
+ North Pole
CANADA
Baffin Bay
Kara Sea
80°
SVALBARD
Greenland (DENMARK)
Longyearbyen
Barents Sea
70°
RUSSIA
Norwegian Sea
Arctic Circle
ICELAND
FINLAND
NORWAY
SWEDEN
EST.
LATVIA
60°
Baltic Sea
LITH.
BELARUS
0 500 mi
0 500 km
North Sea
U.K.
DENMARK
POLAND
UKRAINE
R.Huerta
IRELAND
GERMANY
Geography in the News 3/28/08



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PLOS | ONE

Global Ex-Situ Crop Diversity Conservation and the Svalbard Global Seed Vault: Assessing the Current Status

Ola T. Westengen[1,2]*, Simon Jeppson[1], Luigi Guarino[3]

1 Nordic Genetic Resource Center (NordGen), Alnarp, Sweden, 2 Centre for Development and the Environment, University of Oslo, Oslo, Norway, 3 The Global Crop Diversity Trust, Bonn, Germany

Figure 1. The Svalbard Global Seed Vault. The exterior and interior of the Svalbard Global Seed Vault. Printed under a CC BY license, with permission from Photographer Mari Tefre.
doi:10.1371/journal.pone.0064146.g001

In the 1920s the Russian geneticist and botanist Nicolai Vavilov started systematically collecting and conserving genetic diversity as a resource for crop breeding, making ex-situ (off-site) conservation part of the agricultural R&D system.

Svalbard Global Seed Vault

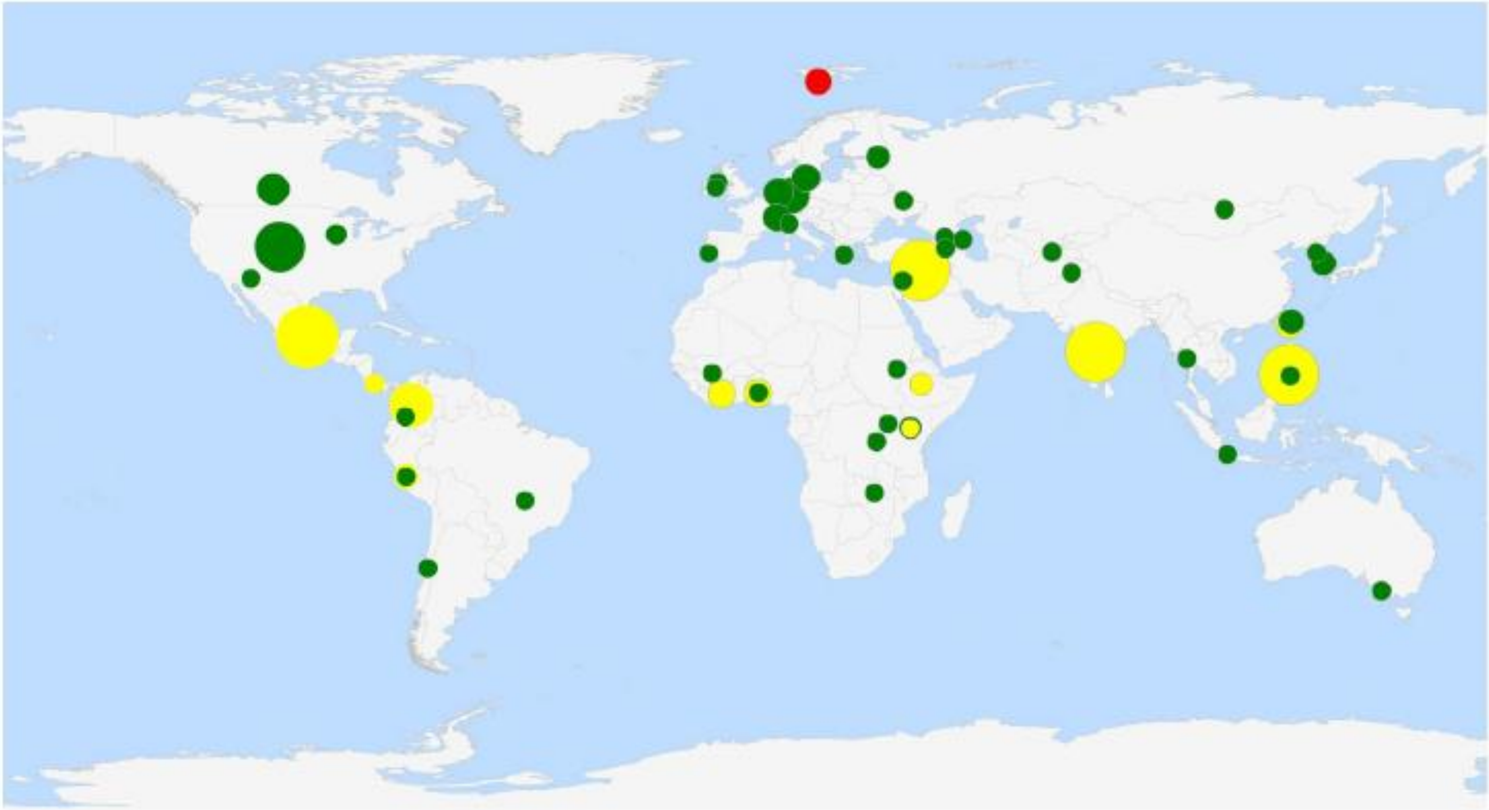


Figure 2. Genebanks with safety deposits in the Svalbard Global Seed Vault. The radius of the circles is relative to the number of samples deposited, and the circle size reflects the size of the deposits according to 25 size classes. Yellow circles are International Agricultural Research Centers, and green circles are regional, national or subnational genebanks. The radius of the red SGSV circle is not relative to the holdings.
doi:10.1371/journal.pone.0064146.g002

Currently, 774,601 samples are deposited at Svalbard by 53 genebanks. We estimate that more than one third of the globally distinct accessions of 156 crop genera stored in genebanks as orthodox seeds are conserved in the Seed Vault.

Multi-million dollar upgrade planned to secure 'failsafe' Arctic seed vault

“The whole reason for the Global Seed Vault in Svalbard in the permafrost area is it has to be self sufficient, in case of a really big disaster in the world,” he said. “[If] all the humans in the lower part of the world are destroyed, perhaps a 100 years later the survivors can come here and find the seeds. The seeds will be OK as they are in the [deep] permafrost layer. But as it is today, the whole entrance will be filled up with water and this will freeze and it will be blocked after a few years, so it will not be possible to get into the seed vault. There will be a big iceberg in the tunnel.”

Other environmental variables can also impact plant growth, and seed characteristics (yield, size, dormancy) and may interact with the effect of increases in mean temperature; a principal one of these is nitrate availability. For example, the **nitrate** content in both soil and seed has an impact on dormancy in *Arabidopsis*

While carbon pollution gets all the headlines for its role in climate change, **nitrogen pollution is arguably a more challenging problem**. Somehow we need to grow more food to feed an expanding population while minimising the problems associated with nitrogen fertiliser use.

In Europe alone, the environmental and human health costs of nitrogen pollution are estimated to be €70-320 billion per year.
Nitrogen emissions such as ammonia, nitrogen oxide and nitrous oxides contribute to particulate matter and acid rain. These cause respiratory problems and cancers for people and damage to forests and buildings.

Nitrogenous gases also play an important role in global climate change. **Nitrous oxide (N_2O)** is a particularly potent greenhouse gas as it is over 300 times more effective at trapping heat in the atmosphere than carbon dioxide.

Nitrogen from fertiliser, effluent from livestock and human sewage boost the growth of algae and cause water pollution. The estimated A$8.2 billion damage bill to the Great Barrier Reef is a reminder that our choices on land have big impacts on land, water and the air downstream.

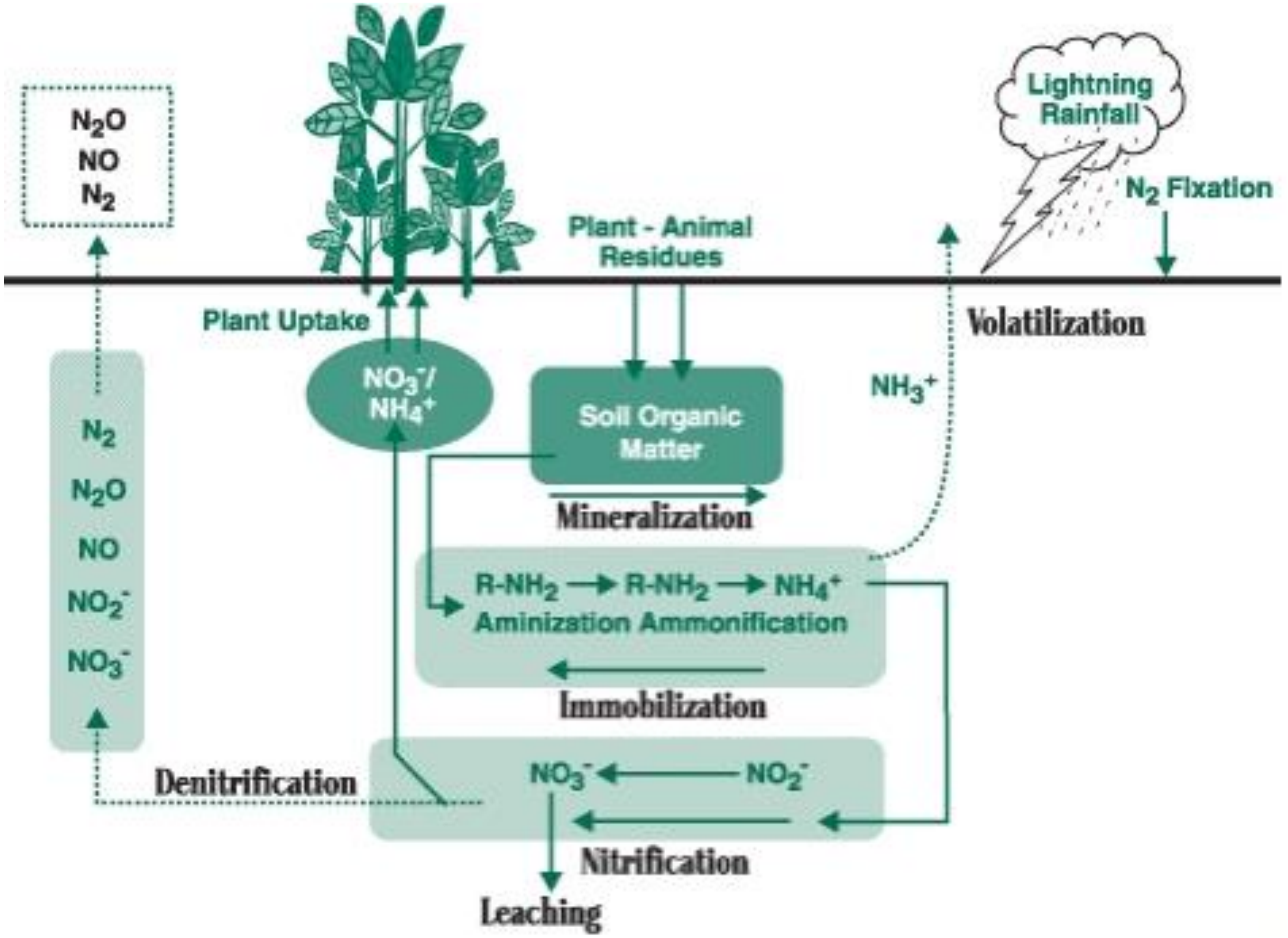
Lost nitrogen harms farmers too, as it represents reduced potential crop growth or wasted fertiliser. This impact is most acute for smallholder farmers in developing countries, for whom nitrogen fertiliser is often the biggest cost of farming. The reduced production from the lost nitrogen can represent as much as 25% of the household income.

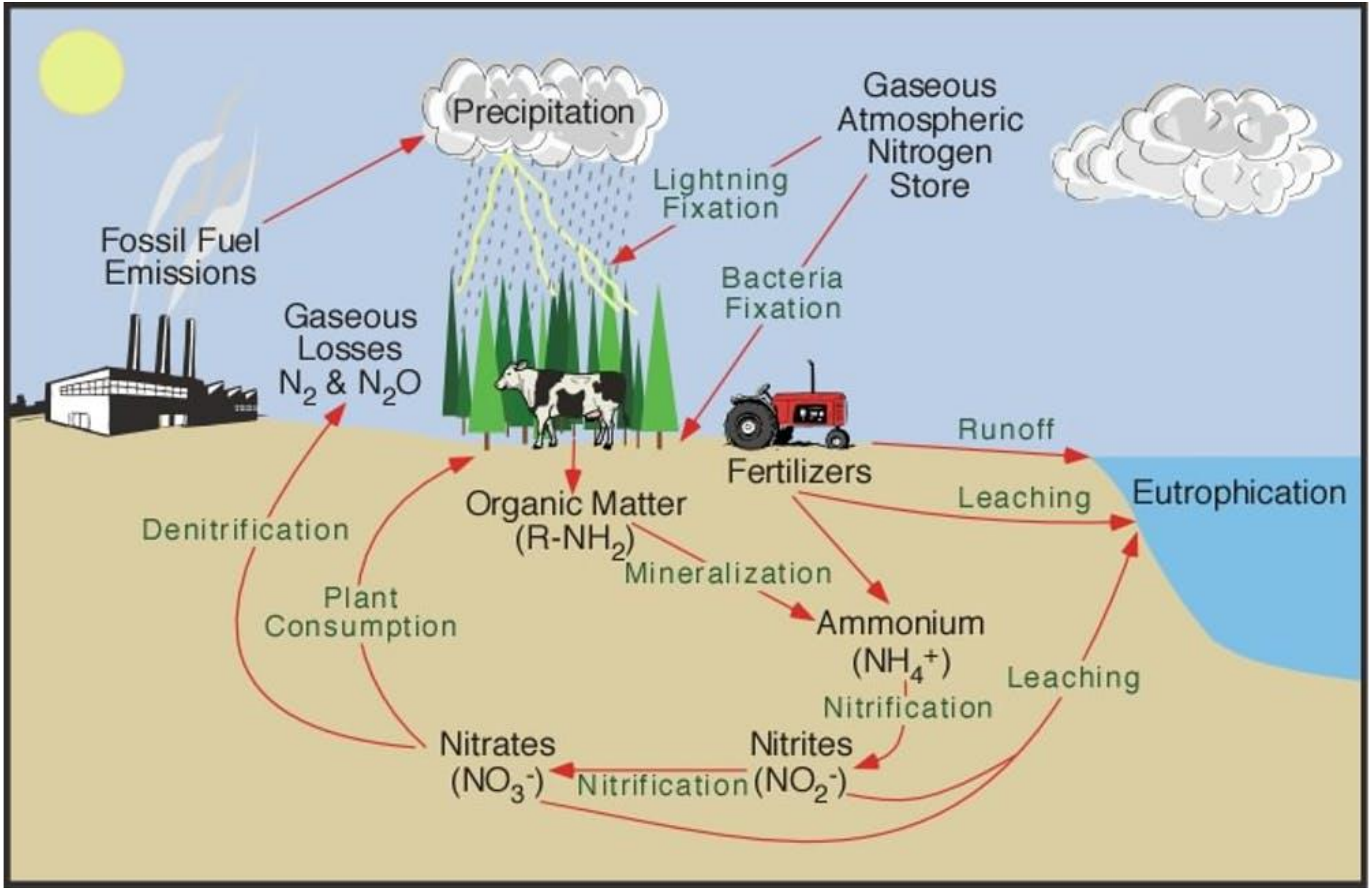
The solution to the nitrogen challenge will need to come from a combination of technological innovation, policy and consumer action.

Low nitrate regime (3mM)

Standard nitrate regime (10mM)

Nitrate: a limiting factor for plant growth


N2O
NO
N2
Plant - Animal Residues
Lightning Rainfall
N2 Fixation
Plant Uptake
Volatilization
NO3-/ NH4+
Soil Organic Matter
NH3+
N2
N2O
NO
NO2-
NO3-
Mineralization
R-NH2 → R-NH2 → NH4+
Aminization Ammonification
Immobilization
Denitrification
NO3- ← NO2-
Nitrification
Leaching


Precipitation
Gaseous
Atmospheric
Nitrogen
Store
Lightning
Fixation
Fossil Fuel
Emissions
Bacteria
Fixation
Gaseous
Losses
N_2 & N_2O
Runoff
Fertilizers
Leaching
Eutrophication
Organic Matter
($R-NH_2$)
Denitrification
Mineralization
Plant
Consumption
Ammonium
(NH_4^+)
Leaching
Nitrification
Nitrates
(NO_3^-)
Nitrification
Nitrites
(NO_2^-)

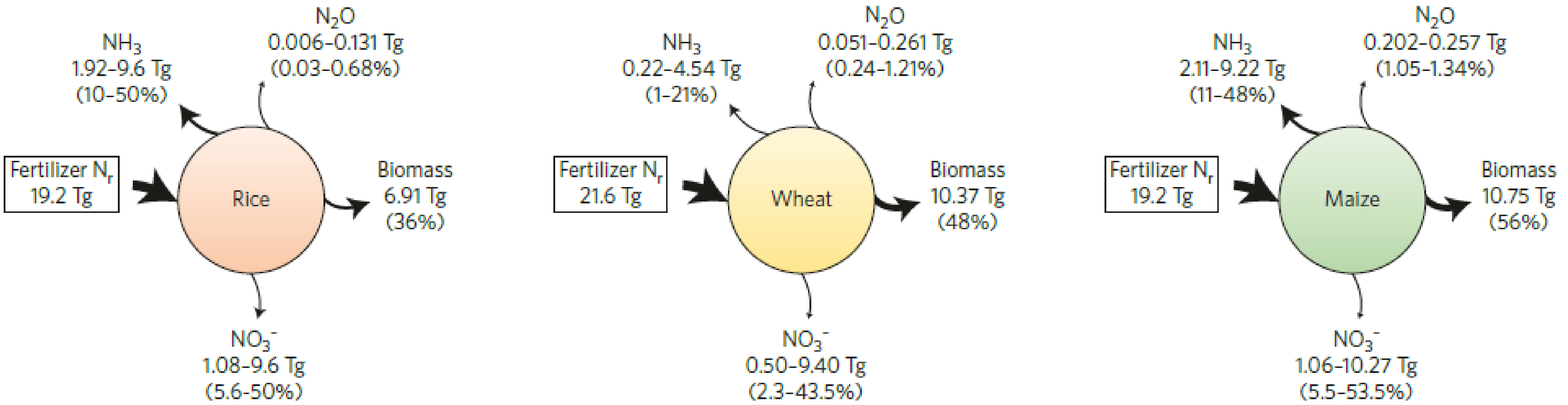


Figure 1 | Nitrogen budgets of the 'big three' crops. Of the *c.* 120 Tg N yr^{-1} fixed by the Haber-Bosch process[2], 50% is applied to the world's three major cereals, rice (16%), wheat (18%) and maize (16%) (ref. 119), which together provide more than 60% of human caloric intake[120] and cover approximately 546 million ha (36%) of global cropland[33]. Global averages of fertilizer N recovery (the proportion of fertilizer N retained as biomass) for the three cereals are shown[119]. The remaining N is lost to the environment through NH_3 volatilization, NO_3^- leaching and runoff, denitrification (producing NO, N_2O, and N_2 gases), and is also immobilized by other organisms or soils[30,33,121-130]. The proportion of N lost will vary depending on fertilizer type and environmental factors, including temperature, wind speed, rain, and soil properties such as cation exchange capacity and pH.

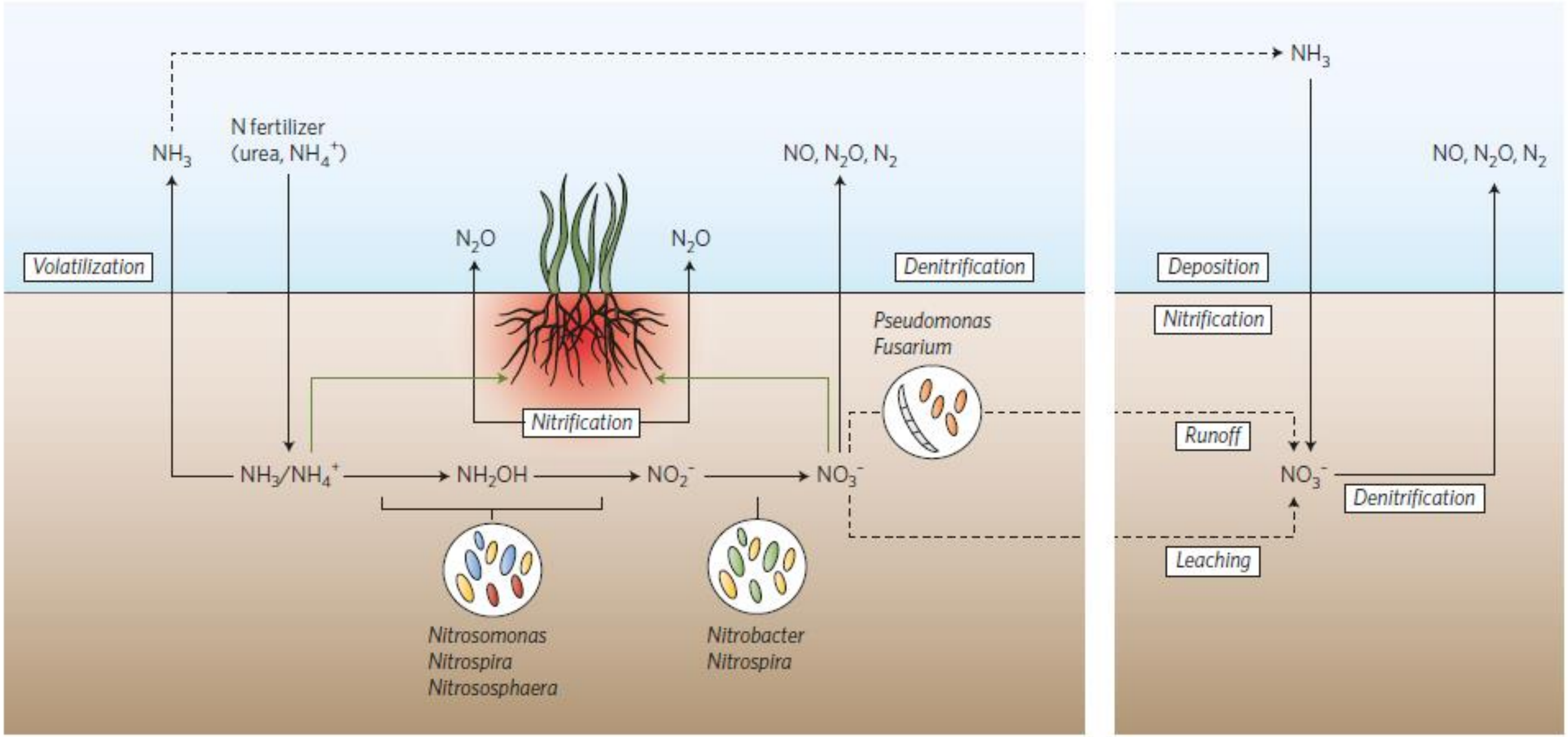


Figure 2 | Schematic overview of the fate of nitrogen fertilizers applied to agricultural systems. N fertilizers (applied mostly as urea or NH_4^+ salts, with the former hydrolysed to NH_3 by ureases) undergo nitrification, in which soil microorganisms (some genera of which are listed) oxidize NH_3 into NO_3^- via NH_2OH and NO_2^-. BNIs exuded from plant roots (shown in red) can inhibit these reactions (see main text for details). Plants can take up either inorganic N source (NH_3/NH_4^+ and NO_3^-; green arrows). N_2O, a potent greenhouse gas, is released predominately during nitrification in agricultural soils but can also stem from microbial denitrification. NO_3^- and NH_3 can travel long distances (dashed arrows) away from agricultural sites and into neighbouring ecosystems (via runoff/leaching and volatilization/deposition, respectively), causing indirect N_2O emissions and other problems locally (for example, soil nutrient losses, acidification, eutrophication and biodiversity loss).

Journal of Experimental Botany, Vol. 57, No. 3, pp. 517–526, 2006
doi:10.1093/jxb/erj060 Advance Access publication 23 December, 2005
Journal of Experimental Botany

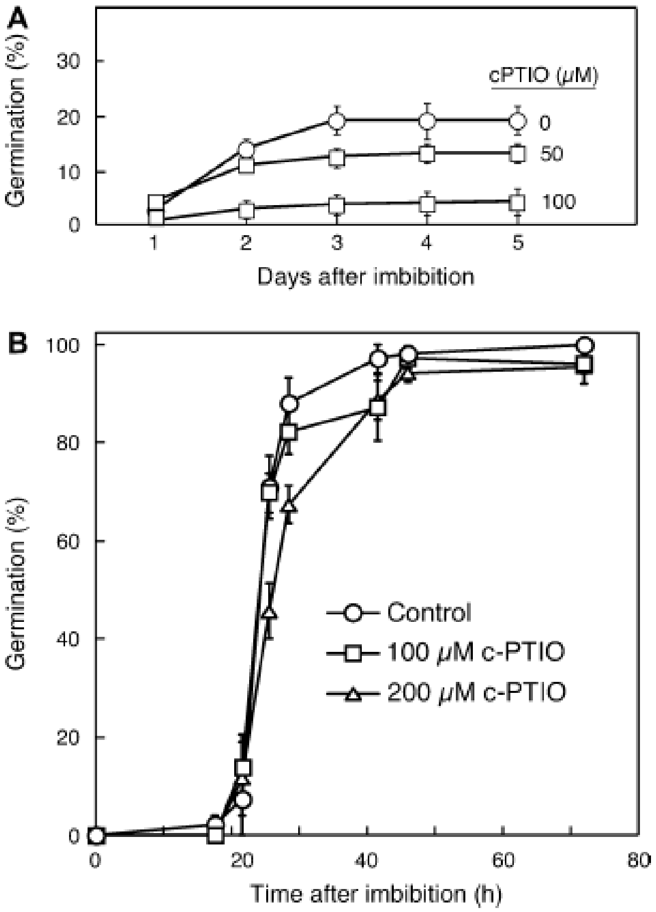
FOCUS PAPER

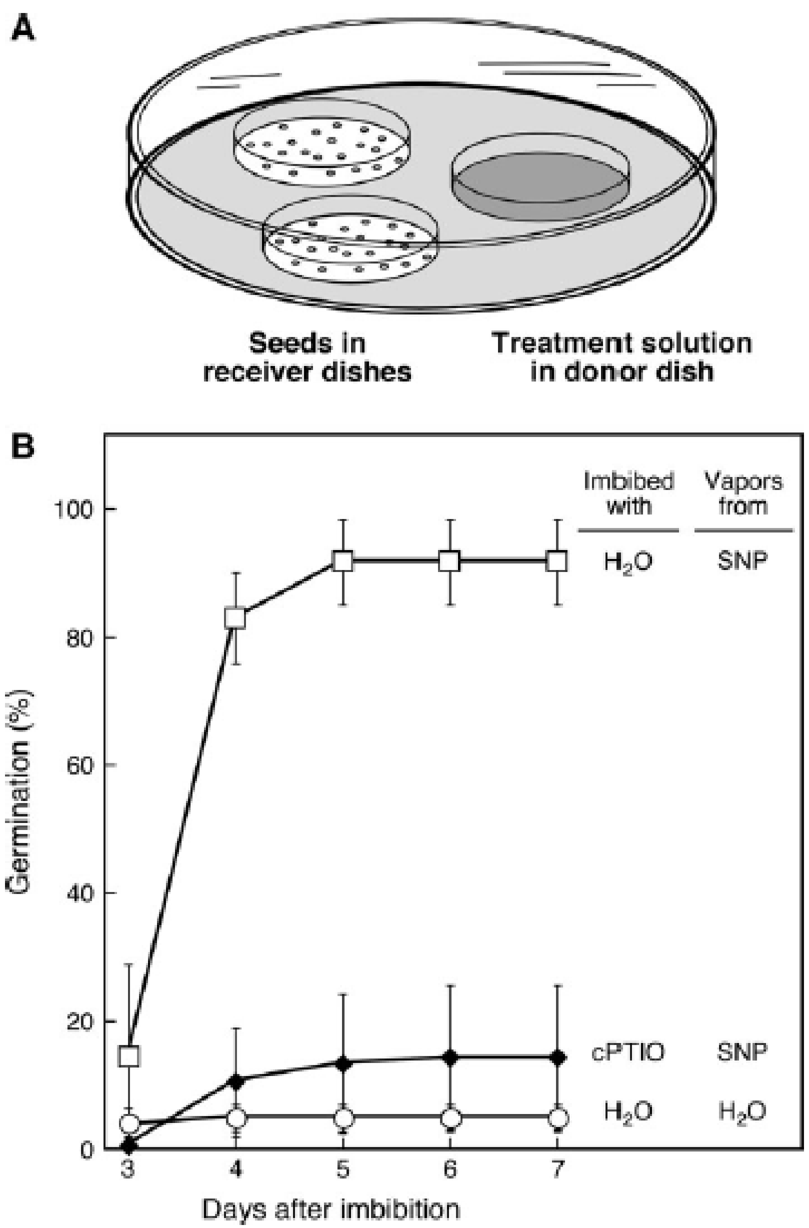
Nitric oxide reduces seed dormancy in *Arabidopsis*

Paul C. Bethke*, Igor G. L. Libourel and Russell L. Jones

<u>SCAVENGER of NO</u>
cPTIO = 2-(4-Carboxyphenyl)-4,4,5,5-tetramethylimidazoline-1-oxyl-3-oxide potassium salt

NO PRODUCER
SNP = Sodium nitroprusside





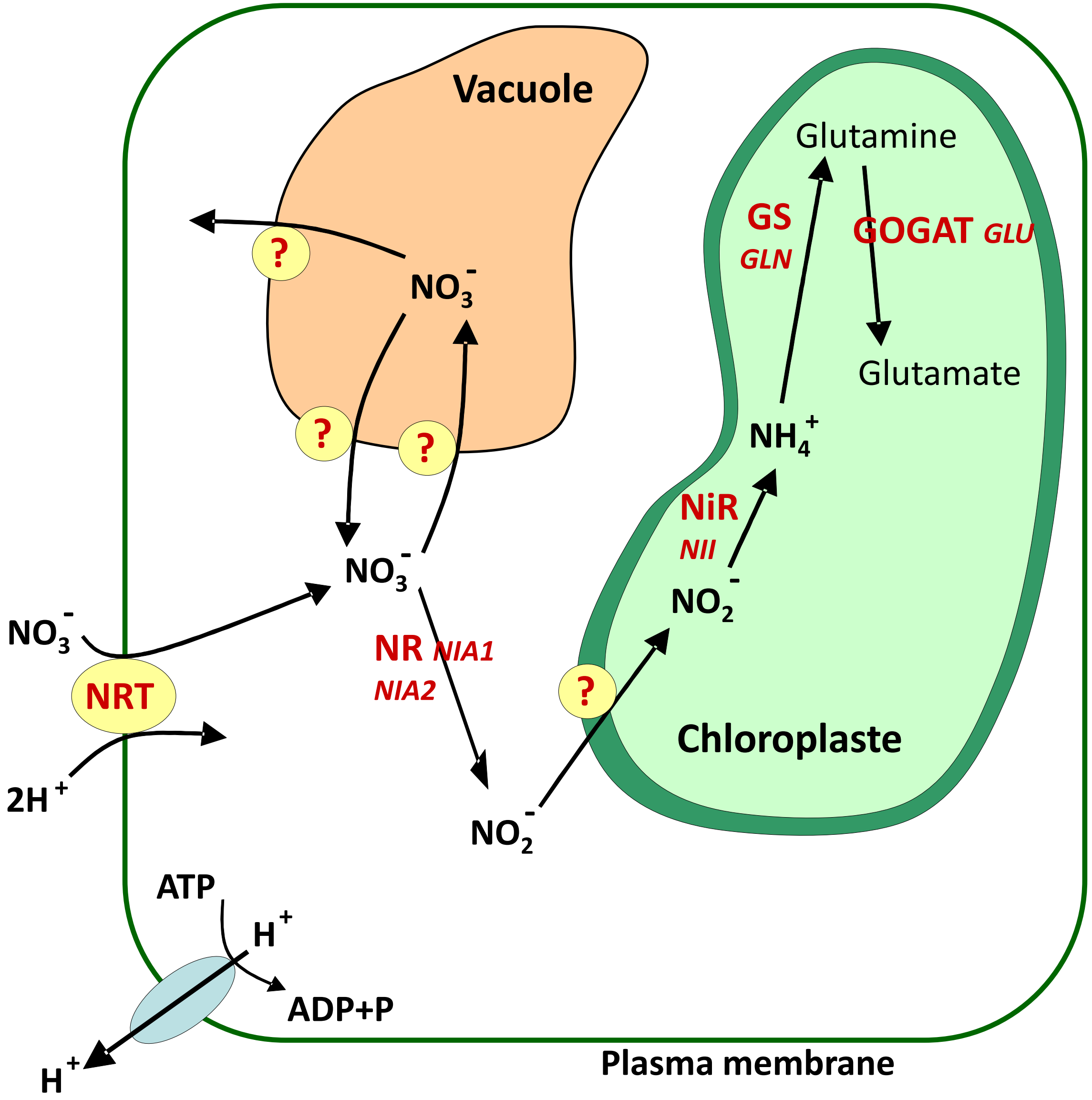
parental environments can therefore facilitate the evolutionary divergence of life history patterns among plant populations

seed behavioral characteristics such as seed dormancy, germination phenology, longevity and persistence in the soil seed bank, which can also be influenced indirectly by seed mass. **Temperature, water stress and nitrate in the maternal environment** influence the phenotypic expression of all these seed characteristics

Nitrogen, nutrient and signaling

- NO_3^- uptake through specific transporters (NRT) and storage in the vacuole
- NO_3^- reduced to NH_4^+ in two steps
- NH_4^+ is incorporated into aminoacids

NO_3^- is a nutrient essential for plant growth



Low nitrate regime (3mM)

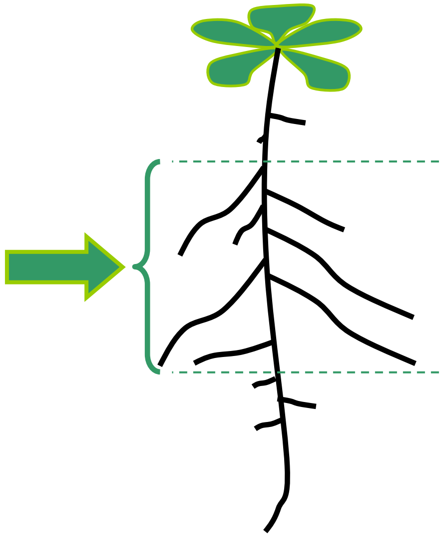
Standard nitrate regime (10mM)

Nitrate: a limiting factor for plant growth

Nitrate: a signal for plant development

Lateral root elongation

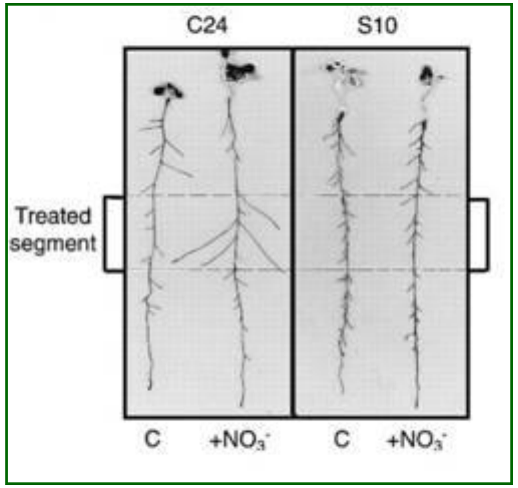
1mM NO_3^-
local
applications



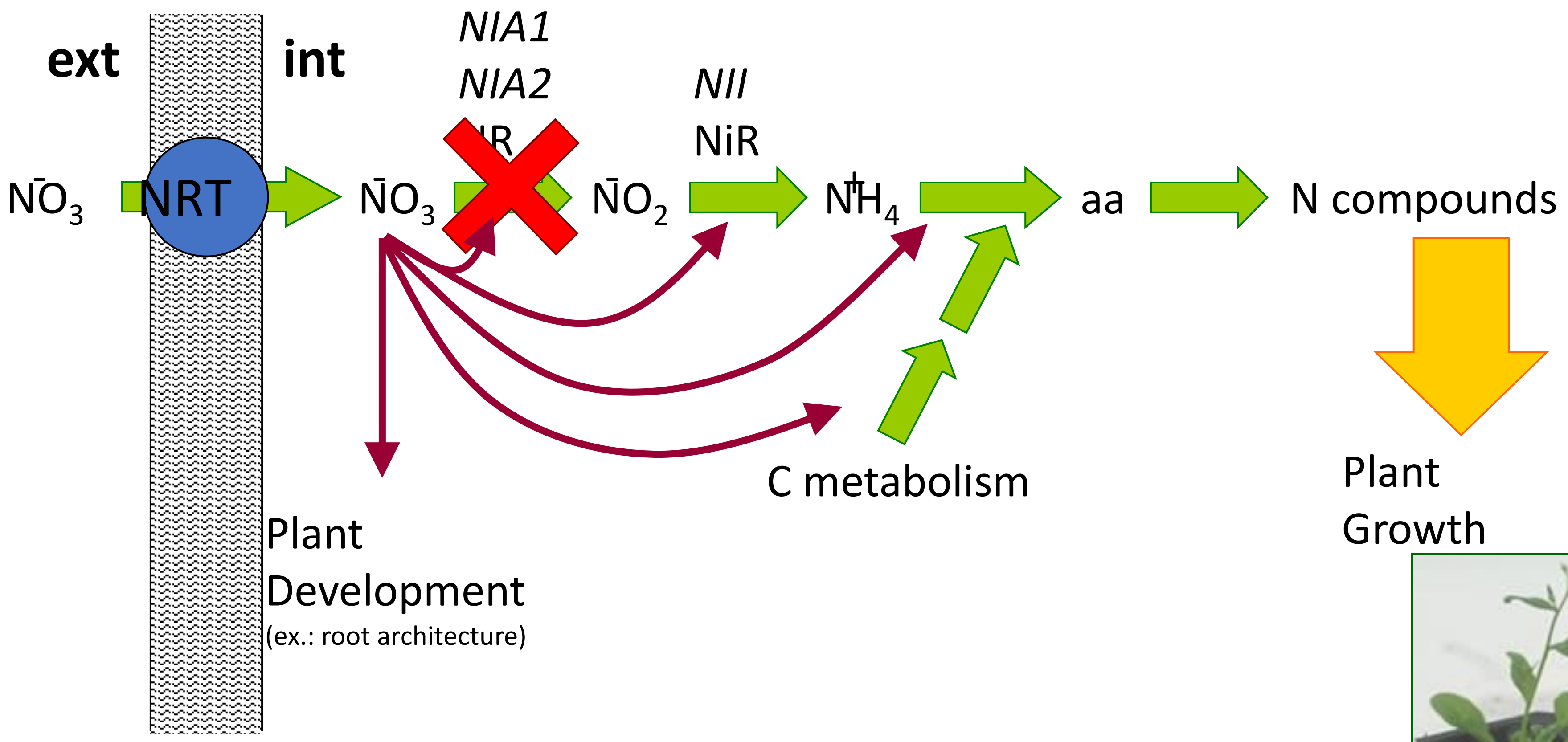
Zhang and Forde, 2000

ANR1, a transcription factor
important for NO_3^- control of lateral root growth

(Zhang and Forde, 1998)



NO_3^-: N source and signaling compound



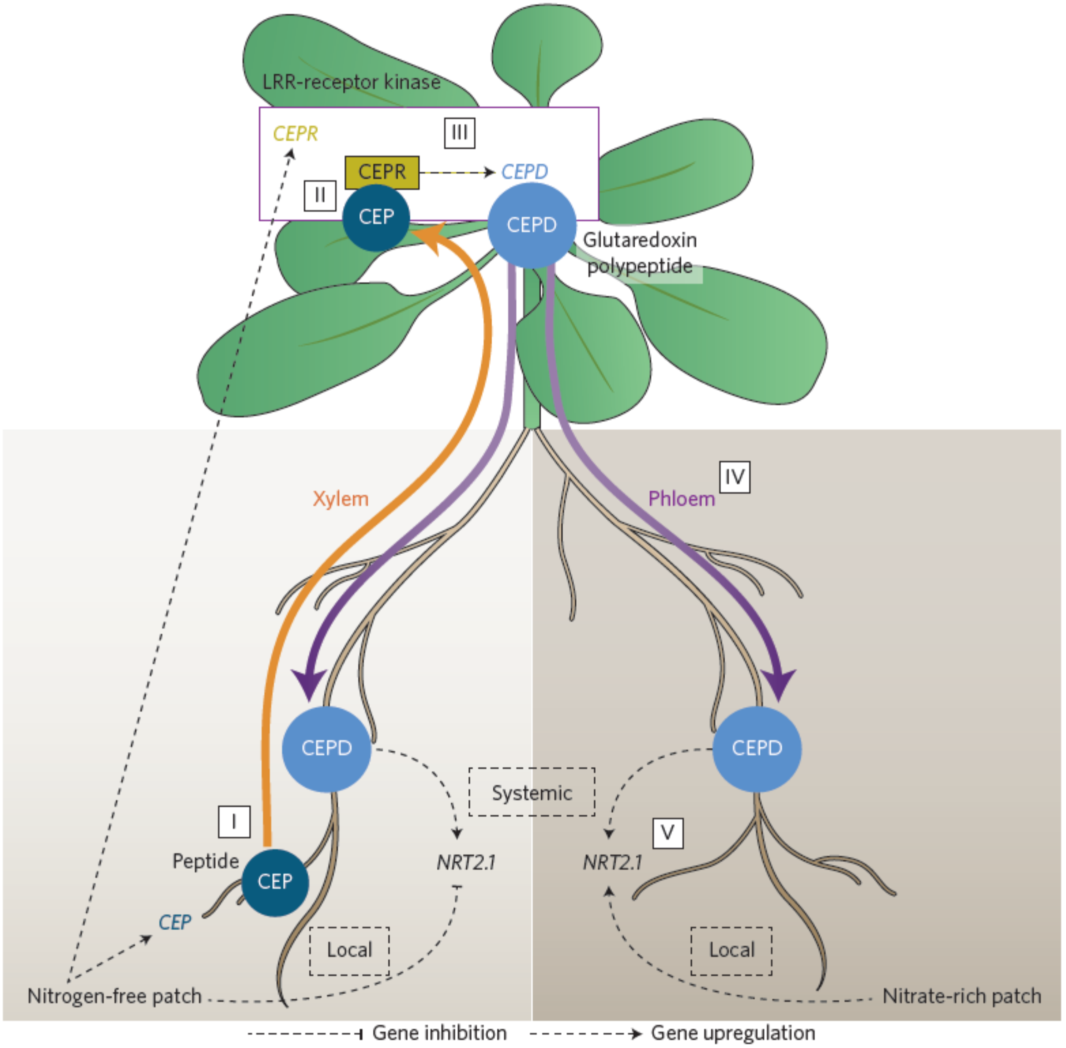
- NO_3^- as N source: plant nutrition and growth
- NO_3^- as signal: root architecture and gene regulation
- NR deficient mutants: dissection of nutritional and signaling role of NO_3^-

SYSTEMIC NUTRIENT SIGNALLING

On the road for nitrate

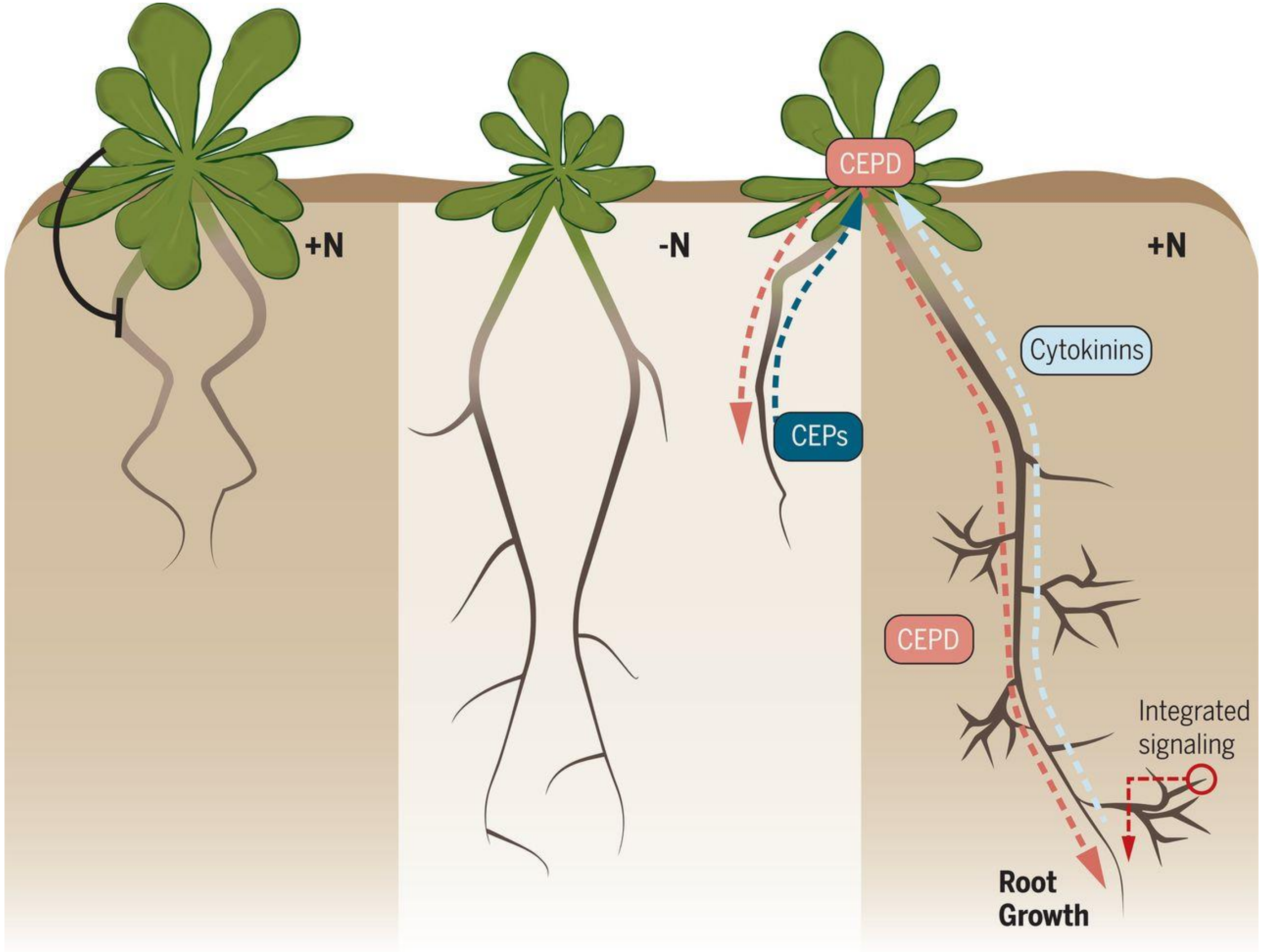
Whole plant nutrient signalling involves bidirectional exchange of signal molecules between roots and shoots. For nitrogen uptake, in addition to the root-to-shoot delivery of nitrogen-deprivation information, a shoot-to-root path is now defined.

Sandrine Ruffel and Alain Gojon



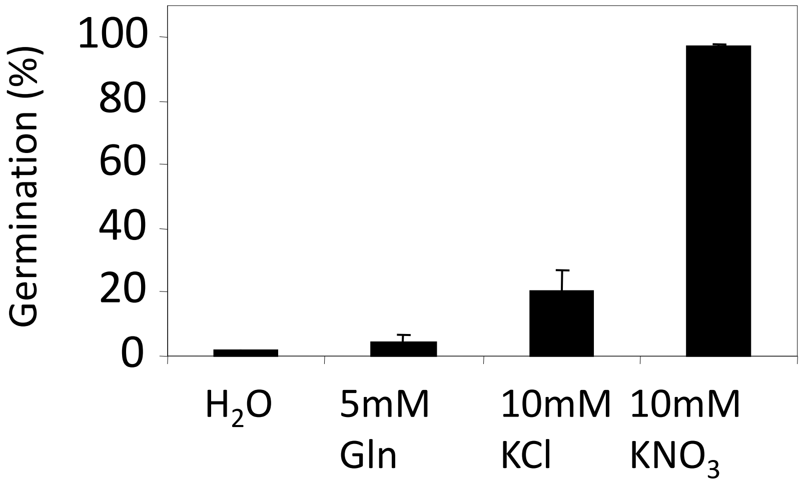
- (I) nitrogen deprivation of one part of the root system induces local synthesis of 15 amino acid CEP peptides, which are translocated to shoots via the xylem stream
- (II) CEP peptides are perceived in shoots by leucine-rich repeat (LRR)-receptor kinases (CEPR1 and CEPR2)
- (III) induction of two glutaredoxin genes in the phloem, named CEPD1 and CEPD2
- (IV) CEPD1 and CEPD2 are phloem-mobile signals that relay nitrogen-deprivation information to roots for upregulation of NRT2.1

Nitrate act as a signal and not only as a nutrient for plants

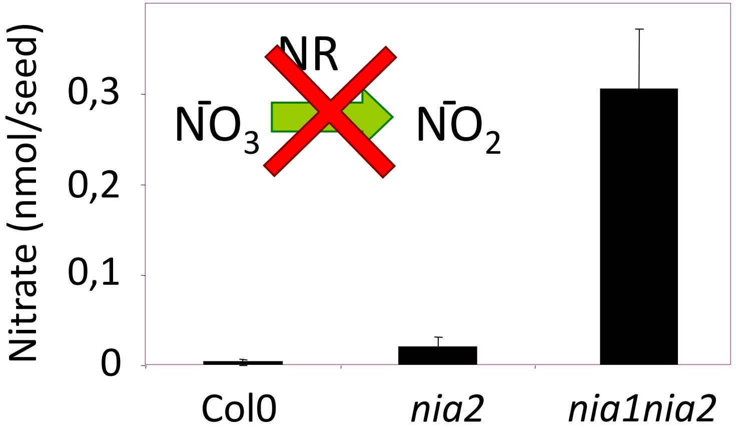


- Exogenous effect:

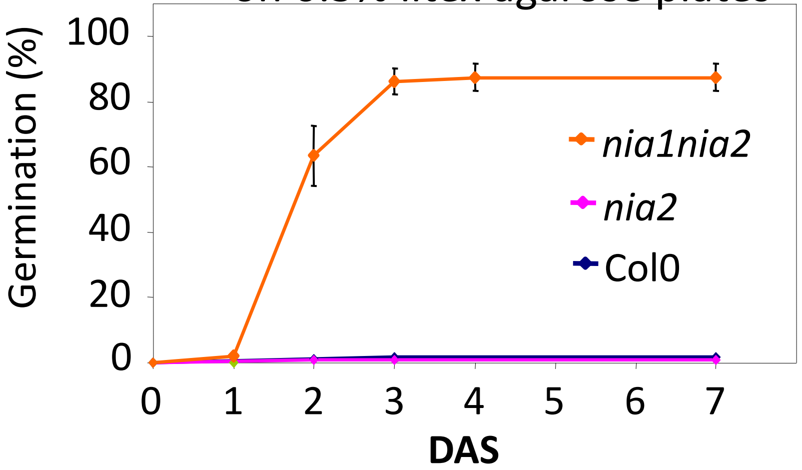
  KNO_3 has a higher effect than KCl, Gln has almost no effect on germination.



- Endogenous effect:

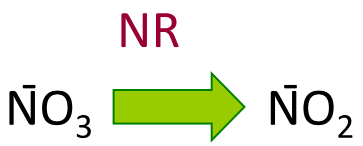


Freshly harvested seeds sown on 0.5% litex agarose plates

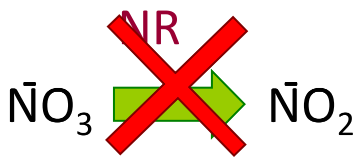


Good correlation: low seed dormancy/NO_3 content in seeds

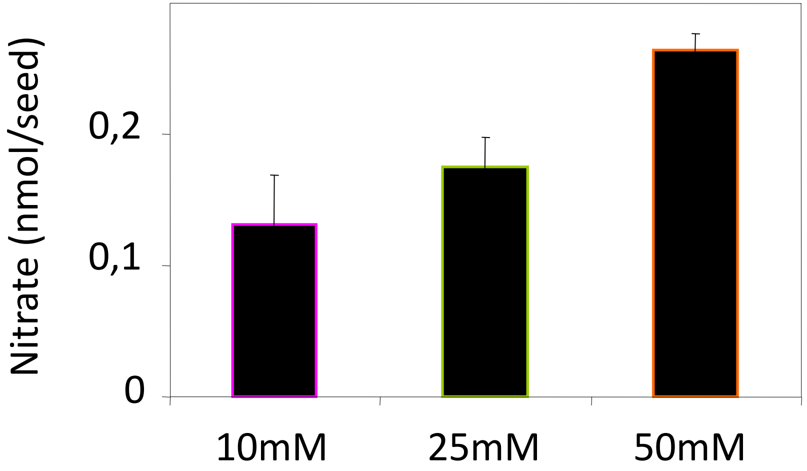
High NO_3 regime alleviates seed dormancy in WT



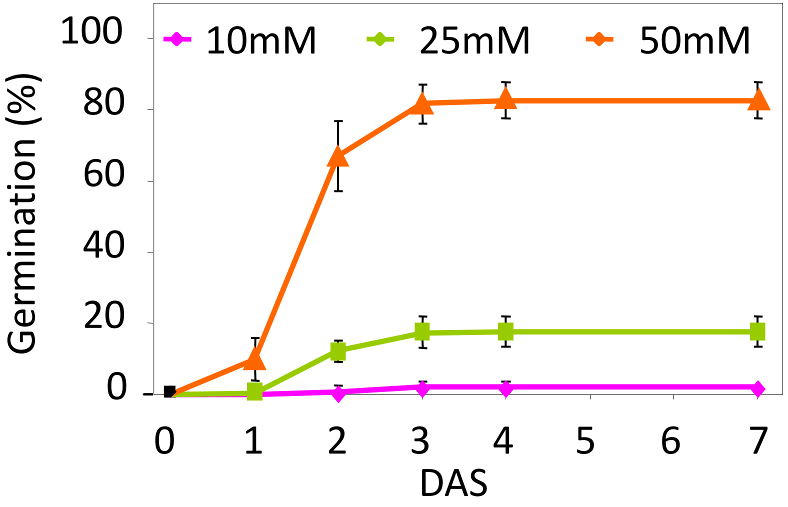
Dissection of nutritional and signalling role of NO_3^-



Nitrate contents in Col0 seeds produced under various NO_3 regimes:



Freshly harvested seeds sown on 0.5% litex agarose plates:



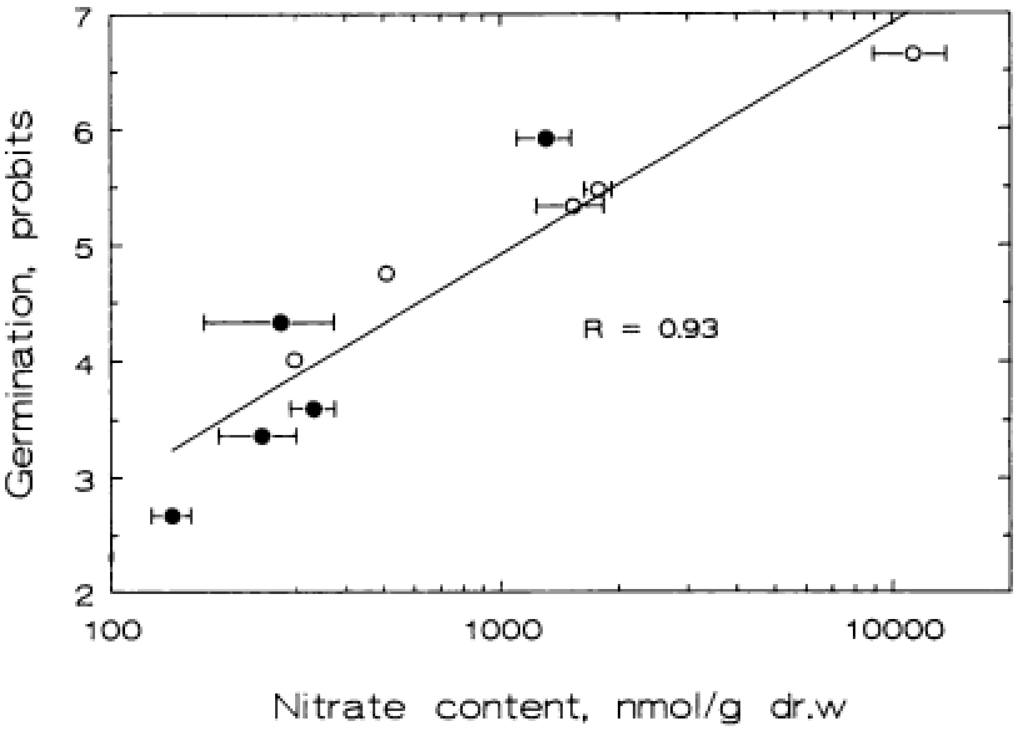
- High NO_3 regime is correlated to:
  -high NO_3 content in the seeds
  -low seed dormancy

Plant Physiol. (1990)94, 1096–1102
0032-0889/90/94/1096/07/$01.00/0

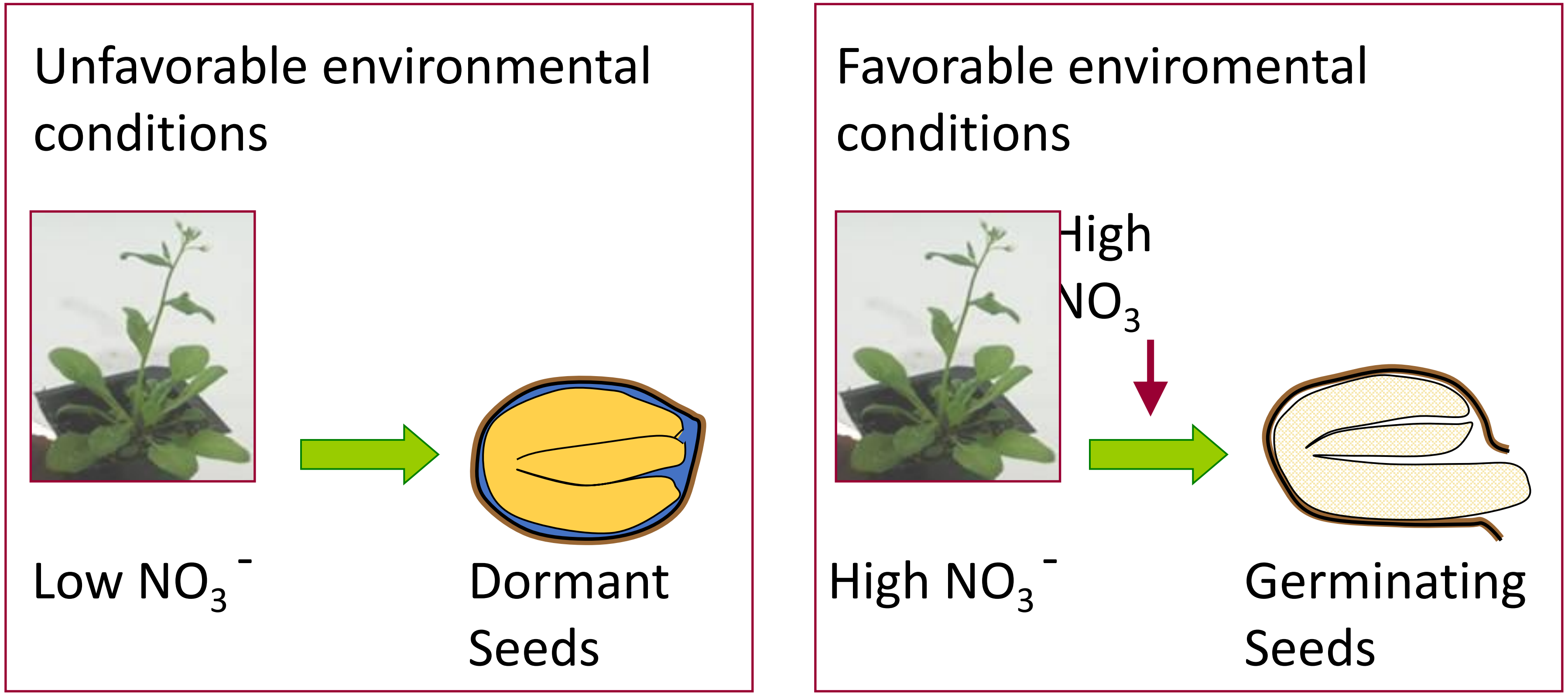
Received for publication April 6, 1990
Accepted July 12, 1990

Dose-Response Analysis of Factors Involved in Germination and Secondary Dormancy of Seeds of *Sisymbrium officinale*

II. Nitrate

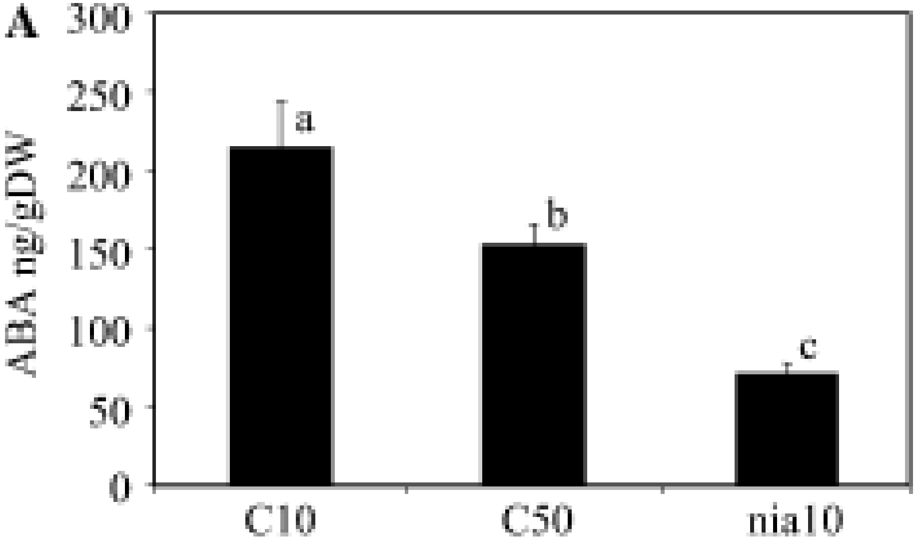


Dormancy regulation by nitrate is part of plant adaptation to its environment.

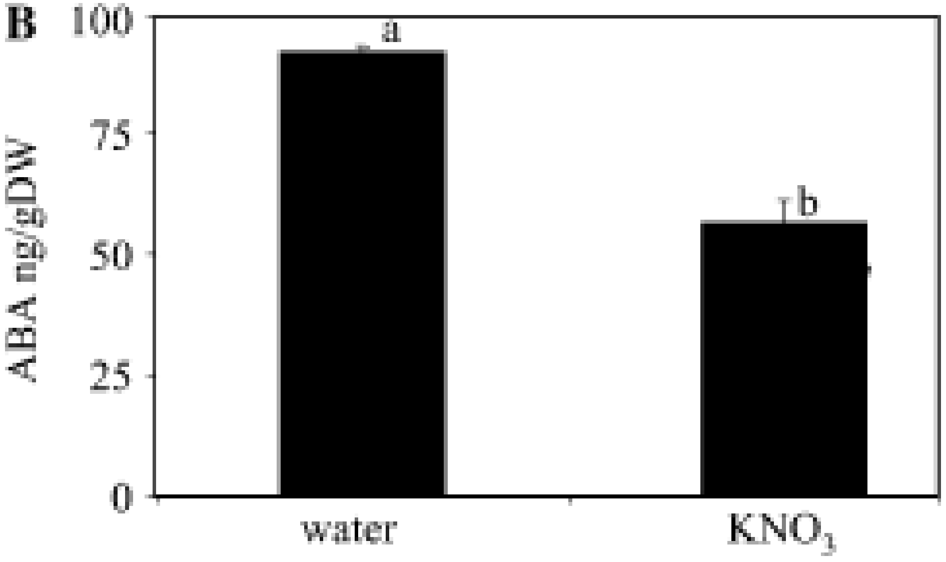


More nitrate -> less dormancy

at hormone level, what do you expect?

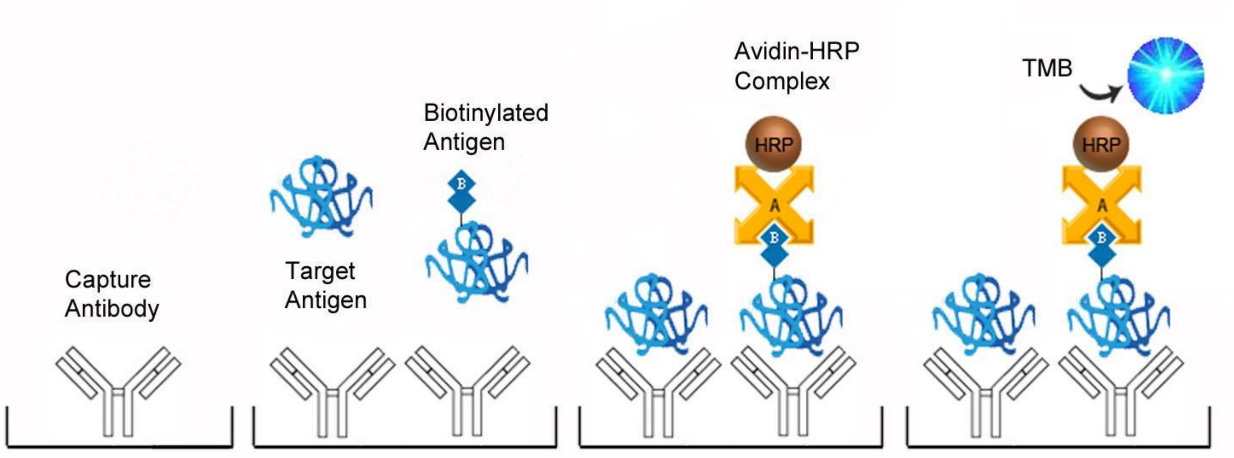


ABA content of seeds treated with endogenous nitrate.



ABA content of seeds treated with exogenous nitrate.

- ELISA



- HPLC

ELSEVIER
Plant Physiology and Biochemistry
Volume 43, Issue 4, April 2005, Pages 407-411

A rapid method for analysis of abscisic acid (ABA) in crude extracts of water stressed *Arabidopsis thaliana* plants by liquid chromatography—mass spectrometry in tandem mode

Marta López-Carbonell [a], Olga Jáuregui [b]

More nitrate -> less ABA

How does nitrate break seed dormancy?

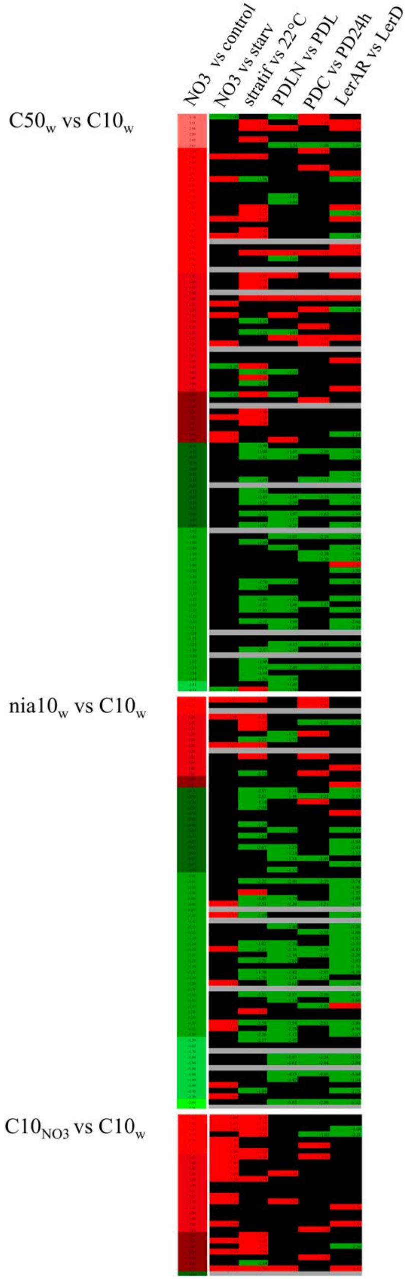
↓

compare dormant versus non-dormant

↓

What conditions can you choose?

Transcriptomics of various conditions



<u>Exogenous effect</u>

- w = water
- NO3 = nitrate in the germination medium

<u>Endogenous effect</u>

- C10 = WT mother plant watered with 10mM nitrate
- C50 = WT mother plant watered with 50mM nitrate
- nia10 = nia1nia2 mutant plant watered with 10mM nitrate

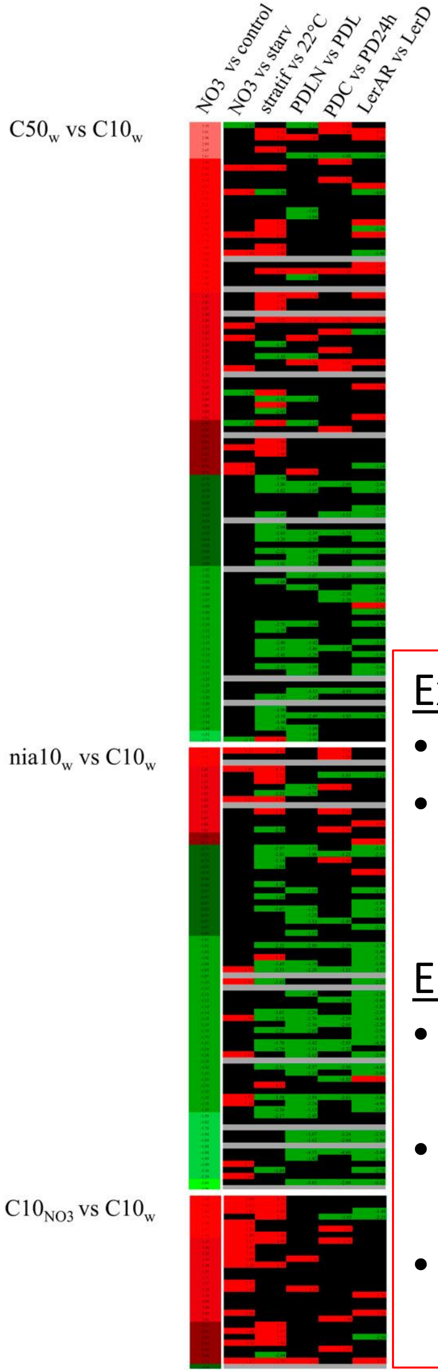
Published array data (second to sixth columns):

- nitrate provision to starved plants
- comparison of Ler seeds imbibed at 4C and 22C imbibed seeds
- nitrate-treated primary dormant Cvi seeds afterripened for 91 d and then imbibed for 24 h in the light compared with the same seeds imbibed in the light without nitrate
- cold-treated primary dormant Cvi seeds afterripened for 117 d compared with 20C imbibed primary dormant Cvi seeds in the dark
- after-ripened Ler seeds imbibed for 24 h compared with freshly harvested Ler seeds imbibed for 24 h (Carrera et al., 2007; Ler AR versus Ler D).

More nitrate -> less ABA

what ABA-reated genes could be of interest?

Transcriptomics of various conditions



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- C50 = WT mother plant watered with 50mM nitrate
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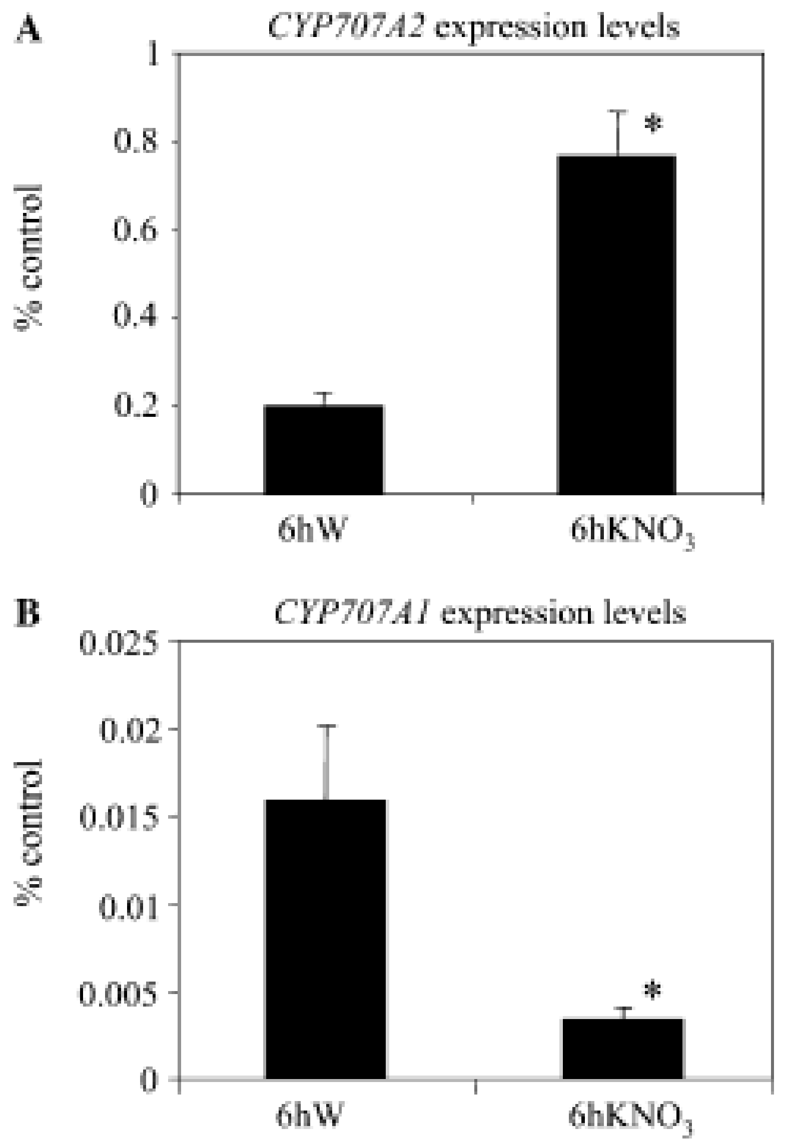
qRT-PCR validation

CYP707a2 is involved in ABA breakdown



ABA has a breakdown

Abscisic acid (ABA) dynamically balances plant water use and availability. It is synthesized during water deficit and quickly catabolized into breakdown products previously thought to be largely inactive. New work demonstrates that phaseic acid, a major ABA catabolite, is a weak ABA receptor agonist with its own auxiliary role in water relations.

Jorge Lozano-Juste and Sean R. Cutler

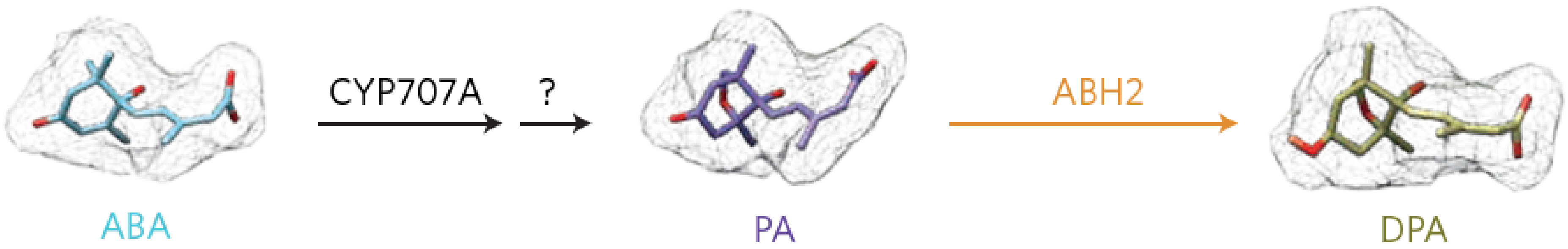
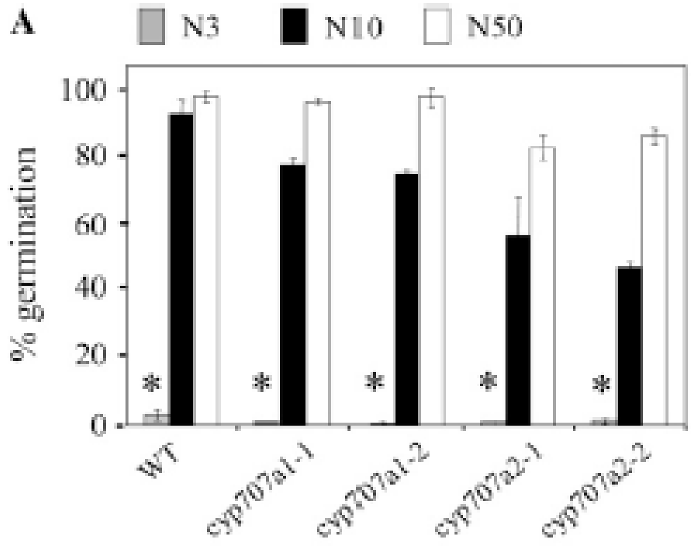
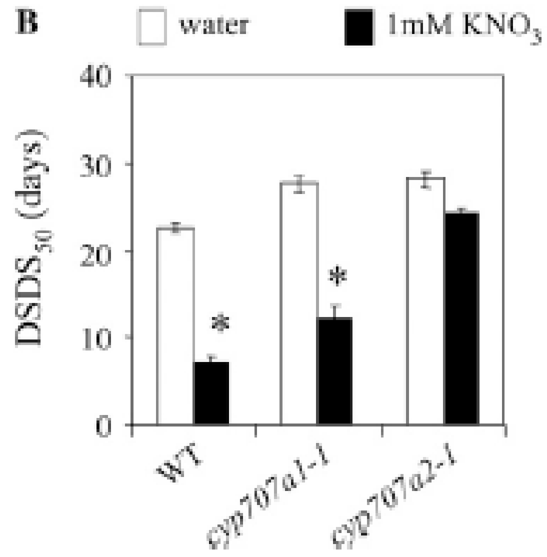


Figure 1 | ABA catabolism. Abscisic acid (ABA) is hydroxylated by CYP707A to 8′-OH-ABA; this then isomerizes spontaneously to yield phaseic acid (PA), which is subsequently reduced to dihydrophaseic acid (DPA). Weng *et al.* have identified *ABA HYPERSENSITIVE 2* (*ABH2*), a member of the dihydroflavonol reductase family, as the PA reductase. Using a combination of genetics, biochemistry and structural biology, the authors demonstrate that PA is a weak but stable ABA receptor agonist that regulates transpiration and responses to water deficit.

CYP707a2 is involved in dormancy release



«Endogenous nitrate», nitrate given to the mother and accumulated in the embryo during maturation

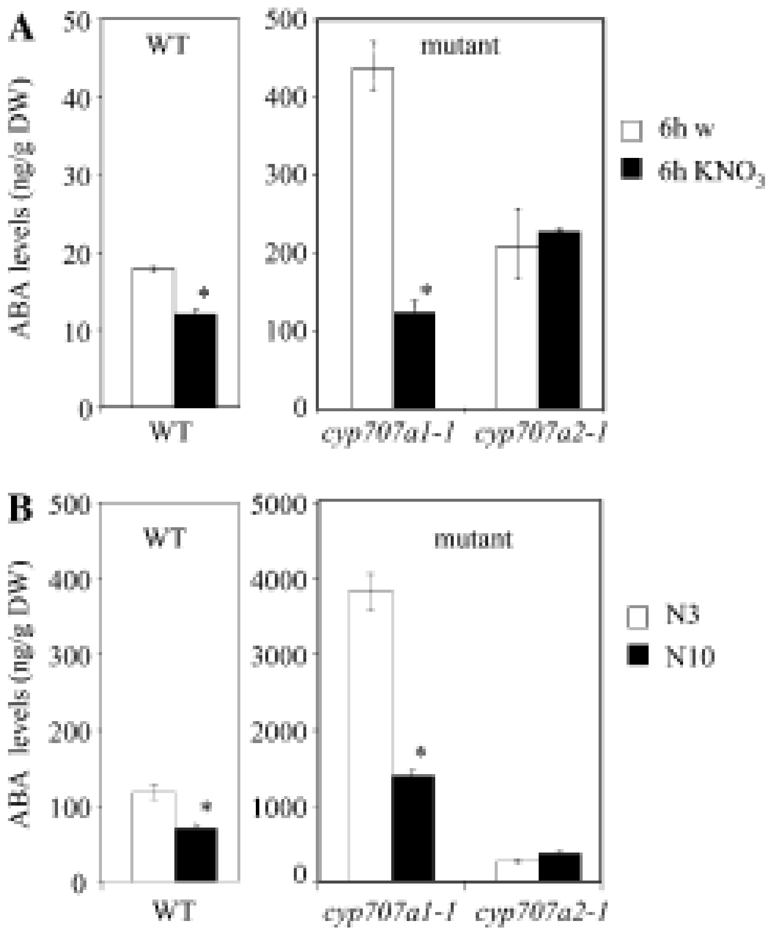


«Exogenous nitrate», nitrate given to the seed in the germination medium

CYP707a2 is involved in nitrogen sensing

$DSDS_{50}$ = number of days of seed dry storage necessary to obtain 50% germination

CYP707a2 is involved in dormancy release



CYP707a2 is involved in ABA breakdown

Transcription factors involved in nitrogen sensing

ARTICLE

Received 31 Mar 2015 | Accepted 9 Sep 2016 | Published 12 Oct 2016

DOI: 10.1038/ncomms13179

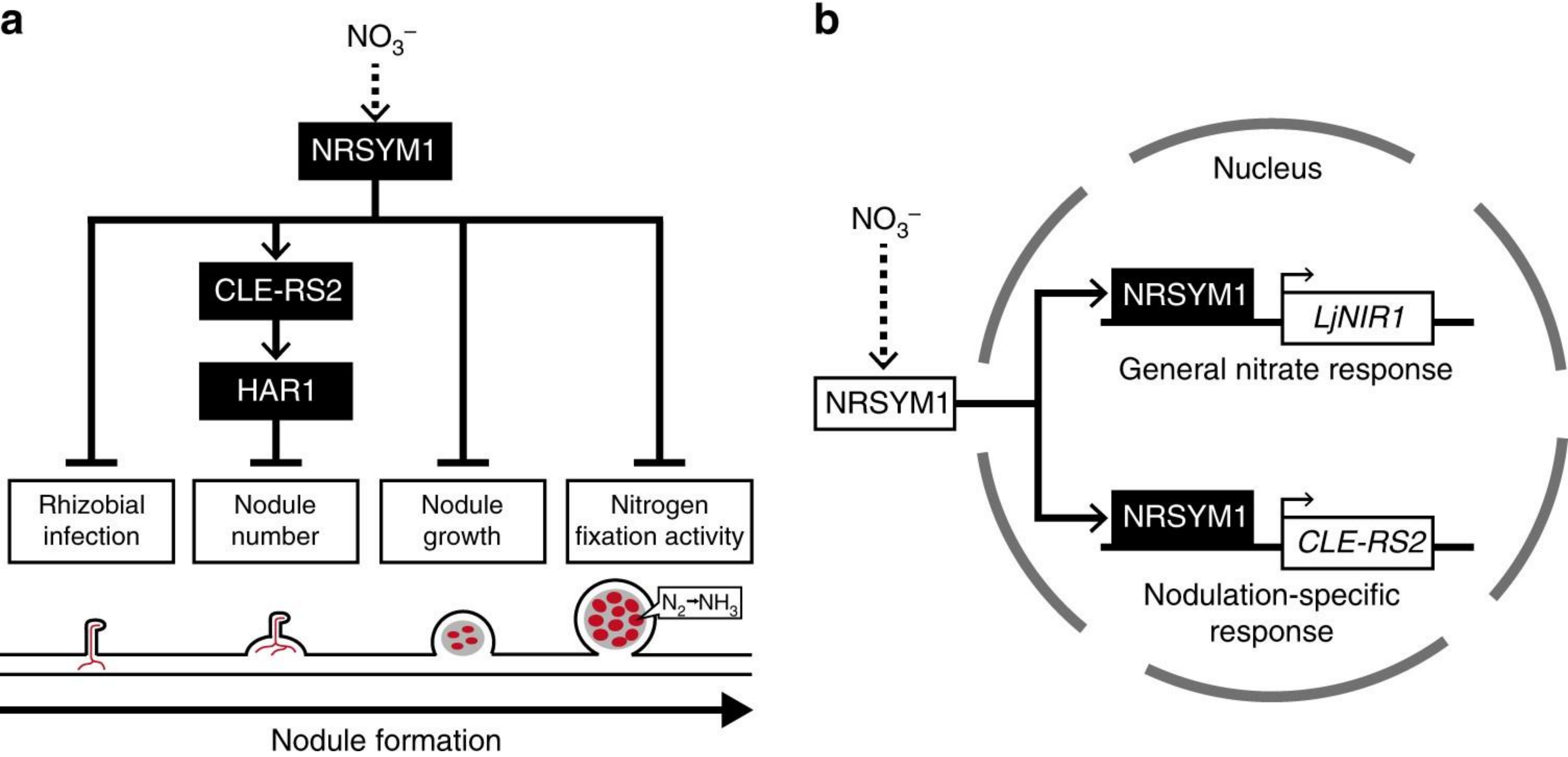
OPEN

NIN-like protein 8 is a master regulator of nitrate-promoted seed germination in *Arabidopsis*

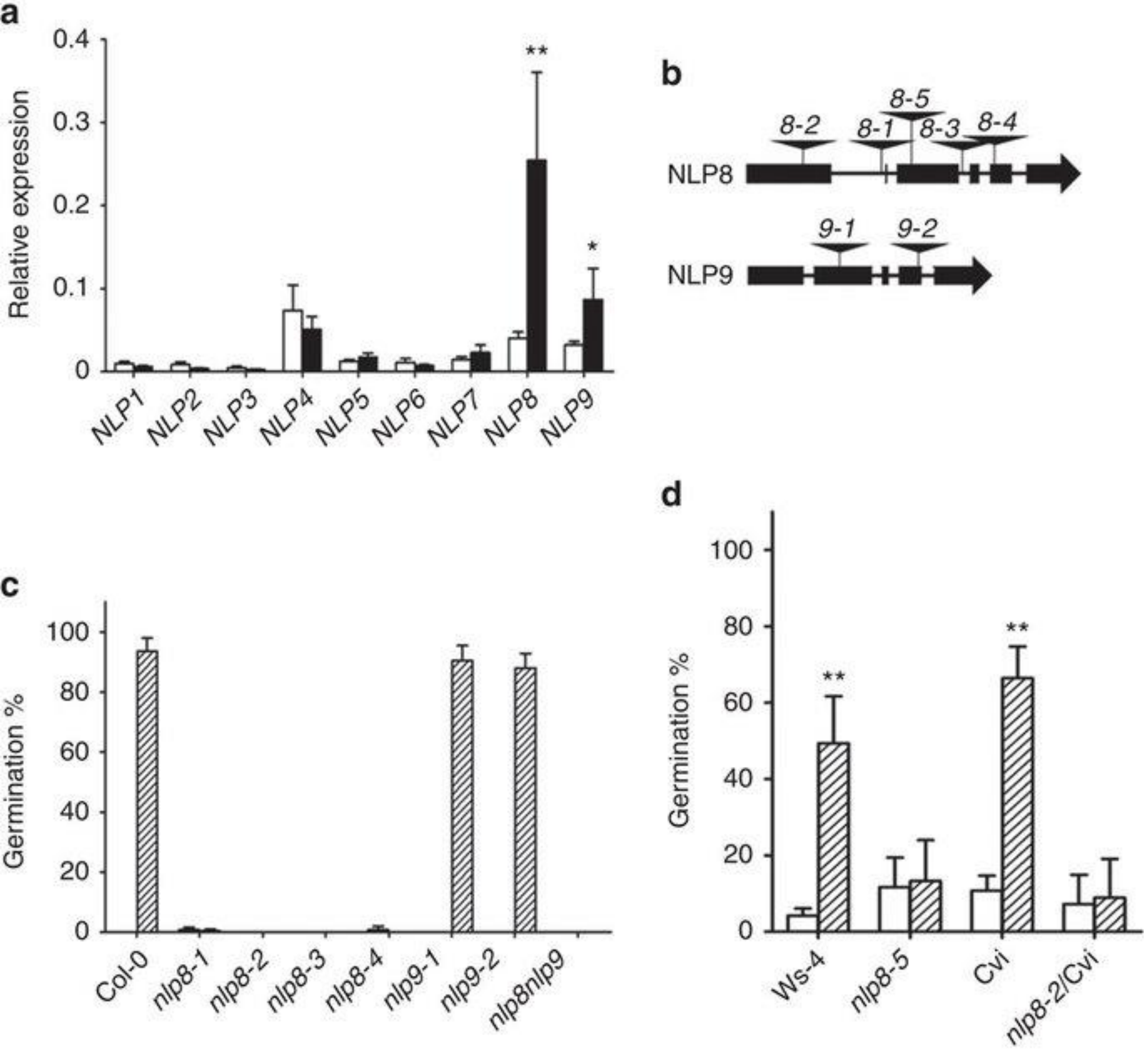
NIN-like protein (NLP) have been shown to be involved in nitrate responses

- NLPs have been shown to directly bind to the nitrate-responsive cis-element (NRE) to induce nitrate-mediated transcription

NIN-like protein (NLP), rhizobium formation in *Lotus*


a
NO3−
NRSYM1
CLE-RS2
HAR1
Rhizobial infection
Nodule number
Nodule growth
Nitrogen fixation activity
N2→NH3
Nodule formation
b
Nucleus
NO3−
NRSYM1
NRSYM1
LjNIR1
General nitrate response
NRSYM1
CLE-RS2
Nodulation-specific response

Nitrate promotes seed germination in an NLP8-dependent manner.

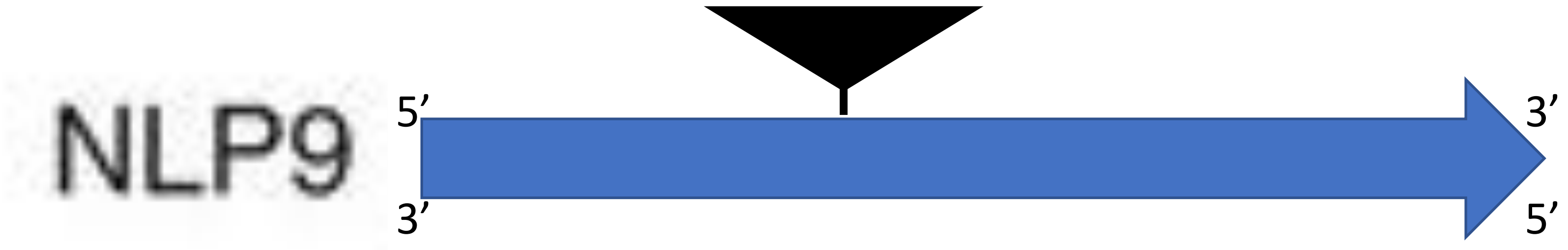


(a) Relative expression level of NLPs in dry seeds (white bar) and 6-h imbibed Col-0 seeds (black bar) from 16 °C. (b) Locations of T-DNA insertions in the *NLP8* and *NLP9*. (c) Seeds were imbibed in water with 1 mM KCl (white bar) or KNO_3 (lined bar) for 7 days. Note that all samples did not germinate in water with 1 mM KCl, thus the white bars are invisible. (d) Germination of *nlp8* mutants of Ws-4 and Cvi backgrounds in the presence of nitrate. Seeds were harvested from plants grown at 22 °C. Freshly harvested Ws-4 and *nlp8-5*, and 2-month stored Cvi and *nlp8-2*/Cvi were used for germination tests. Seeds were imbibed in water with 1 mM KCl (white bar) or KNO_3 (lined bar) for 7 days.

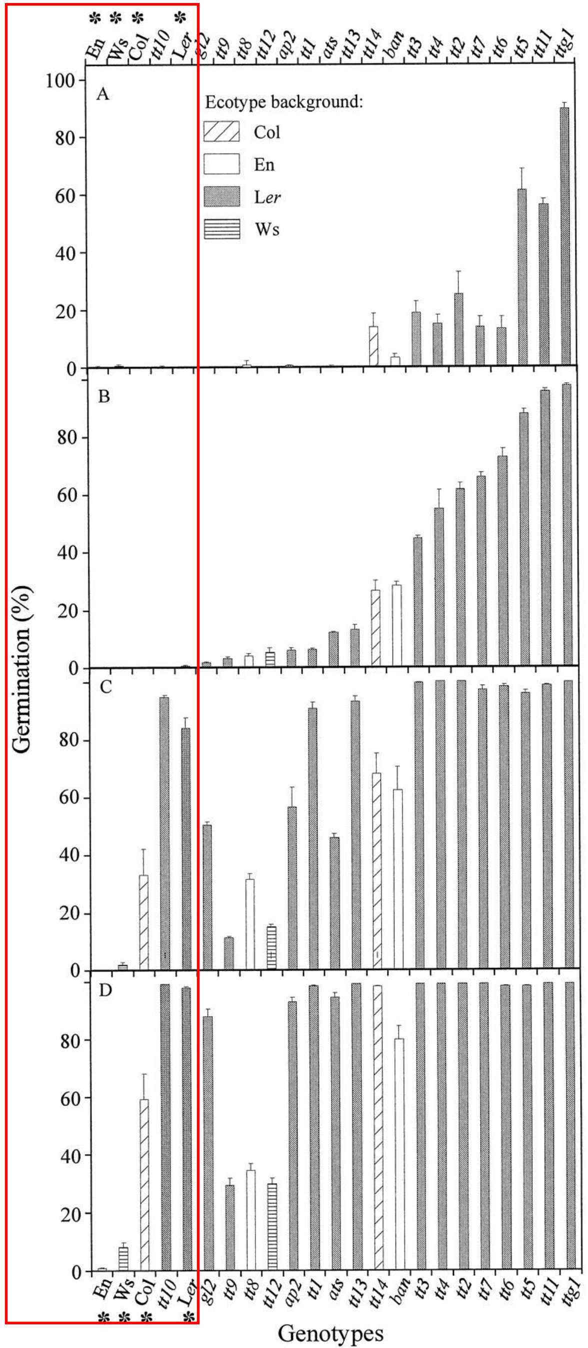
Insertion 9.1

Inorder to characterize this locus by PCR, in which region do you design primers:

- The insertion in mutant allele
- The WT allele

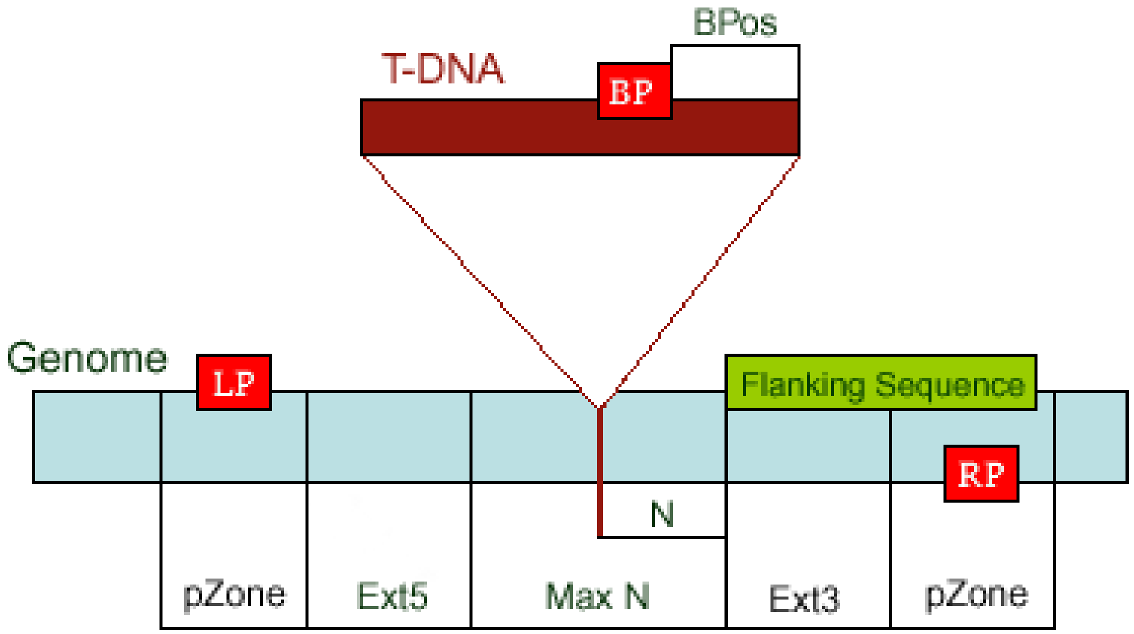


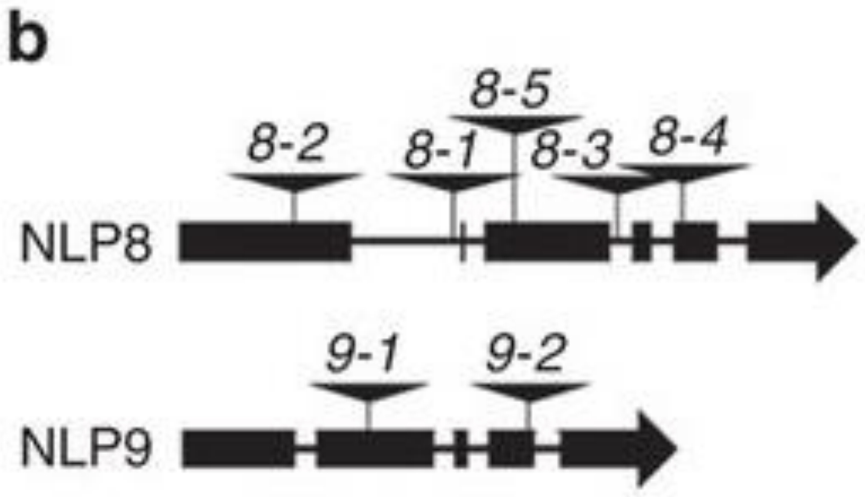
Effect of dry storage on dormancy release.

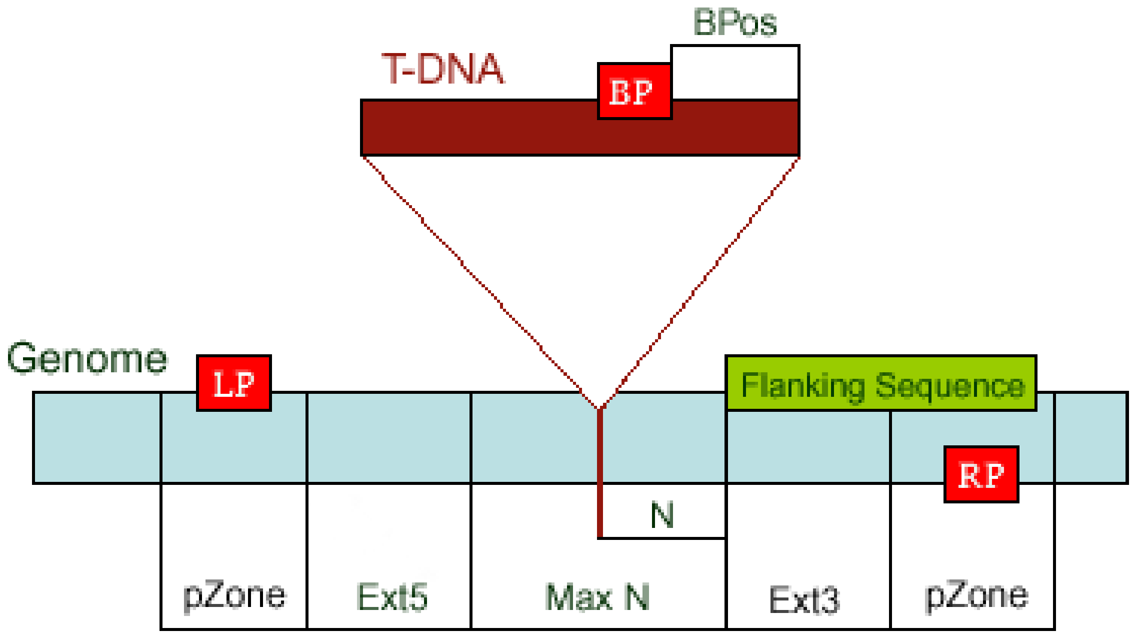


Germination was scored 2 d (A), 9 d (B), 18 d (C), and 27 d (D) after seed harvest.

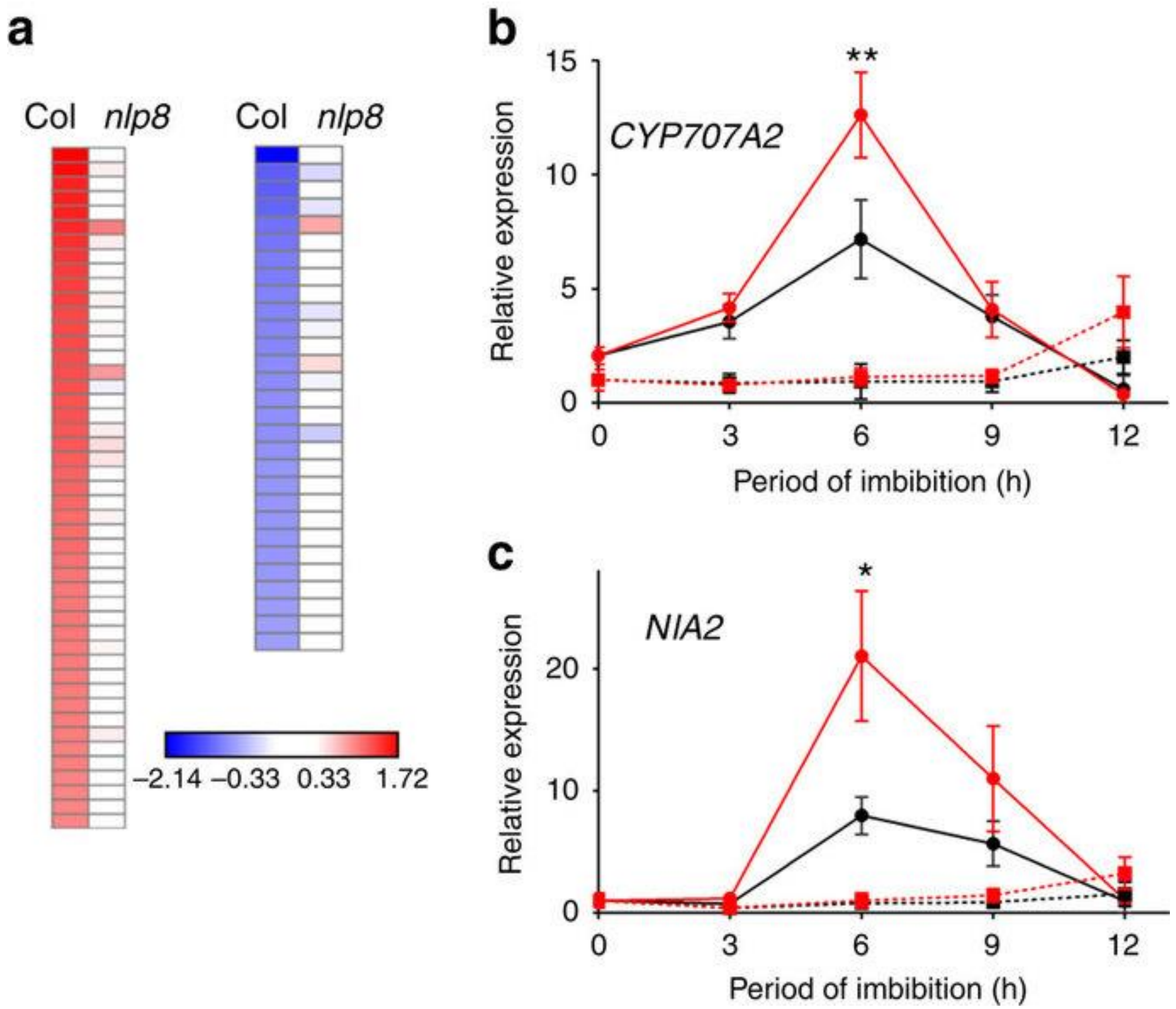
Differences in germination in different ecotypes


BPos
T-DNA
BP
Genome
LP
Flanking Sequence
RP
N
pZone
Ext5
Max N
Ext3
pZone


b
8-5
8-2
8-1
8-3
8-4
NLP8
9-1
9-2
NLP9


BPos
T-DNA
BP
Genome
LP
Flanking Sequence
RP
N
pZone
Ext5
Max N
Ext3
pZone


WT
HZ
HM
900
410+N
* N = 0 ~ 300



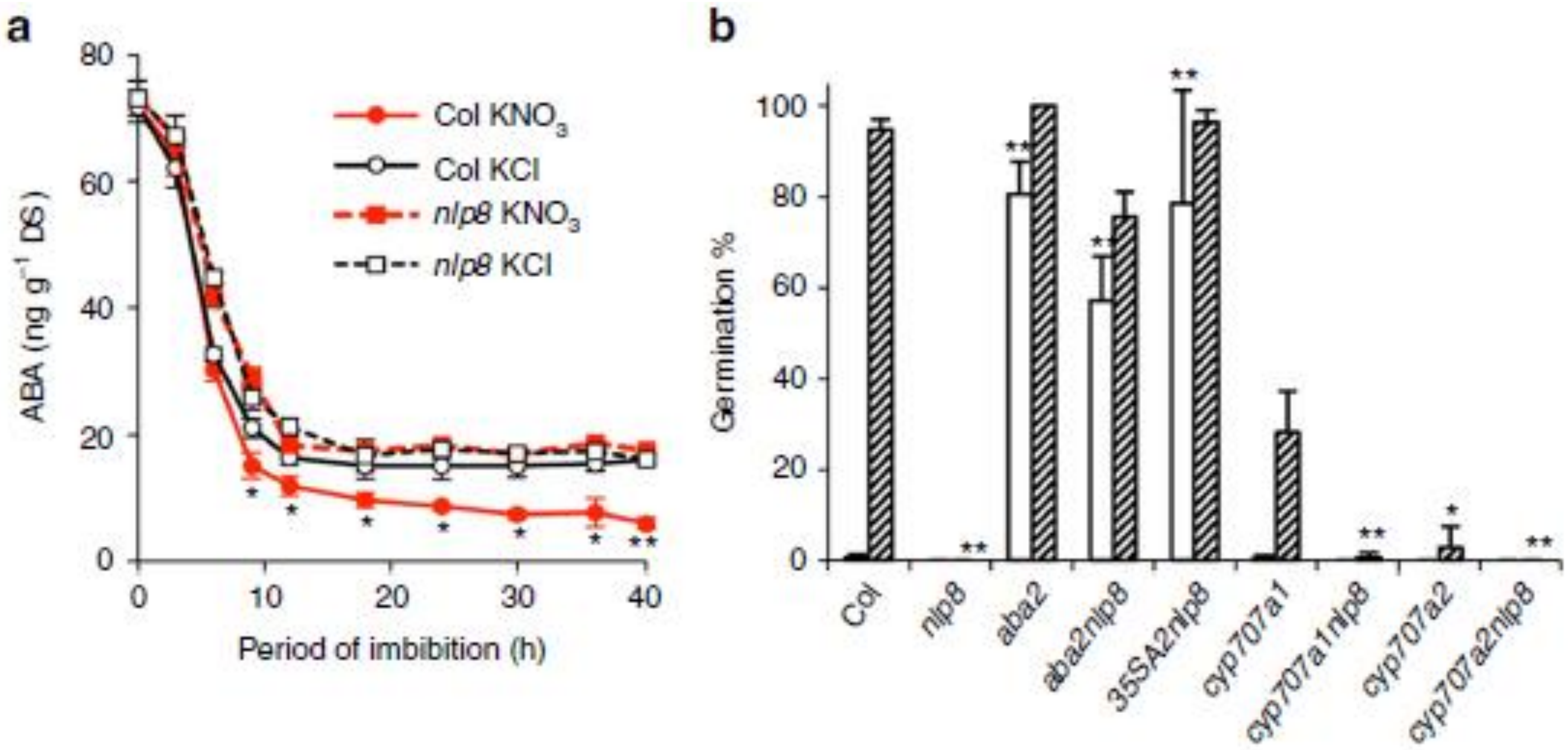
ABA CATABOLISM

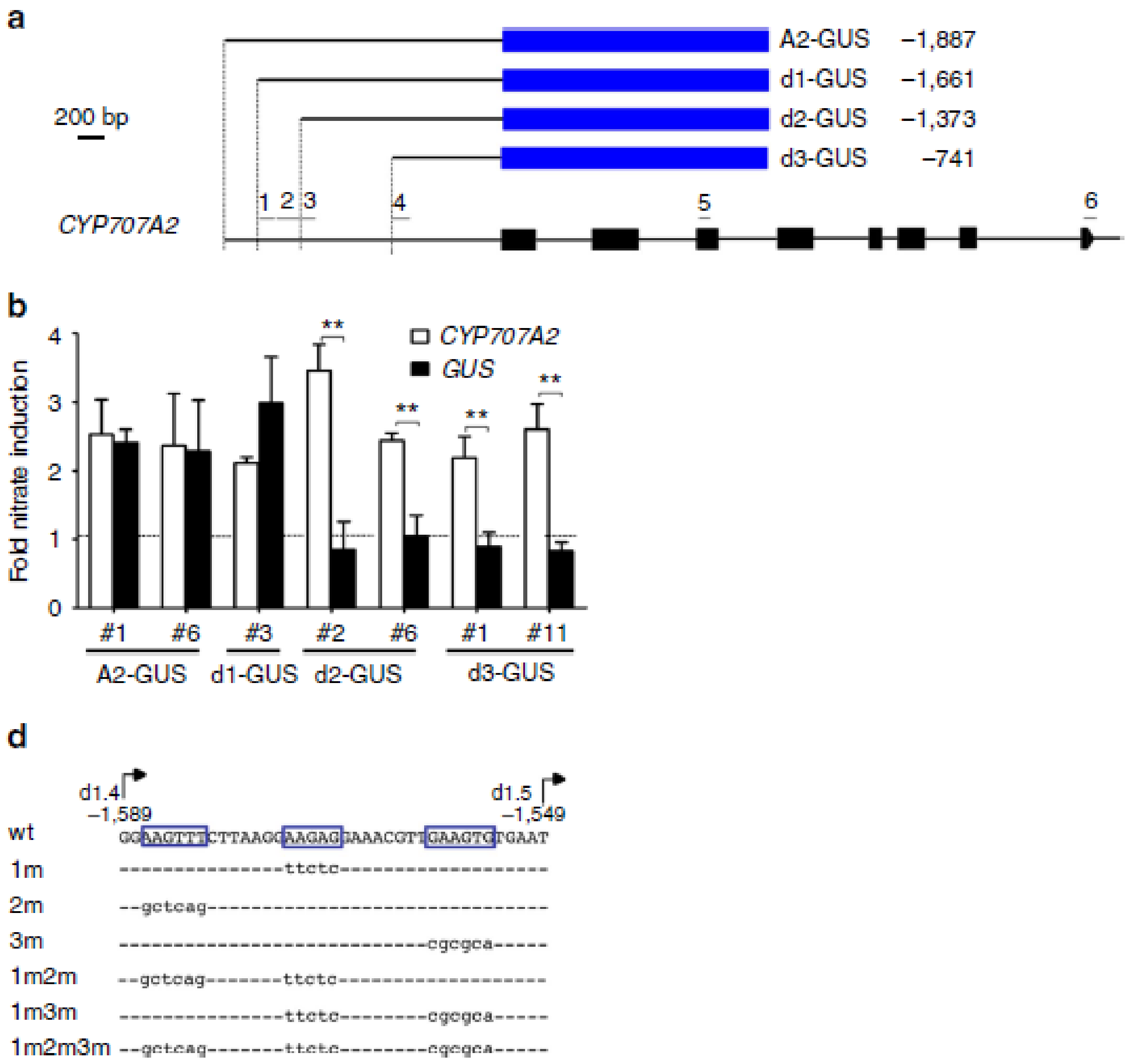
Col-0 imbibed in KCl, black circle with solid line; Col-0 imbibed in KNO3, red circle with solid line; nlp8-2 imbibed in KCl, black square with dotted line; nlp8-2 imbibed in KNO3, red square with dotted line.

NITRATE REDUCTASE

Nitrate-upregulated (left) and downregulated (right) genes in 6-h imbibed seeds in Col-0 or the nlp8-2 mutant. Seeds were imbibed in water with 1mM KCl or KNO_3 for 6 h and RNA was extracted for RNA-seq.

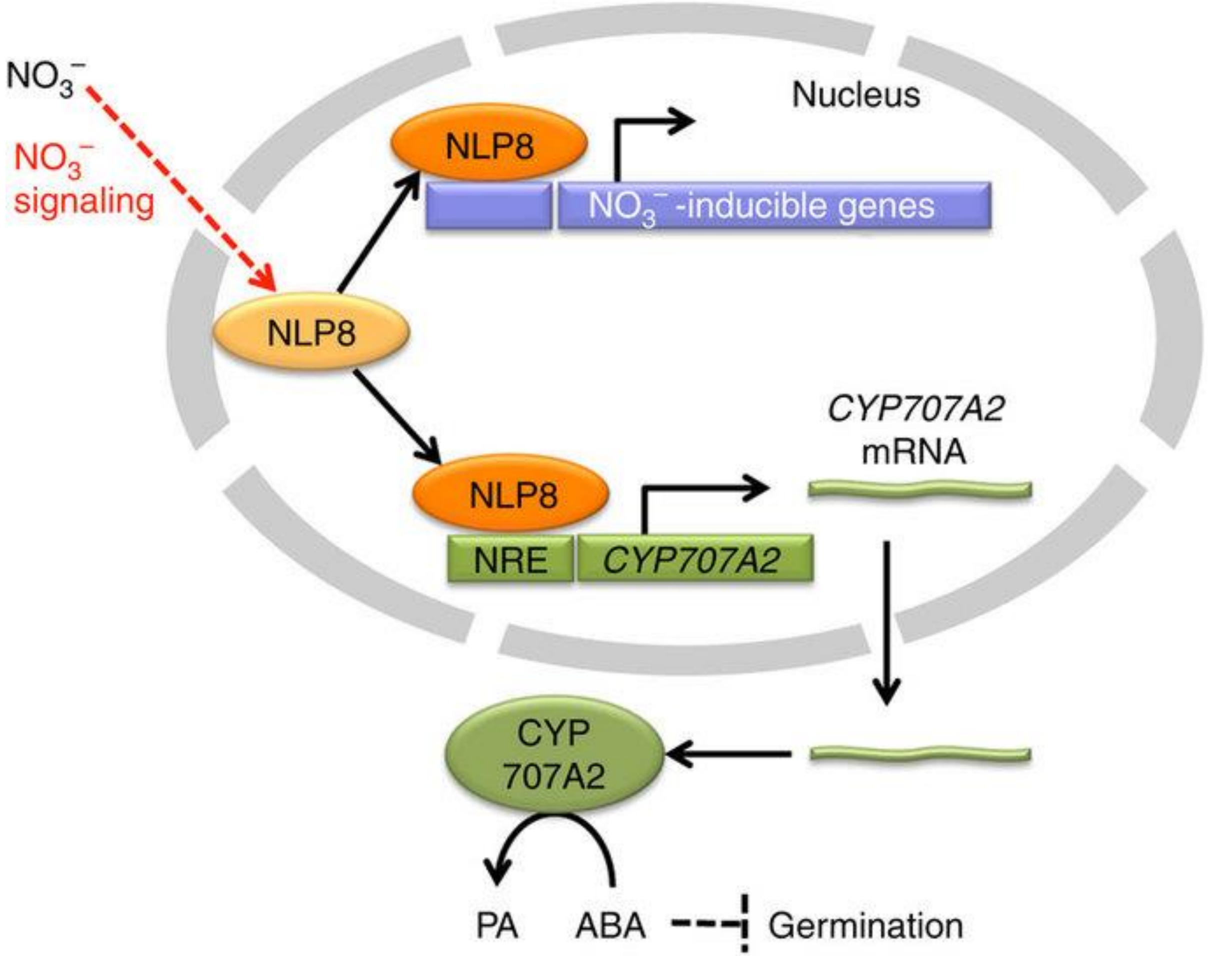
NLP8 regulates ABA catabolism during seed germination. (a) Quantification of **ABA contents** in Col-0 and nlp8-2 seeds. Seeds were imbibed in water with 1mM KCl or KNO_3 for the indicated time periods. The ABA content was measured by liquid chromatography equipped with a mass spectrometry. (b) Germination of ABA metabolism and nlp8 mutants in the presence of nitrate.





NLP8 binding motifs

A proposed schematic model for NLP8 activity in regulating nitrate-promoted seed germination.



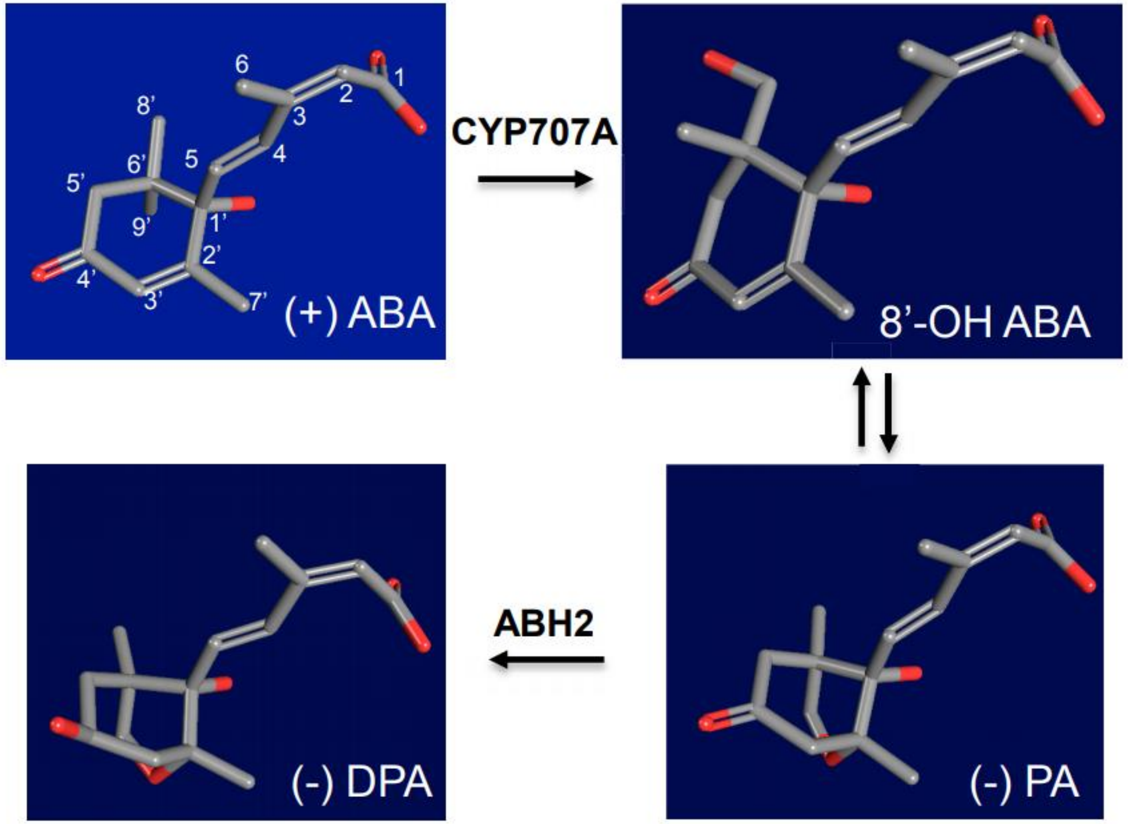
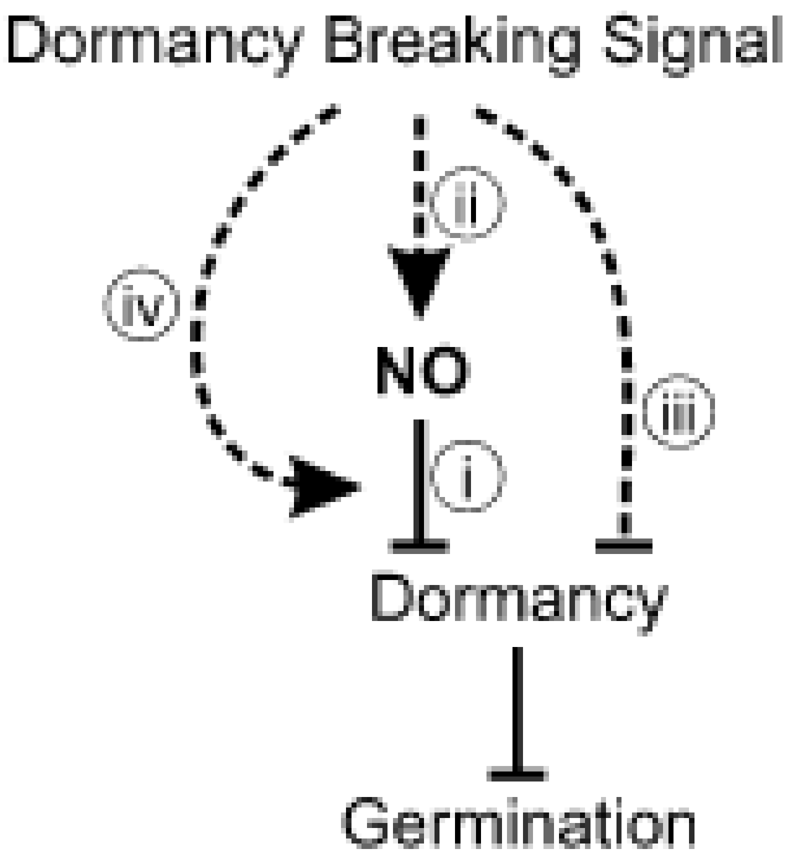
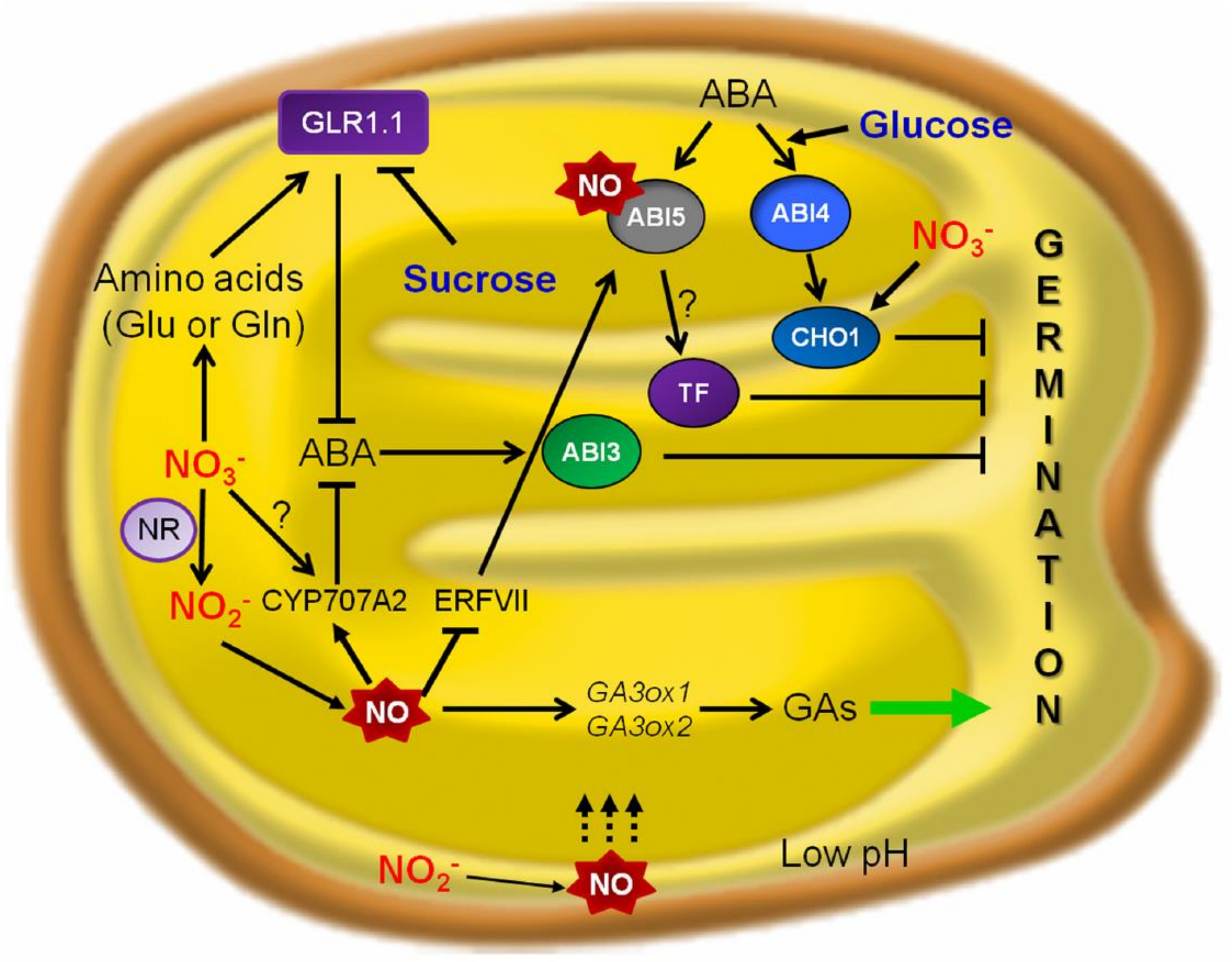


Figure 1. Catabolism of ABA through the 8′-Hydroxylation Pathway.

Cyclization of 8′-OH ABA into PA is a reversible reaction under abiotic conditions; however, under *in vivo* conditions 8′-OH spontaneously (and/or enzymatically) isomerizes to PA. ABA, abscisic acid; 8′-OH ABA, 8′-hydroxy ABA; PA, phaseic acid; DPA, dihydrophaseic acid; CYP707A, CYP707A family cytochrome P450 mono-oxygenases; ABH2, PA reductase.





NO has also a strong effect in releasing seed dormancy

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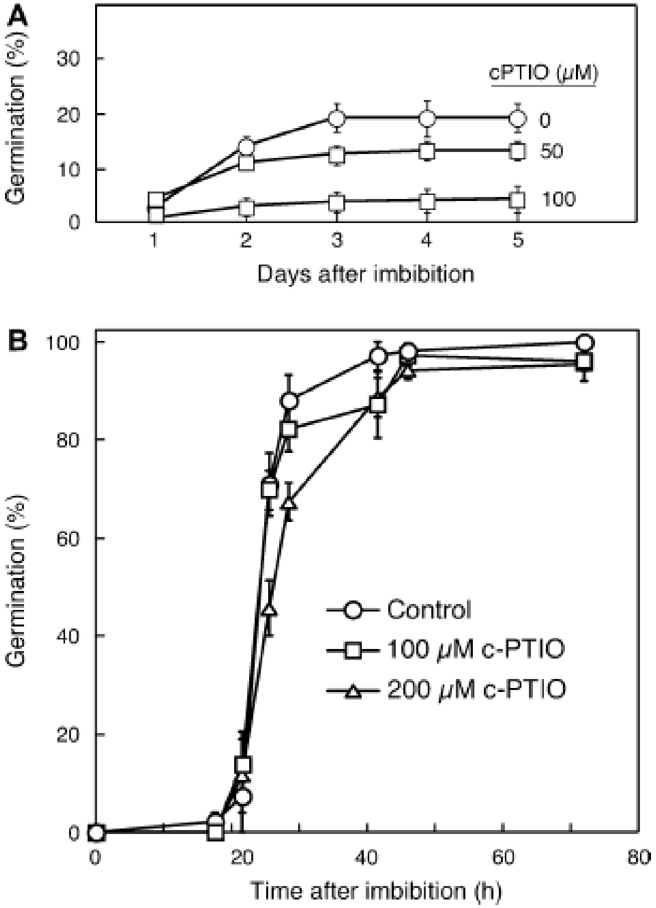
FOCUS PAPER

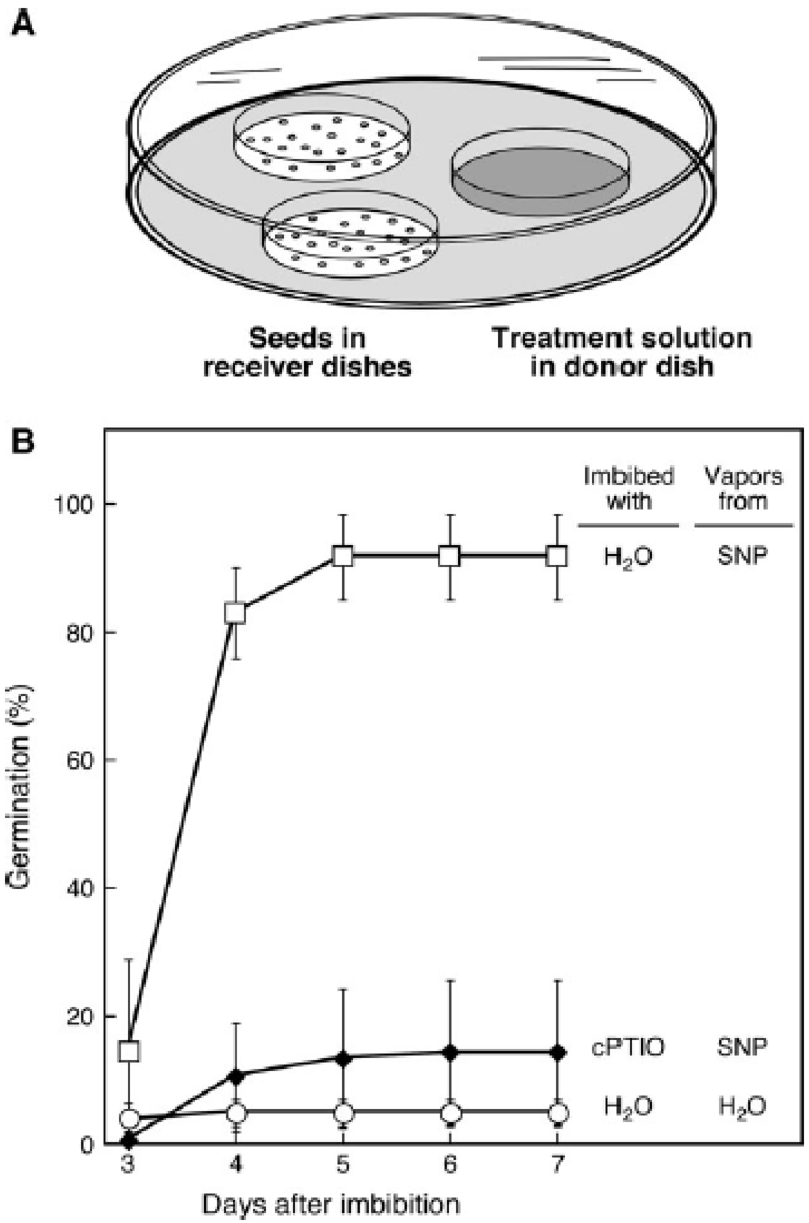
Nitric oxide reduces seed dormancy in *Arabidopsis*

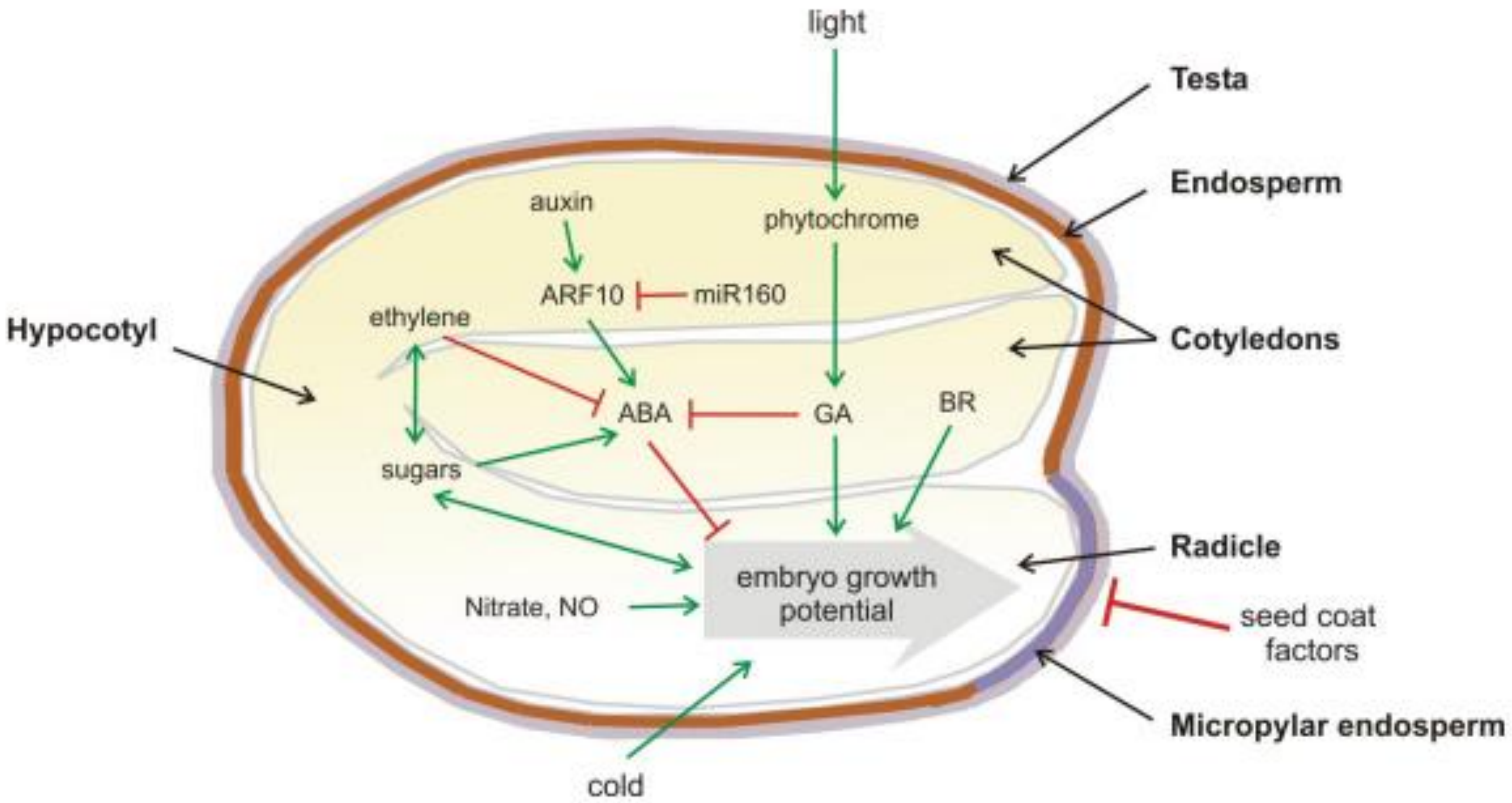
Paul C. Bethke*, Igor G. L. Libourel and Russell L. Jones

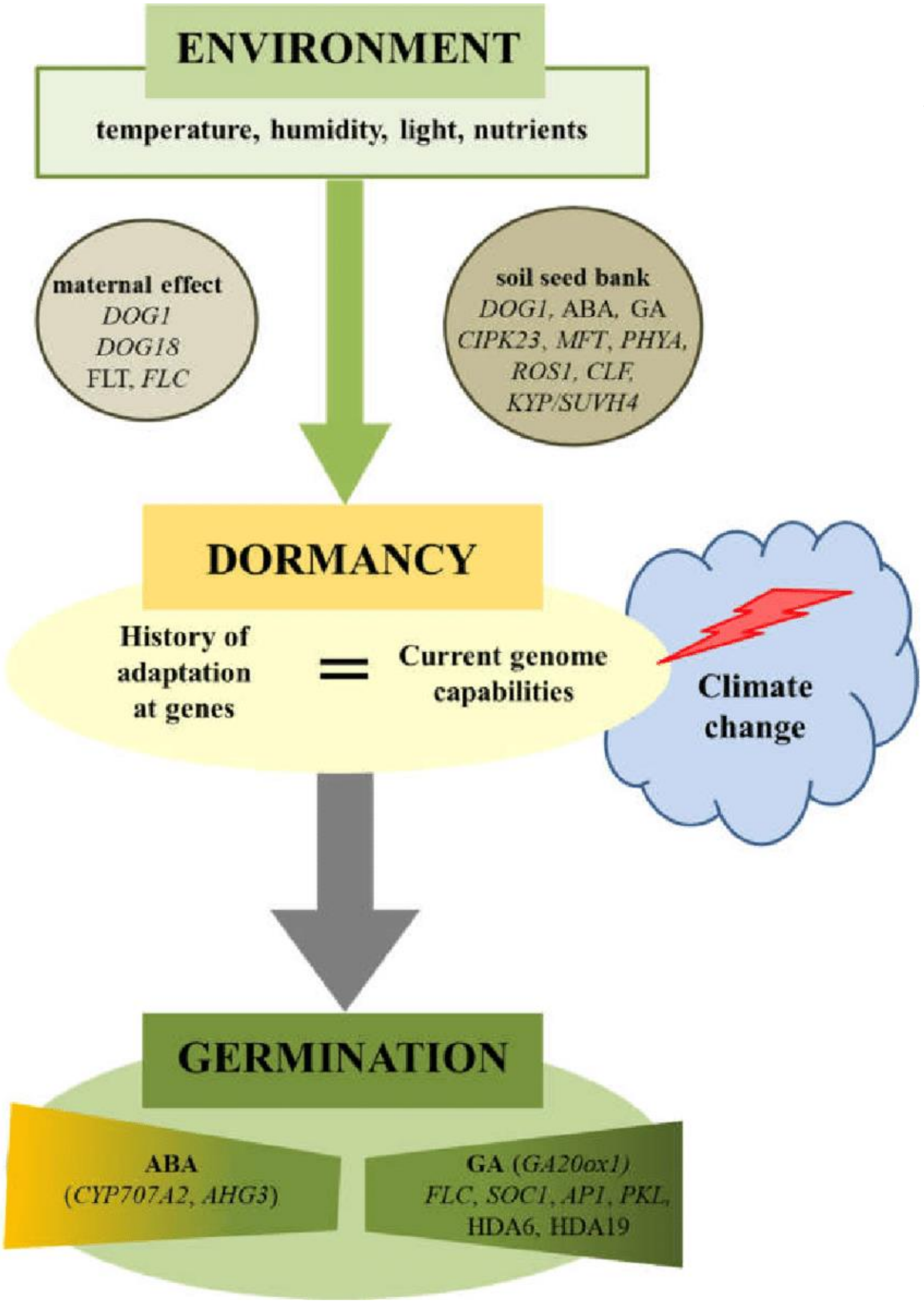
<u>SCAVENGER of NO</u>
cPTIO = 2-(4-Carboxyphenyl)-4,4,5,5-tetramethylimidazoline-1-oxyl-3-oxide potassium salt

NO PRODUCER
SNP = Sodium nitroprusside






light
Testa
Endosperm
auxin
phytochrome
ARF10
miR160
ethylene
Hypocotyl
Cotyledons
ABA
GA
BR
sugars
Radicle
embryo growth
potential
Nitrate, NO
seed coat
factors
Micropylar endosperm
cold



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Review

Regulation of Seed Dormancy and Germination Mechanisms in a Changing Environment

Ewelina A. Klupczyńska and Tomasz A. Pawłowski *