De novo domestication of wild plant species: a novel approach to plant breeding

Lázaro E. P. Peres

São Paulo, November 2017

In collaboration with:

Jörg Kudla

What is domestication and “Domestication syndrome”?

Domestication

Fox

De novo Domestication

“Domesticated” Fox

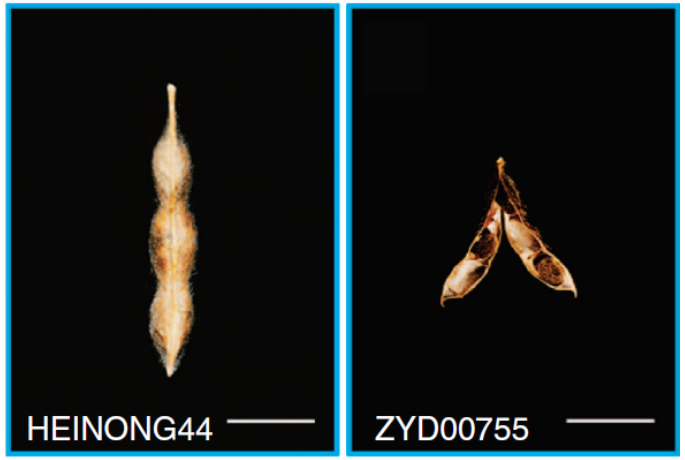
What characterizes the “domestication syndrome” in plants?

10.1126/science.1126410

Non-shattering spikes or pods

SHAT1-5 (NAC)

qSH1 (BEL1-Like)



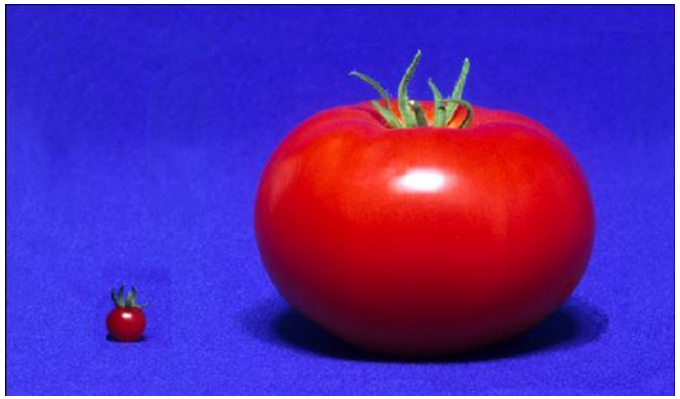
NATURE COMMUNICATIONS | 5:3352 | DOI: 10.1038/ncomms4352

Plant Cell, Vol. 22: 1057–1073, April 2010,

Gigantism

FW2.2

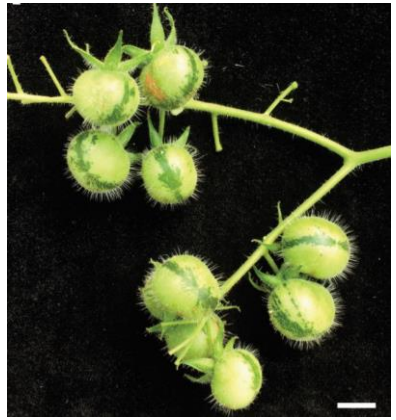
FW2.2 + FAS + LC + FW3.2, etc.



Cell *127*, December 29, 2006

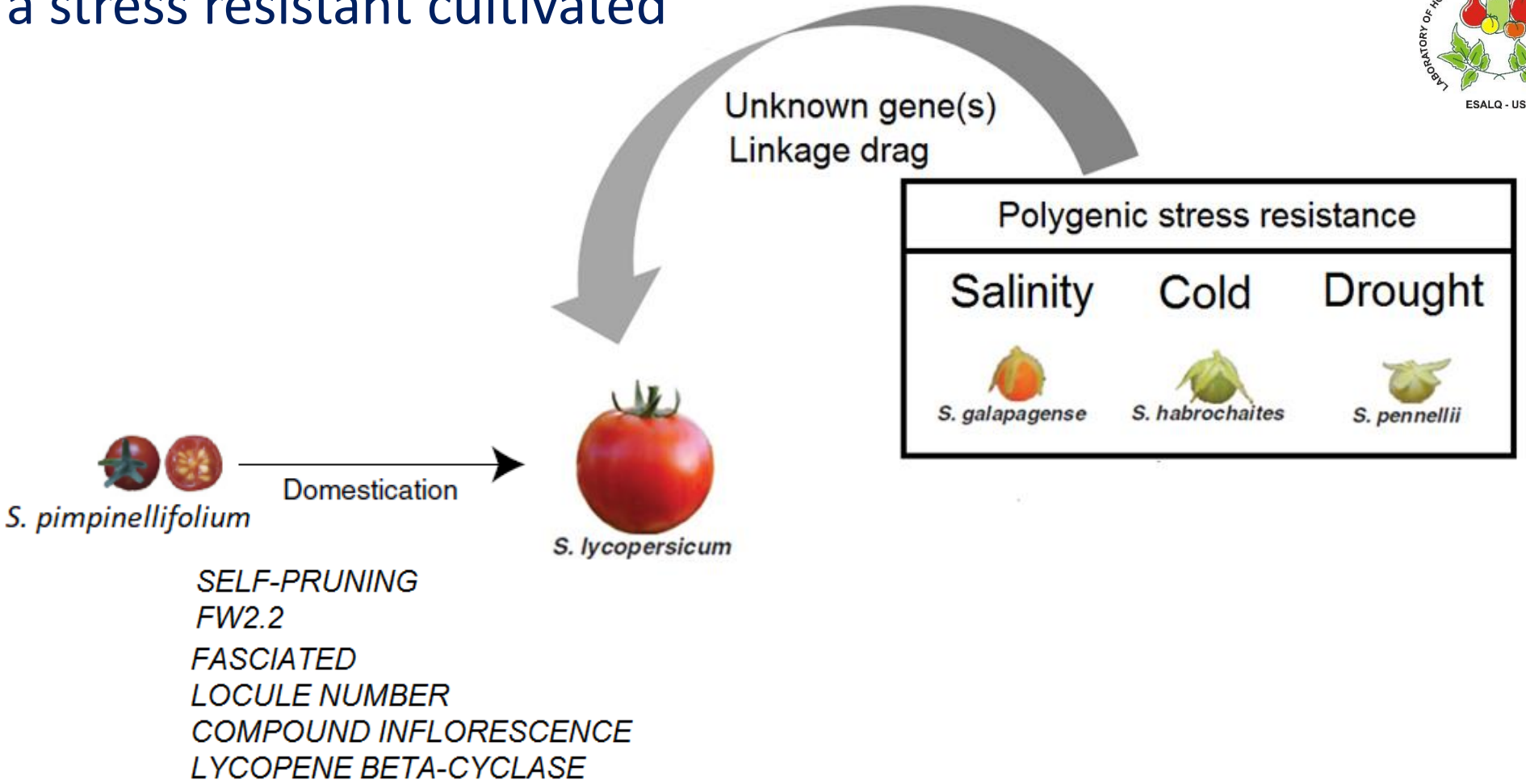
Why perform *de novo* domestication?

Case study in tomato (*Solanum lycopersicum*) wild relatives:



S. pennellii – drought resistance, insect resistance
S. habrochaites – cold resistance, insect resistance
S. galapagense – salt resistance, insect resistance

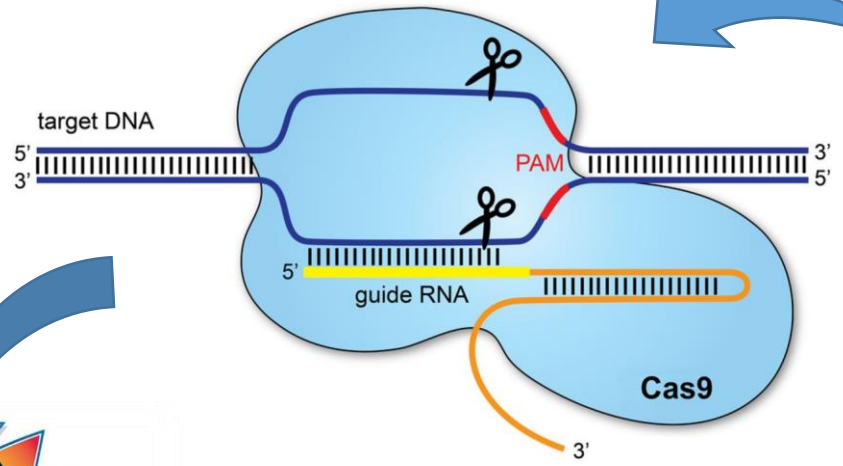
How to create a stress resistant cultivated tomato?



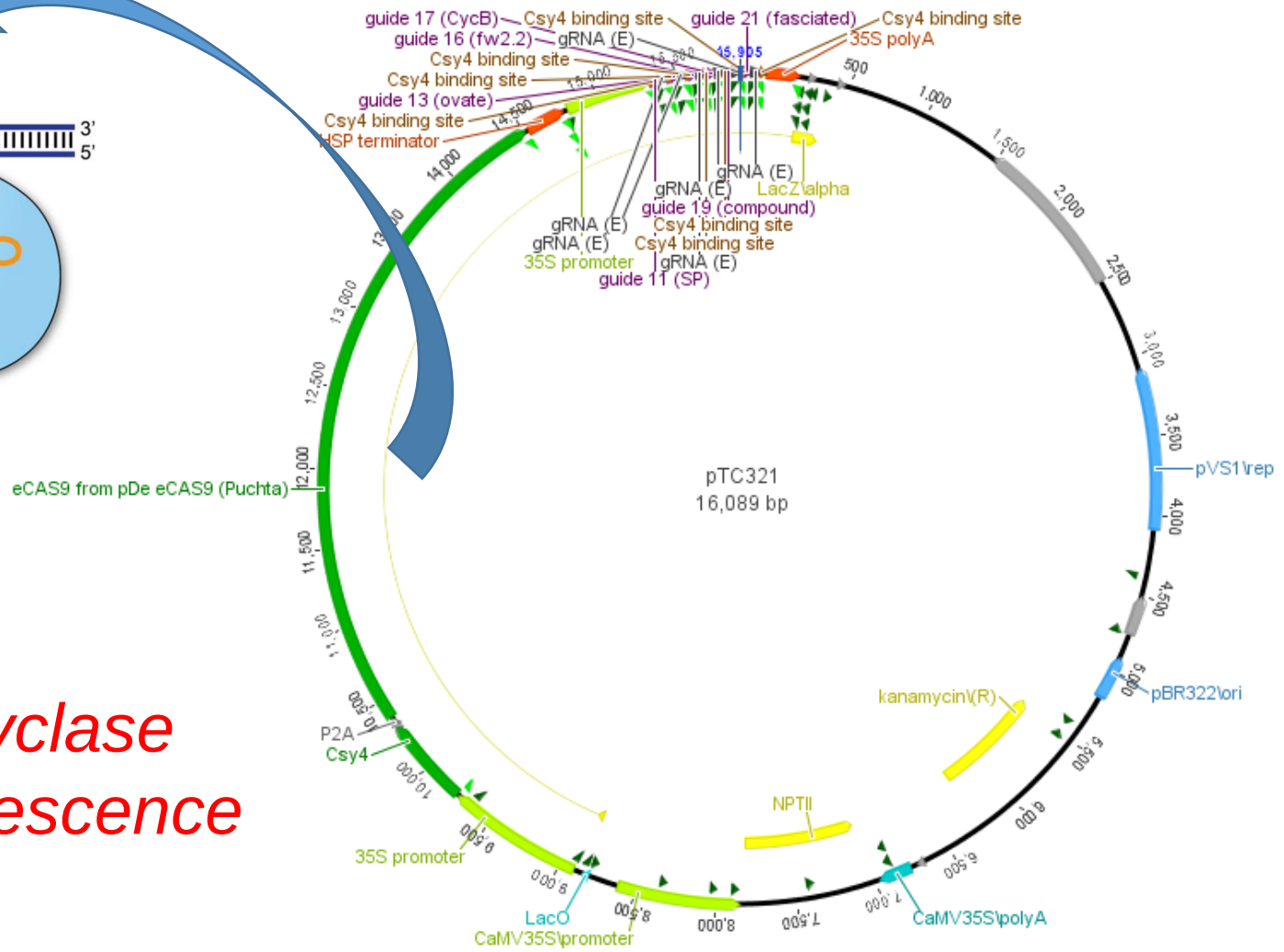
De novo domestication

Cultivated *S. galapagense*
Cultivated *S. habrochaites*
Cultivated *S. pennellii*

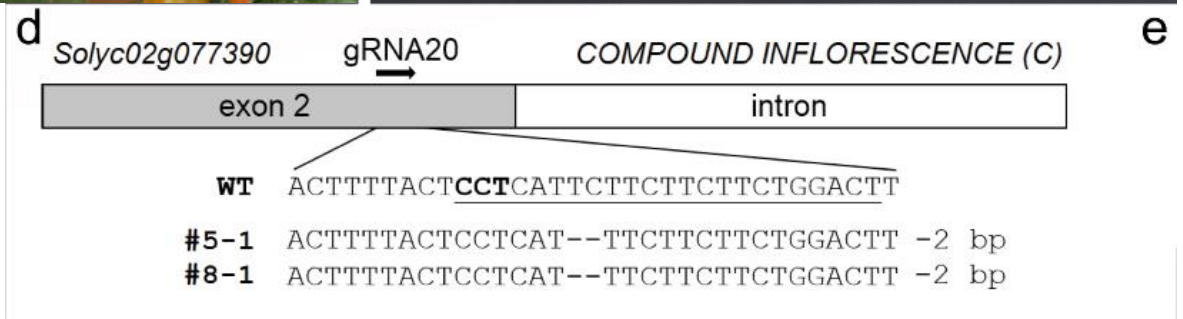
Proof of concept: using CRISPR/Cas9 to create similar domestication-related (loss-of-function) alleles in the wild species *S. pimpinellifolium*.

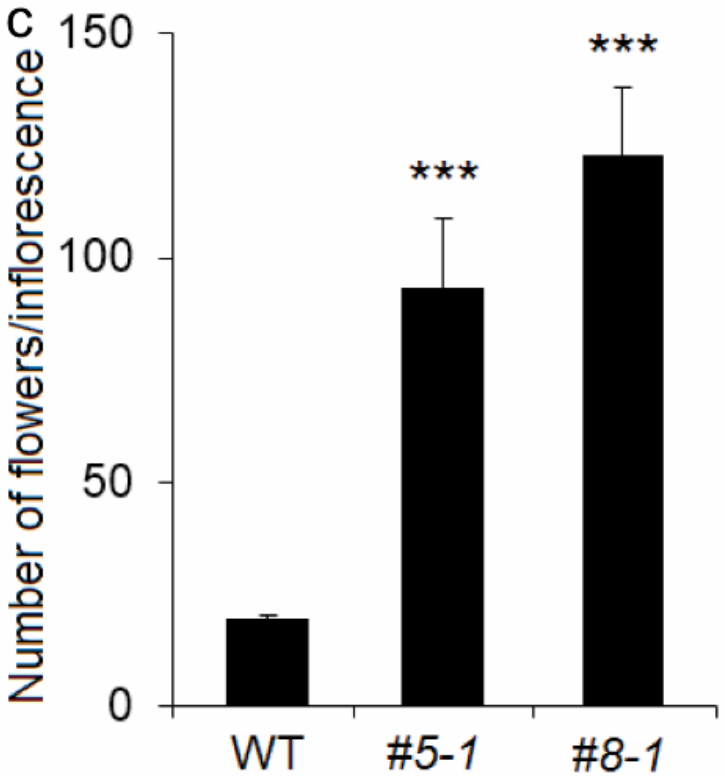


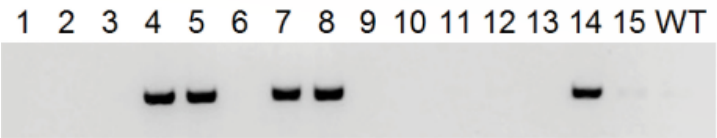
self-pruning (sp)
fw2.2
fasciated (fas)
lycopene beta cyclase
compound inflorescence
ovate



The new *compound inflorescence* loss-of-function allele potentially increases yield of the wild species *S. pimpinellifolium*.



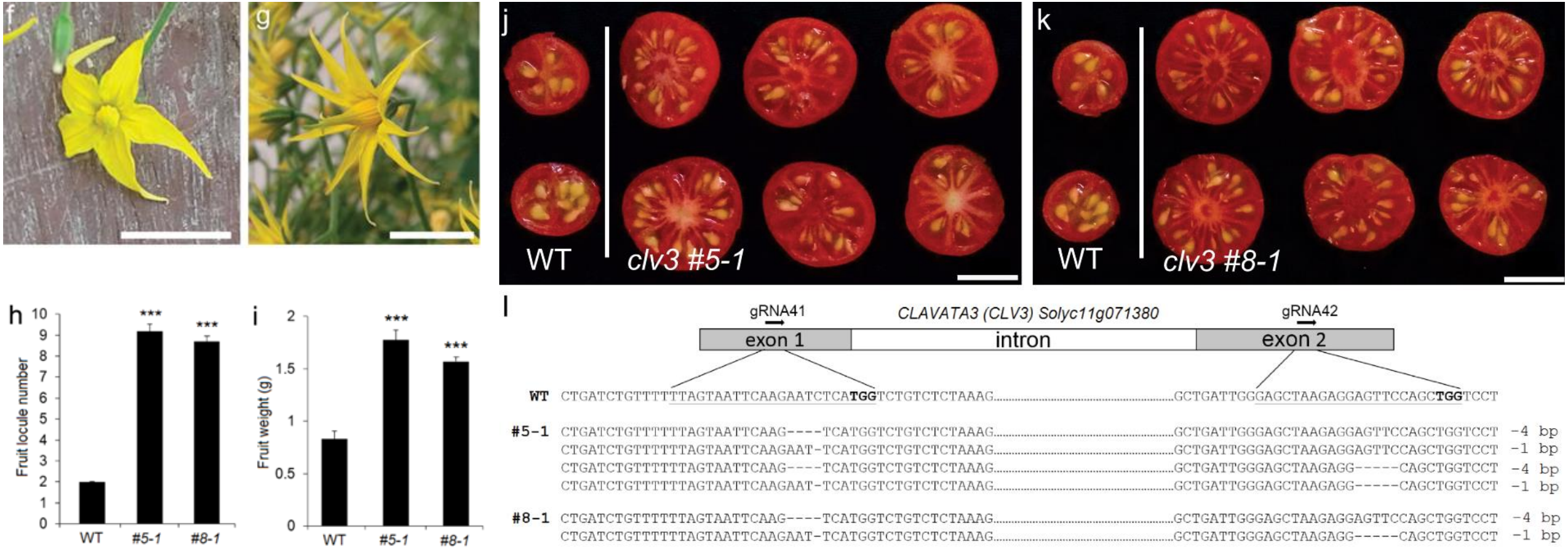




(Zögön et al., unpublished)

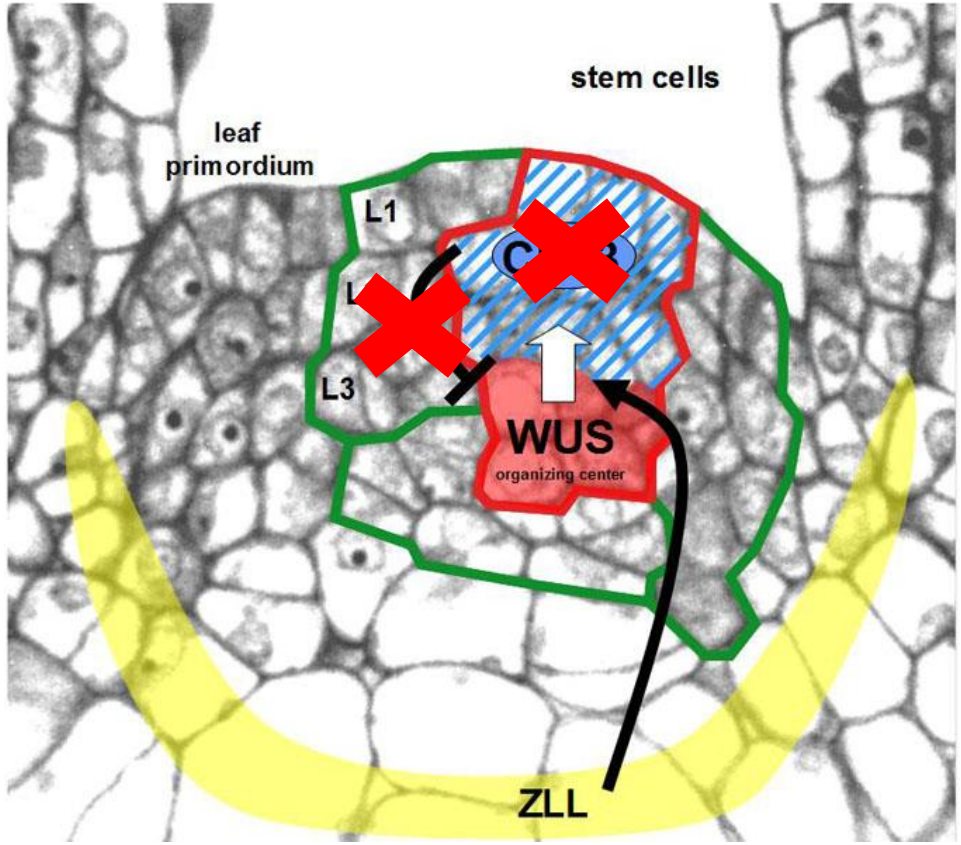
The new *fasciated/clavata3* loss-of-function allele increases fruit weight and yield of the wild species *S. pimpinellifolium*.

(Zögön et al., unpublished)



Side effects of the new loss-of-function *fasciated/clavata3* allele:

Undesired fasciation of shoots

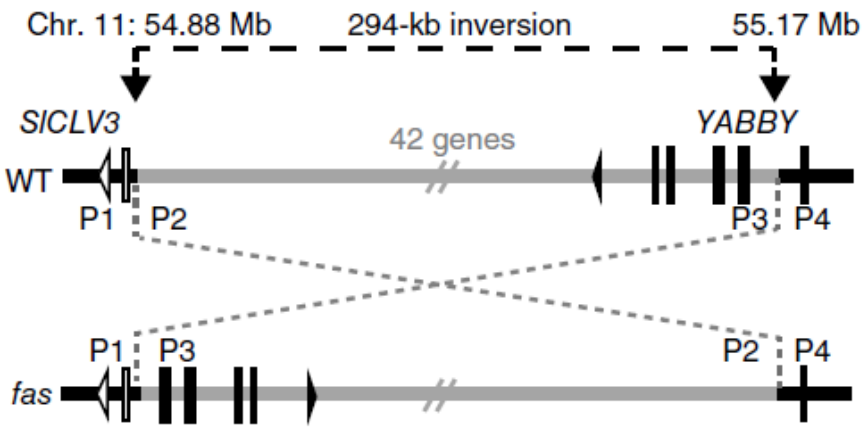


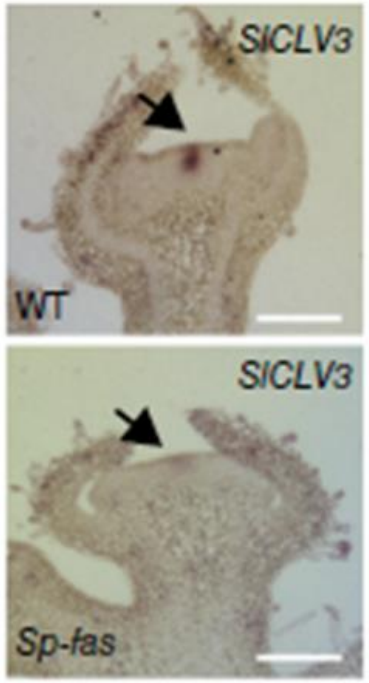
Tomato domestication involved the selection of unique alleles that it might not be possible to create using the current version of the CRISPR/Cas9 technology:

The *fw2.2* locus involves heterochronic gene expression

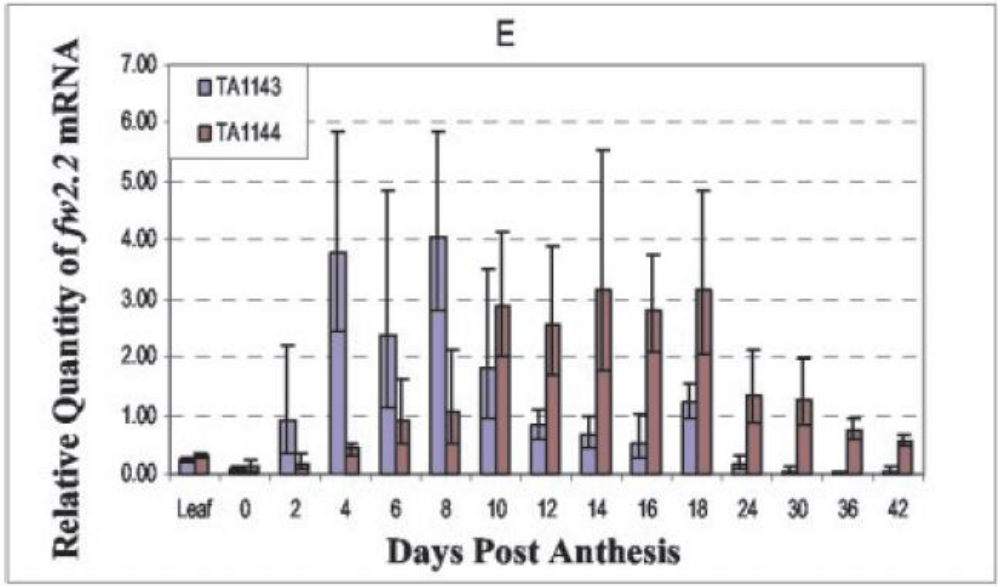
TA1143 = NIL with large fruit mutated allele
TA1144 = NIL with the small fruit wild type allele

The *fas* locus is an inversion between CLV3 and YABBY genes





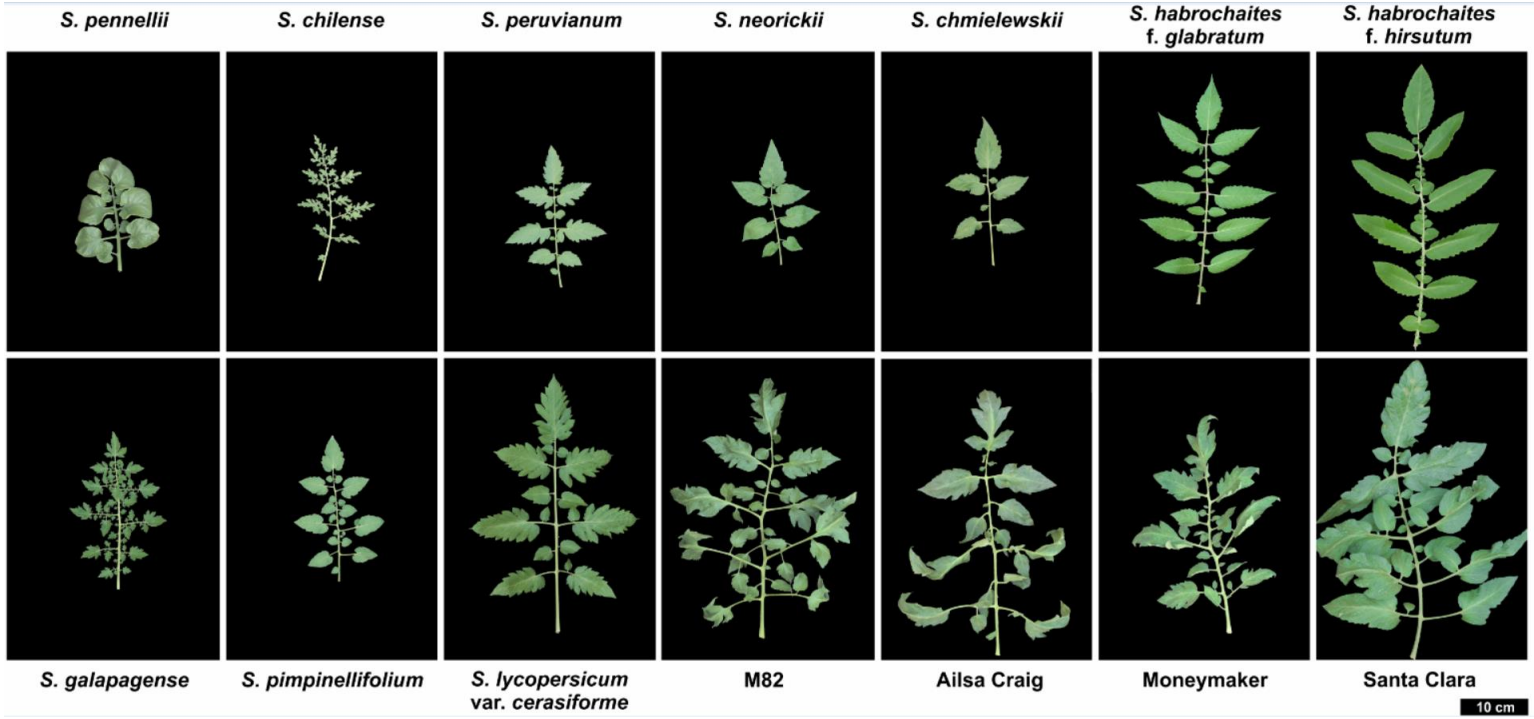
Xu et al., 2015 (10.1038/ng.3309)



Cong et al. 2002 (10.1073/pnas.172520999

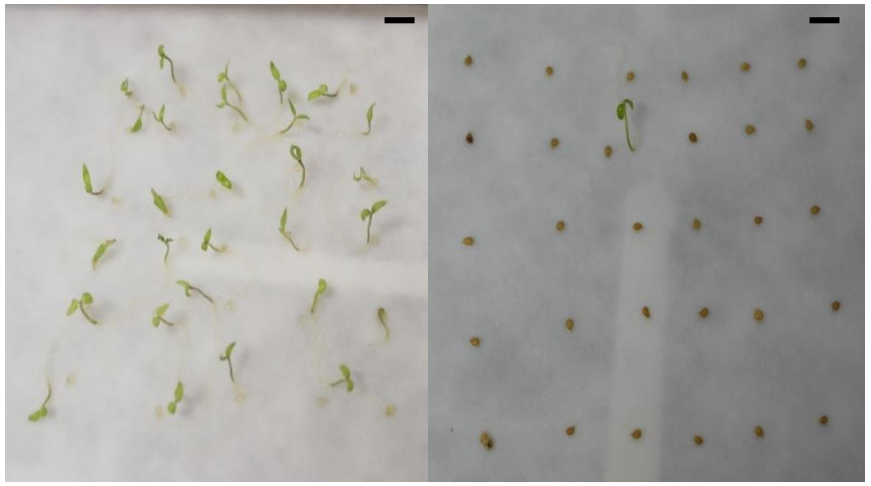
We can´t perform gene editing (CRISPR/Cas9) for those domestication-related traits that we still don´t known their genetic bases

Gigantism of vegetative parts of cultivated tomato

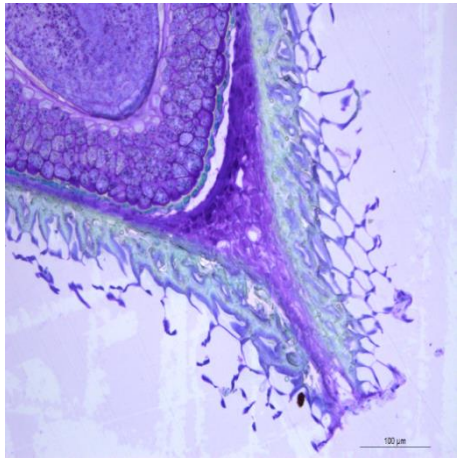


(Vicente et al., unpublished)

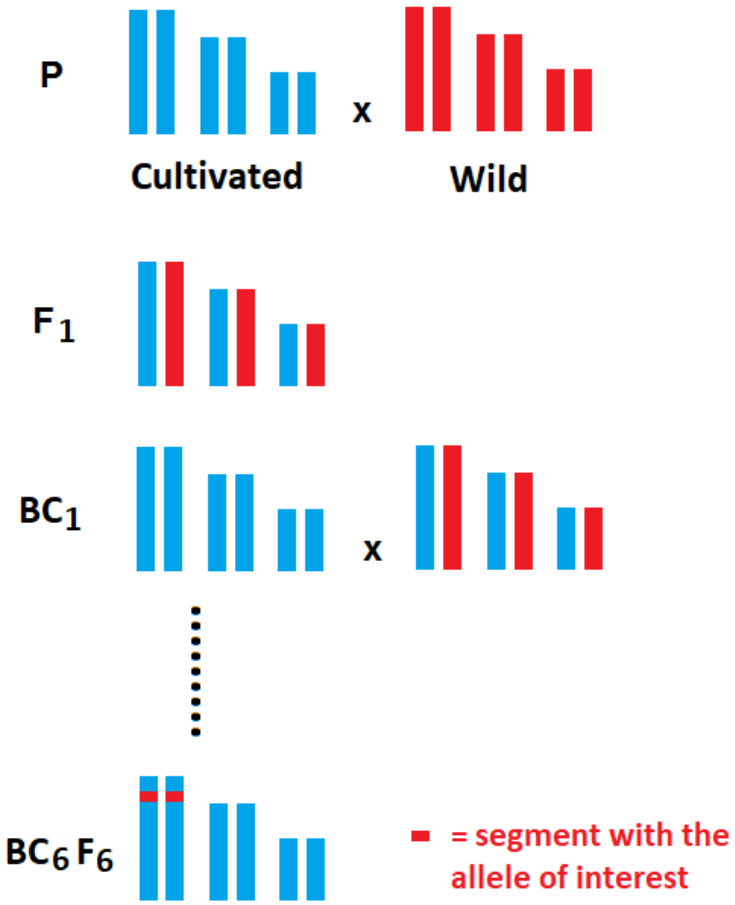
S. galapagense seed dormancy

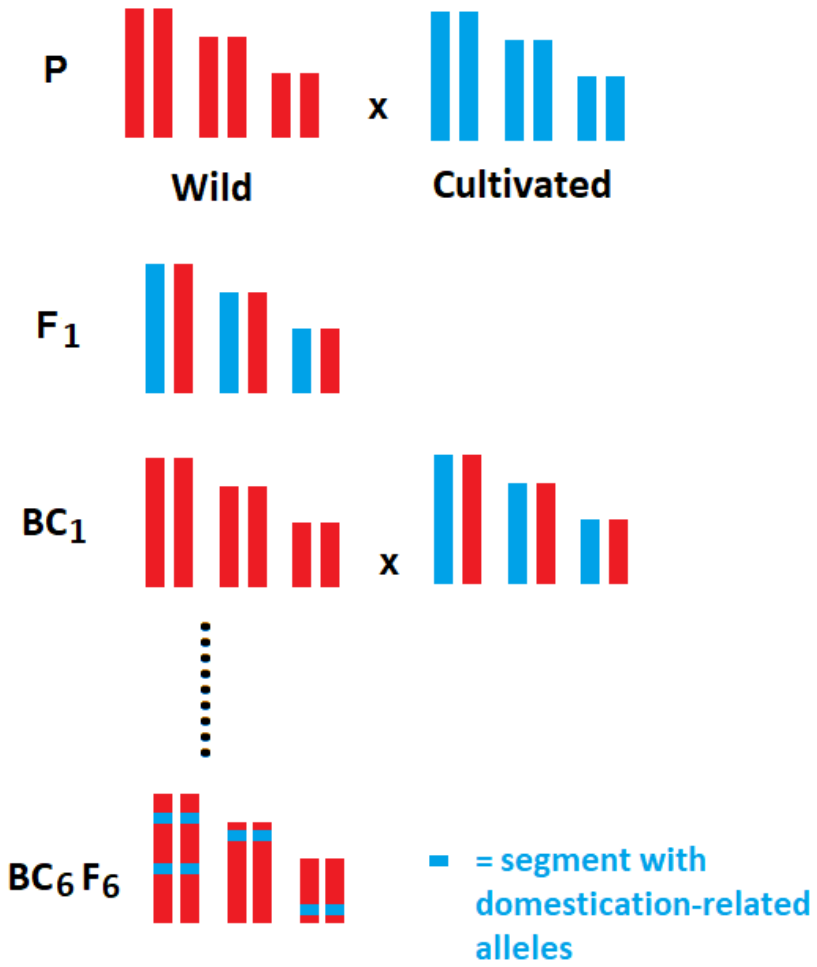


Seed scarification No seed scarification



Introgression can be used for *de novo* domestication when we have unique alleles (e.g *fas, fw2.2*) or traits whose genetic bases are not known (e.g. seed dormancy)

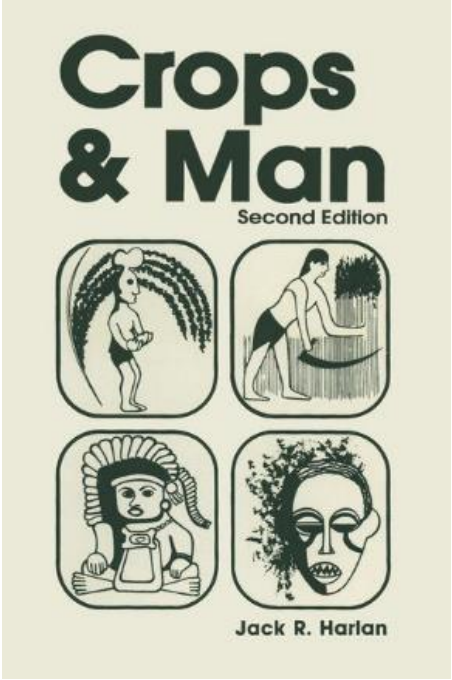


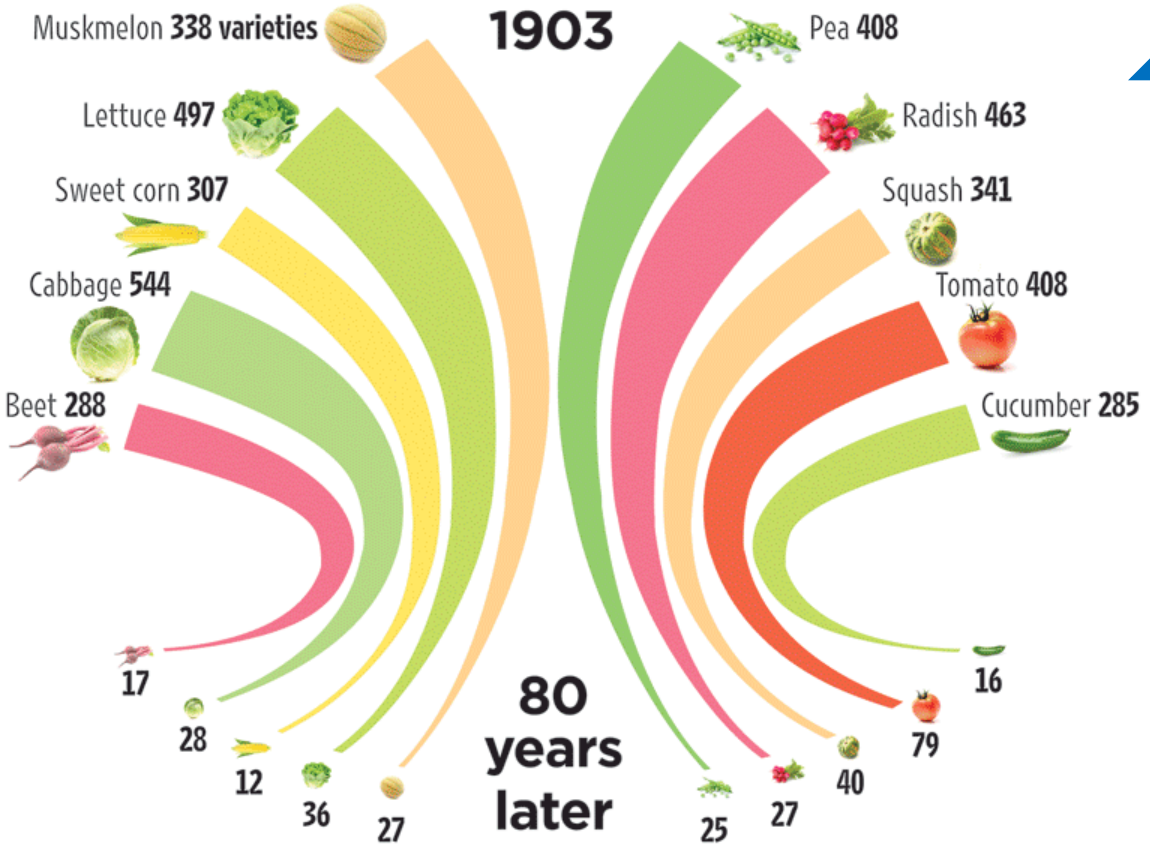


The main impact of *de novo* domestication: food security!

Domestication and improvement

"Man gathered more species than he domesticated, and domesticated many more than he now grows"





Source: RAFI

De novo domestication

Laboratory of Hormonal Control of Plant Development

Marcela Notini – PhD student (former)
Mayara Carvalho – PhD student
Mateus Vicente – PhD student
Maísa Siqueira Pinto – Post-Doc
Ariadne Lopo de Sá – Post-Doc





Collaborators

University of Münster, Germany

Jörg Kudla

University of Viçosa-MG, Brazil

Agustin Zsögön

University of Minnesota, USA

Tomas Cermak

Dan Voytas

Example of the polygenic basis of stress resistance:

Insect resistance in *S. galapagense*.