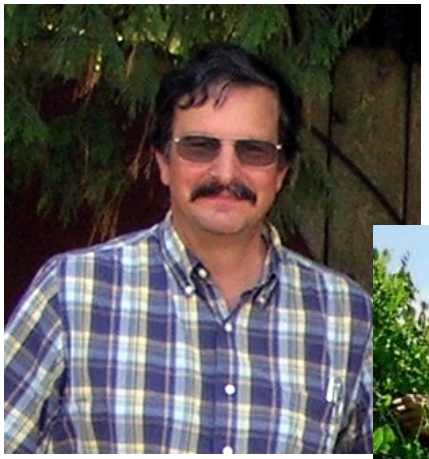
The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

How to breed new plant varieties: imagining and engineering crops

Jim Myers & Abi Graham

Department of Horticulture

Oregon State University



The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

Putting the snap back in snap peas

Jim Myers & Abi Graham

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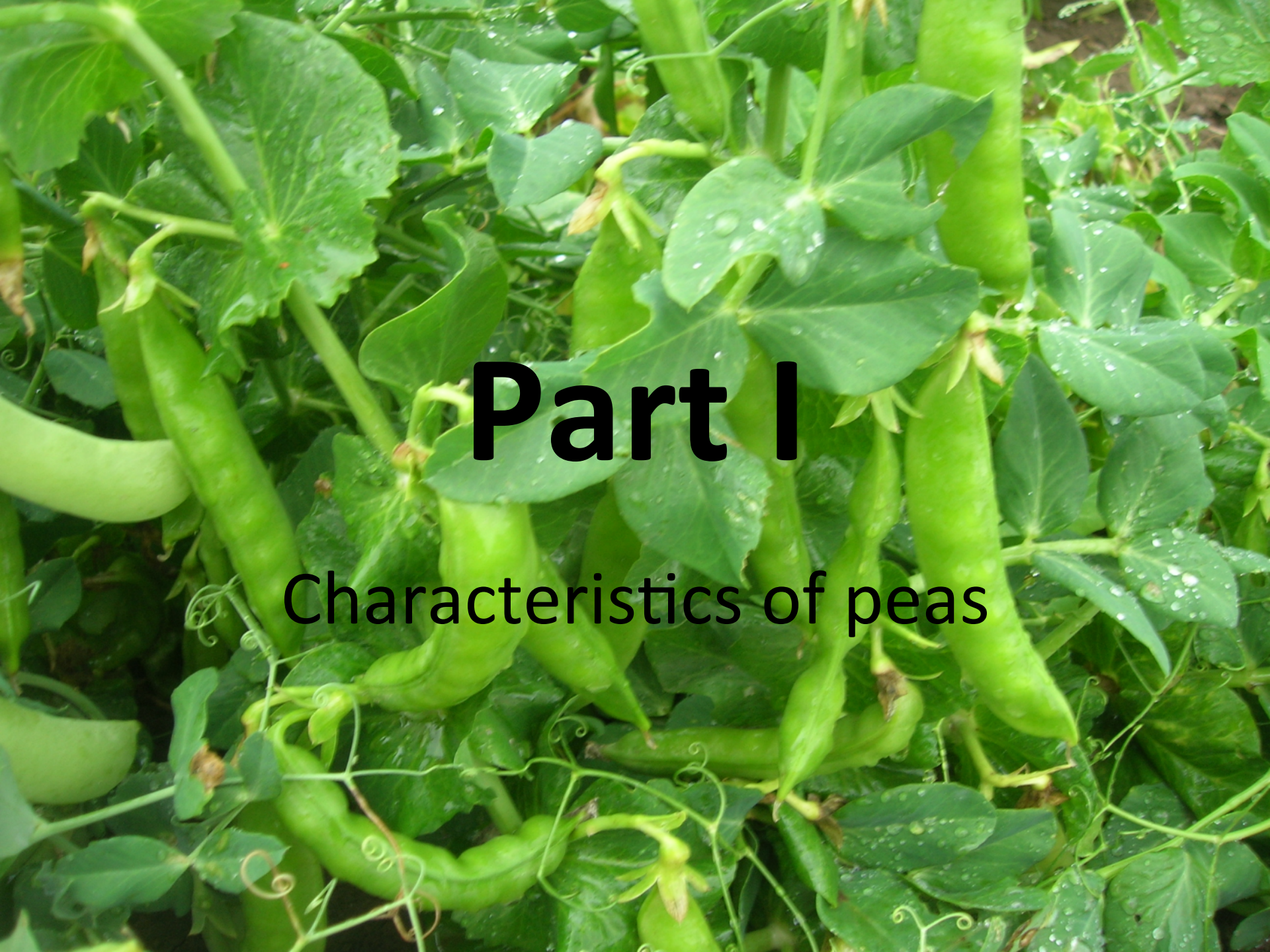


Part I

Characteristics of peas

Pisum sativum L.

- Cool Season (frost hardy)
- 2n =14 (diploid)
- Self pollinated
  - Anthers dehisce 24 hr before the flower opens
- Varieties are purelines

Pea: *Pisum sativum*

- Domesticated 8000-10,000 years ago in the Fertile Crescent
- Historically important to genetics: Mendel

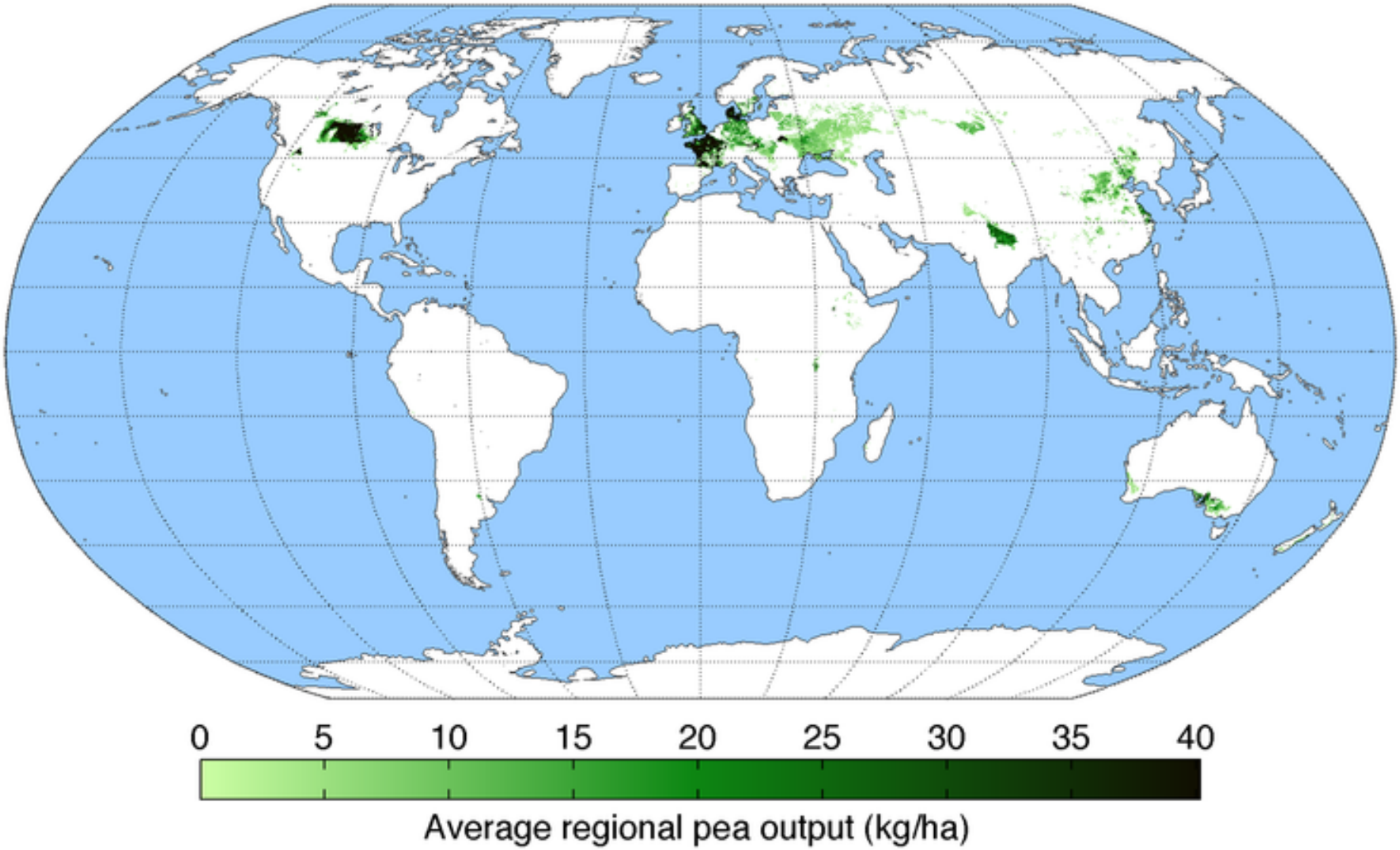
http://www.public.iastate.edu/~cfford/fertile%20crescent.jpg

Changes under Domestication

- Same as other legumes
  - (reduced seed dormancy, non shattering pods, increased seed size)
- White vs. purple flowers and colored seeds
- Green vs. yellow cotyledons
- Round vs. wrinkled seed (garden peas)

Dry & Green Pea Production in U.S.

- Dry: primarily Palouse (ID, WA); Mindak (ND, MN) region
- Green shell processed): NY, WI, MN, WA, OR, MI
- Snap (processed): Columbia Basin (WA), Magic Valley (ID)
- Snap (fresh): CA, FL, various



http://upload.wikimedia.org/wikipedia/commons/thumb/5/59/PeaYield.png/800px-PeaYield.png

Types of Peas

- Two main types:
  - Field (dry grain) peas
  - Vegetable peas
- Vegetable peas can be divided into:
  - Snow peas
  - Snap peas

Market Classes

	Cotyledon		Pod		Plant	Consumption
Type	**Color (*I*)**	**Shape (*R*)**	**Parchment (*P, V*)**	**Wall thick-ness (*N*)**	**Plant Height (*Le*)**	**Parts Consumed**
Field	Yellow or Green	Smooth	Present	Thin	Mostly tall	Mature seeds
Garden	Green	Mostly wrinkled, some smooth	Present	Thin	Mostly short	Immature seeds
Snow	Green	Smooth or wrinkled	Absent	Thin	Tall and short	Very young pods and seeds
Snap	Green	Wrinkled	Absent	Thick	Mostly short	Immature pods and seeds

Part II

What makes a snap pea a snap pea?

http://upload.wikimedia.org/wikipedia/commons/thumb/7/7f/Tokarski_Still_life_with_pea.jpg/792px-Tokarski_Still_life_with_pea.jpg

Snap Pea Origins: stepwise mutations

- Snow peas derived from field and garden peas
  - Mutation eliminates pod wall fiber
- Snap peas arose from snow pea
  - Mutation of thin to thick pod walls
- Contemporary snap peas usually white flowered and wrinkled green cotyledons (garden pea origins)

Historic evidence for snap pea

- "Sickle" peas described by John Ray (1686) probably refers to a snap pea
- Vilmorin (1885) *Vegetable Garden* described 'Butter Pea' ('Pois Beurre‘)
- Wellensiek (1925) 'Reuzenboterpeul' ('Great Butter Pea')
- Hedrick (1928) "Butter Sugar" group (6 varieties)

Snap pea history

- Snap peas have been around for along time but never very popular

‘Sugar Snap’

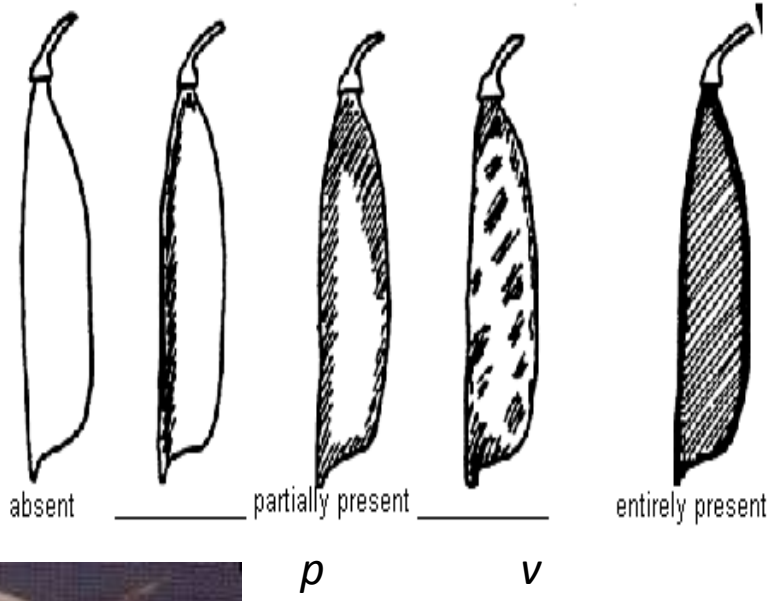
- ‘Sugar Snap’ developed by Calvin Lamborn (Gallatin Valley Seed Co., 1979)
- Trying to solve problem of pod distortion in snow peas
- RS87, a thick-walled ‘Dark Skin Perfection’ off-type, crossed to ‘Mammoth Melting Sugar’
- ‘Sugar Snap’: tall, stringy pods, white flowers, excellent flavor, lacks disease resistance.
- Constantly promoted the type

Traits specific to snap pea

http://www.inspection.gc.ca/plants/seeds/inspection-procedures/pulse-crops/eng/1347350063134/1347350364579

Pod Fiber

- "Parchment"



High Fiber

Low Fiber

Pod Wall Thickness

- Pod wall thickness controlled by *n*
- Recessive
- Pleiotropic effects: overall reduction in pod size, round cross section, and tendency to be curved
- Increase in number of parenchyma cells, but also an increase in cell size

Stringless Pods

- Stringless pod produced by *sin2* for *sine-fili*.
- Temperature dependent (increased stringlessness at higher temperatures
- Smaller pods and shorter plants. Most pronounced when plants grown in heat & stressful environments

Sin2 Genetics

- Stringlessness is controlled by a single recessive gene
- Sin2 shows unexpected inheritance ratios: lower than expected numbers of stringless progeny in the F2 generation
- Plants that carry sin2 also have reduced pollen tube growth rates
- When *sin2* and *rr* are combined, the seed shape phenotype is dimpled

Part III

Snap Pea Breeding

Snap Pea Breeding

- Breeding techniques for self pollinated crops
  - Pedigree method
  - Single Seed Descent
  - Backcross breeding (simple traits)
  - Inbred backcross (quantitative traits)
  - Recurrent selection
  - Bulk breeding

Breeding Constraints/Advantages for Peas

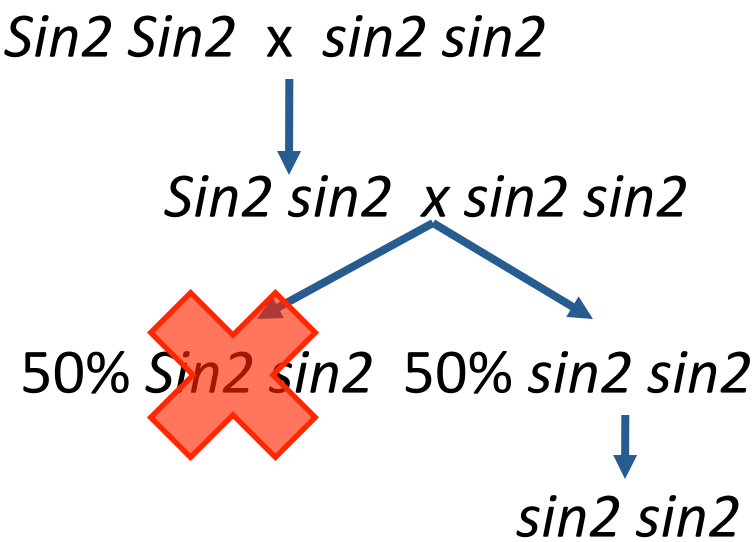
- Limited seed multiplication ratio (1:10)
- Low crossing efficiency
  - 2-3 seeds/ hand cross
- High selfing efficiency
- Short (3-4 month) reproductive period
- Cool season annual
- Large seed

Snap Pea Breeding

- Stringy snap x Stringy snap
  - No special considerations
- Stringy snap x garden or field pea
  - Segregates for many traits in F2
  - Only 1 in 1,024 w/ complete snap phenotype
  - Improve odds w/ backcross

Snap Pea Breeding

- Stringless snap x Stringless snap
  - No special considerations
- Stringless snap x Stringy pea
  - Low recovery of stringless phenotype in F2
  - Backcross:



Seed Shape

- Wrinkled, round, (dimpled)
- *Rugosus (r)* gene (recessive)
- Defective starch branching enzyme slows starch accumulation and increases sugar content
- At least 5 other loci involved in the sugar-starch pathway known

Cotyledon Color

- Cotyledon color is determined by the *I* locus on linkage group 1
- *I*- produces yellow cotyledons while *ii* produces green

Pod Apex Shape

- The *Bt* gene controls the shape of the pod apex
- *BtBt* plants have blunt pod apices, while *btbt* plants have pointed apices
- Blunt preferred to increase shedding of senesced blossoms

Anthocyanin

- *AA* plants have purple flowers, pigmented stems and pods, purple flecked seeds, and a colored ring at the maculum.
- Pods w/ anthocyanin are astringent

Plant Height

Plant height is controlled by several genes, but the most important one is *Le*.

- Plants with *Le*- typically are taller than one meter, while *lele* plants are less than one meter.
- *Le* is linked to the *v* gene (for pod fiber) on linkage group 3.

Leaflets & Tendrils

- The *afila (af)* trait replaces leaflets with tendrils
- Reduced lodging
- Better under heat stress
- Better spray and light penetration
- Reduced biomass allows for easier mechanical harvest

Yield

- Two qualitative genes affect yield: *fn* & *fna*
- *Fn-Fna:* one flower/ node
- *Fn-fnafna* or *fnfnFna-*: 2or 3 flowers/node
- *fnfn fnafna:* up to 5 flowers

Disease resistance

- Fusarium wilt (several races)
- Powdery mildew
- Downy mildew
- Pea Enation Mosaic Virus
- Bean Leafroll Virus
- Pea Seedborne Mosaic Virus

Source

- Myers, James, Baggett Myers, and Lamborn Calvin 2001. Origin, History, and Genetic Improvement of the Snap Pea (*Pisum sativum* L.) . Plant Breeding Reviews. 21:93-138.

National Association of Plant Breeders
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