

## 交雑親和性 (Cross-compatibility)



☆ 交雑障壁 (Crossing barrier)

☆ 生殖隔離 (Reproductive isolation)

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## Hawkes (1990)の分類

Subsection  
*ESTOLONIFERA*  
Subsection  
*POTATOE*

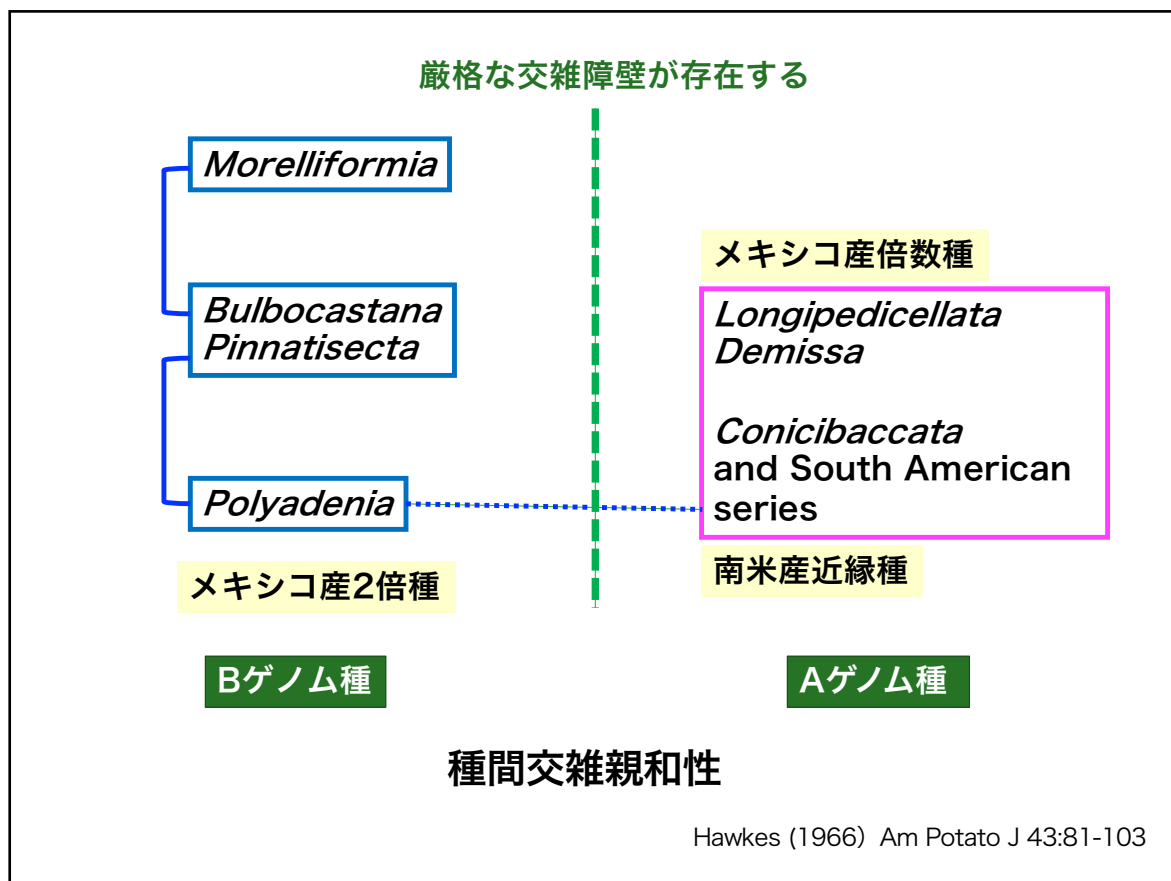
分類群

種数

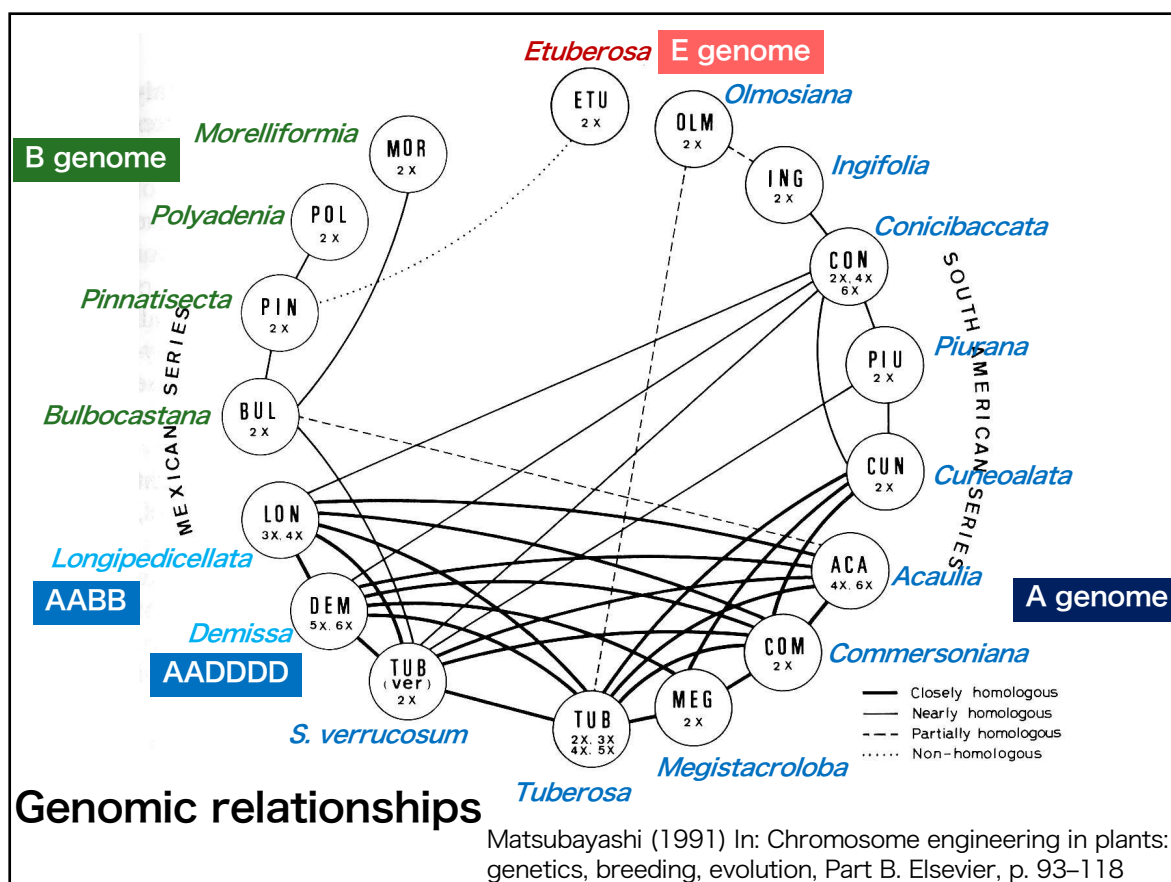
|                         |          |    |
|-------------------------|----------|----|
| <i>Etuberosa</i>        | 非塊茎形成種   | 5  |
| <i>Juglandifolia</i>    |          | 4  |
| <i>Morelliformia</i>    |          | 1  |
| <i>Bulbocastana</i>     | メキシコ産2倍種 | 2  |
| <i>Pinnatisecta</i>     |          | 11 |
| <i>Polyadenia</i>       |          | 2  |
| <i>Commersoniana</i>    |          | 2  |
| <i>Circaeifolia</i>     |          | 3  |
| <i>Lignicaulia</i>      |          | 1  |
| <i>Olmosiana</i>        |          | 1  |
| <i>Yungasensa</i>       |          | 9  |
| <i>Megistacroloba</i>   | 南米産近縁種   | 11 |
| <i>Cuneoalata</i>       |          | 3  |
| <i>Conicibaccata</i>    |          | 40 |
| <i>Piurana</i>          |          | 15 |
| <i>Ingifolia</i>        |          | 2  |
| <i>Maglia</i>           |          | 1  |
| <i>Tuberosa</i>         |          |    |
| グループ 1 (メキシコからエクアドル)    |          | 11 |
| グループ 2 (ペルー)            |          | 53 |
| グループ 3 (ボリビア以南地域)       |          | 33 |
| 栽培種                     |          | 7  |
| <i>Acaulia</i>          |          | 4  |
| <i>Longipedicellata</i> | メキシコ産倍数種 | 7  |
| <i>Demissa</i>          |          | 8  |

Hawkes (1990) The potato: evolution, biodiversity and genetic resources. Belhaven Press

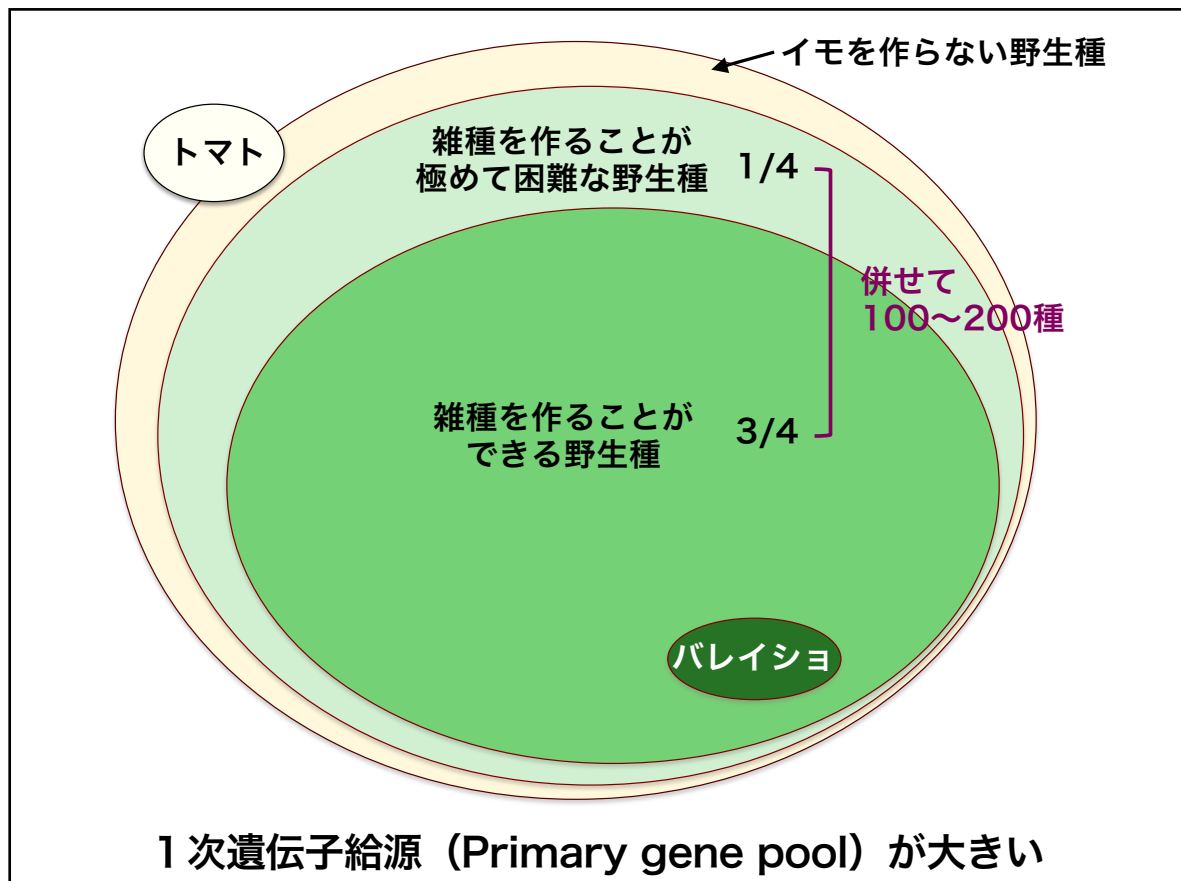
2



3



4



5

## 交雑障壁 (Crossing barrier)

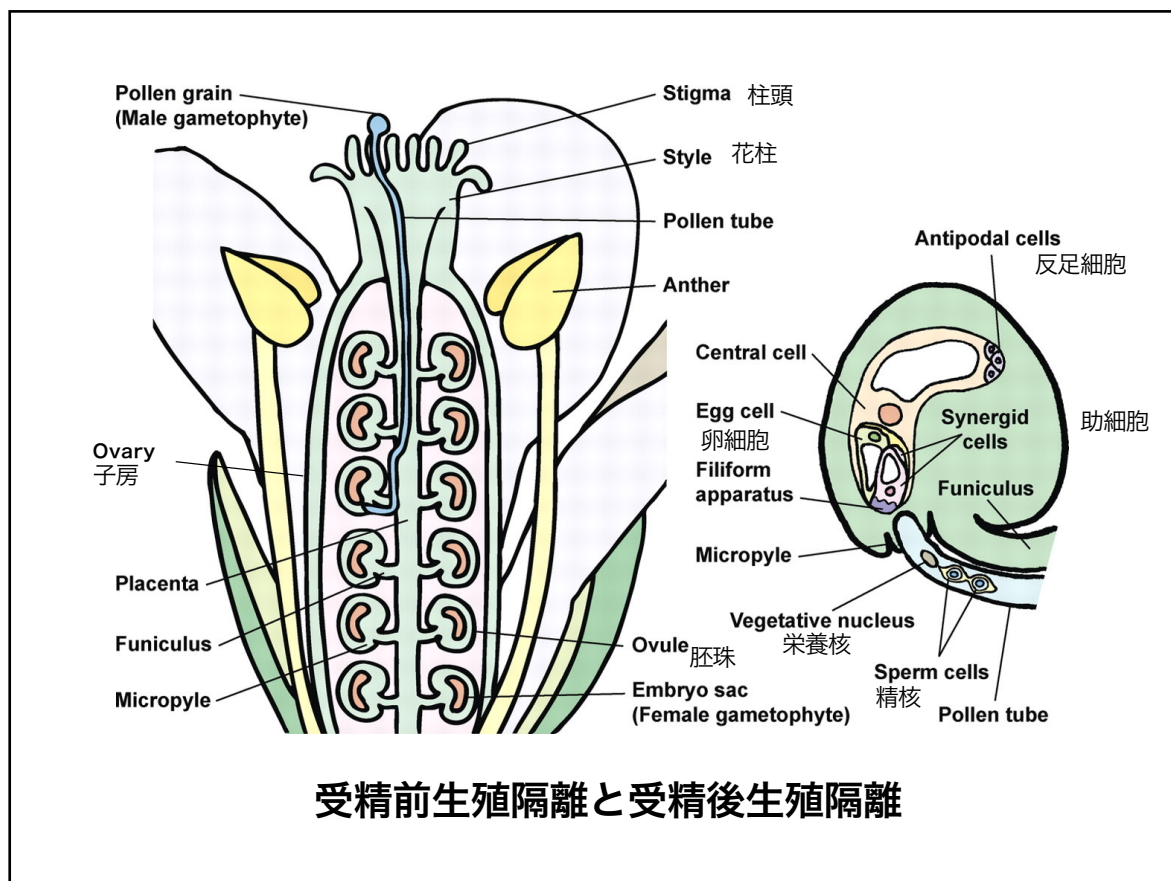
### 受精前生殖隔離 (Pre-zygotic barrier)

- 自家不和合性 (Self-incompatibility)
- 一側性交雑親和性 (Unilateral, or one-way cross-compatibility)
- 雄性不稔性 (Male sterility)
- 雌性不稔性 (Female sterility)

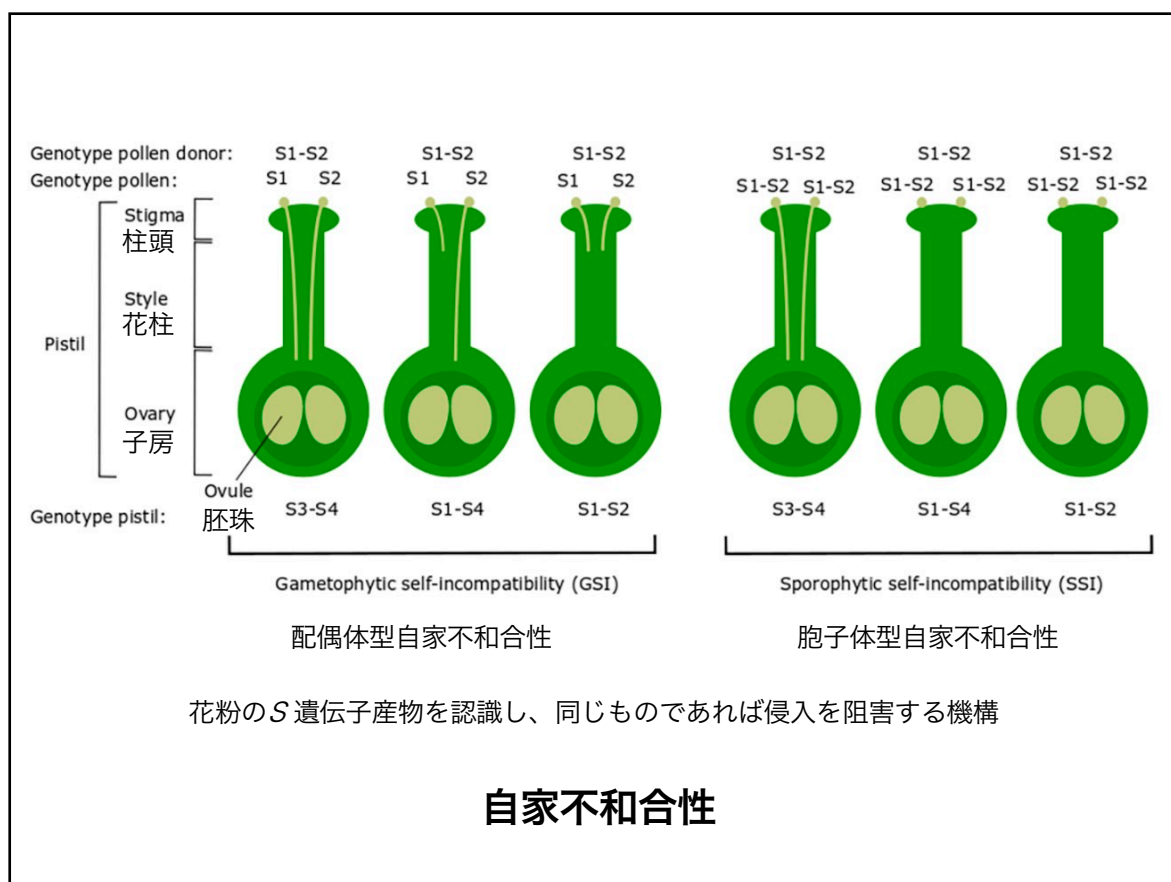
### 受精後生殖隔離 (Post-zygotic barrier)

- 胚乳崩壊 (Endosperm abortion)
- 雑種崩壊 (Hybrid breakdown)

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## バレイショ近縁種における自家不和合性

- ★ 下記の例外を除き、2倍種は全て *S* 遺伝子（第1番染色体に座乗）による配偶体型自家不和合性を示す

*S. brevidens* and *S. etuberosum* (series *Etuberosa*)  
*S. morelliforme* (series *Morelliformia*)  
*S. polyadenium* (series *Polyadenia*)  
*S. verrucosum* (series *Tuberosa*)

- ★ 倍数種は全て自家和合性を示し、あるものは極端に高い自殖稔性を示す（例えば、*S. acaule*、*S. stoloniferum*、*S. demissum* など）

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## 4倍体と2倍体を交雑するとほとんどは4倍体になる

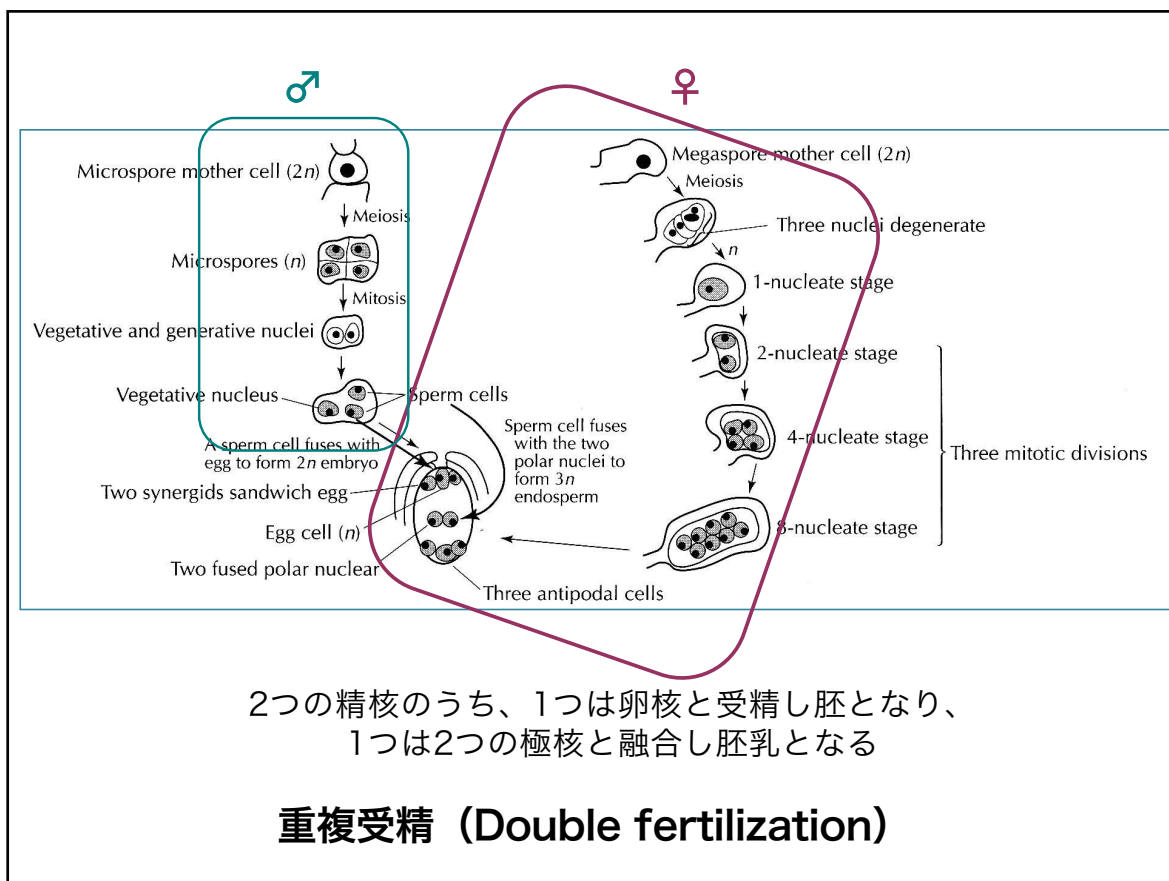
|         | 2x   | 3x   | 4x    |
|---------|------|------|-------|
| 4x x 2x | 0.6% | 7.6% | 91.9% |
| 2x x 4x | 3.3% | 1.9% | 94.8% |

Hanneman & Peloquin (1968)  
 Am Potato J 45:255-261

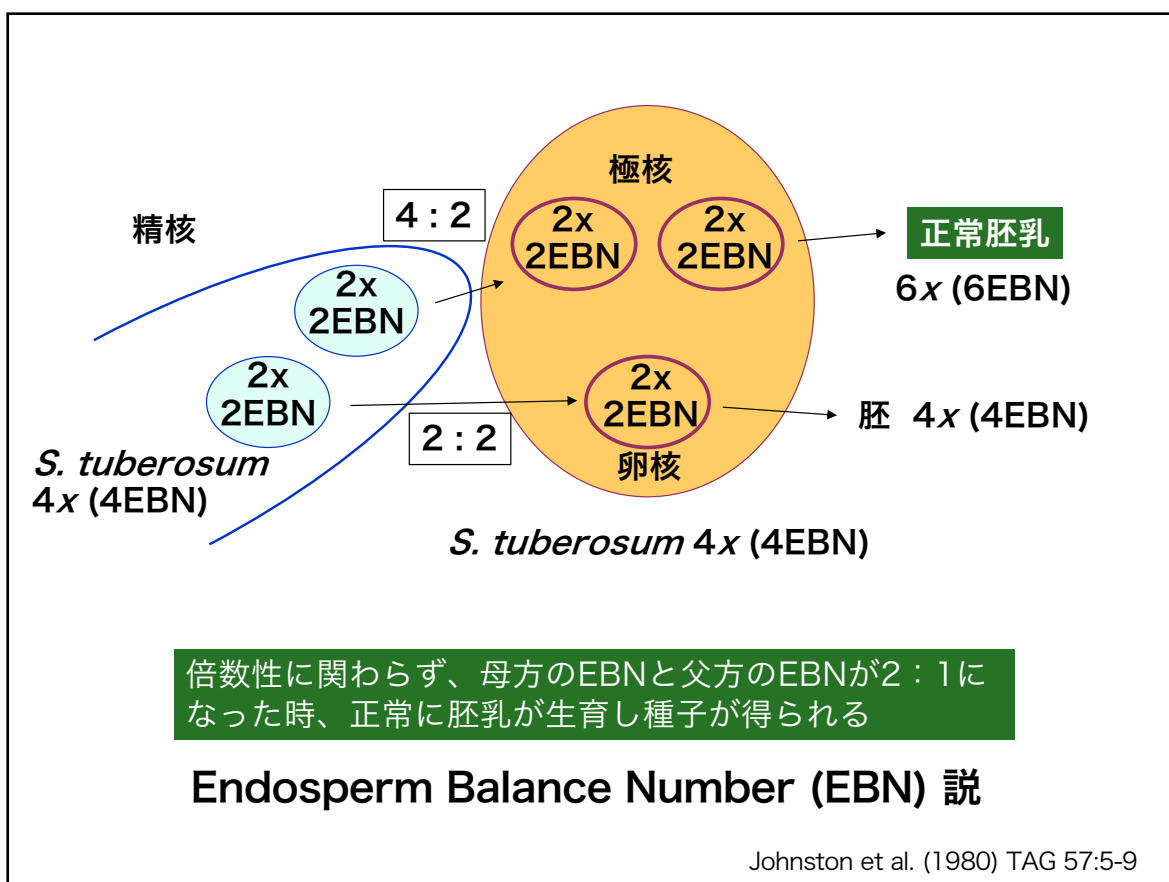
### Triploid block

Marks (1966) Evolution  
 20:552-557

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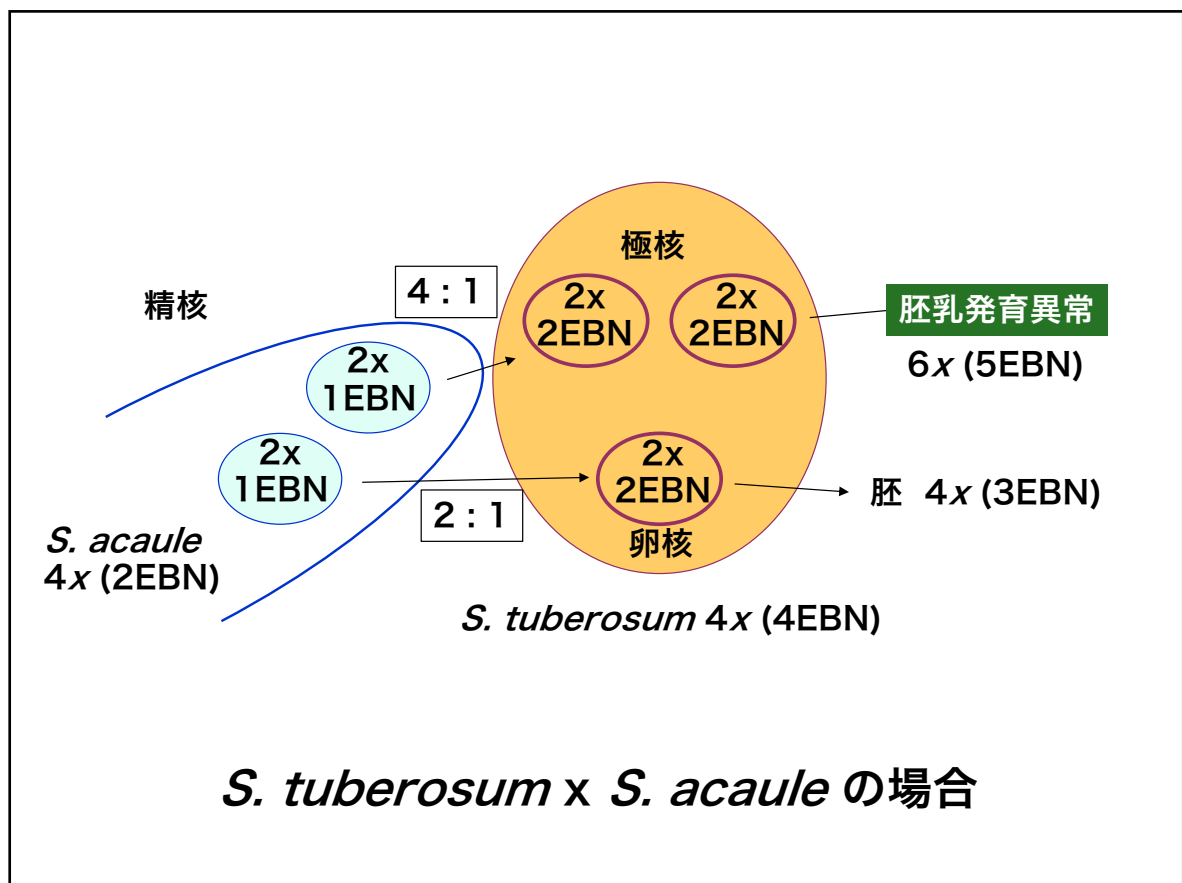


11

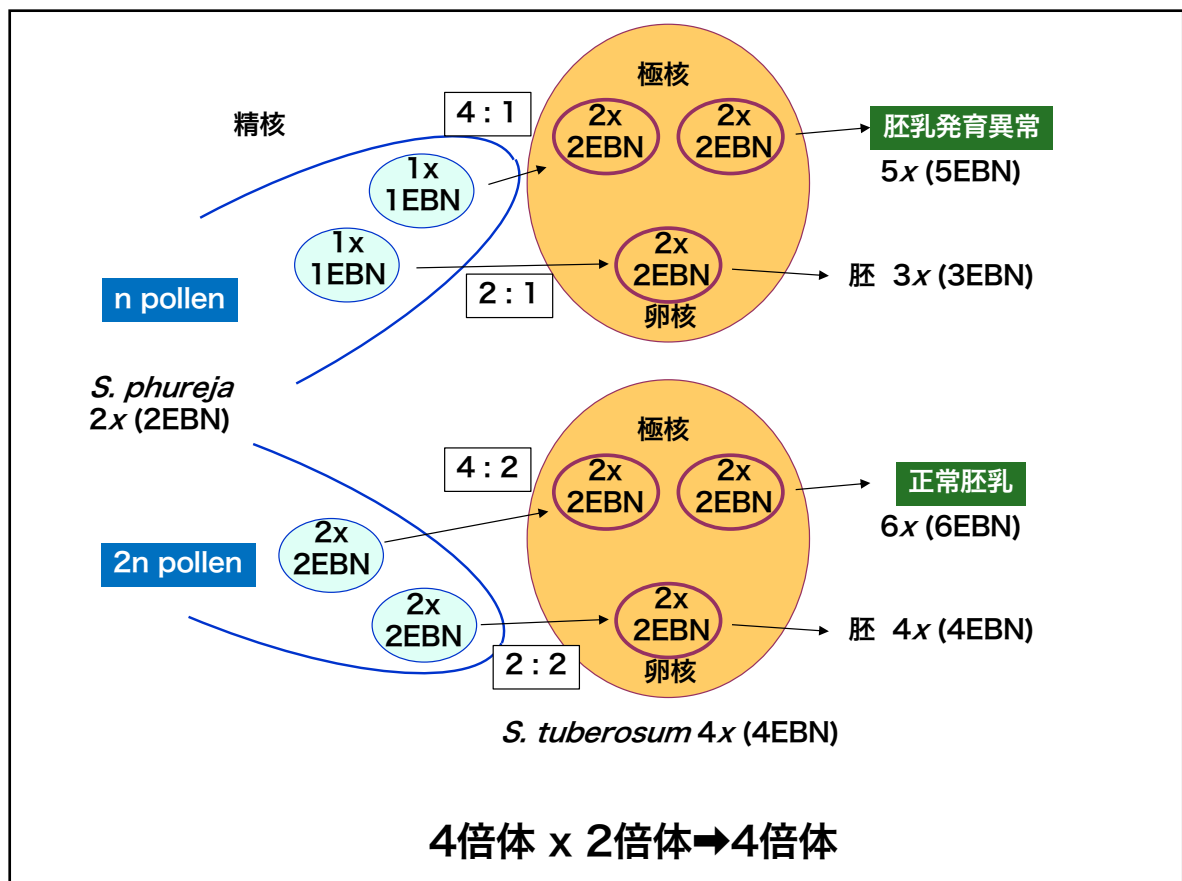


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## How to determine EBN

### Cross with EBN standards

**2x (1EBN)** *S. cardiophyllum*, *S. commersonii*

**2x (2EBN)** *S. chacoense*, *S. phureja*

**4x (4EBN)** 4x *S. chacoense*, *S. tuberosum* ssp. *andigena*

### Determine based on the following criteria

- 1) Seed viability (i.e. plumpness, germinability and/or size)
- 2) Number of viable seeds/fruit
- 3) If failed, check at least if pollen tubes reached the ovary
- 4) Ploidy of offspring

Hanneman (1994) Euphytica 74:19-25

## EBN 値

**2x (1EBN)**

非塊茎形成種  
メキシコ産2倍種  
*S. chancayense*, *S. commersonii*,  
および *S. mochiquense*

**2x (2EBN)**

南米産近縁種のほとんど

**4x (2EBN)**

メキシコ産4倍種、*Conicibaccata* 群の4倍種、  
*S. acaule*, *S. tuquerrense*

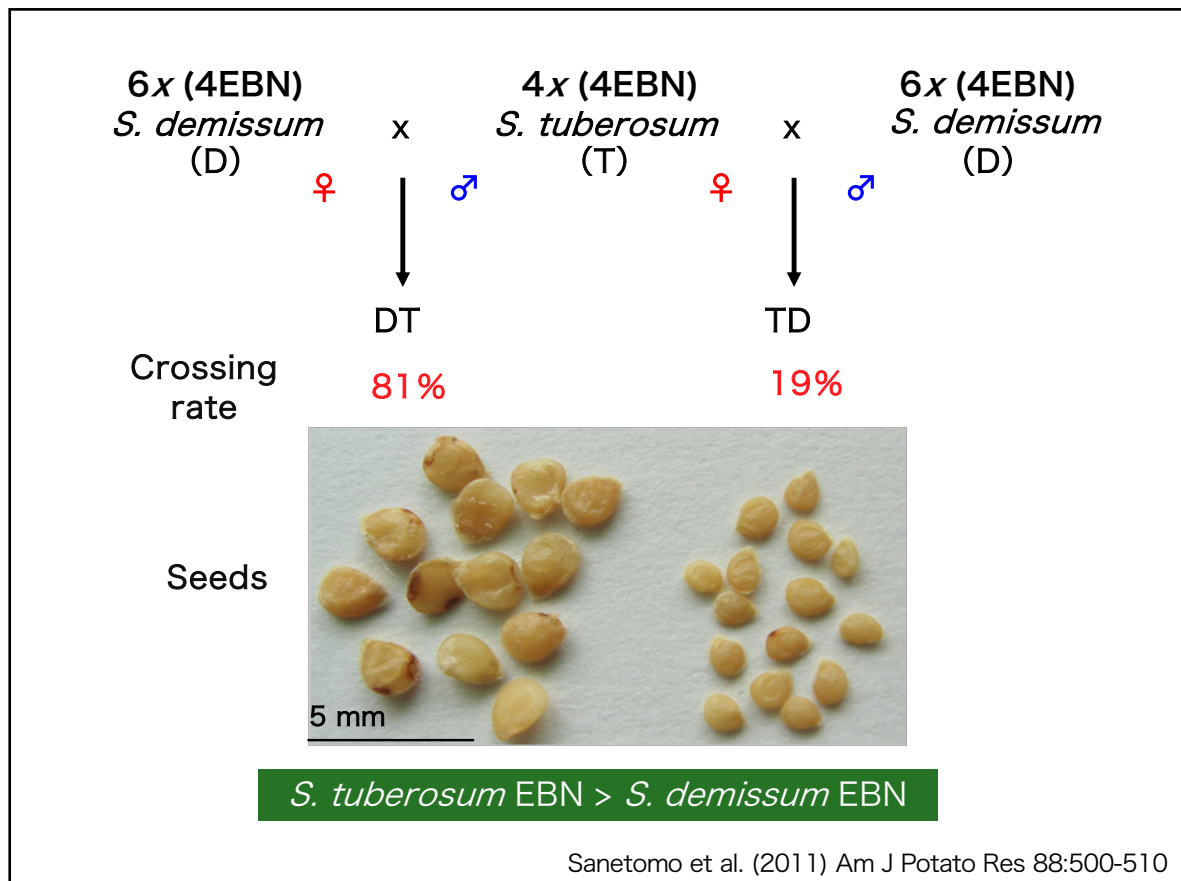
**4x (4EBN)**

*S. tuberosum*, *S. sucrense*

**6x (4EBN)**

メキシコ産6倍種、*Conicibaccata* 群の6倍種、  
*S. albicans*

Hanneman (1994) Euphytica 74:19-25



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## 自家和合性 *Solanum chacoense* の発見

*Self Fertility in Solanum chacoense*. Hanneman, Jr., R.E., USDA, ARS, NCR, University of Wisconsin-Madison, Madison, Wisconsin.

Several lines of *S. chacoense* have been inbred to the S4 to S6 generation. Inbreeding was begun in an attempt to associate the S-locus with a specific chromosome using the trisomic series. This effort was given up when it was determined that self-compatibility may have been introduced into some of the trisomic lines. In this study, nearly half of the progeny of several families set over 100 seeds per fruit. The range in seeds per fruit across all families was 0-590 with family averages ranging from 3-108. While rigorous genetic analysis has not been done, and may be confounded by pseudo-compatibility, selfing rates among the selected families can be explained with as few as two genes being involved. *Paper not read.*

Hanneman (1985) Am Potato J 62:428-429

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## Genetics of self-compatibility in a self-incompatible wild diploid potato species *Solanum chacoense*. 1. Detection of an S locus inhibitor (Sli) gene

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Received 10 March 1997; accepted 3 September 1997

**Key words:** inbreeding, self-compatibility, S locus inhibitor, sporophytic action, *Solanum chacoense*

単一優性遺伝子が花粉側のS遺伝子の働きを阻害する  
**S locus inhibitor (Sli) gene** スライジーン

### Summary

A self-compatible (SC) variant of a wild diploid potato species, *Solanum chacoense*, which is normally self-incompatible (SI), was investigated for the nature and genetics of self-compatibility. It was crossed with a SI cultivated diploid potato species, *S. phureja*. The F<sub>1</sub> progeny segregated SC vs. SI. Diallel crosses were made among 15 F<sub>1</sub>'s. Self-compatibility was tested in a selfed family of a parental SC variant and in sib-mated and

Hosaka & Hanneman (1998) Euphytica 99:191-197

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## Genetics of self-compatibility in a self-incompatible wild diploid potato species *Solanum chacoense*. 2. Localization of an S locus inhibitor (Sli) gene on the potato genome using DNA markers \*

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<sup>1</sup> Experimental Farm, Kobe University, 1348 Uzurano, Kasai, Hyogo 675-2103, Japan; <sup>2</sup> USDA, Agricultural Research Service, Vegetable Crops Research Unit, Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, Wisconsin, 53706, U.S.A.

Received 4 November 1997; accepted 23 April 1998

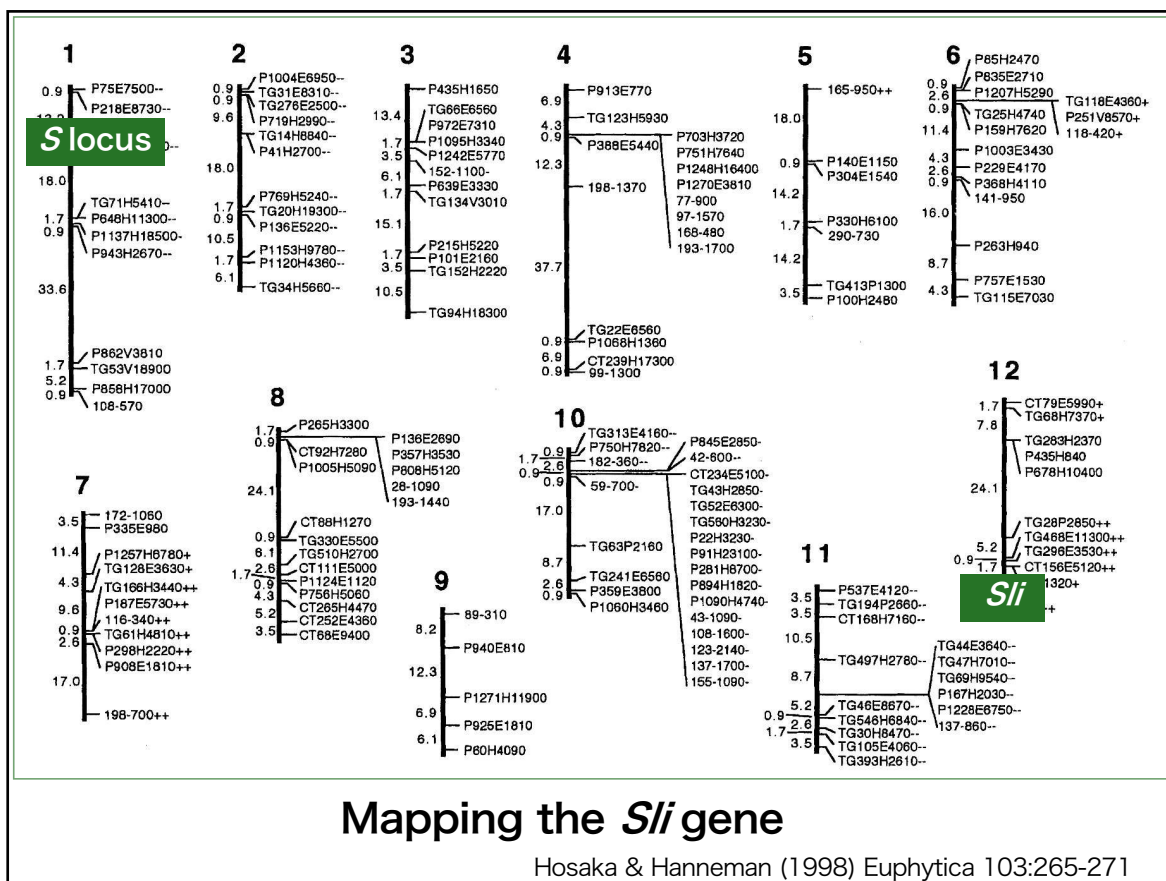
**Key words:** genetic linkage map, self-compatibility, S locus inhibitor, Sli gene, *Solanum chacoense*

### Summary

A self-compatible (SC) hybrid plant F<sub>1</sub>-1 was obtained from a cross between a SC variant of a wild diploid potato species, *Solanum chacoense*, and a self-incompatible (SI) cultivated diploid species, *S. phureja*. The clone F<sub>1</sub>-1 has previously been proposed to have a dominant S locus inhibitor gene (Sli) in a heterozygous condition. It was crossed as a male parent with a selected clone from a *S. stenotomum*-*S. phureja* population, resulting in a segregating population consisting of 116 hybrid plants. Self-compatibility was assessed by selfing each of the hybrids. Sixty-

Hosaka & Hanneman (1998) Euphytica 103:265-271

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## Production of inbred progenies of diploid potatoes using an *S*-locus inhibitor (*Sli*) gene, and their characterization

**R.K. Birhman and K. Hosaka**

**Abstract:** To develop inbred lines from self-incompatible, cultivated diploid potatoes, an *S*-locus inhibitor (*Sli*) gene derived from a self-compatible variant of a wild potato species, *Solanum chacoense*, was incorporated into various cultivated diploid potatoes. The progeny was selfed twice by the action of the *Sli* gene to obtain 74  $S_2$  inbred clones belonging to 8 families. More than 40% of them were either non-flowering or pollen sterile. Among the pollen fertile clones, self-compatible clones occurred with a much lower frequency (20.9%) than expected (83.3%). The result demonstrated that self-compatibility was introduced and expressed in the gene pool of cultivated diploid potatoes by an action of the *Sli* gene, although serious inbreeding depression associated with selfing occurred. The genotypes of  $S_2$  inbreds were surveyed using 46 *S. chacoense* - specific RFLP (restriction fragment length polymorphism) markers covering the whole potato genome. More than half of the markers (67.4%) showed distorted segregation. Particularly, all markers on chromosome 12 were overrepresented in the  $S_2$  inbreds. This confirms our earlier finding that the *Sli* gene locates on chromosome 12 and the alleles linked with this gene are preferentially transmitted because of its essential requirement for selfing.

**Key words:** RFLP markers, inbreds, diploid potato, distorted segregation.

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<sup>1</sup>Dr. Birhman passed away on December 29, 1999.  
<sup>2</sup>Author to whom all correspondence should be addressed (e-mail: hosaka@kobe-u.ac.jp).

Birhman & Hosaka (2000) Genome 43:495-502

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## Neofunctionalisation of the *Sli* gene leads to self-compatibility and facilitates precision breeding in potato

Ernst-Jan Eggers<sup>1,2</sup>, Ate van der Burgt<sup>1</sup>, Sjaak A. W. van Heusden<sup>2</sup>, Michiel E. de Vries<sup>1</sup>, Richard G. F. Visser<sup>1,2</sup>, Christian W. B. Bachem<sup>2</sup> & Pim Lindhout<sup>1</sup>

Genetic gain in potato is hampered by the heterozygous tetraploid genome of cultivated potato. Converting potato into a diploid inbred-line based F1-hybrid crop provides a promising route towards increased genetic gain. The introduction of a dominant S-locus inhibitor (*Sli*)

Eggers et al. (2021) Nature Communications 12:4141

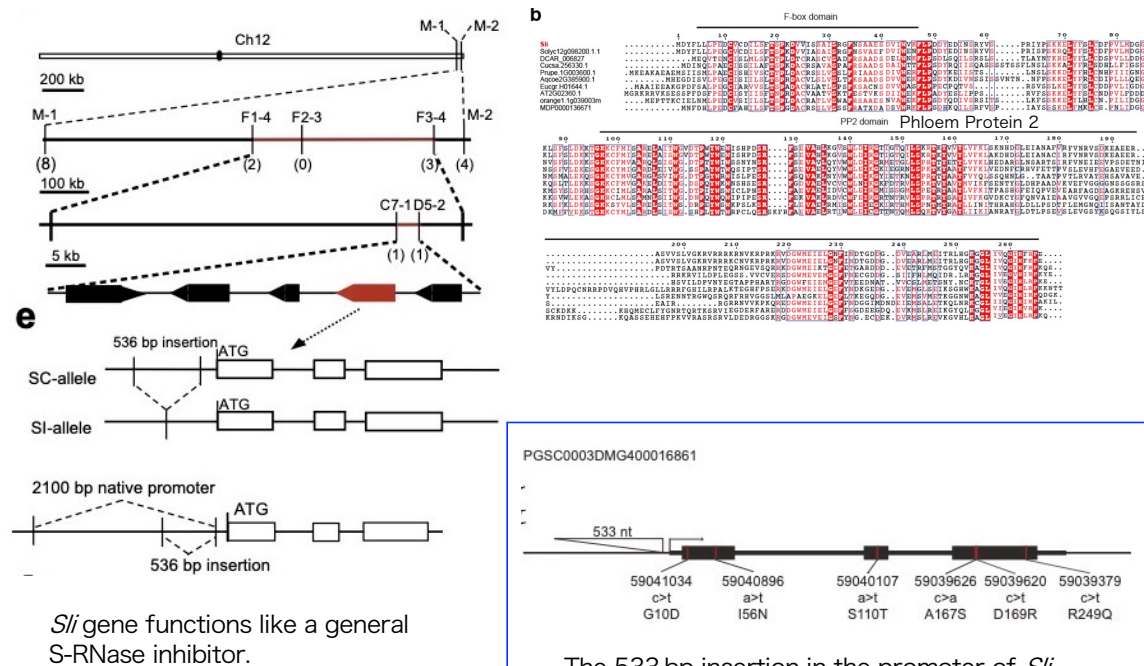
## A nonS-locus F-box gene breaks self-incompatibility in diploid potatoes

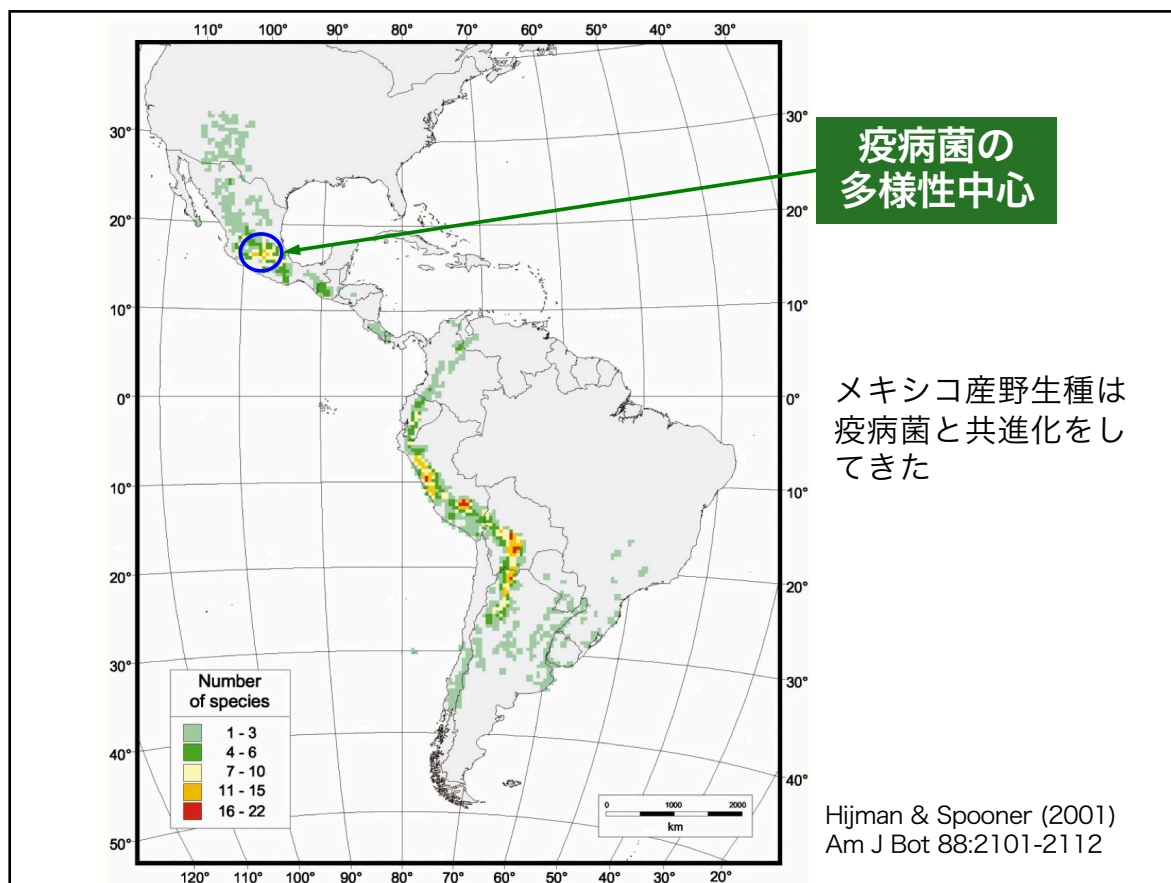
Ling Ma<sup>1,7</sup>, Chunzhi Zhang<sup>2,7</sup>, Bo Zhang<sup>1,7</sup>, Fei Tang<sup>1</sup>, Futing Li<sup>1</sup>, Qinggang Liao<sup>2</sup>, Die Tang<sup>2</sup>, Zhen Peng<sup>3</sup>, Yuxin Jia<sup>2</sup>, Meng Gao<sup>1</sup>, Han Guo<sup>4</sup>, Jinzhe Zhang<sup>5</sup>, Xuming Luo<sup>2</sup>, Huiqin Yang<sup>1</sup>, Dongli Gao<sup>1</sup>, William J. Lucas<sup>2,6</sup>, Canhui Li<sup>1</sup>, Sanwen Huang<sup>2</sup> & Yi Shang<sup>1</sup>

Potato is the third most important staple food crop. To address challenges associated with global food security, a hybrid potato breeding system, aimed at converting potato from a tuber-propagated tetraploid crop into a seed-propagated diploid crop through crossing inbred

Ma et al. (2021) Nature Communications 12:4142

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強度疫病抵抗性を持つメキシコ産野生2倍種  
栽培バレイショとは交雑できない

*Solanum pinnatisectum* Dunal  
( $2n=2x=24$ , 1EBN)

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## 自家不和合性阻害遺伝子 (S-locus inhibitor, *Sli*) の利用

*Sli* 遺伝子供与系統  
(97H32-6)



自家不和合性だけではなく受精前障壁を突破するのでは？

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受精後における種間交雑の成否は  
雌雄の力 (EBN) のバランスによる

| 倍数性 | 種 名                     | EBN  |
|-----|-------------------------|------|
| 2x  | <i>S. pinnatisectum</i> | 1EBN |
| 2x  | <i>S. bulbocastanum</i> | 1EBN |
| 2x  | <i>S. verrucosum</i>    | 2EBN |
| 2x  | <i>S. phureja</i>       | 2EBN |
| 2x  | <i>Sli</i> 供与系統         | 2EBN |
| 4x  | <i>S. stoloniferum</i>  | 2EBN |
| 4x  | <i>S. acaule</i>        | 2EBN |
| 4x  | <i>S. tuberosum</i>     | 4EBN |
| 6x  | <i>S. demissum</i>      | 4EBN |

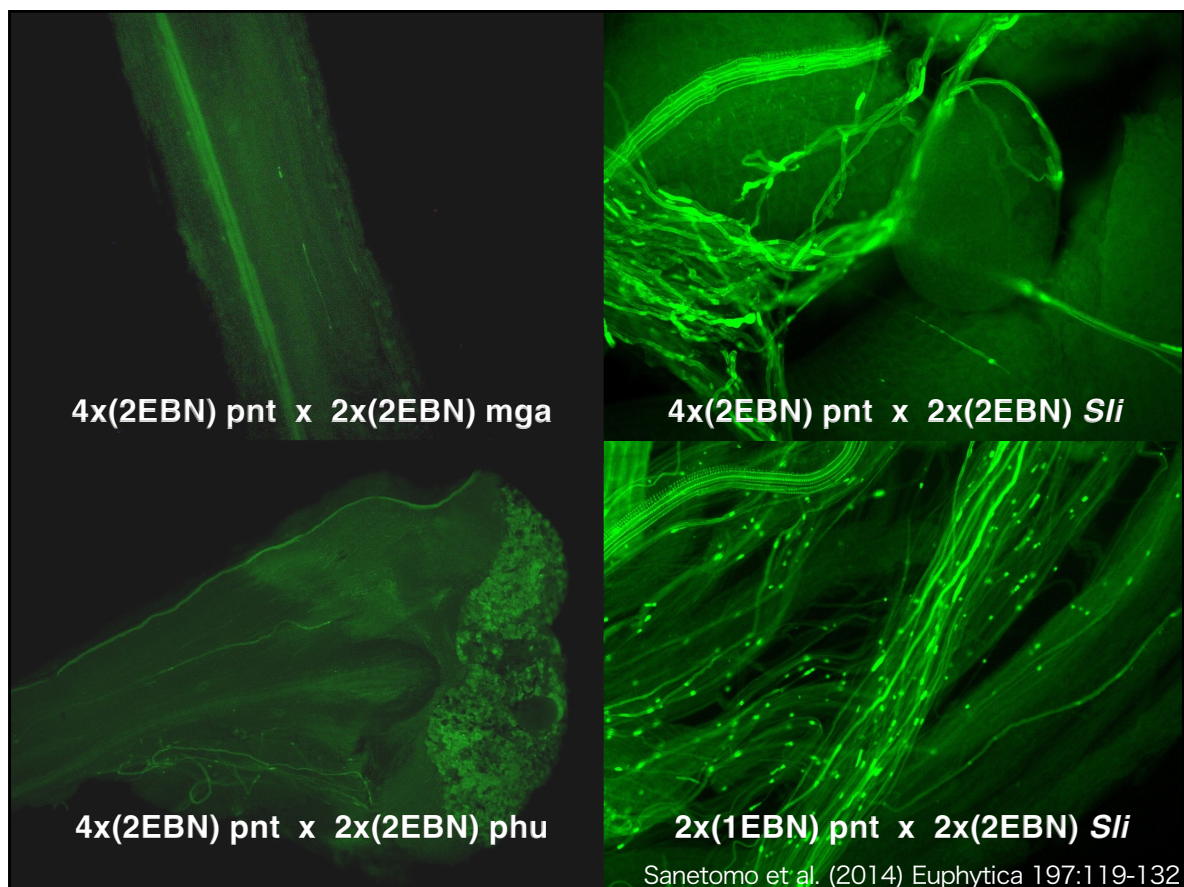


2x (1EBN)  
コルヒチン処理に  
よる染色体倍加



4x (2EBN)

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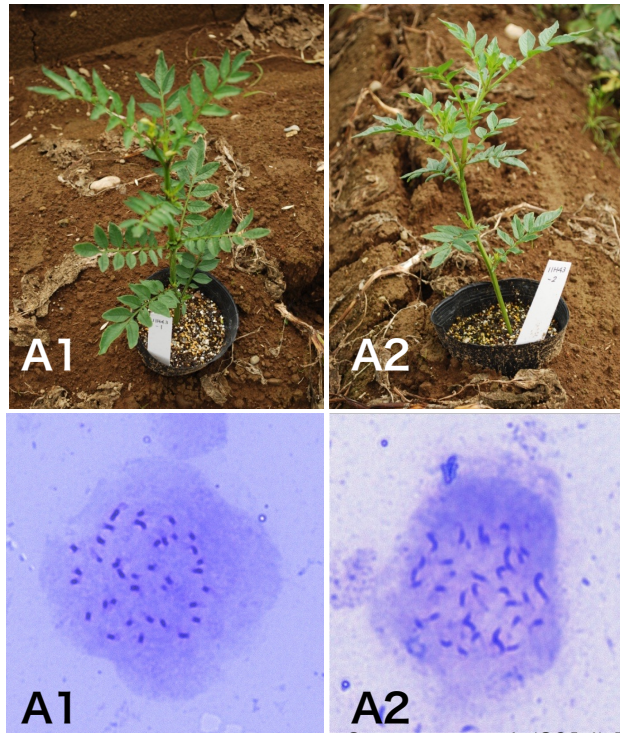
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| 交雑試験結果        |               |      |     |        |       |
|---------------|---------------|------|-----|--------|-------|
| 母親            | 父親            | 授粉花数 | 着果数 | 交雑率(%) | 種子数   |
| 2x <i>pnt</i> | <i>Sli</i>    | 148  | 70  | 37.8   | 0     |
| 2x <i>pnt</i> | 4x <i>Sli</i> | 104  | 0   | 0      |       |
| 4x <i>pnt</i> | <i>Sli</i>    | 971  | 357 | 20.8   | 9 → 2 |
| 4x <i>pnt</i> | 4x <i>Sli</i> | 39   | 0   | 0      | 植物体   |
| 4x <i>pnt</i> | <i>mga</i>    | 74   | 0   | 0      |       |
| 4x <i>pnt</i> | <i>phu</i>    | 17   | 0   | 0      |       |
| 2x <i>pnt</i> | 2x <i>tbr</i> | 1683 | 10  | 0.5    | 0     |

Sanetomo et al. (2014) Euphytica 197:119-132

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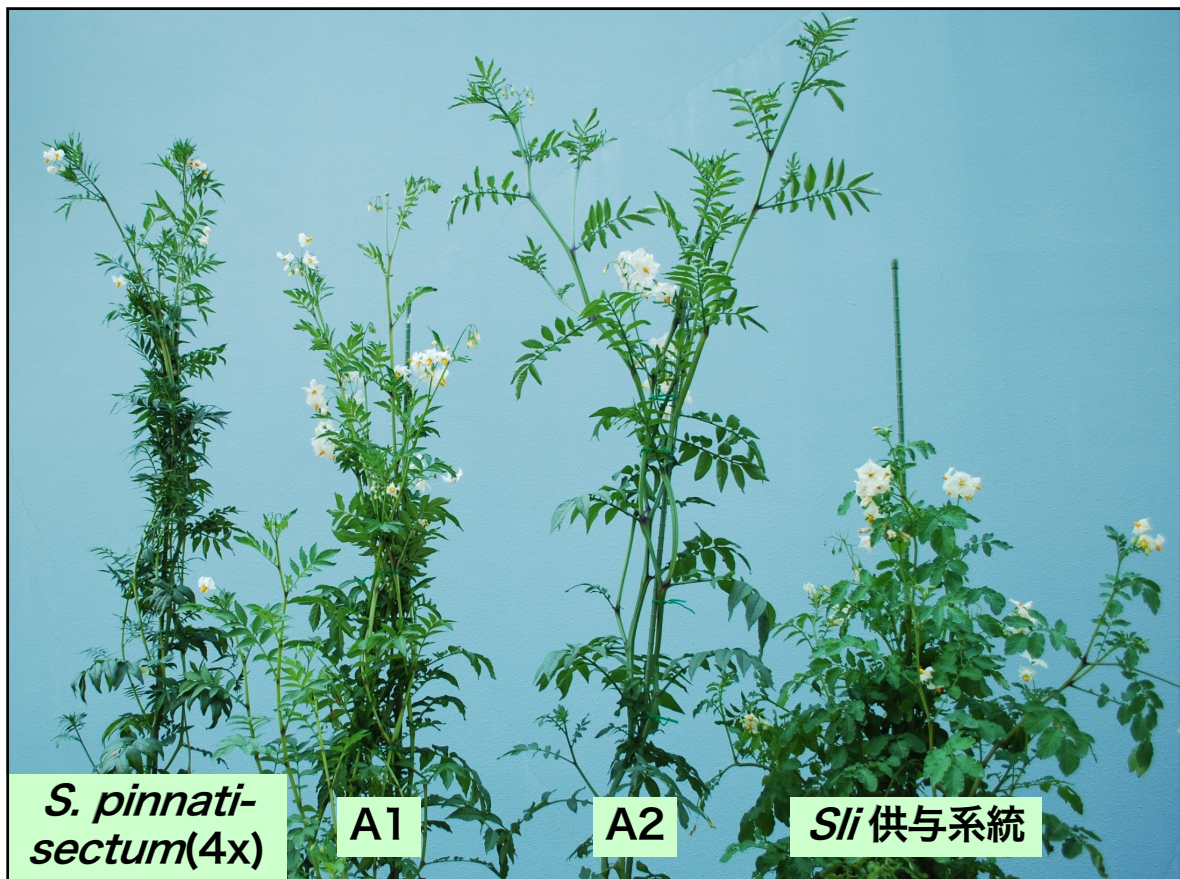
4x *Solanum pinnatisectum* × *Sli* 供与系統の3倍雑種  
A1とA2



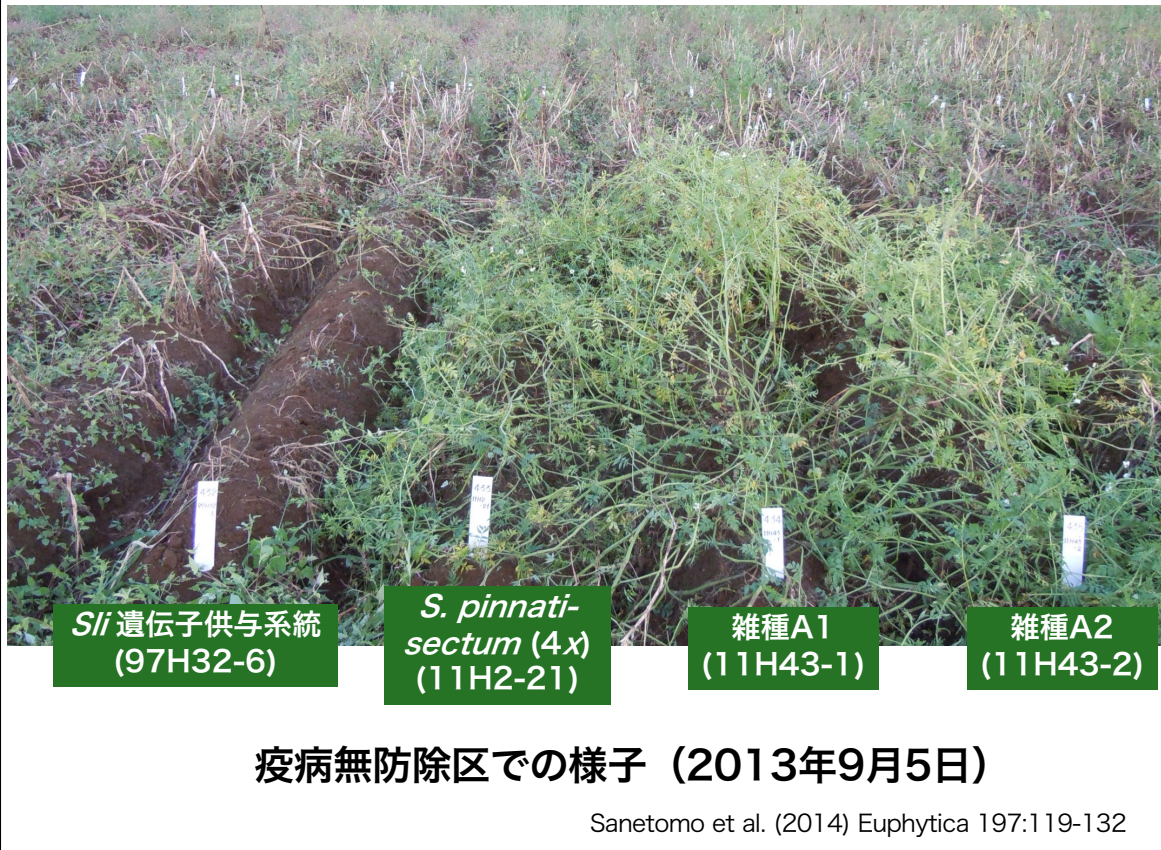
根端細胞  
 $2n=3x=36$

Sanetomo et al. (2014) Euphytica 197:119-132

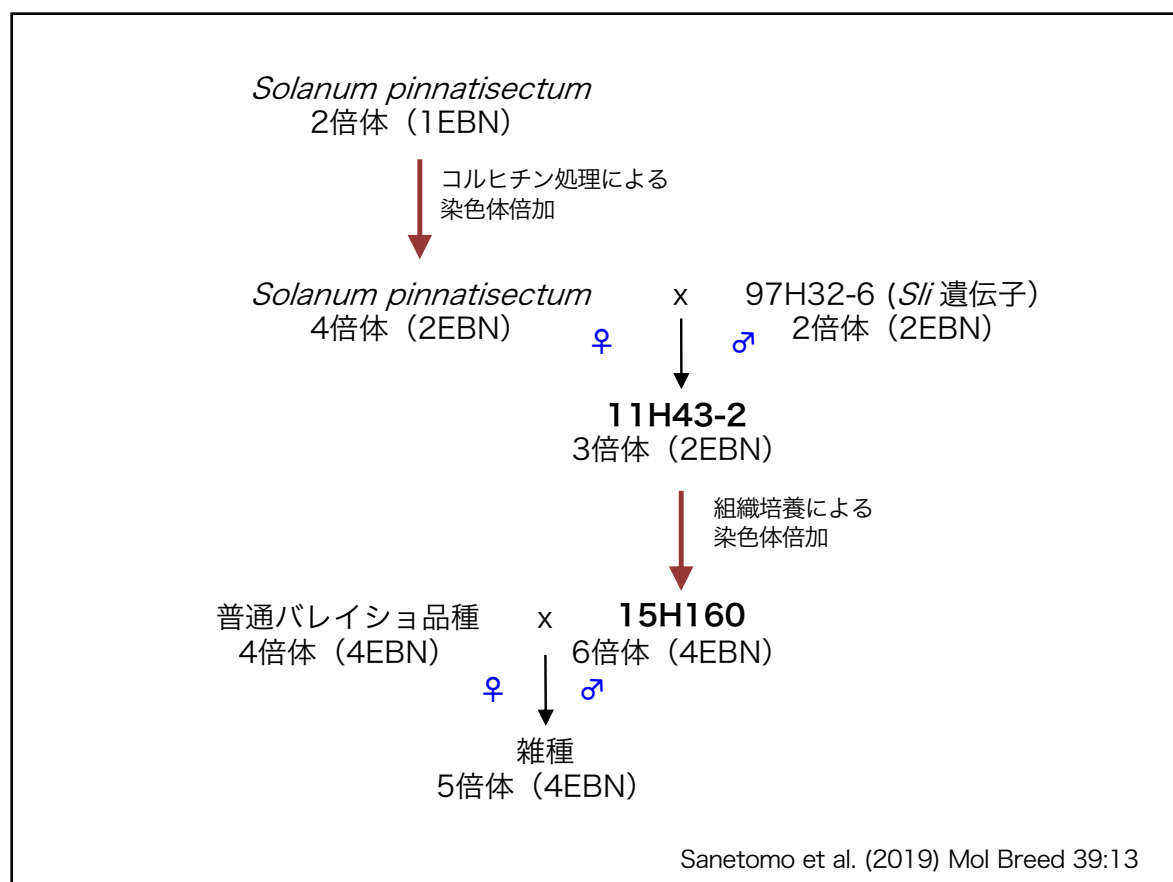
33



34



35



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