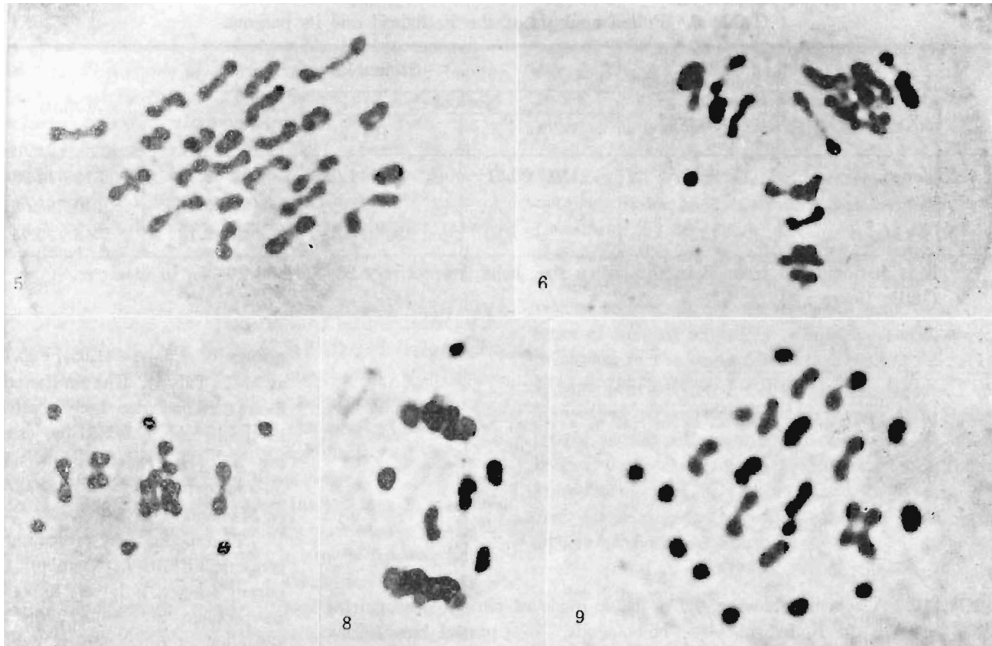
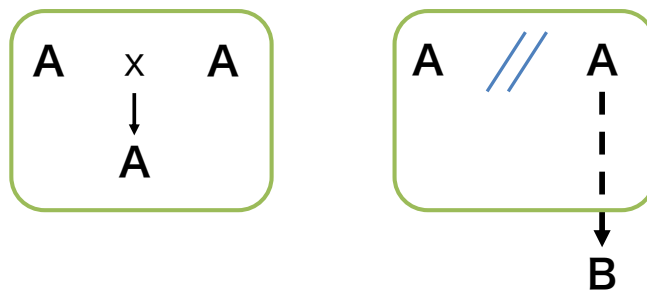


染色体対合に基づくゲノム分析



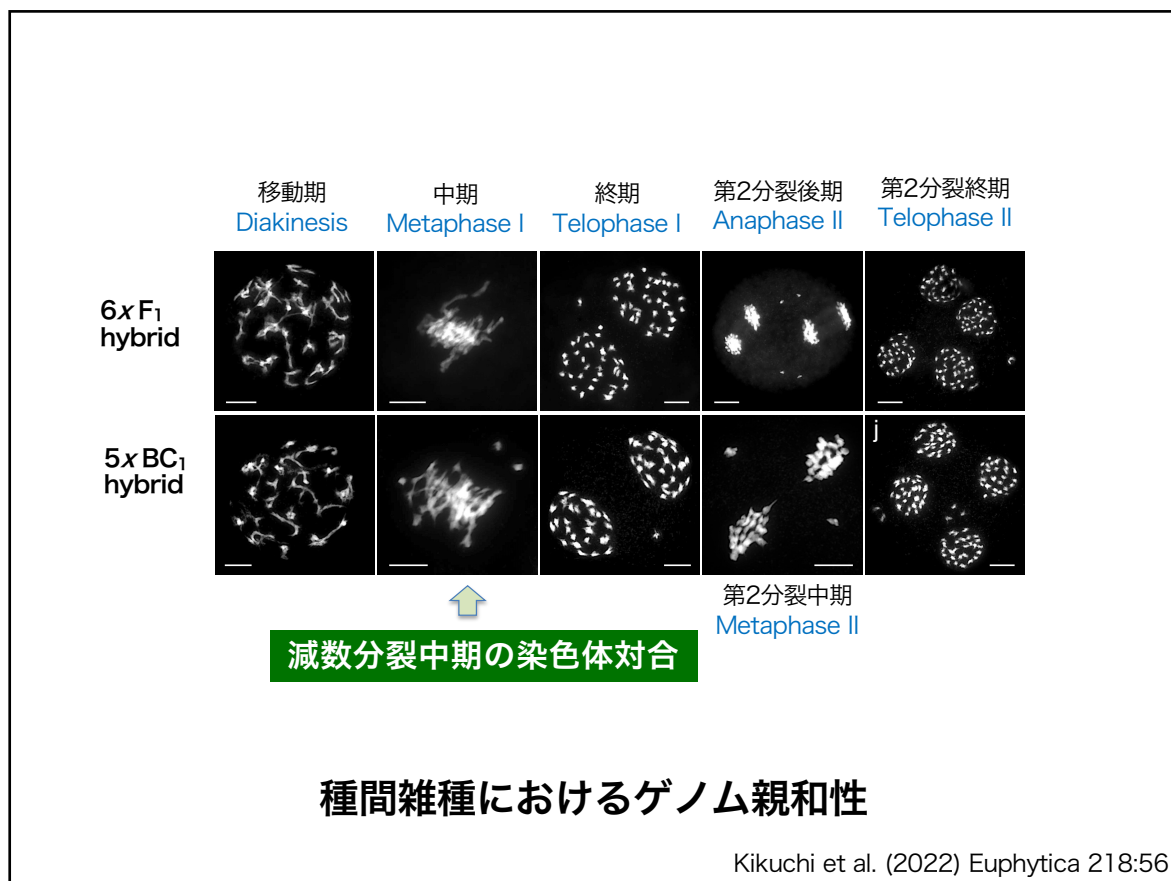
1

ゲノム分化 (Genome differentiation)



交雑障壁により遺伝子交換ができなくなると種分化が起こり、さらに進むとゲノム分化が起こる

2



3

染色体対合 (Chromosome pairing)

減数分裂 (meiosis) あるいは還元分裂 (Reduction division) において、相同染色体がペアを作ること

I	1価染色体	Univalent	正常 多価染色体 (Multivalent)
II	2価染色体	Bivalent	
III	3価染色体	Trivalent	
IV	4価染色体	Quadrivalent	
V	5価染色体	Pentavalent	
VI	6価染色体	Hexavalent	
.	.	.	
.	.	.	
.	.	.	

4

2倍種間F₁雑種の染色体対合

2x F ₁ clone	I	II	III	IV	Ref.
<i>S. phureja</i> x <i>S. stenotomum</i>	0	12.0	0	0	(1)
<i>S. kurtzianum</i> x <i>S. microdontum</i>	0	12.0	0	0	(2)
<i>S. verrucosum</i> x <i>S. chacoense</i>	0	12.0	0	0	(3)
<i>S. verrucosum</i> x <i>S. chacoense</i>	0.20	11.90	0	0	(4)
<i>S. verrucosum</i> x <i>S. phureja</i>	0.03	11.98	0.04	0	(4)
<i>S. phureja</i> x <i>S. chacoense</i>	0	12.0	0.16	0	(5)
<i>S. verrucosum</i> x <i>S. bulbocastanum</i>	1.86	11.13	0	0	(6)
<i>S. sambucinum</i> x <i>S. jamesii</i>	0.25	11.88	0	0	(7)
<i>S. sambucinum</i> x <i>S. bulbocastanum</i>	0.30	11.85	0	0	(7)
<i>S. jamesii</i> x <i>S. bulbocastanum</i>	0.63	10.77	0.20	0.31	(7)
<i>S. etuberosum</i> x <i>S. pinnatisectum</i>	16.65	3.64	0.04	0	(8)
<i>S. fernandezianum</i> x <i>S. pinnatisectum</i>	12.23	5.78	0.16	0	(8)

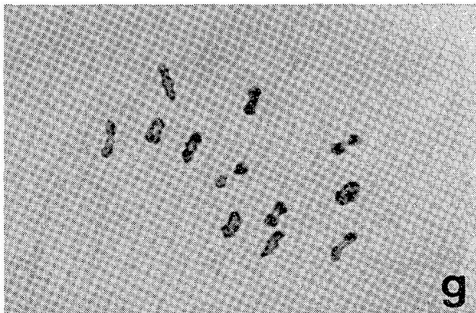
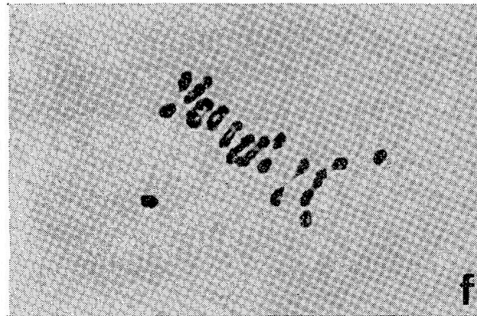
1) Rybin (1933), 2) Swaminathan (1950), 3) Propach (1940), 4) Matsubayashi & Misoo (1979), 5) Koopmans (1951), 6) Hermesen & Ramanna (1976), 7) Matsubayashi & Misoo (1977), 8) Ramanna & Hermesen (1979, 1981)

5

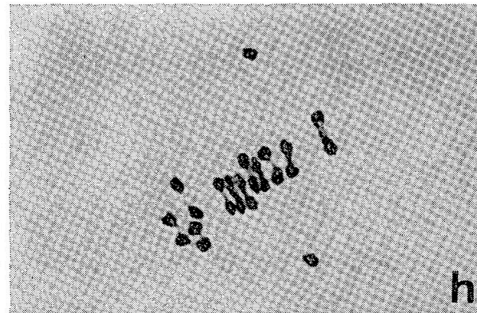
S. verrucosum x *S. chacoense* 12 II



S. verrucosum x *S. chacoense* 11 II + 2 I



S. verrucosum x *S. phureja* 12 II

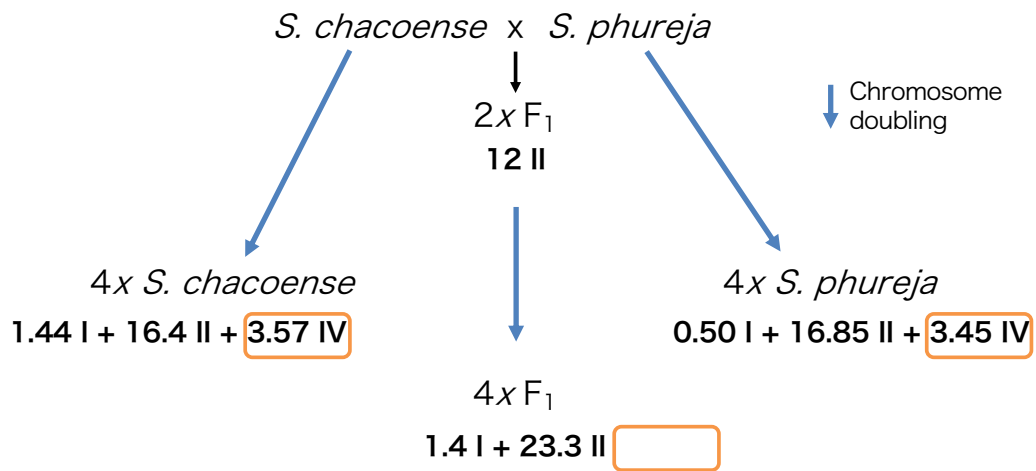


S. verrucosum x *S. stenotomum* 11 II + 2 I

Matsubayashi & Misoo (1979) Jpn J Breed 29:121-132

6

微少なゲノム間差異を検出する方法 Amphidiploid method



III価染色体以上の多価染色体形成頻度に着目する

Howard & Swaminathan (1952) Euphytica 1:20-28

7

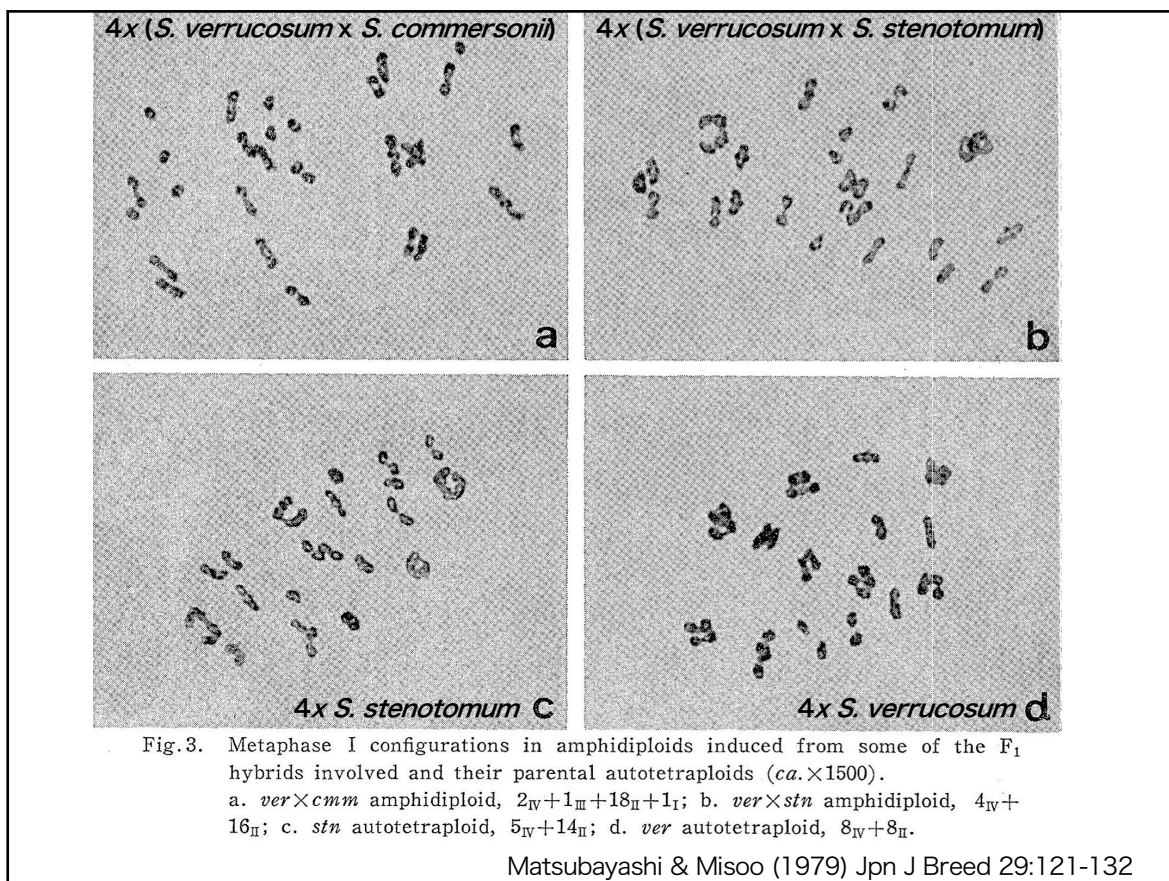
多価染色体形成頻度 (Aゲノム間)

2倍種とF ₁ 雑種の倍加系統	>II	Ref.
<i>S. phureja</i>	3.82	(1)
<i>S. chacoense</i>	3.87	(1)
<i>S. sparsipilum</i>	3.92	(1)
<i>S. commersonii</i>	4.54	(1)
<i>S. verrucosum</i>	6.14	(2)
<i>S. phureja</i> × <i>S. chacoense</i>	3.06	(1)
<i>S. chacoense</i> × <i>S. sparsipilum</i>	3.54	(1)
<i>S. verrucosum</i> × <i>S. chacoense</i>	2.84	(2)
<i>S. verrucosum</i> × <i>S. commersonii</i>	2.62	(2)
<i>S. verrucosum</i> × <i>S. phureja</i>	3.91	(2)

1) Matsubayashi (1983) Sci Rept Fac Agr Kobe Univ 15:203-216

2) Matsubayashi and Misoo (1979) Jpn J Breed 29:121-132

8



9

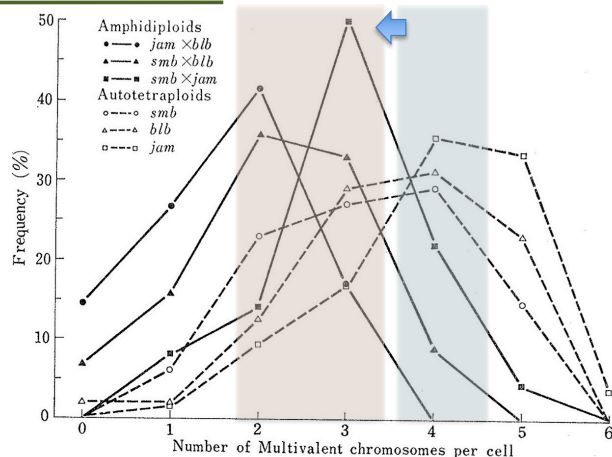
メキシコ産2倍種が多価染色体形成頻度

2倍種と F_1 雑種の倍加系統

>II

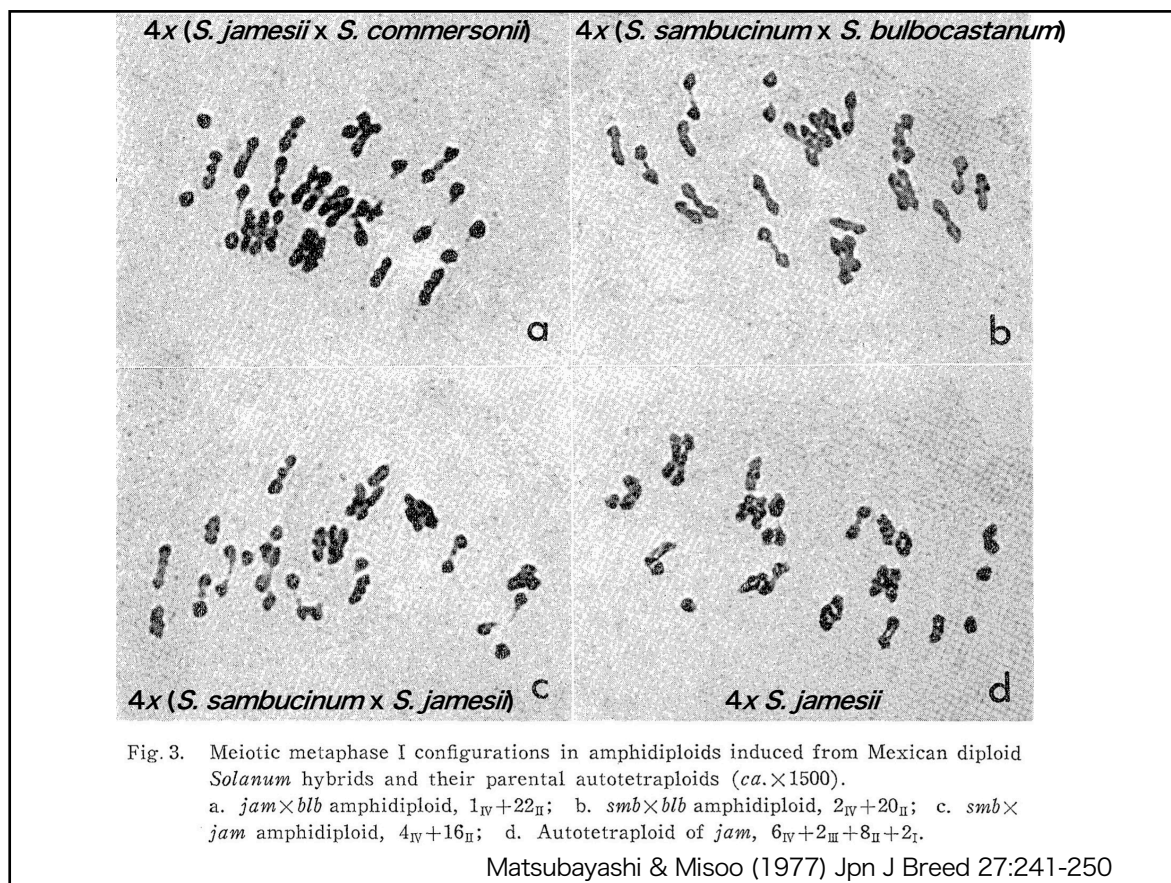
<i>S. jamesii</i>	4.00
<i>S. bulbocastanum</i>	3.55
<i>S. sambucinum</i>	3.23
<i>S. sambucinum</i> $\times$ <i>S. jamesii</i>	3.04
<i>S. sambucinum</i> $\times$ <i>S. bulbocastanum</i>	2.20
<i>S. jamesii</i> $\times$ <i>S. bulbocastanum</i>	1.61

同質4倍体に比べ、複2倍体の多価染色体形成頻度は下がる



Matsubayashi & Misoo (1979)
Jpn J Breed 29:121-132

10



11

A-Bゲノム間雑種の対合頻度

Plant	Number of cells studied	Chromosome associations			
		IV	III	II	I
<i>S. verrucosum</i>	80	—	—	12.0	—
<i>S. bulbocastanum</i>	75	—	—	12.0	—
VB 3 (2x)	45	—	—	11.40	1.91
VB 4 (2x)	60	—	—	10.98	2.03
VB 5 (2x)	50	—	—	11.04	1.92
VB 6 (2x)	55	—	—	11.20	1.64
VB 7 (2x)	50	—	—	11.10	1.80
VB 5 (4x)	35	0.11	0.02	23.11	0.71
VB 6 (4x)	40	0.15	0.15	23.58	0.93

低い多価染色体形成頻度

Hermesen & Ramanna (1976) Euphytica 25:1-10

12

F_1 (*S. verrucosum* x *S. bulbocastanum*)

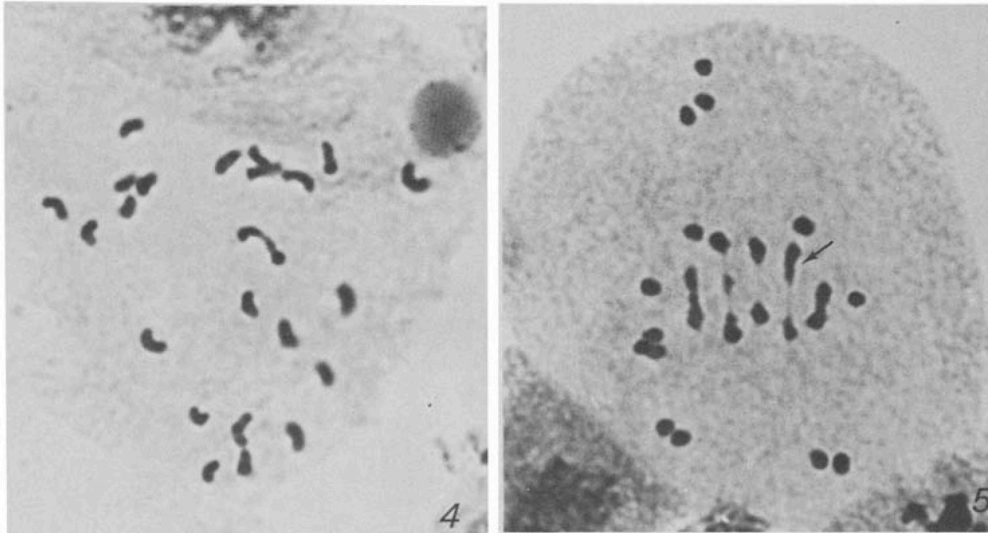


Fig. 4. Diakinesis showing 1 trivalent (Y-shaped) + 2 bivalents + 17 univalents (rod-shaped). Only one univalent is attached to the nucleolus.

Fig. 5. Metaphase I showing 5 bivalents + 14 univalents (round structures). Arrow indicates the heteromorphic bivalent.

Ramanna & Hermesen (1979) Euphytica 28:9-15

13

F_1 (*S. verrucosum* x *S. bulbocastanum*)

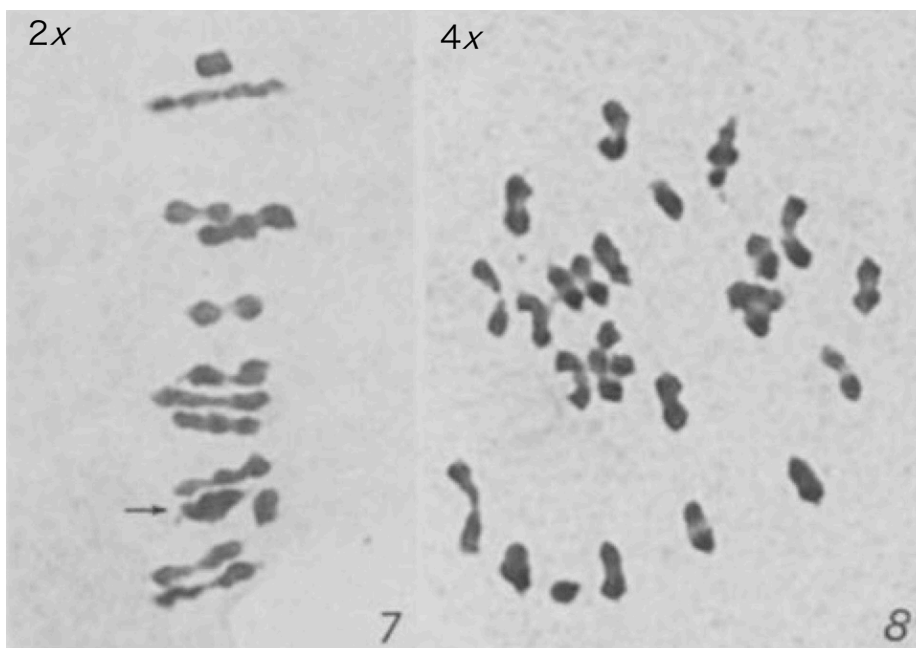


Fig. 7. Metaphase I in VB 7, showing 11 bivalents and 2 univalents. Note there is only one ring bivalent (arrow).

Fig. 8. Metaphase I in 4x-VB 5, showing 1 IV + 21 II + 2 I.

Hermesen & Ramanna (1976) Euphytica 25:1-10

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E-Bゲノム間雑種の対合頻度

Table 1. Chromosome associations in the F₁-plants of *S. etuberosum* × *S. pinnatisectum*.

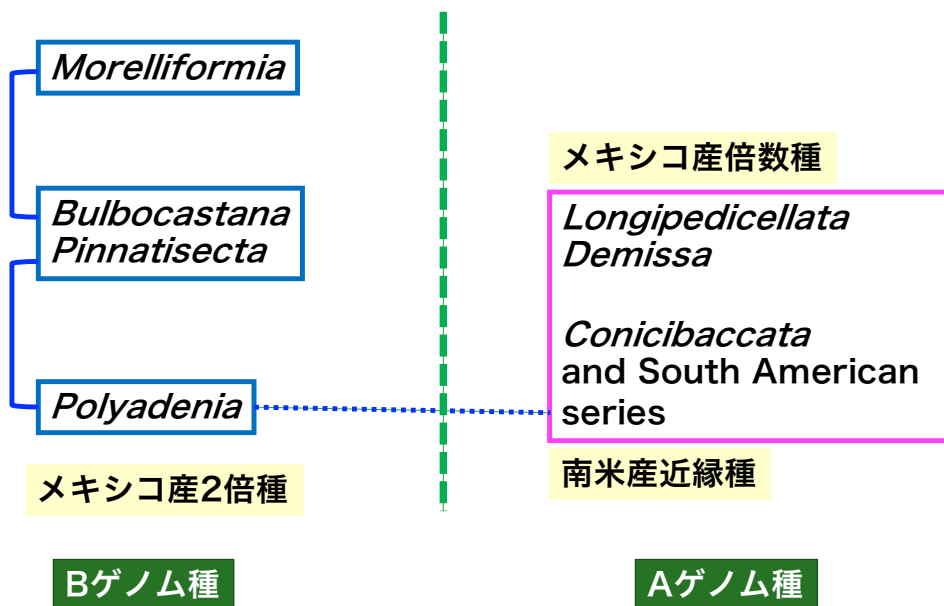
Plant No. EP	Number of cells studied	Chromosome associations/cell		
		III	II	I
11	72	0.03	3.60 ± 1.96	16.78 ± 3.85
14	87	0.02	2.83 ± 1.54	18.28 ± 3.06
15	57	0.04	4.11 ± 1.75	15.68 ± 3.54
16	86	0.05	3.91 ± 1.86	16.15 ± 3.72
17	74	0.03	3.61 ± 1.91	16.70 ± 3.86
19	81	0.04	3.58 ± 1.86	16.83 ± 3.61
38	85	0.04	3.87 ± 1.78	16.15 ± 3.59

低いII価染色体形成頻度

Ramanna & Hermesen (1979) Euphytica 28:9-15

15

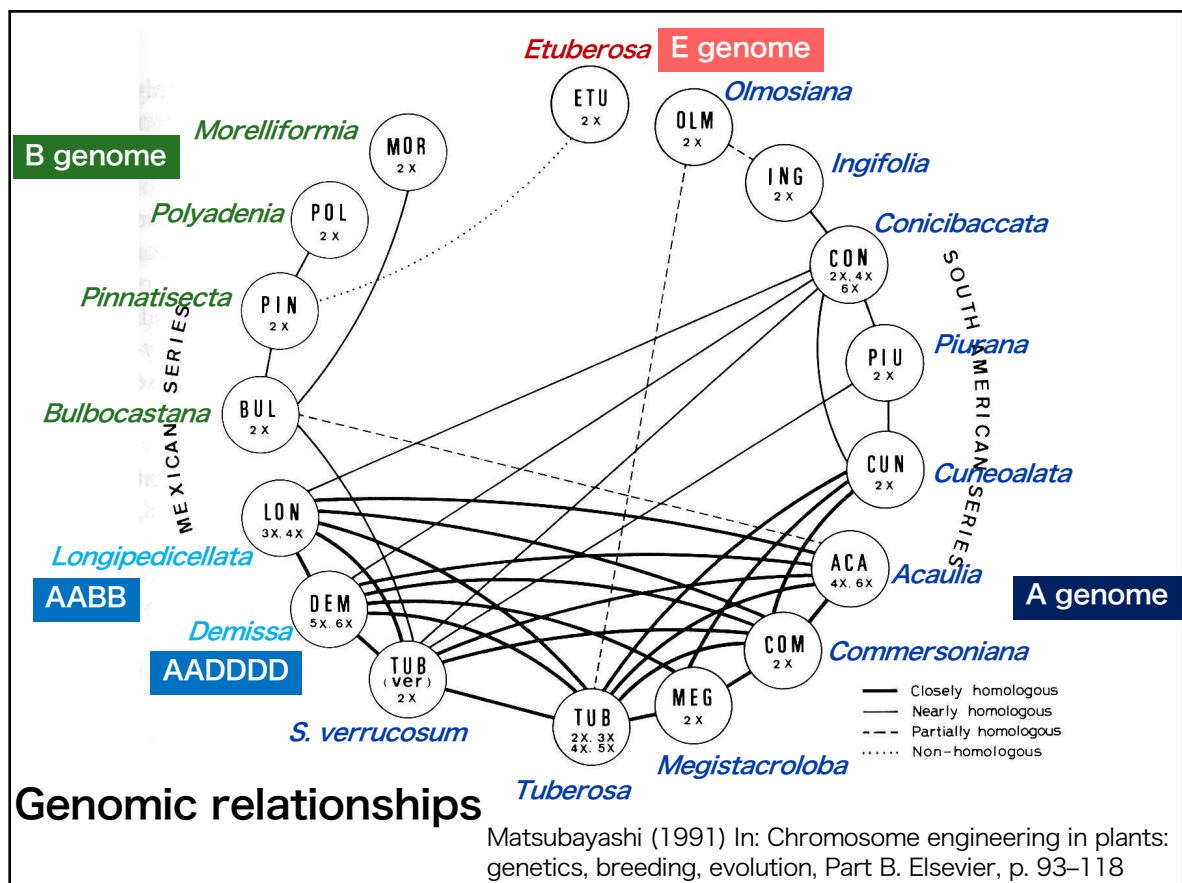
厳格な交雑障壁が存在する



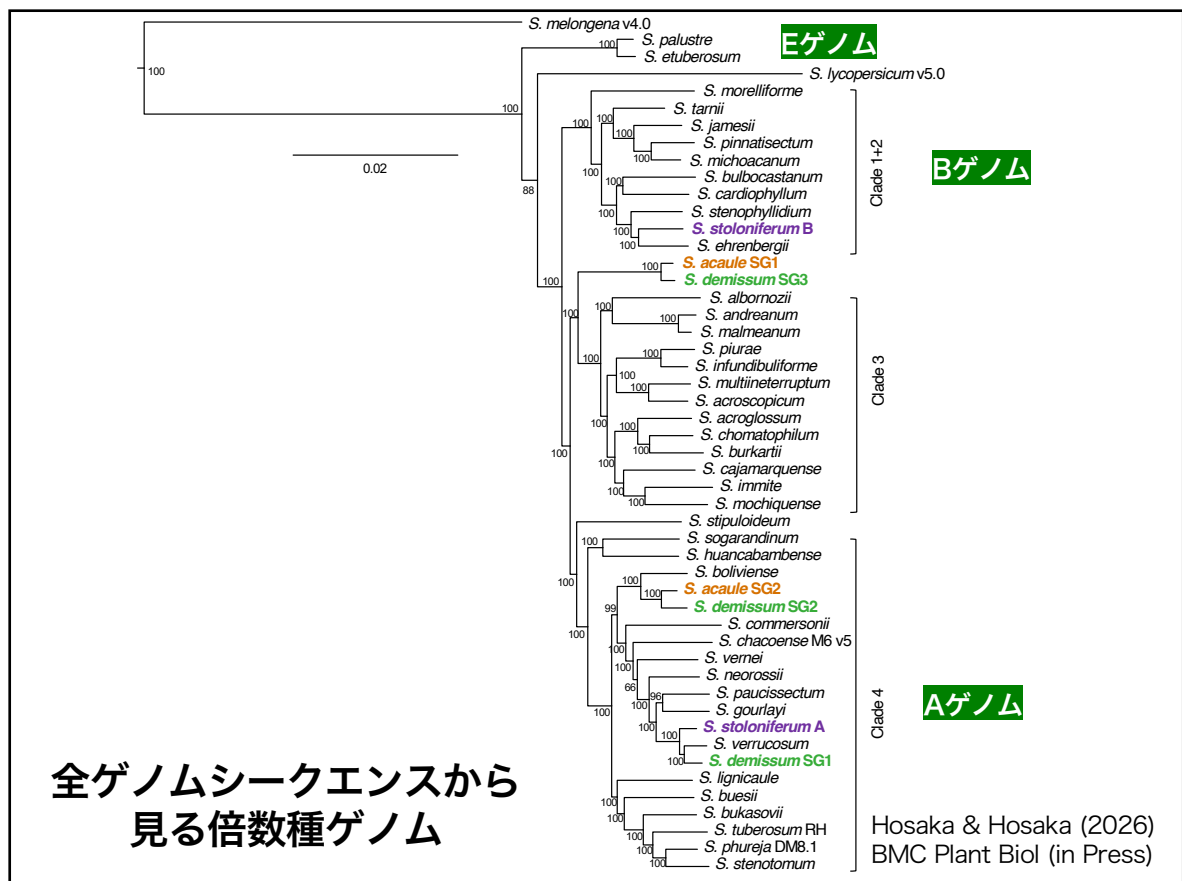
異種ゲノム間の交雑親和性

Hawkes (1966) Am Potato J 43:81-103

16



17



18

普通バレイショ品種の染色体対合頻度

Clone	I	II	III	IV	Ref.
Duke of York	2.2	18.6	0.2	2.0	1)
Norin No. 1	1.6	18.3	0.8	1.9	2)
Irish Cobbler	1.1	19.6	0.7	1.4	3)
Dejima	3.2	18.2	2.0	0.7	4)
Pepo	0.9	18.4	0.5	2.2	2)
Deodara	1.6	17.3	1.2	2.1	5)
36/209	1.1	20.3	0.5	1.3	5)
Gladstone	5.7	17.9	0.7	1.1	5)
Cl.650	4.0	18.1	0.4	1.7	6)
Cl.B 72	3.5	17.9	0.6	1.7	6)
Fichtelgold	1.8	18.9	0.9	1.4	7)

2~4の多価染色体

1) Swaminathan (1954), 2) Irikura (1976), 3) ? , 4) Yamada et al. (1998), 5) Lamm (1945), 6) Bains (1951), 7) Wangenheim (1954)

19

人為4倍体の染色体対合頻度

Material	No. of cells observ.	Mean frequency per cell of				Mean multivalent frequency per cell
		IV	III	II	I	
Amphidiploids between diploid species						
<i>phureja</i> × <i>stenotomum</i>	51	4.02	0.43	15.06	0.51	4.45
,,	52	4.38	0.17	14.85	0.25	4.56
<i>rybinii</i> * × <i>stenotomum</i>	60	4.93	0.53	13.00	0.67	5.47
Tetraploids induced from self-incompatible spp.						
<i>S. stenotomum</i>	68	3.81	0.21	15.49	1.18	4.02
<i>S. phureja</i>	66	3.70	0.42	15.09	1.76	4.12
<i>S. sparsipilum</i>	69	3.39	0.53	14.93	2.97	3.92
<i>S. chacoense</i>	72	3.33	0.53	15.60	1.92	3.87
<i>S. commersonii</i>	61	4.03	0.51	14.33	1.69	4.54
<i>S. saltense</i> *	53	3.60	0.79	14.89	1.43	4.39
Tetraploids induced from self-compatible spp.						
<i>S. verrucosum</i>	58	5.69	0.45	11.57	0.76	6.14
<i>S. polyadenium</i>	78	6.63	1.31	7.87	1.82	7.94
<i>S. suaveolens</i> **	84	5.82	0.43	11.39	0.64	6.25

普通品種は
2~4の多価
染色体

4本の相同染色体の相同性が高いほど
4価染色体形成頻度が高い

松林（私信）

20

普通バレイショ (*S. tuberosum*) のゲノム構成

★ 部分異質4倍体 (Segmental allotetraploid)

AAA^tA^t Matsubayashi (1991) In: Chromosome engineering in plants: genetics, breeding, evolution, Part B. Elsevier, p. 93-118

★ 同質4倍体 (Autotetraploid)

AAAA Swaminathan (1954) Genetics 39:59-76)

通常の遺伝育種においては同質4倍体として扱う