ASSBT
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Speed Breeding Practices in Sugar Beet:

An application to

Yellowing Disease Resistant Breeding

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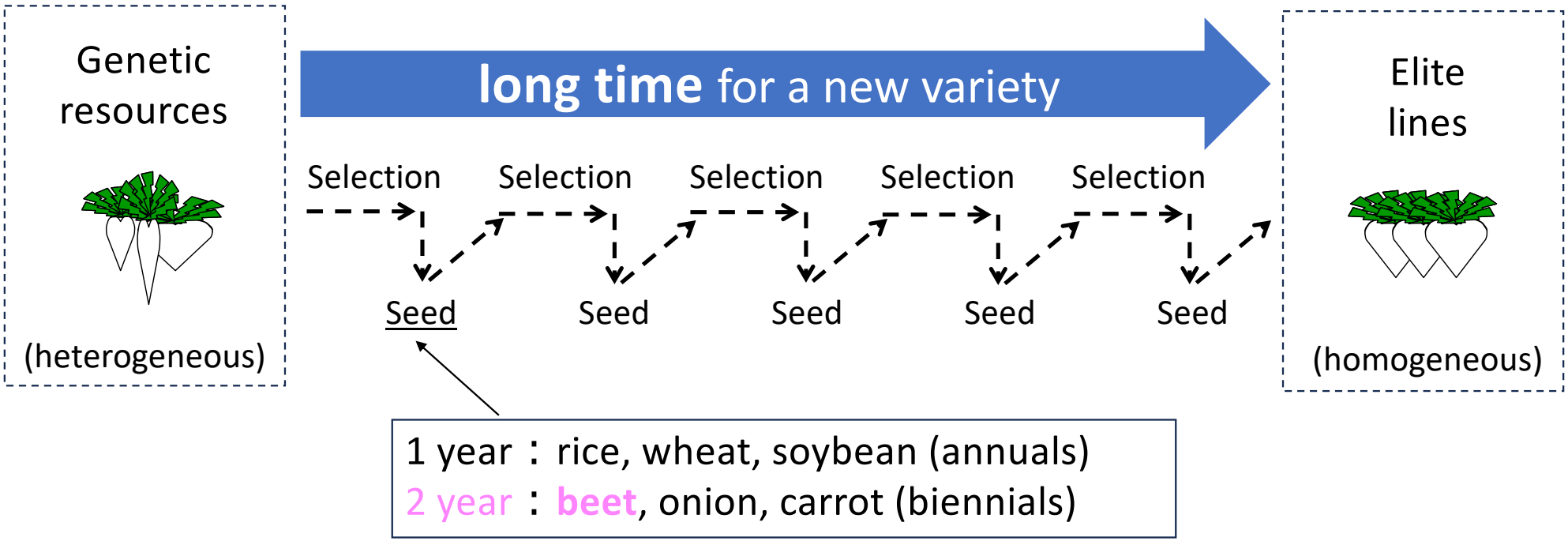
NARO

<Key questions>

- Are there any materials that can be used for speed breeding?

- Do these materials shorten the breeding period? (A case study on breeding for VY resistance)

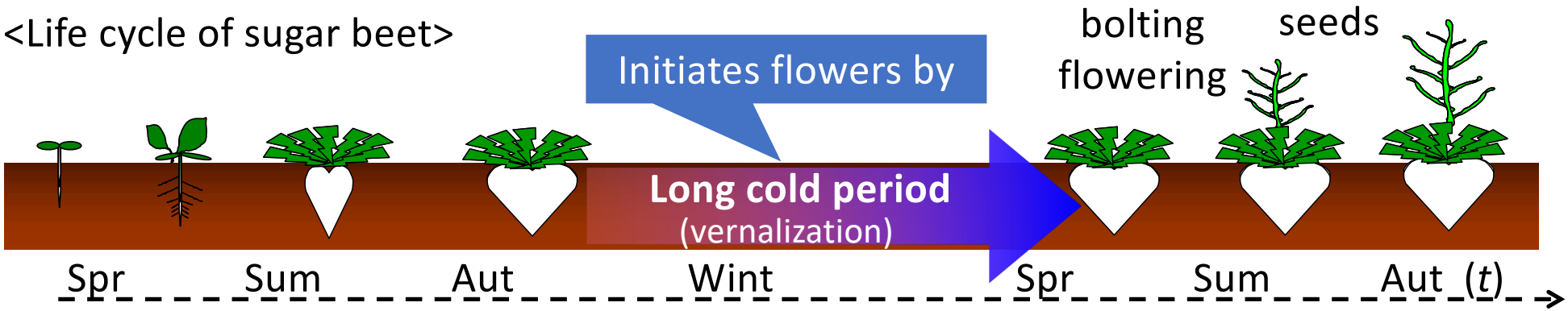
A common breeding constraint



Why do biennials need two years to produce seeds?

Biennials need long cold for seed

<Life cycle of sugar beet>

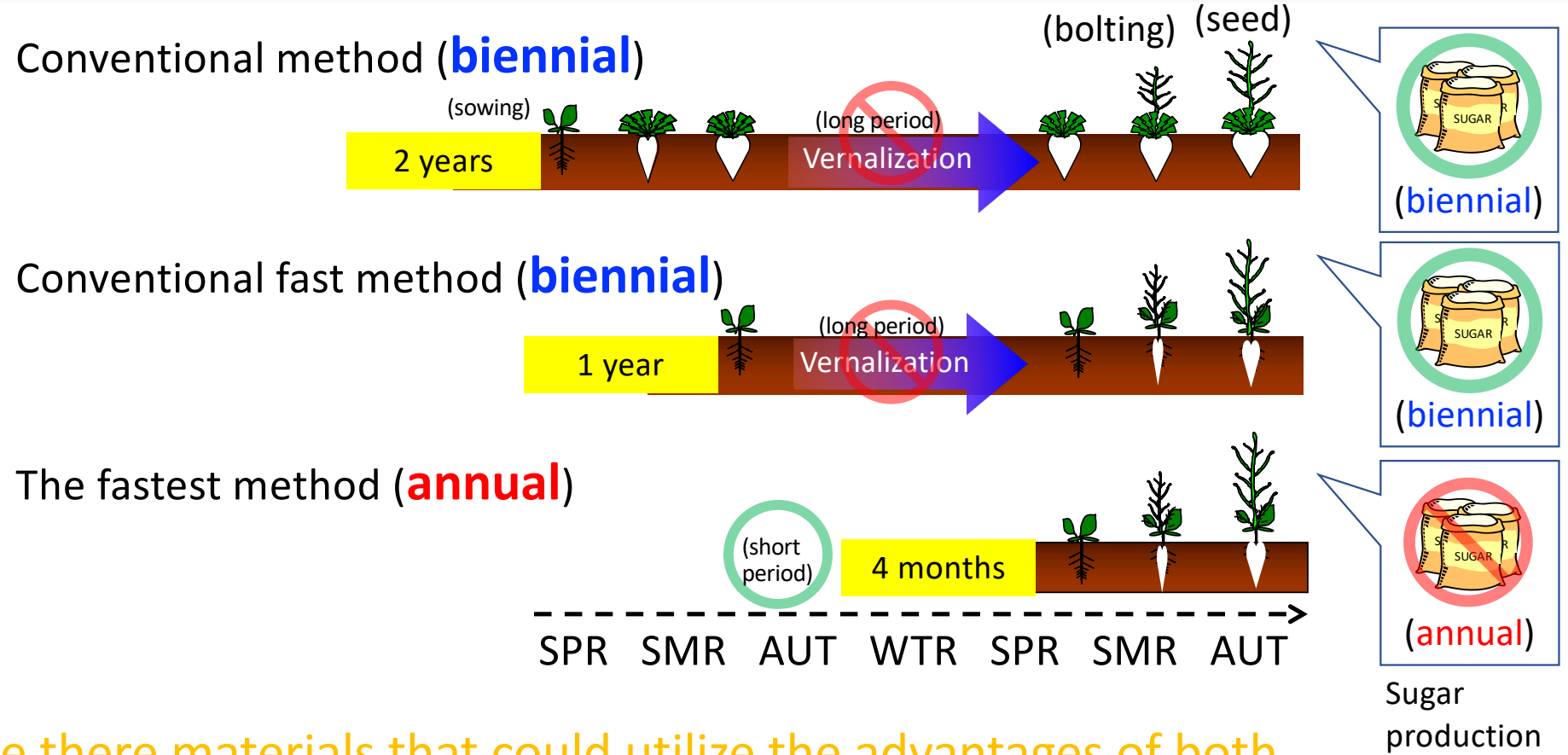


1st year
(sugar producing field)

Hypothesis: Is it possible to skip the vernalization period and shorten the seed production period?

2nd years
(seed producing field)

Shortened to 4 mos. without vernali.



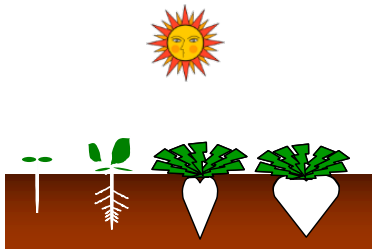
Are there materials that could utilize the advantages of both biennial beet (large roots) and annual beet (early flowering) ?

A unique locus can avoid a long cold period

BLOND (Bolting by LOnger than Natural Daylength)

Nat. Day
(non-bolting)

Act as biennial

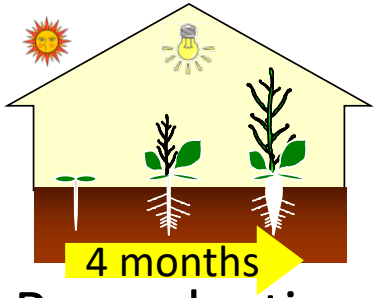


Vegetative

Sugar production
(○)

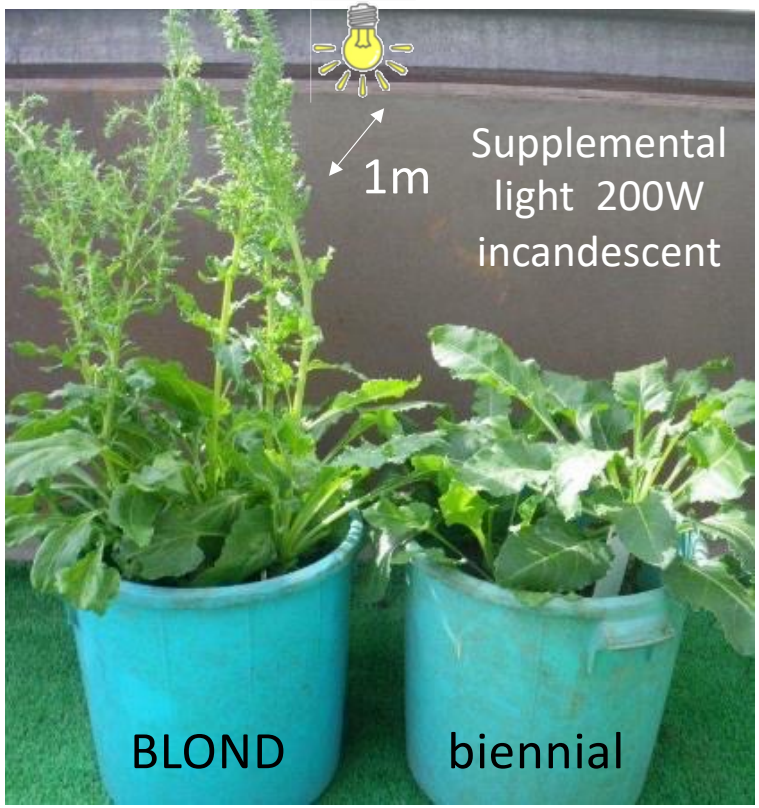
All Day
(bolting)

Act as annual

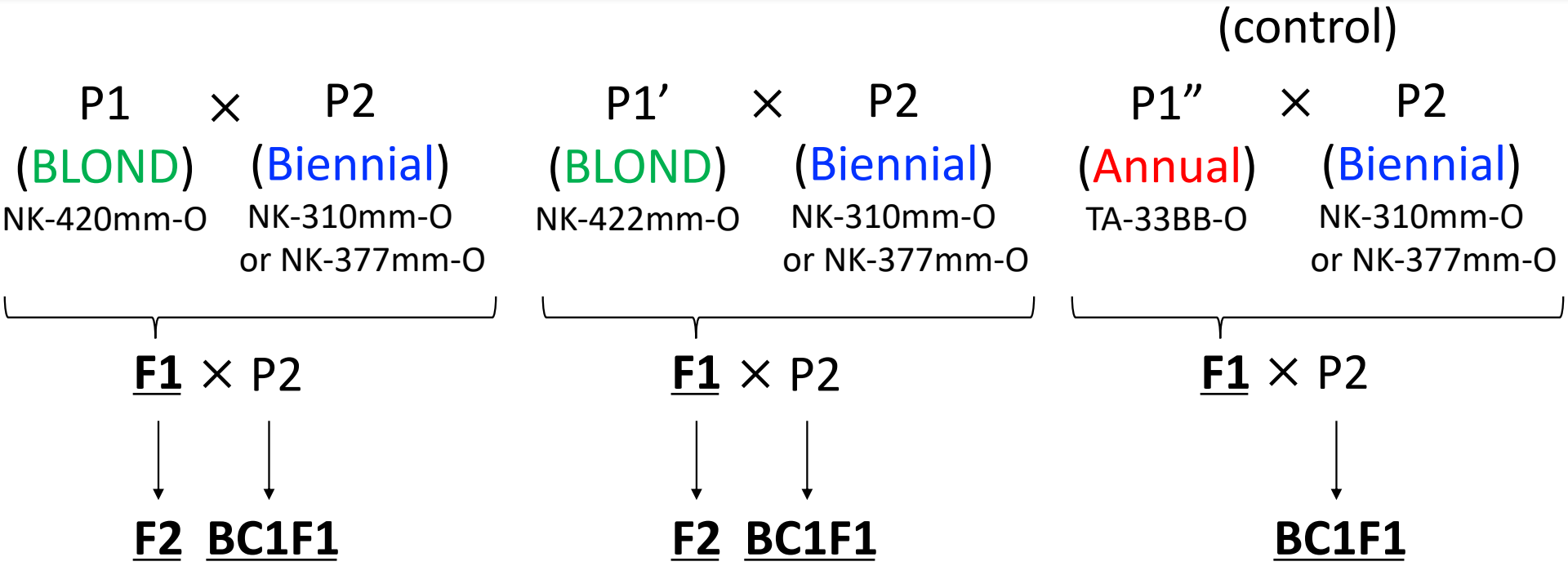


Reproductive

Speed breeding
(○)



Test progenies for bolting segregation



Phenotyping (bolting)

- **Field (natural daylength)**: April ~ September
- **Glasshouse (24h daylength)**: April ~ August / November ~ February

All day* → Bolting without vernalization

Biennial

≠

BLOND

F1 & *F2* (Biennial x BLOND)

=

Annual

F1 (Biennial x Annual)

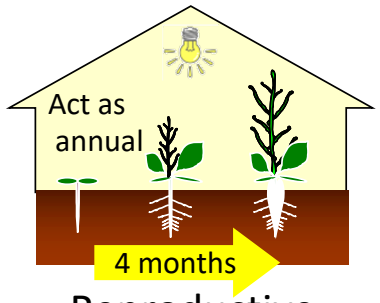
*24-h daylength, with daytime sunlight (~ 100,000 lx) and nighttime illumination (300 lx)

All day (Number of bolting plants)

	Materials	Summer greenhouse				Winter greenhouse				H_B [6]
		2014		2015		2013		2014		
		N_T	N_B	N_T	N_B	N_T	N_B	N_T	N_B	
BLOND (**Bd**)	NK-420 mm-O	8	8	12	12	6	6	27	27	1.00
	NK-422 mm-O	36	36	11	11	22	21	27	27	0.66
Biennial x BLOND	F_1 (NK-377×NK-420)	45	45	≒ 84~100% (Dominant, F1)				–	–	–
	F_1 (NK-377×NK-422)	45	38					–	–	–
	F_2 (NK-310×NK-420)	–	–	139	115* [4]	≒ 3:1 (F2)		270	169*	–
	F_2 (NK-310×NK-422)	–	–	149	146*			262	193 ns	–
	BC_1F_1 (NK-377×NK-420×NK-310)	–	–	149	82 ns 5	≒ 1:1 (BC1)		90	48 ns	–
	BC_1F_1 (NK-377×NK-422×NK-310)	–	–	147	71 ns			90	42 ns	–
Annual (**B**)	TA-33BB-O	36	36	24	24	18	18	27	27	–
	Biennial strains [1]	18	0	18	0	18	0	27	0	–
										–
										–

BLOND behaved as an annual beet in 24h daylength, is presumed to be controlled by one dominant gene (‘Bd’ ≠ known annual gene ‘B’).

All day (Number of days to bolting)



Reproductive

	Materials	Summer green-house		Winter green-house	
		2014	2015	2014	2015
BLOND (Bd)	NK-420 mm-O	36.0[a 1]	35.0[a]	48.6[a]	42.3[a]
BLOND (Bd)	NK-422 mm-O	36.5[a]	37.0[b]	55.8[b]	48.0[b]
Biennial x BLOND	F_1 (NK-377×NK-420)	37.0[a]	–	–	–
Biennial x BLOND	F_1 (NK-377×NK-422)	40.8[b]	–	–	–
Annual (B)	TA-33BB-O	36.0[a]	35.1[a]	51.9[ab]	45.6[ab]
Biennial x Annual	F_1 (NK-377×TA-33BB)	36.6[a]	–	–	–

Bolting in BLOND is as fast as in annual beet (useful for speed breeding)

Field natural day → non-bolting

Biennial

=

BLOND

F1 & F2
(Biennial x BLOND)

≠

Annual

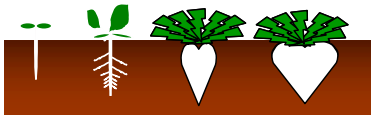
F1
(Biennial x Annual)

Field natural day → root enlargement

F1 (Biennial x BLOND) | BLOND | Annual

Field natural day (Number of bolting plants)

Act as biennial



Vegetative

BLOND (**Bd**)

Biennial x BLOND

Annual (**B**)

Biennial x Annual

Materials	Bolting tendency				Weight/root (g)	
	2014		2015		2014	
	N_T	N_B	N_T	N_B	average	sd
NK-420 mm-O	11	0	42	0	773.4	496.8$^{bc\ 5}$
NK-422 mm-O	30	0	–	–	735.1	620.8^{bc}
F_1 (NK-377×NK-420)	30	0	–	–	1084.4	518.0^{cd}
F_1 (NK-377×NK-422)	30	0	–	–	1274.2	927.7^{d}
F_2 (NK-310×NK-420)	–	–	120	0	–	–
F_2 (NK-310×NK-422)	–	–	120	0	–	–
BC_1F_1 (NK-377×NK-420×NK-310)	–	–	120	0	–	–
BC_1F_1 (NK-377×NK-422×NK-310)	–	–	85	0	–	–
TA-33BB-O	30	30	15	15	54.2	19.4^{a}
Biennial strains [1]	30	0	38	0	–	–
F_1 (NK-377×TA-33BB)	12	12	–	–	395.5	259.7^{ab}

BLOND behaved as an biennial beet in natural daylength, can be used to evaluate agronomic traits in the field.

<Key questions>

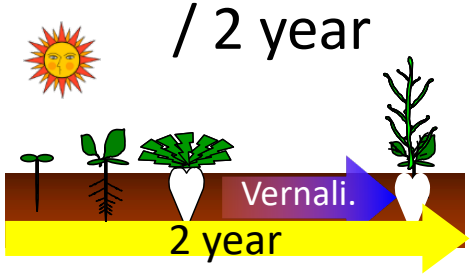
- Are there any materials that can be used for speed breeding?

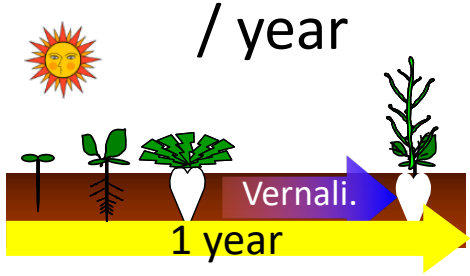
  Yes

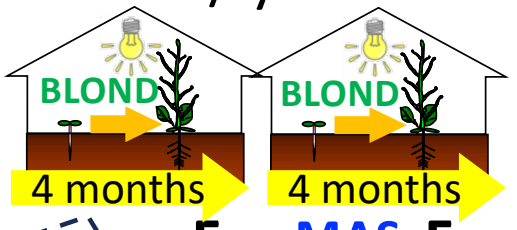
- Do these materials shorten the breeding period? (A case study on breeding for VY resistance)

Speed breeding using the 'BLOND-MAS' method

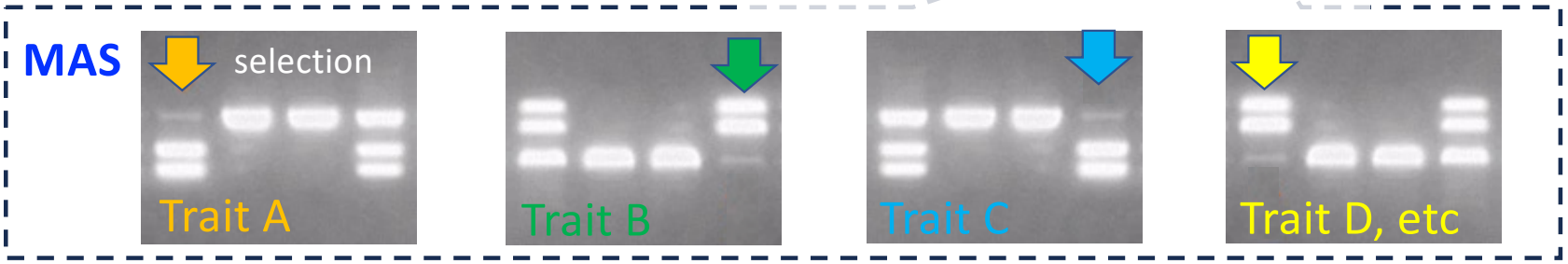
Option1 *Conventional*	Option2 *Conventional fast*	Option3 (new) **Speed breeding**
1 generation / 2 year	1 generation / year	2 generations / year







BLOND-MAS method



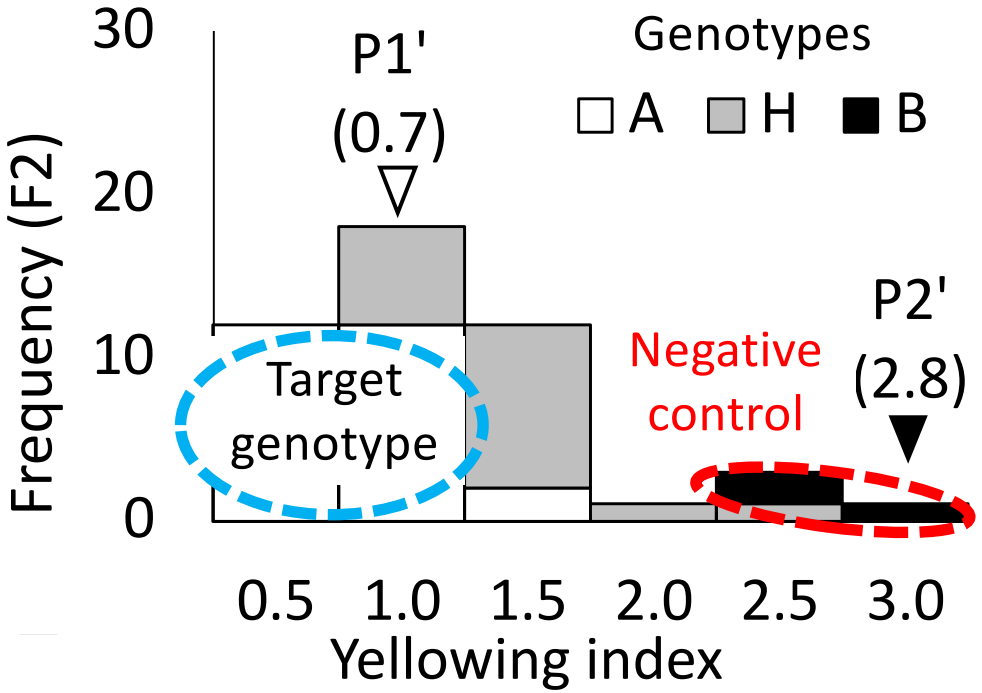
A targeted trait: Virus Yellows (VY)* resistance

(42nd meeting)

* Virus Yellows (Beet Leaf Yellowing Virus)

P1’

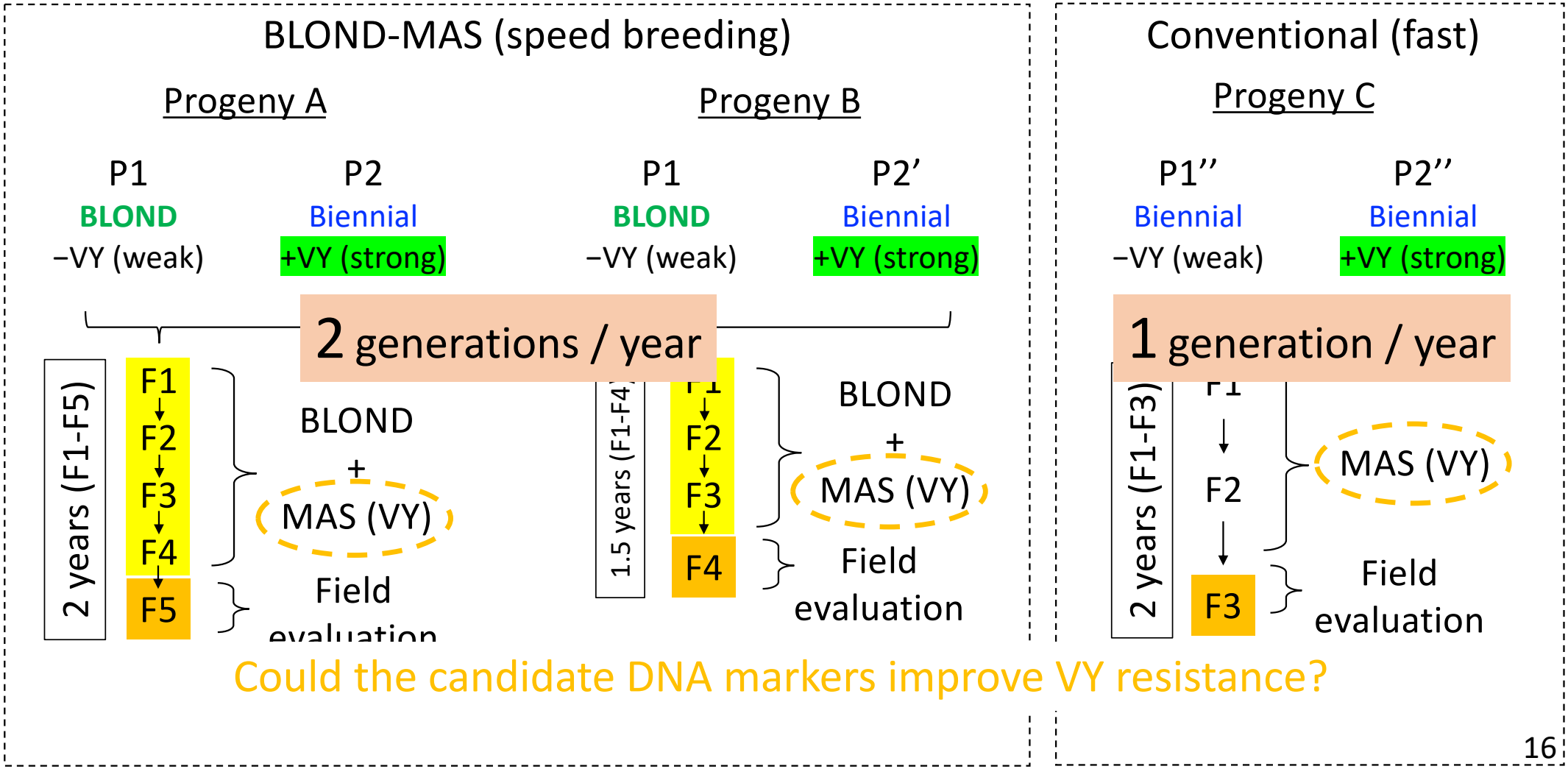
Strong resistance



P2’

Weak resistance

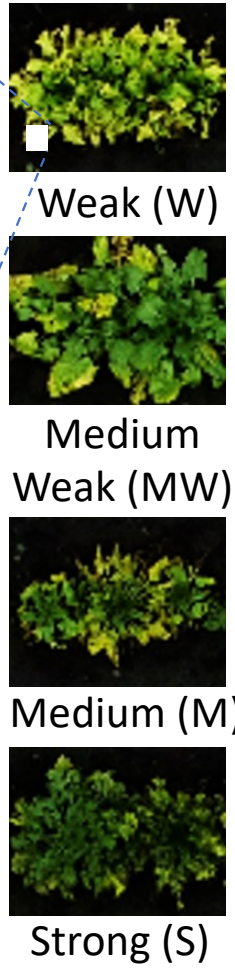
Speed breeding project



Could the candidate DNA markers improve VY resistance?

VY resistance in progenies selected with DNA markers

Virus Yellows (Beet Leaf Yellowing Virus)

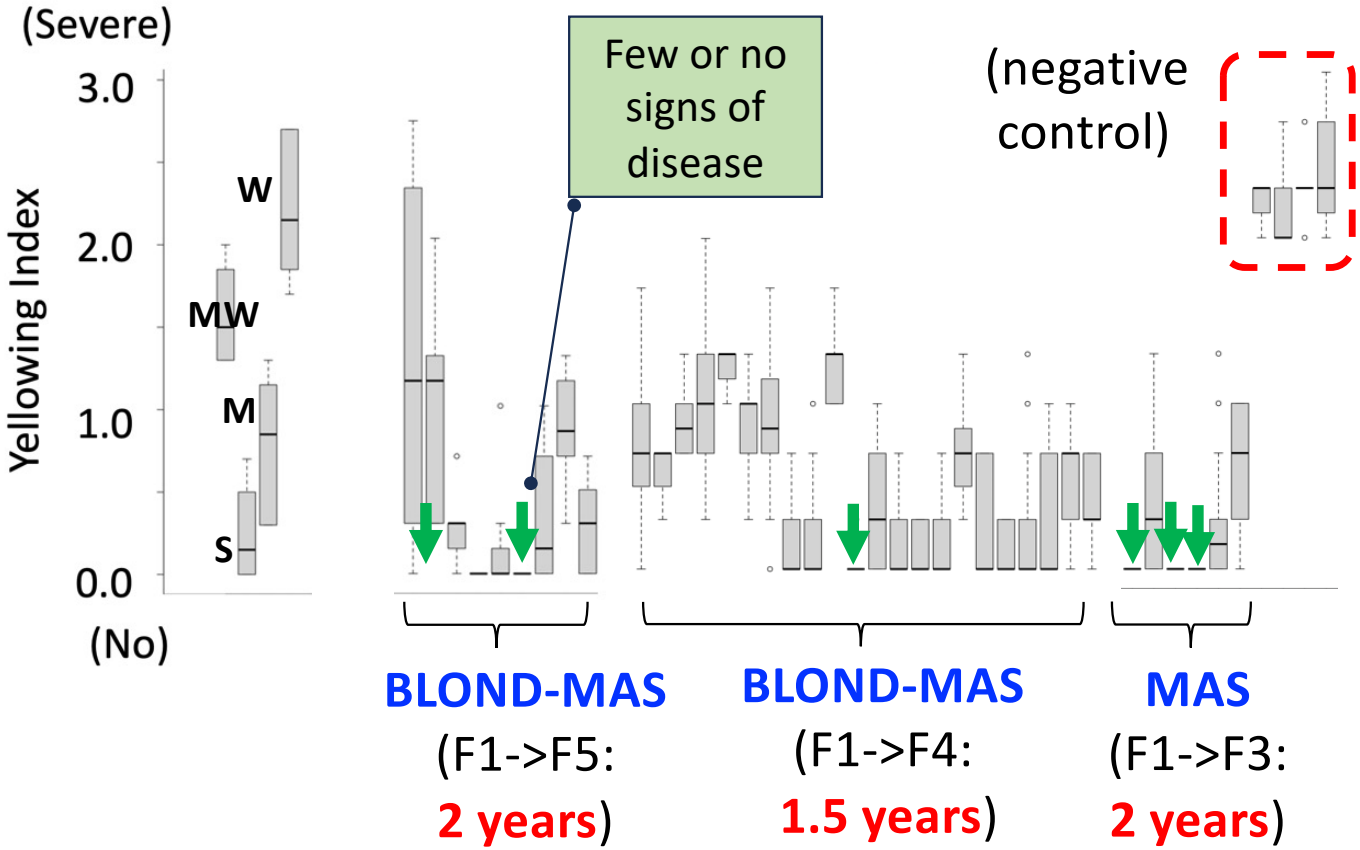


Weak (W)

Medium Weak (MW)

Medium (M)

Strong (S)



- Effect of MAS on VY resistance is significant
- BLOND can shorten the time required for breeding

<Key questions>

- Are there any materials that can be used for speed breeding?

  Yes

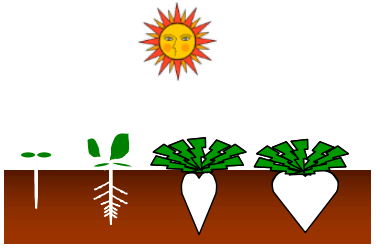
- Do these materials shorten the breeding period? (A case study on breeding for VY resistance)

  Yes

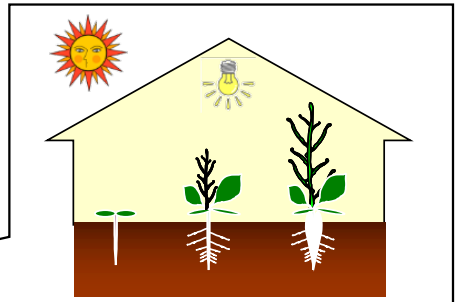
Summary

Controlled by single dominant gene

Ecotype	Biennial	BLOND	Annual
Nat. Day (root)	○	○	×
All Day (flower)	×	○	○



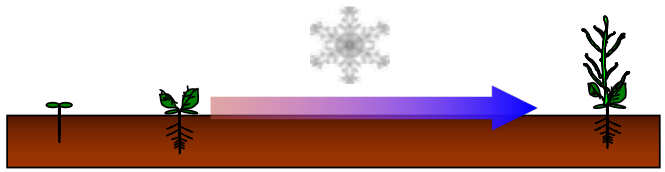
Enlarged root



Early flowering

1 generation / year

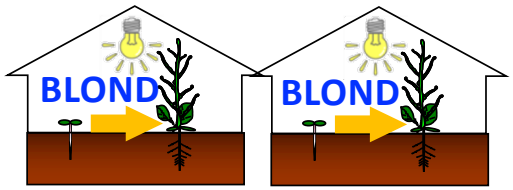
(Conventional fast method)



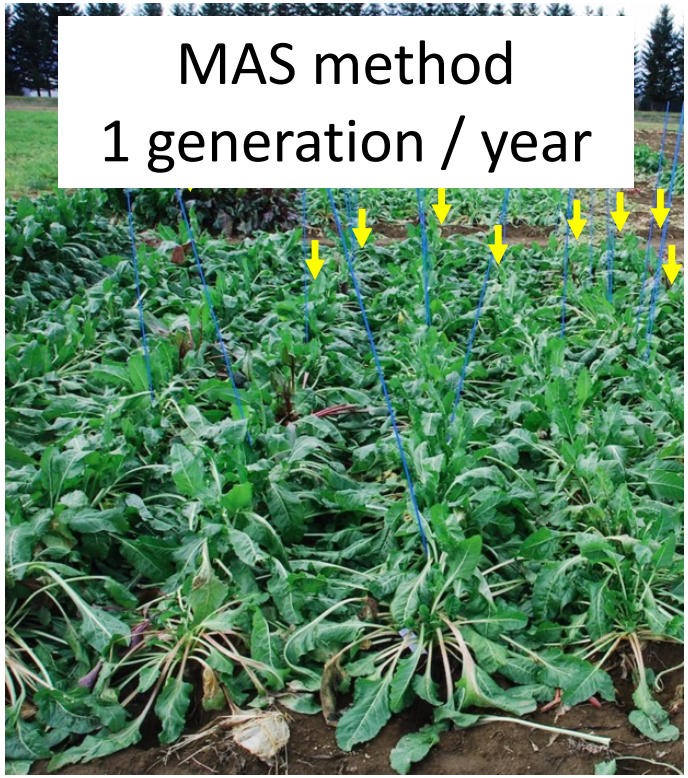
F_1

2 generation / year

(**BLOND-MAS** method: Speed Breeding)



F_1 F_2

Acknowledgements

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