



Hybrid Rye - new breeding technologies targeting yield, ergot defense and FHB/DON

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SEEDING
THE FUTURE
SINCE 1856

KWS



- Steps in hybrid rye breeding
- Breeding KWS hybrid rye for North America
- Breeding for ergot resistance
- Breeding for low DON content

A close-up photograph of several Hybrid Rye spikes. The spikes are golden-brown and have a feathery appearance due to the long awns. They are set against a blurred background of green leaves and other spikes.

Steps in breeding KWS Hybrid Rye

Breeding Hybrid Rye: Crossing

Intercrossing of best parents



Breeding Hybrid Rye: Seed Production and Selection



Intercrossing of best parents

**Development of inbred lines
and selection**

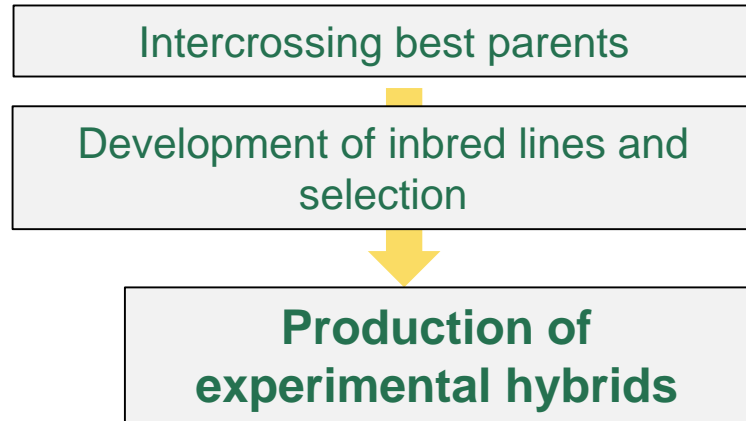


Nursery: selfing under paper bags

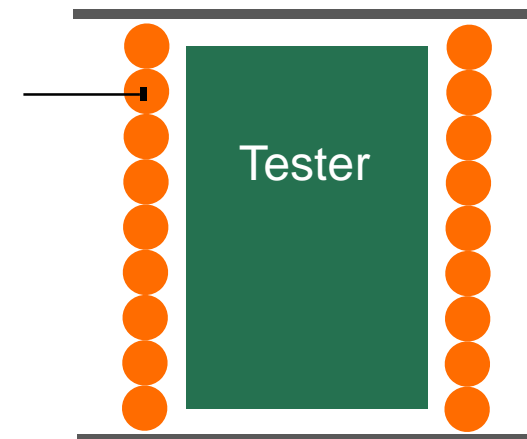


Observation rows with inbred lines

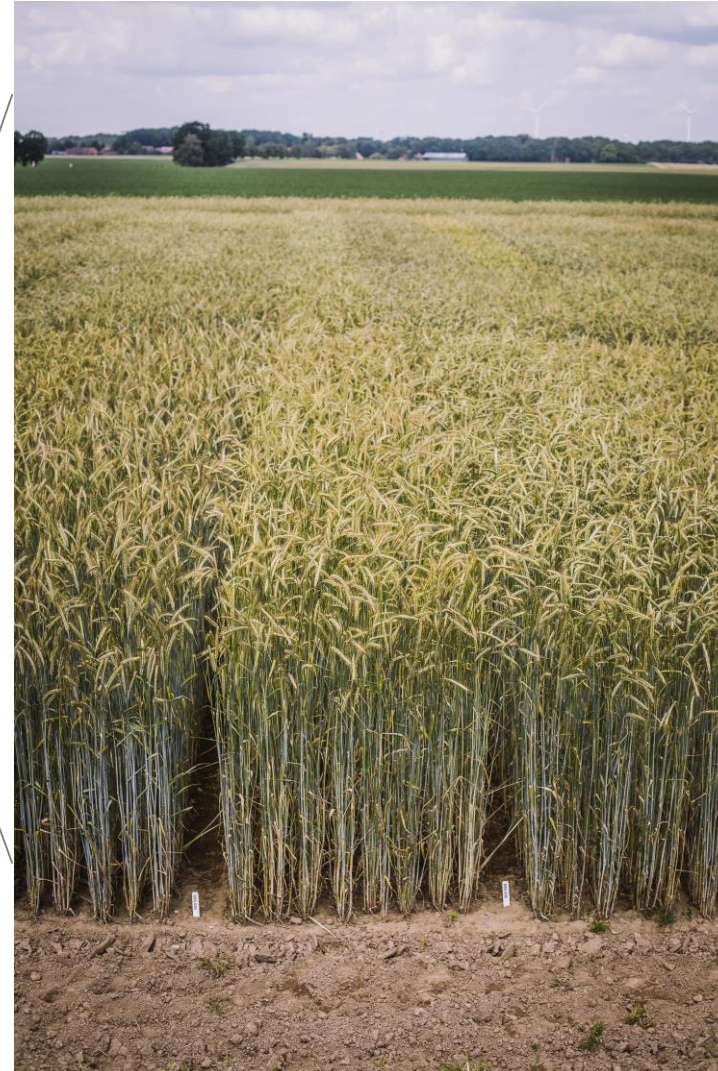
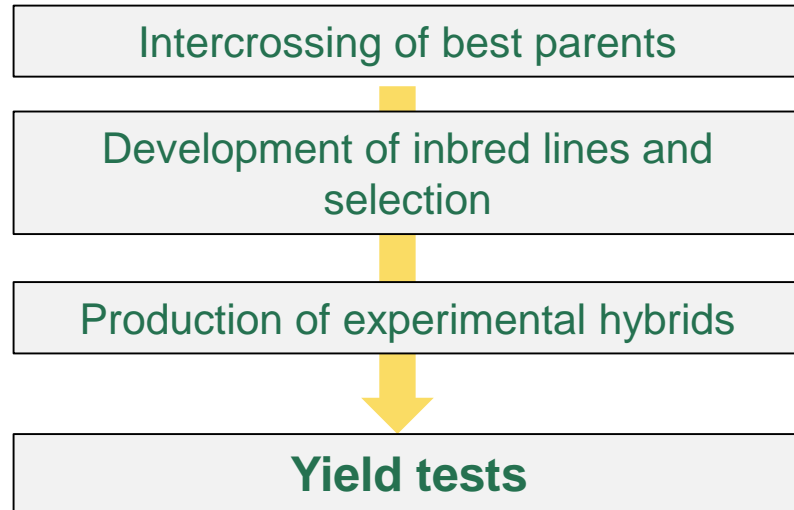
Breeding Hybrid Rye: Production of Experimental Hybrids



Crossing a candidate line to a tester of the opposite pool



Breeding Hybrid Rye: Testing for General Combining Ability



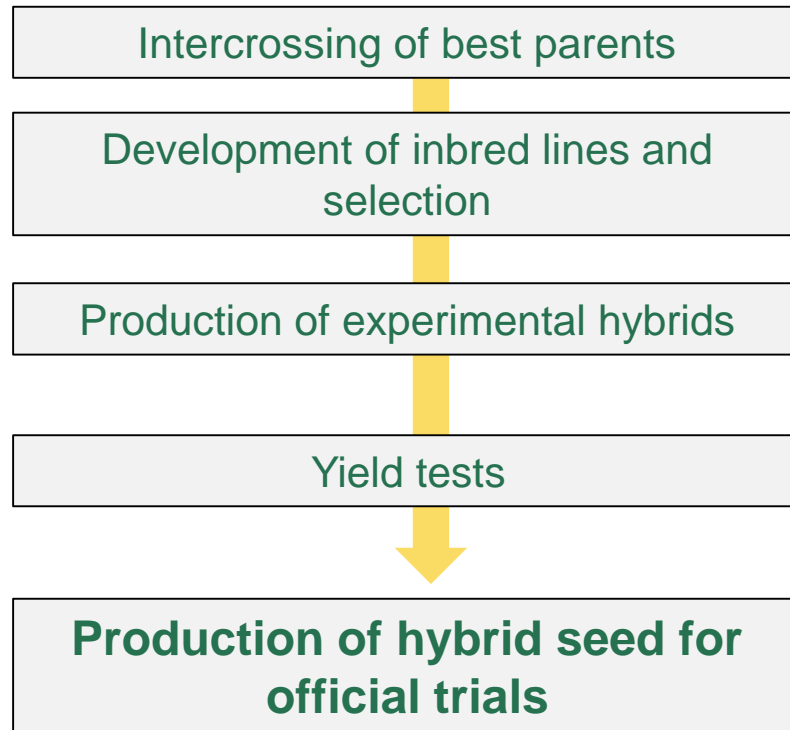
Breeding Hybrid Rye: Harvest of Yield Trials (1)



Breeding Hybrid Rye: Harvest of Yield Trials (2)



Breeding Hybrid Rye: Production of Hybrid Seed for Official Trials

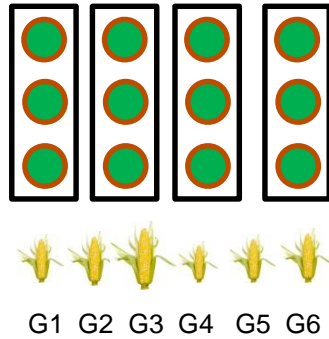




Genomic selection

Training population

Field trials



Marker data

ID	Marker				
	1	2	3	..	M
G1	AA	TT	GG	..	AA
G2	GG	TT	CC	..	AA
G3	AA	AA	CC	..	GG
.
G6	AA	TT	GG	..	AA

Train the GS model

$$\begin{bmatrix} \hat{\mu} \\ \hat{u} \end{bmatrix} = \begin{bmatrix} \mathbf{1}_n' \mathbf{1}_n & \mathbf{1}_n' \mathbf{Z} \\ \mathbf{Z}' \mathbf{1}_n & \mathbf{Z}' \mathbf{Z} + I\lambda^2 \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{1}_n' \mathbf{y} \\ \mathbf{Z}' \mathbf{y} \end{bmatrix}$$

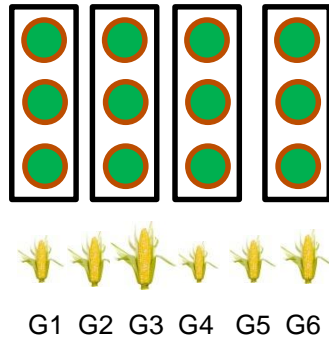


Marker effects

Marker	estimated effects
1	0,02
2	-0,04
3	-0,07
.	.
M	0,01

Training population

Field trials



Marker data

ID	Marker				
	1	2	3	..	M
G1	AA	TT	GG	..	AA
G2	GG	TT	CC	..	AA
G3	AA	AA	CC	..	GG
⋮	⋮	⋮	⋮	⋮	⋮
G6	AA	TT	GG	..	AA

Train the GS model

$$\begin{bmatrix} \hat{\mu} \\ \hat{u} \end{bmatrix} = \begin{bmatrix} 1_n' 1_n & 1_n' Z \\ Z' 1_n & Z' Z + I\lambda^2 \end{bmatrix}^{-1} \begin{bmatrix} 1_n' y \\ Z' y \end{bmatrix}$$



Marker effects

Marker	estimated effects
1	0,02
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⋮	⋮
M	0,01

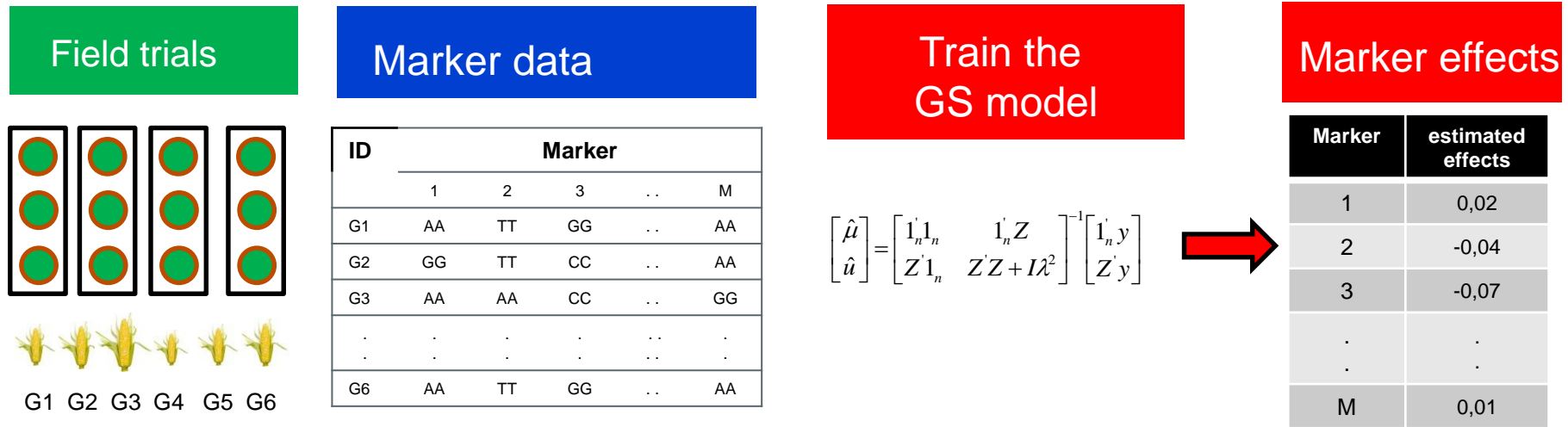
Target population

Field trials

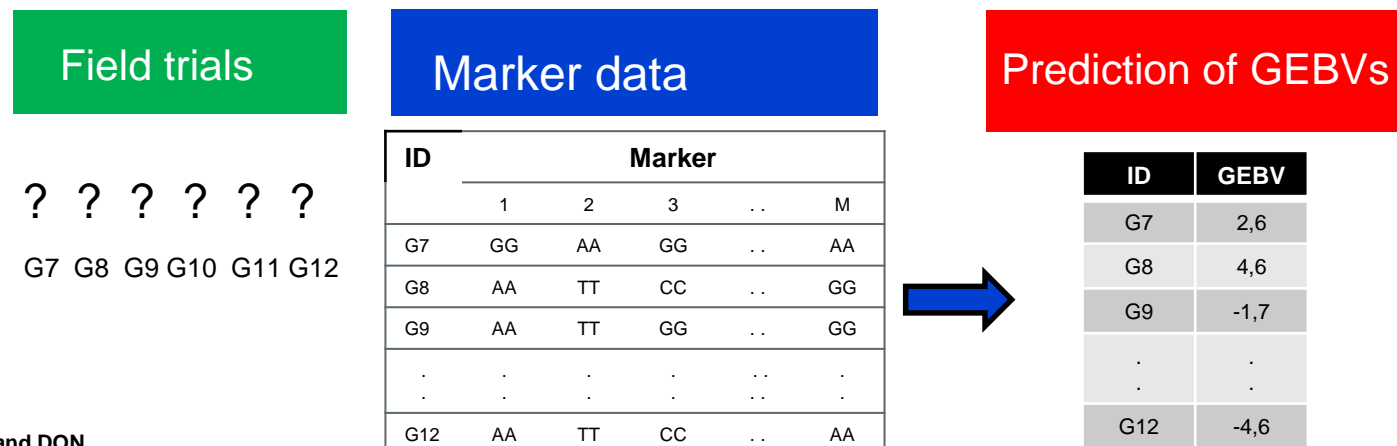
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G7 G8 G9 G10 G11 G12

Training population



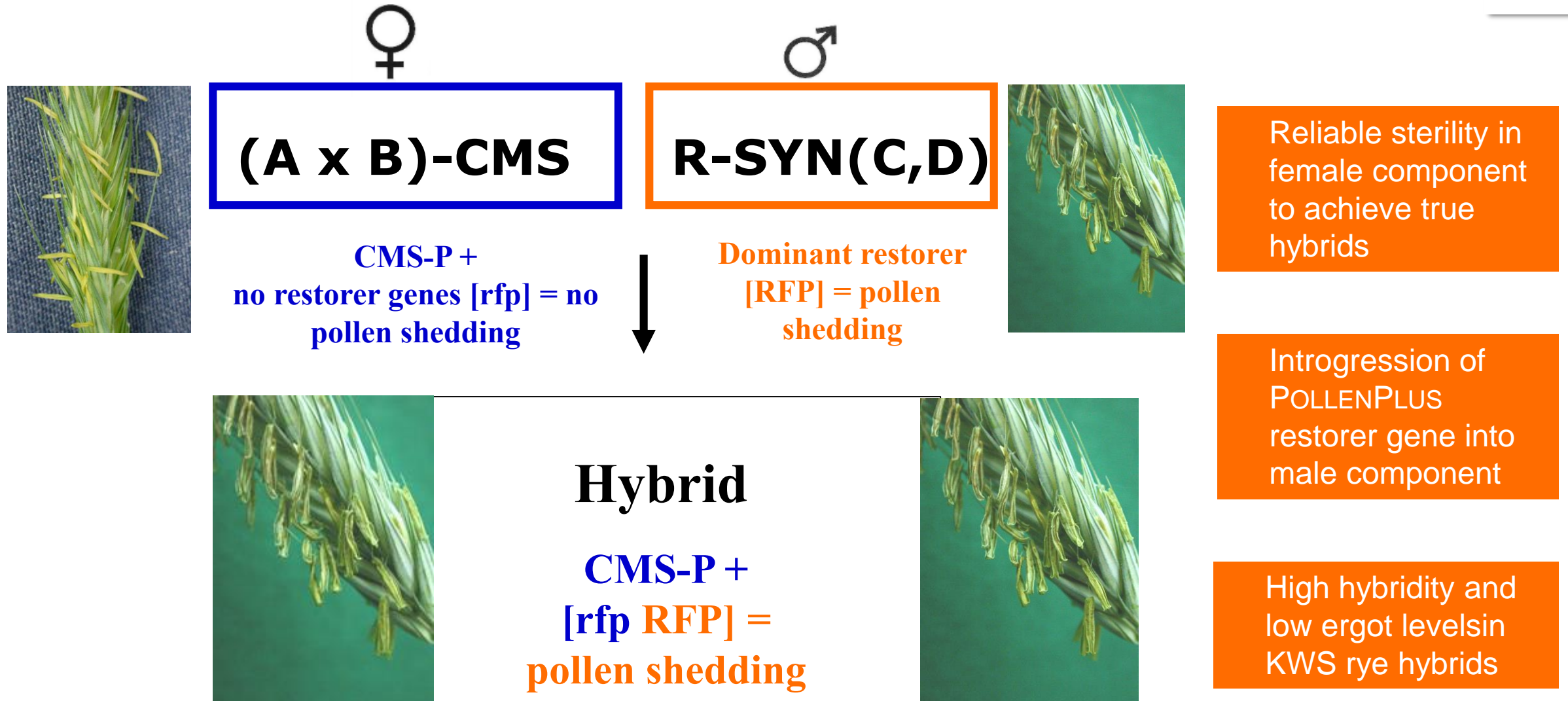
Target population





POLLENPLUS: KWS Hybrid
Rye Strategy against
Ergot

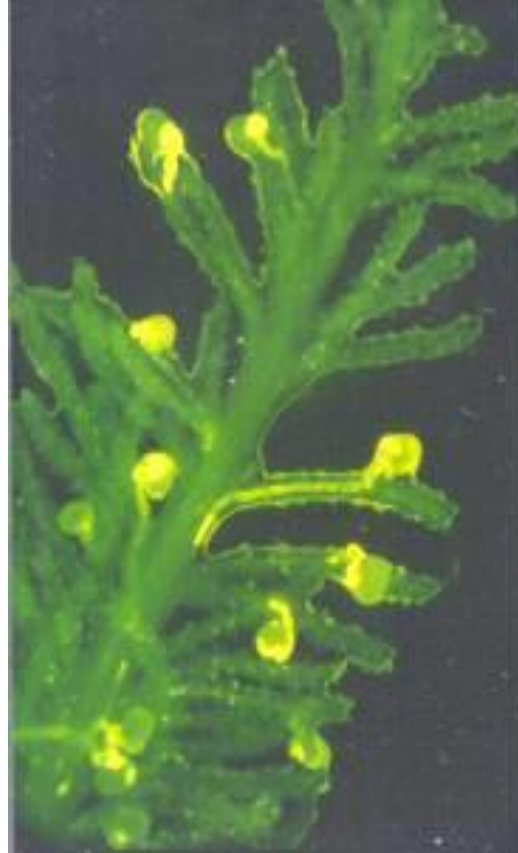
Hybrid system in rye based on cytoplasmic male sterility (CMS) and restoration of male fertility



Reproduction Biology of Rye: Cross Pollination, Open Flowers, and Ergot



Cross pollination in rye facilitates development of hybrids in rye



In absence of pollen, open flowers in rye may lead to ergot infection, and formation of alkaloid containing sclerotia



Inoculation procedure

- Inoculation with ergot spore suspension
- Multiple inoculation dates before, during, and after flowering time
- Inoculation in the evening or early morning to profit from dew for spore development

Target trait

- Weight percentage of ergot sclerotia in harvest ware



Safeguarding Low DON Contents in KWS Hybrid Rye

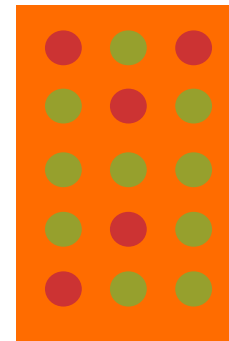
Inoculation of Rye with Spores of *Fusarium culmorum*



FHB incidence



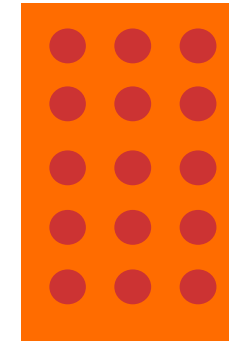
- FHB incidence within plot
- affected ears / plot [%]
- independent of individual infection rate of ear



$$5/15 = 33 \%$$



$$10/15 = 66 \%$$



$$15/15 = 100 \%$$

estimates type 1 resistance: infection of plant

FHB severity



0% 10% 50% 90%

- FHB incidence within ear
- affected spikelets / ear [%]
- estimation only at single ears

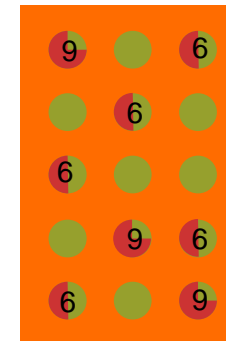
estimates type 2 resistance: FHB spreading within head

Field Scoring Scheme for FHB Infection in Rye

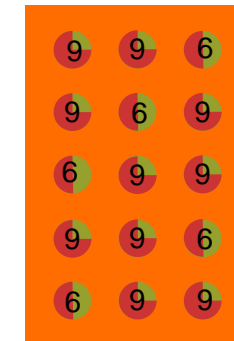
Percentage of diseased (i.e. whitened or pinkish) spikelets of total number of spikelets per plot. Corresponds to plot incidence x head severity.

Score	Description	% diseased spikelets
1	No visible Infestation	0
2	Beginning of whitening of single spikelets	1
3	all ears of the plot have single infested spiklets	2 - 3
4	whitening of connected ear rows / spikelets	4 - 10
5	all ears are whitened to 1/4	11 - 25
6	all ears are whitened to 1/3	26 - 33
7	all ears are whitened to 1/2	34 - 50
8	all ears are whitened to 2/3	50 - 75
9	more than 3/4 of pikelets across all ears are whitened	75 - 100

12 spikelets /spike; 15 spikes/plot



$57/180 = 32\%$
score 6



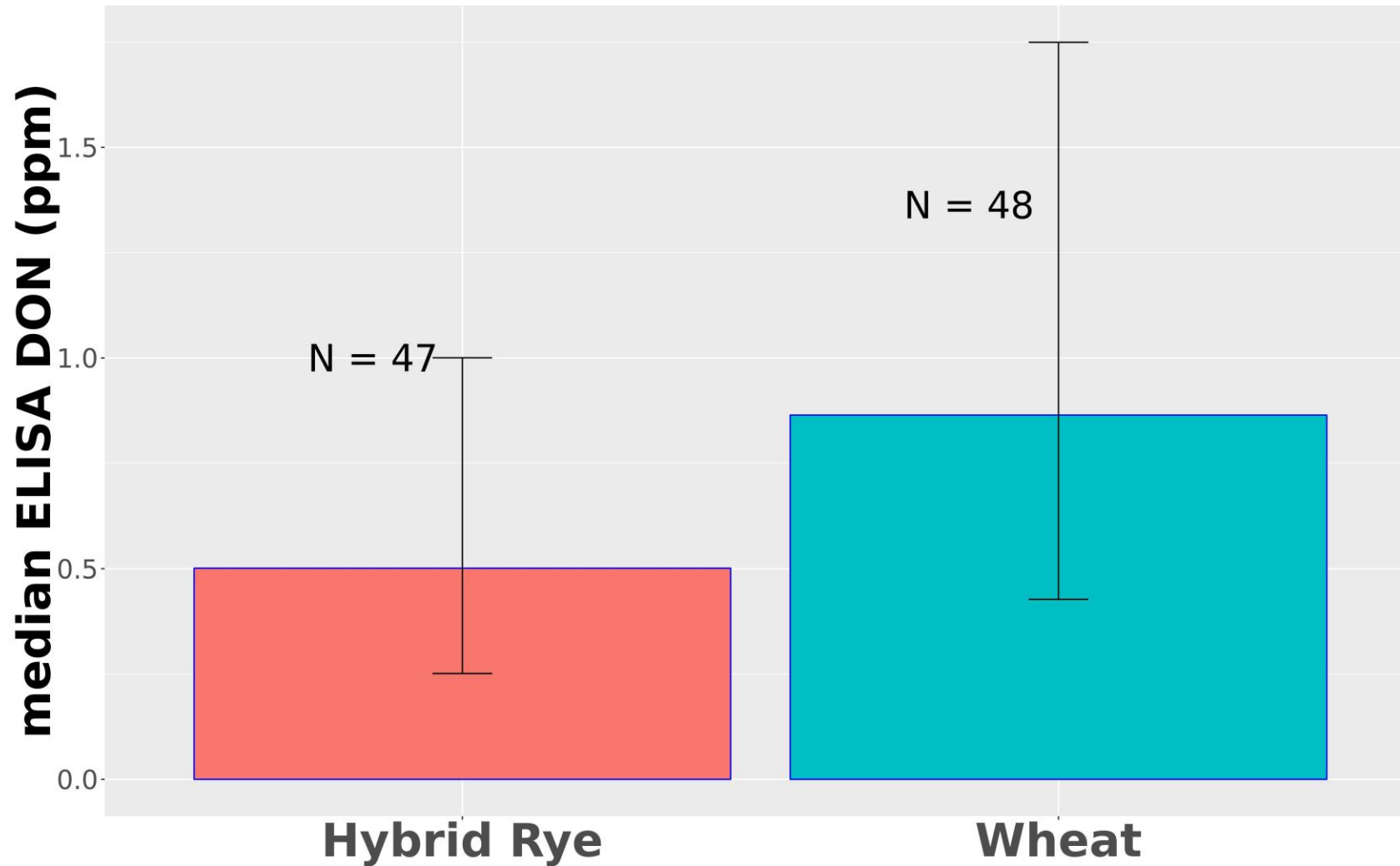
$120/180 = 67\%$
score 8

index = mean plot severity (% diseased spikelets per plot)

estimates type 1 + type 2 resistance

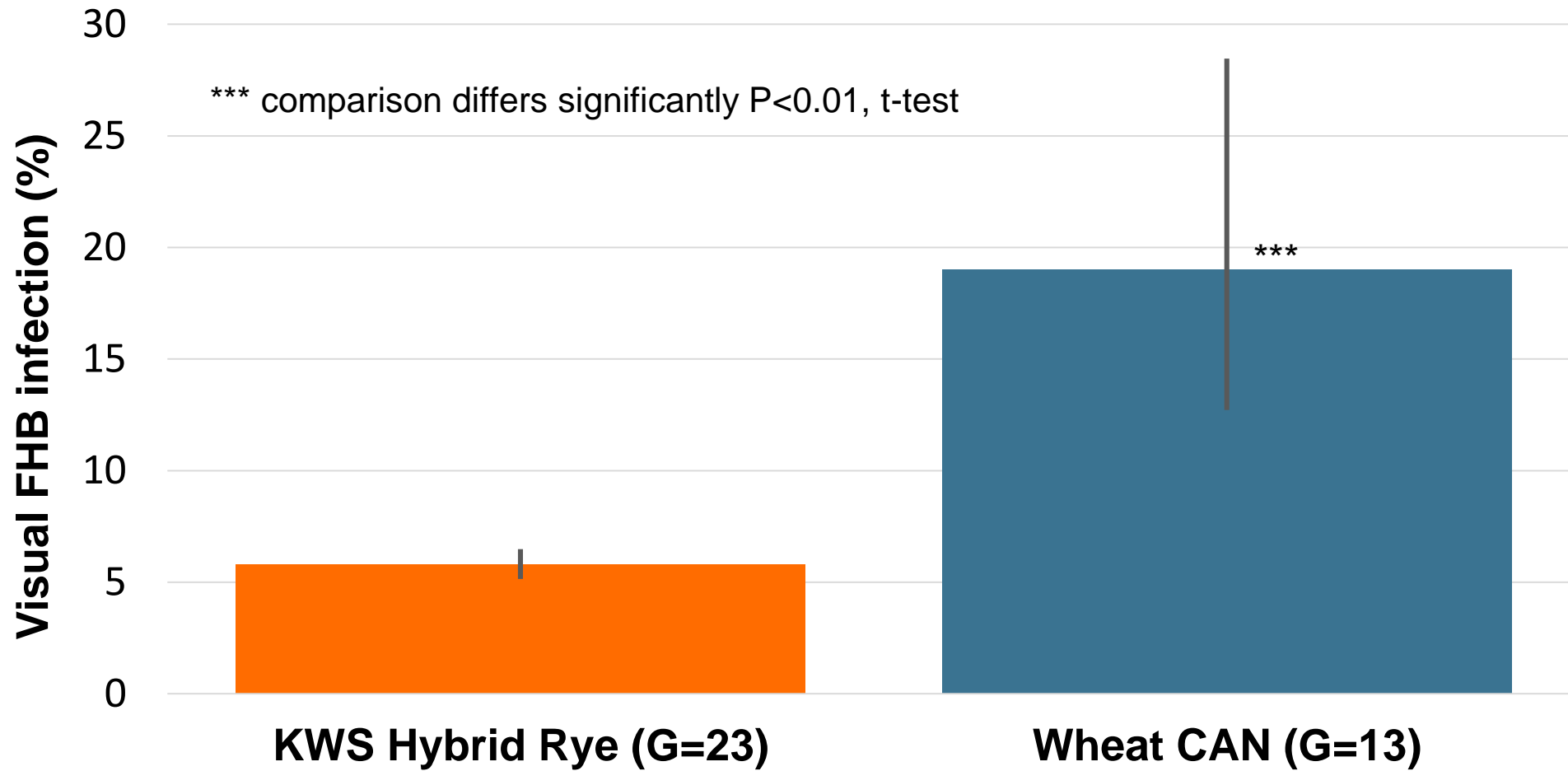
DON for Hybrid Rye and Wheat in CAN and USA (2016)

(bars indicate lower and upper 95 % confidence interval)



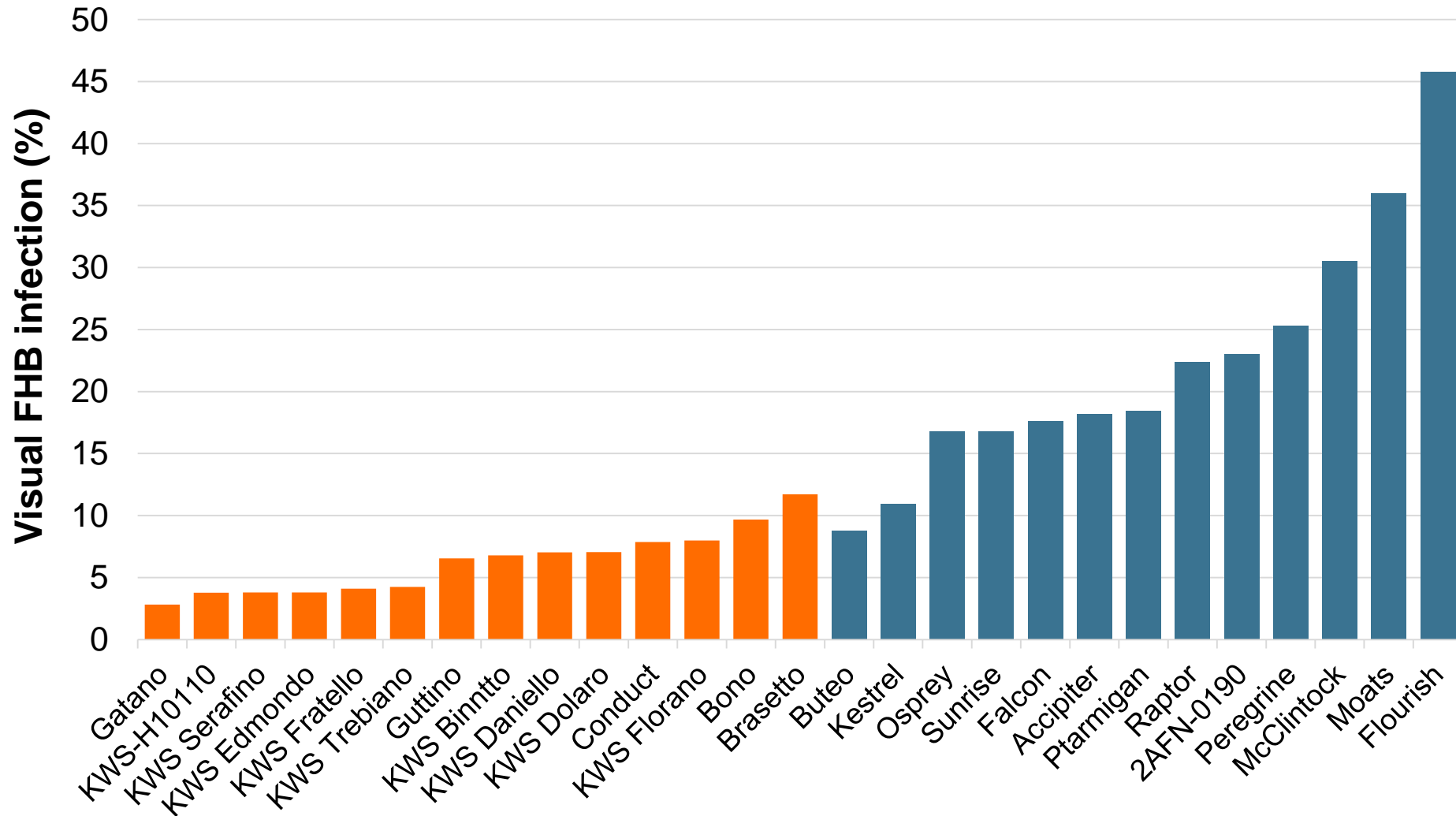
Data: KWS, 2016
Locations = 25

FHB infection in Rye and Wheat in Canada in 2018 (1)



Data:
Uni Manitoba, 2018
Locations = 2
Reps = 6

FHB infection in Rye and Wheat in Canada in 2018 (2)



Data:
Uni Manitoba, 2018
Locations = 2
Reps = 6