Julius Kühn-Institut
Federal Research Centre for Cultivated Plants

LupiBreed

Improving narrow-leafed lupin – Novel genetic resources for higher yield and yield stability

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Gefördert durch:
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aufgrund eines Beschlusses des Deutschen Bundestages
ptble
Projektträger Bundesanstalt für Landwirtschaft und Ernährung

LupiBreed – Consortium (2015-2018)

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Aims of the consortium

Part I

Improving yield…

- Identification of high-yield prebreeding lines based on a mutant population by performance testing in different locations over 3 years (grain yield, protein content, alkaloid content)

Improving yield stability…

- Early shattering resistance: field testing and molecular markers
- Anthracnose resistance: greenhouse and field testing, genetic mapping of resistance loci *LanrBo* and *Lanr1*

Part II (Anne Zaar, JKI Institute for Resistance Research and Stress Tolerance)

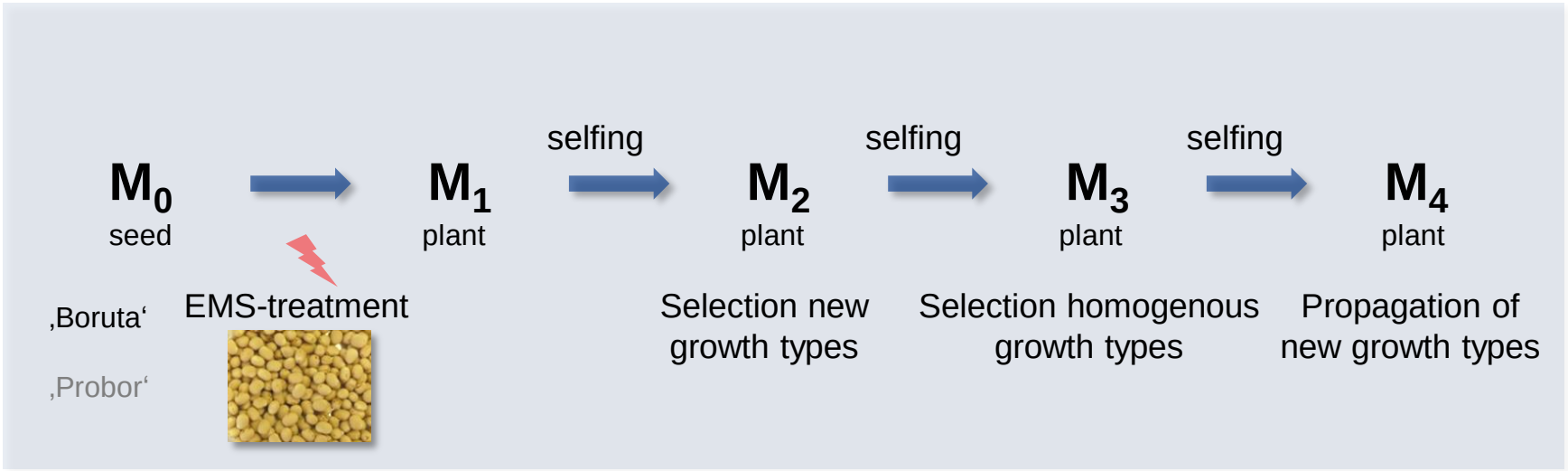
Analysis of the range of variation for protein and alkaloid content in plant genetic resources and novel mutant collection of narrow-leafed lupin

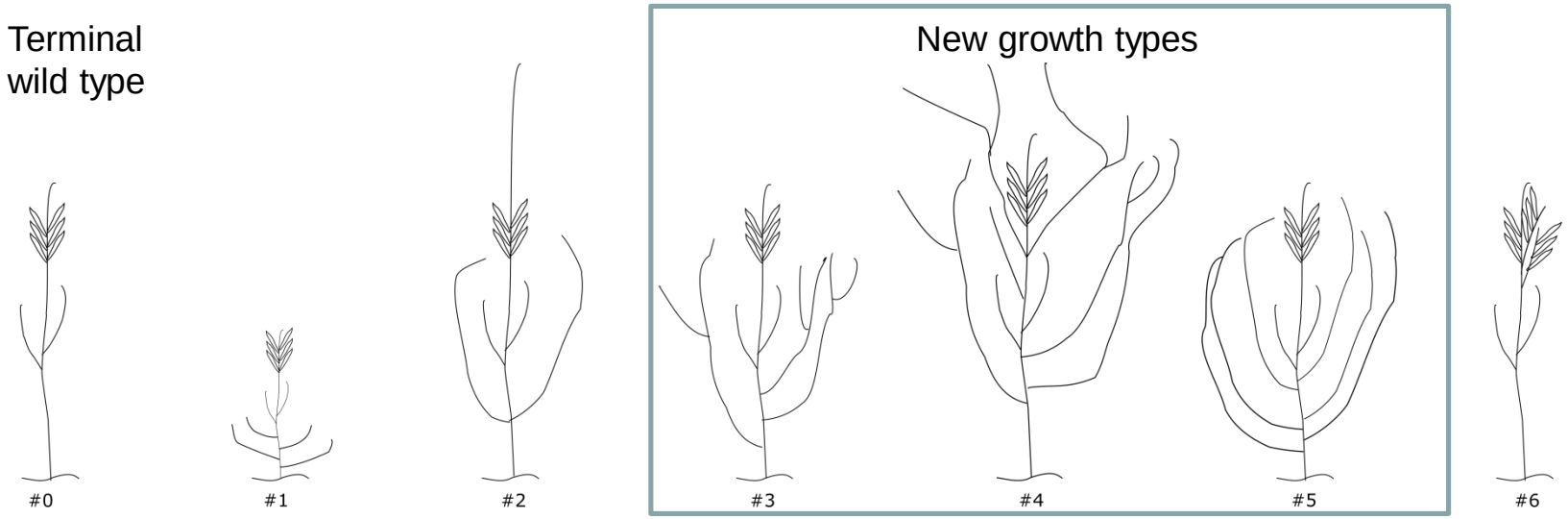
Improving yield

Increase genetic variation – EMS population

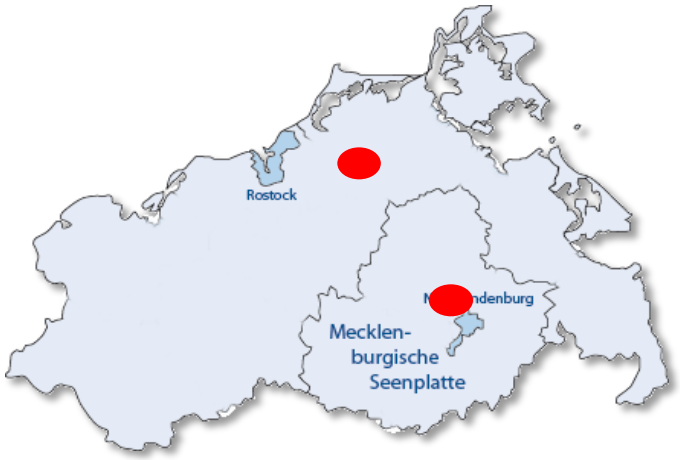
Field testing yield performance

Development mutant lines





Yield performance field testing



Material
cv. ‘Boruta‘, ‘Boregine‘, ‘Probor‘
22 **early M-lines A (Donor: ‘Boruta’)**
(22 **late M-lines B (Donor: ‘Boruta’, ‘Probor’)**)

3 locations
Groß Lüsewitz JKI I (conv) und II (eco), Bocksee SZS

3 years
2015, 2016, 2017

Sowed
5m^2 – plots, 100 grains/m^2

Traits
flowering, ripening, plant height, grain yield (dt/ha), TKG, protein content, protein yield (dt/ha), alkaloid content

Means yield and protein, early M-lines, 2015 – 2017

Location		Grain yield (dt/ha)	Protein content (%)	Protein yield (dt/ha)
GL konv	Min.	33.1	28.8	9.2
BP40-47	Max.	51.1	33.0	15.2
	Mean	42.5	30.2	12.5
	Boruta	43.7	30.6	13.1
	Probor	52.4	31.9	16.3
	Boregine	57.1	28.6	15.9
GL öko	Min.	20.5	24.8	5.5
BP40-47	Max.	36.4	30.5	9.8
	Mean	29.6	26.8	7.8
	Boruta	29.6	25.7	7.4
	Probor	35.1	29.8	10.2
	Boregine	41.5	27.8	11.2
Bocksee	Min.	10.3	24.6	2.4
BP18-20	Max.	18.7	28.5	7.6
	Mean	15.1	26.4	4.1
	Boruta	15.4	26.2	3.9
	Probor	17.6	28.5	5.2
	Boregine	18.2	26.5	6.0
gesamt	Min.	21.4	26.1	5.8
	Max.	35.4	29.3	10.0
	Mean	29.1	27.6	8.0
	Boruta	29.6	27.5	8.2
	Probor	35.0	30.0	10.5
	Boregine	38.9	27.6	10.7

Good soil compostition, some M-lines better than wild type

No herbicides (competition) water accessability plant diseases, -pests

Low soil quality, water accessability

Yield performance early M-lines, A

9 environments (3 locations, 2015-2017)

M-line	Grain yield (dt/ha)
A4^{Bor}	35.4 *
A15^{Bor}	33.8 *
A3^{Bor}	33.3 *
A18^{Bor}	32.9 *
A5^{Bor}	32.6 *
A19^{Bor}	32.2
A17^{Bor}	31.3
A12^{Bor}	30.9
A7^{Bor}	30.5
A9^{Bor}	29.2
A16^{Bor}	29.1
A14^{Bor}	29.1
A10^{Bor}	28.4
Boruta	29.5
Probor	35.0
Boregine	38.9

M-line	Protein content (%)
A9^{Bor}	29.3 *
A4^{Bor}	28.5 *
A11^{Bor}	28.5 *
A17^{Bor}	28.3 *
A5^{Bor}	28.3 *
A13^{Bor}	28.2
A8^{Bor}	28.1
A3^{Bor}	28.1
A18^{Bor}	28.0
A15^{Bor}	27.9
A22^{Bor}	27.6
A12^{Bor}	27.5
A19^{Bor}	27.5
Boruta	27.5
Probor	30.0
Boregine	27.6

M-line	Alkaloid content (%)
A8^{Bor}	0.010 *
A20^{Bor}	0.011 *
A2^{Bor}	0.014 *
A13^{Bor}	0.015 *
A14^{Bor}	0.015 *
A1^{Bor}	0.016 *
A6^{Bor}	0.018 *
A15^{Bor}	0.018 *
A16^{Bor}	0.018 *
A19^{Bor}	0.019 *
A9^{Bor}	0.020 *
A12^{Bor}	0.020 *
A22^{Bor}	0.021 *
Boruta	0.026
Probor	0.027
Boregine	0.039

A ^{Bor} Mutant line based on cv ‚Boruta‘

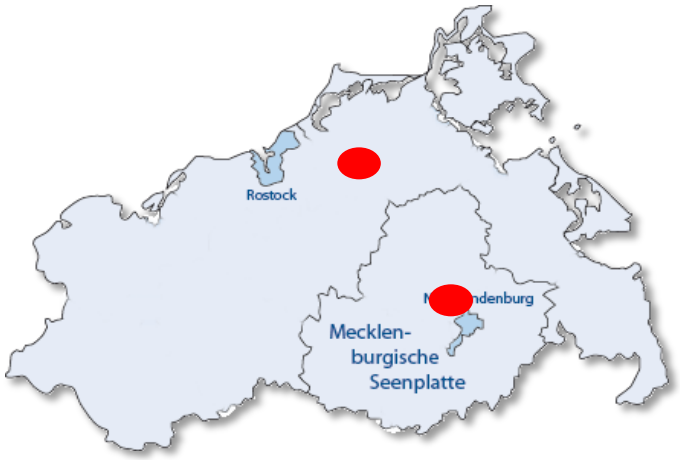
Comparison to wild type ‚Boruta‘

Variant analysis LSD-Test, α=0.05

Increasing yield stability

Early shattering resistance

Shattering resistance field testing



Material
VB Antaniai -> strongly shattering
Tanjil, Uniwhite, Unicrop, Lila Baer -> high resistance

22 **early M-lines A** + 10 breeding lines
(22 **late M-lines B** + 10 breeding lines)

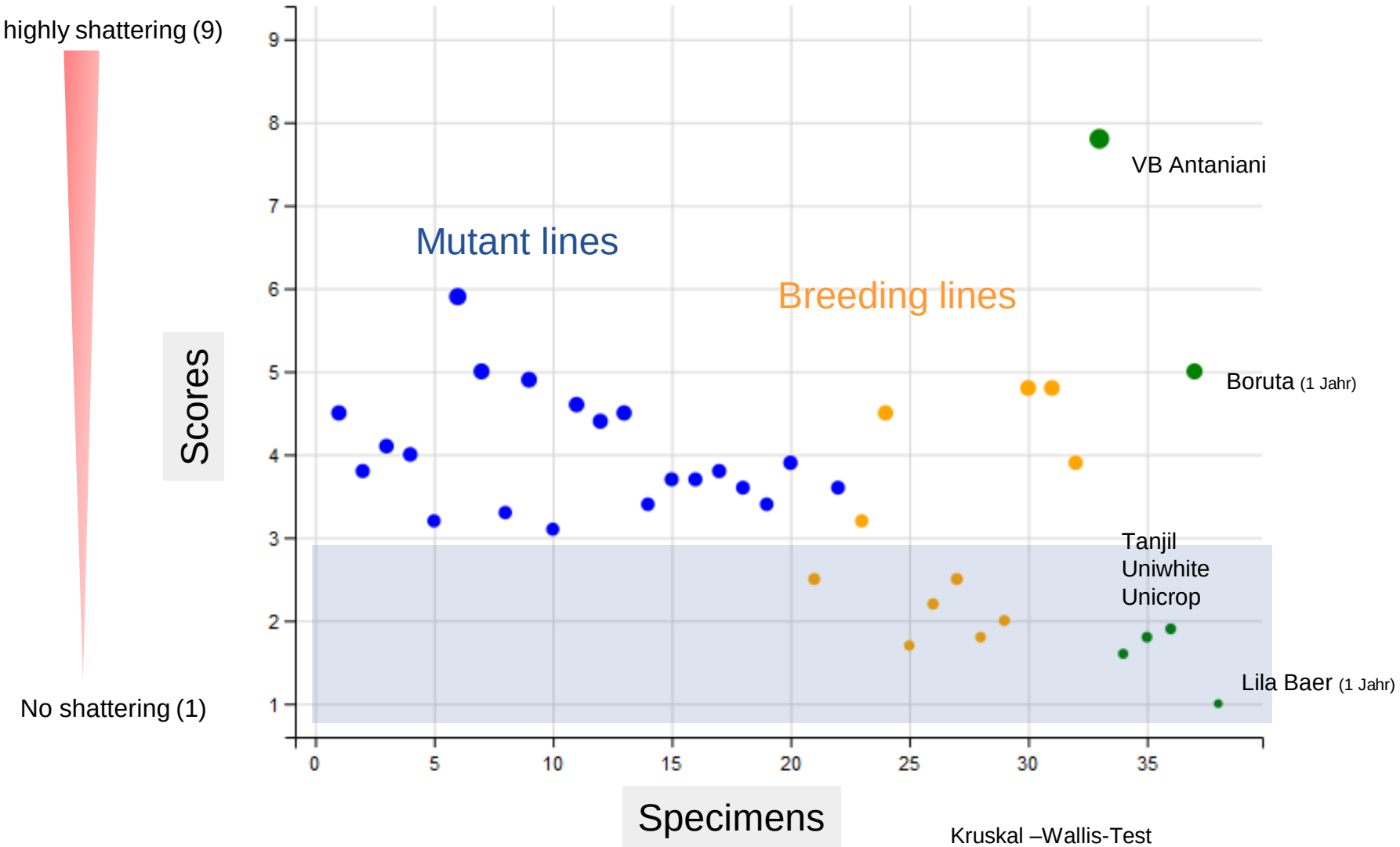
2 locations
Groß Lüsewitz JKI, Bocksee SZS

3 years
2015, 2016, 2017

Sowing
2-row micro plots, 5 x 5 grids

Scoring
1 – 9 (shattering resisant – highly shattering)

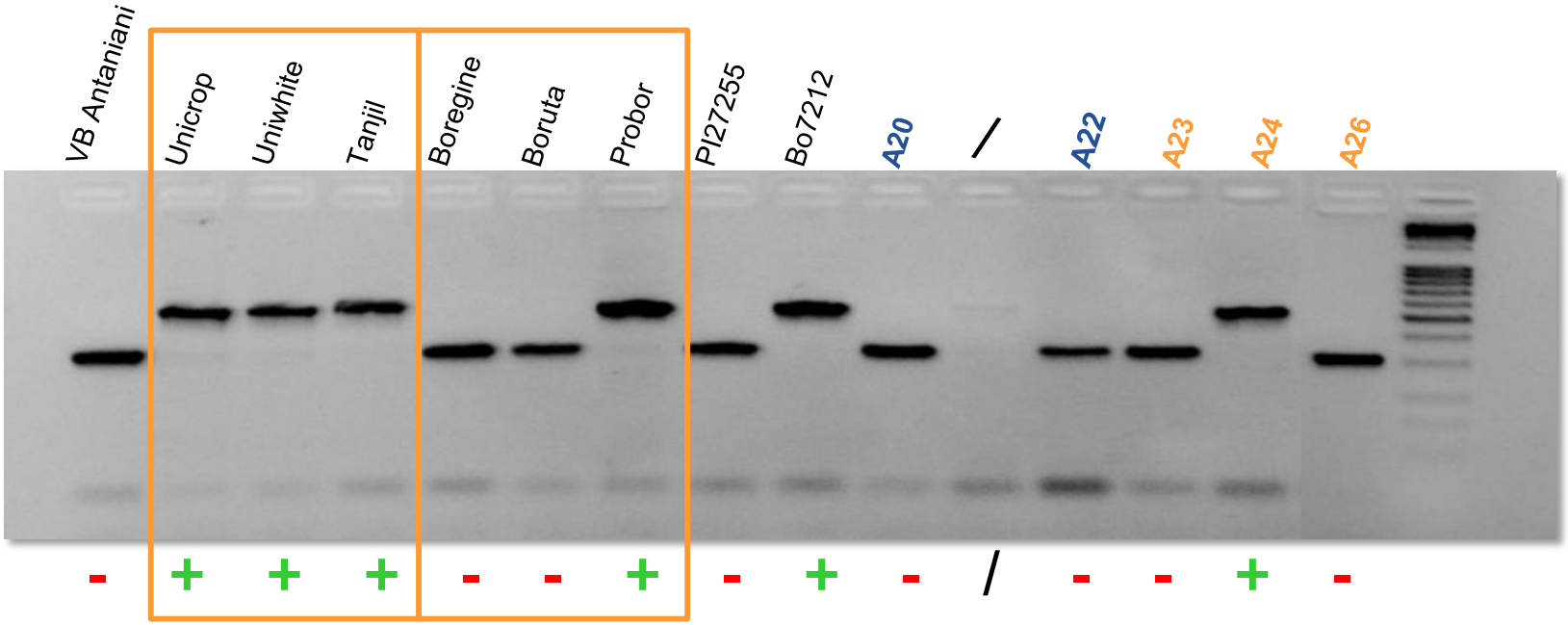
Shattering resistance, **early** M-lines, 2015 – 2017, A



Kruskal –Wallis-Test
(χ^2 = 155.7, df = 35, p = < 0.05)
PostHoc: Dunn-Bonferroni-Test

Molecular characterization

Example: *tardus*



Marker*: TaLi (tardus,* Li et al., 2010)

Breeding lines

Mutant-lines

Increasing yield stability

Anthracnose resistance

Resistance resources

Resource	Resistance-level	Inheritance	Loucs	LG	Selection-marker
cv. ‚Tanjil' (Australia)	High (some spots on pods)	monogenic dominant	*Lanr 1**	NLL-11 (distal)	*Lanr1_1* *Lanr1_2*
Zuchtlinie Bo7212 (SZS)	High (almost no symptoms)	monogenic dominant	*LanrBo***	NLL-11	*BoSeq196* *LanM_19*

Greenhouse testing

Field testing

*Yang et al. 2004

**Fischer et al. 2015

Allelic association test

F2-Population

‚Tanjil' Bo7212

hor hor

Lanr1 **x** *LanrBo*

↓

her

S

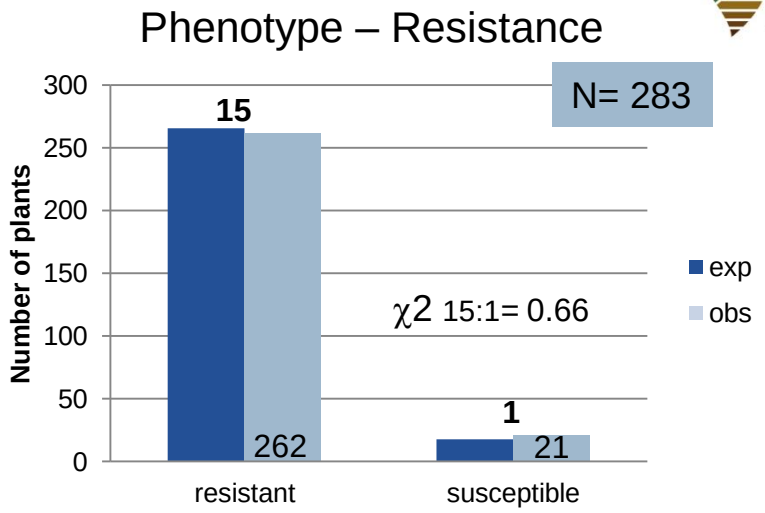
F1

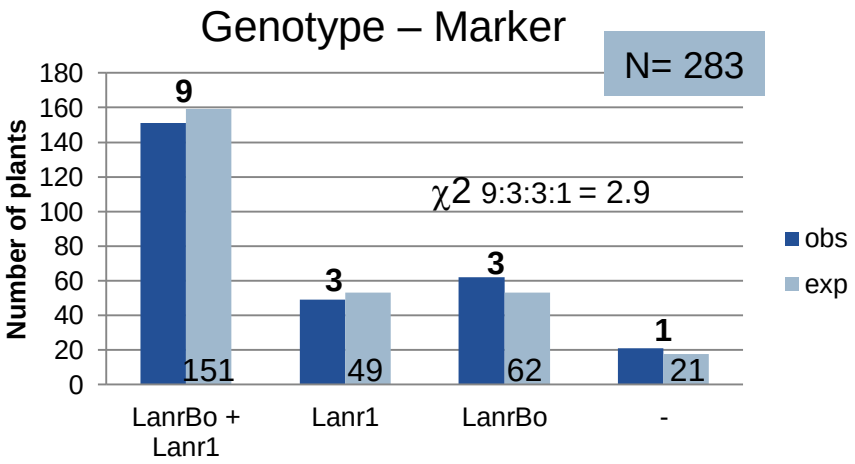
Lanr1+ LanrBo

↓

hor her her sus

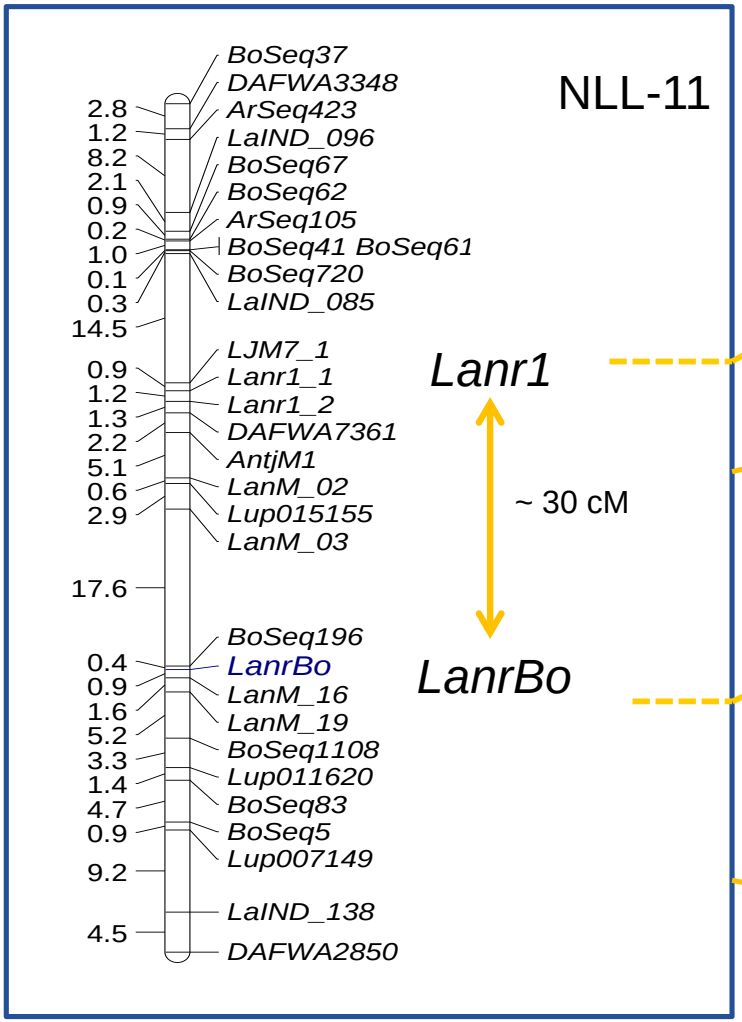
hor = homozygous resistant for *Lanr1* and *LanrBo*
her = heterozygous resistant für *Lanr1* and/or *LanrBo*
sus. = susceptible



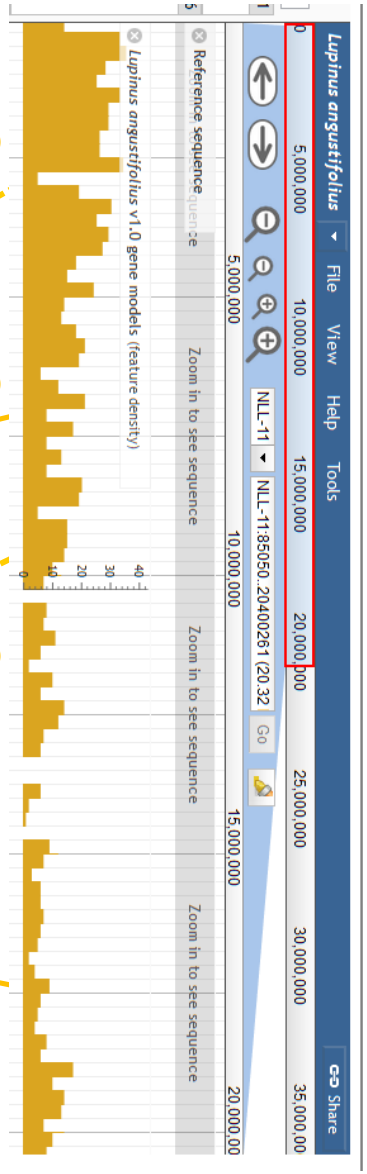


Mapping of resistance locus

Genetic map (cM)



Physical map (Mbp)



Sum up yield performance and stability

Mutant lines:

- ✓ Significantly higher grain yields compared to donor ‚Boruta' (9 environments)
- ✓ Significantly higher grain yield compared to high yield cultivar ‚Boregine' in poor soil location
- ✓ Significantly higher protein content compared to high yield cultivar ‚Boregine' → positive effect on protein yield
- ✓ Significantly lower alkaloid contents in early types
- ✓ High heritability → breeding progress
- ✓ Selection of mutant-lines with multiple improved traits → pre-breeding
- ✓ Marker assisted breedingc approaches possible for shattering and anthracnose resistance

Thanks to...

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Kerstin Kadzban
Birgit Schütt


Thank you for your attention!

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