Breeding for IDC and SCN Tolerance: Why is it So Difficult?

Dr. Carrie Miranda

2-8-23

Why is it difficult to find varieties with IDC <u>OR</u> SCN resistance?

A quick genetics / breeding lesson…

There are two types of traits...

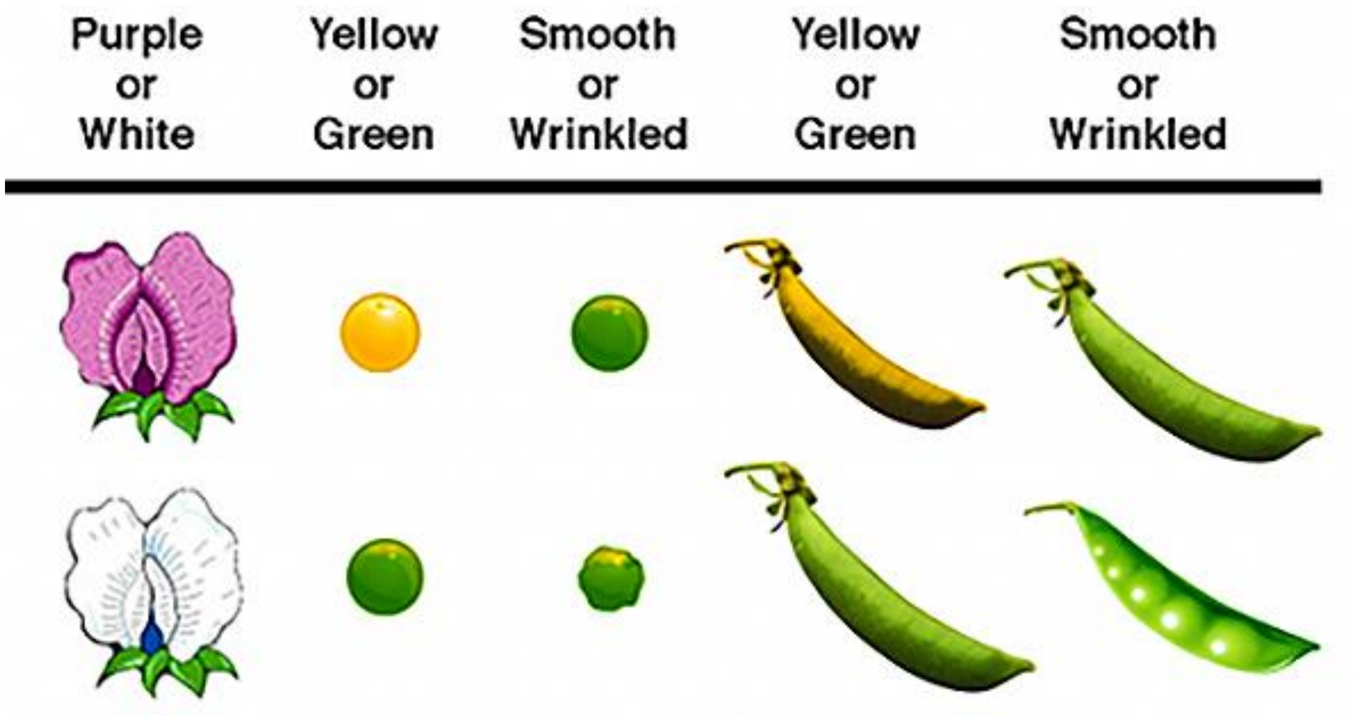
A trait is a characteristic that we are interested in:

- Season Length/ Maturity
- Herbicide Tolerance
- Yield
- Height
- Disease resistance

A trait can be controlled by 1-2 genes or many, many genes

Trait types: Qualitative

- 1-2 genes
- Easy(ier) to breed for
- It's either present or not present
- Examples: Flower color, herbicide resistance, seed color

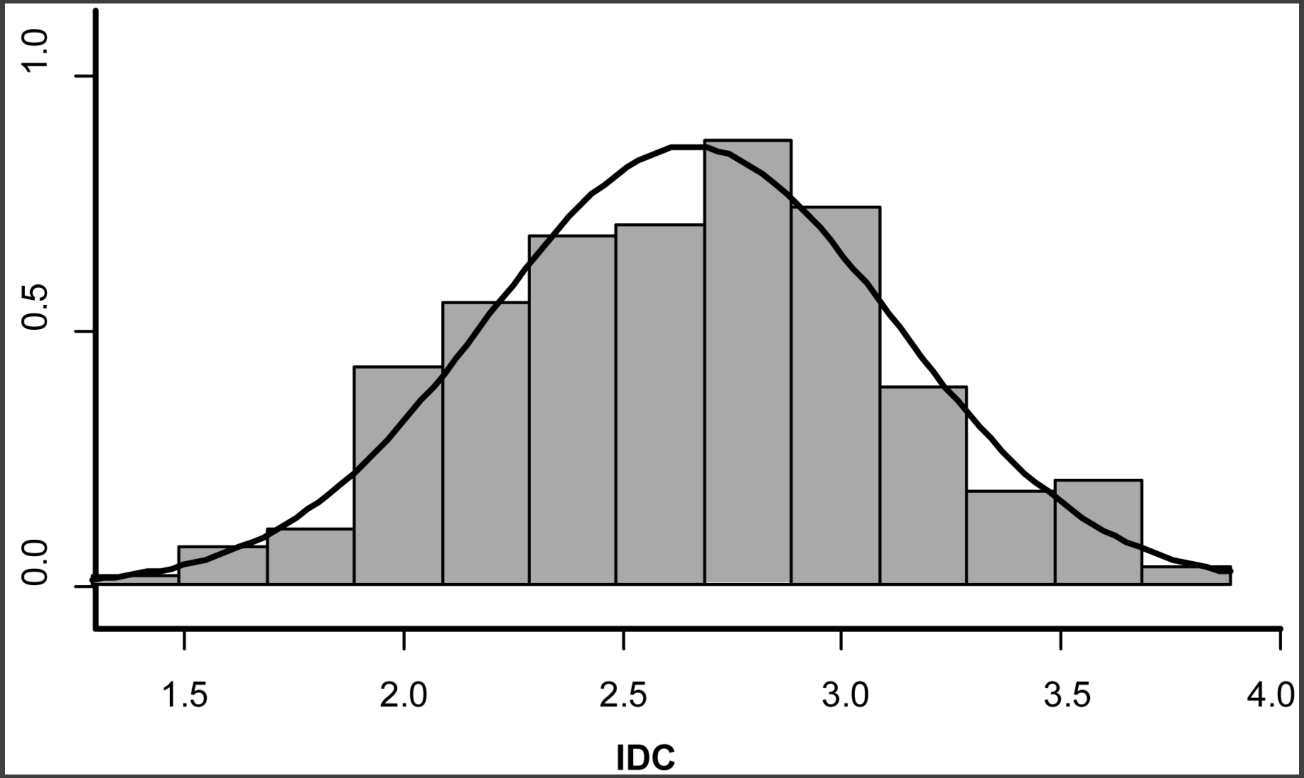


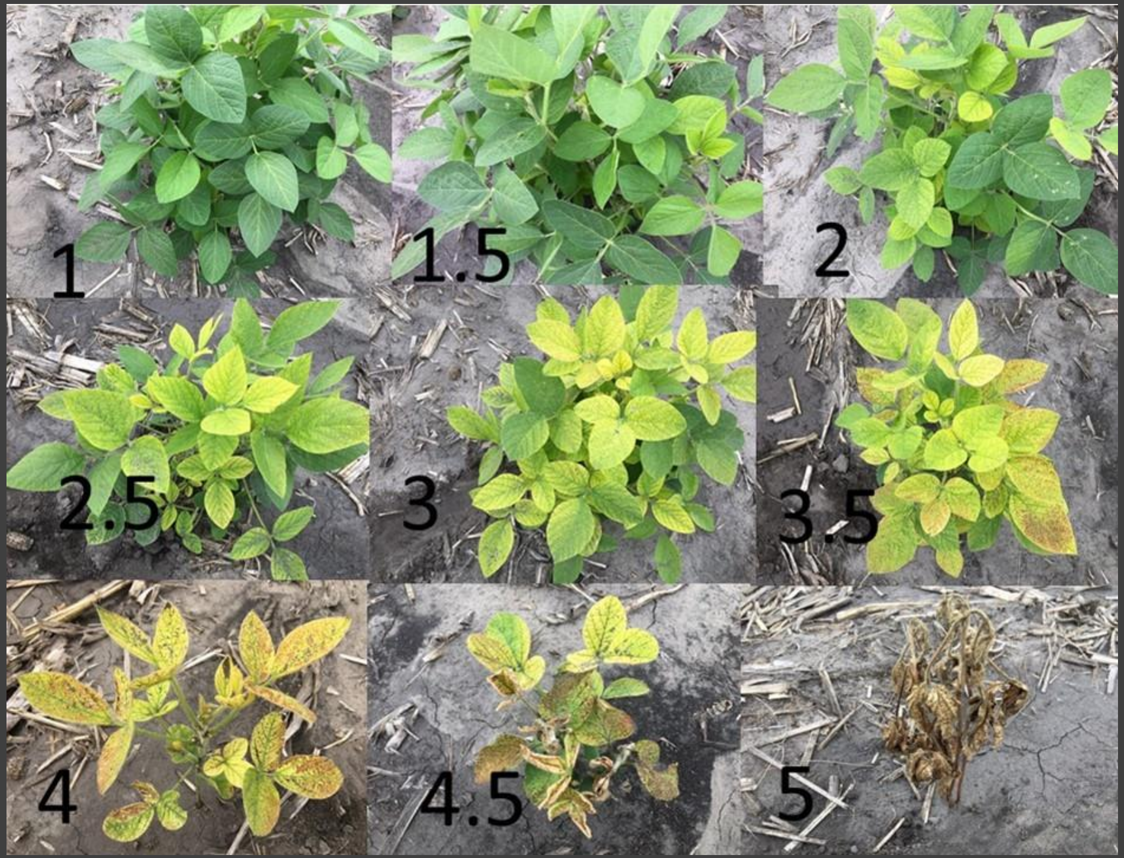
	P	p
P	PP	Pp
p	Pp	pp

3:1

Trait types: Quantitative

- Many, many genes
- Difficult to breed for
- A spectrum of phenotypes
- Examples (all the good traits): maturity, yield, IDC tolerance



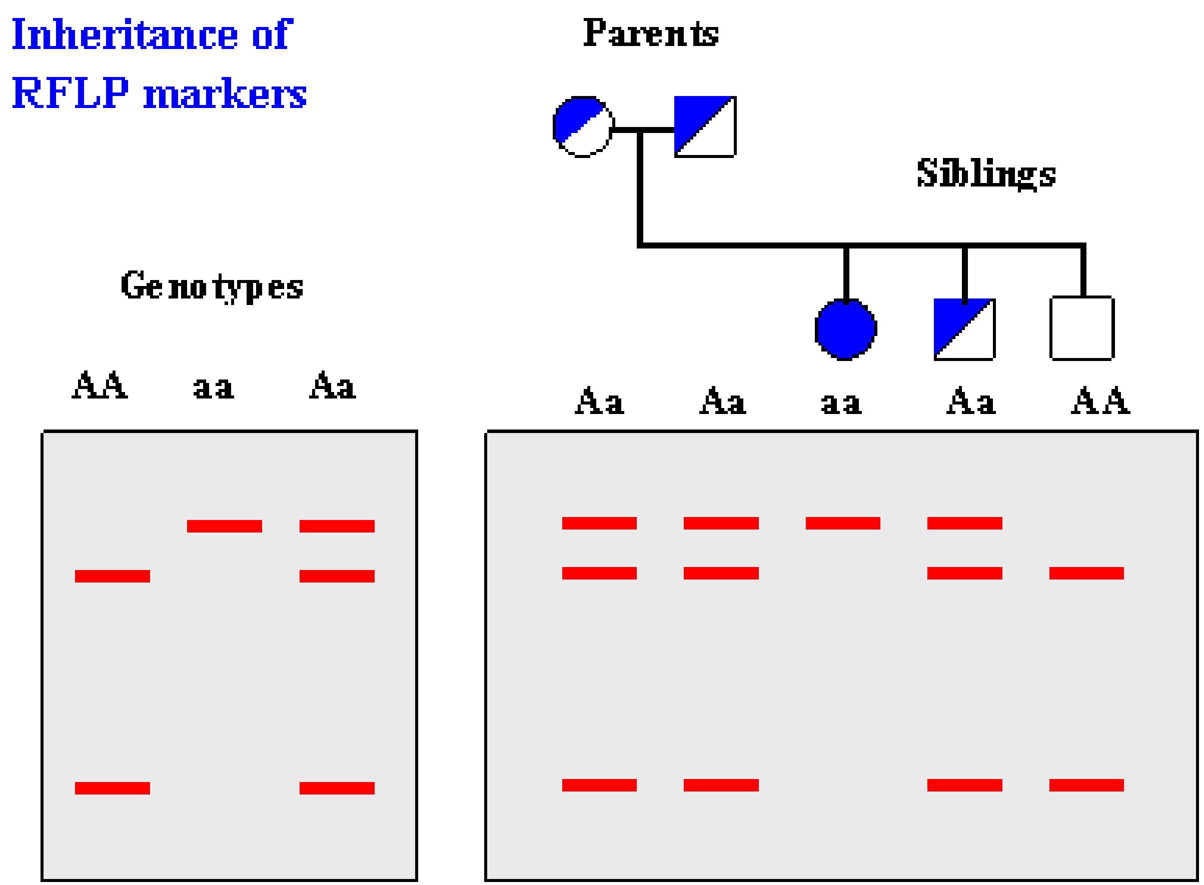


There is help!

Molecular marker tools!

These tools can detect genomic/ nucleotide data that detects the likelihood of a phenotype

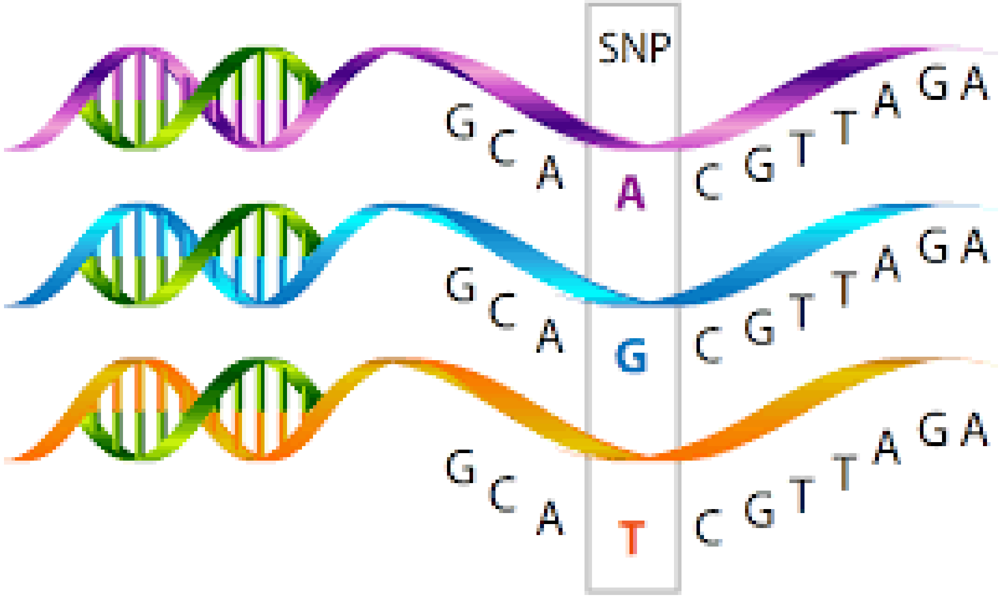
Old School: Gel based

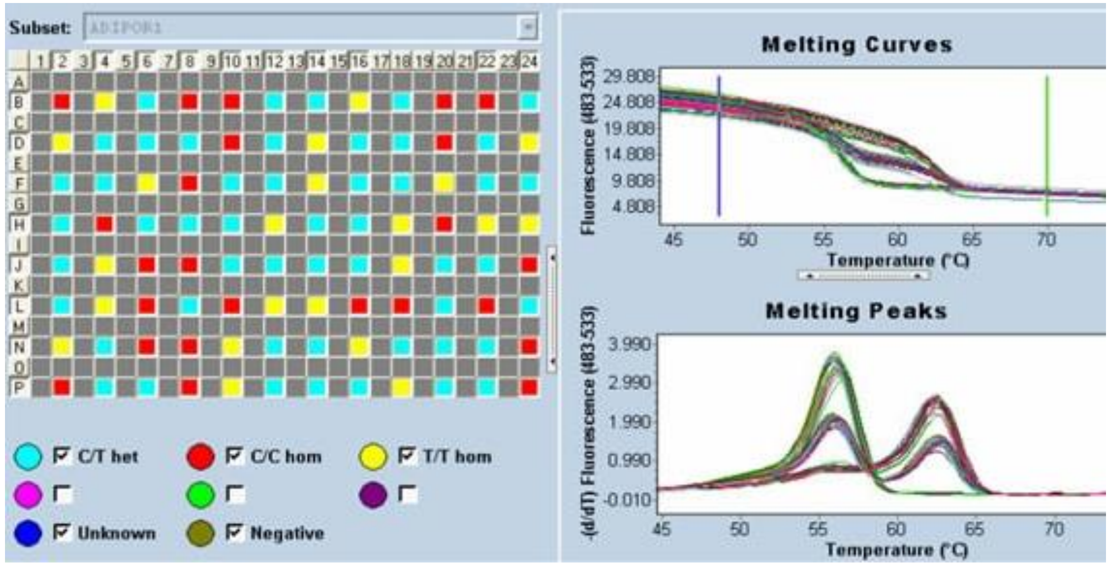


There is help!

Molecular marker tools!

These tools can detect genomic/ nucleotide data that detects the likelihood of a phenotype





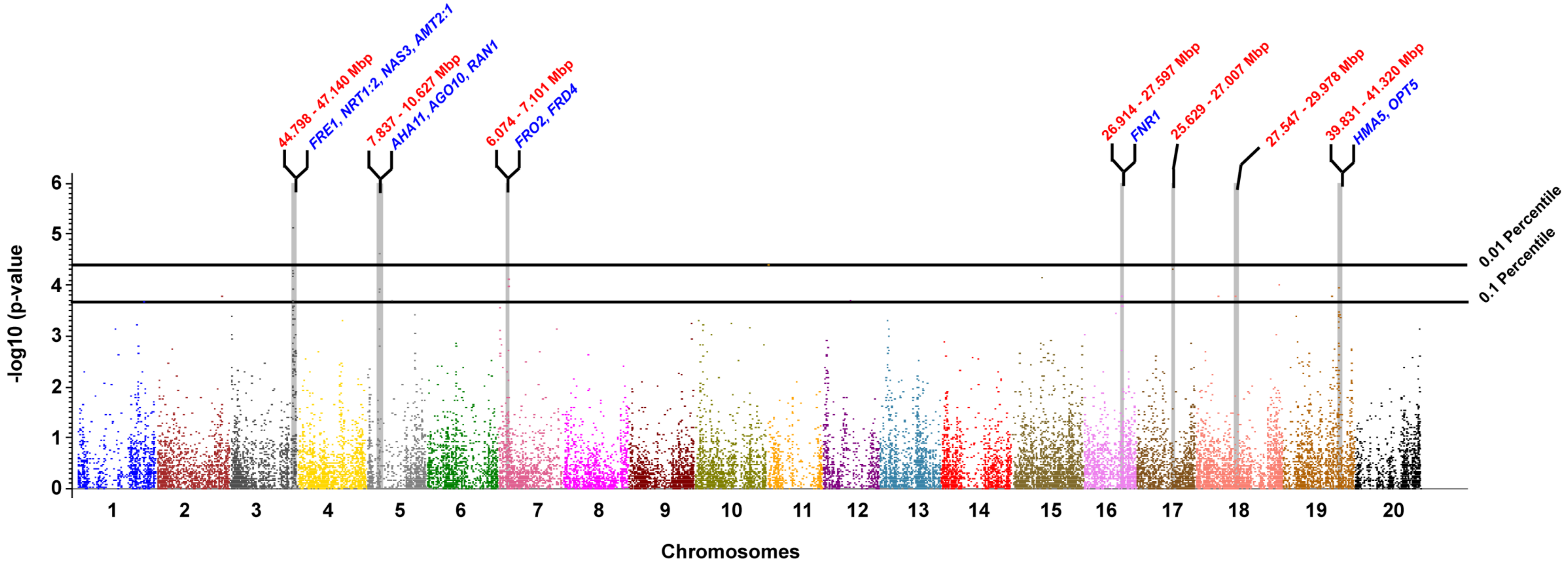
OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Genome-Wide Association Studies Identifies Seven Major Regions Responsible for Iron Deficiency Chlorosis in Soybean (*Glycine max*)

Sujan Mamidi, Rian K. Lee, Jay R. Goos, Phillip E. McClean

Published: September 16, 2014 • https://doi.org/10.1371/journal.pone.0107469



S. Mamidi et al. *PLOS ONE*(2014)

Allelic combination[§]	# of genotypes	IDC			
		Minimum	Maximum	Mean	Standard Deviation
CTTATTGA	3	1.63	2.23	1.88	0.31
TGTATTGA	7	1.46	2.58	2.17	0.37
CGTAGTGA	2	2.18	2.34	2.26	0.11
CTTATTGC	6	1.96	2.86	2.29	0.33
TTTATTGA	11	1.95	3.25	2.32	0.40
CGCATTGA	9	2.08	2.83	2.38	0.26
CTCGTTAA	1	2.4	2.4	2.40	
CTTATTAA	2	2.16	2.66	2.41	0.35
CTCATTGA	26	1.8	3.01	2.41	0.33
CTTGTTGC	2	2.16	2.69	2.43	0.37
CTCATTGC	9	2.11	3.03	2.44	0.33
CGTATTGA	5	2.31	2.57	2.47	0.13
CTTATCGC	2	2.42	2.52	2.47	0.07
CGTATTGC	1	2.5	2.5	2.50	
TTCGTTAC	1	3.56	3.56	3.56	
TTCAGTAC	1	3.58	3.58	3.58	
TGCAGCGC	1	3.68	3.68	3.68	
TGCGTTGC	1	3.7	3.7	3.70	
TGCGTTAA	1	3.72	3.72	3.72	
TGCGTTAC	1	3.79	3.79	3.79	

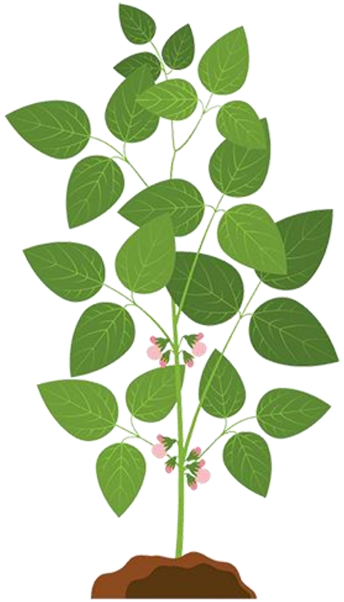
[§]The order of the markers for the allelic combination are Gm03_45031929, Gm05_8877264, Gm07_6397319, Gm11_530116, Gm16_27300116, Gm17_25859992, Gm18_28141888, and Gm19_40193564.

doi:10.1371/journal.pone.0107469.t003

S. Mamidi et al. *PLOS ONE*(2014)

Breeding for Quantitative Traits

How many plants to grow to find one with IDC tolerance?



IDC tolerant

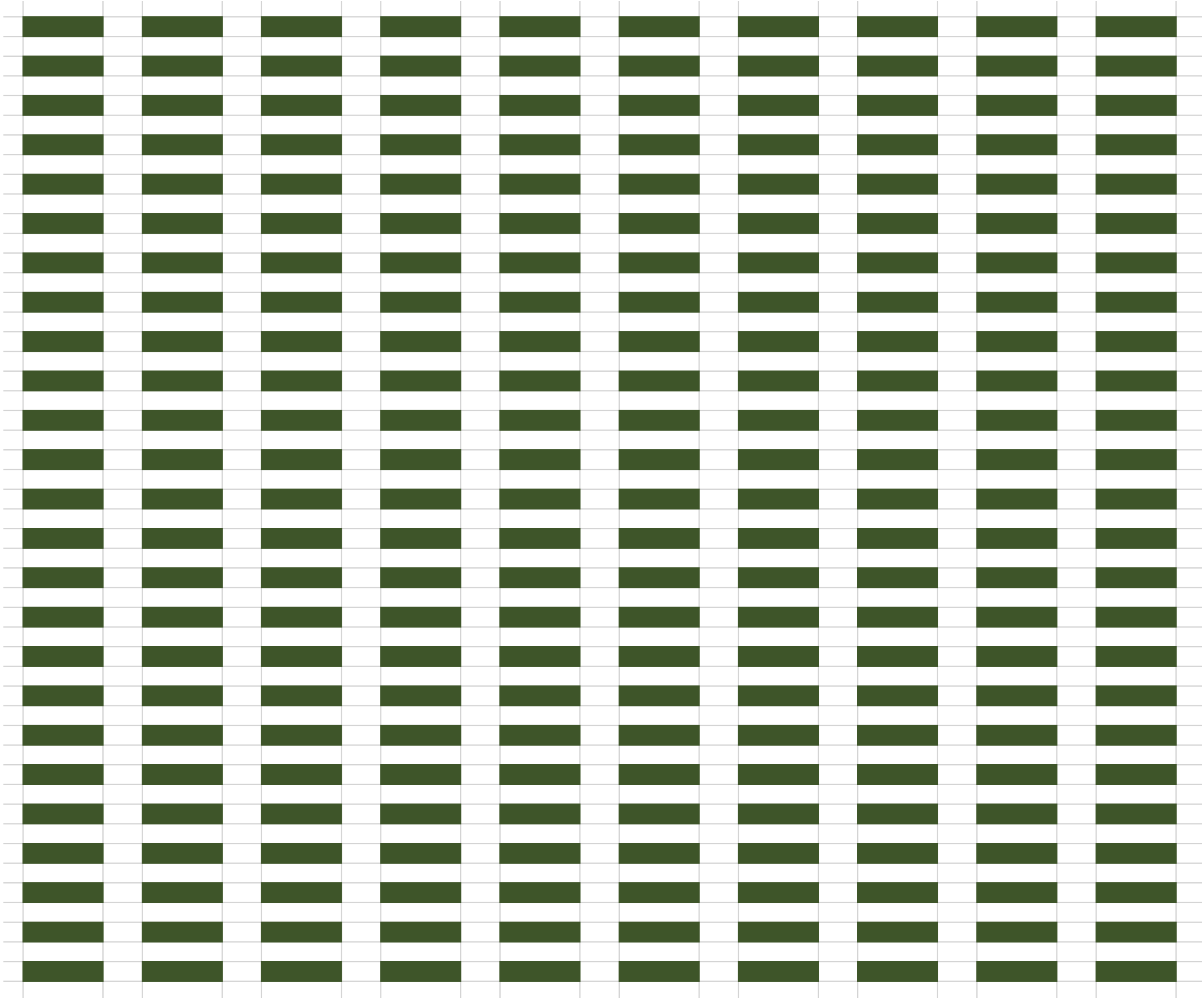
X

high yielding/ no IDC tolerance

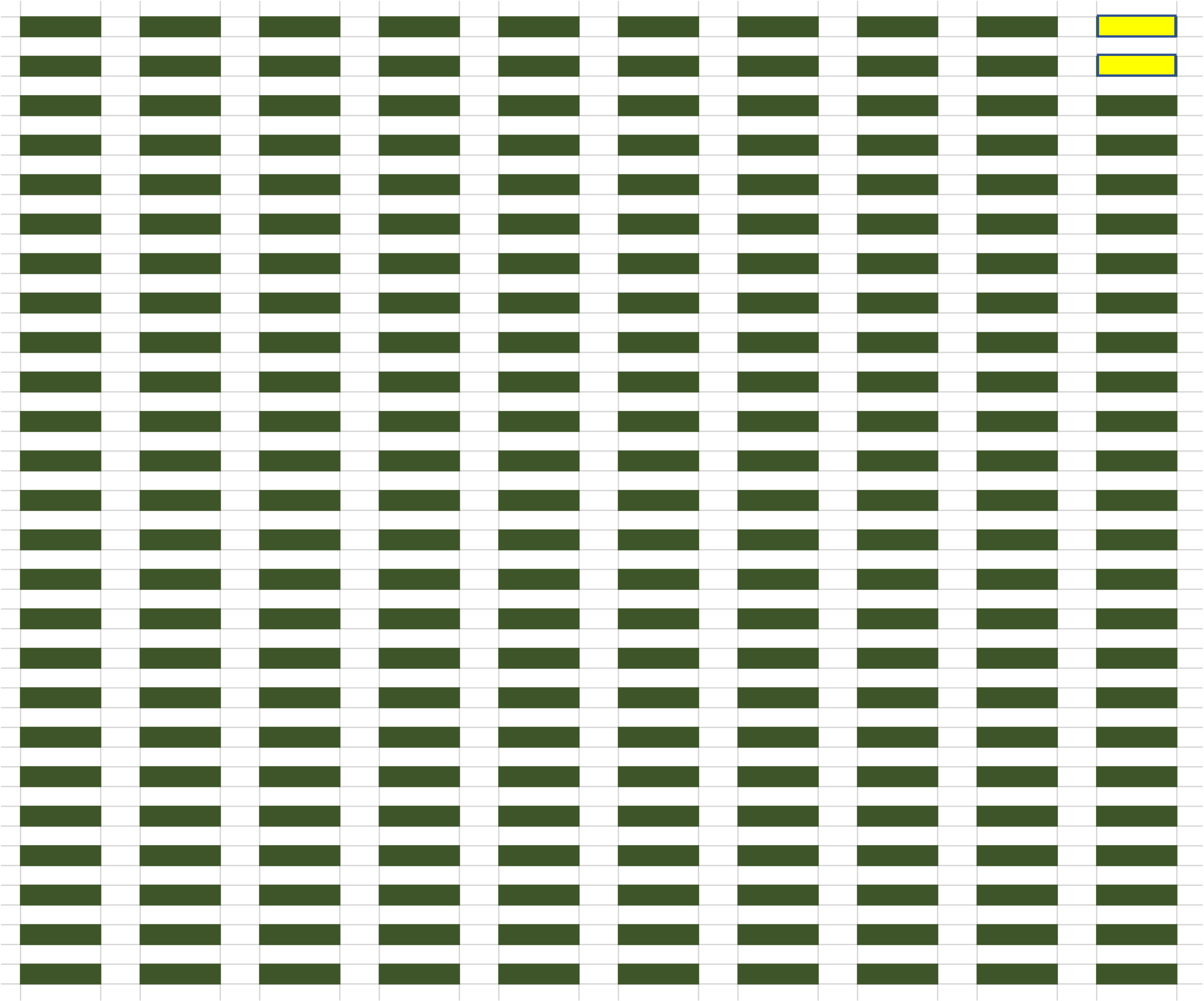
7 genes necessary for IDC score of 1

0.78% change of finding and individual!!!

Population with 250 individuals



Population with 250 individuals



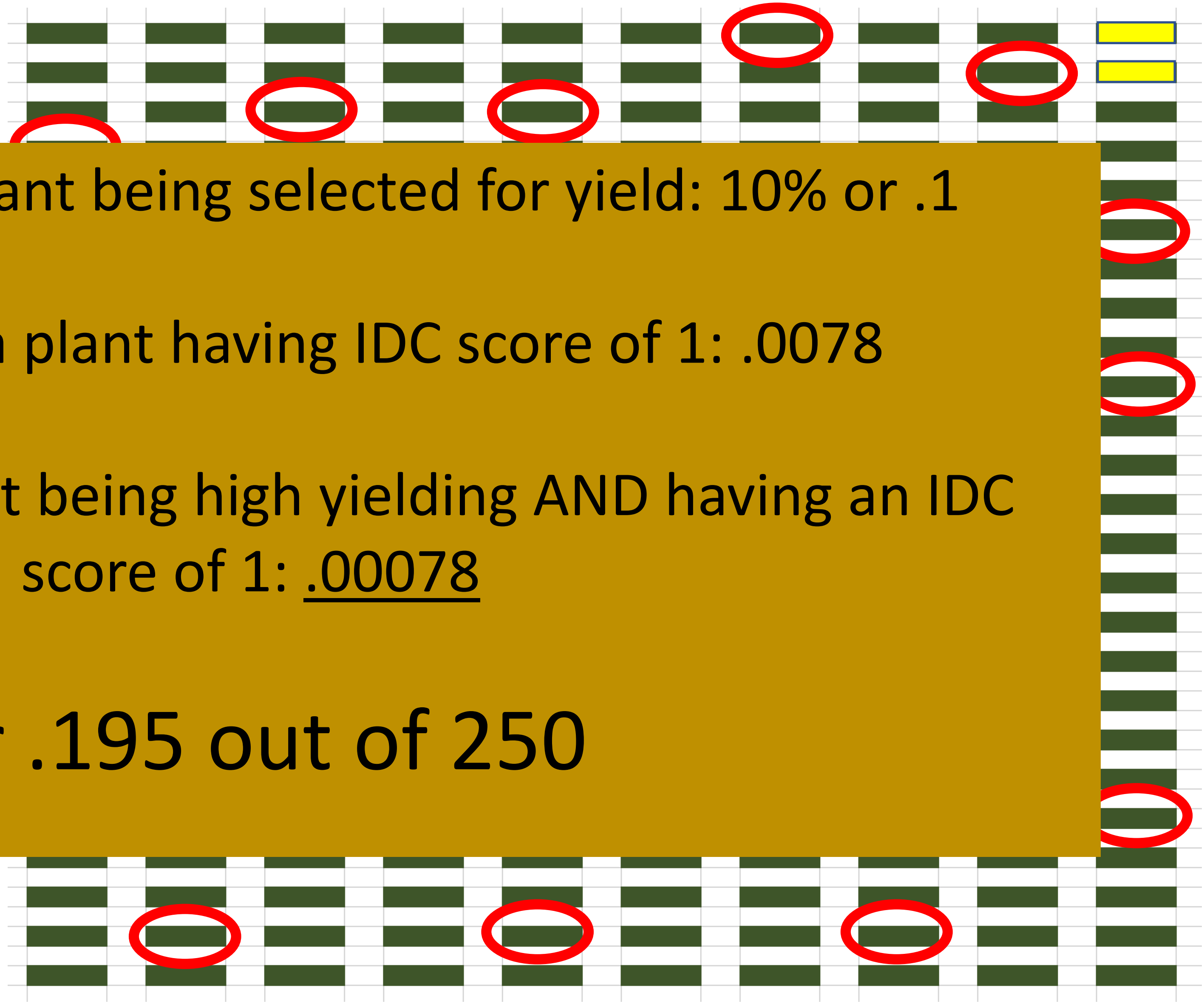
250 x .0078 = 1.95
or 2 plants!!

Probability of a plant being selected for yield: 10% or .1

Probability of a plant having IDC score of 1: .0078

Probability of a plant being high yielding AND having an IDC score of 1: <u>.00078</u>

Or .195 out of 250



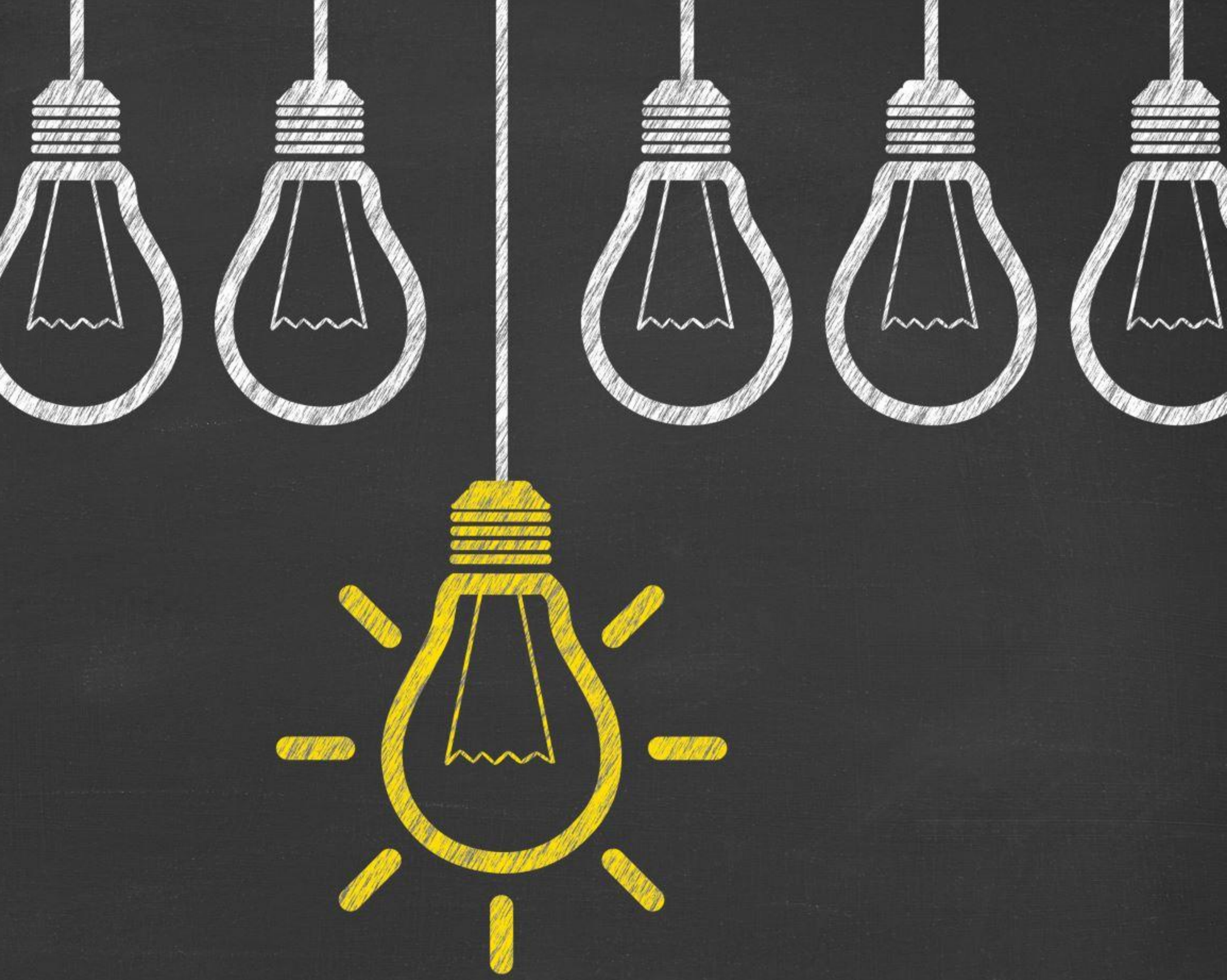
The dilemma….
yield comes first!
Select top 10% highest yielding lines

Priorities…. Breed for IDC!

Establish that IDC AND yield are important

Develop molecular marker tools to help find IDC tolerant varieties early

Choose parents that have some IDC tolerance already- improve your probabilities



Solution!

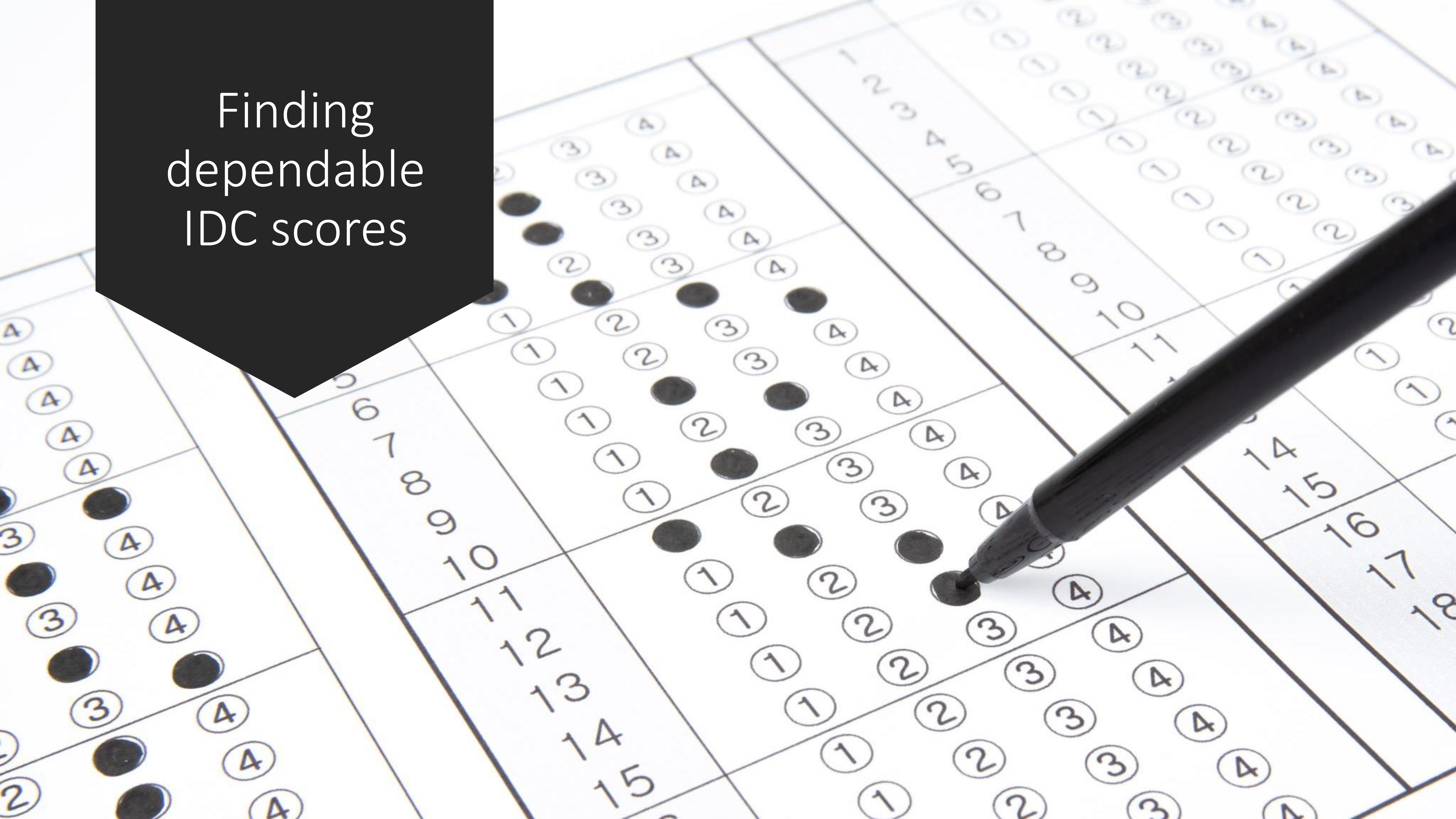
NDSU is here to help!

Involved in projects to:

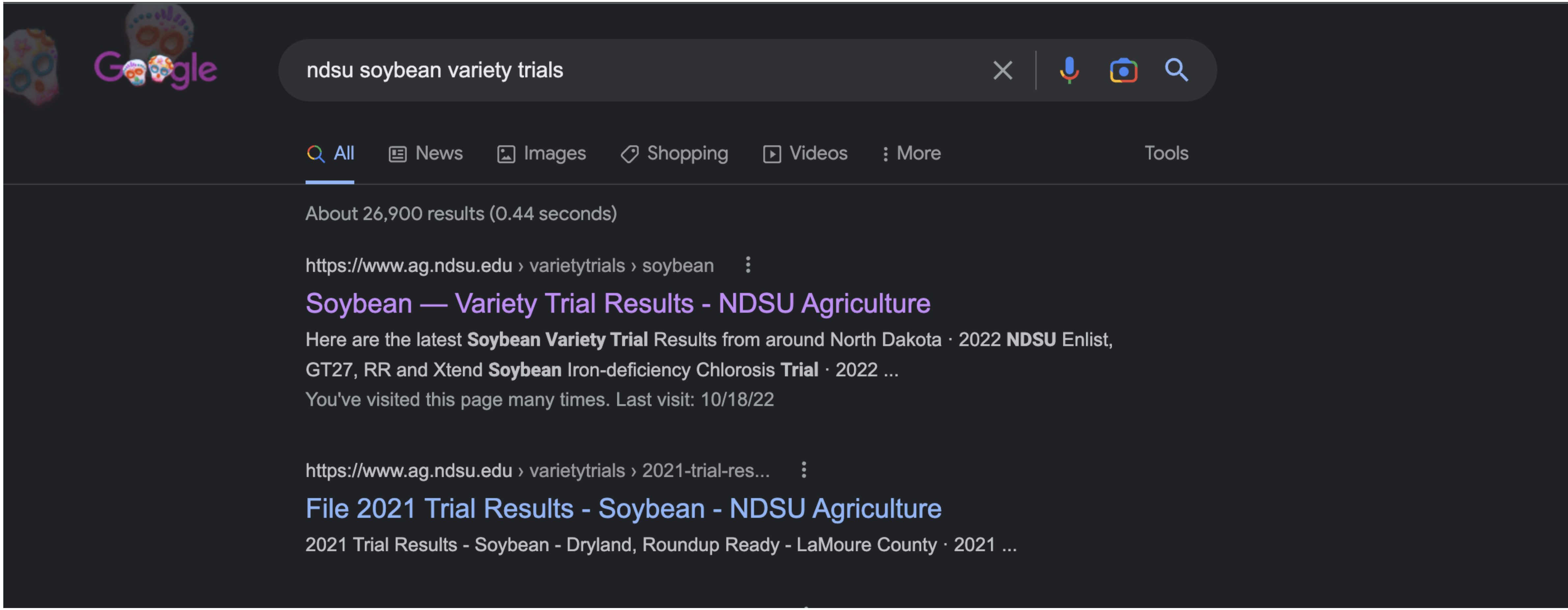
Develop reliable markers (hopefully reduce numbers)

Determine environmental stability of IDC tolerance

Finding dependable IDC scores



To find the reports:



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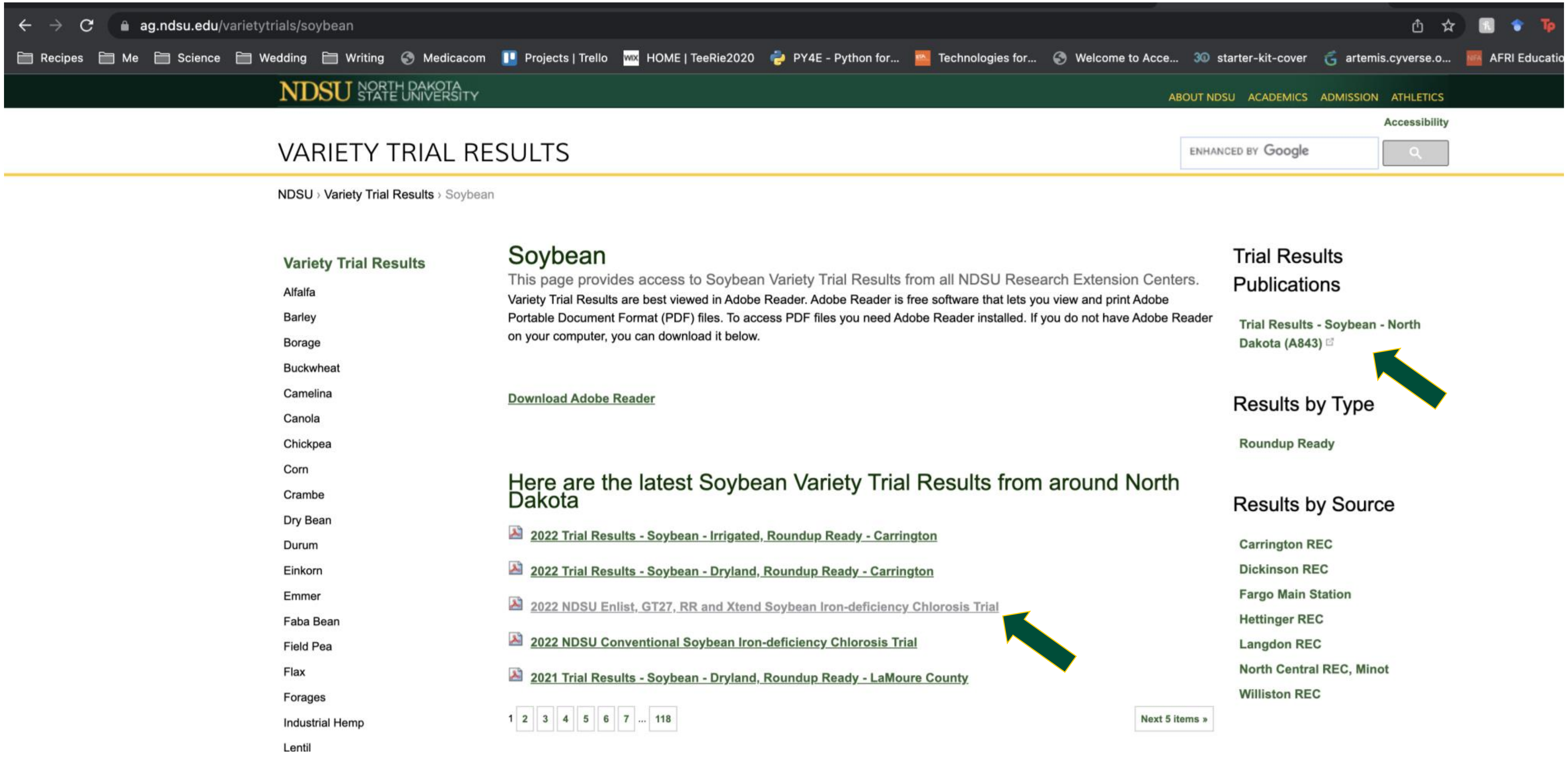

Download results as .pdf

Iron Deficiency Chlorosis Report

2022 NDSU Enlist, GT27, RR and Xtend Soybean Iron-deficiency Chlorosis Trial - Author, C. Miranda (Page 3 of 3).

Company	Variety	Trial Mean IDC[1]	Company	Variety	Trial Mean
Pioneer	P06A38E	2.8	Stine	05EB23	3.4
Pioneer	P06A85E	2.6	Stine	06EC[illegible]	3.4
Proseed	EL30-33	3.1	Stine	07EA36	3.8
Proseed	EL30-53	3.4	Stine	08EC32	3.0
Proseed	EL30-93N	3.9	Stine	11EC02	3.3
Proseed	EL31-13N	3.6	Stine	16EC32	3.4
Proseed	EL31-43N	3.5	Sunrise	SR 00630XF	3.3
Proseed	EL80-33	3.6	Syng NK	NK02-T4E3	3.1
Proseed	EL90-93N	3.6	Syng NK	NK03-V5E3	3.4
Proseed	XF30-42N	3.1	Syng NK	NK05-W3XF	3.4
Proseed	XF30-52N	3.0	Syng NK	NK06-D9E3	3.2
Proseed	XF30-62N	3.8	Syng NK	NK06-P2XF	3.1
Proseed	XF30-72N	3.4	Syng NK	NK08-M1XF	3.5
Proseed	XF30-82N	3.4	Syng NK	NK09-B5XF	3.6
Proseed	XF30-92N	3.8	Syng NK	NK09-H7E3	3.8
Proseed	XF31-12	3.3	Syng NK	NK10-W8XF	3.7
Proseed	XF31-32N	3.1	Syng NK	NK13-Y4XF	3.1
Proseed	XT90-50	3.3	Syng NK	SO4-Q7X	3.4
REA	R0112XF	3.6	Thunder	SB8104N	3.2
REA	R0422XF	3.1	Thunder	SB8903N	2.9
REA	R0632XF	3.4	Thunder	TE7207	3.0
REA	R0843XF	3.2	Thunder	TE7304N	3.6
REA	R1042XF	3.6	Thunder	TE7309N	3.4
REA	R1133XF	3.3	Thunder	TX8211N	3.1
REA	RX0721	3.0	Thunder	TX8304N	2.7
Stine	01EA63	3.6	Thunder	TX8305N	3.1
Stine	03EB02	3.4	Thunder	TX8307N	3.8
Stine	04EE06	3.2	Thunder	TX8309N	3.5
Stine	05EA23	3.6	Thunder	TX8312N	3.2
Mean		3.5	Mean		3.5
CV %		16.1	CV %		16.1
LSD 0.05		0.8	LSD 0.05		0.8
LSD 0.10		0.7	LSD 0.10		0.7

[1]IDC score was 1-5, with 1-green, 3-yellow, 5-dead tissue.

Results are posted yearly in August

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Breeding for SCN resistance

Goals

As a breeder, want complete genetic tolerance/resistance to IDC and SCN

However, genetic tolerance to SCN is more important because other management strategies are…. not great

Types of genetic resistance

SCN races: 16 races

PI 88788:

- Oldest source
- Resistant to 8 races: (1, 2, 4, 5 ,7 ,11, 15, 16)

Peking:

- Newer
- (2, 4, 9, 11, 12, 13, 14, 16)

Genetic source of resistance

PI 88788:

- *Rhg1-b*
- requires multiple copy numbers
- Slower mechanisms of resistance-death at J3/J4 stage

Peking:

- *Rhg1-a*
- *Rhg4*
- Two genes work together for fast death of the parasite at J2

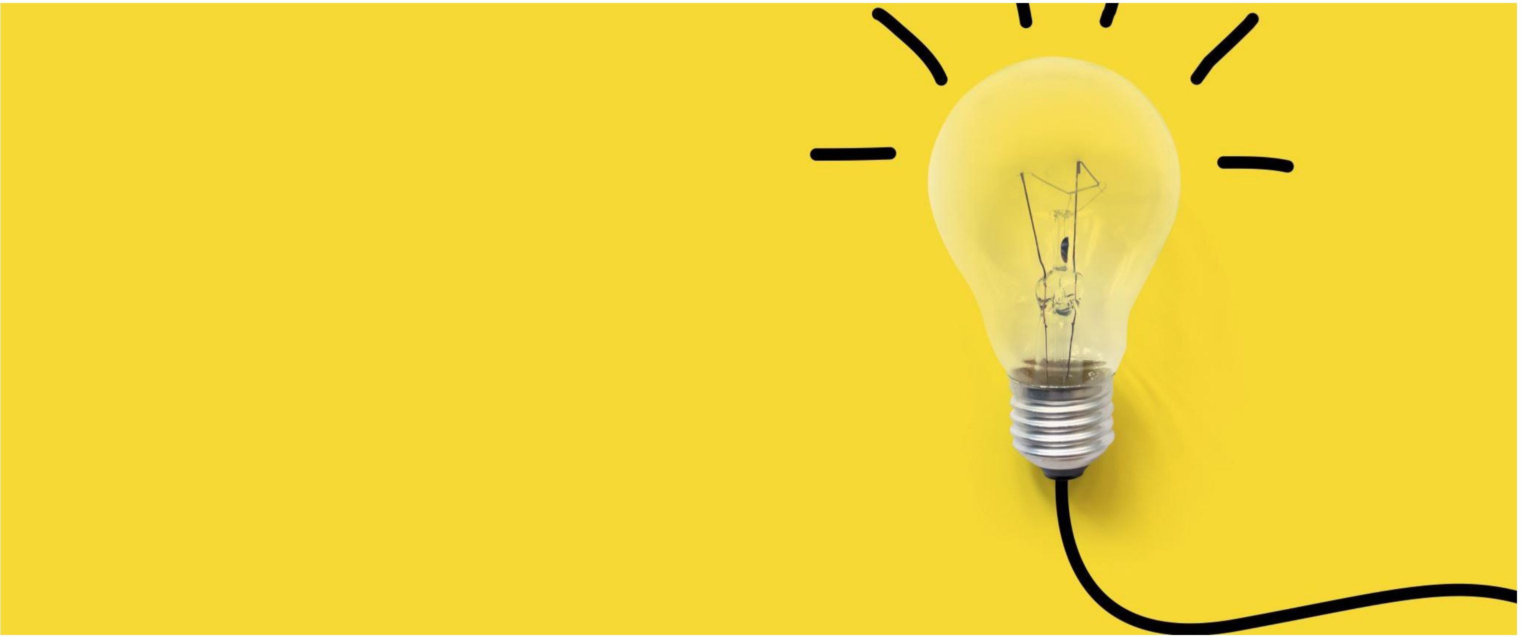
Chu, Shanshan, et al. *Frontiers in Genetics* 13 (2022).

Effort!   Tools!

How do you design a tool to detect number of genes??

New sources of resistance

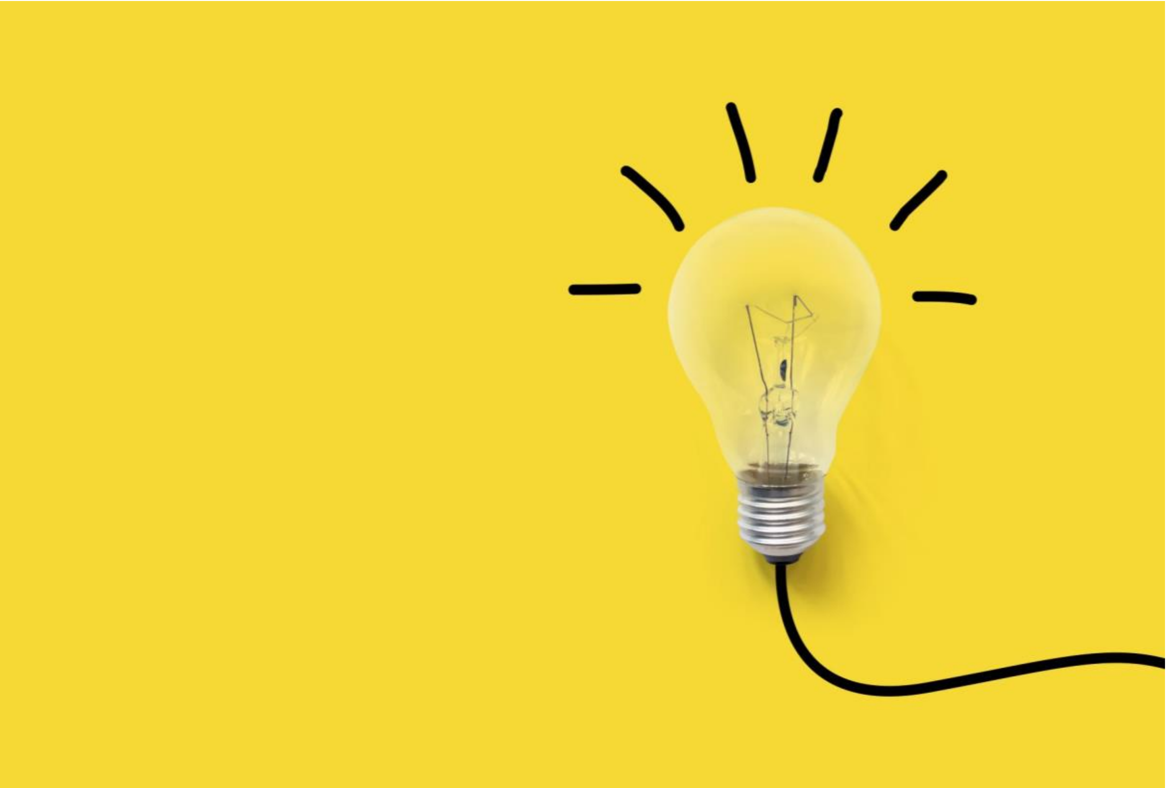
Breeding challenges



Solution

Hire a nematologist

Guiping Yan



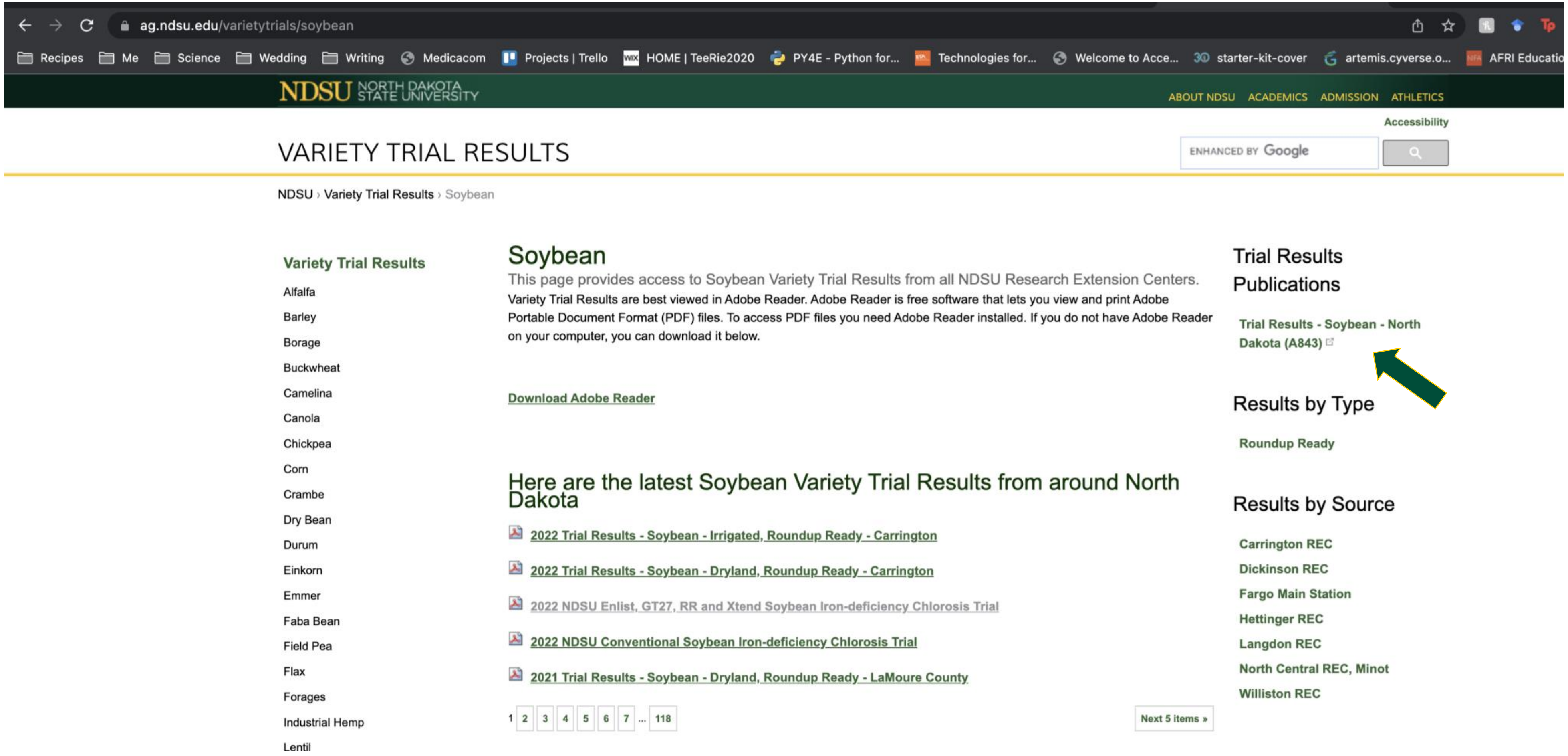
Solution

Talk to your extension agent

Sam Markell

Test your fields!!

To find the reports:



SCN Yield Test Reports:
GMO and Conv

Table 5. 2021 NDSU Enlist, GT27, RR and Xtend Soybean Cyst Nematode Yield Trial - Author, C. Miranda.

Company	Variety	Mat.	Maturity[1]	Seed Oil	Seed Protein	Seed Yield Colfax	Seed Yield Prosper	Seed Yield 2-site Avg.	Seed Yield 2-yr. Avg.
			(date)	(%)	(%)	(bu/a)			
Dahlman	1201E3N	0.1	9/10	19.5	37.5	24.5	[illegible]	34.0	--
Dahlman	1213E3N	1.3	9/1	19.7	37.0	41.7	[illegible]	47.2	--
Dahlman	7203XF	0.3	9/8	21.0	37.4	19.6	22.9	21.3	--
Dahlman	[illegible]10XF	1.0	9/28	20.3	36.6	45.8	58.0	51.9	--
Dahlman	[illegible]XF	1.3	9/28	20.4	36.2	42.4	53.1	47.8	--
Golden H.	GH0502XF	0.5	9/14	19.2	37.3	42.3	46.8	44.5	--
Golden H.	GH0593E3	0.5	9/16	20.5	36.0	37.5	31.1	34.3	--
Golden H.	GH0749X	0.7	9/24	19.8	37.4	48.4	48.8	48.6	51.4
Golden H.	GH0822XF	0.8	9/22	20.0	35.8	27.0	51.4	39.2	--
Golden H.	GH0842E3	0.8	9/22	19.2	37.3	33.9	51.2	42.6	--
Golden H.	GH1032XF	1.0	9/24	18.7	38.1	63.5	47.5	55.5	--
Golden H.	GH1362E3	1.3	9/30	19.2	37.6	64.9	56.1	60.5	--
Golden H.	GH1442XF	1.4	9/30	20.3	36.4	55.5	54.4	55.0	--
Golden H.	GH1472E3	1.4	9/28	19.7	38.1	49.0	54.0	51.5	--
REA	R0632XF	0.6	9/14	19.1	37.3	31.6	49.5	40.5	--
REA	R1042XF	1.0	9/28	19.6	37.6	38.5	38.7	38.6	--
REA	R1350XF	1.3	9/28	20.7	35.6	38.5	36.4	37.5	--
REA	RX0411	0.4	9/12	19.6	37.2	35.2	33.6	34.4	38.8
REA	RX0721	0.7	9/20	--	--	31.6	49.8	40.7	46.1
Syng NK	NK08-B7XF	0.8	9/22	20.0	35.4	35.1	48.4	41.7	--
Syng NK	NK10-W8XF	1.0	9/18	18.6	37.3	37.1	48.2	42.7	--
Syng NK	NK14-C7XF	1.4	10/2	19.7	37.3	33.0	40.3	36.7	--
Syng NK	S14-U9X	1.4	9/30	19.8	36.4	47.0	46.3	46.6	--
Mean		0.9	9/22	19.8	36.9	40.2	46.2	43.2	45.5
CV %		--	17.1	--	--	41.1	18.8	30.5	--
LSD 0.05		--	4.5	--	--	19.5	10.3	12.7	--
LSD 0.10		--	3.5	--	--	15.1	7.9	10.6	--

Colfax Planted: May 11. Harvested: Oct 15 . Previous crop: Corn
Prosper Planted: May 17. Harvested: Oct 5 . Previous crop: Wheat
[1]Maturity is date of 95% brown or tan pods

Table 6. 2021 NDSU Combined SCN-infested Soil Soybean non-GMO Variety Trial - Author, C. Miranda.

Company/ Brand	Variety	Mat. Group	Maturity[1]	Seed Oil	Seed Protein	Seed Yield Colfax	Seed Yield Prosper	Seed Yield 2-site Avg.	Seed Yield 2-yr. Avg.
			(date)	(%)		(bu/a)			
MS Tech.	XO 0311E	0.3	9/10	19.5	[illegible]	59.0	44.4	51.7	--
MS Tech.	XO 0521E	0.5	9/12	17.0	42.1	31.5	24.1	27.8	--
MS Tech.	XO 0731E	0.7	9/25	19.8	36.8	67.0	46.3	56.6	--
MS Tech.	XO 1041E	1.0	9/28	18.8	38.0	61.1	59.2	60.2	--
NDSU	ND Benson	0.4	9/11	19.0	39.4	58.9	42.8	50.9	49.0
NDSU	ND Dickey	0.7	9/15	17.7	41.1	36.6	20.0	28.3	37.3
Sevita	Skyline	1.0	9/31	19.2	38.6	49.6	43.4	46.5	46.4

Results are posted yearly in December online and in the A843 publication

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Takeaway

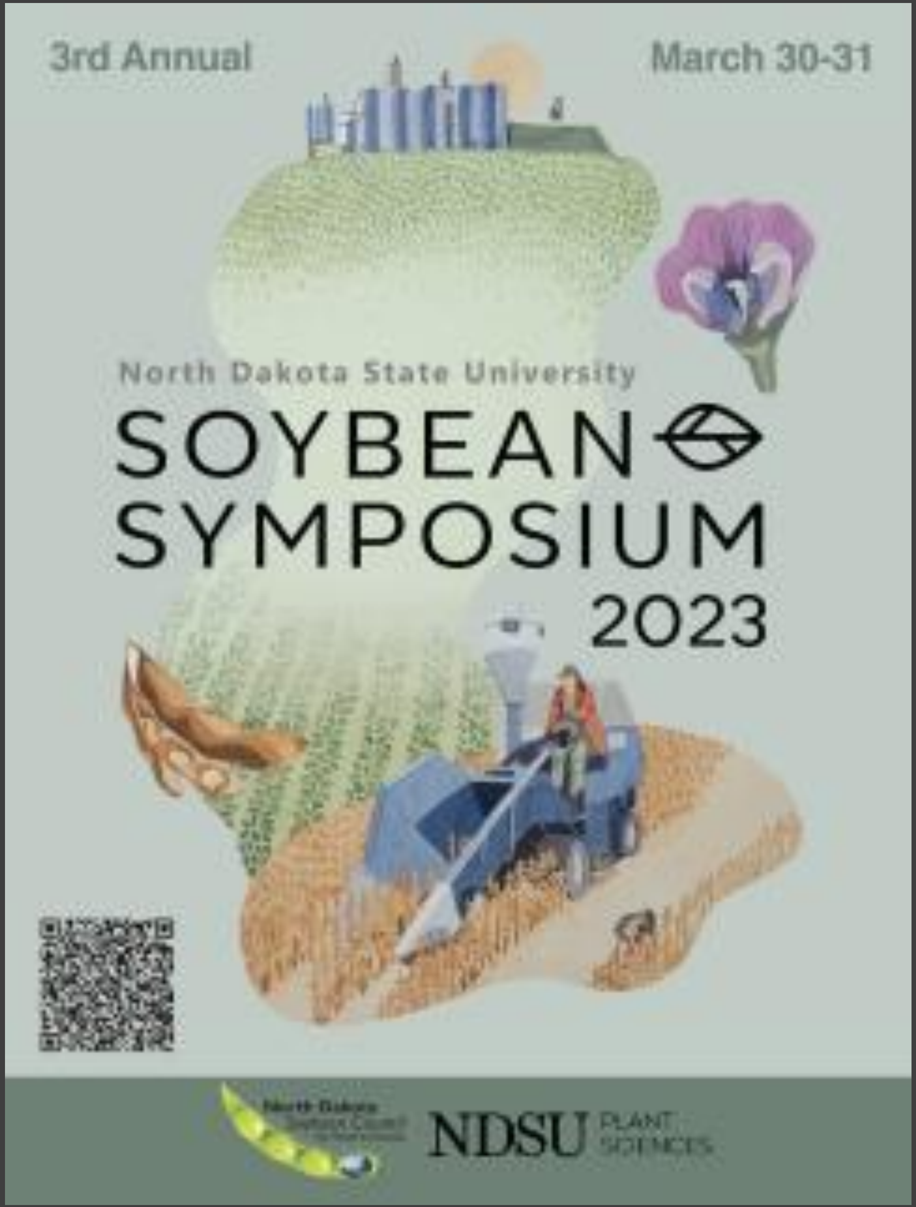
- Yes, breeding for resistance to only one stress is challenging
- And breeding for two ONLY SEEMS impossible
- But with priorities, tools, (and funding), and time, it is possible

NDSU Soybean Symposium

March 30-31st NDSU Alumni Center

Keynote: Ed Anderson, PhD
Executive Director of NCSRP

"The Soybean Checkoff's Leadership Role in Research for Advancing the Soybean Industry"



https://www.ndsu.edu/agriculture/academics/events/ndsu-soybean-symposium

NDSU NORTH DAKOTA STATE UNIVERSITY

Thank you!!

NDSU breeding team:

Gustavo Kreutz

Clara Mvuta

Forrest Hanson

Cole Williams

Ashley Cooper

NDSU soybean breeding support

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