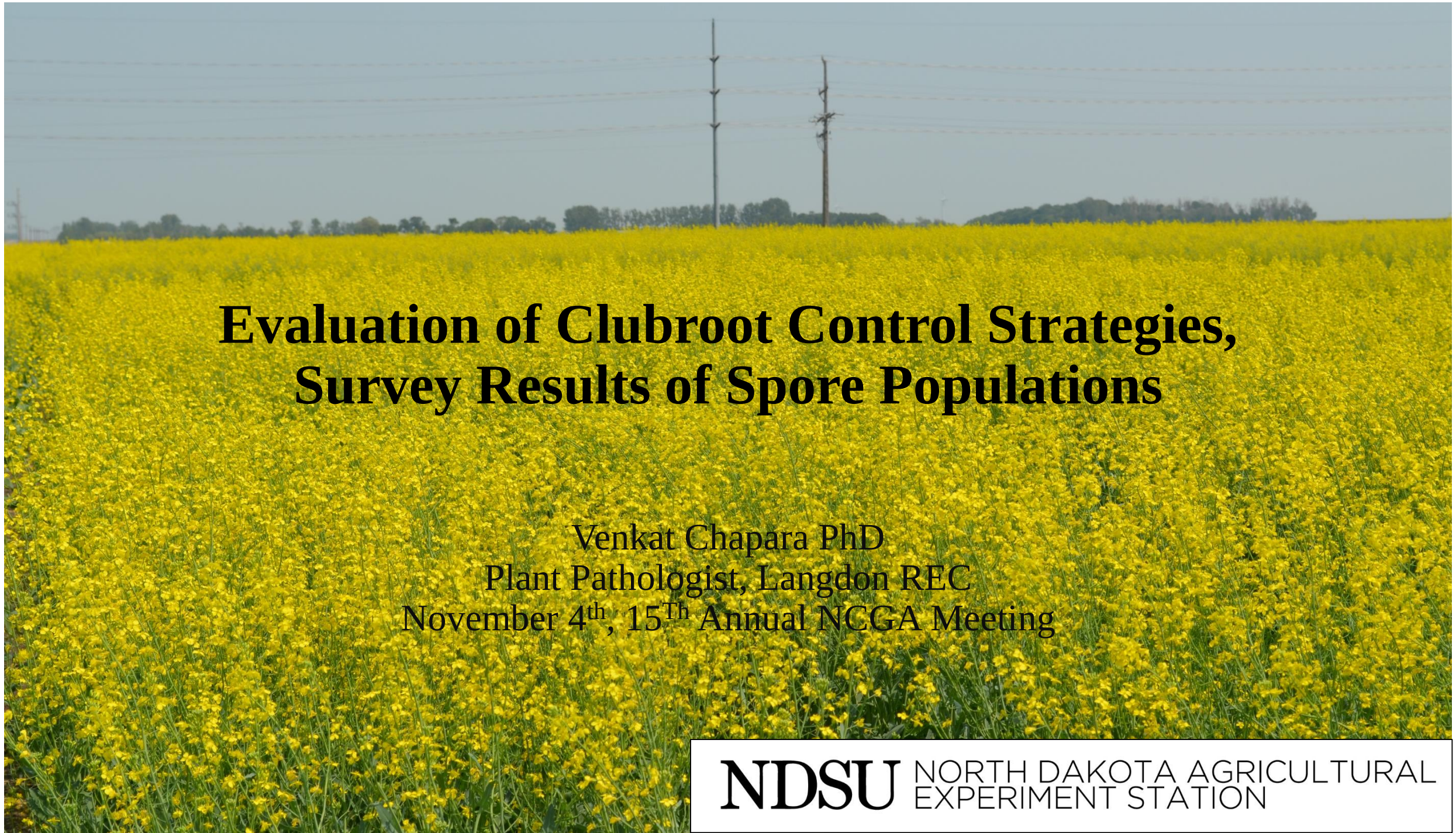


Evaluation of Clubroot Control Strategies, Survey Results of Spore Populations

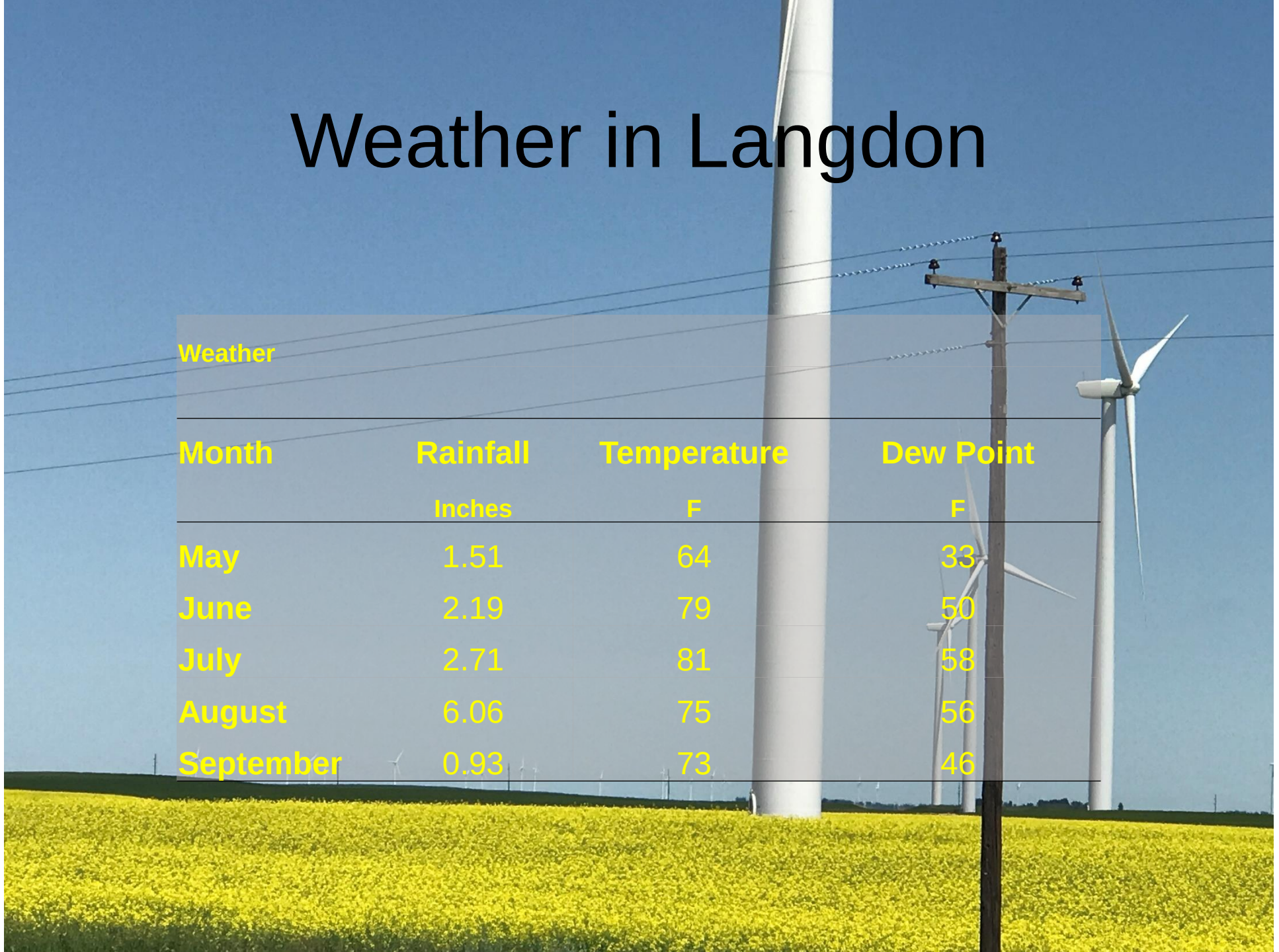
Venkat Chapara PhD
Plant Pathologist, Langdon REC
November 4th, 15Th Annual NCGA Meeting

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

Outline

- Annual Survey
- Prevalence of Clubroot in ND through Quantification studies-2020
- Ongoing Statewide Survey program-2021
- Clubroot Management Studies
- Pathotypes of *P. brassicae* in North Dakota
- A nuisance pathogen?
- Summary

Weather in Langdon

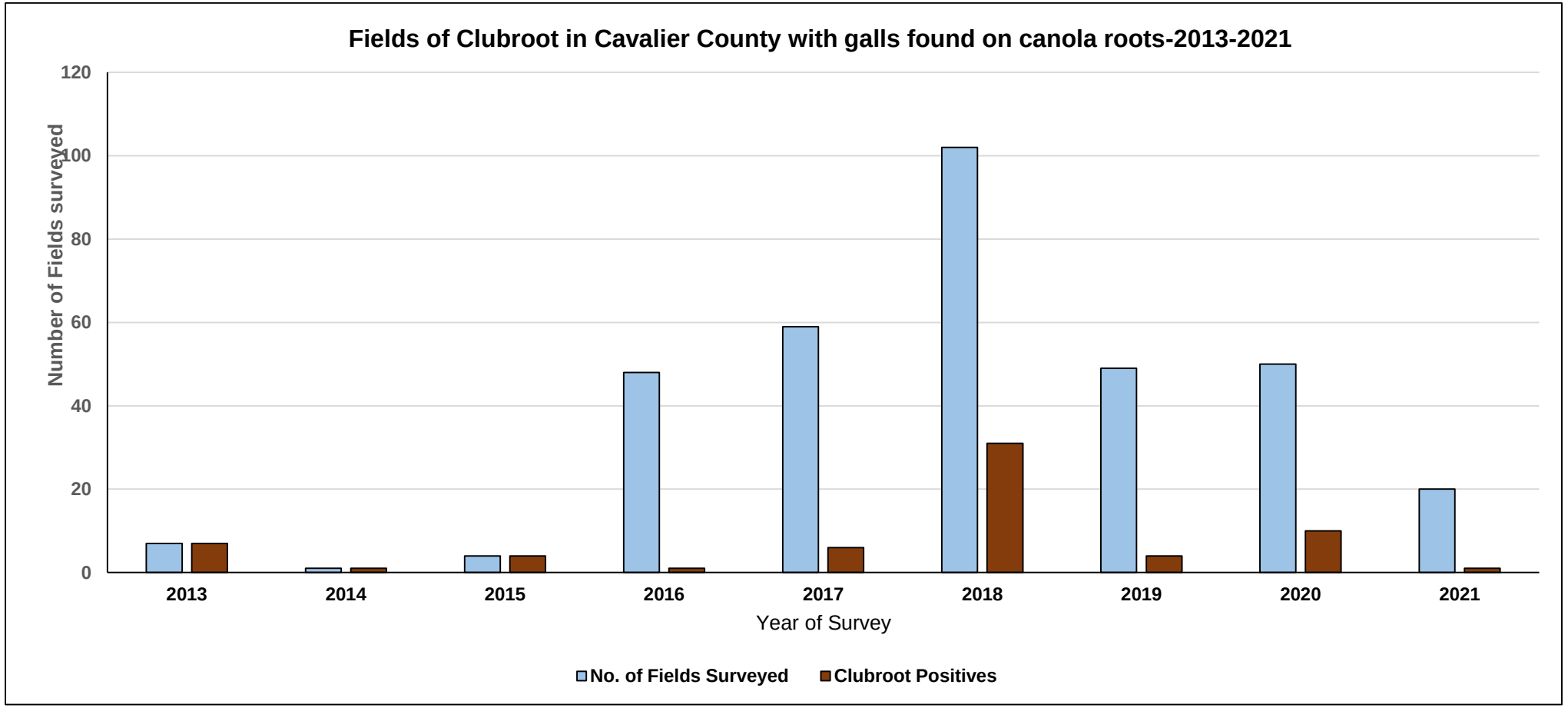


Weather

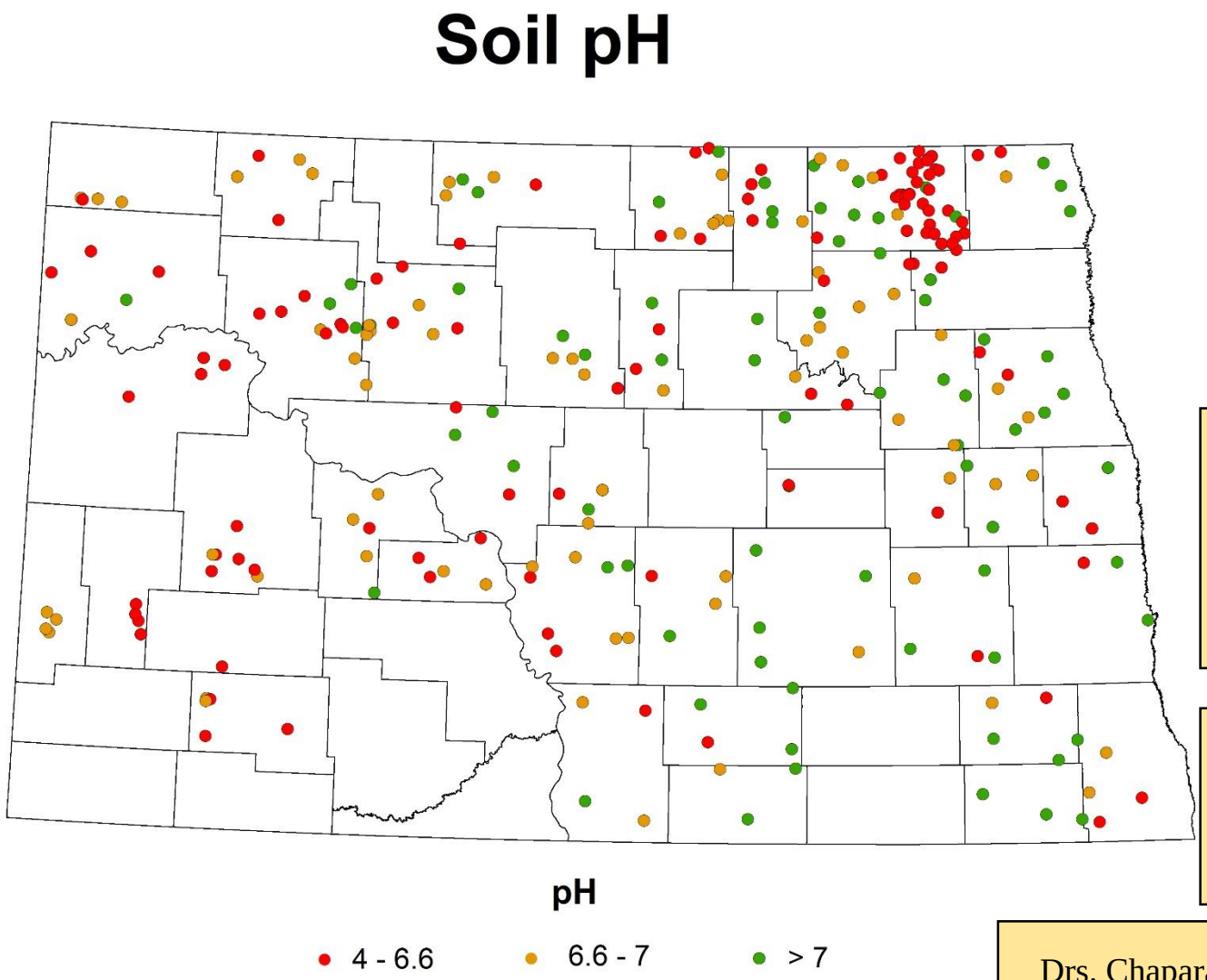
Month	Rainfall	Temperature	Dew Point
	Inches	F	F
May	1.51	64	33
June	2.19	79	50
July	2.71	81	58
August	6.06	75	56
September	0.93	73	46

Found very late

Annual Clubroot Survey data of Cavalier County



Soil pH-Map of North Dakota-2020



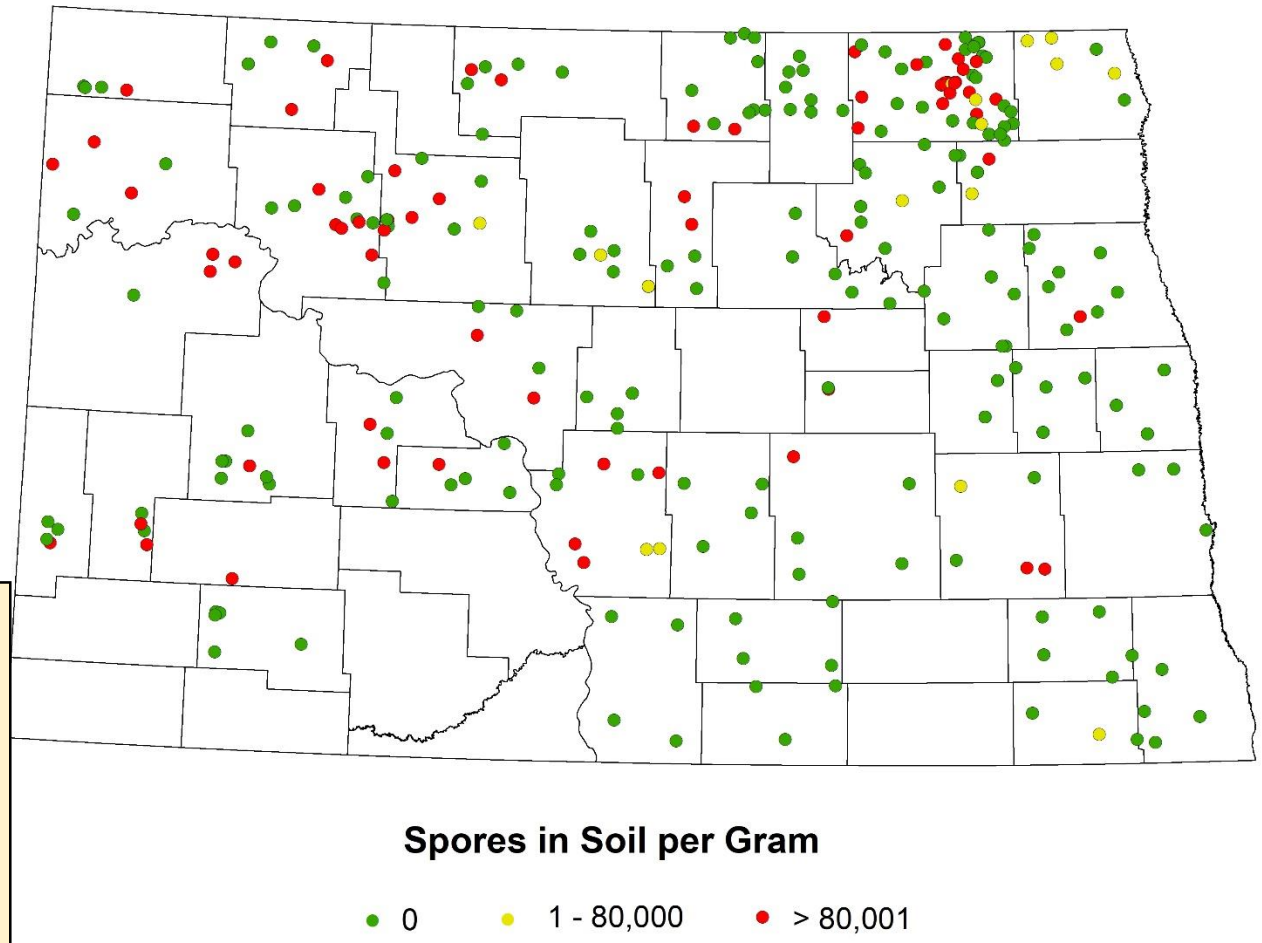
4 - 6.6 – Fields with Acidic pH
6.6 - 7.2 - Neutral pH
> 7.2- Basic pH

Note: Clubroot Pathogen *Plasmodiophora brassicae* prefers acidic soils can be found in Neutral pH-too.

Drs. Chapara, Liu, Prochaska, Kalil, Jingwei, Shi, Del Rio, Teboh, Chirumamilla, Knodel and Honggang

***Plasmodiophora brassicae* resting spores**
found in soil samples that were collected from various counties in 2020 survey

2020 Clubroot Survey in North Dakota



- **Take home message**

- 26 Counties out of 44 Counties scouted have resting spores of clubroot pathogen
- > 80,000 spores/g will start showing symptoms under field conditions if the soil has acidic pH and on planting susceptible canola variety
- Presence of resting spores doesn't mean disease

Measures to be followed on finding resting spores/g of soil in a field by molecular assays:

- Practice 4-year crop rotation
- Use clubroot resistant variety
- Practice no-till
- Sanitize tillage Equipment, Planters, Swathers, Combines etc.

Note:
Fields with visible galls symptoms on Canola roots were found only in Cavalier County out of the 44 Counties surveyed in the year 2020

Drs. Chapara, Liu, Prochaska, Kalil, Jingwei, Shi, Del Rio, Teboh, Chirumamilla, Knodel and Honggang

2021-Ongoing State wide Clubroot survey

- Travis Prochaska, NCREC : 10 Counties
- Audrey Kalil, WREC: 10 Counties
- Dante Marino (Grad Student from Del Rio's lab): 10 Counties
- My self did : 14 Counties
- BASF (Richard Johnson): 16 Samples
- St Paul, MN (Chris Mann, Frog town Farm, Saskatchewan Ministry of Agriculture): Samples are on the way

Results obtained so far of the soil samples-2021

Sample ID			N	W	County	Grower	Ph	spores
BASF-01	-	-	48.54406	-101.534227	Renville	Grant Guidinger	6.03	0
BASF-02		14 -	48.79904	-100.715108	Bottineau	Karson Schepp	6.81	0
BASF-03	-	-	48.30306	-100.324536	McHenry	Peter Haman	6.99	0
BASF-04		8 -	48.61358	-102.082792	Ward	Mugur Bunduc	5.47	0
BASF-05	-	-	47.96438	-101.805193	Ward	Steven Bryelow	6.32	0
BASF-06		2 -	48.44828	-103.728869	Williams	Ben Poeckes	5.2	0

County	# of fields with spores/total surveyed	Resting spore range
Cass	3/10	1200-1800
Barnes	1/20	2600
Ransom	0/20	0
Lamoure	1/20	300
Richland	7/20	300-8200
Sargent	14/20	300-33.5million
Dickey	13/20	600-11.7million
McIntosh	7/20	400-58K
Logan	7/20	400-600
Stutsman	13/20	1000-248K
Kidder	8/20	500-5931100
Emmons	3/20	600-1400
Burleigh	11/20	1100-75.9millions
Morton	10/20	500-12.4489millions
Grant	2/20	700-3300
Sioux	3/20	500-700

Samples collected by Mr. Dante from Dr. Del Rio's lab
Molecular testing done by Drs. Gongjun Shi and Liu

Clubroot Management Studies

- Bio-safe product evaluation on clubroot
- Non-Traditional Products study
- Lime with and without Non-traditional Products

Clubroot Trial Activities

Plot Size: 10 x 5 ft
Cultivar: L233P
Planting Date: June10th
Evaluated in First week of August

Clubroot Trial Activities

Evaluation of Bio-safe Products to Manage Clubroot

	Clubroot	
Treatments	**Incidence (%)**	**DSI (0-100)**
Non-treated Check	91	89
SANIDATE+OXIPHOS+TERRAGROW	10	8
GUARDA+OHIPHOS+TERRAGROW	27	23
RANMAN	22	20
EXTRACT	37	35
Mean	**37**	**35**
CV%	**75**	**81**
LSD	**43**	**44**
p-Value (0.05)	**0.013***	**0.014***

Non-traditional Treatments to Manage Clubroot

	Clubroot		
Treatments	**Incidence (%)**	**Disease severity Index (0-100)**	**Yield (bu/a)**
Ranman 20 fl. oz/a	87	82	23
OR-079-B 4 pts/a	95	95	12
OR 009-A 4 pts/a	86	84	20
OR-369-A 4 pts/a	92	88	17
Untreated	92	90	12
OR-079-B 4 pts/a+OR-329-H 2.8 fl. oz/a	94	89	16
Mean	**91**	**87**	**16**
CV (%)	**12**	**17**	**47**
LSD	**NS**	**NS**	**NS**
p- Value (0.05)	**NS**	**NS**	**NS**

Canola Cultivar: L233P

Evaluation of Non-Traditional Products with and without lime - Results

cv. L233P

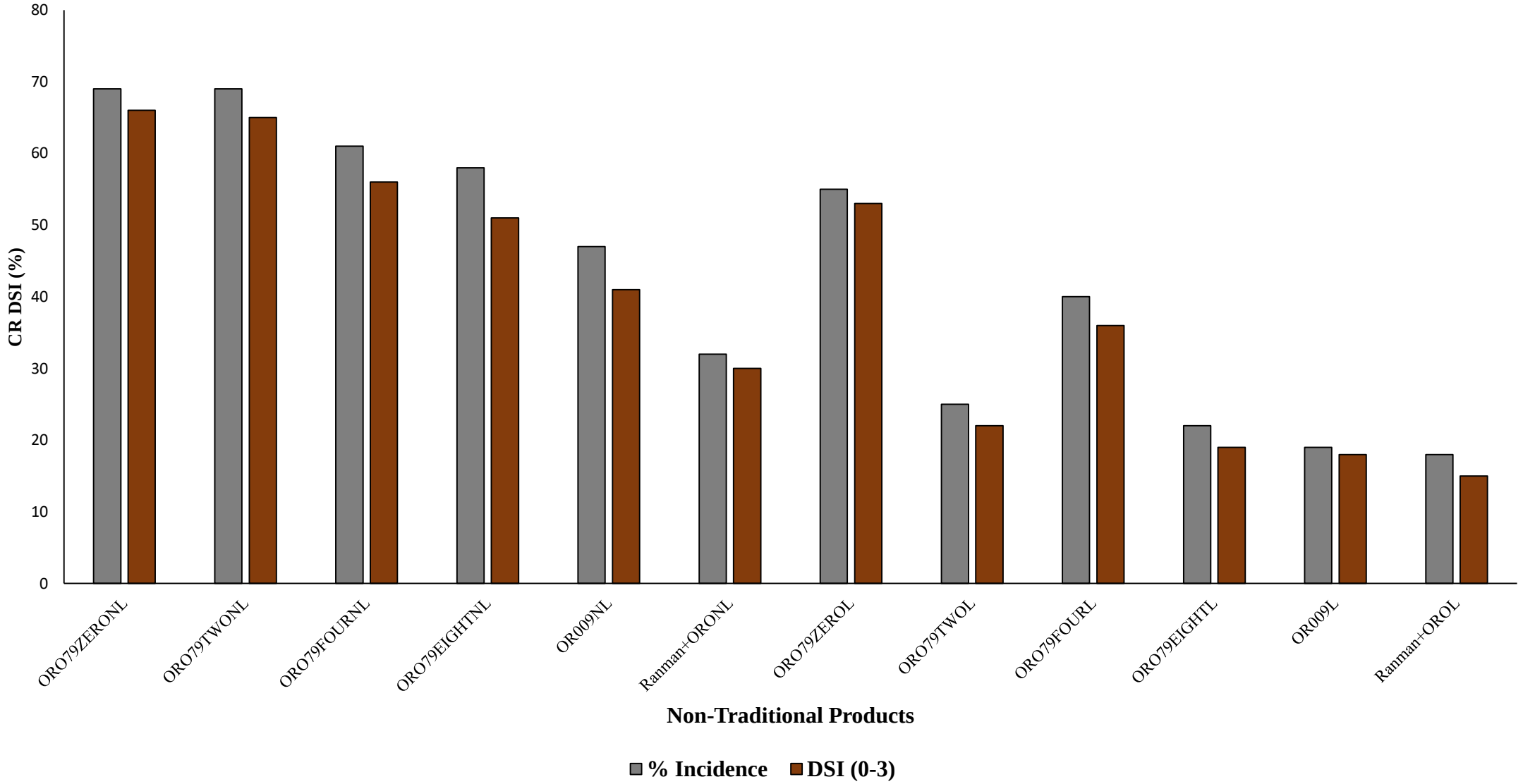
Beet lime@ 10t/a

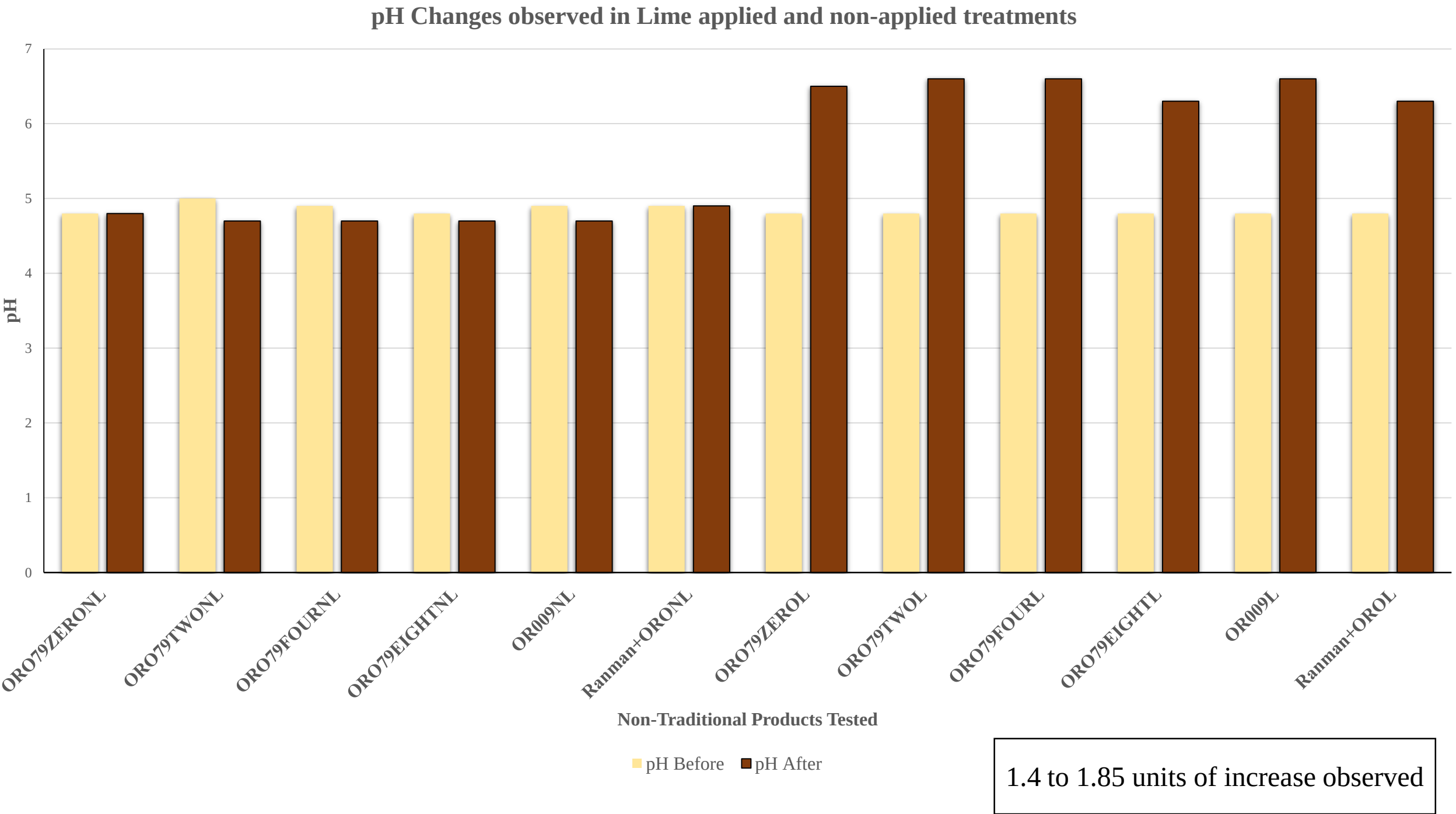
	Clubroot Disease Index P-value
Bloc	0.0006
Main Plot (Lime vs without Lime)	0.0007
Main Plot*Bloc	0.038
Sub Plots	0.06
Main Plot*Sub Plot	NS

Treatments	Rate	CR DI
Ranman+ORO	20 fl oz+2 pt/A	22.5
ORO Zero	CHK	60
ORO79 TWO	2 pt/A	44
ORO79 FOUR	4 pt/A	46
ORO79 EIGHT	8 pt/A	35
ORO09	4 pt/A	30
Mean		40
CV%		62
LSD(0.05)		14

NDSU NORTH DAKOTA STATE UNIVERSITY

Evaluation of non-traditional products with and without Lime on Clubroot of Canola





1.4 to 1.85 units of increase observed

Wild Mustard

Pathotypes of *P. brassica* in North Dakota

Virginia Peppergrass or Field Pennycress?

Clubroot on Canola- Pathotype designations of *Plasmodiphora brassicae* from North Dakota.

Common Clubroot Pathotypes: 2,3,5,6 and 8 (Williams et al. 1966) - 4 differentials can separate 16 pathotypes (PA is Variant of P3)

Some et al. 1996: P1, P2, P3,P4 and P5 (3 differentials, 5 pathotypes)

Over 35 Pathotypes were Identified in Canada so far as per Canadian Clubroot Differentials {CCD} set; Uses 13 brassica hosts.

Pathotypes are designated as:

3A,2B,5C,3D,8E,2F,5G,3H,5I,8J,5K,5L,6M,8N,3O,8P and 5X

- Red font pathotypes are variants that resulted in resistance breakdown in canola CR Cultivars

Strelkov et al. 2020

European Clubroot Differential (ECD) – 15 Differentials can differentiate 35 pathotypes (16/15/15)

NDSU NORTH DAKOTA STATE UNIVERSITY

Sample	*Plasmodiophora brassicae* Pathotype Designation-North Dakota		
	Some et al. (1996)	Williams (1966)	Strelkov et al. (2018)
FFCR	P3	8	8
MMCR	P3	2	2
PBCR-2	P2	8	8
RBCR-4	P3	8	8
RBCR-5	P3	8	8
YCR-16	P3	8	8
CBN	P3	8	8D
MRCR	P3	3	3B
YCR-1	P2	3	3D (Mutant)
YCR-3	P3	8	8A
YCR-6	P3	8	8A
YCR-7	P2	3	3H
YCR-10	P3	3	3E
YCR-12	P3	8	8A
YCR-15	P3	8	8A

NDSU

Strelkov S., V. Manoli and V. Chapara 2021

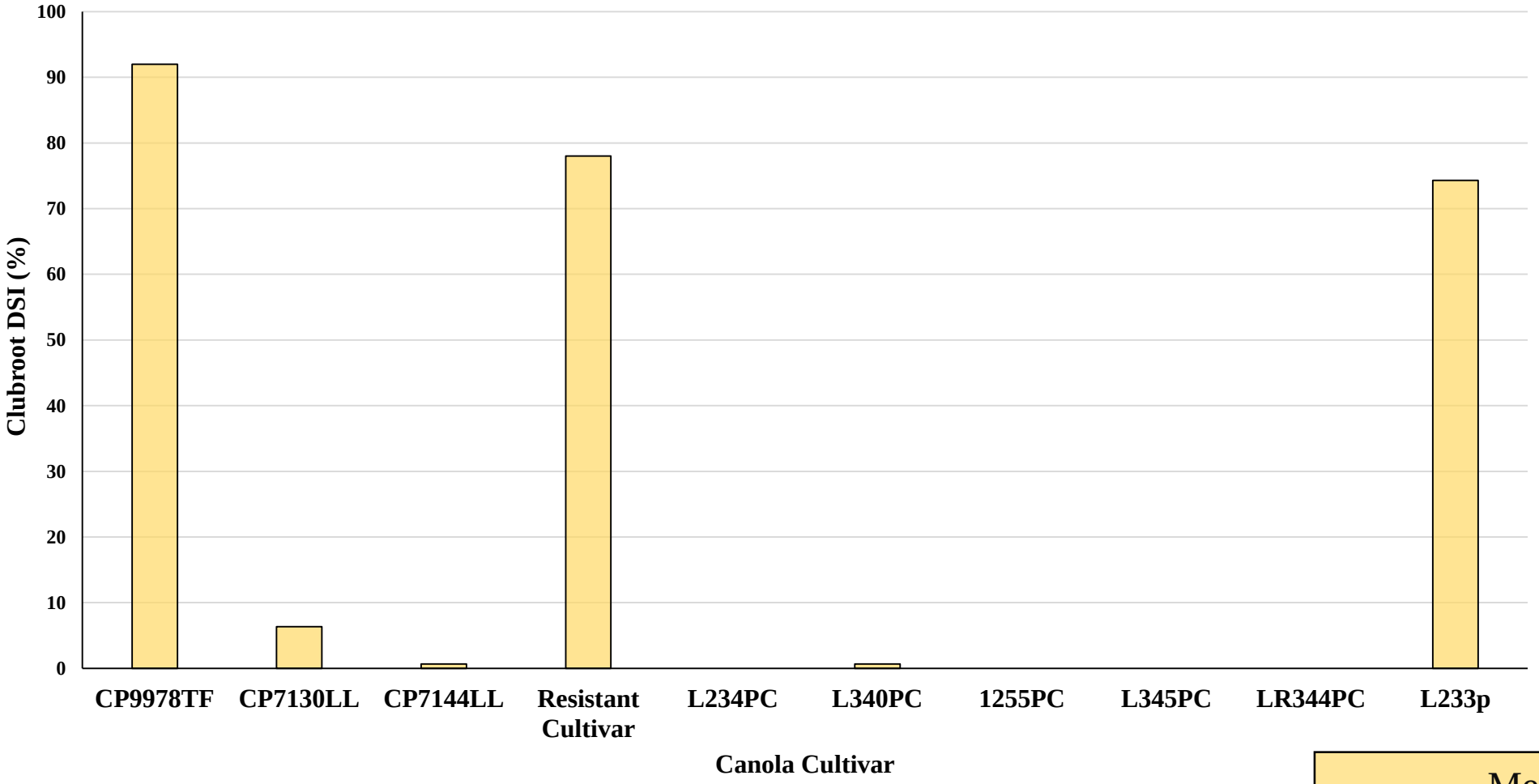
Pathotypes of ND

- Pathotypes 3E & 8H have only been reported from ND
- We found the first pathotype able to overcome first generation CR resistance
- Pathotype 3D (sample YCR-1); this is the 2nd most common resistance breaking pathotype on the Canadian Prairies
- Pathotype 2C has only been found in MB and ND

Cultivar screening to the mutant pathotype

Cultivar screening to the mutant pathotype

Canola cultivars evaluated in soils detected with mutant pathotype of *P. brassicae*

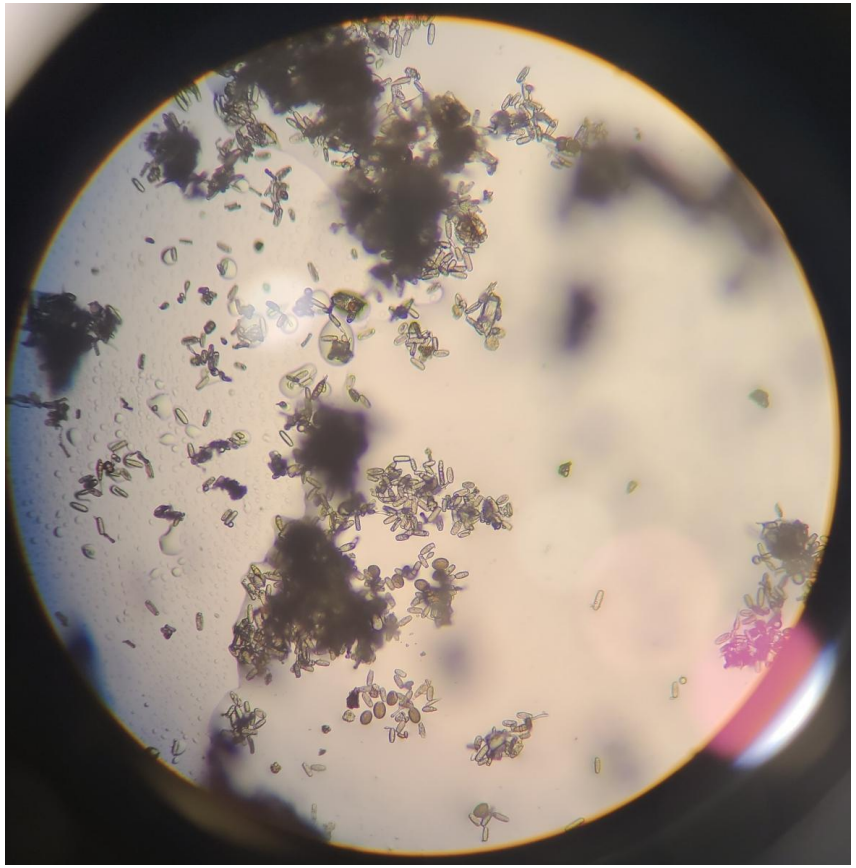


Mean: 25
LSD:27
P-Value (0.05): 0.0001

A nuisance pathogen?


ronmental,Inc.

Spores of the pathogen that cause Powdery mildew were found



Summary

- Visual surveys indicate 5% of fields surveyed has Clubroot on Canola in Cavalier County
- Molecular studies of soil samples indicate 59% of the counties surveyed has clubroot resting spores in ND
- Non-traditional products had an effect on Clubroot, however more testing has to be done
- Pathotyping studies found one mutant pathotypes of P. brassicae in Cavalier County (Courtesy: University of Alberta, Edmonton, Canada)
- Clubroot Resistant Varieties are still holding good against the pathotypes present in ND soils except one

Literature available on clubroot from NDSU

Chapara V, et al., J Agron Agri Sci 2019, 2: 008

HSOA Journal of Agronomy and Agricultural Science

Short Communication

Prevalence of Clubroot on Canola in North Dakota

Chapara V[1]*, Kalwar N[2], Lubenow L[2] and Chirumamilla A[2]

[1]Langdon Research Extension Center, North Dakota State University, Langdon, USA

[2]NDSU Extension Service, Langdon, ND-58249, USA

Abstract

Clubroot on canola was regular and more prevalent than expected in Cavalier County in the current survey. Prevalence of clubroot on canola has been increasing at rapid pace in North Dakota and has been confirmed in 33 fields in Cavalier County in 2016, which is five times more than it was in 2017. Contrastingly, no clubroot positive fields were found in any other canola growing counties of North Dakota that were surveyed. Continuous survey in coming years is required to prevent the spread and to design management plan of clubroot along with extensive outreach activities throughout North Dakota. Extensive education of growers in identifying clubroot disease, the biology of the pathogen, its prevalence and prevention is needed.

Keywords: Canola; Clubroot; *Plasmodiophora brassicae*

Clubroot of canola caused by Plasmodiophora brassicae (Woronin) is the new emerging disease in North Dakota since its identification on canola in 2013 (Chitteni et al. 2014). Clubroot is a soil borne disease that causes swellings, or galls on the plantroots of Brassicae family (Dixon 2009). These galls cause stefans premature ripening of canola plants and yield loss in the canola (Strelkov et al. 2005). Examination of roots for galls by digging up from the affected areas is the quick identification of clubroot incidence (Changara and Wright 2012). Clubroot disease incidence and development is favored by acidic soils (Tewari et al. 2005). However, later research proved that clubroot on canola is not only limited to acidic soils but can also occur in alkaline soils (Strelkov et al. 2007). The highest degree of clubroot disease infestation was observed at pH 6.6 (Palm 1963). P. brassicaeis soil-borne obligate parasite, thrives in the soil as resting spores that can remain viable in the soil up to 17.3 years indicating crop rotation of 3-4 years may not be a viable option and can spread from field to field on both agricultural and non-agricultural equipment (Wallenhammar 1996). Three-year survey was conducted by a survey group consisting one plant pathologist, two extension specialists of Langdon Research Experiment Station, Langdon, North Dakota and one NDSU Extension personnel of Cavalier County, North Dakota. Current objective of determination of clubroot spread and prevalence was done by visual inspection of canola plant roots for galls at two phases in the growing season; once at flowering (10 -100%) stage and at swathing of canola in seven northeastern counties (Pembina, Walsh, Nelson, Ramsey, Towner, Rolette and Cavalier) of North Dakota. The survey was done from the main entrance of the field, where the survey group walked along in a "W" pattern by stopping at 10 spots and uprooting 10 consecutive stems from the ground at each spot. Excess soil was shacked off. Roots then were visually examined for presence of galls. The three-year data prior to 2016 was obtained from North Dakota State University, industry and commodity group surveys done in Cavalier County North Dakota (Figure 2). Selection of counties to survey was donebased on canola acreage planted in that particular year and on assumptions of P brassicae resting spore dissemianted in all directions through equipment, soil, and water to neighboring counties of Cavalier. In each county, one field in every 5,000 acres was scouted. Soil samples were collected from the clubroot positive and likely positive fields with an intent to know the pH of the infected soil at which clubroot infections were found. In all, a minimum of 5-10 fields per county were targeted for scouting. The survey results indicatedthat clubroot on canola was more prevalent in Cavalier Countythan expected in low pH soils that ranged from 4.5 to 6.4 (Data not shown).Likewise, the current survey results indicated that the prevalence of clubroot on canola has been increasing at rapid pacein North Dakota and has been confirmed in 33 fields in 2018, which is five times more than it was in 2017 (Figure 1), apart from Cavalier County there were no clubroot findings in any other counties surveyed (Figure 2). Disease surveys has been very crucial worldwide in managing a newly emerging disease like clubroot. Research reports of canola survey in central Sweden indicated that 78% of 190 fields surveyed were infested with clubroot (Wallenhammar 1996). Survey reports of clubroot in Alberta andManitoba provinces of Canada confirmed over 3000 and 600canola fields respectively were clubroot positives (Strelkov, 2018 Personnel communication at Clubroot International workshop). Spread of clubroot can be reducedby thorough sanitation and throughadopting integrated disease management consistingdisease resistant cultivars, longer crop rotations, and soil reclamation (Donald and Porter 2009). Extensive crop survey, determination of soil pH of canola fields with clubroot was foundto be an important arsenal in educating growers about the prevalence of clubroot in North Dakota on Canola. The prevalence data will be more fruitful when integrated with other available clubroot management practices. Survey and prevalence data can be used inoutreach activities to educate producers in identifying the disease, inform of potential risks and to encourage clubroot monitoring and adoption of sanitation practices. Removal of potentially contaminated soil from field equipment is an ideal one if practiced (Strelkov et al. 2011). Likewise, length of crop rotation with canola can be determined with the knowledge of detection of clubroot in a field.

*Corresponding author: Venkataramana Chapara, Langdon Research Extension Center, North Dakota State University, ND-58249, Langdon, USA, Tel: +91 7012562580; Fax: +91 7012562580; E-mail: venkata.chapara@ndsu.edu

Citation: Chapara V, Kalwar N, Lubenow L, Chirumamilla A (2019) Prevalence of Clubroot on Canola in North Dakota. J Agron Agri Sci 2: 008.

Received: February 11, 2019; Accepted: February 14, 2019; Published: March 01, 2019

NDSU North Dakota Agricultural Experiment Station

Soil Sampling to Quantify Clubroot Spores From Soil in North Dakota

Note: Please complete this form in its entirety to identify the soil sample location. The information will be used to compile a distribution map of clubroot infestations in North Dakota.

County: _____ Grower's name: _____ Phone: _____
(will remain confidential)

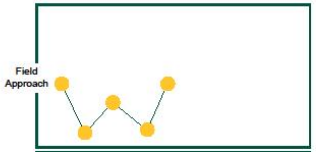
Field Identity							
Field ID	Latitude N	Longitude W (-)	OR	Township	Range	Section	¼

Latitude and longitude in decimal degrees is preferred.

Example: ***N: 48.659444 W: 98.24444 (GPS coordinates)*** - GPS coordinates can be obtained through "preferences" or other "setup" functions within the systems software.

Soil Sampling Survey Procedure

1. Walk in a "W" pattern in the field starting from the main entrance of the field (approach), low spots or flooded areas, low pH spots and areas of diseased patches as shown in the figure below.



Precautions: Do not drive into the field. Wear disposable boots and gloves, and disinfect your soil sampling equipment in the field.

2. At each sample point, clear away residue on the soil surface and collect soil core or scoop from the top 3 to 6 inches (a representative sample is five scoops or cores from each field). Be sure to maintain 300 feet from point to point of soil collection.
3. Air-dry the soil samples indoors in paper boxes and send or drop them off at one of the following address:

Zhaohui Liu
Department of Plant Pathology
NDSU Department 7660
P.O. Box 6050
Fargo, ND 58108-6050

UPS/FEDEX to
Zhaohui Liu
Department of Plant Pathology
Walster Hall 306
Fargo, ND 58102

Venkat Chapara
Langdon Research Extension Center
9280 107th Ave. N.E.
Langdon, ND 58249

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION
North Dakota State University, Fargo, North Dakota

NDSU EXTENSION — EXTENDING KNOWLEDGE » CHANGING LIVES

PP1998


(Venkata Chapara, NDSU)

Canola Diseases: Clubroot

Madeleine Smith, NDSU Extension Agent, Pembina County
Anitha Chirumamilla, NDSU Extension Agent, Cavalier County
Lindy Berg, NDSU Extension Agent, Towner County
Venkata Chapara, Plant Pathologist, Langdon Research Extension Center
Fereshteh Shahoveisi, Canola Research Assistant, Department of Plant Pathology
Luis E. del Rio Mendoza, Canola Pathologist, Department of Plant Pathology
Sam Markell, Extension Plant Pathologist, Department of Plant Pathology

Clubroot is a serious disease threat to canola

NDSU EXTENSION
North Dakota State University, Fargo, North Dakota
December 2020

The host range of *Plasmodiophora brassicae* in North Dakota

Venkataramana Chapara[1], Prochaska T. J.[2], and Anitha Chirumamilla[3]

[1]North Dakota State University/Langdon Research Extension Center, Langdon, ND-58249
[2] North Dakota State University/North Central Research Extension Center, Minot, ND-58701
[3]NDSU Extension Service, Langdon, ND-58249
Corresponding author: Venkataramana Chapara
Fax number: 7012562580
e-mail address: venkata.chapara@ndsu.edu

Abstract

Plasmodiophora brassicae causes clubroot on brassica crops and is a new emerging disease on rapeseed in North Dakota. A two-year study was conducted to document the host range and symptomology on various brassica hosts to *P. brassicae* infections in field conditions. The results indicated that out of the 13 brassica hosts tested, 12 of them developed ellipsoidal galls on roots exhibiting the clubroot symptomology with a disease index (DI) ranging from 41 to 100%. False flax/ camelina (*Camelina sativa*) showed the least susceptibility among the brassica hosts tested. Symptomology of clubroot on various brassica hosts will serve as a pictorial guide in the future to educate growers and in choosing non-brassica cover crops in clubroot infected fields.

Prevalent Pathotypes of *Plasmodiophora brassicae* in North Dakota

Venkat Chapara[1], and Stephen E. Strelkov[2]

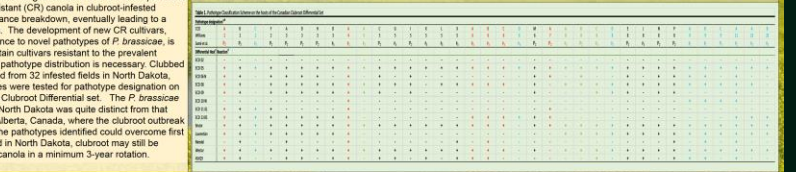
[1]Langdon Research Extension Center, North Dakota State University, Langdon, ND, 58249 U.S.A.,
[2]University of Alberta, Edmonton, AB, Alberta T6G 2P5, Canada.

ABSTRACT

Clubroot (*Plasmodiophora brassicae*) on canola (*Brassica napus*) is spreading faster than expected in North Dakota, causing significant economic losses. An integrated management approach, including longer crop rotations, sanitation and cultivar resistance, are recommended to minimize the impact of this disease. Currently, cultivar resistance is the main management tool sought by growers for clubroot management, without longer rotations out of host crops. Short rotations with clubroot resistant (CR) canola in clubroot-infested regions may lead to resistance breakdown, eventually leading to a decline in canola hectares. The development of new CR cultivars, preferably carrying resistance to novel pathotypes of *P. brassicae*, is therefore important. To obtain cultivars resistant to the prevalent pathotypes, knowledge of pathotype distribution is necessary. Clubbed canola roots were collected from 32 infested fields in North Dakota, and representative samples were tested for pathotype designation on the hosts of the Canadian Clubroot Differential set. The *P. brassicae* pathotype composition in North Dakota was quite distinct from that reported previously from Alberta, Canada, where the clubroot outbreak is most severe. None of the pathotypes identified could overcome first generation resistance, and in North Dakota, clubroot may still be managed by planting CR canola in a minimum 3-year rotation.

MATERIALS & METHODS

* Clubbed galls from 32 canola fields were collected in annual survey of clubroot in North Dakota, USA
* Pathotyping was done under greenhouse conditions
* Six representative samples were evaluated for pathotype designation on the Canadian Clubroot Differential (CCD) set
* Thirteen differentials were inoculated with resting spores of *P. brassicae* and the experiment was repeated
* Galls on the differentials were evaluated after 45 days with clubroot



* Pathotype designations on the CCD set include a number to indicate the classification according to the system of Williams (1966), followed by a letter denoting the CCD designation (e.g., pathotype 2A, 2B, 2C) (Strelkov et al. 2020; Askarian et al. 2020)
* Since the CCD set includes all of the differentials of Somé et al. (1996), designations according to that system can also be obtained

INTRODUCTION

- *Plasmodiophora brassicae* causes clubroot on canola and is an emerging disease in North Dakota
- Can cause significant yield losses under favorable conditions (low pH soils, susceptible cultivar)
- Cultivar resistance, crop rotation and equipment sanitation are some of the common recommended practices to manage clubroot
- Planting resistant cultivars at shorter intervals increases the chances of resistance breakdown and development of novel pathotypes of *P. brassicae*
- Knowledge on the prevalent pathotypes in an area helps breeders to develop resistant cultivars and to develop integrated disease management guidelines
- The objective of this research is to determine the prevalent pathotypes of *P. brassicae* in North Dakota

Figure 1: Galls on canola roots due to *P. brassicae* infections in field were collected for pathotyping study

RESULTS

Sample	North Dakota clubroot Pathotype Designation		
	Somé et al. (1996)	Williams (1966)	Canadian Clubroot Differential Set
FFCR	P3	8	Novel
MMCR	P3	2	2C
PBCR-2	P2	8	8N
RBCR-4	P3	8	Novel
RBCR-5	P3	8	8D
YCR-16	P3	8	Novel

DISCUSSION

* The *P. brassicae* pathotype composition in North Dakota was quite distinct from that reported previously from Alberta, Canada, where the clubroot outbreak is most severe.
* None of the pathotypes identified could overcome first generation resistance, and
* In North Dakota, clubroot may still be managed by planting CR canola in a minimum 3-year rotation.

Acknowledgments

We thank technical and review assistance of Dr. Strelkov lab personnel at University of Alberta, Edmonton, Canada and Special thanks to the support given by all the funding agencies: Northern Canola Growers Association, State Board of Agriculture Research and Education, ND Crop Protection Product Harmonization Board, and the Northern Canola Research Program (NIFA/USDA).

Literature Cited

- Askarian H., Akhavan A., Manolii V. P., T. Cao, Hwang S-F., and Strelkov S. E. (2020). Virulence spectrum of single-spore and field isolates of *Plasmodiophora brassicae* able to overcome resistance in canola (*Brassica napus*). June 20, Plant Disease.
- Strelkov S. E., Hwang S. F., Manolii V. P., Turnbull G., Fredua-Agyeman R., Keisha Hollman K. and Kaus S. (2020): Characterization of clubroot (*Plasmodiophorabrassicae*) from canola (*Brassicanapus*) in the Peace Country of Alberta, Canada, Canadian Journal of Plant Pathology, DOI: 10.1080/07060661.2020.1778931

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

TH DAKOTA
E UNIVERSITY

Acknowledgements

- To all the Growers and my colleagues at LREC
- Jacob, Sean, Tucker, Vivek Muddana, Amanda Arens, Sara McGregor, Randy, Mukhlesur, Del Rio, Liu, Shi, Travis, Audrey, Dante Marino, Jan Knodel, Edwin Pearson, Anitha, Todd (Simplot), ORZ supplier Corey Sundby, Shawn Kasprick and Johan Coetzee
- All the Funding Sources: Northern Canola Growers Association, Northern Canola Research Program (USDA/NIFA), SBARE, Cibus, Bio-Safe and ORO AGRI
- Mr. Barry Coleman and all the Canola Board members for their constant updates and guidance
- Dr. Strelkov and Victor Manoli, University of Alberta, Edmonton, Canada
- To the growers and collaborators across the state
- NDSU Soil testing lab and Dr. Liu's lab for Quantification of resting spores from soil