Lakehead UNIVERSITY | Agricultural Research Station

ANNUAL REPORT

2020

TARLOK SINGH SAHOTA
BLAINE TOMECK
DILLON B. MULDOON

Dr. Sahota (L); Allan Mol and Martin Schep (R)

Dr. Andrew Dean, Melissa Burton and Karen Davies (L); Parneet Kaur, Martin Schep, Dr. Sahota and Allan Mol (R)

Trevor Pennings, Bill Meyer and Dr. Sahota (L); Victoria Desmoulin and Team from Mobert First Nations 400 km from Thunder Bay at LUARS! (R)

Preface

Lakehead University Agricultural Research Station, 2020

The Office of the Vice-President, Research and Innovation is pleased to present the 2020 Annual Report of the Lakehead University Agricultural Research Station (LUARS).

This year is our third year of operations at LUARS. Funding for operations and research programs are provided through a special grant from OMAFRA. In this report, you will see numerous examples of applied research and extension services offered through the station. Most of this research deals with the introduction of new crops/varieties and methods for increasing yields, especially for grain and forage crops. This is extremely important for this region as farmers are continually looking for innovative ways to increase feedstock quality and quantity for cattle. The station has also been involved in the introduction of new cash crops in the region.

Although protocols at LUARS have adapted due to COVID-19, operations remain active, and research and outreach have continued to progress. We currently have nine projects, valued at $245,277, funded through the LUARS Agricultural Research Capacity Development Program to investigate a diverse selection of research projects that actively use the station and the expertise of the scientific director. You will be able to read about some of the progress made on these projects in this report. We will be awarding the third round of funding soon. The current and future research activities at LUARS will further develop and diversify the agricultural sector in the Thunder Bay district and Northwestern Ontario.

The station is a vibrant research centre for Lakehead University, and we are committed to ensuring that the research is applicable to local farming needs while also advancing the area of agricultural research at national and international levels.

Vice-President, Research and Innovation:

Andrew P. Dean, Ph.D.
Lakehead University
Thunder Bay, ON P7B 5E1
Phone: 807-343-8201; Fax: 807-766-7105
Email: vpresearch@lakeheadu.ca

Director, Lakehead University Agricultural Research Station:

Tarlok Singh Sahota, Ph.D. CCA
Lakehead University
Thunder Bay, ON P7B 5E1
Phone: 807-707-1987; Fax: 807-343-8116
Email: tssahota@lakeheadu.ca
Website: www.lakeheadu.ca/centre/luars

Our Collaborators

Gerry Heinrichs/Riley Verhelst James Richardson International Limited N Water Street Thunder Bay ON P7A 8C2 Tel: 807 343 5571 Email: Riley.verhelst@richardson.ca	RICHARDSON
GFO – Josh Cowan Manager Research and Innovation 679 Southgate Drive, Guelph ON N1G 4S2 Tel: 519 767-4138 Fax: 519 767-9713 Email: joshcowan@gfo.ca	GRAIN FARMERS OF ONTARIO
Ken Jackle Technician University of Saskatchewan University Services Building 110 Maintenance Road Saskatoon SK S7N 5C5 Tel: 306 966-5878 E-mail: ken.jackle@usask.ca	Agriculture and Bioresources
Kendall Williams Executive Director NWO Innovation Centre 2400 Nipigon Road Thunder Bay, ON P7C 4W1 Email: kendall@nwoinnovation.ca Tel: 807 768 6682	NORTHWESTERN ONTARIO INNOVATION CENTRE
NOFIA – Cameron Ford 90 Whitewood Ave. PO Box 2976 New Liskeard ON P0J 1P0 Tel: 705 647 4782 Fax: 705 647 4783 Email: cameron.nofia@gmail.com	NOFIA
RAIN - David Thompson Rural Agri-Innovation Network c/o Sault Ste. Marie Innovation Centre 99 Foster Drive, Level Six Sault Ste. Marie ON P6A 5X6 Tel: 705 942 7927 Ext. 3027 Email: dthompson@ssmic.com	RAIN RURAL AGRI-INNOVATION NETWORK

Our Collaborators

Rich Joy Director of Malting and Technical Services Canada Malting Company 3316 Bonnybrook Rd. SE, Calgary, Alberta, T2G 4M9 Tel: 403 571 7000 Email: rich.joy@canadamalting.com	Canada Malting A GrainCorp business
Rigas E Karamanos Senior Agronomist Koch Fertilizer Canada, ULC 61 Sunhaven Close SE Calgary, AB T2X 2X5 Tel: 587 955 9395 Email: Rigas.Karamanos@kochind.com	KOCH FERTILIZER
Ryan Brophy In-charge Eastern Ontario Timac Agro Canada/V6 Agronomy Inc. 9236 Branch Rd. RR#2 North Augusta, ON K0G 1R0 Tel: 613 802 2559 Email: ryan.brophy@ca.timacagro.com	Timac AGRO Canada
Steph Kowalski CCA-ON Agronomy Lead, Crop Production – Ontario and Atlantic, Sollio Agriculture 17554 Plover Mills Road, Thorndale, ON N0M 2P0 Tel: 519-878-0067 Email: Steph.Kowalski@sollio.ag	Sollio Agriculture
Thunder Bay Co-op Farm Supplies - Darren Fisk, Manager RR #3, 560 Boundary Drive Thunder Bay ON P7C 4V2 Tel: 807 475 5190 Email: tbcoop@tbaytel.net	CO-OPERATIVE FARM SUPPLIES

Table of Contents

Cont'd to next page….

Table of Contents

1. Weather Data

1. Weather Data

1.1 WEATHER - 2020					
Month	Precipitation (mm)	Max Temp (˚C)	Min Temp (˚C)	GDD	CHU
April	9.9	23.3	-10.7	0	0
May	36.6	26.0	-7.3	161	247
June	48.8	31.0	-1.5	297	470
July	53.8	34.0	6.0	419	644
August	103.7	29.0	1.0	340	474
September	41.8	25.5	-4.4	177	283
October	49.6	19.4	-13.5	33	45
Total/Mean	***344.2***	***26.9***	***-4.3***	***1427***	***2163***

The start date for CHU was May 1, 2020 and end date was October 14, 2020.
Precipitation up to September end was 295 mm.

1.2 WEATHER - 2019					
Month	Precipitation (mm)	Max Temp (˚C)	Min Temp (˚C)	GDD	CHU
April	26.6	20.2	-12.8	0	0
May	59.0	22.7	-7.5	80	114
June	74.9	27.1	-1.6	220	352
July	70.0	29.0	4.0	400	632
August	57.0	29.5	-0.2	290	485
September	93.0	25.1	-5.0	189	296
October	101.6	18.0	-7.0	33	40
Total/Mean	***482.1***	***24.5***	***-4.3***	***1213***	***1918***

The start date for CHU was May 1, 2019 and end date was September 28, 2019.
Precipitation up to September end was 381 mm.

1.3 WEATHER - 2018					
Month	Precipitation (mm)	Max Temp (˚C)	Min Temp (˚C)	GDD	CHU
April	4.2	21.2	-16.0	0	0
May	40.8	28.0	-8.0	159	326
June	37.8	31.0	-4.0	245	411
July	101.6	30.0	4.0	367	599
August	48.6	29.0	2.0	302	496
September	71.0	24.5	-4.0	166	290
October	88.6	20.3	-7.4	0	0
Total/Mean	***392.6***	***26.3***	***-4.8***	***1238***	***2123***

The start date for CHU was May 1, 2018 and end date was September 22, 2018.
Precipitation up to September end was 304 mm.

1.4 Weather - 2016-2020										
	2020		**2019**		**2018**		**2017**		**2016**	
Month	Rain (mm)	CHU	Rain (mm)	CHU	Rain (mm)	CHU	Rain (mm)	CHU	Rain (mm)	CHU
April	9.9	0	26.6	0	4.2	0	44.0	0	11.4	0
May	36.6	247	59.0	114	40.8	326	95.0	141	46.2	297
June	48.8	470	74.9	352	37.8	411	76.4	359	209.1	364
July	53.8	644	70.0	632	101.6	599	84.8	555	63.8	571
August	103.7	474	57.0	485	48.6	496	50.6	481	85.2	614
September	41.8	283	93.0	296	71.0	290	101.8	320	75.0	393
October	49.6	44	101.6	40	88.6	0	82.0	50	45.2	65
Total	***344.2***	***2162***	***482.1***	***1918***	***392.6***	***2123***	***534.6***	***1906***	***535.9***	***2304***

Start dates for CHU 2020 - 2016: May 1 during all the years.
End dates for CHU 2020 - 2016: October 14, September 28, September 22, October 6, and October 8, respectively.

2. Summary of Research Results

2. Summary of Research Results 2020

Our summer was extremely hot and dry with day temperatures touching 31° C in June and 34° C in July with a rainfall of only 102.6 mm during the two months. As a result, yields of most crops were poor; except edible beans and soybeans, which did exceptionally well. Summer heat and sufficient rain in August (103.7 mm) helped the beans to grow and yield very well (average yield ~5 MT/ha – highest ever!).

2.1 Screening of crop varieties:

2.1.1 Spring Cereals:

Wheat Varieties:

- Thirty-three varieties were evaluated; 21 of which were CWRS (mostly new).
- Grain yield with a trial mean of 2.83 MT/ha was extremely low this year (very hot and dry summer!).
- Highest grain yield (4.46 MT/ha) was obtained with *Easton*. The next best two varieties in grain yield were *AAC Starbuck* (3.63 MT/ha) and *AAC Russell VB* (3.59 MT/ha).
- *AAC Prevail* and *CDC Credence* had the highest straw yield (7.07 and 7.04 MT/ha) and *CDC Credence* the highest biomass yield (10.13 MT/ha).
- Averaged over 2019 and 2020, three varieties that topped in the grain yield were *Easton* (5.18 MT/ha), *AAC Wheatland* (4.78 MT/ha) and *AAC Starbuck* (4.68 MT/ha). Grain yield from *Prosper* was 4.40 MT/ha.
- Grain protein content in *AAC Wheatland* last year was17.8 % as *compared to* 16.6 %, in *Prosper*.
- Since *Easton* is not considered HRW by the Grain Elevators, *AAC Wheatland* and *AAC Starbuck* (both CWRS) can be recommended for cultivation on farms in 2021!

Barley Varieties:

- Fourteen high yielding barley varieties (4 two row and 10 six row) were compared for their production potential.
- *Synasolis* (5.16 MT/ha) among 6 row and *TR1867* (5.00 MT/ha) among 2 row barley produced the highest grain yields. *Chambly* (4.89 MT/ha) was the third best grain yielding variety.
- Straw yield was highest with *AB Advantage* (6.80 MT/ha), *AAC Bell* (2 row; 6.47 MT/ha) and *Amberly* (6.32 MT/ha).
- *AB Advantage* (11.1 MT/ha), *Chambly* (11.0 MT/ha) and *TR1867* (10.7 MT/ha) recorded the highest biomass yields.
- Averaged over 2019 and 2020, grain yields were in the order of *Synasolis* (6.40 MT/ha) ≥ *Boroe* (6.05 MT/ha) ≥ *Chambly* (5.98 MT/ha). However, only 7 varieties were common in 2019 and 2020.

Malting Barley Varieties:

- Thirteen varieties were evaluated. *AB Brewnet* and *CDC Churchill* were the new varieties added this year.
- Three top grain yielding varieties were *Lowe* (6.54 MT/ha), *AB Brewnet* (6.31 MT/ha) and *CDC Fraser* (5.96). *CDC Bow* that has been producing the highest grain yield in the past lagged behind in grain yield last year and this year too (5.53 MT/ha). It seems that *CDC Bow* didn't like the heat in June-July this year. *OAC 21* had the lowest grain yield (4.03 MT/ha). *AB Brewnet* recorded the highest straw yield (5.89 MT/ha), followed by *CDC Copeland* (5.74 MT/ha) and *Lowe* (5.33 MT/ha).
- Grain yield of other varieties ranged from 4.35 MT/ha (*CDC Kindersley*) to 5.86 MT/ha in AA*C Synergy*.
- Averaged over 2017-'20 (*AB Brewnet* and *CDC Churchill* that had only one year data were excluded), *CDC Bow* produced the highest grain (6.29 MT/ha), straw (8.31 MT/ha) and biomass (14.6 MT/ha) yields. And, two second best varieties in (i) grain yield were *AAC Synergy* (5.90

MT/ha) and *AAC Connect* (5.75 MT/ha) and (ii) in straw yield were *Bentley* (6.86 MT/ha) and *AAC Synergy* (6.52 MT/ha).

- *OAC21* had the highest grain protein content (14.7 %). Ten other varieties had higher than 13 % protein. Only *CDC Curchill* (12.5 %) and *CDC Copeland* (12.95 %) had grain protein lower than 13.0 %.

Oat Varieties:

- Eleven oat varieties were evaluated for their yield potential.
- *CDC Arborg* produced the highest grain (6.05 MT/ha) and biomass (11.71 MT/ha) yields, and Vitality the highest straw yield (6.10 MT/ha). Two other equally good varieties in grain yield were *AC Rigodon* (5.83 MT/ha) and *AC Douglas* (5.79 MT/ha).
- Grain yield from the two milling oat varieties *Ore 3541M* and *Ore 3542M* was 5.25 and 5.17 MT/ha, respectively.
- Averaged over 2019 and 2020, *CDC Arborg* (6.01 MT/ha) and *AC Rigodon* (5.93 MT/ha) recorded the highest grain yield!

2.1.2 Winter Cereals:

Winter Wheat Varieties (seeded on August 26, 2019):

- Twelve winter wheat varieties from the west and east of Canada, including *Gallus, AAC Icefield, JDC78* and *AAC Wildfire*, were compared for their production potential.
- *AAC Wildlife* (5.10 MT/ha), *Keldin* (4.97 MT/ha) and *Gallus* (4.88 MT/ha) were the three highest grain yielding varieties; though the grain yield differences between all the tested varieties weren't significant. The grain yields this year were much lower than that during the last year due to hot and dry weather during June-July this year.
- *Goldrush, Moats, CDC Buteo, AAC Wildlife* and *Gallus* had straw yield above 7.0 MT/ha.
- *AAC Wildlife* (12.13 MT/ha), *Gallus* (11.93 MT/ha) and *Keldin* (11.57 MT/ha) recorded the highest Biomass yields.
- Averaged over 2019 and 2020, *Keldin* (6.57 MT/ha), *Gallus* (6.27 MT/ha) and *AAC Gateway* (5.63 MT/ha) produced the highest grain yields. Straw yield (8.97 MT/ha) was highest with *CDC Buteo*.
- *JDC 78* was the most dwarf (76 cm tall) and *CDC Buteo*, *Moats* and *Swainson* the tallest varieties (95-96 cm). *AAC Gateway* with a height of 84 cm was a medium variety.

Late Seeded Winter Wheat Varieties (seeded on September 17, 2019):

- Six varieties were tested under late seeding.
- *Adrianus* (5.90 MT/ha), PRO 81 (5.73 MT/ha) and *CDC Falcon* (5.48 MT/ha) produced the highest grain yields. The yield differences between the varieties were not statistically significant though.
- Straw (7.84 MT/ha) and biomass (12.87 MT/ha) yields were highest with *AAC Gateway*. *CDC Falcon* was the next best/equally good variety in straw (7.33 MT/ha), and biomass (12.81 MT/ha) yields.
- *AAC Gateway* was the most dwarf (76 cm tall) and *CDC Falcon* the tallest variety (82 cm).

2.1.3 Grain Legumes and Oil Seeds Varieties:

Soybean Varieties:

- Twenty-six varieties were compared for their grain production potential.
- *Bourke* R2X (5.39 MT/ha), *Akras* (5.25 MT/ha), and *Mahony R2* (5.00 MT/ha) recorded the highest grain yields! *Lono R2* had given the highest grain yield during the past two years.
- *Mani R2X* (23.1 g), *PV16 S004 RR2X* (22.8 g) and *Amiran* R2 (22.5 g) topped in 100 kernel weights.
- Averaged over 20 varieties that were common during 2019 and 2020, highest grain yields were produced by *Bourke* R2X (3.57 MT/ha), *Lono R2* (3.45 MT/ha), and *NSC Tilston RR2Y* (3.36 MT/ha). *PV16 S004 RR2X* (3.32 MT/ha) and *Mahony R2* (3.30 MT/ha).
- *Lono R2* (124 cm) was the tallest and *Bourke R2X* (92 cm)/*Akras* (91 cm) the medium tall varieties.

Edible Bean Varieties:

- Ten edible bean varieties from different classes and of different colours (mostly new from last year) were evaluated for grain yield.
- Grain yield differences between the varieties were statistically not significant. However, *AAC Scotty – Cranberry beans* (5.91 MT/ha), *AAC Y015* (5.83 MT/ha) and *AAC Whitehorse* (5.71 MT/ha) gave better grain yield than all other varieties (4.63 MT/ha in *AAC Earlired* to 5.61 MT/ha in *AAC Argosy*). *AAC Earlired* has been the highest yielding variety in the past several years.
- Averaged over 2019 and 2020, *AAC Scotty* (4.02 MT/ha), and *AAC Argosy* (3.87 MT/ha)/and *AAC Shock* (3.87 MT/ha) registered the highest grain yields.
- Overall, the edible beans grain yield was very good this year.

Edible beans (easy weed control with Basagram Forte) if they fetch a good price in the market could be an integral part of the cropping systems in northwestern Ontario!

Pea Varieties:

- Ten field pea varieties (6 yellow, 3 green and 1 brown/specialty pea) were evaluated.
- Pods were eaten by geese and deer; hence no grain yield could be recorded. Therefore, only biomass yield is reported.
- *CDC Lewochko – new this year* (3.82 MT/ha), *CDC Forest* (3.39 MT/ha) and *CDC Spruce* (3.31 MT/ha) produced higher biomass yield than other varieties.
- Last year too, *CDC Forest* and *CDC Spruce* were among the top biomass producing varieties.

Lentil Varieties:

- Three lentil varieties (two yellow and one green) were evaluated. Grain yield was very poor (< 1 MT/ha).
- Averaged over 2019-2020, grain yield was in the order of *CDC Impulse CL* (green; 2.02 MT/ha) = *Lima* (2.00 MT/ha) > *CDC Rosetown* (1.50 MT/ha). Straw yield depicted a trend similar to the grain yield and was 3.63 MT/ha in *CDC Impulse CL*, 3.48 MT/ha in *Lima* and 3.14 in *Rosetown*.

Linseed Flax Co-op Trial (Varieties/Biotypes):

- Twenty varieties/biotypes (7 varieties and 13 biotypes) were compared.
- Flax was seeded on May 21 and was soon caught up in the extremely hot and dry weather in June and hence didn't grow well this year. The seed yield was too low and ranged from 0.28 to 0.74 MT/ha (trial mean 0.46 MT/ha). The yield was too low to properly evaluate the varieties.

Liberty Canola Varieties:

- Nine varieties were evaluated; 7 of which had Clubroot resistance and 5 of them had shatter reduction trait.
- Seed yield was extremely low (trial mean 2.02 MT/ha) because of extremely hot and dry weather in June and hot and dry weather at flowering. Growth as seen from straw yield didn't get converted into seed yield.
- Seed yield was in the order of *LR344PC* (2.42 MT/ha) ≥ *L352C* (2.23 MT/ha) = *L252* (2.21 MT/ha). However, seed yield differences between all the varieties were not significant.
- *LR344PC* (two in one LibertyLink® and TruFlex™ canola with Roundup Ready® Technology) recorded the highest straw yield (5.40 MT/ha) followed closely by *L241C* (5.36 MT/ha) and *L345PC* (5.13 MT/ha). Straw yield differences between the varieties too were not significant.
- Four varieties (L255PC, L241C, L230 and L252) were common during 2018-2020. Averaged over 2018-2020, L252 produced the maximum seed yield (4.45 MT/ha) and L241C produced the maximum straw yield (7.25 MT/ha).
- *P stands for 'Shatter Reduction' and C for Clubroot resistance.*

Other Canola Varieties (seeded on May 14, 2020):

- Seven varieties were compared; four Roundup, two Clearfield and one Liberty (as a check).

- Seed yield was extremely low (trial mean 2.04 MT/ha) because of extremely hot and dry weather in June and hot and dry weather at flowering. Growth as seen from straw yield didn't get converted into seed yield.
- Seed yield was in the order of *5545CL* (2.53 MT/ha) = *L241C* (2.52 Mt/ha) ≥ *BY6204TF* (2.32 MT/ha). However, seed yield differences between the varieties were not significant.
- Straw yield followed a bit different trend to the seed yield; *L241C* (6.01MT/ha) > *5545CL* (5.21 MT/ha) > *BY6204TF* (4.79 MT/ha). Straw yield differences between the varieties too were not significant.

Winter Canola Varieties:

- Two winter canola varieties, *Mercedes* and *Inspiration*, were seeded on September 6, 2019 and none survived the winter of 2019-2020.
- This is the second year when these two varieties failed to survive during the winter at LUARS.

Mustard Varieties:

- Four varieties were compared. Due to scant stand the seed yield was very poor and ranged from 0.52 MT/ha (*Adagio*) to 0.86 MT/ha (*AAC Brown 120*).
- Last year, *AC 200* (Oriental mustard; 2.33 MT/ha) and *AC Vulcan* - Oriental mustard (2.15 MT/ha) produced higher seed yield than *AAC Brown 120* (1.65 MT/ha) and *Adagio* (1.41 MT/ha).
- Compared to canola, mustard is a low input crop, is used for culinary purposes, can be sold in retail and could fetch a higher market price than canola!

2.1.4 Forage Crops/Varieties:

Comparative Performance of Alfalfa and Galega: Two cuts were taken!

- Dry matter yields from Galega seeded @ 25, 35 or 45 kg seed/ha and alfalfa seeded @ 13 kg/ha in 2011 were compared.
- Alfalfa (mostly volunteer grasses; there wasn't much of alfalfa left in alfalfa plots) recorded highest dry matter yield (5.092 kg/ha) this year. Galega dry matter yield at different seed rates ranged from 3,297 kg/ha to 3,747 kg/ha and these differences in yield were not significant.
- Galega @ 25-45 kg/ha had ~2-3 higher % points in protein content in the first cut and ~1-2 higher % points in protein content in the second cut.
- Averaged over 2012-2020, Galega seeded @ 35 kg/ha produced over 500 kg/ha/year (= over 4,500 kg/ha) higher dry matter yield than alfalfa. Protein content in Galega was 2 % point higher in the first cut and 3 % point higher in the second cut as compared to alfalfa.
- *Higher yield and higher protein content in Galega than in alfalfa, could make Galega a better fodder than alfalfa!*

Optimizing Seeding Rate in Kernza and Comparing its Forage Production Potential with Perennial Rye and in Mixture with Alfalfa:

- Regrowth was too poor to take the second cut. Therefore, only one cut was taken.
- Optimum seed rate of *Kernza* appeared to be 90 seeds/m^2. At this rate, it produced 4,384 kg/ha dry matter yield. Dry matter yield from *Kernza* at other populations (70, 110 and 130 seeds/m^2) varied from 3,460 kg/ha to 3,877 kg/ha.
- *Alfalfa + Kernza* (80:20 mixture) recorded the highest dry matter yield (5,761 kg/ha) in 2020 and the highest total dry matter yield over three years (2018-2020 – 14.2 MT/ha). Dry matter yield from *alfalfa + Ace 1* (*Perennial Rye*) 80:20 mixture was 4,676 kg/ha. However, *Ace 1* did not survive beyond winter 2018-2019 and *alfalfa + Ace 1* was virtually alfalfa alone.
- In the first cut, protein content was higher in *alfalfa + Ace 1* (80:20) mixture (17.4 %) followed by *alfalfa + Kernza* 80:20 mixture (16.7 %). Protein content in *Kernza* at varying populations (70-130 seeds/m^2) ranged from 10.6 % to 11.8 %.
- RFV was highest (130) in *alfalfa + Ace 1* (80:20 mixture) followed by *alfalfa + Kernza* 80:20 mixture (119). RFV in *Kernza* varied from 94 to 101.

Comparative performance of Kernza, Perennial Rye, RR Alfalfa, Conventional Alfalfa, Sainfoin and Chicory:

- Perennial Rye, Chicory, and Sainfoin didn't survive and Kernza regrowth after the first cut was too poor to take the first cut.
- Dry matter yield from the two cuts ranged from 4,960 kg/ha (*Kernza*) to 8,475 kg/ha (RR Alfalfa variety *WL319HQ*).
- Other two Roundup Ready alfalfa varieties *WL354HQ* (6,732 kg/ha) and *Mission HVXRR* (6,170 kg/ha) produced lower dry matter yield than the two conventional alfalfa varieties; *135* (7,777 kg/ha) and *Instinct* (7,521 kg/ha).
- First cut protein content in *Kernza* was 16.4 % and ranged from 16.7 to 17.7 % in almost all alfalfa varieties. In the second cut (alfalfa only), the protein content ranged from 18.7 % to 19.4 %. *Protein content in the Roundup ready alfalfa wasn't higher than that in the conventional alfalfa*.
- *Mission HVXRR* that gave the lowest dry matter yield had the highest RFV (136) in the first cut. In the second cut, RFV was highest (145) in *WL354HQ* (Roundup Ready).
- In the three years total dry matter yield, *WL319HQ* had the highest yield (18.0 MT/ha), followed by the two conventional alfalfa varieties (135 and Instinct; both 16.7 MT/ha).

Therefore, RR Alfalfa variety WL319HQ could be recommended for cultivation on farms!

2.2 Fertilizer Management Practices and Soil Amendments (Grain/seed crops):

2.2.1 Cereals:

Nitrogen and Sulphur Management for Malting Barley (Cultivar CDC Bow) Production:

- N from urea and urea + ESN (3:1 on N basis) was compared at 3 rates of N (35, 70 and 105 kg/ha along with a check – zero N) at 3 rates of S (0, 8, and 16 kg S/ha).
- Due to hot and dry weather in June, crop growth and the grain yield were poor (trial mean grain yield of only 2.29 MT/ha). It seems the crop couldn't get benefit from ESN due to dry weather.
- Grain yield continued to increase with both urea and urea + ESN up to 70 kg/ha (with each increment of N from zero to 70 kg/ha). Grain yield after 70 kg N/ha either leveled off (urea) or tended to decline (urea + ESN). Averaged over S rates grain yield from urea and urea + ESN was the same.
- Grain yields from urea and urea + ESN (3:1 on N basis) @ 105 kg N/ha, without S, were 2.84 MT/ha and 3.03 MT/ha, respectively (~0.2 MT/ha higher grain yield with urea + ESN than with urea alone). Straw yield increased with every increment of N from 0 to 105 kg N/ha; both with urea and urea + ESN. Straw yields with urea and urea + ESN @ 105 kg/ha were 2.11 and 2.29 MT/ha.
- Grain (3.03 MT/ha) and straw (2.68) yields were highest with urea + ESN @ 105 kg/ha.
- Application of S @ 8 or 16 kg S/ha didn't improve the grain yield (even though the available S at seeding was only 5.75 ppm) but increased the straw yield by over 18 %. This means that the vegetative growth was not translated grain yield (most likely dur to high temperature).
- *Averaged over 2018-2020, (i) highest grain (5.51 MT/ha) and straw (5.56 MT/ha) yields were obtained with urea + ESN @ 105 kg N/ha. Urea at the same level of N produced 4.93 MT/ha grain and 4.77 MT/ha straw yield, and (ii) application of S didn't affect the grain/or the straw yield. The results clearly indicate that it pays to use urea + ESN rather than urea alone!*
- Grain protein content appeared to be within limits for malting quality and increased from 10.9 % without N application to 12.1-13.3 % with N application at different rates from urea (average 12.8 %) and urea + ESN (average 12.9 %). Application of S didn't impact grain protein content.

Evaluation of Fish Waste (a liquid product) as a Source of N for Spring Wheat (Prosper) Production:

- Urea + ESN (3:1 on N basis), fish waste and 50:50 N blend of fish waste and (urea + ESN) were compared at 4 rates of N; 0, 40, 80 and 120 kg/ha (applied at seeding).

- Seeding was done on June 3. June and July turned out to be hot and exceptionally dry. The plot range was of relatively poor fertility. Therefore, the crop growth in this experiment and consequently the yield was extremely poor (trial mean of only 1.13 MT grains/ha).
- Averaged over 2018-2020, grain yields were in the order of urea + ESN (3.97 MT/ha) ≥ 50 % N from fish waste + 50 % N from urea + ESN (3.83 MT/ha) ≥ fish waste (3.50 MT/ha). Straw yield exhibited a trend similar to the grain yield.
- Grain yield increased up to 80 kg N/ha and leveled off thereafter.

Winter Wheat Survival:

- Effect of agrochemicals (seed treatment with fungicide + insecticide and spray of Abscisic acid, Seaweed Extract and Headline at tillering) at two rates of potassium application (recommended rate and double the recommended rate) was studied on winter wheat survival and yield. However, winter wheat survived very well in all treatments and the treatments' effect on grain and straw yield was non-significant. None of the treatments gave higher grain or straw yield than the check (no fungicides, insecticides or other chemicals with 20 kg K_2O/ha).
- Grain and straw yields in the check treatment were 4.96 and 8.05 MT/ha.
- Doubling the rate of K_2O from 20 to 40 kg/ha didn't improve grain or straw yield.
- Averaged over 2019 and 2020 the results were similar to those during 2020. Which means that none of the treatments was better than the check in grain or straw yield.

Population and NPK Fertilizer Regimes for Winter Rye: Effect was studied on 4 varieties with spring barley (after fall fallow) as check.

- Grain yield was in the order of *Guttino* (5.47 MT/ha) > *Hazlet* (4.71 MT/ha) > *Brasetto* (4.03 MT/ha) > *Bono* (3.55 MT/ha). Straw yield was in the order of *Hazlet* (6.60 MT/ha) > *Guttino* (5.65 MT/ha) > *Brasetto* (4.86 MT/ha) > *Bono* (4.77 MT/ha). Averaged over 2019 and 2020, grain and straw yield trends were the same as in 2020.
- Lowering the rate of NPK fertilizers application from 100 %, but not the lowering of seed rate, lowered the grain, straw and biomass yields. Highest grain yield (5.56 MT/ha) was obtained with 100 % of recommended NPK fertilizers. Among the seed rates, 75 % of recommended seed rate seemed to give the highest grain (4.59 MT/ha) and biomass (10.09 MT/ha) yields; though the yields at 50 or 100 % seed rates were not significantly different from those at 75 % of recommended seed rate. Averaged over 2019 and 2020, 100 % of recommended NPK fertilizers/or seed rate recorded the highest grain, straw and biomass yields.
- Spring barley kept as a check treatment yielded only 2.90 MT grain and 2.83 MT straw/ha this year, because we were late to seed barley (on June 16).

Residual Effect of Winter Rye Cover Crop – Different Seeding and NPK Fertilizer Rates on Canola:

- Winter rye cover crop was seeded in the fall 2019 at different seed and NPK fertilizers rates with a check (fallow plot without seeding rye) and its effect was studied on canola in 2020.
- The canola seed yield was not significantly affected by the cover crop treatments and ranged from 2.87 to 4.24 MT/ha. The seed yield in the fallow (check) plot was 3.43 MT/ha; not significantly less than any of the other treatments. Seed yields this year were only about half of those in the last year due to hot and dry weather in June-July this year.
- The results indicated that there was no benefit of winter rye cover cropping and the fertilizers applied to it on the seed yield of the following canola crop!
- Straw yield ranged from 4.73 MT/ha in 75% seeding rate + 0% NPK to winter rye to 9.31 MT/ha with 50% seeding rate + 50% NPK fertilizers to winter rye.
- Soil analyses data in spring 2020 indicated that winter rye cover crop at any of the seed or fertilizers rates didn't affect organic matter, pH or available nutrients.

2.2.2 Grain Legumes and Oil Seeds:

Evaluation of NK21 as a Source of N and K for Soybean (25-10RY) Production:

- NK21 (a relatively new fertilizer with 21 % N and 21 % K_2O) was compared @ 21, 42, 63 and 84 kg/ha N and K_2O with urea + MOP (muriate of potash; 0-0-60) at equal rates of N and K_2O along with three checks (No N, No K_2O and No N or K_2O).
- Grain yield ranged from 5.24 MT/ha in control (no N and K_2O) to 5.80 MT/ha with NK21 @ 84 kg N/ha and 84 kg K_2O/ha. The grain yield with N and K_2O each @ 21 kg/ha from urea + MOP was 5.75 MT/ha. However, these yield differences were statistically not significant. This means that soybeans could be grown without N and K_2O application at Thunder Bay.
- Grain yields were similar with urea + MOP and NK21.
- Averaged over 2018-2020, the responses to NK21, urea + MOP and rates of N and K_2O were similar to those in 2020.
- *It may be kept in mind that NK21 has the advantage of applying two nutrients from one source*.

Response of Canola (L252) to High Rates of N Application from Different Sources:

- Application of N @ 90, 180, 240 and 360 kg/ha from urea, urea + ESN (2:1 ratio on N basis), urea superU, urea + urea superU (2:1 ratio on N basis) and urea + ESN + urea superU each @ 60 kg N/ha (total 180 kg N/ha) significantly improved the canola seed yield as compared to the check.
- Maximum seed yield (4.63 MT/ha) was obtained with urea @ 270 kg N/ha followed by urea + ESN + urea superU (4.53 MT/ha) @ 180 kg N/ha (60 kg N/ha from each) and urea superU @ 360 kg N/ha (4.28 MT/ha). However, the increase in seed yield beyond 180 kg N/ha (either as urea or as urea + ESN) wasn't significant.
- Averaged over sources of N, seed yield increase beyond 90 kg N/ha was not significant and averaged over rates of N, all sources/or blends of N had equal seed yield. Low response to N and lack of response to different N sources this year is ascribed to dry weather leading to relatively poor yields.
- Straw yield was highest with urea @ 270 kg N/ha (8.93 MT/ha) followed by urea superU @ 360 kg N/ha (8.10 MT/ha).
- Averaged over 2019 and 2020, urea + ESN @ 180 kg N/ha have as much seed yield (4.78 MT/ha) as urea @ 270 kg N/ha. Urea superU @ 360 kg N/ha was a bit better in seed yield (5.05 Mt/ha) than urea @ 270 kg N/ha/or urea + ESN @ 180 kg N/ha. Straw yield was highest (8.72 MT/ha) with urea superU @ 360 kg N/ha.
- But for the heat and moisture stress in June and July, seed yields and response to N could be better!

Effect of Apex, Top Phos, EXCELIS MAXX and Bio-Stimulants on Canola:

- Apex (30 % N - 5 % ammoniacal N and 25 % urea N, 2.9 % Ca, 1.2 % Mg and 8 % S), or Top Phos (8 % N, 30 % P_2O_5, 0 % K_2O and 4.8 % S) applied at equivalent rates of N/or P from other fertilizers (urea, ESN, ammonium sulphate and 0-45-0) didn't give higher canola seed yield than the fertilizers used by our growers.
- Out of the Biostimulants (FA Starter, IRYS, FL Gold and Genea), FA Starter and IRYS seemed to improve the seed yield.
- Treatment of urea with EXCELIS MAXX equal yield (4.39 MT/ha) to the one from farmers' practice of applying N from a blend of urea, ESN and ammonium sulphate (4.35 MT/ha), when 48 kg S/ha was applied in both the treatments.
- The experiment was seeded on 1st June and June had been very hot and extremely dry. Hence the seed yield was low (trial mean of 4.27 MT/ha) and ranged from 3.86 MT/ha (with FL Gold spray @ 3l/ha at first petal falling) to 4.77 MT/ha (with FA Starter spray @ 3 L/ha at 2-3 leaves); seed yield with farmers' practice was 4.35 MT/ha.
- Highest straw yield (7.41 MT/ha) was recorded with Apex.

Evaluation of Gypsum and Ammonium Sulphate as Sources of S for Barley, Canola and Pea Production (Gypsum was applied @ 19.5 kg S/ha in the seed row and ammonium sulphate at the same rate of S was broadcast incorporated at seeding in 2019!) – Residual effect on Wheat:

- Grain yield of wheat was extremely low this year (hot and dry summer and the plot range wasn't all that fertile) – trial mean of < 1 MT/ha.
- Averaged over three years (2018-2020) grain yield of wheat after canola (3.82 MT/ha) was ≥ that after pea (3.52 MT/ha) ≥ that after barley (3.35 MT/ha). Straw yield followed a trend similar to that of grain yield.
- There was no residual effect of Gypsum or ammonium sulphate applied to the previous crops on wheat (grain or straw yield).
- Soil analysis in spring 2020 indicated that the nutrients contents (P, K, Ca and Mg) and CEC were somewhat higher after pea than after canola or barley (in the previous year). P content was lowest after barley, which means that barley removed more P than canola and pea.

Effect of Nitrogen and Sulphur on Lentils Grain Yield:

- Treatments included all combinations of 3 rates of N (0, 22.5 and 45 kg N/ha) and 4 rates of S (0. 8, 16 and 24 kg S/ha).
- Grain yield was extremely poor due to hot and dry summer (trial mean of 0.78 MT/ha only; compared to 3.48 MT/ha last year).
- Averaged over 2019-2020, grain yield from check plot (no N or S) was 1.81 MT/ha. Application of N or S didn't improve the grain yield over check.

Effect of P and K on Lentils Grain Yield:

- Treatments included all combinations of 3 rates of P_2O_5 and 3 rates of K_2O each @ 0, 20 and 40 kg/ha).
- Grain yield was very poor due to hot and dry summer (trial mean of <1 MT/ha).
- Application of P or K had no significant effect on lentils grain yield. In other words, lentils didn't respond to application of P and K; may be because of low yield (1.40 MT/ha averaged over 2019-2020).
- From the two nutrient management experiments on lentils, it appears that the lentils could be grown without application on N, P, K and S!

2.2.3 Forages:

Galega:

Comparative Performance of Gypsum and Lime for Galega Production:

- Only one cut was taken this year because of poor regrowth after the first cut.
- Application of gypsum at varying rates (1.25-3.75 MT/ha) didn't improve dry matter yield of Galega. Lime @ 2.14 MT/ha brought a marginal increase in dry matter yield of Galega (by 325 kg/ha). However, this yield increase was statistically not significant.
- Unlike last year, the two amendments didn't improve the first cut protein content this year as compared to the check (no lime/or gypsum application).
- Total yield of the two years (2019 and 2020): Gypsum @ 2.5 MT/ha increased Galega yield by ~700 kg/ha and lime @ 2.14 MT/ha resulted in more than 950 kg/ha increase in yield as compared to the check (no lime/or gypsum application).
- Averaged over 2019 and 2020, Gypsum @ 2.5 MT/ha increased first cut Galega protein content by 2 % points and lime @ 2.14 MT/ha by 1.3 % points as compared to the check (no lime/or gypsum application).

Maximizing Yield and Quality of Galega:

- Only one cut was taken this year because of poor regrowth after the first cut.
- Maximum dry matter yield of Galega was obtained with the application of 60 kg N + 36 kg S + 2 kg B + 7 kg Zn + 2 kg Mn/ha (1,853 kg/ha; ~750 kg/ha increase over check – no nutrients application). The next best treatments were 45 kg N + 24/or 36 kg S + 1/or 3 kg B + 7 kg Zn + 2

kg Mn/ha (1,625-1,690 kg/ha). These three treatments were also best in two years (2019 and 2020) total yield.

- Protein content and RFV in the first cut was not affected by the nutrients application.
- Averaged over the two years protein content in the first cut was highest (18.6 %; 1.1 % point higher than the check-no nutrient application) with the application of 60 kg N + 36 kg S + 2 kg B + 7 kg Zn + 2 kg Mn/ha.

2.3 Other Agronomic Practices:

Effect of Fungicides on Diseases and Yield in Spring Cereals:

- Stratego (sprayed at tillering), Prosaro (sprayed at anthesis) and Cramba sprayed a week later than Prosaro were used to control foliar fungal diseases in spring cereals – wheat, barley and oats (total 12 treatments).
- There was hardly any disease incidence because of very hot and dry summer; FHB score in particular was zero. Consequently, none of the fungicides treatments gave higher grain yield than no fungicide spray (4.39 MT/ha; averaged over three cereals). Though Septoria score came down from 3 with no fungicide spray to 2 with Stratego, 1 with Stratego and Prosaro and 0 with Stratego, Prosaro and Cramba.
- The three cereals had statistically similar grain yields; wheat (*AAC Wheatland*) – 4.04 MT/ha, barley (*CDC Bow*) – 4.16 MT/ha and oat (*AC Rigodon*) – 4.33 MT/ha. Barley produced the highest straw yield (4.82 MT/ha). Straw yield in wheat and oat was equal at 3.85 MT/ha.

Winter Rye (Cultivar Hazlet) Date of Seeding:

- Winter rye was seeded at 10 days interval from August 25 to October 15.
- Plant height (126 cm), and grain (5.40 MT/ha), straw (6.84 MT/ha) and biomass (12.24 MT/ha) yields were highest with September 15 seeding. Delay in each consecutive seeding from August 25 to September 15 increased the yields and reduced the yields thereafter.
- Seeding on October 15, with only 2.51 MT/ha grain yield, wasn't worth it.
- Averaged over 2018-2020, September 15 seeding produced the highest grain (7.25 MT/ha), straw (7.82 MT/ha) and biomass (15.07 MT/ha) yields. Delay in seeding from September 15 to 25 reduced the grain and straw yields by 1.85 MT/ha (185 kg/ha/day) and 1.59 MT/ha, respectively.

Winter Rye Date and Rate of Seeding:

- Possibility of getting good yield from winter rye by increasing seed rate with delay in seeding was explored.
- Increasing seed rate by 25-50% delay in seeding from September 25 to October 25 didn't help arresting the consistent decline in yield with each successive delay in seeding date.
- Grain, straw and biomass yields of winter rye with September 25 seeding were 3.95, 4.82 and 8.77 MT/ha. Corresponding values for October 25 seeding were 1.51, 2.03 and 3.54 MT/ha.

Effect of Winter Rye Cover Cropping on Spring Crops:

- Winter rye as a cover crop was grown in 2019-2020 fall-winter with and without fertilizers and compared with fallow (no cover cropping) for its effect on six spring crops (wheat, barley, canola, soybean, lentils and flax) production.
- Spring crops were seeded on June 6 and were caught in hot and dry weather. The crops didn't reach maturity. Hence only biomass yields were recorded.
- Winter rye with or without fertilizers didn't produce higher biomass yield of the following spring crops than the fallow (no cover cropping). Among crops (averaged over cover crop treatments), canola recorded the highest biomass yield (6.0 MT/ha), followed by barley (4.02 MT/ha). Biomass yields of other crops were: wheat 0.81 MT/ha, soybean 0.92 MT/ha, lentils 1.13 MT/ha and flax 2.80 MT/ha

Optimizing Seeding Rate in Kernza and Comparing its Grain Production Potential with Perennial Rye:

- *Kernza* was seeded @ 70, 90, 110 and 130 seed/m^2.
- *Ace 1* (perennial rye) didn't survive to produce any grain yield.

- *Kernza* grain yield was extremely poor this year due to extremely hot and dry summer.
- Highest grain (0.36 MT/ha), straw (10.41 MT/ha) and biomass (10.77 MT/ha) yields were obtained at a seeding rate of 110 seed/m^2. Same was true for average grain (1:30 MT/ha), straw (12.86 MT/ha) and biomass (14.15 MT/ha) yields over three years (2018-2020).

Alternate Forage legumes:

- Alfalfa, Red clover, Galega, birdfoot trefoil and Sainfoin (last one at 4 seeding rates; 20-50 kg/ha) were compared for their forage production potential and feed quality.
- Dry matter yields were in the order of alfalfa (3,444 kg/ha) ≥ Red clover (2,939 kg/ha) ≥ birdfoot trefoil (2,385 kg/ha) ≥ Galega (1,854 kg/ha) = Sainfoin (> 1,880 kg/ha) @ 30-40 kg seed/ha.
- First cut protein content was > 19 % in birdfoot trefoil, Sainfoin and Red clover and was close to 19 % in alfalfa. Other treatments had 13.4 % or less protein content.
- RFV was higher in alfalfa (130), birdfoot trefoil (128) and Sainfoin (128) than other crops (117-122).

Galega Establishment under Weed Pressure:

- Seeding in the experiment and herbicides spraying was done only in 2018 to work out suitable strategies for weed control in Galega. Only one cut was taken this year, because the crop didn't grow well after the first cut due to hot and dry weather.
- Top dry matter yields of Galega (2,052 kg/ha) were obtained by seeding Galega as early as possible in early spring or after pre plant incorporation of Rival (Trifluralin) @ 3L/ha (2,008 kg/ha).
- Treatments that gave over 20 % protein in Galega were; seeding Galega as early as possible in spring or seeding after killing emerged weeds/or after harvesting barley at boot stage and post emergence spray of Basagram Forte @ 1.75L/ha/or Pursuit @ 210 ml/ha + Ag-Surf @ 0.25% v/v.
- RFV was highest in Galega seeded after harvesting barley (127) and seeding Galega after pre plant incorporation of Rival (Trifluralin) @ 3L/ha (126).

2.4 Extension and Outreach:

A proactive approach to extension and outreach activities was adopted by LUARS for Dissemination of Technology to the end users (farmers, extension scientists and researchers not only in northwestern Ontario, but also in the other parts of the province, and the country/other countries). The impact of our Extension and Outreach activities could be seen in the form of favourable changes as follows:

- Thunder Bay Co-op brought in 88 MT of CDC Bow barley, some Maverick, a Truck load of Brandon, lots of different corn, 7 MT of Akras soybean, L252, L233P (most popular) and L255PC canola, a bit of alfalfa from General Seeds, a few 4010 peas and barley mix.
- Ryan and Fritz Jaspers: Seeded 190 acres Brandon wheat (tested at LUARS), 100 acres corn under biodegradable plastic mulch, 210 acres canola (160 acres Liberty 233P and 50 acres Liberty 255PC), 90 acres Synasolis barley under seeded with alfalfa and timothy, and 40 acres soybeans (Akras). Fritz Jaspers created a new record by getting 2.4 MT grains and 90 small straw bales/acre from his 90 acre Brandon wheat field grown after canola. Wheat at LUARS was found to give higher yield after canola than after other crops! He had a record 1.7 MT/acre seed yield from a 53 acres canola field. His overall canola seed yield averaged at ~1.6 MT/acre. His silage corn (20 MT/acre) and soybean grain (1.23 MT/acre) yields were good too! Jaspers have been applying part of N to their crops as ESN in the seed rows.
- Fred Breukelman seeded 170 acres canola and obtained 1.5 MT seed yield/acre. Fred Breukelman also grew Sorghum Sudangrass, tested at and recommended by LUARS in 40 acres.

- Ed Breukelman: Seeded 150 acres CDC Bow barley (out of which 50 acres under seeded with alfalfa and 40 acres after winter rye that had significant winter kill), 90 acres corn under biodegradable plastic mulch, and 50 acres of Liberty 233P canola. Ed Breukelman got ~2 MT/acre average grain yield from barley and 1.5 MT/acre from canola. Almost all area growers got at least 1.5 MT/acre seed yield from canola this year.
- Bernie Kamphof: Planted 205 acres of corn, 165 acres of Austenson barley and 60 acres of alfalfa – all for forage/feed.
- Evan Grootenboer: Applied wood ash in 121 acres, seeded Tabasco Fababeans in 16 acres.
- Mark Veurink: seeded 25 acres winter wheat, 150 acres corn, 100 acres AAC Penhold spring wheat, 95 acres canola and 140 acres barley 2 row. Mark Veurink created a new record by getting a very high grain (2.8 MT/acre) and straw (6 large scale bales/acre) yield from winter wheat. His barley and wheat grain yields were ~2 MT/acre and he got 1.5 MT/ha seed yield from canola.
- Gert Brekveld continued trial cultivation of lentils at his farm in ~20 acres for the second year.
- Gerrit Cramer seeded Bono hybrid winter rye (tested at LUARS) first time in 90 acres. He has applied ESN to winter rye in the seed row. He also seeded 300 acres under cover crop (a mixture of turnip, barley and peas) for the first time.
- Allan and Henry Mol seeded canola for the first time this year in 64 acres and recorded 90 MT seed production, which equaled ~1.5 MT/acre seed yield. Mols also seeded winter wheat (variety AAC Gateway recommended by LUARS) in 42 acres for the first time this year.
- Henry and Peter Aalbers seeded winter rye in 25 acres for the first time.
- Land clearing and tile drainage on farms continued!
- Farmers continued to use multiple sources of N (urea, ESN and ammonium sulphate) for crop production. Farmers have also started applying ESN in the seed row; a practice recommended by LUARS. One producer applied ESN in seed row in over 400 acres for spring wheat, canola, barley, and corn production! Research at LUARS has proved that use of multiple sources of N instead of a single source was conducive to high yields.
- Inspired by research at TBARS/LUARS dairy farmers around Calgary continued to expand their acreage under MasterGraze corn. TBARS pioneered in research on MasterGraze corn that produces 8 MT dry matter yield/ha in 80 days. Its feeding to dairy cows improved milk yield by 3l/cow/day and butter fat yield from 3.93 % to 4.40 %.
- Richardson International Limited procured 12,926 tonnes grains/seeds from local producers as at November 25, 2019 at a value of ~3.8 million dollars from Thunder Bay and Rainy River Districts. This is 4,126 tonnes more than that in 2019 and over 7,100 tonnes more than that in 2018 (see also Figure 1). I believe at least one more Grain Elevator procured grains from the area as well (volumes not known). This is in addition to some malting barley procured by the Canada Malting Company from our area.

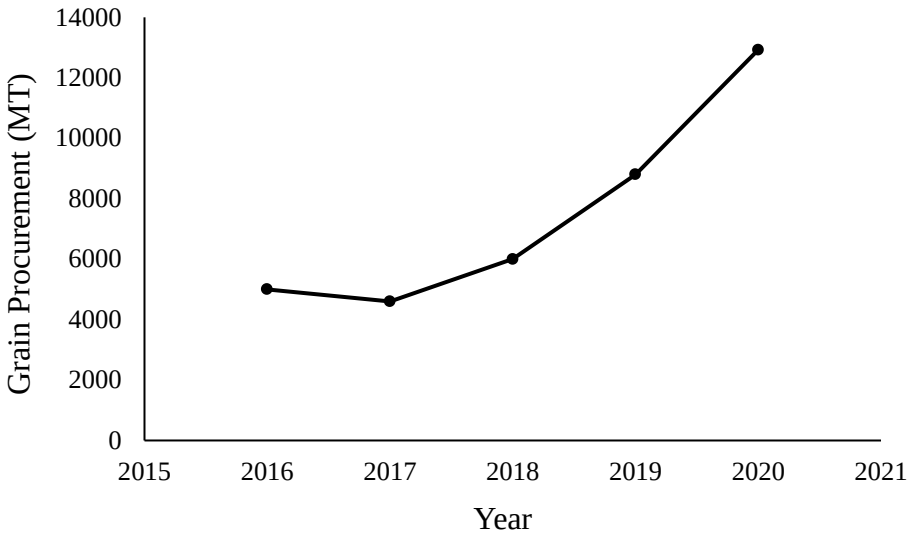

Figure 1: Grain procurement from NWO by Richardson International Limited

Thunder Bay producers are continuing to diversify their cropping systems, renovate, expand/or make additions to their fields and dairy operations! At least one dairy farmer installed a super modern Robot Milk Barn!

Dr. Tarlok Singh Sahota CCA **November 30, 2020**
Director LUARS Thunder Bay

3. Screening of Crop Varieties

Spring Cereals Varieties

3.1.1 Spring Wheat Varieties

PLANTING DATE: May 5, 2020

FERTILIZATION: 74 kg N/ha (152 kg/ha 46-0-0, 38 kg/ha 11-52-0) 20 kg K_2O/ha (33 kg/ha 0-0-60)
20 kg P_2O_5/ha (38 kg/ha 11-52-0)

HERBICIDES: Logic M @ 1.25 L/ha applied post - emergent June 19, 2019

HARVEST DATE: August 13, 2020

PREVIOUS CROP: Berseem Clover

			…….YIELD…….				
	WHEAT♠	GRAIN ♣	GRAIN [b]	STRAW [b]	BIOMASS [b]	HARVEST	HEIGHT
VARIETIES	TYPE	kg/kg NUTRIENTS [b]	.....(MT/ha).....			INDEX (%) [b]	(cm) [b]
AAC Penhold	CPSR	23.6	2.69	5.23	7.92	33.8	58
AAC Viewfield	CWRS	19.6	2.23	4.31	6.53	34.1	61
AAC Connery	CWRS	14.5	1.65	5.26	6.91	23.9	67
AAC W1876	CWRS	27.3	3.11	4.51	7.62	43.1	67
AAC Tisdale	CWRS	24.0	2.73	5.66	8.39	32.1	67
AAC Goodwin	CPSR	29.7	3.39	5.25	8.64	39.0	68
AAC Warman	CWRS	25.7	2.93	5.26	8.19	35.4	73
AAC Starbuck	**CWRS**	**31.9**	**3.63**	**5.60**	**9.23**	**40.3**	**68**
AAC Wheatland	CWRS	27.3	3.12	5.12	8.24	38.1	65
AAC Alida	CWRS	24.8	2.83	5.17	8.01	36.0	74
AAC Crossfield	CPSR	28.0	3.19	5.28	8.47	38.5	70
AAC Succeed	CWAD	18.4	2.10	5.48	7.58	25.8	75
AAC Magnet	CWRS	17.4	1.98	5.02	7.00	27.6	71
CDC Adament	CWRS	25.0	2.85	4.91	7.76	35.2	62
CDC Landmark	CWRS	15.9	1.82	5.39	7.20	24.6	61
Dakosta	CERS	25.8	2.95	4.19	7.13	39.9	71
Easton	**CERS**	**39.1**	**4.46**	**5.23**	**9.69**	**46.0**	**65**
Ellerslie	CWRS	21.5	2.45	4.14	6.58	38.3	65
Minnedosa	CWSP	29.7	3.39	4.88	8.27	40.9	70
Panata	CWRS	24.8	2.83	5.47	8.30	34.3	75
Prosper	CNHR	24.8	2.83	5.35	8.18	34.5	66
SY Obsidian	CWRS	23.7	2.70	4.92	7.62	34.6	67
AAC Brandon	CWRS	27.3	3.12	6.01	9.12	34.4	66
AAC Prevail	CWRS	19.5	2.23	7.07	9.29	22.6	79
Raven	CERS	32.5	3.70	6.28	9.98	37.1	75
Jake	CWRS	14.3	1.63	5.57	7.21	21.8	70
CDC Reign	CPSR	29.6	3.38	5.06	8.44	40.1	65
ACC Russell VB	**CWRS**	**31.5**	**3.59**	**4.85**	**8.44**	**42.6**	**69**
ACC Redstar	CWRS	26.8	3.06	5.81	8.87	35.6	68
SY Torach	CWRS	22.4	2.56	5.22	7.78	33.0	61
CS Accelerate	CPSR	26.7	3.04	4.33	7.37	40.7	65
CS Tracker	CWRS	19.9	2.26	5.21	7.48	29.6	65
CDC Credence	CWAD	27.1	3.09	7.04	10.13	31.0	79
MEAN		**24.9**	**2.83**	**5.27**	**8.11**	**34.7**	**68**
C.V. (%)		37.3	37.3	24.5	21.5	28.0	10.7
Pr>F		0.4700	0.4700	0.0860	0.0842	0.7910	0.1100
SE		0.81	0.092	0.1130	0.152	0.85	0.6
LSD (0.05)		NS	NS	NS	NS	NS	NS

Notes:

♣ Indicates nutrients utilization efficiency.

♠ CNHR=Canada Northern Hard Red, CWAD=Canada Western Amber Durum, CWSP=Canada Western Special Purpose, CERS=Canada Eastern Red Spring, CPSR=Canada Priarie Spring Red, CWRS=Canada Western Red Spring.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.1.1 Spring Wheat Varieties….Cont'd from previous page

VARIETIES	1000 K WT.(g)	TEST WT. (kg/hl)	…..DAYS TO….. HEAD [b]	MATURE [b]	PLANT (m^2) [b]	…..TILLERS/….. (m^2) [b]	PLANT [b]	LODGING▼ (0-9)
AAC Penhold	43	79	53	94	340	483	1.7	0
AAC Viewfield	39	78	53	97	320	497	1.6	0
AAC Connery	38	79	53	93	330	470	1.6	0
AAC W1876	39	78	50	94	283	493	1.8	0
AAC Tisdale	41	78	52	96	377	560	1.5	0
AAC Goodwin	40	80	52	93	377	467	1.3	0
AAC Warman	39	80	49	93	280	453	1.6	0
AAC Starbuck	**41**	**79**	**51**	**95**	**380**	**530**	**1.5**	**0**
AAC Wheatland	41	78	51	92	377	543	1.6	0
AAC Alida	40	79	52	92	380	570	1.6	0
AAC Crossfield	38	79	53	95	370	483	1.4	0
AAC Succeed	51	77	56	97	240	447	2.3	0
AAC Magnet	43	78	49	93	257	477	2.0	0
CDC Adament	37	78	52	89	383	547	1.4	0
CDC Landmark	41	77	53	93	330	433	1.4	0
Dakosta	42	79	53	93	383	463	1.3	0
Easton	**40**	**78**	**57**	**95**	**387**	**517**	**1.3**	**0**
Ellerslie	37	78	53	94	253	433	1.8	0
Minnedosa	46	74	50	90	397	503	1.3	0
Panata	37	78	48	89	420	550	1.4	0
Prosper	46	78	53	96	317	463	1.5	0
SY Obsidian	41	79	49	96	327	490	1.6	0
AAC Brandon	40	81	53	94	363	610	1.7	0
AAC Prevail	38	69	53	93	310	503	1.7	0
Raven	36	78	56	95	360	470	1.3	0
Jake	36	78	50	88	423	467	1.1	0
CDC Reign	40	80	54	94	437	510	1.2	0
ACC Russell VB	**44**	**78**	**49**	**86**	**457**	**653**	**1.5**	**0**
ACC Redstar	39	75	50	90	383	473	1.2	0
SY Torach	34	77	49	96	340	577	1.7	0
CS Accelerate	36	80	49	92	360	487	1.4	0
CS Tracker	33	78	52	96	300	510	1.7	0
CDC Credence	46	77	56	96	360	470	1.4	0
MEAN	**40**	**78**	**52**	**93**	**352**	**503**	**1.5**	**0**
C.V. (%)	-	-	4.8	2.9	31.1	23.1	35.8	-
Pr>F	-	-	0.529	0.0743	0.161	0.4700	0.1970	-
SE	-	-	0.2	0.2	9.5	10.1	0.05	-
LSD (0.05)	-	-	NS	NS	NS	NS	NS	-

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.1.1 Spring Wheat Varieties….Cont'd from previous page

VARIETIES	BYDV [b]	SEPTORIA [b]	TAN SPOT [b]	RUST [b]	FHB [b]	SMUT [b]
			……DISEASES*……..			
AAC Penhold	1	2	0	1	0	0
AAC Viewfield	0	4	0	0	0	0
AAC Connery	5	1	0	0	0	0
AAC W1876	5	3	0	0	0	0
AAC Tisdale	4	2	0	0	0	0
AAC Goodwin	6	1	0	0	0	0
AAC Warman	1	4	0	0	0	0
AAC Starbuck	**0**	**4**	**0**	**1**	**0**	**0**
AAC Wheatland	1	5	0	0	0	0
AAC Alida	1	5	0	0	0	0
AAC Crossfield	4	1	0	0	0	0
AAC Succeed	3	2	0	0	2	0
AAC Magnet	2	3	0	0	0	0
CDC Adament	0	3	0	0	0	0
CDC Landmark	1	3	0	0	0	0
Dakosta	4	1	0	0	0	0
Easton	**3**	**1**	**0**	**1**	**0**	**0**
Ellerslie	0	3	0	0	0	0
Minnedosa	4	2	0	0	0	0
Panata	5	1	0	0	0	0
Prosper	2	2	0	0	0	0
SY Obsidian	5	0	0	0	0	0
AAC Brandon	1	4	0	1	0	0
AAC Prevail	6	2	0	1	0	0
Raven	0	2	0	2	2	0
Jake	7	2	0	0	0	0
CDC Reign	2	5	0	0	0	0
ACC Russell VB	**4**	**2**	**0**	**0**	**0**	**0**
ACC Redstar	1	3	0	1	0	0
SY Torach	1	4	0	1	0	0
CS Accelerate	0	3	0	0	0	0
CS Tracker	1	4	0	0	0	0
CDC Credence	0	5	0	1	1	0
MEAN	**2**	**3**	**0**	**0**	**0**	**0**
C.V. (%)	107.3	72.6	658.2	239.0	494.1	-
Pr>F	0.4939	0.0863	0.5020	0.2930	0.4270	-
SE	0.2	0.2	0.0	0.1	0.0	-
LSD (0.05)	NS	NS	NS	NS	NS	-

Notes:

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.1.1 Spring Wheat Varieties….Cont'd from previous page

Averaged Over 2019 - 2020

VARIETIES	WHEAT♠ TYPE	GRAIN ♣ kg/kg NUTRIENTS	…….YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)
AAC Penhold	CPSR	24.5	3.64	5.21	8.85	40.8	64
AAC Viewfield	CWRS	24.9	3.86	5.00	8.85	41.6	65
AAC Connery	CWRS	19.4	3.02	5.22	8.24	34.9	71
AAC W1876	CWRS	26.3	3.84	4.84	8.68	45.1	73
AAC Tisdale	CWRS	24.1	3.55	5.94	9.49	36.6	73
AAC Goodwin	CPSR	30.8	4.58	5.52	10.10	44.7	76
AAC Warman	CWRS	27.7	4.16	6.25	10.41	39.2	81
AAC Starbuck	**CWRS**	**31.8**	**4.68**	**5.94**	**10.62**	**44.2**	**75**
AAC Wheatland	**CWRS**	**31.5**	**4.78**	**5.62**	**10.40**	**44.7**	**72**
AAC Alida	CWRS	27.3	4.10	5.67	9.77	41.3	79
AAC Crossfield	CPSR	30.5	4.59	5.65	10.24	44.2	73
AAC Succeed	CWAD	23.1	3.57	5.63	9.20	36.2	79
AAC Magnet	CWRS	22.2	3.43	5.09	8.52	38.1	78
CDC Adament	CWRS	25.2	3.73	4.91	8.64	41.8	69
CDC Landmark	CWRS	21.5	3.36	5.97	9.34	33.7	72
Dakosta	CERS	26.9	4.00	4.86	8.86	43.9	83
Easton	**CERS**	**35.8**	**5.18**	**6.61**	**11.79**	**44.4**	**72**
Ellerslie	CWRS	23.3	3.49	4.76	8.25	42.2	72
Minnedosa	CWSP	29.6	4.36	4.66	9.03	47.8	76
Panata	CWRS	26.8	4.03	5.31	9.33	42.4	80
Prosper	CNHR	28.9	4.40	5.63	10.04	42.3	73
SY Obsidian	CWRS	26.7	4.04	5.33	9.36	41.5	73
AAC Brandon	CWRS	27.4	4.05	6.16	10.20	39.2	72
AAC Prevail	CWRS	23.1	3.53	7.07	10.60	31.8	83
MEAN		**26.6**	**4.00**	**5.54**	**9.53**	**40.9**	**74**

Notes:

♣ Indicates nutrients utilization efficiency.

♠ CNHR=Canada Northern Hard Red, CWAD=Canada Western Amber Durum, CWSP=Canada Western Special Purpose, CERS=Canada Eastern Red Spring, CPSR=Canada Priarie Spring Red, CWRS=Canada Western Red Spring.

3.1.1 Spring Wheat Varieties….Cont'd from previous page
Averaged Over 2019 - 2020

VARIETIES	1000 K WT.(g)	TEST WT. (kg/hl)	…..DAYS TO….. HEAD	MATURE	PLANT (m^2)	…..TILLERS/….. (m^2)	PLANT	LODGING▼ (0-9)
AAC Penhold	46	77	49	95	313	535	1.7	0
AAC Viewfield	40	77	48	96	322	620	1.9	0
AAC Connery	42	68	48	95	318	622	2.0	0
AAC W1876	41	76	46	94	310	652	2.1	0
AAC Tisdale	42	76	47	96	372	682	1.8	0
AAC Goodwin	43	77	48	93	372	618	1.7	0
AAC Warman	40	77	46	93	290	633	2.2	0
AAC Starbuck	**43**	**76**	**47**	**95**	**365**	**647**	**1.8**	**0**
AAC Wheatland	**43**	**76**	**47**	**94**	**372**	**612**	**1.6**	**0**
AAC Alida	40	75	47	93	353	670	1.9	0
AAC Crossfield	40	76	48	94	338	620	1.8	0
AAC Succeed	53	73	52	97	247	570	2.3	0
AAC Magnet	44	75	45	94	275	562	2.0	0
CDC Adament	40	72	47	91	367	723	2.0	0
CDC Landmark	42	76	47	94	332	622	1.9	0
Dakosta	44	78	48	94	362	592	1.6	1
Easton	**41**	**75**	**53**	**96**	**330**	**643**	**1.9**	**0**
Ellerslie	40	73	48	94	298	587	2.0	0
Minnedosa	48	73	46	91	333	657	2.0	0
Panata	40	75	44	90	410	623	1.5	0
Prosper	48	75	49	95	337	627	1.9	2
SY Obsidian	42	76	46	95	347	622	1.8	0
AAC Brandon	41	76	49	94	358	718	2.0	0
AAC Prevail	40	71	48	93	330	603	1.8	0
MEAN	**43**	**75**	**48**	**94**	**335**	**627**	**1.9**	**0**

Notes:
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

3.1.1 Spring Wheat Varieties….Cont'd from previous page

Averaged Over 2019 - 2020

	…….…….DISEASES*……..					
VARIETIES	BYDV	SEPTORIA	TAN SPOT	RUST	FHB	SMUT
AAC Penhold	1	1	0	0	0	0
AAC Viewfield	0	2	0	0	0	0
AAC Connery	2	1	0	0	0	0
AAC W1876	3	1	0	0	0	0
AAC Tisdale	2	1	0	0	0	0
AAC Goodwin	3	0	0	0	0	0
AAC Warman	1	2	0	0	0	0
AAC Starbuck	**1**	**2**	**0**	**0**	**0**	**0**
AAC Wheatland	**1**	**3**	**0**	**0**	**0**	**0**
AAC Alida	2	3	0	0	0	0
AAC Crossfield	3	1	0	0	0	0
AAC Succeed	2	1	0	0	1	0
AAC Magnet	2	2	0	0	0	0
CDC Adament	1	2	0	0	0	0
CDC Landmark	1	2	0	0	0	0
Dakosta	2	0	0	0	0	0
Easton	**2**	**0**	**0**	**0**	**0**	**0**
Ellerslie	1	2	0	0	0	0
Minnedosa	2	1	0	0	0	0
Panata	3	1	0	0	0	0
Prosper	1	1	0	0	0	0
SY Obsidian	4	0	0	0	0	0
AAC Brandon	1	2	0	0	0	0
AAC Prevail	3	1	0	0	0	0
MEAN	**2**	**1**	**0**	**0**	**0**	**0**

Notes:

***** Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

3.1.2 Spring Barley Varieties

PLANTING DATE: May 6, 2020

FERTILIZERS: 75 kg N/ha (152 kg/ha 46-0-0, 39 kg/ha 11-52-0) 20 kg K_2O/ha (34 kg/ha 0-0-60) 20 kg P_2O_5/ha (39 kg/ha 11-52-0)

HERBICIDES: Logic M @ 1.25 L/ha applied post - emergent June 1, 2020

HARVEST DATE: August 11, 2020

PREVIOUS CROP: Berseem Clover

		…….YIELD…….						
VARIETIES	GRAIN kg/kg ♣ NUTRIENTS [b]	GRAIN [b]	STRAW [b]	BIOMASS [b]	HARVEST INDEX (%) [b]	HEIGHT (cm) [b]	1000 K WT.(g)	TEST WT. (kg/hl)
		.....(MT/ha).....						
(TWO-ROW BARLEY)								
AB Wrangler	35.3	4.06	6.01	10.1	40	60	50	61
TR1867	**43.5**	**5.00**	**5.65**	**10.7**	**48**	**60**	**48**	**61**
AAC Ling	38.2	4.40	5.99	10.4	42	67	46	63
AAC Bell	34.9	4.01	6.47	10.5	38	66	58	64
(SIX-ROW BARLEY)								
AAC Bloomfield	26.0	2.99	3.34	6.3	49	69	47	59
Alyssa	36.0	4.14	6.16	10.3	40	60	46	60
Amberly	39.7	4.57	6.32	10.9	42	67	48	61
Boroe	38.6	4.44	5.87	10.3	43	67	46	59
AB Tofield	35.3	4.06	4.91	8.97	46	64	45	60
Chambly	**42.5**	**4.89**	**6.16**	**11.0**	**45**	**64**	**50**	**55**
Oceanik	36.1	4.15	5.81	10.0	42	64	49	59
Synasolis	**44.9**	**5.16**	**4.85**	**10.0**	**51**	**63**	**44**	**59**
AB Advantage	37.0	4.26	6.80	11.1	38	64	51	60
AB Cattelac	40.9	4.70	5.36	10.1	46	61	48	61
MEAN	**37.8**	**4.34**	**5.69**	**10.0**	**43.7**	**64.0**	**48**	**60**
C.V. (%)	22.8	22.8	25.0	19.7	16.2	11.4	-	-
PR>F	0.2440	0.2440	0.9707	0.5563	0.4800	0.8700	-	-
SE	1.15	0.132	0.190	0.264	0.94	1.0	-	-
LSD (0.05)	NS	NS	NS	NS	NS	NS	-	-

Notes:

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

							…….DISEASES*……..				
	…..DAYS TO…..		PLANT	…..TILLERS/…..					SPOT		
VARIETIES	HEAD [a]	MATURE [b]	(m^2) [b]	(m^2) [a]	PLANT [b]	LODGING▼	BYDV [a]	SEPTORIA	BLOTCH [b]	FHB [b]	SMUT [a]
(TWO-ROW BARLEY)											
AB Wrangler	59 *ab*	84	303	533 *a*	2.3	0	0.0 *b*	0	3.0	0	2 *a*
TR1867	**60 *ab***	**84**	**387**	**567 *a***	**1.7**	**0**	**0.3 *b***	**0**	**2.8**	**0**	**0 *ab***
AAC Ling	57 *b*	86	437	480 *a*	0.7	0	3.3 *ab*	0	2.8	0	0 *b*
AAC Bell	57 *b*	87	313	513 *a*	0.7	0	0.5 *b*	0	3.3	0	0 *b*
(SIX-ROW BARLEY)											
AAC Bloomfield	61 *a*	94	137	267 *a*	0.5	0	0.5 *b*	0	2.0	0	0 *b*
Alyssa	57 *ab*	84	417	237 *a*	0.8	0	1.5 *ab*	0	0.8	0	0 *b*
Amberly	56 *b*	87	360	223 *a*	0.7	0	1.3 *ab*	0	1.5	0	0 *b*
Boroe	56 *b*	87	380	163 *a*	1.4	0	2.0 *ab*	0	3.0	0	0 *b*
AB Tofield	58 *ab*	89	340	217 *a*	0.5	0	0.8 *ab*	0	1.8	0	0 *b*
Chambly	**55 *b***	**84**	**370**	**233 *a***	**1.0**	**0**	**0.5 *b***	**0**	**2.0**	**0**	**0 *ab***
Oceanik	56 *b*	85	427	190 *a*	1.1	0	4.0 *ab*	0	1.0	0	0 *b*
Synasolis	**60 *ab***	**87**	**313**	**290 *a***	**2.4**	**0**	**2.0 *ab***	**0**	**1.0**	**0**	**0 *b***
AB Advantage	59 *ab*	94	317	410 *a*	1.3	0	1.8 *ab*	0	1.5	0	0 *b*
AB Cattelac	56 *b*	84	317	277 *a*	1.4	0	4.8 *a*	0	0.5	0	0 *b*
MEAN	**57**	**87**	**344**	**329**	**1.2**	**0**	**1.6**	**0**	**1.9**	**0**	**0**
C.V. (%)	3.5	4.1	32	66	90	-	122	-	71.5	-	409.9
PR>F	**0.0260**	0.2700	0.9800	**0.0026**	0.0660	**-**	**0.001**	-	**0.0001**	-	0.0160
SE	0.3	0.5	14.5	29.1	0.14	-	0.3	-	0.2	-	0.1
LSD (0.05)	2.7	NS	NS	277	NS	-	2.4	-	1.7	-	1

Notes:

***** Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Spring Barley Varieties...Cont'd from previous page

Average Over 2019-2020

VARIETIES	GRAIN ♣ kg/kg NUTRIENTS	…….YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)	1000 K WT.(g)	TEST WT. (kg/hl)
(SIX-ROW BARLEY)								
AAC Bloomfield	30.2	4.61	4.54	9.2	50	77	53	59
Alyssa	32.8	4.76	5.99	10.7	44	73	51	58
Amberly	38.0	5.56	6.52	12.1	46	77	53	61
Boroe	**40.4**	**6.05**	**5.40**	**11.5**	**52**	**79**	**50**	**58**
Chambly	**40.8**	**5.98**	**5.95**	**11.9**	**50**	**70**	**54**	**57**
Oceanik	38.2	5.72	5.19	10.9	52	76	52	59
Synasolis	**43.5**	**6.40**	**4.67**	**11.1**	**57**	**70**	**47**	**59**
MEAN	**38.1**	**5.61**	**5.81**	**11.4**	**49**	**75**	**52**	**58**

VARIETIES	TILLERS (m^2)	…..DAYS TO….. HEAD	MATURE	LODGING▼	……..…….DISEASES*…….. BYDV	SEPTORIA	SPOT BLOTCH	FHB
(SIX-ROW BARLEY)								
AAC Bloomfield	477	55	94	2	1	0	2	0
Alyssa	485	54	89	1	1	0	1	0
Amberly	463	53	91	1	1	0	2	0
Boroe	**420**	**52**	**90**	**1**	**2**	**0**	**4**	**0**
Chambly	**502**	**51**	**88**	**1**	**1**	**0**	**2**	**0**
Oceanik	413	52	89	1	3	0	1	0
Synasolis	**565**	**55**	**91**	**1**	**2**	**0**	**3**	**0**
MEAN	**457**	**52**	**89**	**1**	**2**	**0**	**2**	**0**

Notes:

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

♣ Indicates nutrients utilization efficiency.

3.1.3 Malting Barley Varieties

PLANTING DATE: May 6, 2020

FERTILIZERS: 70 kg N/ha (128 kg/ha 46-0-0; 38 kg/ha 11-52-0)
20 kg P_2O_5/ha (38 kg/ha 11-52-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)

HERBICIDES: Logic M @ 1.25 L/ha applied post - emergent; June 1, 2020

HARVEST DATE: August 6, 2020 OAC 21
August 11, 2020 All other varieties

PREVIOUS CROP: Berseem Clover

		…….YIELD…….						
VARIETIES	GRAIN ♣ kg/kg NUTRIENT [b]	GRAIN [b]	STRAW [a]	BIOMASS [b]	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT (cm) [b]
		....….....(MT/ha).....						
OAC 21	36.6	4.03	2.80 *b*	6.8	57.9	40	59	54
Lowe	**59.5**	**6.54**	**5.33 *a***	**11.9**	**54.9**	**53**	**63**	**57**
AAC Connect	53.2	5.85	4.94 *ab*	10.8	53.8	57	62	50
AC Newdale	47.9	5.27	4.96 *ab*	10.2	51.8	52	61	54
CDC Copeland	47.9	5.27	5.74 *a*	11.0	47.6	53	62	52
CDC Kindersley	39.5	4.35	4.56 *ab*	8.9	48.8	47	60	50
CDC Bow	50.3	5.53	4.71 *ab*	10.2	53.9	53	61	49
CDC Fraser	**54.2**	**5.96**	**5.04 *ab***	**11.0**	**54.7**	**58**	**61**	**45**
AAC Synergy	53.3	5.86	5.23 *a*	11.1	52.7	52	61	48
AAC Goldman	48.6	5.34	5.12 *ab*	10.5	51.3	60	63	58
Bentley	44.5	4.90	4.49 *ab*	9.4	52.1	55	61	49
AB Brewnet	**57.4**	**6.31**	**5.89 *a***	**12.2**	**51.5**	**53**	**62**	**53**
CDC Churchill	48.8	5.37	5.02 *ab*	10.4	51.6	55	60	52
MEAN	**49.4**	**5.43**	**4.91**	**10.34**	**52.5**	**53**	**61**	**52**
C.V. (%)	21.0	21.0	21.0	17.5	12.5	-	-	13.1
PR>F	0.43	0.43	**0.0390**	0.0860	0.30	-	-	0.46
SE	1.43	0.158	0.143	0.251	0.91	-	-	0.9
LSD (0.05)	NS	NS	1.4	NS	NS	-	-	NS

Notes:

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

							…..……..……DISEASES*……...……..…			
	…..DAYS TO…..		PLANT	…..TILLERS…..		LODGING▼		SPOT		
VARIETIES	HEAD [a]	MATURE [a]	(m^2) [b]	(m^2) [b]	PLANT [b]	(0-9) [a]	BYDV [a]	BLOTCH [b]	SEPTORIA [b]	RUST [b]
OAC 21	52 *b*	77 *c*	297	513	2	1 *a*	7 *a*	0	0	0
Lowe	**60 *a***	**88 *ab***	**323**	**567**	**2**	**0 *b***	**0 *b***	**3**	**0**	**1**
AAC Connect	59 *a*	82 *bc*	397	777	2	0 *b*	3 *ab*	2	0	0
AC Newdale	60 *a*	85 *ab*	390	573	2	0 *b*	0 *b*	2	0	1
CDC Copeland	60 *a*	87 *ab*	330	423	2	0 *b*	0 *b*	2	0	0
CDC Kindersley	60 *a*	85 *ab*	303	793	3	0 *b*	1 *b*	2	0	0
CDC Bow	60 *a*	87 *ab*	480	477	1	0 *b*	0 *b*	4	0	0
CDC Fraser	**59 *a***	**85 *ab***	**357**	**513**	**1**	**0 *b***	**0 *b***	**2**	**0**	**0**
AAC Synergy	59 *a*	87 *ab*	373	507	1	0 *b*	2 *b*	1	0	1
AAC Goldman	60 *a*	89 *ab*	190	603	3	0 *b*	0 *b*	1	0	1
Bentley	61 *a*	89 *ab*	200	647	4	0 *b*	1 *b*	1	0	1
AB Brewnet	**60 *a***	**91 *a***	**307**	**507**	**2**	**0 *b***	**0 *b***	**2**	**0**	**1**
CDC Churchill	60 *a*	85 *ab*	340	583	2	0 *b*	3 *ab*	1	0	0
MEAN	**60**	**87**	**333**	**582**	**2**	**0**	**1**	**2**	**0**	**0**
C.V. (%)	3.8	4.2	33.5	46.3	61.6	349.8	183.2	68.7	-	220.7
PR>F	**0.0010**	**0.0010**	0.1500	0.7916	0.4329	**0.0010**	**0.0180**	0.4300	-	0.3450
SE	0.3	0.5	15.3	36.9	0.2	0.0	0.3	0.2	-	0.1
LSD (0.05)	2.8	4.1	NS	NS	NS	0.4	2.9	NS	-	NS

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

VARIETIES	MOISTURE (%)	EXT FINE (%)	EXT COARSE (%)	F/C	ASBC COLOUR	DP (U/ml)	AA (U/ml)	TOTAL PROTEIN (%)	S/T RATIO (%)	WART PROTEIN (%)	pH	WORT VISCOSITY (Cp)	BG (mg/L)	TURBIDITY (NTU)	FAN (mg/L)
OAC 21	5.5	74.8	71.3	3.5	1.31	116	35.7	14.69	27.8	4.08	6.00	1.84	859	15.9	158
Lowe	5.6	78.9	75.4	3.5	2.06	93	37.8	13.13	27.1	3.55	6.20	1.86	902	39.4	131
AAC Connect	5.2	80.5	78.4	2.1	1.44	113	53.9	13.18	33.9	4.47	5.99	1.52	434	8.2	186
AC Newdale	5.4	79.8	77.2	2.5	1.17	112	50.4	13.79	30.8	4.25	6.08	1.54	566	4.6	165
CDC Copeland	5.2	79.8	77.9	1.9	1.41	133	48.6	12.95	38.4	4.98	6.00	1.54	337	9.2	220
CDC Kindersley	5.2	79.3	77.8	1.5	2.13	123	44.6	13.64	43.1	5.88	5.94	1.53	185	16.6	218
CDC Bow	5.2	79.1	77.1	1.9	1.83	109	46.1	13.70	37.6	5.16	5.94	1.53	343	15.6	209
CDC Fraser	5.4	80.0	78.5	1.5	1.84	159	51.1	13.76	39.4	5.42	5.96	1.49	213	15.6	239
AAC Synergy	5.5	81.0	79.2	1.8	1.51	103	48.5	13.28	34.9	4.63	5.99	1.54	315	9.3	169
AAC Goldman	5.6	79.5	77.5	2.0	1.26	143	50.1	13.95	29.7	4.15	6.00	1.52	377	4.9	156
Bentley	5.5	79.7	77.8	1.9	1.54	126	55.7	13.04	36.0	4.70	5.97	1.48	347	4.6	214
AB Brewnet	5.3	79.7	78.1	1.6	1.52	116	55.9	14.09	35.3	4.98	5.96	1.49	237	5.9	205
CDC Churchill	5.2	80.1	78.4	1.7	1.49	105	52.5	12.50	34.9	4.37	6.02	1.49	284	7.3	170
MEAN	**5.4**	**79.4**	**77.3**	**2.1**	**1.58**	**119**	**48.5**	**13.52**	**34.5**	**4.66**	**6.00**	**1.57**	**415**	**12.1**	**188**

3.1.3 Malting Barley Varieties...Cont'd from previous page
Average Over 2017-2020

VARIETIES	GRAIN ♣ kg/kg NUTRIENT [b]	…….YIELD……. GRAIN [a] (MT/ha)	STRAW [a] (MT/ha)	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT (cm) [b]
OAC 21	30.5	4.18 *bc*	4.14 *c*	8.3 *c*	49.8	39	57	80
Lowe	38.4	5.28 *abc*	6.14 *abc*	11.4 *abc*	46.4	46	55	77
AAC Connect	41.3	5.75 *ab*	6.23 *abc*	12.0 *ab*	47.8	47	58	72
AC Newdale	26.1	3.65 *c*	5.61 *bc*	9.6 *bc*	37.3	45	55	70
CDC Copeland	**40.6**	**5.69 *ab***	**6.40 *abc***	**12.1 *ab***	**46.8**	**50**	**58**	**77**
CDC Kindersley	39.5	5.61 *ab*	5.63 *bc*	11.2 *abc*	50.2	42	58	71
CDC Bow	**44.9**	**6.29 *a***	**8.31 *a***	**14.6 *a***	**44.2**	**54**	**58**	**74**
CDC Fraser	40.0	5.56 *abc*	6.32 *abc*	11.9 *abc*	46.6	51	56	71
AAC Synergy	**42.2**	**5.90 *ab***	**6.52 *ab***	**12.4 *ab***	**47.7**	**47**	**59**	**74**
Bentley	34.1	4.79 *abc*	6.86 *ab*	11.7 *abc*	41.7	51	56	77
MEAN	**38.6**	**5.41**	**6.49**	**11.93**	**45.3**	**48**	**57**	**73**
C.V. (%)	39.7	32.3	34.3	28.7	19.5	-	-	23.4
PR>F	0.1700	**0.0540**	**0.0003**	**0.0009**	0.2020	-	-	0.6000
SE	1.18	0.135	0.168	0.261	0.71	-	-	1.4
LSD (0.05)	NS	1.2	1.4	2.200	NS	-	-	NS

Notes:
♣ Indicates nutrients utilization efficiency.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.1.3 Malting Barley Varieties...Cont'd from previous page
Average Over 2017-2020

					……..……..……DISEASES*……...……..……			
	…..DAYS TO…..		TILLERS	LODGING▼			SPOT	
VARIETIES	HEAD [a]	MATURE [b]	(m^2) [b]	(0-9) [a]	BYDV [b]	SEPTORIA [b]	BLOTCH [b]	RUST [b]
OAC 21	50 *b*	95	596	1.8 *a*	4 *a*	0	0	0
Lowe	58 *a*	99	616	0.6 *ab*	3 *ab*	0	1	0
AAC Connect	57 *a*	98	721	0.6 *ab*	3 *ab*	0	1	0
AC Newdale	60 *a*	98	412	0.1 *b*	1 *b*	0	1	0
CDC Copeland	**58 *a***	**99**	**626**	**0.7 *ab***	**2 *ab***	**0**	**1**	**0**
CDC Kindersley	58 *a*	98	738	0.4 *b*	3 *ab*	0	1	0
CDC Bow	**58 *a***	**98**	**641**	**0.1 *b***	**1 *b***	**0**	**1**	**0**
CDC Fraser	58 *a*	98	720	0.7 *ab*	2 *b*	0	1	0
AAC Synergy	**57 *a***	**98**	**632**	**0.6 *b***	**2 *ab***	**0**	**1**	**0**
Bentley	59 *a*	99	639	0.2 *b*	2 *ab*	0	1	0
MEAN	**57**	**98**	634	1	2	0	1	0
C.V. (%)	9.2	9.9	32.5	193.6	78.5	238.8	122.5	218.0
PR>F	**0.0017**	0.5700	0.1767	**0.0030**	**0.0076**	0.8100	0.9300	0.1800
SE	0.4	0.8	16.3	0.1	0.2	0.028	0.1	0.04
LSD (0.05)	3.6	NS	NS	0.8	1.3	NS	NS	NS

Notes:
* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.1.3 Malting Barley Varieties...Cont'd from previous page

Average over 2018-2020

		…….YIELD…….						
VARIETIES	GRAIN ♣ kg/kg NUTRIENT [b]	GRAIN [b]	STRAW [a]	BIOMASS [a]	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT (cm) [b]
		.....(MT/ha).....						
OAC 21	33.3	4.38	3.98 *b*	8.36 *b*	51.9	37	57	80
Lowe	45.8	6.17	6.86 *a*	13.03 *a*	48.6	45	56	81
AAC Connect	**47.5**	**6.44**	**6.68 *ab***	**13.12 *a***	**49.4**	**45**	**57**	**73**
AC Newdale	31.0	4.25	5.74 *ab*	9.99 *ab*	41.1	46	56	72
CDC Copeland	**46.0**	**6.29**	**6.62 *ab***	**12.91 *a***	**48.8**	**50**	**57**	**79**
CDC Kindersley	43.4	6.00	5.86 *ab*	11.87 *ab*	51.0	41	57	72
CDC Bow	45.3	6.06	7.48 *a*	13.54 *a*	45.8	53	58	72
CDC Fraser	45.8	6.20	6.60 *ab*	12.80 *a*	48.9	50	56	71
AAC Synergy	**46.3**	**6.27**	**6.37 *ab***	**12.64 *a***	**49.9**	**44**	**58**	**73**
Bentley	37.9	5.17	6.91 *a*	12.08 *ab*	43.7	50	56	79
MEAN	**42.9**	**5.83**	**6.53**	**12.37**	**47.3**	**47**	**57**	**74**
C.V. (%)	33.1	27.1	34.1	26.0	18.1	-	-	26.0
PR>F	0.3820	0.2200	**0.0169**	**0.0250**	0.2210	-	-	0.5100
SE	1.28	0.142	0.197	0.286	0.79	-	-	1.8
LSD (0.05)	NS	NS	2.90	2.50	NS	-	-	NS

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.1.3 Malting Barley Varieties...Cont'd from previous page
Average over 2018-2020

VARIETIES	…..DAYS TO….. HEAD [a]	MATURE [b]	TILLERS (m^2) [b]	LODGING▼ (0-9) [a]	……..……..……DISEASES*……...……..…… BYDV [b]	SEPTORIA	SPOT BLOTCH [b]	RUST
OAC 21	50 *b*	92	534	2 *a*	4 *a*	0	0	0
Lowe	58 *a*	98	614	1 *b*	2 *b*	0	1	0
AAC Connect	**55 *ab***	**96**	**723**	**1 *b***	**3 *ab***	**0**	**1**	**0**
AC Newdale	58 *a*	96	488	0 *b*	1 *b*	0	1	0
CDC Copeland	**57 *a***	**97**	**596**	**1 *ab***	**2 *ab***	**0**	**1**	**0**
CDC Kindersley	56 *ab*	96	721	1 *b*	3 *ab*	0	1	0
CDC Bow	57 *a*	96	616	0 *b*	1 *b*	0	2	0
CDC Fraser	56 *ab*	96	656	1 *ab*	1 *b*	0	1	0
AAC Synergy	**56 *ab***	**96**	**608**	**1 *b***	**2 *ab***	**0**	**1**	**0**
Bentley	57 *a*	97	669	0 *b*	1 *b*	0	1	0
MEAN	**56**	**96**	622	1	2	0	1	0
C.V. (%)	9.1	11.1	31.8	160.2	93.7	-	121.6	-
PR>F	**0.0330**	0.5500	0.1808	**0.0018**	**0.0053**	-	0.7900	-
SE	0.5	1.0	18.1	0.1	0.2	-	0.1	-
LSD (0.05)	4	NS	NS	1	1		NS	

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.1.4 Oat Varieties

PLANTING DATE: May 6, 2020
FERTILIZERS: 74 kg N/ha (152 kg/ha 46-0-0, 39 kg/ha 11-52-0)
20 kg P_2O_5/ha (39 kg/ha 11-52-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
HERBICIDES: June 1, 2020 - Post-emergent; Logic M @ 1.25 L/ha
HARVEST DATE: August 26, 2020
PREVIOUS CROP: Berseem Clover

		…….YIELD…….							…..TILLERS/…..	
VARIETIES/ BIOTYPE	GRAIN ♣ [b] kg/kg NUTRIENTS	GRAIN [b]	STRAW [b]	BIOMASS [b]	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	PLANTS (m^2) [b]	(m^2) [b]	PLANT [b]
		.....(kg/ha).....								
AAC Bullet	42.0	4.79	5.40	10.19	47.3	40	48	240	580	2.5
AAC Noranda	44.0	5.02	5.45	10.47	48.1	38	48	407	637	1.9
AAC Roskens	47.2	5.38	4.89	10.27	52.6	43	49	380	740	1.9
AC Rigodon	**51.2**	**5.83**	**5.07**	**10.91**	**53.4**	**41**	**48**	**403**	**570**	**1.5**
CDC Arborg	**53.1**	**6.05**	**5.66**	**11.71**	**51.7**	**41**	**49**	**343**	**673**	**2.1**
Akina♦	45.3	5.16	4.64	9.80	53.1	39	46	310	583	1.9
Vitality	45.3	5.16	6.10	11.26	46.1	39	49	403	767	2.2
Ore 3541M	46.1	5.25	4.90	10.15	51.8	41	51	440	660	1.6
Ore 3542M	45.3	5.17	4.85	10.02	51.8	41	50	377	693	1.9
CDC Skye	46.7	5.33	5.52	10.84	49.2	32	51	367	697	2.1
AAC Douglas	**50.7**	**5.79**	**5.16**	**10.95**	**52.9**	**37**	**46**	**363**	**653**	**2.0**
MEAN	**47.0**	**5.36**	**5.24**	**10.60**	**50.7**	**39**	**49**	**367**	**659**	**2.0**
C.V. (%)	10.7	10.7	16.1	11.5	7.2	-	-	29.8	30.6	46.5
PR>F	0.2293	0.2293	0.8390	0.6770	0.2750	-	-	0.2697	0.5000	0.7270
SE	0.76	0.087	0.127	0.184	0.55	-	-	16.4	30.4	0.10
LSD (0.05)	NS	NS	NS	NS	NS	-	-	NS	NS	NS

Notes:
♣ Indicates nutrients utilization efficiency.
♦Milling varieties
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

VARIETIES/ BIOTYPE	…..DAYS TO….. HEAD [a]	MATURE [a]	HEIGHT (cm) [b]	LODGING▼	……DISEASES*…….. BYDV [b]	SEPTORIA [b]	SPOT BLOTCH [b]	RUST [b]
AAC Bullet	54 *ab*	84 *a*	70	0	1	3	0	0
AAC Noranda	56 *a*	83 *abc*	76	0	0	6	0	1
AAC Roskens	52 *b*	81 *c*	68	0	5	5	0	0
AC Rigodon	**53 *ab***	**83 *abc***	**77**	**0**	**0**	**5**	**0**	**0**
CDC Arborg	**55 *ab***	**82 *abc***	**84**	**0**	**0**	**6**	**0**	**0**
Akina	53 *b*	81 *abc*	80	0	0	4	0	1
Vitality	54 *ab*	84 *ab*	80	0	0	5	0	0
Ore 3541M	52 *b*	81 *bc*	75	0	3	5	0	0
Ore 3542M	53 *b*	81 *c*	74	0	1	5	0	0
CDC Skye	53 *b*	82 *abc*	76	0	1	2	0	0
AAC Douglas	**53 *b***	**82 *abc***	**69**	**0**	**1**	**6**	**0**	**1**
MEAN	**53**	**82**	**75**	**0**	**1**	**5**	**0**	**0**
C.V. (%)	2.4	1.6	9.9	-	204.6	37.2	-	298.0
PR>F	**0.0010**	**0.0087**	0.9700	-	0.7940	0.6010	-	0.6800
SE	0.2	0.2	1.1	-	0.3	0.3	-	0.1
LSD (0.05)	1.6	1.8	NS	-	NS	NS	-	NS

Notes:

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.1.4 Oat Varieties…Cont'd from previous page

Average Over 2019-2020

VARIETIES/ BIOTYPE	GRAIN ♣ kg/kg NUTRIENTS	…….YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K WT.(g)	TEST WT. (kg/hl)
AAC Bullet	**34.3**	**4.79**	**6.20**	**11.00**	**44.0**	**42**	**50**
AAC Noranda	36.4	5.11	4.99	10.10	50.8	41	47
AAC Roskens	37.4	5.20	4.92	10.11	51.5	42	49
AC Rigodon	**42.3**	**5.93**	**5.45**	**11.38**	**52.4**	**44**	**49**
CDC Arborg	**43.0**	**6.01**	**5.76**	**11.77**	**51.2**	**43**	**50**
Akina	37.5	5.28	4.64	9.92	53.4	42	47
Vitality	34.6	4.74	5.41	10.15	46.6	46	46
Ore 3541M	36.1	4.99	5.41	10.40	48.3	42	52
Ore 3542M	36.1	5.01	4.78	9.79	51.4	45	49
MEAN	**37.5**	**5.23**	**5.28**	**10.51**	**50.0**	**43**	**49**

VARIETIES/ BIOTYPE	TILLERS (m^2)	…..DAYS TO….. HEAD	MATURE	HEIGHT (cm)	LODGING▼	…….DISEASES*…….. BYDV	SEPTORIA	SPOT BLOTCH	RUST
AAC Bullet	**477**	**51**	**88**	**78**	**0**	**2**	**2**	**1**	**1**
AAC Noranda	530	52	88	82	0	1	4	1	2
AAC Roskens	580	49	87	77	0	5	3	1	1
AC Rigodon	**480**	**50**	**88**	**85**	**0**	**2**	**3**	**1**	**1**
CDC Arborg	**518**	**51**	**87**	**89**	**0**	**1**	**4**	**1**	**1**
Akina	462	50	87	81	0	3	3	1	1
Vitality	597	51	88	87	0	2	3	1	1
Ore 3541M	520	49	87	84	0	4	4	1	1
Ore 3542M	578	50	87	80	0	3	3	1	1
MEAN	**527**	**50**	**88**	**83**	**0**	**3**	**3**	**1**	**1**

Notes:

♣ Indicates nutrients utilization efficiency.

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

Winter Cereals Varieties

3.2.1 Winter Wheat Varieties

PLANTING DATE: August 26, 2019

FERTILIZERS: 120 kg N/ha (91 kg/ha 44-0-0; 174 kg/ha 46-0-0)
50 kg P_2O_5/ha (111 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
5.6 kg S/ha (35 kg/ha 0-0-0-16-20)
7 kg Zinc/ha (35 kg/ha 0-0-0-16-20)
1 kg Boron/ha (7 kg/ha 0-0-0-15)

HERBICIDE: Refine SG @ 30 g/ha applied September 23, 2019

HARVEST DATE: July 29, 2020

PREVIOUS CROP: Fallow

		…….YIELD…….						
	GRAIN ♣	GRAIN [b]	STRAW [a]	BIOMASS [a]	1000 K	TEST WT.	PLANTS [b]	TILLERS [b]
VARIETIES	kg/kg NUTRIENTS [b]	.....(MT/ha).....			WT.(g)	(kg/hl)	…/m^2…	
AAC Elevate	20.3	4.14	5.81 *a*	9.95 *ab*	39	77	490	347
Gallus	**24.0**	**4.88**	**7.05** *a*	**11.93** ***ab***	**44**	**79**	**410**	**190**
Swainson	22.2	4.51	6.32 *a*	10.83 *ab*	38	78	383	310
Moats	18.3	3.73	7.13 *a*	10.86 *ab*	36	79	467	577
AAC Gateway	22.6	4.61	6.50 *a*	11.11 *ab*	32	79	477	257
Keldin	**24.4**	**4.97**	**6.60** *a*	**11.57** ***ab***	**42**	**78**	**483**	**187**
CDC Falcon	22.4	4.56	6.37 *a*	10.93 *ab*	36	77	613	480
CDC Buteo	18.2	3.71	7.10 *a*	10.81 *ab*	37	80	463	580
AAC Wildfire	**25.1**	**5.10**	**7.02** *a*	**12.13** ***ab***	**38**	**78**	**490**	**357**
Goldrush	21.6	4.40	7.15 *a*	11.55 *ab*	35	77	440	517
JDC 78	17.7	3.60	4.47 *a*	8.07 *ab*	40	73	530	453
AAC Icefield	17.6	3.58	3.70 *a*	7.29 *b*	32	77	300	390
MEAN	**21.2**	**4.32**	**6.27**	**10.59**	**37**	**78**	**462**	**387**
C.V. (%)	19.3	19.3	24.8	19.3	-	-	30.3	55.7
PR>F	0.1340	0.1340	**0.0330**	**0.0240**	-	-	0.8050	0.0860
SE	0.59	0.120	0.224	0.295	-	-	20.2	31.1
LSD (0.05)	NS	NS	2.10	2.80	-	-	NS	NS

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.2.1 Winter Wheat Varieties… Cont'd from previous page

VARIETIES	HARVEST INDEX (%) [b]	DAYS TO HEADING [a]	DAYS TO MATURE [a]	HEIGHT (cm) [a]	LODGING▼ (0-9)	LEAF SPOT (0-9)* [b]
AAC Elevate	41.7	285 *abc*	323 *a*	87 *ab*	0	5
Gallus	**41.0**	**283 *c***	**325 *a***	**89 *ab***	**0**	**6**
Swainson	42.4	283 *bc*	324 *a*	95 *a*	0	4
Moats	35.0	283 *bc*	324 *a*	96 *a*	0	4
AAC Gateway	41.8	283 *bc*	324 *a*	84 *ab*	0	3
Keldin	**43.2**	**285 *ab***	**324 *a***	**85 *ab***	**0**	**6**
CDC Falcon	41.7	285 *ab*	323 *a*	88 *ab*	0	4
CDC Buteo	34.2	285 *abc*	323 *a*	96 *a*	0	4
AAC Wildfire	**42.0**	**286 *a***	**325 *a***	**90 *ab***	**0**	**6**
Goldrush	38.3	285 *abc*	324 *a*	89 *ab*	0	4
JDC 78	44.5	286 *a*	325 *a*	76 *b*	0	5
AAC Icefield	49.5	285 *abc*	325 *a*	81 *ab*	0	7
MEAN	**41.3**	**285**	**324**	**88**	**0**	**5**
C.V. (%)	14.9	0.4	0.3	8.1	-	40.3
PR>F	0.1800	**<0.0001**	**0.0190**	**0.0090**	**-**	0.4900
SE	0.89	0.2	0.1	1.0	-	0.3
LSD (0.05)	NS	1.3	1.3	9.6	-	NS

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.2.1 Winter Wheat Varieties… Cont'd from previous page
Averaged Over 2019 - 2020

VARIETIES	GRAIN ♣ kg/kg NUTRIENTS	…….YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	1000 K WT.(g)	TEST WT. (kg/hl)	PLANTS …/m^2…	TILLERS …/m^2…
AAC Elevate	26.6	5.12	7.18	12.30	38	75	540	882
Gallus	**32.7**	**6.27**	**8.00**	**14.27**	**41**	**78**	**485**	**665**
Swainson	27.8	5.34	7.61	12.95	34	76	450	807
Moats	25.9	4.95	7.96	12.92	32	77	497	968
AAC Gateway	**29.3**	**5.63**	**7.59**	**13.22**	**32**	**78**	**515**	**803**
Keldin	**34.3**	**6.57**	**7.84**	**14.42**	**40**	**76**	**510**	**757**
CDC Falcon	24.9	4.81	6.51	11.32	29	73	553	907
CDC Buteo	24.3	4.66	8.97	13.63	32	78	513	905
AAC Wildfire	26.4	5.11	8.29	13.41	34	75	517	858
Goldrush	27.6	5.31	8.06	13.36	30	74	467	958
JDC 78	25.9	4.95	5.99	10.93	36	73	568	932
AAC Icefield	25.4	4.86	6.34	11.20	30	75	442	770
MEAN	**27.6**	**5.30**	**7.53**	**12.83**	**34**	**76**	**505**	**851**

Notes:
♣ Indicates nutrients utilization efficiency
a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.2.1 Winter Wheat Varieties… Cont'd from previous page
Averaged Over 2019 - 2020

VARIETIES	HARVEST INDEX (%)	DAYS TO HEADING	DAYS TO MATURE	HEIGHT (cm)	LODGING▼ (0-9)	LEAF SPOT (0-9)*
AAC Elevate	41.7	291	331	91	0	3
Gallus	**43.6**	**289**	**333**	**95**	**0**	**3**
Swainson	41.2	290	333	105	3	3
Moats	38.2	290	332	101	1	3
AAC Gateway	**42.8**	**290**	**332**	**90**	**0**	**2**
Keldin	**45.2**	**291**	**333**	**91**	**0**	**4**
CDC Falcon	42.5	291	331	92	1	3
CDC Buteo	34.2	291	332	102	3	3
AAC Wildfire	38.8	292	334	98	2	4
Goldrush	39.6	291	332	94	0	2
JDC 78	45.0	291	333	81	0	3
AAC Icefield	44.7	291	333	89	1	4
MEAN	**41.5**	**291**	**332**	**94**	**1.0**	**3.1**

Notes:
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

3.2.2 Late Seeded Winter Wheat Varieties

PLANTING DATE: September 17, 2019
FERTILIZERS: 120 kg N/ha (173 kg/ha 46-0-0; 91 kg/ha 44-0-0) 5.6 kg S/ha (35 kg/ha 0-0-0-16-20)
50 kg P_2O_5/ha (111kg/ha 0-45-0) 7 kg Zinc/ha (35 kg/ha 0-0-0-16-20)
20 kg K_2O/ha (33 kg/ha 0-0-60) 1 kg Boron/ha (7 kg/ha 0-0-0-15)
HERBICIDE: Post-emergence; Refine SG @ 30 g/ha + 0.2% v/v surfactant
HARVEST DATE: July 29,2020
PREVIOUS CROP: Fallow

		YIELD				
VARIETIES	GRAIN ♣ [b] kg/kg NUTRIENTS	GRAIN [b] (t/ha)	STRAW [a] (t/ha)	BIOMASS [a] (t/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)
JDC 78	22.1	4.49	5.15 *b*	9.65 *a*	46.5	40
Lexington	24.0	4.88	5.38 *ab*	10.26 *a*	47.6	44
CDC Falcon	**26.9**	**5.48**	**7.33 *ab***	**12.81 *a***	**43.2**	**32**
Adrianus	**29.0**	**5.90**	**6.22 *ab***	**12.12 *a***	**48.7**	**43**
PRO 81	**28.2**	**5.73**	**6.42 *ab***	**12.16 *a***	**47.4**	**37**
AAC Gateway	24.7	5.03	7.84 *a*	12.87 *a*	39.0	34
MEAN	**25.8**	**5.25**	**6.39**	**11.64**	**45.4**	**38**
C.V. (%)	15.6	15.6	21.3	15.9	10.5	-
PR>F	0.0891	0.0891	**0.0048**	**0.0042**	0.0970	-
SE	0.82	0.167	0.278	0.378	0.97	-
LSD (0.05)	NS	NS	1.70	2.30	NS	-

VARIETIES	TEST WT. (kg/hl)	DAYS TO MATURE [b]	LODGING▼ (0-9)	PLANTS (m^2) [b]	TILLERS (m^2) [b]	HEIGHT (cm) [b]
JDC 78	74	310	0	460	857	70
Lexington	77	308	0	513	350	78
CDC Falcon	**76**	**308**	**0**	**553**	**867**	**82**
Adrianus	**74**	**310**	**0**	**483**	**480**	**77**
PRO 81	**79**	**309**	**0**	**457**	**517**	**80**
AAC Gateway	77	308	0	423	863	76
MEAN	**76**	**309**	**0**	**482**	**656**	**77**
C.V. (%)	-	0.3	-	18.3	38.8	6.4
PR>F	-	0.5100	-	0.2500	0.8900	0.1400
SE	-	0.2	-	18.0	51.9	1.0
LSD (0.05)	-	NS	-	NS	NS	NS

Notes:
♣ Indicates nutrients utilization efficiency
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Grain Legumes Varieties

3.3.1 Soybean Varieties

PLANTING DATE: May 23, 2020
FERTILIZERS: 35 kg N/ha (76 kg/ha 46-0-0)
HERBICIDE: Roundup @ 3 L/ha post-emergence, June 16, 2020
HARVEST DATE: September 22 and 25, 2020
PREVIOUS CROP: Malting Barley

VARIETIES	CORN HEAT UNITS	GRAIN YIELD (MT/ha) [a]	100 K WT.(g) [a]	HEIGHT (cm)
Pekko R2	2325	3.39 *d*	20.3 *abcdefg*	84
Podaga R2	2525	4.09 *abcd*	20.3 *abcdefg*	97
S007-Y4	2350	4.66 *abcd*	20.6 *abcdefg*	85
NSC Tilston RR2Y	2400	4.74 *abcd*	20.3 *abcdefg*	89
NSC Waston RR2Y	2250	4.61 *abcd*	19.2 *abcdefg*	75
NSC Redvers RR2X	2350	3.71 *cd*	18.5 *cdefg*	70
NSC Culross RR2X	2400	4.60 *abcd*	18.7 *bcdefg*	84
NSC Sperling RR2X	2450	4.44 *abcd*	19.8 *abcdefg*	79
NSC Starbuck RR2X	2425	3.88 *abcd*	19.2 *abcdefg*	78
NSC Greenridge RR2Y	2500	4.27 *abcd*	22.2 *abcd*	79
Mani R2X	2425	3.78 *bcd*	23.1 *a*	78
Lono R2	2450	4.78 *bcd*	18.7 *bcdefg*	124
Renuka R2X	2350	4.72 *abcd*	16.3 *g*	94
Amiran R2	2150	4.24 *abcd*	22.5 *ab*	89
S003 - Z4X	2325	4.46 *abcd*	18.7 *bcdefg*	88
NSC Newton RR2X	2375	4.25 *abcd*	20.1 *abcdefg*	94
Karpo R2	2350	4.11 *abcd*	19.2 *abcdefg*	85
Vidar R2X	2500	1.46 *abcd*	16.5 *fg*	79
S006 - MYX	2375	3.79 *e*	17.3 *efg*	71
S0009 - M2	2275	3.77 *bcd*	19.8 *abcdefg*	79
Bourke R2X	**2400**	**5.39 *a***	**20.3 *abcdefg***	**92**
Mahony R2	**2350**	**5.00 *abc***	**21.1 *abcde***	**82**
PV16 S004 RR2X	2400	4.65 *abcd*	22.8 *ab*	92
PV15 S0009 RR2X	2300	4.47 *aabcd*	19.2 *abcdefg*	93
S006 - W5	2350	4.73 *abcd*	17.9 *defg*	78
Akras	**2375**	**5.25 *ab***	**21.7 *abcd***	**91**
MEAN		**4.28**	**19.8**	**86**
C.V. (%)		21.0	11.2	23.1
PR>F		**<0.0001**	**<0.0001**	0.0590
SE		0.088	0.21	1.9
LSD (0.05)		0.80	2.2	NS

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

3.3.1 Soybean Varieties…Cont'd from previous page
Average Over 2019 - 2020

VARIETIES	CORN HEAT UNITS	GRAIN YIELD (MT/ha)	100 K WT.(g)	HEIGHT (cm)
Pekko R2	2325	2.31	18.5	74
Podaga R2	2525	2.96	18.9	86
NSC Tilston RR2Y	**2400**	**3.36**	**17.9**	**85**
NSC Waston RR2Y	2250	2.91	17.6	73
NSC Redvers RR2X	2350	2.60	16.3	67
NSC Sperling RR2X	2450	3.27	18.2	74
NSC Starbuck RR2X	2425	2.70	18.1	72
NSC Greenridge RR2Y	2500	3.11	21.5	72
Mani R2X	2425	2.80	21.9	71
Lono R2	**2450**	**3.45**	**16.6**	**104**
NSC Newton RR2X	2375	2.93	18.0	84
Karpo R2	2350	2.74	17.2	77
Vidar R2X	2500	1.68	15.6	76
S006 - MYX	2375	2.89	16.0	68
S0009 - M2	2275	2.34	17.5	77
Bourke R2X	**2400**	**3.57**	**18.3**	**81**
Mahony R2	2350	3.30	18.9	81
PV16 S004 RR2X	2400	3.32	20.5	81
PV15 S0009 RR2X	2300	2.96	17.2	84
S006 - W5 RR2Y	2350	3.34	15.6	73
MEAN		**2.93**	**18.0**	**78**

3.3.2 Edible Beans Varieties

PLANTING DATE: June 1, 2020
FERTILIZERS: 35 kg N/ha (76 kg/ha 46-0-0)
HERBICIDES: None
HARVEST DATE: September 22, 2020
PREVIOUS CROP: Soybeans

VARIETIES	MARKET CLASS	SEED COAT COLOUR	GRAIN♣ kg/kg NUTRIENTS [b]	GRAIN YIELD (MT/ha) [b]	100 K WT (g) [b]	TEST WT (kg/hl)
AC Earlired	Small Red	Red	132.2	4.63	39.4	80
AAC Whitestar	Great Northern	White	150.7	5.27	42.9	77
AAC Y012	Yellow	Yellow	151.7	5.31	48.4	84
AAC Y015	**Yellow**	**Yellow**	**166.5**	**5.83**	**52.4**	**84**
AAC Whitehorse	**Great Northern**	**White**	**163.2**	**5.71**	**39.0**	**78**
Nautica	Navy	White	126.2	4.42	33.3	70
AAC Shock	Navy	White	158.3	5.54	30.5	79
AAC Argosy	Navy	White	160.3	5.61	26.8	77
AAC Scotty	**Cranberry**	**Cream with Red Spots**	**168.9**	**5.91**	**66.0**	**75**
AAC Expedition	Pinto	Cream with Brown Spots	130.6	4.57	42.6	80
MEAN			**150.9**	**5.28**	**42.1**	**78**
C.V. (%)			14.6	14.6	28.7	-
PR>F			0.6980	0.6980	0.9400	-
SE			4.02	0.141	2.20	-
LSD (0.05)			NS	NS	NS	-

Notes:
♣ Indicates nutrients utilization efficiency.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

3.3.2 Edible Beans Varieties… Cont'd from previous page

Averaged Over 2019 - 2020

VARIETIES	MARKET CLASS	SEED COAT COLOUR	GRAIN♣ kg/kg NUTRIENTS	GRAIN YIELD (MT/ha)	100 K WT (g)	TEST WT (kg/hl)
AC Earlired	Small Red	Red	71.0	3.35	33.7	81
AAC Whitestar	Great Northern	White	79.8	3.71	41.3	77
AAC Y012	Yellow	Yellow	74.6	3.19	41.5	81
AAC Y015	Yellow	Yellow	84.4	3.73	43.5	86
AAC Whitehorse	Great Northern	White	83.1	3.70	36.7	77
Nautica	Navy	White	63.3	2.77	22.5	77
AAC Shock	**Navy**	**White**	**83.6**	**3.87**	**24.5**	**84**
AAC Argosy	**Navy**	**White**	**84.2**	**3.87**	**22.6**	**79**
AAC Scotty	**Cranberry**	**Cream with red spots**	**88.1**	**4.02**	**55.4**	**77**
AAC Expedition	Pinto	Cream with brown spots	65.9	2.90	41.4	81
MEAN			**77.8**	**3.51**	**36.3**	**80**

Notes:

♣ Indicates nutrients utilization efficiency.

3.3.3 Field Pea Varieties

PLANTING DATE: April 30, 2020
FERTILIZERS: 70 kg N/ha (152 kg/ha 46-0-0)
20 kg P_2O_5/ha (44 kg/ha 0-45-0)
20 kg K_2O /ha (33 kg/ha 0-0-60)
HERBICIDES: Rival @ 3 L/ha on May 14, 2020
HARVEST DATE: September 24, 2020
PREVIOUS CROP: Berseem clover

VARIETIES	KIND	BIOMASS [a] (MT/ha)
AAC Carver	Yellow	3.22 *a*
AAC Comfort	Green	2.45 *ab*
AAC Chrome	Yellow	2.39 *ab*
CDC Forest	**Green**	**3.39 *a***
CDC Spruce	**Green**	**3.31 *a***
CDC Spectrum	Yellow	2.37 *ab*
CDC Canary	Yellow	2.66 *ab*
Gold Harvest Bush Pea	Brown	1.20 *b*
AAC Profit	Yellow	2.64 *ab*
CDC Lewochko	**Yellow**	**3.82 *a***
MEAN		**2.75**
C.V. (%)		30.1
PR>F		0.7600
SE		0.130
LSD (0.05)		1.20

Notes:
Only plant biomass data were collected as the pods were eaten by geese and deer.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

3.3.4 Lentil Varieties

PLANTING DATE: May 14, 2020
FERTILIZERS: 74 kg N/ha (152 kg/ha 46-0-0, 38 kg/ha 11-52-0)
20 kg P_2O_5/ha (38 kg/ha 11-52-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
HERBICIDES: Rival @ 3 L/ha applied pre - emergent May 14, 2020
HARVEST DATE: August 25, 2020
PREVIOUS CROP: Berseem Clover

			…….YIELD…….				
VARIETIES	KIND	GRAIN♣ kg/kg NUTRIENTS [a]	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST INDEX (%) [a]	1000 K (g)
			.....(MT/ha).....				
CDC Rosetown	Yellow	3.3	0.38	1.57	1.95	20.4	29
CDC Impulse CL	Green	3.4	0.38	1.62	2.00	19.2	48
CDC Lima	**Yellow**	**3.9**	**0.44**	**2.12**	**2.56**	**17.7**	**61**
MEAN		**3.5**	**0.40**	**1.77**	**2.17**	**19.1**	**46**
C.V. (%)		26.8	26.8	27.3	23.8	26.7	-
PR>F		0.3183	0.3183	0.2620	0.1980	0.7426	-
SE		0.27	0.031	0.140	0.149	1.470	-
LSD (0.05)		NS	NS	NS	NS	NS	-

Notes:
♣ Indicates nutrients utilization efficiency.
a Letter codes not displayed for the means were not affected by the treatment (P>0.05)

3.3.4 Lentil Varieties…Cont'd from previous page
Average Over 2019- 2020

VARIETIES	KIND	GRAIN♣ kg/kg NUTRIENTS	…….YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K (g)
CDC Rosetown	Yellow	11.4	1.50	3.14	4.64	27.7	47
CDC Impulse CL	**Green**	**15.2**	**2.02**	**3.63**	**5.65**	**29.1**	**55**
CDC Lima	Yellow	15.1	2.00	3.48	5.48	30.1	55
MEAN		**13.9**	**1.84**	**3.42**	**5.26**	**29.0**	**52**

Notes:
♣ Indicates nutrients utilization efficiency.

Oil Seeds Varieties

3.4.1 Linseed Flax Coop Trial

PLANTING DATE: May 21, 2020
FERTILIZERS: 70 kg N/ha (152 kg/ha 46-0-0)
HERBICIDES: None
HARVEST DATE: September 23, 2020
PREVIOUS CROP: Soybean

VARIETIES	SEED♣ [b] kg/kg NUTRIENTS	SEED [b] YIELD (MT/ha)	….DAYS TO*…. FLOWER [b]	MATURE [b]
CDC Bethune	6.2	0.44	52 *ab*	106
AAC Bright	7.1	0.49	56 *a*	116
CDC Glas	5.9	0.42	51 *ab*	103
AAC Marvelous	**8.7**	**0.61**	**50 *ab***	**111**
CDC Rowland	6.3	0.44	53 *ab*	113
AAC Prairie Sunshine	8.3	0.58	51 *ab*	111
CDC Dorado	4.7	0.33	43 *b*	110
FP2573	7.5	0.53	51 *ab*	113
FP2591	**8.4**	**0.59**	**50 *ab***	**113**
FP2592	**10.5**	**0.74**	**50 *ab***	**111**
FP2596	5.5	0.39	50 *ab*	106
FP2597	7.6	0.53	48 *ab*	109
FP2598	6.6	0.46	48 *ab*	103
FP2599	4.9	0.34	53 *ab*	112
FP2600	5.9	0.42	51 *ab*	112
FP2601	4.6	0.32	57 *a*	112
FP2602	4.1	0.28	58 *a*	117
FP2603	6.3	0.44	51 *ab*	103
FP2604	7.8	0.55	54 *ab*	113
FP2605	4.0	0.28	57 *a*	113
MEAN	**6.6**	**0.46**	**52**	**110**
C.V. (%)	32.7	32.7	6.7	3.9
PR>F	0.0880	0.0880	0.0610	0.5600
SE	0.34	0.023	0.5	0.7
LSD (0.05)	4.3	0.30	6.9	8.9

Notes:

♣ Indicates nutrients utilization efficiency.

*Flowering: when 50% of the plants start to blossom; Maturity: when 75% bolls have turned brown.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

VARIETIES	STEM/STRAW DRY DOWN• (1-9)	DETERMINATE HABIT♠ (1-9) [b]	LODGING▼ (0-9)
CDC Bethune	4	7	0
AAC Bright	4	7	0
CDC Glas	4	7	0
AAC Marvelous	**4**	**5**	**0**
CDC Rowland	4	6	0
AAC Prairie Sunshine	4	7	0
CDC Dorado	4	5	0
FP2573	4	4	0
FP2591	**4**	**5**	**0**
FP2592	**4**	**6**	**0**
FP2596	4	7	0
FP2597	4	6	0
FP2598	4	5	0
FP2599	4	6	0
FP2600	4	5	0
FP2601	4	7	0
FP2602	4	3	0
FP2603	4	7	0
FP2604	4	7	0
FP2605	4	7	0
MEAN	**4**	**6**	**0**
C.V. (%)	-	21.5	-
PR>F	-	0.7200	-
SE	-	0.2	-
LSD (0.05)	-	2.7	-

Notes:

•Stem/Straw dry down is rated on the scale 1-9, where 1 = all stems grass green and 9 = all stems brown.

♠Determinant habit is rated on the scale 1-9, when 1 = greater than 40% plants with flowers/unopened buds and 9 = no plants with flowers and unopened buds.

▼Lodging is rated on the scale 0-9, where 0 = standing tall and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

3.4.2 Liberty Canola Varieties

PLANTING DATE: May 14, 2020

FERTILIZERS: 186 kg N/ha (239 kg/ha 46-0-0, 91 kg/ha 44-0-0, 38 kg/ha 11-52-0, 150 kg/ha 21-0-0-24)
20 kg P_2O_5/ha (38 kg/ha 11-52-0)
20 kg K_2O/ha (33 kg/ha 0-0-60) 36 kg S/ha (150 kg/ha 21-0-0-24)

HERBICIDES: Rival @ 3 L/ha applied pre-plant incorporate; May 14, 2020
Liberty @ 3 L/ha applied June 8, and June 18, 2020

HARVEST DATE: August 24, 2020

PREVIOUS CROP: Berseem Clover

		…….YIELD…….					……DAY TO…….		
	SEED ♣	SEED [a]	STRAW [a]	BIOMASS [b]	HARVEST	HEIGHT			LODGING▼
VARIETIES	kg/kg NUTRIENT [a]	.....(MT/ha).....			INDEX (%) [a]	(cm) [b]	FLOWER [a]	MATURE [a]	(0-9)
L255PC	8.3 *a*	2.17 *a*	4.42 *ab*	6.59	32.2 *ab*	91	45 *a*	99 *b*	0
L241C	6.3 *a*	1.65 *a*	5.36 *a*	7.01	23.3 *d*	94	44 *bc*	92 *g*	0
L230	8.3 *a*	2.18 *a*	4.33 *ab*	6.51	33.4 *ab*	96	44 *c*	98 *c*	0
L252	**8.5 *a***	**2.21 *a***	**3.48 *b***	**5.69**	**38.5 *a***	**91**	**45 *a***	**102 *a***	**0**
L345PC	8.3 *a*	2.18 *a*	5.13 *a*	7.31	29.8 *bcd*	99	45 *a*	93 *f*	0
L352C	**8.5 *a***	**2.23 *a***	**4.91 *a***	**7.14**	**31.1 *bc***	**92**	**45 *a***	**102 *a***	**0**
LR344PC	**9.2 *a***	**2.42 *a***	**5.40 *a***	**7.81**	**30.8 *bc***	**94**	**45 *ab***	**96 *d***	**0**
L234PC	6.3 *a*	1.66 *a*	4.90 *a*	6.56	25.3 *cd*	96	44 *abc*	95 *e*	0
B3010M	5.7 *a*	1.49 *a*	4.48 *ab*	5.97	24.5 *cd*	93	44 *bc*	95 *e*	0
MEAN	**7.7**	**2.02**	**4.71**	**6.73**	**29.9**	**94**	**44**	**97**	**0**
C.V. (%)	25.3	25.3	17.6	16.9	17.8	6.9	1.4	3.6	-
PR>F	**0.0282**	**0.0282**	0.0026	0.0852	**<0.0001**	0.6126	**<0.0001**	**<0.0001**	-
SE	0.32	0.085	0.138	0.190	0.88	1.1	1.4	0.6	-
LSD (0.05)	2.2	0.58	0.86	NS	4.1	NS	0.47	0.35	

Notes:

♣ Indicates nutrients utilization efficiency. **P stands for 'Shatter Reduction' and C stands for 'Clubroot Resistance'.**

LR344PC is both the LibertyLink® and TruFlex™ canola with Roundup Ready® Technology!

B3010M (straight cut from Brevant™ seeds) has resistance to Clubroot, Black Leg and Fusarium Wilt.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05). ▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

Liberty Canola Varieties…Cont'd from previous page
Averaged Over 2018 - 2020

VARIETIES	SEED ♣ kg/kg NUTRIENT	……YIELD……. SEED (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)	……DAY TO……. FLOWER	MATURE	LODGING▼ (0-9)
L255PC	22.8	3.70	6.04	9.74	30.0	116	51	104	0
L241C	21.9	4.17	7.25	11.43	30.5	114	50	102	0
L230	22.9	4.13	6.17	10.31	33.2	112	50	103	0
L252	**24.6**	**4.45**	**6.46**	**10.91**	**34.5**	**116**	**51**	**105**	**0**
MEAN	**23.1**	**4.11**	**6.48**	**10.59**	**32.0**	**115**	**50**	**104**	**0**

Notes:
♣ Indicates nutrients utilization efficiency.
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
P stands for 'Shatter Reduction' and C stands for 'Clubroot Resistance'.

3.4.3 Roundup Ready/Clearfield Canola Varieties

PLANTING DATE May 14, 2020

FERTILIZERS: 181 kg N/ha (239 kg/ha 46-0-0, 91 kg/ha 44-0-0, 150 kg/ha 21-0-0-24)
20 kg P_2O_5/ha (44 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
36 kg S/ha (150 kg/ha 21-0-0-24)

HERBICIDES: Rival @ 3 L/ha applied pre-plant incorporate; May 14, 2020
• Roundup @ 0.67 L/ha applied June 17, 2020
† Liberty @ 3.33 L/ha applied June 19, 2020
‡ Odyssey @ 43 g/ha applied June 19, 2020

HARVEST DATE: August 24, 2020

PREVIOUS CROP: Berseem Clover

			…….YIELD…….						
		SEED ♣	SEED [b]	STRAW [b]	BIOMASS [b]	HARVEST	HEIGHT	.....DAY TO.....	
VARIETIES	TRAIT	kg/kg NUTRIENT [b]	.....(MT/ha).....			INDEX (%) [b]	(cm) [b]	FLOWER [a]	MATURE [b]
CS2300 •	Roundup Ready	8.5	2.20	4.90	7.10	31.4	97	45 *a*	98
BY6204TF •	**Roundup Ready**	**9.0**	**2.32**	**4.79**	**7.11**	**32.8**	**93**	**44 *ab***	**98**
2028 ‡	Clearfield	5.6	1.45	3.91	5.36	27.1	87	45 *ab*	100
6086CR •	Roundup Ready	6.2	1.58	3.37	4.95	32.0	88	44 *b*	99
5545CL ‡	**Clearfield**	**9.8**	**2.53**	**5.21**	**7.74**	**32.5**	**97**	**45 *ab***	**102**
L241C †	**Liberty**	**9.8**	**2.52**	**6.01**	**8.53**	**29.6**	**95**	**44 *ab***	**93**
PV585GC •	Roundup Ready	6.6	1.69	4.79	6.48	25.7	91	44 *b*	102
MEAN		**7.9**	**2.04**	**4.71**	**6.75**	**30.1**	**93**	**45**	**99**
C.V. (%)		27.9	27.9	24.5	24.1	13.7	7.2	1.3	3.1
PR>F		0.9770	0.9770	0.2830	0.4530	0.0818	0.8840	**0.0116**	0.6000
SE		0.42	0.108	0.218	0.307	0.78	1.3	0.1	0.6
LSD (0.05)		NS	NS	NS	NS	NS	NS	1	NS

Notes:

♣ Indicates nutrients utilization efficiency. **BY6204TF** has DefendR rated Blackleg resistance plus Clubroot protection.

C in L241C stands for 'Clubroot Resistance'. L241C was included as a check.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

3.4.4 Winter Canola Varieties

PLANTING DATE: September 6, 2019
FERTILIZERS: 91 kg N/ha (152 kg/ha 46-0-0, 100 kg/ha 21-0-0-24)
50 kg P_2O_5/ha (111 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
24 kg S/ha (100 kg/ha 21-0-0-24)
HERBICIDES: None
HARVEST DATE: Winter canola didn't survive in the winter and hence there was nothing to harvest*.
PREVIOUS CROP: Winter rye

		…….YIELD…….					…….DAY TO…….		
	SEED ♣	SEED	STRAW	BIOMASS	HARVEST	HEIGHT			LODGING▼
VARIETIES	kg/kg NUTRIENT	.....(kg/ha).....			INDEX (%)	(cm)	FLOWER	MATURE	(0-9)
Mercedes									
Inspiration		**The two varieties didn't survive the winter of 2019-2020!**							
MEAN									

Notes:
♣ Indicates nutrients utilization efficiency.
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
***This is the second year when winter canola failed to survive at LUARS Thunder Bay.**

Mustard Varieties

PLANTING DATE: May 18, 2019
FERTILIZERS: 70 kg N/ha (154 kg/ha 46-0-0)
HERBICIDES: May 14, 2020 applied pre-plant incorporated; Rival @ 3 L/ha May 19, 2020 applied pre emergent; Roundup @ 3L/ha
HARVEST DATE: September 2, 2020
PREVIOUS CROP: Winter canola seeded in fall 2019; which hadn't survived

VARIETIES	MUSTARD TYPE	SEED ♣ [b] kg/kg NUTRIENT	……YIELD……. SEED [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST [b] INDEX (%)	……DAY TO……. FLOWER [b]	MATURE [b]	LODGING▼ (0-9)
AC Vulcan	**Oriental**	**9.5**	**0.66**	**1.88**	**2.54**	**25.9**	**42**	**95 *a***	**0**
Adagio	Yellow	7.5	0.52	2.89	3.41	14.5	38	95 *a*	0
AC 200	Oriental	9.1	0.64	2.59	3.23	20.0	40	91 *b*	0
AAC Brown 120	**Brown**	**12.3**	**0.86**	**2.80**	**3.66**	**23.7**	**40**	**89 *c***	**0**
MEAN		**9.6**	**0.67**	**2.54**	**3.21**	**21.0**	**40**	**92**	**0**
C.V. (%)		47.8	47.8	48.1	46.6	22.2	3.7	2.8	-
PR>F		0.1934	0.1934	0.2140	0.1778	0.9230	0.2510	**<0.0001**	-
SE		1.15	0.080	0.305	0.374	1.2	0.4	0.6	-
LSD (0.05)		NS	NS	NS	NS	NS	NS	1	-

Average Over 2018 - 2020

VARIETIES	MUSTARD TYPE	SEED ♣ kg/kg NUTRIENT	……YIELD……. SEED (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	DAY TO MATURE	LODGING▼ (0-9)
AC Vulcan	Oriental	11.1	1.39	3.04	4.43	30.1	101	0
Adagio	Yellow	8.5	1.04	3.79	4.84	20.5	101	0
AC 200	Oriental	12.4	1.58	3.67	5.26	28.2	100	0
AAC Brown 120 †	Brown	12.2	1.44	3.49	4.93	28.5	98	0
MEAN		**10.6**	**1.34**	**3.50**	**4.84**	**26.3**	**101**	**0**

Notes:

♣ Indicates nutrients utilization efficiency. † Average over 2019-2020

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

Forages Varieties

3.5.1 Comparative Performance of Alfalfa and Galega

PLANTING DATE: May 12, 2011 (Alfalfa and Galega)
FERTILIZER: 45 kg N/ha (62 kg/ha 46-0-0, 79 kg/ha 21-0-0-24) 1 kg B/ha (7 kg/ha 0-0-0-15)
60 kg K_2O/ha (100 kg/ha 0-0-60) 7 kg Zn/ha (35 kg/ha 0-0-0-16-20)
24 kg S /ha (79 kg/ha 21-0-0-24 , 35 kg/ha 0-0-0-16-20)
HERBICIDE: None
HARVEST DATES: June 12 and August 7, 2020

	……..DRY MATTER YIELD (kg/ha)……..							
	2018	2019	….....2020.....			2018 - 2020	2018 - 2020	2012 - 2020
CROPS/SEED RATES	TOTAL [b]	TOTAL [b]	1st CUT [a]	2nd CUT [b]	TOTAL [a]	TOTAL [b]	AVERAGE [b]	AVERAGE [b]
Alfalfa @ 13 kg/ha (Recommended seed rate)^	**4177**	**4653**	**2785 *a***	**2307**	**5092^ *a***	**13922**	**4166**	**4714**
Galega @ 25 kg/ha	4550	4587	2029 *b*	1592	3621 *b*	12758	4059	4978
Galega @ 35 kg/ha	4396	4704	2110 *b*	1188	3297 *b*	12397	4394	5245
Galega @ 45 kg/ha	**4347**	**4430**	**2159 *b***	**1627**	**3786 *b***	**12563**	**4285**	**5098**
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	4648	4661	1951 *b*	1628	3579 *b*	12888	4300	4839
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	4570	4661	2138 *b*	1609	3747 *b*	12978	4632	4709
MEAN	**4448**	**4616**	**2195**	**1658**	**3606**	**12918**	**4306**	**4930**
C.V. (%)	7.3	7.5	13.6	24.1	16.7	6.3	13.0	28.9
PR>F	0.3316	0.8787	**0.0074**	0.1220	**0.0290**	0.2697	0.4080	0.6400
SE	158.7	187.7	60.9	81.5	131.6	165.1	66.2	102.8
LSD (0.05)	NS	NS	385	NS	861	NS	NS	NS

Notes:
* Was seeded only in 2011.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)
^Mostly volunteer grasses; there was not much of alfalfa left in alfalfa plots!

	……..FRESH MATTER YIELD (kg/ha)……..							
	2018	2019	….....2020.....			2018 - 2020	2018 - 2020	2012 - 2020
CROPS/SEED RATES	TOTAL [b]	TOTAL [b]	1st CUT [b]	2nd CUT [b]	TOTAL [b]	TOTAL [a]	AVERAGE [b]	AVERAGE [b]
Alfalfa @ 13 kg/ha (Recommended seed rate)	**22297**	**25166**	**15245**	**7727**	**22973**	**70436 *a***	**23680**	**27156**
Galega @ 25 kg/ha	24921	28748	15747	5639	21387	75056 *a*	23926	30386
Galega @ 35 kg/ha	25917	27929	14984	3991	18975	72821 *a*	24929	31273
Galega @ 45 kg/ha	25633	27701	15146	5828	20974	74308 *a*	24155	31292
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	25990	28757	15069	5568	20637	75384 *a*	25166	29215
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	**25329**	**28980**	**15980**	**5498**	**21477**	**75786 *a***	**26076**	**28877**
MEAN	**25015**	**27880**	**15362**	**5708**	**21070**	**73965**	**24655**	**29700**
C.V. (%)	8.2	8.1	5.5	23.4	8.1	5.2	14.0	27.9
PR>F	0.0764	0.1187	0.5940	0.1255	0.3790	**0.0371**	0.2500	0.8700
SE	901.0	1039.0	171.7	272.4	347.5	790.4	406.1	597.0
LSD (0.05)	NS	NS	NS	NS	NS	4552.0	NS	NS

Notes:

* Was seeded only in 2011; Residual effect from the year 2011.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

Quality Parameters on Dry Matter Basis: First Cut

CROPS/SEED RATES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Alfalfa @ 13 kg/ha (Recommended seed rate)	20.8	35.9	1.32	36.6	30.9	40.9	70.0	1.60	0.88	1.47	147
Galega @ 25 kg/ha	23.6	35.7	2.22	36.8	35.0	47.0	68.4	1.56	0.79	1.37	122
Galega @ 35 kg/ha	22.7	35.7	2.37	36.8	35.4	47.0	68.8	1.57	0.78	1.36	121
Galega @ 45 kg/ha	22.8	35.8	2.05	36.7	34.3	46.0	68.7	1.56	0.80	1.38	126
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	21.7	35.7	2.30	36.7	37.5	51.9	66.4	1.51	0.73	1.30	107
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	21.1	35.7	2.12	36.7	37.0	49.4	67.4	1.53	0.74	1.31	113
MEAN	**22.1**	**35.7**	**2.06**	**36.7**	**35.0**	**47.0**	**68.3**	**1.56**	**0.79**	**1.37**	**123**

CROPS/SEED RATES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa @ 13 kg/ha (Recommended seed rate)	0.29	2.48	0.25	0.88	0.30	0.39	11.2	28.5	106	21.7	0.04
Galega @ 25 kg/ha	0.40	2.42	0.24	0.96	0.50	0.28	16.8	30.0	217	32.3	0.02
Galega @ 35 kg/ha	0.39	2.33	0.24	0.90	0.48	0.27	16.4	27.2	154	23.1	0.04
Galega @ 45 kg/ha	0.37	2.07	0.22	0.78	0.43	0.30	15.3	27.2	152	22.4	0.03
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	0.41	2.31	0.25	0.88	0.45	0.30	15.1	30.7	219	30.7	0.03
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	0.40	2.23	0.22	0.87	0.46	0.30	16.4	30.7	153	31.2	0.02
MEAN	**0.38**	**2.31**	**0.24**	**0.88**	**0.44**	**0.31**	**15.2**	**29.1**	**167**	**26.9**	**0.03**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

Quality Parameters on Dry Matter Basis: Second Cut

CROPS/SEED RATES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Alfalfa @ 13 kg/ha (Recommended seed rate)	16.2	36.1	0.97	36.5	34.0	44.3	66.5	1.51	0.81	1.39	131
Galega @ 25 kg/ha	18.1	36.0	1.53	36.6	34.3	47.4	66.8	1.52	0.80	1.38	122
Galega @ 35 kg/ha	17.0	36.1	1.62	36.5	34.7	48.5	67.7	1.54	0.79	1.37	119
Galega @ 45 kg/ha	17.0	36.0	1.51	36.6	35.0	46.9	67.4	1.53	0.79	1.37	122
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	17.3	36.1	1.53	36.5	35.2	47.6	66.8	1.52	0.78	1.36	120
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	18.8	35.9	1.46	36.6	32.2	46.1	68.3	1.55	0.85	1.44	129
MEAN	**17.4**	**36.0**	**1.44**	**36.6**	**34.2**	**46.8**	**67.2**	**1.53**	**0.80**	**1.39**	**124**

CROPS/SEED RATES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa @ 13 kg/ha (Recommended seed rate)	0.18	1.72	0.18	1.17	0.29	0.32	9.5	23.8	98	17.0	0.06
Galega @ 25 kg/ha	0.20	1.35	0.19	1.28	0.59	0.23	9.6	24.4	255	21.1	0.02
Galega @ 35 kg/ha	0.20	1.29	0.18	1.22	0.56	0.26	9.1	20.0	118	12.7	0.02
Galega @ 45 kg/ha	0.20	1.42	0.18	1.22	0.57	0.26	9.6	22.5	99	20.5	0.02
Galega @ 35 kg/ha + Berseem* @ 13 kg/ha	0.19	1.10	0.20	1.31	0.60	0.25	8.3	21.9	104	24.2	0.03
Galega @ 35 kg/ha + Berseem* @ 6.5 kg/ha	0.23	1.58	0.21	1.22	0.57	0.27	9.9	29.5	235	34.9	0.03
MEAN	**0.20**	**1.41**	**0.19**	**1.24**	**0.53**	**0.27**	**9.3**	**23.7**	**151**	**21.7**	**0.03**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

3.5.1 Comparative Performance of Alfalfa and Galega…Cont'd from previous page
Quality Parameters on Dry Matter Basis: First Cut 2016 - 2020

CROPS/SEED RATES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Alfalfa @ 13 kg/ha (Recommended seed rate)	17.7	41.7	1.55	33.9	34.9	46.0	66.2	1.50	0.81	1.42	132
Galega @ 25 kg/ha	19.9	38.4	1.93	32.7	37.4	48.5	63.4	1.43	0.71	1.32	111
Galega @ 35 kg/ha	19.1	35.3	1.95	34.1	37.2	48.0	64.4	1.46	0.73	1.33	115
Galega @ 45 kg/ha	20.4	36.9	2.09	34.0	36.7	48.0	65.1	1.48	0.74	1.34	117
MEAN	**19.3**	**38.1**	**1.88**	**33.7**	**36.5**	**47.6**	**64.8**	**1.47**	**0.75**	**1.35**	**119**

CROPS/SEED RATES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa @ 13 kg/ha (Recommended seed rate)	0.30	2.36	0.24	1.17	0.41	0.36	15.2	33.8	386	53.3	0.06
Galega @ 25 kg/ha	0.32	2.08	0.26	0.86	0.43	0.40	14.0	23.4	305	27.6	0.04
Galega @ 35 kg/ha	0.30	2.13	0.20	0.87	0.42	0.38	13.0	16.0	408	24.6	0.03
Galega @ 45 kg/ha	0.31	2.11	0.21	0.90	0.41	0.37	17.5	38.9	387	34.0	0.04
MEAN	**0.31**	**2.17**	**0.23**	**0.95**	**0.42**	**0.38**	**14.9**	**28.0**	**371**	**34.9**	**0.04**

Notes:
UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

Quality Parameters on Dry Matter Basis: Second Cut 2016 - 2020

CROPS/SEED RATES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
Alfalfa @ 13 kg/ha (Recommended seed rate)	15.0	29.2	1.09	24.9	26.5	35.5	52.6	1.19	0.66	1.16	107
Galega @ 25 kg/ha	18.1	29.3	1.49	25.6	27.3	36.6	51.9	1.18	0.64	1.14	102
Galega @ 35 kg/ha	16.7	29.8	1.65	26.5	28.8	38.6	51.1	1.16	0.61	1.10	95
Galega @ 45 kg/ha	17.0	28.8	1.51	21.4	28.3	38.0	51.5	1.17	0.62	1.11	97
MEAN	**16.7**	**29.3**	**1.44**	**24.6**	**27.7**	**37.2**	**51.8**	**1.18**	**0.63**	**1.13**	**100**

CROPS/SEED RATES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa @ 13 kg/ha (Recommended seed rate)	0.24	1.80	0.24	1.29	0.35	0.35	9.6	16.2	145	14.5	0.06
Galega @ 25 kg/ha	0.23	1.49	0.21	1.02	0.49	0.48	10.7	18.3	227	22.9	0.03
Galega @ 35 kg/ha	0.23	1.50	0.19	1.03	0.49	0.29	10.5	15.9	235	19.6	0.02
Galega @ 45 kg/ha	0.24	1.48	0.21	1.08	0.53	0.36	12.2	19.5	291	25.1	0.03
MEAN	**0.24**	**1.57**	**0.21**	**1.11**	**0.47**	**0.37**	**10.8**	**17.5**	**224**	**20.5**	**0.04**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

3.5.2 Optimizing Seeding Rate in Kernza and Comparing its Forage Production Potential with Perennial Rye and in Mixture with Alfalfa

PLANTING DATE: July 10, 2017
FERTILIZER: 70 kg N/ha (153 kg/ha 46-0-0)
20 kg P_2O_5/ha (45 kg/ha 0-45-0)
20 kg K_2O/ha (34 kg/ha 0-0-60)
HERBICIDE: None
HARVEST DATES: First cut: June 30, 2020
PREVIOUS CROP: Soybean

	DRY MATTER YIELD (kg/ha)				
	2018	2019	….....2020.....		2018-2020
TREATMENTS	TOTAL [a]	TOTAL [a]	1st CUT [a]	TOTAL [a]	TOTAL
80:20 Alfalfa and Kernza	**4142 *a***	**4259 *a***	**5761 *a***	**5761 *a***	**14162**
80:20 Alfalfa and Ace 1	3961 *ab*	3138 *b*	4676 *a*	4676 *a*	11775
Kernza @ 70 seed/m^2	4204 *a*	2943 *b*	3460 *a*	3460 *a*	10606
Kernza @ 90 seed/m^2	4943 *a*	3141 *b*	4384 *a*	4384 *a*	12468
Kernza @ 110 seed/m^2	4803 *a*	3099 *b*	3877 *a*	3877 *a*	11779
Kernza @ 130 seed/m^2	4948 *a*	3293 *b*	3618 *a*	3618 *a*	11859
Ace 1 @ 250 seed/m^2	2644 *b*	*N/A*	*N/A*	*N/A*	2644
MEAN	**4235**	**3312**	**4296**	**4296**	**10756**
C.V. (%)	22.0	17.6	32.5	32.5	-
PR>F	**0.0003**	**0.0008**	**0.0134**	**0.0134**	**-**
SE	301.6	213.8	284.7	284.7	-
LSD (0.05)	1346	807	1586	1586	-

Notes:
Kernza is a perennial wheatcrest grass variety. Ace 1 is a perennial rye variety
Ace 1 had extremely poor growth and high weed pressure in 2019 and 2020, therefore no harvesting was done
Second cut was not taken in 2020 due to poor regrowth
a Means with the same letter were not statistically different according to the Tukey-Kramer test (P=0.05)

3.5.2 Optimizing Seeding Rate in Kernza and Comparing its Forage Production Potential with Perennial Rye and in Mixture with Alfalfa...Cont'd from previous page

	FRESH MATTER YIELD (kg/ha)				
	2018	2019	….....2020.....		2018-2020
TREATMENTS	TOTAL [a]	TOTAL [a]	1st CUT [a]	TOTAL [a]	TOTAL
80:20 Alfalfa and Kernza	**17433 *a***	**22592 *a***	**19767 *a***	**19767 *a***	**59792**
80:20 Alfalfa and Ace 1	14754 *ab*	18978 *ab*	16633 *ab*	16633 *ab*	50365
Kernza @ 70 seed/m^2	15358 *ab*	16097 *b*	10517 *b*	10517 *b*	41972
Kernza @ 90 seed/m^2	18263 *a*	17704 *b*	12933 *ab*	12933 *ab*	48900
Kernza @ 110 seed/m^2	17713 *a*	17892 *b*	12250 *ab*	12250 *ab*	47855
Kernza @ 130 seed/m^2	18461 *a*	16684 *b*	11317 *b*	11317 *b*	46462
Ace 1 @ 250 seed/m^2	11955 *b*	*N/A*	*N/A*	*N/A*	11955
MEAN	**16277**	**18325**	**13903**	**13903**	**49224**
C.V. (%)	18.5	16.4	36.6	36.6	-
PR>F	**0.0029**	**0.0023**	**0.0032**	**0.0032**	-
SE	1145.3	1182.3	1038.6	1038.6	-
LSD (0.05)	4225	3892	5587	5587	-

Notes:

Kernza is a perennial wheatcrest grass variety. Ace 1 is a perennial rye variety

Ace 1 had extremely poor growth and high weed pressure in 2019 and 2020, therefore no harvesting was done

Second cut was not taken in 2020 due to poor regrowth

a Means with the same letter were not statistically different according to the Tukey-Kramer test (P=0.05)

3.5.2 Optimizing Seeding Rate in Kernza and Comparing its Forage Production Potential with Perennial Rye and in Mixture with Alfalfa…Cont'd from previous page

Quality Parameters on Dry Matter Basis: First Cut

TREATMENTS	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
80:20 Alfalfa and Kernza	16.7	36.1	0.90	36.5	35.2	48.5	63.5	1.44	0.78	1.36	119
80:20 Alfalfa and Ace 1	17.4	36.0	1.09	36.6	36.0	43.7	63.9	1.44	0.76	1.34	130
Kernza @ 70 seed/m^2	11.8	36.7	0.61	36.2	37.2	55.3	64.1	1.45	0.74	1.31	101
Kernza @ 90 seed/m^2	10.6	36.8	0.49	36.1	39.7	59.9	62.4	1.41	0.68	1.25	90
Kernza @ 110 seed/m^2	11.5	36.6	0.53	36.2	38.4	58.4	62.7	1.42	0.70	1.27	94
Kernza @ 130 seed/m^2	11.4	36.7	0.53	36.2	37.4	57.4	64.1	1.45	0.73	1.30	97
Ace 1 @ 250 seed/m^2					*N/A*						
MEAN	**13.2**	**36.5**	**0.69**	**36.3**	**37.3**	**53.9**	**63.4**	**1.44**	**0.73**	**1.31**	**105**

TREATMENTS	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
80:20 Alfalfa and Kernza	0.18	1.54	0.14	1.50	0.33	0.35	8.3	16.0	69	24.1	0.09
80:20 Alfalfa and Ace 1	0.20	1.65	0.16	1.74	0.36	0.33	8.9	18.6	55	19.6	0.10
Kernza @ 70 seed/m^2	0.21	1.83	0.11	0.43	0.16	0.46	4.4	14.4	77	31.4	0.03
Kernza @ 90 seed/m^2	0.18	1.52	0.09	0.35	0.14	0.45	3.3	12.6	69	31.3	0.02
Kernza @ 110 seed/m^2	0.21	1.93	0.10	0.43	0.14	0.47	4.7	14.5	90	27.8	0.03
Kernza @ 130 seed/m^2	0.21	1.76	0.10	0.40	0.16	0.47	3.9	14.3	82	32.7	0.03
Ace 1 @ 250 seed/m^2					*N/A*						
MEAN	**0.20**	**1.71**	**0.12**	**0.81**	**0.22**	**0.42**	**5.6**	**15.1**	**74**	**27.8**	**0.05**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

Second cut was not taken in 2020 due to poor regrowth

3.5.2 Optimizing Seeding Rate in Kernza and Comparing its Forage Production Potential with Perennial Rye and in Mixture with Alfalfa…Cont'd from previous page

Quality Parameters on Dry Matter Basis: First Cut Average 2018-2020

TREATMENTS	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
80:20 Alfalfa and Kernza	16.8	35.9	1.17	33.7	34.1	47.5	63.5	1.44	0.81	1.39	123
80:20 Alfalfa and Ace 1	16.7	36.0	1.14	33.3	34.3	45.4	64.1	1.45	0.80	1.38	128
Kernza @ 70 seed/m^2	13.0	36.3	0.83	34.3	35.6	55.6	64.3	1.46	0.77	1.35	102
Kernza @ 90 seed/m^2	11.9	36.4	0.86	34.1	37.7	58.4	63.0	1.43	0.73	1.30	95
Kernza @ 110 seed/m^2	12.6	36.3	0.88	34.2	36.9	57.3	63.1	1.43	0.74	1.32	98
Kernza @ 130 seed/m^2	12.4	36.4	0.84	33.9	36.4	57.2	63.7	1.44	0.76	1.33	99
Ace 1 @ 250 seed/m^2 •	13.3	36.1	1.12	31.4	37.6	60.9	64.0	1.45	0.72	1.29	91
MEAN	**13.8**	**36.2**	**0.98**	**33.6**	**36.1**	**54.6**	**63.7**	**1.44**	**0.76**	**1.34**	**105**

TREATMENTS	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
80:20 Alfalfa and Kernza	0.24	2.04	0.22	1.43	0.30	0.41	9.2	19.4	90	30.7	0.08
80:20 Alfalfa and Ace 1	0.24	2.01	0.22	1.49	0.31	0.41	9.0	19.6	75	28.0	0.08
Kernza @ 70 seed/m^2	0.25	2.26	0.17	0.44	0.17	0.54	5.9	15.7	97	33.3	0.05
Kernza @ 90 seed/m^2	0.23	2.13	0.16	0.44	0.17	0.53	5.2	14.6	96	34.8	0.04
Kernza @ 110 seed/m^2	0.25	2.36	0.17	0.48	0.17	0.55	6.0	15.6	109	32.8	0.05
Kernza @ 130 seed/m^2	0.25	2.25	0.16	0.43	0.17	0.55	5.4	14.9	97	34.5	0.04
Ace 1 @ 250 seed/m^2 •	0.28	2.29	0.19	0.33	0.14	0.66	7.6	29.7	96	35.0	0.04
MEAN	**0.25**	**2.19**	**0.18**	**0.72**	**0.20**	**0.52**	**6.9**	**18.5**	**94**	**32.7**	**0.05**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

• Ace 1 quality from 2018 only

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory

PLANTING DATE: July 7, 2017
FERTILIZER: 70 kg N/ha (143 kg/ha 46-0-0, 39 kg/ha 11-52-0)
20 kg P_2O_5/ha (39 kg/ha 11-52-0)
20 kg K_2O/ha (34 kg/ha 0-0-60)
HERBICIDE: None
HARVEST DATES: First cut: June 29, 2020 Treatments 1, 5-9 Second cut: August 6, 2020 Treatments 5-9
PREVIOUS CROP: Soybean

			DRY MATTER YIELD (kg/ha)					
			2018	2019	….....2020.....			2018 - 2020
Trt #	VARIETIES	CROP	TOTAL[a]	TOTAL[a]	1st CUT [b]	2nd CUT [b]	TOTAL [a]	TOTAL
1	Kernza	Perennial Wheatgrass	4518 *a*	4328 *a*	4960	-	4960 *b*	13806
2	Ace 1	Perennial Rye	3179 *bc*	1459 *b*	-	-	-	4638
4	Choice Chicory	Chicory	735 *e*	1042 *b*	-	-	-	1777
5	**WL319HQ**	**Roundup Ready Alfalfa**	**5101 *a***	**4429 *a***	**6680**	**1795**	**8475 *a***	**18005**
6	WL354HQ	Roundup Ready Alfalfa	4268 *a*	4093 *a*	4732	2000	6732 *ab*	15093
7	135	Alfalfa	4842 *a*	4030 *a*	5954	1823	7777 *a*	16649
8	Instinct	Alfalfa	4785 *a*	4378 *a*	5655	1866	7521 *ab*	16684
9	Mission HVXRR	Roundup Ready Alfalfa	4143 *ab*	4486 *a*	4445	1726	6170 *ab*	14799
10	Mountianview	Sainfoin	2259 *cd*	1104 *b*	-	-	-	3363
11	Glenview	Sainfoin	1967 *d*	662 *b*	-	-	-	2629
	MEAN		**3580**	**3001**	**5404**	**1842**	**6939**	**10744**
	C.V. (%)		41.2	50.6	17.7	11.1	18.8	-
	PR>F		**<0.0001**	**<0.0001**	0.7800	0.3800	**0.0540**	-
	SE		226.3	244.0	195.2	45.9	266.7	-
	LSD (0.05)		2141	2389	NS	NS	1835	-

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Perennial Rye, Chicory, and Sainfoindidn't survive this year

A second cut of Kernza was not taken due to poor regrowth

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory… Cont'd from previous page

			FRESH MATTER YIELD (kg/ha)					
			2018	2019	….....2020.....			2018 - 2020
Trt	VARIETIES	CROP	TOTAL[a]	TOTAL[a]	1st CUT [b]	2nd CUT [b]	TOTAL [a]	TOTAL
1	Kernza	Perennial Wheatgrass	18894 *a*	20463 *b*	16217	-	16217 *b*	55574
2	Ace 1	Perennial Rye	13459 *bc*	8849 *c*	-	-	-	22308
4	Choice Chicory	Chicory	5051 *d*	6601 *c*	-	-	-	11652
5	**WL319HQ**	**Roundup Ready Alfalfa**	**20803 *a***	**25546 *a***	**24783**	**6583**	**31367 *a***	**77716**
6	WL354HQ	Roundup Ready Alfalfa	18378 *ab*	22475 *ab*	18883	7770	26603 *ab*	67456
7	135	Alfalfa	20187 *a*	23451 *ab*	23233	6771	30005 *a*	73643
8	Instinct	Alfalfa	20974 *a*	25061 *ab*	20967	7249	28216 *a*	74251
9	Mission HVXRR	Roundup Ready Alfalfa	17606 *ab*	24538 *ab*	16183	6679	22862 *ab*	65006
10	Mountianview	Sainfoin	9632 *cd*	7379 *c*	-	-	-	17011
11	Glenview	Sainfoin	8612 *cd*	5057 *c*	-	-	-	13669
	MEAN		**15360**	**16942**	**20044**	**7010**	**25878**	**47829**
	C.V. (%)		37.9	46.6	19.2	11.9	21.5	-
	PR>F		**<0.0001**	**<0.0001**	0.5400	0.7990	**0.0140**	-
	SE		1023.5	1084.7	784.6	186.2	1133.5	-
	LSD (0.05)		8450	12487	5860	NS	7368	-

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Perennial Rye, Chicory, and Sainfoindidn't survive this year

A second cut of Kernza was not taken due to poor regrowth

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory…Cont'd from previous page

Quality Parameters on Dry Matter Basis: First Cut

VARIETIES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
Kernza	16.4	36.1	0.94	36.5	37.5	45.3	62.9	1.42	0.73	1.30	123
WL319HQ	16.9	36.1	0.98	36.5	37.1	45.2	62.6	1.41	0.74	1.31	124
WL354HQ	17.7	35.9	0.90	36.6	35.2	43.2	64.2	1.45	0.78	1.36	132
135	17.6	36.0	0.98	36.6	34.9	43.7	63.9	1.45	0.79	1.37	131
Instinct	13.8	36.5	0.53	36.3	35.8	55.2	64.2	1.45	0.77	1.35	103
Mission HVXRR	16.7	36.1	0.84	36.5	34.6	42.3	65.5	1.40	0.79	1.37	136
MEAN	**16.5**	**36.1**	**0.86**	**36.5**	**35.8**	**45.8**	**63.9**	**1.43**	**0.77**	**1.34**	**125**

VARIETIES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Kernza	0.23	2.18	0.13	0.43	0.14	0.50	4.3	16.3	85	28.9	0.04
WL319HQ	0.18	1.66	0.14	1.67	0.31	0.36	9.8	18.6	53	30.7	0.05
WL354HQ	0.22	1.76	0.12	1.99	0.30	0.36	9.1	16.9	51	29.7	0.07
135	0.17	1.60	0.18	2.00	0.36	0.34	9.7	18.1	53	22.2	0.06
Instinct	0.19	1.52	0.12	1.70	0.27	0.37	9.1	17.2	55	24.1	0.08
Mission HVXRR	0.20	1.45	0.13	2.01	0.32	0.34	9.7	17.6	46	27.4	0.07
MEAN	**0.20**	**1.70**	**0.14**	**1.63**	**0.28**	**0.38**	**8.6**	**17.4**	**57**	**27.2**	**0.06**

Notes:

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory…Cont'd from previous page
Quality Parameters on Dry Matter Basis: Second Cut

VARIETIES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
WL319HQ	18.7	35.9	1.20	36.7	33.7	42.5	65.2	1.48	0.81	1.39	137
WL354HQ	19.4	35.8	1.11	36.7	31.9	41.2	66.4	1.51	0.86	1.45	145
135	19.1	35.9	1.23	36.6	33.7	42.9	64.9	1.47	0.82	1.40	136
Instinct	19.2	35.7	1.29	36.7	33.8	43.7	64.9	1.47	0.81	1.39	133
Mission HVXRR	18.9	35.8	1.12	36.7	32.9	41.8	66.3	1.50	0.84	1.42	141
MEAN	**19.1**	**35.8**	**1.19**	**36.7**	**33.2**	**42.4**	**65.5**	**1.49**	**0.83**	**1.41**	**138**

VARIETIES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
WL319HQ	0.24	2.03	0.16	1.78	0.34	0.33	11.0	25.0	97	51.2	0.06
WL354HQ	0.25	2.04	0.15	1.93	0.34	0.32	11.2	25.8	102	45.8	0.08
135	0.28	2.00	0.18	1.95	0.39	0.33	12.3	28.1	191	51.6	0.06
Instinct	0.25	2.20	0.16	1.78	0.33	0.32	10.1	25.1	229	47.7	0.06
Mission HVXRR	0.26	2.08	0.16	1.78	0.33	0.34	10.7	25.2	106	44.9	0.06
MEAN	**0.26**	**2.07**	**0.16**	**1.84**	**0.35**	**0.33**	**11.1**	**25.8**	**145**	**48.2**	**0.06**

Notes:
UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.
A second cut of Kernza was not taken do to poor growth

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory…Cont'd from previous page

Quality Parameters on Dry Matter Basis: First Cut 2018 - 2020 Average

VARIETIES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
Kernza	14.7	36.0	0.89	34.2	33.7	50.1	75.5	1.49	0.82	1.40	117
Ace 1	16.0	35.9	1.44	33.5	33.7	51.5	65.3	1.48	0.82	1.40	114
Choice Chicory	19.7	34.9	2.24	40.8	35.0	44.6	60.8	1.37	0.79	1.37	130
WL319HQ	18.1	35.8	1.27	34.2	33.5	42.6	64.3	1.45	0.82	1.40	139
WL354HQ	18.7	35.7	1.42	34.7	33.1	44.0	63.7	1.44	0.83	1.41	134
135	18.2	35.8	1.29	34.3	33.0	45.1	62.4	1.41	0.83	1.42	132
Instinct	17.3	35.9	1.14	33.1	33.6	47.9	63.6	1.44	0.82	1.40	124
Mission HVXRF	18.2	35.8	1.17	33.7	31.9	44.2	64.5	1.42	0.86	1.44	135
Mountianview	15.9	35.7	2.74	36.7	34.2	46.0	58.2	1.31	0.81	1.41	126
Glenview	14.7	36.0	1.94	36.8	33.0	45.0	61.8	1.40	0.84	1.42	132
MEAN	**17.1**	**35.8**	**1.55**	**35.2**	**33.5**	**46.1**	**64.0**	**1.42**	**0.82**	**1.41**	**128**

VARIETIES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Kernza	0.24	2.39	0.16	0.41	0.14	0.59	6.2	21.6	183	34.1	0.02
Ace 1	0.29	2.67	0.22	0.63	0.24	0.56	8.8	22.6	122	37.4	0.04
Choice Chicory	0.33	2.92	0.34	1.78	0.53	0.13	12.2	28.6	300	50.3	0.64
WL319HQ	0.26	2.14	0.22	1.70	0.32	0.39	11.0	23.6	93	31.6	0.05
WL354HQ	0.29	2.34	0.27	1.99	0.35	0.38	11.5	26.8	116	34.4	0.08
135	0.26	2.20	0.26	1.80	0.33	0.37	10.9	23.4	98	27.2	0.06
Instinct	0.26	2.12	0.24	1.81	0.31	0.37	10.7	28.6	97	30.0	0.08
Mission HVXRF	0.26	2.17	0.22	1.85	0.32	0.40	11.1	22.1	99	29.5	0.08
Mountianview	0.33	2.89	0.28	1.30	0.35	0.28	11.4	45.8	171	44.5	0.03
Glenview	0.30	2.66	0.24	1.11	0.37	0.38	10.0	24.9	244	36.5	0.04
MEAN	**0.28**	**2.45**	**0.24**	**1.44**	**0.33**	**0.38**	**10.4**	**26.8**	**152**	**35.6**	**0.11**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

3.5.3 Comparative Performance of Kernza, Perennial Rye, Roundup Ready Alfalfa, Conventional Alfalfa, Sainfoin, and Chicory…Cont'd from previous page

Quality Parameters on Dry Matter Basis: Second cCut 2018 - 2020 Average

VARIETIES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
Kernza	12.9	36.1	0.76	33.7	33.9	56.1	63.3	1.43	0.82	1.40	104
Ace 1	13.8	35.9	1.55	36.4	39.5	36.3	58.8	1.32	0.68	1.25	96
Choice Chicory	-	-	-	-	-	-	-	-	-	-	-
WL319HQ	15.4	35.9	1.25	33.9	37.4	50.4	58.4	1.31	0.72	1.29	116
WL354HQ	19.3	35.7	1.23	35.0	32.3	45.5	62.1	1.40	0.85	1.44	131
135	18.8	35.5	1.20	36.1	33.0	45.7	62.0	1.40	0.83	1.42	130
Instinct	18.7	35.7	1.38	34.9	33.6	46.3	61.7	1.39	0.82	1.40	126
Mission HVXRF	20.0	35.6	1.40	35.2	31.4	44.2	63.5	1.43	0.87	1.45	136
Mountianview	17.2	35.4	1.28	36.1	32.4	45.0	62.8	1.42	0.85	1.43	132
Glenview	16.3	35.9	1.49	35.7	31.8	43.9	62.7	1.42	0.86	1.45	136
MEAN	**16.9**	**35.7**	**1.28**	**35.2**	**33.9**	**45.9**	**61.7**	**1.39**	**0.81**	**1.39**	**123**

VARIETIES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Kernza	0.25	2.26	0.18	0.83	0.25	0.63	6.2	17.9	196	65.0	0.05
Ace 1	0.28	2.81	0.23	0.94	0.38	0.50	8.5	30.2	150	69.8	0.11
Choice Chicory	-	-	-	-	-	-	-	-	-	-	-
WL319HQ	0.26	1.97	0.23	1.78	0.36	0.34	10.8	23.0	102	41.0	0.10
WL354HQ	0.27	2.13	0.25	1.90	0.38	0.38	11.8	24.5	107	41.0	0.11
135	0.30	2.11	0.27	1.93	0.38	0.35	12.5	30.0	152	41.9	0.08
Instinct	0.29	2.41	0.27	1.83	0.36	0.40	12.1	25.6	181	43.5	0.09
Mission HVXRF	0.29	2.27	0.30	2.01	0.38	0.34	12.7	28.9	144	46.5	0.10
Mountianview	0.29	2.40	0.27	1.63	0.40	0.34	12.0	31.1	125	54.9	0.09
Glenview	0.29	2.40	0.29	1.87	0.45	0.25	11.1	31.2	258	62.4	0.12
MEAN	**0.28**	**2.31**	**0.25**	**1.64**	**0.37**	**0.39**	**10.9**	**26.9**	**157**	**51.8**	**0.09**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

4. Fertilizer Management Practices

Cereals

4.1.1 Nitrogen and Sulphur Management for Malting Barley Production

PLANTING DATE: May 13, 2020
FERTILIZERS: N and S as per treatments
20 kg P_2O_5/ha (45 kg/ha 0-45-0)
20 kg K_2O/ha (33kg/ha 0-0-60)
HERBICIDE: Logic M @ 1.25L/ha applied post - emergent; June 1, 2020;
HARVEST DATE: August 14, 2020
VARIETY CDC Bow
PREVIOUS CROP: Spring wheat

…….FACTOR A X B…….		GRAIN kg/kg	…….YIELD…….			
MAIN PLOT	SUB PLOT	NUTRIENTS ♣ [a]	GRAIN [a]	STRAW [b]	BIOMASS [a]	HARVEST INDEX (%) [b]
			.....(MT/ha).....			
1. Check (Zero N)	Zero S	45.8 *a*	1.83 *a*	1.18	3.01 *abc*	60.5
2. Urea @ 35 kg N/ha	Zero S	37.1 *ab*	2.78 *a*	0.73	3.52 *abc*	75.6
3. Urea @ 70 kg N/ha	Zero S	25.1 *ab*	2.76 *a*	0.77	3.53 *abc*	69.7
4. Urea @ 105 kg N/ha	Zero S	19.6 *ab*	2.84 *a*	2.14	4.97 *abc*	57.3
5. Urea + ESN @ 35 kg N/ha♦	Zero S	36.8 *ab*	2.76 *a*	1.27	4.03 *abc*	64.2
6. Urea + ESN @ 70 kg N/ha♦	Zero S	21.8 *ab*	2.40 *a*	2.33	4.73 *abc*	50.5
7. Urea + ESN @ 105 kg N/ha♦	Zero S	20.9 *ab*	3.03 *a*	2.68	5.71 *a*	52.6
8. Check (Zero N)	8 kg S/ha	25.4 *ab*	1.22 *a*	1.31	2.53 *c*	50.2
9. Urea @ 35 kg N/ha	8 kg S/ha	20.3 *ab*	1.68 *a*	1.81	3.49 *abc*	49.3
10. Urea @ 70 kg N/ha	8 kg S/ha	21.3 *ab*	2.51 *a*	2.58	5.09 *abc*	48.6
11. Urea @ 105 kg N/ha	8 kg S/ha	16.5 *ab*	2.52 *a*	1.68	4.20 *abc*	60.6
12. Urea + ESN @ 35 kg N/ha♦	8 kg S/ha	22.5 *ab*	1.87 *a*	1.67	3.54 *abc*	53.3
13. Urea + ESN @ 70 kg N/ha♦	8 kg S/ha	13.9 *ab*	2.82 *a*	2.13	4.95 *abc*	57.5
14. Urea + ESN @ 105 kg N/ha♦	8 kg S/ha	12.3 *b*	1.88 *a*	2.30	4.18 *abc*	47.4
15. Check (Zero N)	16 kg S/ha	23.3 *ab*	1.31 *a*	1.33	2.63 *bc*	48.1
16. Urea @ 35 kg N/ha	16 kg S/ha	15.7 *ab*	1.43 *a*	1.96	3.39 *abc*	39.6
17. Urea @ 70 kg N/ha	16 kg S/ha	20.9 *ab*	2.64 *a*	1.94	4.58 *abc*	57.5
18. Urea @ 105 kg N/ha	16 kg S/ha	17.2 *ab*	2.78 *a*	2.51	5.29 *ab*	51.6
19. Urea + ESN @ 35 kg N/ha♦	16 kg S/ha	21.3 *ab*	1.94 *a*	1.90	3.84 *abc*	50.5
20. Urea + ESN @ 70 kg N/ha♦	16 kg S/ha	21.1 *ab*	2.66 *a*	2.03	4.68 *abc*	56.7
21. Urea + ESN @ 105 kg N/ha♦	16 kg S/ha	15.5 *ab*	2.44 *a*	1.90	4.34 *abc*	56.5
MEAN		**22.6**	**2.29**	**1.82**	**4.11**	**55.1**
C.V. (%)		59.2	47.4	51.6	30.3	34.9
PR>F - A		**0.0350**	**0.0365**	0.0560	**0.0007**	0.9939
PR>F - B		**0.0022**	0.0926	0.3420	0.6280	0.1211
PR>F - (A x B)		0.6777	0.9445	0.3430	0.5060	0.7228
SE - (A x B)		1.47	0.12	0.10	0.14	2.10
LSD (0.05)		15.6	1.42	NS	1.39	NS

Notes:
♣Indicates nutrients utilization efficiency
♦ Blend of Urea and ESN 3:1 on N basis
Sulphur was supplied through gypsum
Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 6, Nitrate N: 8.75, Total N: 14.75, and S: 5.75
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

…….FACTOR A X B…….		1000 K	TEST WT.	DAYS TO	LODGING▼	HEIGHT [b]	PLANT [b]	…..TILLERS/….. [b]	
MAIN PLOT	SUB PLOT	WT.(g)	(kg/hl)	MATURE	(0-9)	(cm)	(m^2)	(m^2)	PLANT
1. Check (Zero N)	Zero S	51	60	83	0	45	217	500	2.4
2. Urea @ 35 kg N/ha	Zero S	48	60	83	0	43	203	427	2.2
3. Urea @ 70 kg N/ha	Zero S	47	61	83	0	44	277	477	2.5
4. Urea @ 105 kg N/ha	Zero S	52	62	83	0	48	180	420	2.3
5. Urea + ESN @ 35 kg N/ha	Zero S	50	61	83	0	43	177	490	3.3
6. Urea + ESN @ 70 kg N/ha	Zero S	49	60	83	0	46	177	500	3.1
7. Urea + ESN @ 105 kg N/ha	Zero S	53	62	83	0	44	243	587	2.6
8. Check (Zero N)	8 kg S/ha	53	62	83	0	44	217	397	2.0
9. Urea @ 35 kg N/ha	8 kg S/ha	52	61	83	0	44	160	427	2.7
10. Urea @ 70 kg N/ha	8 kg S/ha	52	61	83	0	45	233	433	2.2
11. Urea @ 105 kg N/ha	8 kg S/ha	51	62	83	0	45	183	493	2.9
12. Urea + ESN @ 35 kg N/ha	8 kg S/ha	47	61	83	0	45	213	457	2.3
13. Urea + ESN @ 70 kg N/ha	8 kg S/ha	52	62	83	0	45	180	527	2.8
14. Urea + ESN @ 105 kg N/ha	8 kg S/ha	51	61	83	0	44	183	620	3.7
15. Check (Zero N)	16 kg S/ha	53	60	83	0	43	170	493	3.0
16. Urea @ 35 kg N/ha	16 kg S/ha	52	60	83	0	44	190	363	2.0
17. Urea @ 70 kg N/ha	16 kg S/ha	52	62	83	0	42	193	443	2.4
18. Urea @ 105 kg N/ha	16 kg S/ha	51	62	83	0	45	230	460	2.6
19. Urea + ESN @ 35 kg N/ha	16 kg S/ha	51	61	83	0	46	193	437	2.2
20. Urea + ESN @ 70 kg N/ha	16 kg S/ha	53	62	83	0	46	170	367	2.2
21. Urea + ESN @ 105 kg N/ha	16 kg S/ha	50	61	83	0	44	183	477	3
MEAN		**51**	**61**	**83**	**0**	**44**	**199**	**466**	**2.6**
C.V. (%)		-	-	-	-	7.8	32.6	27.4	39.2
PR>F - A		-	-	-	-	0.3066	0.3066	0.1550	0.5224
PR>F - B		-	-	-	-	0.7673	0.7673	0.2620	0.8072
PR>F - (A x B)		-	-	-	-	0.7684	0.7684	0.8210	0.5127
SE - (A x B)		-	-	-	-	0.4	7.1	14.0	0.11
LSD (0.05)		-	-	-	-	NS	NS	NS	NS

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Cont'd from Previous page

FACTOR A	GRAIN ♣ [a] kg/kg NUTRIENTS	……YIELD……. GRAIN [a] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [b]
1. Check (Zero N)	31.5 *a*	1.45 *b*	1.27	2.73 *c*	52.9
2. Urea @ 35 kg N/ha	24.4 *ab*	1.97 *ab*	1.50	3.46 *bc*	54.9
3. Urea @ 70 kg N/ha	20.3 *ab*	2.62 *ab*	1.86	4.48 *ab*	57.6
4. Urea @ 105 kg N/ha	17.8 *ab*	2.71 *a*	2.11	4.82 *a*	56.5
5. Urea + ESN @ 35 kg N/ha	26.9 *ab*	2.19 *ab*	1.61	3.80 *abc*	56.0
6. Urea + ESN @ 70 kg N/ha	22.3 *ab*	2.63 *ab*	2.16	4.79 *a*	54.9
7. Urea + ESN @ 105 kg N/ha	16.1 *b*	2.45 *ab*	2.29	4.74 *a*	52.2
PR>F - A	**0.0215**	**0.0267**	0.0592	**0.0002**	0.9935
SE - (A)	2.02	0.172	0.144	0.306	0.73
LSD (0.05)	9.93	0.795	NS	0.833	NS

FACTOR B	GRAIN ♣ [a] kg/kg NUTRIENTS	……YIELD……. GRAIN [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]
1. Zero S	29.7 *a*	2.62	1.62	4.24	61.2
2. 8 kg S/ha	20.3 *b*	2.07	1.92	3.99	52.4
3. 16 kg S/ha	19.3 *b*	2.17	1.94	4.11	51.5
PR>F - B	**0.0029**	0.1108	0.3650	0.7710	0.0958
SE - (B)	3.31	0.169	0.103	0.072	3.09
LSD (0.05)	6.61	NS	NS	NS	NS

Notes:

♣Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Cont'd from Previous page

FACTOR A	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT [b] (cm)	PLANT [b] (m^2)	…..TILLERS….. [b] (m^2)	PLANT
1. Check (Zero N)	49	60	44	201	463	2.5
2. Urea @ 35 kg N/ha	50	61	43	184	406	2.3
3. Urea @ 70 kg N/ha	53	62	44	234	451	2.3
4. Urea @ 105 kg N/ha	50	61	46	198	458	2.6
5. Urea + ESN @ 35 kg N/ha	52	61	45	194	461	2.6
6. Urea + ESN @ 70 kg N/ha	52	61	46	176	464	2.7
7. Urea + ESN @ 105 kg N/ha	51	61	44	203	561	3.1
PR>F - A	-	-	0.2590	0.3349	0.1290	0.5206
SE - (A)	-	-	0.4	7.0	17.6	0.10
LSD (0.05)	-	-	NS	NS	NS	NS

FACTOR B	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT [b] (cm)	PLANT [b] (m^2)	…..TILLERS….. [b] (m^2)	PLANT
1. Zero S	52	61	45	210	486	2.6
2. 8 kg S/ha	51	61	44	196	479	2.7
3. 16 kg S/ha	50	61	44	190	434	2.5
PR>F - B	-	-	0.7600	0.4237	0.2570	0.7965
SE - (B)	-	-	0.3	5.9	16.3	0.06
LSD (0.05)	-	-	NS	NS	NS	NS

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.1.1 Nitrogen and Sulphur Management for Malting Barley Production…Cont'd from Previous page

Grain Malting Quality Analysis 2020

…….FACTOR A X B…….		MOISTURE	EXT FINE	EXT COARSE		ASBC	DP	AA	TOTAL PROTEIN	S/T RATIO	WART PROTEIN		WORT VISCOSITY	BG	TURBIDITY	FAN
MAIN PLOT	SUB PLOT	(%)	(%)	(%)	F/C	COLOUR	(U/ml)	(U/ml)	(%)	(%)	(%)	pH	(Cp)	(mg/L)	(NTU)	(mg/L)
1. Check (Zero N)	Zero S	5.1	81.0	79.5	1.4	2.48	98	43.7	10.95	46.0	5.03	5.77	1.56	195	19.2	238
2. Urea @ 35 kg N/ha	Zero S	5.6	79.6	77.8	1.8	2.76	100	41.5	12.57	40.7	5.12	5.72	1.55	288	22.8	249
3. Urea @ 70 kg N/ha	Zero S	5.7	79.8	78.3	1.5	2.50	127	50.3	12.93	42.3	5.48	5.77	1.52	200	18.6	274
4. Urea @ 105 kg N/ha	Zero S	5.0	79.0	77.1	1.9	1.84	114	44.8	13.46	37.2	5.01	5.80	1.54	355	10.1	199
5. Urea + ESN @ 35 kg N/ha	Zero S	5.9	79.2	77.5	1.8	2.44	117	41.1	12.67	41.4	5.24	5.69	1.56	285	25.1	261
6. Urea + ESN @ 70 kg N/ha	Zero S	4.8	79.5	77.7	1.8	2.06	107	45.5	13.02	39.7	5.17	5.86	1.53	320	9.9	203
7. Urea + ESN @ 105 kg N/ha	Zero S	4.9	79.6	77.6	1.9	2.41	92	39.6	13.04	39.8	5.19	5.75	1.54	347	12.2	202
8. Check (Zero N)	8 kg S/ha	5.0	82.1	80.6	1.5	2.40	94	44.6	10.54	46.7	4.92	5.82	1.56	225	16.6	236
9. Urea @ 35 kg N/ha	8 kg S/ha	5.9	80.4	78.9	1.4	2.22	115	44.4	11.68	43.7	5.10	5.70	1.53	184	22.1	262
10. Urea @ 70 kg N/ha	8 kg S/ha	4.5	79.7	77.6	2.1	2.24	101	46.2	12.92	39.8	5.14	5.85	1.53	426	10.8	209
11. Urea @ 105 kg N/ha	8 kg S/ha	5.0	79.1	77.0	2.1	1.70	122	48.3	13.29	36.8	4.90	5.95	1.53	399	7.7	193
12. Urea + ESN @ 35 kg N/ha	8 kg S/ha	5.7	79.2	77.6	1.6	2.55	126	48.0	12.77	43.2	5.52	5.71	1.54	219	19.8	269
13. Urea + ESN @ 70 kg N/ha	8 kg S/ha	4.8	79.7	78.0	1.7	1.96	107	43.7	12.30	41.6	5.12	5.84	1.51	265	10.3	209
14. Urea + ESN @ 105 kg N/ha	8 kg S/ha	5.0	78.8	77.0	1.8	2.52	96	39.4	13.04	40.3	5.25	5.70	1.53	293	14.6	214
15. Check (Zero N)	16 kg S/ha	5.4	80.5	78.9	1.5	2.46	93	41.4	11.15	44.3	4.94	5.79	1.56	217	21.0	232
16. Urea @ 35 kg N/ha	16 kg S/ha	5.4	79.7	78.2	1.5	2.69	107	40.7	12.11	44.5	5.39	5.73	1.54	210	24.9	260
17. Urea @ 70 kg N/ha	16 kg S/ha	4.7	79.2	77.4	1.8	2.25	108	45.5	12.94	39.7	5.13	5.83	1.54	327	12.3	204
18. Urea @ 105 kg N/ha	16 kg S/ha	4.9	78.9	76.9	2.0	2.40	97	40.0	13.23	39.1	5.17	5.74	1.54	385	11.4	203
19. Urea + ESN @ 35 kg N/ha	16 kg S/ha	5.5	79.5	78.0	1.5	2.87	114	45.3	12.76	43.5	5.55	5.72	1.52	195	22.3	268
20. Urea + ESN @ 70 kg N/ha	16 kg S/ha	5.2	79.3	77.5	1.9	1.92	116	42.7	12.90	39.4	5.09	5.78	1.53	326	10.4	205
21. Urea + ESN @ 105 kg N/ha	16 kg S/ha	5.1	80.0	78.2	1.7	2.25	104	41.4	13.50	39.2	5.30	5.70	1.53	278	13.9	215
MEAN		**5.2**	**79.7**	**78.0**	**1.7**	**2.33**	**107**	**43.7**	**12.56**	**41.4**	**5.18**	**5.77**	**1.54**	**283**	**16.0**	**229**

Grain Malting Quality Analysis 2020

FACTOR A	MOISTURE (%)	EXT FINE (%)	EXT COARSE (%)	F/C	ASBC COLOUR	DP (U/ml)	AA (U/ml)	TOTAL PROTEIN (%)	S/T RATIO (%)	WART PROTEIN (%)	pH	WORT VISCOSITY (Cp)	BG (mg/L)	TURBIDITY (NTU)	FAN (mg/L)
1. Check (Zero N)	5.2	81.2	79.7	1.5	2.45	95	43.2	10.88	45.7	4.96	5.79	1.56	212	18.9	235
2. Urea @ 35 kg N/ha	5.6	79.9	78.3	1.6	2.56	107	42.2	12.12	43.0	5.20	5.72	1.54	227	23.3	257
3. Urea @ 70 kg N/ha	5.0	79.6	77.8	1.8	2.33	112	47.3	12.93	40.6	5.25	5.82	1.53	318	13.9	229
4. Urea @ 105 kg N/ha	5.0	79.0	77.0	2.0	1.98	111	44.4	13.33	37.7	5.03	5.83	1.54	380	9.7	198
5. Urea + ESN @ 35 kg N/ha	5.7	79.3	77.7	1.6	2.62	119	44.8	12.73	42.7	5.44	5.71	1.54	233	22.4	266
6. Urea + ESN @ 70 kg N/ha	4.9	79.5	77.7	1.8	1.98	110	44.0	12.74	40.2	5.13	5.83	1.52	304	10.2	206
7. Urea + ESN @ 105 kg N/ha	5.0	79.5	77.6	1.8	2.39	97	40.1	13.19	39.8	5.25	5.72	1.53	306	13.6	210
MEAN	**5.2**	**79.7**	**78.0**	**1.7**	**2.33**	**107**	**43.7**	**12.56**	**41.4**	**5.18**	**5.77**	**1.54**	**283**	**16.0**	**229**

FACTOR B	MOISTURE (%)	EXT FINE (%)	EXT COARSE (%)	F/C	ASBC COLOUR	DP (U/ml)	AA (U/ml)	TOTAL PROTEIN (%)	S/T RATIO (%)	WART PROTEIN (%)	pH	WORT VISCOSITY (Cp)	BG (mg/L)	TURBIDITY (NTU)	FAN (mg/L)
1. Zero S	5.3	79.7	77.9	1.7	2.36	108	43.8	12.66	41.0	5.18	5.77	1.54	284	16.8	232
2. 8 kg S/ha	5.1	79.9	78.1	1.7	2.23	109	44.9	12.36	41.7	5.14	5.80	1.53	287	14.6	227
3. 16 kg S/ha	5.2	79.6	77.9	1.7	2.41	106	42.4	12.66	41.4	5.22	5.76	1.54	277	16.6	227
MEAN	**5.2**	**79.7**	**78.0**	**1.7**	**2.33**	**107**	**43.7**	**12.56**	**41.4**	**5.18**	**5.77**	**1.54**	**283**	**16.0**	**229**

4.1.1 Nitrogen and Sulphur Management for Malting Barley Production

Cont'd from Previous page

Average Over 2018-2020

…….FACTOR A X B…….		GRAIN kg/kg	…….YIELD……. GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST	1000 K	TEST WT.
MAIN PLOT	SUB PLOT	NUTRIENTS ♣ [a]	.....(MT/ha).....			INDEX (%) [b]	WT.(g)	(kg/hl)
1. Check (Zero N)	Zero S	46.1 *a*	3.18 *a*	2.95 *a*	6.13 *a*	53.3	52	60
2. Urea @ 35 kg N/ha	Zero S	42.1 *a*	4.47 *a*	3.79 *a*	8.25 *a*	58.4	54	62
3. Urea @ 70 kg N/ha	Zero S	34.5 *a*	5.01 *a*	4.59 *a*	9.60 *a*	54.7	57	62
4. Urea @ 105 kg N/ha	Zero S	27.5 *a*	4.93 *a*	4.77 *a*	9.70 *a*	52.0	55	62
5. Urea + ESN @ 35 kg N/ha♦	Zero S	42.7 *a*	4.54 *a*	4.03 *a*	8.57 *a*	54.5	53	61
6. Urea + ESN @ 70 kg N/ha♦	Zero S	33.7 *a*	4.88 *a*	4.92 *a*	9.80 *a*	49.9	56	62
7. Urea + ESN @ 105 kg N/ha♦	Zero S	30.7 *a*	5.51 *a*	5.56 *a*	11.06 *a*	50.5	56	62
8. Check (Zero N)	8 kg S/ha	38.5 *a*	2.97 *a*	4.00 *a*	6.98 *a*	44.9	53	61
9. Urea @ 35 kg N/ha	8 kg S/ha	36.9 *a*	4.25 *a*	4.24 *a*	8.49 *a*	49.9	54	62
10. Urea @ 70 kg N/ha	8 kg S/ha	34.6 *a*	5.18 *a*	5.28 *a*	10.46 *a*	49.2	54	63
11. Urea @ 105 kg N/ha	8 kg S/ha	26.1 *a*	4.83 *a*	4.84 *a*	9.67 *a*	52.3	56	63
12. Urea + ESN @ 35 kg N/ha♦	8 kg S/ha	36.2 *a*	4.13 *a*	4.00 *a*	8.12 *a*	51.2	53	61
13. Urea + ESN @ 70 kg N/ha♦	8 kg S/ha	34.4 *a*	5.10 *a*	4.84 *a*	9.94 *a*	52.7	56	63
14. Urea + ESN @ 105 kg N/ha♦	8 kg S/ha	27.0 *a*	5.04 *a*	5.24 *a*	10.28 *a*	49.1	56	62
15. Check (Zero N)	16 kg S/ha	34.3 *a*	2.73 *a*	2.91 *a*	5.64 *a*	47.2	51	60
16. Urea @ 35 kg N/ha	16 kg S/ha	36.3 *a*	4.34 *a*	4.75 *a*	9.08 *a*	45.5	53	61
17. Urea @ 70 kg N/ha	16 kg S/ha	33.1 *a*	5.07 *a*	4.29 *a*	9.36 *a*	56.8	55	63
18. Urea @ 105 kg N/ha	16 kg S/ha	28.0 *a*	5.31 *a*	5.08 *a*	10.39 *a*	51.2	56	63
19. Urea + ESN @ 35 kg N/ha♦	16 kg S/ha	36.2 *a*	4.27 *a*	4.43 *a*	8.70 *a*	49.3	54	61
20. Urea + ESN @ 70 kg N/ha♦	16 kg S/ha	33.4 *a*	5.14 *a*	4.90 *a*	10.04 *a*	52.4	56	62
21. Urea + ESN @ 105 kg N/ha♦	16 kg S/ha	27.3 *a*	5.20 *a*	5.11 *a*	10.31 *a*	51.9	56	63
MEAN							**55**	**62**
C.V. (%)		42.4	45.1	50.3	44.4	25.3	-	-
PR>F - A		**0.0002**	**0.0001**	**0.0059**	**0.0001**	0.8040	-	-
PR>F - B		0.1290	0.8930	0.7597	0.9830	0.1970	-	-
PR>F - (A x B)		0.9839	1.0000	0.9781	0.9990	0.6660	-	-
SE - (A x B)		0.92	0.13	0.14	0.25	0.82	-	-
LSD (0.05)		10.76	1.54	1.74	3.04	NS	-	-

Notes:

♣Indicates nutrients utilization efficiency

♦ Blend of Urea and ESN 3:1 on N basis

Sulphur was supplied through gypsum

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.1.1 Nitrogen and Sulphur Management for Malting Barley Production

Cont'd from Previous page

Average Over 2018-2020

…….FACTOR A X B…….		DAYS TO	LODGING▼	HEIGHT [b]	PLANT [b]	…..TILLERS…..	
MAIN PLOT	SUB PLOT	MATURE	(0-9)	(cm)	(m^2)	(m^2) [a]	PLANT [b]
1. Check (Zero N)	Zero S	94	0	62	298	572 *a*	2.1
2. Urea @ 35 kg N/ha	Zero S	94	0	68	311	578 *a*	2.0
3. Urea @ 70 kg N/ha	Zero S	95	0	74	356	693 *a*	2.1
4. Urea @ 105 kg N/ha	Zero S	94	0	74	336	638 *a*	2.0
5. Urea + ESN @ 35 kg N/ha♦	Zero S	94	0	67	296	634 *a*	2.4
6. Urea + ESN @ 70 kg N/ha♦	Zero S	94	0	72	310	677 *a*	2.5
7. Urea + ESN @ 105 kg N/ha♦	Zero S	94	0	73	326	702 *a*	2.3
8. Check (Zero N)	8 kg S/ha	94	0	61	317	498 *a*	1.8
9. Urea @ 35 kg N/ha	8 kg S/ha	94	0	69	317	610 *a*	2.1
10. Urea @ 70 kg N/ha	8 kg S/ha	94	0	71	332	634 *a*	2.1
11. Urea @ 105 kg N/ha	8 kg S/ha	94	0	75	292	689 *a*	2.6
12. Urea + ESN @ 35 kg N/ha♦	8 kg S/ha	94	0	68	304	639 *a*	2.2
13. Urea + ESN @ 70 kg N/ha♦	8 kg S/ha	94	0	71	296	680 *a*	2.4
14. Urea + ESN @ 105 kg N/ha♦	8 kg S/ha	94	0	72	330	708 *a*	2.5
15. Check (Zero N)	16 kg S/ha	94	0	61	304	600 *a*	2.3
16. Urea @ 35 kg N/ha	16 kg S/ha	94	0	68	279	569 *a*	2.1
17. Urea @ 70 kg N/ha	16 kg S/ha	94	0	72	324	630 *a*	2.1
18. Urea @ 105 kg N/ha	16 kg S/ha	94	0	74	313	680 *a*	2.4
19. Urea + ESN @ 35 kg N/ha♦	16 kg S/ha	94	0	68	322	637 *a*	2.1
20. Urea + ESN @ 70 kg N/ha♦	16 kg S/ha	94	0	72	284	652 *a*	2.4
21. Urea + ESN @ 105 kg N/ha♦	16 kg S/ha	94	0	71	296	632 *a*	2.4
MEAN		**94**					
C.V. (%)		-	-	27.2	38.7	28.1	34.8
PR>F - A		-	-	0.0941	0.8790	**0.0224**	0.1420
PR>F - B		-	-	0.9868	0.7230	0.8904	0.9331
PR>F - (A x B)		-	-	1.0000	0.9980	0.9479	0.7999
SE - (A x B)		-	-	1.2	7.6	11.3	0.05
LSD (0.05)		-	-	NS	NS	137.4	NS

Notes:

♣Indicates nutrients utilization efficiency

♦ Blend of Urea and ESN 3:1 on N basis

Sulphur was supplied through gypsum

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Cont'd from Previous page

Average Over 2018-2020

FACTOR A	GRAIN kg/kg NUTRIENTS ♣ [a]	……YIELD……. GRAIN [a]	STRAW [b]	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT [b] (cm)	PLANT [b] (m^2)	…..TILLERS….. (m^2)	PLANT
1. Check (Zero N)	39.6 *a*	2.96 *b*	3.29 b	6.25 *b*	48.5	52	60	61	306	557 *b*	2.1
2. Urea @ 35 kg N/ha	38.4 *a*	4.35 *a*	4.26 ab	8.61 *ab*	51.2	54	61	68	302	586 *ab*	2.1
3. Urea @ 70 kg N/ha	34.1 *ab*	5.09 *a*	4.72 ab	9.81 *a*	53.6	55	63	72	337	651 *ab*	2.1
4. Urea @ 105 kg N/ha	27.2 *b*	5.02 *a*	4.90 a	9.92 *a*	51.8	56	62	74	314	669 *ab*	2.3
5. Urea + ESN @ 35 kg N/ha	38.4 *a*	4.31 *ab*	4.15 ab	8.46 *ab*	51.7	54	61	67	307	637 *ab*	2.2
6. Urea + ESN @ 70 kg N/ha	33.8 *ab*	5.04 *a*	4.89 a	9.93 *a*	51.7	56	62	72	297	670 *ab*	2.4
7. Urea + ESN @ 105 kg N/ha	28.3 *b*	5.25 *a*	5.30 a	10.55 *a*	50.5	56	62	72	317	681 *a*	2.4
PR>F - A	**0.0002**	**0.0001**	**0.0044**	**0.0001**	0.7999	-	-	0.0755	0.8680	**0.0182**	0.1316
SE - (A)	1.88	0.30	0.25	0.55	0.58	-	-	1.65	4.98	17.79	0.06
LSD (0.05)	6.42	0.91	1.03	1.79	NS	-	-	NS	NS	81.5	NS

FACTOR B	GRAIN kg/kg NUTRIENTS ♣ [b]	……YIELD……. GRAIN [b]	STRAW [b]	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. (kg/hl)	HEIGHT [b] (cm)	PLANT [b] (m^2)	…..TILLERS….. (m^2)	PLANT
1. Zero S	36.7	4.64	4.37	9.01	53.3	55	62	70	318	641	2.2
2. 8 kg S/ha	33.4	4.50	4.63	9.13	49.9	54	62	69	313	637	2.2
3. 16 kg S/ha	32.7	4.58	4.50	9.07	50.6	54	62	69	303	629	2.3
PR>F - B	0.1460	0.9110	0.7540	0.9800	0.1936	-	-	0.9890	0.7200	0.8950	0.9403
SE - (B)	1.23	0.04	0.08	0.03	1.04	-	-	0.13	4.38	3.8	0.01
LSD (0.05)	NS	NS	NS	NS	NS	-	-	NS	NS	NS	NS

Notes:

♣Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.1.2 Evaluation of Fish Waste as a Source of N for Spring Wheat Production

PLANTING DATE: June 3, 2020
FERTILIZERS: N as per treatments, 20 kg P_2O_5/ha (45 kg/ha 0-45-0), 20 kg K_2O/ha (34 kg/ha 0-0-60)
HERBICIDE: Roundup @ 3 L/ha applied pre - emergent; June 5, 2020
HARVEST DATE: September 9, 2020
PREVIOUS CROP: Spring Wheat

TREATMENTS	GRAIN ♣ [a] kg/kg NUTRIENTS	……YIELD…… GRAIN [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST [b] INDEX (%)	1000 K WT.(g)
1. Urea + ESN @ 0 kg N/ha♦	29.7 *a*	1.19	1.80	2.98	39.7	38
2. Urea + ESN @ 40 kg N/ha♦	**15.7 *bc***	**1.26**	**2.07**	**3.33**	**37.7**	**35**
3. Urea + ESN @ 80 kg N/ha♦	**13.3 *bc***	**1.59**	**2.05**	**3.64**	**43.5**	**37**
4. Urea + ESN @ 120 kg N/ha♦	7.0 *c*	1.11	1.74	2.86	38.4	36
5. Fish Waste @ 0 kg N/ha	22.2 *ab*	0.89	1.48	2.37	36.3	38
6. Fish Waste @ 40 kg N/ha	9.8 *bc*	0.79	1.19	1.97	39.2	36
7. Fish Waste @ 80 kg N/ha	11.4 *bc*	1.37	2.10	3.46	39.1	37
8. Fish Waste @ 120 kg N/ha	6.3 *c*	1.01	1.52	2.53	40.1	37
9. Fish Waste + Urea + ESN @ 0 kg N/ha♠	22.3 *ab*	0.89	1.31	2.20	43.9	37
10. Fish Waste + Urea + ESN @ 40 kg N/ha♠	11.9 *bc*	0.95	1.33	2.28	39.3	37
11. Fish Waste + Urea + ESN @ 80 kg N/ha♠	**11.1 *bc***	**1.33**	**2.05**	**3.39**	**40.2**	**36**
12. Fish Waste + Urea + ESN @ 120 kg N/ha♠	7.6 *c*	1.22	1.86	3.09	40.6	35
MEAN	**14.0**	**1.13**	**1.71**	**2.84**	**39.8**	**37**
C.V. (%)	60.3	37.6	36.2	35.7	14.9	-
PR>F	**<0.0001**	0.2700	0.3400	0.2800	0.9200	-
SE	1.22	0.062	0.089	0.146	0.85	-
LSD (0.05)	7.9	NS	NS	NS	NS	-

Notes:
♣Indicates nutrients utilization efficiency
♦ Blend of Urea and ESN 3:1 on N basis; ♠ Blend of Fish Waste and Chemical Fertilizers (Urea and ESN 3:1) 1:1 on N basis
Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 6, Nitrate N: 10, and Total N: 16
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Cont'd from Previous page

TREATMENTS	LODGING▼ (0-9)	PLANTS/ [a] (m^2)	HEIGHT [b] (cm)
1. Urea + ESN @ 0 kg N/ha♦	0	190 *ab*	58
2. Urea + ESN @ 40 kg N/ha♦	**0**	**173 *b***	**57**
3. Urea + ESN @ 80 kg N/ha♦	**0**	**213 *ab***	**58**
4. Urea + ESN @ 120 kg N/ha♦	0	160 *b*	57
5. Fish Waste @ 0 kg N/ha	0	200 *ab*	55
6. Fish Waste @ 40 kg N/ha	0	180 *b*	55
7. Fish Waste @ 80 kg N/ha	0	207 *ab*	57
8. Fish Waste @ 120 kg N/ha	0	173 *b*	55
9. Fish Waste + Urea + ESN @ 0 kg N/ha♠	0	183 *b*	56
10. Fish Waste + Urea + ESN @ 40 kg N/ha♠	0	213 *ab*	55
11. Fish Waste + Urea + ESN @ 80 kg N/ha♠	**0**	**283 *a***	**57**
12. Fish Waste + Urea + ESN @ 120 kg N/ha♠	0	177 *b*	54
MEAN	**0**	**196**	**56**
C.V. (%)	-	23.8	8.1
PR>F	-	**0.0150**	0.9900
SE	-	6.7	0.7
LSD (0.05)	-	57	NS

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Letter codes not displayed for the means were not affected by the treatment (P>0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

SOURCES OF NITROGEN	GRAIN ♣ kg/kg NUTRIENTS [b]	……YIELD……. GRAIN [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	HEIGHT (cm) [b]
Urea + ESN	**16.4**	**1.29**	**1.91**	**3.20**	**39.8**	**36**	**58**
Fish Waste	12.4	1.01	1.57	2.58	38.7	37	56
Fish Waste + Urea + ESN	13.3	1.10	1.64	2.74	41.0	36	56
MEAN	**14.0**	**1.13**	**1.71**	**2.84**	**39.8**	**37**	**56**
C.V. (%)	60.3	37.6	36.2	35.7	14.9	-	8.1
PR>F	0.3900	0.1900	0.2600	0.2100	0.5500	-	0.3900
SE	1.22	0.062	0.089	0.146	0.85	-	0.7
LSD (0.05)	NS	NS	NS	NS	NS	-	NS

NITROGEN RATE (kg/ha)	GRAIN ♣ [a] kg/kg NUTRIENTS	……YIELD……. GRAIN [a] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	HEIGHT (cm) [b]
0	24.7 *a*	0.99 *b*	1.53	2.52	40.0	38	57
40	12.5 *b*	1.00 *ab*	1.53	2.53	38.7	36	56
80	**11.9 *b***	**1.43 *a***	**2.07**	**3.50**	**40.9**	**37**	**57**
120	7.0 *b*	1.12 *ab*	1.71	2.82	39.7	36	55
MEAN	**14.0**	**1.13**	**1.71**	**2.84**	**39.8**	**37**	**56.3**
C.V. (%)	60.3	37.6	36.2	35.7	14.9	-	8.1
PR>F	**<0.0001**	**0.0340**	0.1100	0.0590	0.8500	-	0.8200
SE	1.22	0.062	0.089	0.146	0.85	-	0.7
LSD (0.05)	4.5	0.33	NS	NS	NS	-	NS

Notes:

♣Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.1.2 Evaluation of Fish Waste as a Source of N for Spring Wheat Production
Averaged Over 2018-2020

TREATMENTS	GRAIN ♣ [b] kg/kg NUTRIENTS	……YIELD…… GRAIN [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g) [b]	TEST WT. * (kg/hl) [b]
1. Urea + ESN @ 0 kg N/ha♦	31.0	3.35	2.85	6.19	50.3	37.8	76
2. Urea + ESN @ 40 kg N/ha♦	24.6	3.90	3.29	7.19	50.3	37.2	76
3. Urea + ESN @ 80 kg N/ha♦	**22.5**	**4.51**	**3.36**	**7.87**	**53.8**	**39.1**	**77**
4. Urea + ESN @ 120 kg N/ha♦	**16.8**	**4.13**	**3.23**	**7.36**	**51.4**	**38.2**	**78**
5. Fish Waste @ 0 kg N/ha	26.6	2.99	2.55	5.54	48.9	38.4	76
6. Fish Waste @ 40 kg N/ha	20.2	3.31	2.57	5.87	50.4	38.6	77
7. Fish Waste @ 80 kg N/ha	19.1	3.81	3.18	6.99	50.6	38.6	77
8. Fish Waste @ 120 kg N/ha	15.9	3.91	3.04	6.95	51.5	39.0	77
9. Fish Waste + Urea + ESN @ 0 kg N/ha♠	28.3	3.22	2.57	5.80	52.4	36.3	76
10. Fish Waste + Urea + ESN @ 40 kg N/ha♠	22.0	3.57	2.84	6.41	50.5	37.5	77
11. Fish Waste + Urea + ESN @ 80 kg N/ha♠	20.2	4.08	3.30	7.38	51.5	38.1	77
12. Fish Waste + Urea + ESN @ 120 kg N/ha♠	**18.1**	**4.45**	**3.41**	**7.86**	**52.4**	**38.8**	**78**
MEAN	**22.1**	**3.77**	**3.02**	**6.78**	**51.2**	**38.1**	**77**
C.V. (%)	63.1	73.5	51.0	63.1	18.1	8.0	2.0
PR>F	0.0930	0.9700	0.8900	0.9500	1.0000	0.2800	0.2800
SE	1.08	0.231	0.128	0.357	0.77	0.3	0.2
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

Notes:

♣Indicates nutrients utilization efficiency

♦ Blend of Urea and ESN 3:1 on N basis; ♠ Blend of Fish Waste and Chemical Fertilizer (Urea and ESN 3:1) 1:1 on N basis

* Test wt. were only averaged over 2018 - 2019

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.1.2 Evaluation of Fish Waste as a Source of N for Spring Wheat Production
Averaged Over 2018-2020

TREATMENTS	LODGING▼ (0-9)	PLANTS (m^2) [b]	…..TILLERS/…..* (m^2) [b]	PLANT [b]	HEIGHT (cm) [b]
1. Urea + ESN @ 0 kg N/ha♦	0	368	672	1.5	66
2. Urea + ESN @ 40 kg N/ha♦	0	349	635	1.5	68
3. Urea + ESN @ 80 kg N/ha♦	**0**	**409**	**738**	**1.5**	**70**
4. Urea + ESN @ 120 kg N/ha♦	**0**	**369**	**658**	**1.4**	**70**
5. Fish Waste @ 0 kg N/ha	0	389	615	1.3	66
6. Fish Waste @ 40 kg N/ha	0	376	645	1.4	67
7. Fish Waste @ 80 kg N/ha	0	368	585	1.3	68
8. Fish Waste @ 120 kg N/ha	0	359	630	1.4	67
9. Fish Waste + Urea + ESN @ 0 kg N/ha♠	0	351	640	1.5	66
10. Fish Waste + Urea + ESN @ 40 kg N/ha♠	0	404	648	1.3	67
11. Fish Waste + Urea + ESN @ 80 kg N/ha♠	0	401	682	1.5	67
12. Fish Waste + Urea + ESN @ 120 kg N/ha♠	**0**	**366**	**633**	**1.4**	**69**
MEAN	**0**	**376**	**648**	**1.4**	**68**
C.V. (%)	-	38.1	14.3	14.8	17.2
PR>F	-	1.0000	0.1900	0.4900	1.0000
SE	-	11.9	9.5	0.02	1.0
LSD (0.05)	-	NS	NS	NS	NS

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

* Tillers/m^2 and per plant were only averaged over 2018 - 2019

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.1.2 Evaluation of Fish Waste as a Source of N for Spring Wheat Production

Averaged Over 2018-2020

SOURCES OF NITROGEN	GRAIN ♣ [b] kg/kg NUTRIENTS	……YIELD……. GRAIN [b]	STRAW [b]	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g) [b]	TEST WT. * (kg/hl) [b]	HEIGHT (cm) [b]
Urea + ESN	**23.7**	**3.97**	**3.18**	**7.15**	**51.5**	**38.1**	**77**	**69**
Fish Waste	20.4	3.50	2.83	6.34	50.4	38.7	76	67
Fish Waste + Urea + ESN	22.2	3.83	3.03	6.86	51.7	37.7	77	67
MEAN	**22.1**	**3.8**	**3.0**	**6.8**	**51.2**	**38.1**	**76.6**	**67.5**
C.V. (%)	63.1	73.5	51.0	63.1	18.1	8.0	2.0	17.2
PR>F	0.4700	0.7000	0.5400	0.6400	0.7600	0.4000	0.4000	0.6800
SE	1.08	0.231	0.128	0.357	0.77	0.3	0.2	1.0
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NITROGEN RATE (kg/ha)	GRAIN ♣ [a] kg/kg NUTRIENTS	……YIELD……. GRAIN [b]	STRAW [b]	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g)	TEST WT. * (kg/hl)	HEIGHT (cm)
0	28.6 *a*	3.19	2.66	5.84	50.5	37.5	76	66
40	22.3 *ab*	3.59	2.90	6.49	50.4	37.8	77	67
80	20.6 *b*	4.13	3.28	7.41	52.0	38.6	77	68
120	**16.9 *b***	**4.16**	**3.23**	**7.39**	**51.8**	**38.7**	**77**	**68**
MEAN	**22.1**	**3.8**	**3.0**	**6.8**	**51.2**	**38.1**	**76.6**	**67.5**
C.V. (%)	63.1	73.5	51.0	63.1	18.1	8.0	2.0	17.2
PR>F	**0.0012**	0.3800	0.2800	0.3400	0.8400	0.0520	0.0520	0.8200
SE	1.08	0.231	0.128	0.357	0.77	0.3	0.2	1.0
LSD (0.05)	5.8	NS	NS	NS	NS	NS	NS	NS

Notes:

♣Indicates nutrients utilization efficiency

* Test wt. were only averaged over 2018 - 2019

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.1.3 Winter Wheat Survival

PLANTING DATE: August 26, 2019

FERTILIZERS: 120 kg N/ha (174 kg/ha 46-0-0; 91 kg/ha 44-0-0) 5.6 kg S/ha (35 kg/ha 0-0-0-16-20)
20 kg P_2O_5/ha (45 kg/ha 0-45-0) 7 kg Zinc/ha (35 kg/ha 0-0-0-16-20)
K_2O as per treatment 1 kg Boron/ha (7 kg/ha 0-0-0-15)

HERBICIDE: September 23, 2019 Post-emergence; Refine SG @ 30 g/ha + 0.2% v/v surfactant

HARVEST DATE: August 30, 2020

PREVIOUS CROP: Fallow

	TREATMENTS				…….YIELD [b] …….						
				GRAIN ♣	GRAIN	STRAW	BIOMASS	1000 K	TEST WT.	PLANTS [b]	TILLERS [b]
				kg/kg NUTRIENTS [b]	.....(MT/ha).....			WT.(g)	(kg/hl)	…/m^2…	
	Seed treatment	Chemical Sprayed [a]	K_2O kg/ha								
1	**No**	**No**	**20**	**29.3**	**4.96**	**8.05**	**13.02**	**33**	**76**	**370**	**653**
2	No	No	40	22.2	4.20	7.45	11.65	31	77	417	713
3	**Fungicide+insecticide**	**No**	**20**	**26.8**	**4.53**	**7.41**	**11.94**	**33**	**77**	**270**	**493**
4	Fungicide+insecticide	No	40	23.5	3.69	7.45	11.75	33	77	330	600
5	No	Abscisic acid	20	24.2	3.99	7.37	11.41	32	77	393	417
6	No	Abscisic acid	40	21.2	4.02	6.91	10.93	32	77	320	697
7	No	Headline	20	24.4	4.14	7.80	11.94	34	77	467	563
8	No	Headline	40	23.5	4.45	8.17	12.62	34	77	410	487
9	**No**	**Seaweed extract**	**20**	**26.6**	**4.51**	**7.16**	**11.67**	**33**	**76**	**300**	**737**
10	No	Seaweed extract	40	22.2	4.20	7.53	11.73	33	77	450	647
	MEAN			**24.4**	**4.27**	**7.53**	**11.87**	**33**	**77**	**373**	**601**
	C.V. (%)			20.1	14.6	11.6	10.6	-	-	27.7	43.6
	PR>F			0.3310	0.5240	0.7700	0.8790	-	-	0.3200	0.9200
	SE			0.75	0.118	0.138	0.196	-	-	16.3	41.4
	LSD (0.05)			NS	NS	NS	NS	-	-	NS	NS

Notes:

Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 4, Nitrate N: 9, Total N: 13, and S: 6

Pre seeding soil analysis 0-15 cm (ppm): Potassium K: 75

♣ Indicates nutrients utilization efficiency

a Applied at tillering

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

K_2O kg/ha	…….YIELD [a] ……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)
20	**4.42**	**7.56**	**11.99**
40	4.11	7.50	11.61
MEAN	**4.27**	**7.53**	**11.80**
C.V. (%)	14.4	11.6	10.6
PR>F	0.1120	0.8400	0.3120
SE	0.118	0.138	0.196
LSD (0.05)	NS	NS	NS

Chemical used	…….YIELD [a] ……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)
None	**4.58**	**7.75**	**12.34**
Fungicide+insecticide [b]	4.11	7.43	11.54
Abscisic acid [c]	4.00	7.14	11.14
Headline [d]	4.29	7.99	12.28
Seaweed extract [e]	4.36	7.34	11.70
MEAN	**4.35**	**7.59**	**11.94**
C.V. (%)	14.4	11.6	10.6
PR>F	0.4120	0.3300	0.1900
SE	0.118	0.138	0.196
LSD (0.05)	NS	NS	NS

Notes:

a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

b Fungicide+insecticide seed treatment: Raxil Pro @325 mL/100 kg of seed

c Abscisic acid @ 21 g/ha

d Headline @ 0.5L/ha

e Seaweed extract: Toggle® @ 3L/ha

4.1.3 Winter Wheat Survival… Cont'd from previous page

	TREATMENTS			HARVEST INDEX (%) [b]	DAYS TO HEADING [b]	DAYS TO MATURE [b]	HEIGHT (cm) [b]	LODGING▼ (0-9)
	Seed treatment	Chemical Sprayed [a]	K_2O kg/ha					
1	No	No	**20**	38.1	284	324	77	0
2	No	No	40	36.1	285	324	79	0
3	Fungicide+insecticide	No	**20**	38.1	284	323	77	0
4	Fungicide+insecticide	No	40	35.7	282	322	74	0
5	No	Abscisic acid	20	36.8	284	323	77	0
6	No	Abscisic acid	40	36.8	285	324	78	0
7	No	Headline	20	34.9	285	324	74	0
8	No	Headline	40	35.1	283	324	80	0
9	No	Seaweed extract	**20**	38.5	285	324	80	0
10	No	Seaweed extract	40	35.7	283	324	77	0
	MEAN			**36.6**	**284**	**323**	**77**	**0**
	C.V. (%)			12.7	0.3	0.3	5.5	-
	PR>F			0.7080	0.5800	0.5800	0.6000	-
	SE			0.72	0.2	0.1	0.7	-
	LSD (0.05)			NS	NS	NS	NS	-

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Applied at tillering

b Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.1.3 Winter Wheat Survival
Averaged Over 2019-2020

	TREATMENTS			GRAIN ♣	YIELD [b] GRAIN	STRAW	BIOMASS	1000 K	TEST WT.	PLANTS [b]	TILLERS [b]
				kg/kg NUTRIENTS [b]		(MT/ha)		WT.(g)	(kg/hl)	…/m^2…	
	Seed treatment	Chemical Sprayed [a]	K_2O kg/ha								
1	**No**	**No**	**20**	**31.9**	**5.87**	**8.40**	**14.27**	**31**	**76**	**475**	**927**
2	No	No	40	26.3	5.40	9.06	14.46	32	78	490	995
3	**Fungicide+insecticide**	**No**	**20**	**30.9**	**5.70**	**8.19**	**13.88**	**32**	**78**	**430**	**825**
4	Fungicide+insecticide	No	40	25.2	5.21	8.13	13.35	33	77	448	963
5	No	Abscisic acid	20	27.2	5.02	7.76	12.77	32	77	475	873
6	No	Abscisic acid	40	24.6	5.03	7.89	12.92	33	78	455	912
7	No	Headline	20	29.6	5.48	8.32	13.79	32	77	527	993
8	No	Headline	40	26.8	5.47	8.21	13.69	30	78	483	922
9	**No**	**Seaweed extract**	**20**	**31.7**	**5.85**	**8.14**	**13.99**	**32**	**77**	**437**	**1017**
10	No	Seaweed extract	40	25.0	5.10	8.11	13.21	32	77	520	1032
	MEAN			**27.9**	**5.41**	**8.22**	**13.63**	**32**	**77**	**474**	**946**
	C.V. (%)			23.4	27.4	16.0	18.5	-	-	27.2	44.0
	PR>F			0.4100	0.6700	0.3400	0.4500	-	-	0.5400	0.5200
	SE			0.72	0.165	0.147	0.282	-	-	14.4	46.8
	LSD (0.05)			NS	NS	NS	NS	-	-	NS	NS

Notes:

♣ Indicates nutrients utilization efficiency

a At tillering

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.1.3 Winter Wheat Survival
Averaged Over 2019-2020… Cont'd from previous page

	…….YIELD [a] …….		
	GRAIN	STRAW	BIOMASS
	.....(MT/ha).....		
K_2O kg/ha			
20	**5.58**	**8.16**	**13.74**
40	5.24	8.28	13.53
MEAN	**5.41**	**8.22**	**13.63**
C.V. (%)	27.4	16.0	18.5
PR>F	0.3100	0.6800	0.7000
SE	0.166	0.147	0.282
LSD (0.05)	NS	NS	NS

	…….YIELD [a] …….		
	GRAIN	STRAW	BIOMASS
	.....(MT/ha).....		
Chemical used			
None	**5.64**	**8.73**	**14.36**
Fungicide+insecticide [b]	5.46	8.16	13.62
Abscisic acid [c]	5.03	7.82	12.85
Headline [d]	5.48	8.26	13.74
Seaweed extract [e]	5.48	8.12	13.60
MEAN	**5.55**	**8.44**	**13.99**
C.V. (%)	27.4	16.0	18.5
PR>F	0.8300	0.4200	0.5800
SE	0.166	0.147	0.282
LSD (0.05)	NS	NS	NS

Notes:
a Letter codes not displayed for the means were not affected by the treatments (P>0.05)
b Fungicide+insecticide seed treatment: Raxil Pro @325 mL/100 kg of seed
c Abscisic acid @ 21 g/ha
d Headline @ 0.5L/ha
e Seaweed extract: Toggle® @ 3L/ha

4.1.3 Winter Wheat Survival
Averaged Over 2019-2020… Cont'd from previous page

	TREATMENTS			HARVEST INDEX (%) [b]	DAYS TO HEADING [b]	DAYS TO MATURE [b]	HEIGHT (cm) [b]	LODGING▼ (0-9)
	Seed treatment	Chemical Sprayed [a]	K_2O kg/ha					
1	No	No	**20**	40.9	290	333	85	0
2	No	No	40	37.0	291	333	85	0
3	Fungicide+insecticide	No	**20**	40.7	290	333	85	0
4	Fungicide+insecticide	No	40	37.9	289	332	84	0
5	No	Abscisic acid	20	38.8	290	332	85	0
6	No	Abscisic acid	40	38.7	291	333	85	0
7	No	Headline	20	39.2	291	333	84	0
8	No	Headline	40	39.5	290	333	88	0
9	No	Seaweed extract	**20**	41.4	291	333	87	0
10	No	Seaweed extract	40	38.2	290	333	86	0
	MEAN			**39.2**	**290**	**333**	**85**	**0**
	C.V. (%)			13.4	2.2	2.8	10.8	-
	PR>F			0.8800	0.9200	0.9200	0.6000	-
	SE			0.59	0.7	1.1	1.0	-
	LSD (0.05)			NS	NS	NS	NS	-

Notes:
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
a Applied at tillering
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.1.4 Population and NPK Fertilizers Regimes for Winter Rye

PLANTING DATE: Winter Rye: August 23 2019; Barley: June 2, 2020

FERTILIZERS: 120 kg N/ha (174 kg/ha 46-0-0, 91 kg/ha 44-0-0) 5.6 kg S/ha (35 kg/ha 0-0-0-16-20) 1 kg Boron/ha (7 kg/ha 0-0-0-15)
50 kg P_2O_5/ha (111 kg/ha 0-45-0) 20 kg K_2O/ha (33 kg/ha 0-0-60) 7 kg Zn/ha (35 kg/ha 0-0-0-16-20)

HERBICIDE: September 23, 2019 Post-emergence; Refine SG @ 30 g/ha + 0.2% v/v surfactant

HARVEST DATE: Winter Rye: August 7, 2020; Barley: September 16, 2020

PREVIOUS CROP: Fallow

		…….YIELD…….					
FACTOR A VARIETY	GRAIN ♣ kg/kg NUTRIENTS [b]	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST INDEX (%) [a]	1000 K WT.(g)	TEST WT. (kg/hl)
		.....(MT/ha).....					
Hazlet	**150**	**4.71 *ab***	**6.60 a**	**11.31 a**	**41.6 b**	**32**	**69**
Guttino	**173**	**5.47 *a***	**5.65 ab**	**11.11 ab**	**49.1 a**	**32**	**69**
Brasetto	135	4.03 *ab*	4.86 b	8.89 ab	45.2 ab	32	69
Bono	113	3.55 *b*	4.77 b	8.32 b	43.4 b	32	69
MEAN	**143**	**4.44**	**5.47**	**9.91**	**44.8**	**32**	**69**
C.V. (%)	112.0	29.0	27.1	26.3	10.4	-	-
PR>F	0.6300	**<0.0001**	**0.0240**	**0.0190**	**0.0019**	-	-
SE	26.64	0.215	0.247	0.435	0.78	-	-
LSD (0.05)	NS	1.10	1.30	2.20	3.7		

FACTOR A VARIETY	HEIGHT (cm) [a]	DAYS TO MATURE	...TILLERS/.. m^2 [b]
Hazlet	**130 *a***	**341**	**493**
Guttino	**101 *c***	**341**	**587**
Brasetto	113 *b*	341	575
Bono	97 *c*	341	535
MEAN	**110**	**341**	**548**
C.V. (%)	12.6	-	27.4
PR>F	**<0.0001**	-	0.5600
SE	2.3	-	25.0
LSD (0.05)	6	-	NS

Notes:

Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 3, Nitrate N: 8, Total N: 11, and S: 9 ♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

FERTILIZERS FOR BARLEY: 70 kg N/ha (152 kg/ha 46-0-0)
20 kg P_2O_5/ha (45 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)

FACTOR B	GRAIN ♣	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST
		…….YIELD…….			
SEEDING RATE & NPK	kg/kg NUTRIENTS [b]	.....(MT/ha).....			INDEX (%) [b]
Spring barley (100 % seed/fertilizers)	26	2.90 *b*	2.83 *b*	5.74 *c*	50.7
50% seeding rate + 0% NPK	342	3.21 *ab*	3.82 *ab*	7.03 *bc*	45.9
50% seeding rate + 50% NPK	38	3.97 *ab*	6.10 *ab*	10.07 *abc*	38.9
50% seeding rate + 100% NPK	**29**	**5.71 *a***	**7.07 *a***	**12.77 *a***	**44.0**
75% seeding rate + 0% NPK	383	3.60 *ab*	4.16 *ab*	7.76 *abc*	46.5
75% seeding rate + 50% NPK	44	4.63 *ab*	5.59 *ab*	10.22 *abc*	45.5
75% seeding rate + 100% NPK	**28**	**5.53 *ab***	**6.76 *a***	**12.29 *ab***	**45.0**
100% seeding rate + 0% NPK	350	3.29 *ab*	3.86 *ab*	7.15 *bc*	46.3
100% seeding rate + 50% NPK	44	4.56 *ab*	5.41 *ab*	9.97 *abc*	45.5
100% seeding rate + 100% NPK	**27**	**5.46 *ab***	**6.45 *a***	**11.91 *ab***	**45.7**
MEAN	**131**	**4.3**	**5.2**	**9.5**	**45.4**
C.V. (%)	118.6	30.6	31.2	29.4	10.5
PR>F	0.5500	**0.0056**	**0.0130**	**0.0052**	0.8500
SE	24.6	0.208	0.257	0.442	0.75
LSD (0.05)	NS	1.60	2.00	3.30	NS

FACTOR B	TEST WT.	1000 K	HEIGHT	DAYS TO	.....TILLERS/.....
SEEDING RATE & NPK	(kg/hl)	WT.(g) [a]	(cm) [b]	MATURE	m^2 [a]
Spring barley (100 % seed/fertilizers)	50	43 *a*	-	-	-
50% seeding rate + 0% NPK	70	34 *b*	112	341	483 *a*
50% seeding rate + 50% NPK	69	34 *b*	110	341	450 *a*
50% seeding rate + 100% NPK	**70**	**31 *b***	**114**	**341**	**557 *a***
75% seeding rate + 0% NPK	69	33 *b*	104	341	473 *a*
75% seeding rate + 50% NPK	69	31 *b*	111	341	437 *a*
75% seeding rate + 100% NPK	**68**	**32 *b***	**112**	**341**	**770 *a***
100% seeding rate + 0% NPK	70	33 *b*	105	341	547 *a*
100% seeding rate + 50% NPK	69	30 *b*	109	341	613 *a*
100% seeding rate + 100% NPK	**69**	**29 *b***	**116**	**341**	**597 *a***
MEAN	**65**	**33.0**	**110**	**341**	**547**
C.V. (%)	-	11.3	12.6	-	27.4
PR>F	-	**<0.0001**	**0.9800**	-	**0.0360**
SE	-	0.59	2.3	-	25.0
LSD (0.05)	-	4	NS	-	207

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

		…….YIELD…….					
SEEDING RATE	GRAIN ♣ kg/kg NUTRIENTS [b]	GRAIN [b]	STRAW [b]	BIOMASS [b]	HARVEST INDEX (%) [b]	1000 K WT.(g) [a]	TILLERS/ m^2 [b]
			.....(MT/ha).....				
50%	136	4.30	5.66	9.96	43.0	33 *a*	497
75%	**152**	**4.59**	**5.50**	**10.09**	**45.7**	**32 *ab***	**560**
100%	140	4.44	5.24	9.68	45.9	31 *b*	586
MEAN	**143**	**4.4**	**5.5**	**9.9**	**44.8**	**31.9**	**547**
C.V. (%)	112	29.0	27.1	26.3	10.4	5.3	27.4
PR>F	0.9500	0.7753	0.4441	0.7710	**0.1300**	**0.0003**	0.1500
SE	26.63	0.215	0.247	0.435	0.78	0.3	25.0
LSD (0.05)	NS	NS	NS	NS	NS	1	NS

NPK RATE	GRAIN ♣ kg/kg NUTRIENTS [a]	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST INDEX (%) [b]	1000 K WT.(g)	TILLERS/ m^2 [a]
			.....(MT/ha).....				
0%	358 *a*	3.37 *c*	3.94 *c*	7.31 *c*	46.2	33 *a*	501 *a*
50%	42 *b*	4.38 *b*	5.70 *b*	10.09 *b*	43.3	32 *b*	500 *a*
100%	**28 *b***	**5.56 *a***	**6.76 *a***	**12.32 *a***	**44.9**	**31 *b***	**641 *a***
MEAN	**143**	**4.4**	**5.5**	**9.9**	**44.8**	**31.9**	**547**
C.V. (%)	112.0	29.0	27.1	26.3	10.4	5.3	27.4
PR>F	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.5100	**<0.0001**	**0.0220**
SE	26.6	0.215	0.247	0.435	0.78	0.3	25.0
LSD (0.05)	69	0.62	0.50	0.81	NS	1	118

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.1.4 Population and NPK Fertilizers Regimes for Winter Rye
Averaged Over 2019-2020

FACTOR A	GRAIN ♣	GRAIN [b]	STRAW [b]	BIOMASS [b]	HARVEST	1000 K	TEST WT.
VARIETY	kg/kg NUTRIENTS [b]	.....(MT/ha).....			INDEX (%) [a]	WT.(g) [b]	(kg/hl)
Hazlet	**126**	**4.54**	**6.14**	**10.69**	**42.3 *b***	**37**	**69**
Guttino	**134**	**4.80**	**5.52**	**10.32**	**46.1 *a***	**37**	**69**
Brasetto	121	4.20	5.28	9.48	44.2 *ab*	38	70
Bono	107	3.92	5.17	9.09	43.1 *ab*	37	69
MEAN	**122**	**4.37**	**5.53**	**9.90**	**43.9**	**37**	**69**
C.V. (%)	108	28.7	24.0	25.0	8.8	15.3	-
PR>F	0.9400	0.1600	0.1200	0.1900	**0.0210**	0.9800	-
SE	15.5	0.148	0.156	0.291	0.456	0.7	-
LSD (0.05)	NS	NS	NS	NS	2.4	NS	

FACTOR A	HEIGHT	DAYS TO	....TILLERS/..
VARIETY	(cm) [a]	MATURE	m^2 [b]
Hazlet	**125 *a***	**339**	**433**
Guttino	**113 *ab***	**339**	**446**
Brasetto	119 *ab*	339	460
Bono	110 *b*	339	479
MEAN	**117**	**339**	**455**
C.V. (%)	12.6	-	35.1
PR>F	**0.0094**	-	0.8400
SE	1.7	-	18.8
LSD (0.05)	9	-	NS

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.1.4 Population and NPK Fertilizers Regimes for Winter Rye... Cont'd from previous page
Averaged Over 2019-2020

FACTOR B	GRAIN ♣	…….YIELD……. GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST
SEEDING RATE & NPK	kg/kg NUTRIENTS [a]	.....(MT/ha).....			INDEX (%) [b]
Spring barley (100 % seed/fertilizers)	181 *ab*	3.63 *cd*	3.18 *d*	6.81 *c*	53.2
50% seeding rate + 0% NPK	271 *a*	2.91 *d*	3.88 *cd*	6.79 *c*	42.9
50% seeding rate + 50% NPK	40 *b*	4.00 *bcd*	5.97 *ab*	9.97 *abc*	39.9
50% seeding rate + 100% NPK	26 *b*	5.03 *abc*	6.39 *a*	11.42 *a*	43.7
75% seeding rate + 0% NPK	308 *a*	3.32 *cd*	4.30 *bcd*	7.62 *bc*	43.6
75% seeding rate + 50% NPK	46 *b*	4.66 *abcd*	5.90 *abc*	10.56 *ab*	44.3
75% seeding rate + 100% NPK	29 *b*	5.46 *ab*	6.49 *a*	11.95 *a*	45.7
100% seeding rate + 0% NPK	301 *a*	3.28 *cd*	4.18 *bcd*	7.46 *bc*	44.2
100% seeding rate + 50% NPK	47 *b*	4.74 *abc*	5.80 *abc*	10.54 *ab*	44.9
100% seeding rate + 100% NPK	31 *b*	5.91 *a*	6.83 *a*	12.74 *a*	46.3
MEAN	**128**	**4.3**	**5.3**	**9.6**	**44.9**
C.V. (%)	106.1	29.0	27.6	26.8	10.9
PR>F	**0.0320**	**<0.0001**	**<0.0001**	**<0.0001**	0.5400
SE	15.2	0.139	0.164	0.287	0.55
LSD (0.05)	133	1.10	1.20	2.20	NS

FACTOR B	TEST WT.	1000 K	HEIGHT	DAYS TO	..TILLERS/.
SEEDING RATE & NPK	(kg/hl)	WT.(g) [a]	(cm) [b]	MATURE	m^2 [b]
Spring barley (100 % seed/fertilizers)	54	45 *a*	-	-	-
50% seeding rate + 0% NPK	70	38 *ab*	115	339	410
50% seeding rate + 50% NPK	69	39 *ab*	118	339	442
50% seeding rate + 100% NPK	70	38 *ab*	119	339	463
75% seeding rate + 0% NPK	69	38 *ab*	113	339	383
75% seeding rate + 50% NPK	69	37 *ab*	121	339	407
75% seeding rate + 100% NPK	69	37 *ab*	116	339	545
100% seeding rate + 0% NPK	70	37 *ab*	108	339	435
100% seeding rate + 50% NPK	70	36 *b*	119	339	513
100% seeding rate + 100% NPK	70	36 *ab*	123	339	492
MEAN	**66**	**38**	**117**	**339**	**454**
C.V. (%)	-	15.5	17.4	-	38.0
PR>F	-	**0.0028**	0.7110	-	0.1400
SE	-	0.7	2.3	-	19.2
LSD (0.05)	-	6	NS	-	NS

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.1.4 Population and NPK Fertilizers Regimes for Winter Rye... Cont'd from previous page
Averaged Over 2019-2020

SEEDING RATE	GRAIN ♣ kg/kg NUTRIENTS [b]	GRAIN [b] (MT/ha)	STRAW [b] (MT/ha)	BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [a]	1000 K WT.(g) [b]	TILLERS/ m^2 [b]
50%	112	3.98	5.41	9.39	42.1 *b*	38	438
75%	128	4.48	5.56	10.04	44.5 *ab*	37	445
100%	126	4.64	5.61	10.25	45.1 *a*	36	480
MEAN	**122**	**4.4**	**5.5**	**9.9**	**43.9**	**37**	**454**
C.V. (%)	107.8	28.7	24.0	25.0	8.8	15.3	35.1
PR>F	0.9800	0.0610	0.6050	0.2190	**0.0066**	0.1800	0.3700
SE	15.50	0.148	0.156	0.291	0.46	0.7	18.8
LSD (0.05)	NS	NS	NS	NS	2.1	NS	NS

NPK RATE	GRAIN ♣ kg/kg NUTRIENTS [a]	GRAIN [a] (MT/ha)	STRAW [a] (MT/ha)	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [b]	1000 K WT.(g) [b]	TILLERS/ m^2 [a]
0%	293 *a*	3.17 *c*	4.12 *c*	7.29 *c*	43.6	38	409 *a*
50%	44 *b*	4.47 *b*	5.89 *b*	10.35 *b*	43.0	37	454 *a*
100%	32 *b*	5.30 *a*	6.42 *a*	11.72 *a*	45.0	39	496 *a*
MEAN	**123**	**4.3**	**5.5**	**9.8**	**43.9**	**38**	**453**
C.V. (%)	107.8	28.7	24.0	25.0	8.8	15.3	35.1
PR>F	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.1400	0.7800	**0.0490**
SE	15.50	0.148	0.156	0.291	0.46	0.7	18.8
LSD (0.05)	43	0.45	0.46	0.80	NS	NS	90

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola

PLANTING DATE: June 2, 2020

FERTILIZERS: 222 kg N/ha (435 kg/ha 46-0-0, 100 kg/ha 21-0-0-24)
30 kg P_2O_5/ha (67 kg/ha 0-45-0) 24 kg S/ha (100 kg/ha 21-0-0-24)
30 kg K_2O/ha (50 kg/ha 0-0-60) 1 kg Boron/ha (7 kg/ha 0-0-0-15)

HERBICIDE: None

HARVEST DATE: September 24, 2019

PREVIOUS CROP: Galega

VARIETY: L252

		…….YIELD…….						
SEEDING RATE & NPK	SEED ♣ kg/kg NUTRIENTS [a]	SEED [a]	STRAW [a]	BIOMASS [a]	HARVEST INDEX (%) [a]	HEIGHT (cm) [a]	DAY TO FLOWER [a]	LODGING▼ (0-9)
		.....(MT/ha).....						
Fallow	11.2	3.43	7.04	10.47	33.4	117	43	0
50% seeding rate + 0% NPK	11.2	3.43	7.46	10.89	33.1	120	45	0
50% seeding rate + 50% NPK	**13.8**	**4.24**	**9.31**	**13.55**	**32.5**	**116**	**46**	**0**
50% seeding rate + 100% NPK	11.4	3.50	6.51	10.01	35.2	115	46	0
75% seeding rate + 0% NPK	10.6	3.26	4.73	7.99	40.5	118	46	0
75% seeding rate + 50% NPK	9.3	2.87	5.31	8.18	35.2	120	45	0
75% seeding rate + 100% NPK	12.9	3.95	8.08	12.03	34.7	116	46	0
100% seeding rate + 0% NPK	**12.0**	**3.69**	**5.88**	**9.57**	**38.6**	**119**	**45**	**0**
100% seeding rate + 50% NPK	**12.4**	**3.82**	**7.84**	**11.66**	**33.2**	**116**	**46**	**0**
100% seeding rate + 100% NPK	10.7	3.28	5.71	9.00	37.0	119	43	0
MEAN	**11.6**	**3.55**	**6.79**	**10.33**	**35.3**	**118**	**45**	**0**
C.V. (%)	23.0	23.0	38.6	31.7	13.9	3.8	2.6	-
PR>F	0.9660	0.9660	0.3860	0.4830	0.2040	0.8020	0.7850	-
SE	0.42	0.129	0.415	0.519	0.78	0.7	0.2	-
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	-

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

♣ Indicates nutrients utilization efficiency.

a Letter codes are not displayed for the means that were not affected by the treatments (P>0.05)

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola

Cont'd from previous page

SEEDING RATE	SEED ♣ kg/kg NUTRIENTS [a]	……YIELD……. SEED [a] (MT/ha)	STRAW [a] (MT/ha)	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [a]	HEIGHT (cm) [a]	DAY TO FLOWER [b]	LODGING▼ (0-9)
50%	**12.1**	**3.72**	**7.76**	**11.48**	**33.6**	**117**	**45 *a***	**0**
75%	10.9	3.36	6.04	9.40	36.8	118	46 *a*	0
100%	11.6	3.56	6.62	10.17	35.6	118	44 *b*	0
MEAN	**11.5**	**3.55**	**6.81**	**10.35**	**35.3**	**118**	**45**	**0**
C.V. (%)	23.0	23.0	38.6	31.7	13.9	3.8	2.6	-
PR>F	0.5730	0.5730	0.2750	0.3070	0.2780	0.7750	**0.0020**	-
SE	0.42	0.129	0.415	0.519	0.78	0.7	0.2	-
LSD (0.05)	NS	NS	NS	NS	NS	NS	2	-

NPK	SEED ♣ kg/kg NUTRIENTS [a]	……YIELD……. SEED [a] (MT/ha)	STRAW [a] (MT/ha)	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [a]	HEIGHT (cm) [a]	DAY TO FLOWER [b]	LODGING▼ (0-9)
Fallow	11.2	3.43	7.04	10.47	33.4	117	43 *b*	0
0%	11.3	3.46	6.02	9.48	37.4	119	45 *a*	0
50%	**11.9**	**3.64**	**7.49**	**11.13**	**33.6**	**117**	**46 *a***	**0**
100%	11.7	3.58	6.77	10.35	35.6	117	45 *a*	0
MEAN	**11.5**	**3.53**	**6.83**	**10.36**	**35.0**	**118**	**45**	**0**
C.V. (%)	23.0	23.0	38.6	31.7	13.9	3.8	2.6	-
PR>F	0.9500	0.9500	0.6200	0.7000	0.2500	0.6100	**0.0007**	-
SE	0.42	0.129	0.415	0.519	0.78	0.7	0.2	-
LSD (0.05)	NS	NS	NS	NS	NS	NS	2	-

Notes:

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

♣ Indicates nutrients utilization efficiency.

a Letter codes are not displayed for the means that were not affected by the treatments (P>0.05)

b Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola

Pre Canola Seeding Soil Test Results…Cont'd from previous page

SEEDING RATE & NPK	Organic Matter	Phosphorus Bicarbonate	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	pH	pH Buffer
Fallow	3.7	11 L	91 M	565 VH	2060 M	38 M	6.8	6.9
50% seeding rate + 0% NPK	3.8	8 VL	71 L	526 VH	1870 M	37 H	6.6	6.9
50% seeding rate + 50% NPK	3.8	12 L	86 M	550 VH	1930 M	34 M	6.6	6.9
50% seeding rate + 100% NPK	3.7	13 L	83 M	544 VH	1950 M	37 M	6.4	6.8
75% seeding rate + 0% NPK	3.7	14 L	81 M	565 VH	2020 M	36 M	6.7	6.9
75% seeding rate + 50% NPK	3.6	9 VL	73 L	595 VH	2040 M	38 M	6.5	6.9
75% seeding rate + 100% NPK	3.7	11 L	96 M	530 H	1900 L	32 M	6.4	6.7
100% seeding rate + 0% NPK	3.5	7 VL	70 L	549 VH	1920 M	39 H	6.7	6.9
100% seeding rate + 50% NPK	3.8	9 VL	78 L	537 VH	1930 M	35 M	6.8	6.8
100% seeding rate + 100% NPK	3.8	14 L	78 L	529 VH	1870 M	35 M	6.6	6.8

SEEDING RATE & NPK	CEC meg/100g	Percent Base Solutions % K	% Mg	% Ca	% H	% Na	Sulphur S ppm	Zinc Zn ppm
Fallow	16.5	1.4	28.5	62.3	6.9	1.0	13 VL	3.5 M
50% seeding rate + 0% NPK	15.2	1.2	28.8	61.4	7.5	1.1	7 VL	3.1 M
50% seeding rate + 50% NPK	15.7	1.4	29.1	61.3	7.2	0.9	7 VL	3.2 M
50% seeding rate + 100% NPK	17.0	1.3	26.7	57.4	13.8	0.9	7 VL	4.8 M
75% seeding rate + 0% NPK	16.3	1.3	28.9	61.9	7.0	1.0	7 VL	3.1 M
75% seeding rate + 50% NPK	16.6	1.1	29.8	61.3	6.8	1.0	6 VL	3.5 M
75% seeding rate + 100% NPK	17.8	1.4	24.8	53.2	19.8	0.8	6 VL	3.6 M
100% seeding rate + 0% NPK	15.7	1.1	29.2	61.3	7.3	1.1	7 VL	3.0 M
100% seeding rate + 50% NPK	16.8	1.2	26.6	57.4	13.9	0.9	7 VL	9.9 H
100% seeding rate + 100% NPK	16.5	1.2	26.8	56.8	14.2	0.9	6 VL	4.0 M

Note: VL=very low, L=low, M=medium, H=high, VH=very high, G=good

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola

Pre Canola Seeding Soil Test Results…Cont'd from previous page

SEEDING RATE & NPK	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Saturation %P	Aluminum Al ppm	Saturation %Al
Fallow	14 L	99 VH	1.6 H	0.4 L	4 L	824	0.1 G
50% seeding rate + 0% NPK	15 M	94 VH	1.4 H	0.4 L	3 L	820	0.2 G
50% seeding rate + 50% NPK	13 L	95 VH	1.5 H	0.4 L	3 L	811	0.2 G
50% seeding rate + 100% NPK	12 L	98 VH	1.5 H	0.4 L	4 L	851	0.2 G
75% seeding rate + 0% NPK	15 M	98 VH	1.6 H	0.4 L	3 L	829	0.2 G
75% seeding rate + 50% NPK	13 L	96 VH	1.6 H	0.5 L	3 L	871	0.2 G
75% seeding rate + 100% NPK	14 L	98 VH	1.5 H	0.4 L	3 L	855	0.2 G
100% seeding rate + 0% NPK	14 L	97 VH	1.6 H	0.3 VL	2 VL	814	0.2 G
100% seeding rate + 50% NPK	13 L	98 VH	1.5 H	0.4 L	4 L	847	0.1 G
100% seeding rate + 100% NPK	14 L	99 VH	1.5 H	0.4 L	4 L	836	0.2 G

SEEDING RATE & NPK	Nitrate N ppm	NH4N ppm	K/Mg Ratio	ENR
Fallow	10 M	7	0.05	49
50% seeding rate + 0% NPK	6 L	7	0.04	50
50% seeding rate + 50% NPK	8 L	6	0.05	50
50% seeding rate + 100% NPK	9 L	7	0.05	49
75% seeding rate + 0% NPK	5 L	7	0.04	49
75% seeding rate + 50% NPK	8 L	6	0.04	48
75% seeding rate + 100% NPK	8 L	6	0.06	49
100% seeding rate + 0% NPK	4 VL		0.04	47
100% seeding rate + 50% NPK	6 L	7	0.05	50
100% seeding rate + 100% NPK	9 L	10	0.04	50

Note: VL=very low, L=low, M=medium, H=high, VH=very high, G=good

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola
Cont'd from previous page
Avergaed Over 2019 - 2020

SEEDING RATE & NPK	SEED ♣ kg/kg NUTRIENTS	……YIELD……. SEED (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)	LODGING▼ (0-9)
Fallow	16.7	4.84	8.47	13.31	36.0	126	0
50% seeding rate + 0% NPK	16.6	4.82	8.85	13.67	35.6	129	0
50% seeding rate + 50% NPK	**17.8**	**5.19**	**9.96**	**15.14**	**34.8**	**126**	**0**
50% seeding rate + 100% NPK	15.4	4.47	7.78	12.26	36.8	126	0
75% seeding rate + 0% NPK	15.2	4.42	7.11	11.53	39.0	131	0
75% seeding rate + 50% NPK	14.0	4.07	7.54	11.61	35.3	126	0
75% seeding rate + 100% NPK	**17.8**	**5.18**	**9.70**	**14.88**	**35.3**	**125**	**0**
100% seeding rate + 0% NPK	15.1	4.41	7.67	12.08	36.8	127	0
100% seeding rate + 50% NPK	**16.9**	**4.90**	**9.51**	**14.41**	**34.0**	**123**	**0**
100% seeding rate + 100% NPK	15.6	4.52	7.78	12.31	36.9	128	0
MEAN	**16.1**	**4.68**	**8.44**	**13.12**	**36.1**	**127**	**0**

Notes:
♣ Indicates nutrients utilization efficiency.

4.1.5 Residual Effect of Winter Rye Cover Crop - Different Seeding and NPK Fertilizer Rates on Canola
Avergaed Over 2019 - 2020…Cont'd from previous page

SEEDING RATE	SEED ♣ kg/kg NUTRIENTS	…….YIELD……. SEED	STRAW	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)
50%	**18.9**	**5.38**	**9.42**	**14.79**	**36.8**	**132**
75%	18.1	5.16	9.15	14.31	36.4	132
100%	17.9	5.12	9.24	14.36	35.7	130
MEAN	**18.3**	**5.22**	**9.27**	**14.49**	**36.3**	**131**

NPK	SEED ♣ kg/kg NUTRIENTS	…….YIELD……. SEED	STRAW	BIOMASS (MT/ha)	HARVEST INDEX (%)	HEIGHT (cm)
Fallow	**19.4**	**5.54**	**9.19**	**14.73**	**37.4**	**130**
0%	17.9	5.10	8.80	13.90	37.0	134
50%	18.4	5.26	9.76	15.02	35.3	129
100%	18.6	5.30	9.25	14.55	36.7	131
MEAN	**18.6**	**5.30**	**9.25**	**14.55**	**36.6**	**131**

Notes:
▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.
♣ Indicates nutrients utilization efficiency.

Grain Legumes

Evaluation of NK21 as a Source of N and K for Soybean Production

PLANTING DATE: May 19, 2020
FERTILIZER: N and K as per treatments
30 kg P_2O_5/ha (67 kg/ha 0-45-0)
19.5 kg S/ha (115 kg/ha 0-0-0-17)
PESTICIDE: Roundup @ 3 L/ha applied post - emergent; June 16, 2020
HARVEST DATE: September 25, 2020
PREVIOUS CROP: Malting Barley
VARIETY: 25-10RY

TREATMENTS	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day)
1. No N	**5.33**	**22.2**	**90 *b***	**120**	**44.4**
2. No K	4.57	20.3	94 *ab*	120	38.1
3. No N or K (absolute control)	5.24	21.1	95 *ab*	120	43.7
4. NK21 @ 21 kg N + 21 kg K_2O/ha	5.12	21.9	101 *a*	120	42.7
5. NK21 @ 42 kg N + 42 kg K_2O/ha	5.15	23.0	98 *a*	120	42.9
6. NK21 @ 63 kg N + 63 kg K_2O/ha	5.11	21.9	100 *a*	120	42.6
7. NK21 @ 84 kg N + 84 kg K_2O/ha	**5.80**	**22.5**	**99 *a***	**120**	**48.3**
8. Urea @ 21 kg N/ha + MOP @ 21 kg K_2O/ha	**5.75**	**20.6**	**98 *a***	**120**	**47.9**
9. Urea @ 42 kg N/ha + MOP @ 42 kg K_2O/ha	5.22	21.4	95 *ab*	120	43.5
10. Urea @ 63 kg N/ha + MOP @ 63 kg K_2O/ha	5.17	21.9	100 *a*	120	43.1
11. Urea @ 84 kg N/ha + MOP @ 84 kg K_2O/ha	4.42	22.5	99 *a*	120	36.8
MEAN	**5.17**	**21.8**	**97**	**120**	**43.1**
C.V. (%)	18.9	6.5	4.2	-	18.9
PR>F	0.7300	0.1700	**0.0004**	-	0.7300
SE	0.147	0.21	0.6	-	1.23
LSD (0.05)	NS	NS	4	-	NS

Notes:
Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 5, Nitrate N: 6, Total N: 11
Pre seeding soil analysis 0-15 cm (ppm): K: 107
MOP: Muriate of Potash
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Cont'd from previous page

SOURCE OF NITROGEN	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
No N	5.29	21.7	93 *b*	120	44.0
Urea	5.03	21.3	97 *a*	120	41.9
NK 21	**5.30**	**22.3**	**100 *a***	**120**	**44.1**
Mean	**5.20**	**21.8**	**96**	**120**	**43.4**
C.V. (%)	18.9	6.5	4.2	-	18.9
PR>F	0.6600	0.1100	**0.0001**	**-**	0.6600
SE	0.147	0.21	0.6	-	1.23
LSD (0.05)	NS	NS	3	-	NS

NITROGEN kg/ha	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
0	**5.29**	**21.7**	**93 *b***	**120**	**44.0**
21	5.15	20.9	98 *a*	120	42.9
42	5.18	22.2	96 *ab*	120	43.2
63	5.14	21.9	100 *a*	120	42.8
84	5.11	22.5	99 *a*	120	42.6
Mean	**5.17**	**21.9**	**97**	**120**	**43.1**
C.V. (%)	18.9	6.5	4.2	-	18.9
PR>F	0.7500	0.0620	**0.0017**	**-**	0.7500
SE	0.147	0.21	0.6	-	1.23
LSD (0.05)	NS	NS	3	-	NS

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Cont'd from previous page

SOURCE OF K_2O	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [a]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
No K_2O	4.91	20.7 *b*	95 *b*	120	40.9
Muriate of Potash	5.18	21.7 *ab*	96 *b*	120	43.1
NK 21	**5.30**	**22.3 *a***	**100 *a***	**120**	**44.1**
Mean	**5.13**	**21.6**	**97**	**120**	**42.7**
C.V. (%)	18.9	6.5	4.2	-	18.9
PR>F	0.6500	**0.0260**	**0.0064**	**-**	0.6500
SE	0.147	0.21	0.6	-	1.23
LSD (0.05)	NS	1.0	3	**-**	NS

K_2O kg/ha	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [a]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
0	4.91	20.7 *a*	95 *a*	120	40.9
21	**5.40**	**21.6 *a***	**97 *a***	**120**	**45.0**
42	5.18	22.2 *a*	96 *a*	120	43.2
63	5.14	21.9 *a*	100 *a*	120	42.8
84	5.11	22.5 *a*	99 *a*	120	42.6
Mean	**5.15**	**21.8**	**97**	**120**	**42.9**
C.V. (%)	18.9	6.5	4.2	-	18.9
PR>F	0.9800	**0.0130**	**0.0082**	**-**	0.1100
SE	0.147	0.21	0.6	-	1.23
LSD (0.05)	NS	1.4	5	**-**	NS

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Evaluation of NK21 as a Source of N and K for Soybean Production 100
Average Over 2018 - 2020

TREATMENTS	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [b]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
1. No N	3.49	18.4	83	128	27.8
2. No K	3.68	17.8	87	128	29.0
3. No N or K (absolute control)	3.89	18.4	86	128	30.7
4. NK21 @ 21 kg N + 21 kg K_2O/ha	3.82	18.9	89	128	30.2
5. NK21 @ 42 kg N + 42 kg K_2O/ha	3.88	19.1	89	128	30.6
6. NK21 @ 63 kg N + 63 kg K_2O/ha	3.92	18.7	90	128	30.9
7. NK21 @ 84 kg N + 84 kg K_2O/ha	**4.03**	**19.0**	**92**	**128**	**31.9**
8. Urea @ 21 kg N/ha + MOP @ 21 kg K_2O/ha	**4.03**	**18.0**	**88**	**129**	**31.9**
9. Urea @ 42 kg N/ha + MOP @ 42 kg K_2O/ha	**4.04**	**18.9**	**89**	**128**	**31.9**
10. Urea @ 63 kg N/ha + MOP @ 63 kg K_2O/ha	**4.13**	**18.8**	**91**	**128**	**32.5**
11. Urea @ 84 kg N/ha + MOP @ 84 kg K_2O/ha	3.64	19.3	93	128	28.6
MEAN	**3.87**	**18.7**	**89**	**128**	**30.6**
C.V. (%)	31.2	13.9	12.3	-	35.2
PR>F	0.9800	0.9700	0.6700	-	0.9900
SE	0.105	0.23	0.9	-	0.94
LSD (0.05)	NS	NS	NS	-	NS

Notes:
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

Evaluation of NK21 as a Source of N and K for Soybean Production
Average Over 2018 - 2020…Cont'd from previous page

SOURCE OF NITROGEN	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [b]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
No N	3.69	18.4	85	128	29.3
Urea	3.90	18.6	89	128	30.8
NK 21	**3.91**	**18.9**	**90**	**128**	**30.9**
Mean	**3.84**	**18.6**	**88**	**128**	**30.0**
C.V. (%)	31.2	13.9	12.3	-	35.2
PR>F	0.7300	0.7100	0.1200	-	0.8100
SE	0.105	0.23	0.9	-	0.94
LSD (0.05)	NS	NS	NS	-	NS

NITROGEN kg/ha	GRAIN YIELD (MT/ha) [b]	100 K WT. (g) [b]	HEIGHT (cm) [a]	DAYS TO MATURE	YIELD/DAY (kg/ha/day) [b]
0	3.69	18.4	85 *a*	128	29.3
21	3.84	18.3	88 *a*	128	30.4
42	3.96	19.0	89 *a*	128	31.3
63	**4.02**	**18.7**	**90 *a***	**128**	**31.7**
84	3.84	19.2	93 *a*	128	30.3
Mean	**3.87**	**18.7**	**89**	**128**	**30.6**
C.V. (%)	31.2	13.9	12.3	-	35.2
PR>F	0.5500	0.2100	**0.0078**	-	0.6300
SE	0.105	0.23	0.9	-	0.94
LSD (0.05)	NS	NS	5	-	NS

Notes:
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

SOURCE OF K_2O	GRAIN YIELD (MT/ha)	100 K WT. (g)	HEIGHT (cm)	DAYS TO MATURE	YIELD/DAY (kg/ha/day)
No K_2O	3.78	18.1	86	128	29.9
Muriate of Potash	3.86	18.7	89	128	30.5
NK 21	**3.91**	**18.9**	**90**	**128**	**30.9**
Mean	**3.85**	**18.6**	**88**	**128**	**30.4**
C.V. (%)	31.2	13.9	12.3	-	35.2
PR>F	0.9100	0.4900	0.3900	-	0.9300
SE	0.105	0.23	0.9	-	0.94
LSD (0.05)	NS	NS	NS	-	NS

K_2O kg/ha	GRAIN YIELD (MT/ha)	100 K WT. (g)	HEIGHT (cm)	DAYS TO MATURE	YIELD/DAY (kg/ha/day)
0	3.78	18.1	86 *a*	128	29.9
21	3.78	18.5	87 *a*	128	30.0
42	3.96	19.0	89 *a*	128	31.3
63	**4.02**	**18.7**	**90 *a***	**128**	**31.7**
84	3.84	19.2	93 *a*	128	30.3
Mean	**3.88**	**18.7**	**89**	**128**	**30.6**
C.V. (%)	31.2	13.9	12.3	-	35.2
PR>F	0.6300	0.1600	**0.0150**	-	0.6900
SE	0.105	0.23	0.9	-	0.94
LSD (0.05)	NS	NS	7	-	NS

Notes:

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.2.2 Nitrogen and Sulphur Management for Lentil Production

PLANTING DATE: May 9, 2020
FERTILIZERS: N and S as per treatments
20 kg P_2O_5/ha (45 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
HERBICIDE: Odyssey + Merge @ 43 g/ha applied post - emergent; June 3, 2020
HARVEST DATE: August 25, 2020
PREVIOUS CROP: Winter Rye
VARIETY CDC Impulse

…….FACTOR A X B…….		GRAIN ♣ [b]	GRAIN YIELD [b]	1000 K	TEST WT.
FACTOR A	FACTOR B	kg/kg NUTRIENTS	(MT/ha)	WT.(g)	(kg/hl)
1. Check (Zero N)	0 kg S/ha	14.5	0.58	51	71
2. 22.5 kg N/ha	0 kg S/ha	11.0	0.68	54	71
3. 45 kg N/ha	**0 kg S/ha**	**9.3**	**0.79**	**50**	**71**
4. 0 kg N/ha	8 kg S/ha	13.1	0.63	48	70
5. 22.5 kg N/ha	8 kg S/ha	10.1	0.71	48	71
6. 45 kg N/ha	**8 kg S/ha**	**9.4**	**0.88**	**50**	**71**
7. 0 kg N/ha	16 kg S/ha	11.2	0.63	50	71
8. 22.5 kg N/ha	16 kg S/ha	8.8	0.69	48	70
9. 45 kg N/ha	16 kg S/ha	6.9	0.70	53	70
10. 0 kg N/ha	24 kg S/ha	6.4	0.41	51	70
11. 22.5 kg N/ha	24 kg S/ha	7.7	0.67	50	71
12. 45 kg N/ha	**24 kg S/ha**	**9.0**	**0.98**	**53**	**71**
MEAN		**9.8**	**0.70**	**50.50**	**70.63**
C.V. (%)		45.1	42.9	-	-
PR>F - A		0.2240	0.0515	-	-
PR>F - B		0.1330	0.9514	-	-
PR>F - (A x B)		0.6580	0.8114	-	-
SE		0.64	0.043	-	-
LSD (0.05)		NS	NS	-	-

Notes:
♣Indicates nutrients utilization efficiency
N was supplied through urea; Sulphur was supplied through gypsum
Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 6, Nitrate N: 9, Total N: 15 and S: 6
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

Cont'd from Previous page

FACTOR A	GRAIN ♣ [b] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)	TEST WT. (kg/hl)
1. Check (Zero N)	11.3	0.56	50	71
2. 22.5 kg N/ha	9.4	0.69	50	71
3. 45 kg N/ha	**8.7**	**0.84**	**52**	**71**
MEAN	**9.8**	**0.70**	**51**	**71**
C.V. (%)	45.1	42.9	-	-
PR>F - A	0.2240	0.0515	-	-
SE	0.64	0.043	-	-
LSD (0.05)	NS	NS	-	-

FACTOR B	GRAIN ♣ [b] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)	TEST WT. (kg/hl)
1. Zero S	11.6	0.68	52	71
2. 8 kg S/ha	**10.9**	**0.74**	**49**	**71**
3. 16 kg S/ha	9.0	0.67	50	70
4. 24 kg S/ha	7.7	0.68	51	71
MEAN	**9.8**	**0.70**	**51**	**71**
C.V. (%)	45.1	42.9	-	-
PR>F - B	0.1330	0.9514	-	-
SE	0.64	0.043	-	-
LSD (0.05)	NS	NS	-	-

Notes:

♣Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.2.2 Nitrogen and Sulphur Management for Lentil Production
Averaged over 2019 - 2020

…….FACTOR A X B…….		GRAIN ♣	GRAIN YIELD	1000 K	TEST WT.
FACTOR A	FACTOR B	kg/kg NUTRIENTS	(MT/ha)	WT.(g)	(kg/hl)
1. Check (Zero N)	**0 kg S/ha**	**26.6**	**2.03**	**47**	**72**
2. 22.5 kg N/ha	0 kg S/ha	17.1	1.65	47	73
3. 45 kg N/ha	0 kg S/ha	14.5	1.72	47	72
4. 0 kg N/ha	8 kg S/ha	21.6	1.79	48	72
5. 22.5 kg N/ha	8 kg S/ha	16.9	1.78	45	72
6. 45 kg N/ha	**8 kg S/ha**	**14.8**	**1.87**	**47**	**72**
7. 0 kg N/ha	**16 kg S/ha**	**20.5**	**1.89**	**48**	**72**
8. 22.5 kg N/ha	16 kg S/ha	15.8	1.80	45	71
9. 45 kg N/ha	16 kg S/ha	11.1	1.51	48	70
10. 0 kg N/ha	24 kg S/ha	14.9	1.54	49	72
11. 22.5 kg N/ha	24 kg S/ha	13.5	1.65	48	72
12. 45 kg N/ha	24 kg S/ha	12.6	1.77	48	72
MEAN		**16.6**	**1.75**	**47**	**72**

Notes:
♣Indicates nutrients utilization efficiency
N was supplied through urea; Sulphur was supplied through gypsum

4.2.2 Nitrogen and Sulphur Management for Lentil Production Averaged Over 2019 - 2020...Cont'd from Previous page

FACTOR A	GRAIN ♣ [a] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)	TEST WT. (kg/hl)
1. Check (Zero N)	**20.9**	**1.81**	**48**	**72**
2. 22.5 kg N/ha	15.8	1.72	46	72
3. 45 kg N/ha	13.2	1.72	47	71
MEAN	**16.6**	**1.75**	**47**	**72**

FACTOR B	GRAIN ♣ kg/kg NUTRIENTS	GRAIN YIELD (MT/ha)	1000 K WT.(g)	TEST WT. (kg/hl)
1. Zero S	19.4	1.80	47	72
2. 8 kg S/ha	**17.7**	**1.81**	**47**	**72**
3. 16 kg S/ha	15.8	1.73	47	71
4. 24 kg S/ha	13.7	1.65	49	72
MEAN	**16.63**	**1.75**	**47**	**72**

Notes:
♣Indicates nutrients utilization efficiency

4.2.3 Phosphorus and Potassium Management for Lentil Production

PLANTING DATE: May 9, 2020
FERTILIZERS: P and K as per treatments
45 kg N/ha (71 kg/ha 21-0-0-24, 65 kg/ha 46-0-0)
17 kg S/ha (71 kg/ha 21-0-0-24)
HERBICIDE: Odyssey + Merge @ 43 g/ha applied post - emergent; June 3, 2020
HARVEST DATE: August 25, 2020
PREVIOUS CROP: Soybeans

…….FACTOR A X B…….		GRAIN ♣ [b]	GRAIN YIELD [b]	1000 K
FACTOR A	FACTOR B	kg/kg NUTRIENTS	(MT/ha)	WT.(g)
1. 0 kg P_2O_5/ha	0 kg K_2O/ha	8.2	0.51	44
2. 20 kg P_2O_5/ha	**0 kg K_2O/ha**	**10.2**	**0.84**	**46**
3. 40 kg P_2O_5/ha	**0 kg K_2O/ha**	**6.7**	**0.69**	**47**
4. 0 kg P_2O_5/ha	**20 kg K_2O/ha**	**8.3**	**0.68**	**44**
5. 20 kg P_2O_5/ha	20 kg K_2O/ha	5.4	0.55	45
6. 40 kg P_2O_5/ha	20 kg K_2O/ha	5.3	0.64	49
7. 0 kg P_2O_5/ha	40 kg K_2O/ha	4.6	0.47	48
8. 20 kg P_2O_5/ha	40 kg K_2O/ha	4.3	0.53	45
9. 40 kg P_2O_5/ha	40 kg K_2O/ha	3.3	0.47	46
MEAN		**6.3**	**0.60**	**46**
C.V. (%)		48.3	40.2	-
PR>F - A		0.0870	0.6339	-
PR>F - B		**0.0002**	0.0962	-
PR>F - (A x B)		0.2562	0.3300	-
SE		0.50	0.040	-
LSD (0.05)		NS	NS	-

Notes:
♣Indicates nutrients utilization efficiency
Pre seeding soil analysis 0-30 cm (ppm): P: 16; K: 126
Test wt. was not taken due to poor yeild
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

Cont'd from Previous page

FACTOR A	GRAIN ♣ [b] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)
1. 0 kg P_2O_5/ha	7.1	0.55	45
2. 20 kg P_2O_5/ha	**6.6**	**0.64**	**45**
3. 40 kg P_2O_5/ha	5.1	0.60	47
MEAN	**6.3**	**0.60**	**46**
C.V. (%)	48.3	40.2	-
PR>F - A	0.0870	0.6339	-
SE	0.50	0.040	-
LSD (0.05)	NS	NS	-

FACTOR B	GRAIN ♣ [a] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)
1. 0 kg K_2O/ha	**8.4 *a***	**0.68**	**46**
2. 20 kg K_2O/ha	6.3 *a*	0.63	46
3. 40 kg K_2O/ha	4.1 *b*	0.49	46
MEAN	**6.3**	**0.60**	**46**
C.V. (%)	48.3	40.2	-
PR>F - B	**0.0002**	0.0962	-
SE	0.50	0.040	-
LSD (0.05)	1.8	NS	-

Notes:
♣Indicates nutrients utilization efficiency
Test wt. was not taken due to poor yeild
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

4.2.3 Phosphorus and Potassium Management for Lentil Production
Averaged over 2019 - 2020

…….FACTOR A X B…….		GRAIN ♣ [a]	GRAIN YIELD [b]	1000 K
FACTOR A	FACTOR B	kg/kg NUTRIENTS	(MT/ha)	WT.(g)
1. 0 kg P_2O_5/ha	0 kg K_2O/ha	20.7	1.28	44
2. 20 kg P_2O_5/ha	**0 kg K_2O/ha**	**17.7**	**1.46**	**45**
3. 40 kg P_2O_5/ha	**0 kg K_2O/ha**	**14.3**	**1.46**	**47**
4. 0 kg P_2O_5/ha	**20 kg K_2O/ha**	**20.0**	**1.64**	**45**
5. 20 kg P_2O_5/ha	20 kg K_2O/ha	11.4	1.16	44
6. 40 kg P_2O_5/ha	20 kg K_2O/ha	11.9	1.45	48
7. 0 kg P_2O_5/ha	40 kg K_2O/ha	14.0	1.43	46
8. 20 kg P_2O_5/ha	40 kg K_2O/ha	9.5	1.16	44
9. 40 kg P_2O_5/ha	40 kg K_2O/ha	8.1	1.15	44
MEAN		**14.2**	**1.36**	**45**

Notes:
♣Indicates nutrients utilization efficiency
Test wt. was not taken in 2020 due to poor yeild

4.2.3 Phosphorus and Potassium Management for Lentil Production Averaged Over 2019 - 2020…Cont'd from Previous page

FACTOR A	GRAIN ♣ [a] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)
1. 0 kg P_2O_5/ha	**18.1**	**1.41**	**45**
2. 20 kg P_2O_5/ha	12.7	1.23	45
3. 40 kg P_2O_5/ha	11.4	1.33	46
MEAN	**14.1**	**1.32**	**45**

FACTOR B	GRAIN ♣ [a] kg/kg NUTRIENTS	GRAIN YIELD [b] (MT/ha)	1000 K WT.(g)
1. 0 kg K_2O/ha	17.6	1.40	46
2. 20 kg K_2O/ha	**14.4**	**1.42**	**46**
3. 40 kg K_2O/ha	10.6	1.25	45
MEAN	**14.2**	**1.36**	**45**

Notes:
♣Indicates nutrients utilization efficiency
Test wt. was not taken in 2020 due to poor yeild

Oil Seeds

4.3.1 Response of Canola to High Rates of N Application from Different Sources

PLANTING DATE: May 18, 2020
FERTILIZERS: N as per treatments
20 kg P_2O_5/ha (44 kg/ha 0-45-0) 7 kg Zn/ha (35 kg/ha 0-0-0-16-20)
20 kg K_2O/ha (33 kg/ha 0-0-60) 1 kg B/ha (7 kg/ha 0-0-0-15)
36 kg S/ha (182 kg/ha 0-0-0-17, 35 kg/ha 0-0-0-16-20)
PESTICIDES: Liberty @ 3 L/ha applied; June 8, and June 18, 2020
HARVEST DATE: September 1, 2020
PREVIOUS CROP: Winter wheat
VARIETY: L252

Trt	Nitrogen (kg N/ha) from: Urea	ESN	Urea SuperU	Total N (kg N/ha)	SEED ♣ kg/kg NUTRIENTS [b]	YIELD SEED [a]	STRAW [b]	BIOMASS [b]	HARVEST INDEX (%) [b]
						(MT/ha)			
1	0	0	0	0	14.3	1.29 *c*	4.98	6.26	21.0
2	90	0	0	90	17.2	3.10 *abc*	5.60	8.70	35.9
3	180	0	0	180	12.8	3.47 *abc*	6.94	10.41	35.4
4	**270**	**0**	**0**	**270**	**12.9**	**4.63 *a***	**8.93**	**13.55**	**34.6**
5	360	0	0	360	7.0	3.16 *abc*	5.32	8.47	37.4
6	60	30	0	90	16.6	2.98 *abc*	6.09	9.07	32.9
7	120	60	0	180	12.9	3.47 *abc*	5.17	8.64	40.2
8	180	90	0	270	11.0	3.97 *ab*	6.82	10.79	40.0
9	240	120	0	360	8.4	3.78 *ab*	4.67	8.46	48.6
10	0	0	90	90	12.9	2.32 *abc*	5.24	7.57	30.9
11	0	0	180	180	12.0	3.25 *abc*	6.75	10.00	33.5
12	0	0	270	270	9.5	3.43 *abc*	6.97	10.40	32.7
13	**0**	**0**	**360**	**360**	**9.5**	**4.28 *ab***	**8.10**	**12.38**	**35.5**
14	60	0	30	90	11.7	2.11 *bc*	4.26	6.37	34.0
15	120	0	60	180	12.1	3.27 *abc*	5.92	9.19	35.1
16	180	0	90	270	10.0	3.60 *abc*	6.62	10.22	36.2
17	240	**0**	120	360	9.3	4.17 *ab*	5.65	9.82	43.5
18	**60**	**60**	**60**	**180**	**16.8**	**4.53 *ab***	**6.96**	**11.49**	**39.5**
	MEAN				**12.1**	**3.38**	**6.17**	**9.54**	**35.9**
	C.V. (%)				28.1	29.2	33.0	27.3	25.9
	PR>F				0.0629	**0.0123**	0.8000	0.2600	0.0820
	SE				0.40	0.116	0.240	0.307	1.10
	LSD (0.05)				NS	1.30	NS	NS	NS

NOTES:

Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 13, Nitrate N: 13, Total N: 26, and S: 6

Trt: Treatment

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

4.3.1 Response of Canola to High Rates of N Application from Different Sources
Cont'd from previous page

Trt	Nitrogen (kg N/ha) from: Urea	ESN	Urea SuperU	Total N (kg N/ha)	HEIGHT (cm)	……DAYS TO…… FLOWER [a]	MATURE [a]	LODGING♠ (0-9)
1	0	0	0	0	108	45 *b*	106 *b*	0
2	90	0	0	90	123	45 *b*	106 *b*	0
3	180	0	0	180	125	45 *b*	106 *b*	0
4	**270**	**0**	**0**	**270**	**123**	**46 *ab***	**107 *ab***	**0**
5	360	0	0	360	125	45 *b*	106 *b*	0
6	60	30	0	90	121	46 *ab*	107 *ab*	0
7	120	60	0	180	124	46 *ab*	107 *ab*	0
8	180	90	0	270	129	45 *b*	106 *b*	0
9	240	120	0	360	123	46 *ab*	107 *ab*	0
10	0	0	90	90	124	45 *b*	106 *b*	0
11	0	0	180	180	119	45 *b*	106 *b*	0
12	0	0	270	270	120	46 *ab*	107 *ab*	0
13	**0**	**0**	**360**	**360**	**130**	**47 *a***	**108 *a***	**0**
14	60	0	30	90	117	45 *b*	106 *b*	0
15	120	0	60	180	123	46 *ab*	107 *ab*	0
16	180	0	90	270	128	46 *ab*	107 *ab*	0
17	240	0	120	360	130	46 *ab*	107 *ab*	0
18	**60**	**60**	**60**	**180**	**136**	**45 *b***	**106 *b***	**0**
	MEAN				**124**	**46**	**107**	**0**
	C.V. (%)				-	1.4	0.6	-
	PR>F				-	**0.0150**	**0.0150**	-
	SE				-	0.1	0.1	-
	LSD (0.05)				-	0.88	0.88	-

NOTES:
Trt: Treatments
a Letter codes not displayed for the means were not affected by the treatments (P>0.05)
b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

4.3.1 Response of Canola to High Rates of N Application from Different Sources

Cont'd from previous page

N RATE	SEED ♣ [b]	SEED [a]	STRAW [b]	BIOMASS [b]	HARVEST	HEIGHT	DAYS TO
kg N/ha	kg/kg NUTRIENTS	.....Yield (MT/ha).....			INDEX (%) [b]	(cm)	FLOWER [a]
0	14.3	1.29 *b*	4.98	6.26	21.0	108	45 *a*
90	12.5	3.59 *a*	6.69	10.28	35.8	124	45 *a*
180	12.4	3.31 *a*	5.60	8.91	38.5	124	46 *a*
270	10.7	3.27 *a*	6.52	9.79	33.9	122	46 *a*
360	**12.0**	**3.89 *a***	**6.29**	**10.18**	**38.6**	**129**	**46 *a***
MEAN	**12.4**	**3.07**	**6.02**	**9.08**	**33.6**	**121**	**46**
C.V. (%)	28.1	29.2	33.0	27.3	25.9	-	1.4
PR>F	0.1800	**0.0046**	0.6100	0.1500	0.0680	-	
SE	0.40	0.116	0.240	0.307	1.10	-	0.1
LSD (0.05)	NS	0.88	NS	NS	NS	-	1

N SOURCE	SEED ♣ [a]	SEED [b]	STRAW [b]	BIOMASS [b]	HARVEST	HEIGHT	DAYS TO
	kg/kg NUTRIENTS	.....Yield (MT/ha).....			INDEX (%) [b]	(cm)	FLOWER [b]
Urea	12.5 *ab*	3.59	6.69	10.28	35.8	124	45
Urea+ESN (2:1 on N basis)	12.2 *ab*	3.55	5.69	9.24	40.4	124	46
Urea SuperU	11.0 *b*	3.32	6.77	10.09	33.1	123	46
Urea+Urea SuperU 2:1	10.8 *b*	3.29	5.61	8.90	37.2	124	46
Urea+ESN+Urea SuperU*	**16.8 *a***	**4.53**	**6.96**	**11.49**	**39.5**	**136**	**45**
MEAN	**12.6**	**3.7**	**6.3**	**10.0**	**37.2**	**127**	**46**
C.V. (%)	28.4	24.8	32.8	25.8	23.9	-	1.4
PR>F	0.0140	0.1000	0.3000	0.2600	0.2000	-	0.2300
SE	0.41	0.105	0.248	0.305	1.07	-	0.1
LSD (0.05)	4.2	NS	NS	NS	NS	-	NS

NOTES: ♣ Indicates nutrients utilization efficiency. *Each @ 60 kg N/ha

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

4.3.1 Response of Canola to High Rates of N Application from Different Sources
Cont'd from previous page
Averaged over 2019 - 2020

Trt	Nitrogen (kg N/ha) from: Urea	ESN	Urea SuperU	Total N (kg N/ha)	SEED ♣ kg/kg NUTRIENTS	YIELD (MT/ha) SEED	STRAW	BIOMASS	HARVEST INDEX (%)
1	0	0	0	0	18.0	3.41	6.29	9.70	31.6
2	90	0	0	90	17.2	4.23	6.54	10.77	38.8
3	180	0	0	180	18.3	4.00	7.01	11.01	37.2
4	**270**	**0**	**0**	**270**	**16.9**	**4.78**	**7.71**	**12.49**	**38.9**
5	360	0	0	360	11.3	4.07	6.58	10.65	38.1
6	60	30	0	90	21.4	3.79	6.35	10.14	37.1
7	**120**	**60**	**0**	**180**	**15.9**	**4.78**	**6.96**	**11.75**	**40.6**
8	180	90	0	270	13.7	4.46	7.40	11.85	39.3
9	240	120	0	360	11.9	4.29	5.83	10.13	44.7
10	0	0	90	90	17.4	3.64	6.05	9.69	36.5
11	0	0	180	180	14.9	3.98	6.53	10.52	38.1
12	0	0	270	270	15.8	4.48	7.29	11.77	37.5
13	**0**	**0**	**360**	**360**	**16.1**	**5.05**	**8.72**	**13.78**	**37.4**
	MEAN				**16.1**	**4.23**	**6.87**	**11.10**	**38.1**

NOTES:
Trt: Treatment
♣ Indicates nutrients utilization efficiency.

4.3.1 Response of Canola to High Rates of N Application from Different Sources
Cont'd from previous page
Averaged over 2019 - 2020

Trt	Nitrogen (kg N/ha) from: Urea	ESN	Urea SuperU	Total N (kg N/ha)	HEIGHT (cm)	DAYS TO FLOWER	LODGING♠ (0-9)
1	0	0	0	0	113	50	0
2	90	0	0	90	123	50	0
3	180	0	0	180	122	49	0
4	**270**	**0**	**0**	**270**	**121**	**50**	**0**
5	360	0	0	360	122	50	0
6	60	30	0	90	119	50	0
7	**120**	**60**	**0**	**180**	**121**	**50**	**0**
8	180	90	0	270	122	50	0
9	240	120	0	360	120	50	0
10	0	0	90	90	124	50	0
11	0	0	180	180	118	49	0
12	0	0	270	270	115	51	0
13	**0**	**0**	**360**	**360**	**122**	**51**	**0**
	MEAN				**120**	**50**	**0**

NOTE:
Trt: Treatment

4.3.1 Response of Canola to High Rates of N Application from Different Sources
Cont'd from previous page
Averaged Over 2019 - 2020

N RATE	SEED ♣	SEED	STRAW	BIOMASS	HARVEST	HEIGHT	DAYS TO
kg N/ha	kg/kg NUTRIENTS	.....Yield (MT/ha).....			INDEX (%)	(cm)	FLOWER
0	18.0	3.41	6.29	9.70	31.6	113	50
90	18.7	3.89	6.31	10.20	37.4	122	50
180	16.4	4.25	6.84	11.09	38.6	121	50
270	**15.5**	**4.57**	**7.47**	**12.04**	**38.6**	**120**	**50**
360	13.1	4.47	7.05	11.52	40.1	121	50
MEAN	**16.3**	**4.12**	**6.79**	**10.91**	**37.3**	**119**	**50**

	SEED ♣	SEED	STRAW	BIOMASS	HARVEST	HEIGHT	DAYS TO
N SOURCE	kg/kg NUTRIENTS	.....Yield (MT/ha).....			INDEX (%)	(cm)	FLOWER
Urea	15.9	4.27	6.96	11.23	38.3	122	50
Urea+ESN 2:1*	**15.7**	**4.33**	**6.64**	**10.97**	**40.4**	**120**	**50**
Urea SuperU	16.1	4.29	7.15	11.44	37.4	120	50
MEAN	**15.9**	**4.30**	**6.92**	**11.21**	**38.7**	**121**	**50**

NOTES:
♣ Indicates nutrients utilization efficiency.
*On N basis

4.3.2 Effect of Apex, Top Phos, EXCELIS MAXX and Bio-Stimulants on Canola
Treatment Details

Trt #	PRODUCT	CROP STAGE/TIME OF APPLICATION	RATE OF APPLICATION
1	Farmers' practice	At seeding	See Footnote
2	TOP PHOS	At seeding	See Footnote
3	FA STARTER	BBCH 12-13 (2-3 leaves)	3 L/ha
4	IRYS	BBCH 12-13 (2-3 leaves)	3 L/ha
5	FL GOLD	BBCH 19-31 (End cabbage- beginning bolt)	3 L/ha
6	GENEA	BBCH 19-31 (End cabbage- beginning bolt)	3 L/ha
7	FL GOLD	BBCH 65 (First petals falling)	3 L/ha
8	GENEA	BBCH 65 (First petals falling)	3 L/ha
9	APEX	Replace N application during crop cycle	See Footnote
10	EXCELIS MAXX	Applied to urea	See Footnote

Trt #	TREATMENT DETAILS OF FERTILIZERS/PRODUCTS
1	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate) – Farmers' Practice
2	180 kg N/ha (90.3 kg from urea, 45.2 kg from ESN & 39.2 kg from ammonium sulphate, 5.3 from Top Phos), P from Top Phos•
3	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate); FA Starter @ 3l/ha at 2-3 leaves
4	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate); IRYS @ 3l/ha at 2-3 leaves
5	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate); FL Gold 3l/ha at beginning bolting
6	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate) Genea 3l/ha at beginning bolting
7	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate); FL Gold 3l/ha at first petal falling
8	180 kg N/ha (92 kg from urea, 46 kg from ESN & 42 kg from ammonium sulphate); Genea 3l/ha at first petal falling
9	180 kg N/ha from Apex*
10	180 kg N/ha from urea treated with EXCELIS MAXX

Notes:

All treatments received 180 kg N/ha, 20 kg P_2O_5/ha (1, 3-10 from 0-45-0, 2 from Top Phos), 20 kg K_2O/ha from 0-0-60,
48 kg S/ha (1-8 from ammonium sulphate, 9 from Apex and 10 from gypsum except that in treatment 2, in which 3.2 kg out of 48 kg S came from Top Phos), and 1 kg B/ha. All fertilizer nutrients were applied at seeding.

•Top Phos is 8-30-0-4.8 (8 % N, 30 % P_2O_5, 0 % K_2O and 4.8 % S)

*Apex contains 30 % N (5 % ammoniacal N and 25 % urea N), 2.9 % Ca, 1.2 % Mg & 8 % S.

4.3.2 Effect of Apex, Top Phos, EXCELIS MAXX and Bio-Stimulants on Canola

Cont'd from previous page

PLANTING DATE: June 1, 2020
FERTILIZERS: As per treatments
PESTICIDES: Roundup @ 3 L/ha applied June 5 and June 16, 2020,
Lorsban 4E @ 2.5 L/ha applied July 9, 2020, and
Malathion @ 535 mL/ha applied August 13, 2020
HARVEST DATE: September 1, 2020
PREVIOUS CROP: Linseed
VARIETY: BY 6204TF

Trt	TREATMENT	SEED ♣ kg/kg NUTRIENTS [b]	YIELD SEED [b] (MT/ha)	YIELD STRAW [b] (MT/ha)	YIELD BIOMASS [b] (MT/ha)	HARVEST INDEX (%) [b]
1	ESN, urea, AS and TSP	16.2	4.35	6.52	10.87	40.4
2	ESN, urea, AS and Top Phos	14.8	3.99	5.42	9.42	42.4
3	ESN, urea, AS, TSP and FA Starter @ 3 L/ha at 2-3 leaves	17.7	4.77	6.92	11.69	40.8
4	ESN, urea, AS, TSP and IRYS @ 3 L/ha at 2-3 leaves	17.1	4.60	6.08	10.68	43.7
5	ESN, urea, AS, TSP and FL Gold @ 3 L/ha at beginning bolting	14.4	3.88	5.16	9.04	43.5
6	ESN, urea, AS, TSP and Genea @ 3 L/ha at beginning bolting	14.9	4.02	5.22	9.23	43.6
7	ESN, urea, AS, TSP and FL Gold @ 3l/ha at first petal falling	14.3	3.86	5.79	9.65	41.3
8	ESN, urea, AS, TSP and Genea @ 3l/ha at first petal falling	17.6	4.73	6.50	11.23	42.9
9	Apex (supplied both N and S) and TSP	15.3	4.12	7.41	11.52	36.6
10	Urea treated with EXCELIS MAXX; and TSP	16.3	4.39	5.90	10.28	43.7
	MEAN	**15.9**	**4.27**	**6.09**	**10.36**	**41.9**
	C.V. (%)	19.3	19.3	30.3	24.6	10.6
	PR>F	0.8652	0.8652	0.7171	0.8309	0.8400
	SE	0.48	0.12	0.29	0.40	0.70
	LSD (0.05)	NS	NS	NS	NS	NS

Notes:

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

Pre seeding soil analysis 0-30 cm (ppm): Ammoniacal N: 6, Nitrate N: 13, Total N: 19, and S: 6

AS: Ammonium Sulphate

TSP: Tripple Superphosphate

4.3.2 Effect of Apex, Top Phos, EXCELIS MAXX and Bio-Stimulants on Canola
Cont'd from previous page

Trt	Treatment	HEIGHT [b] (cm)	.....DAYS TO..... FLOWER [b]	MATURE	LODGING♠ (0-9)	PLANTS [b] /m^2
1	ESN, urea, AS and TSP	112	39	101	0	51
2	ESN, urea, AS and Top Phos	102	40	101	0	49
3	ESN, urea, AS, TSP and FA Starter @ 3 L/ha at 2-3 leaves	110	39	101	0	47
4	ESN, urea, AS, TSP and IRYS @ 3 L/ha at 2-3 leaves	113	39	101	0	53
5	ESN, urea, AS, TSP and FL Gold @ 3 L/ha at beginning boltin	110	40	101	0	51
6	ESN, urea, AS, TSP and Genea @ 3 L/ha at beginning bolting	108	39	101	0	52
7	ESN, urea, AS, TSP and FL Gold @ 3l/ha at first petal falling	104	39	101	0	52
8	ESN, urea, AS, TSP and Genea @ 3l/ha at first petal falling	111	39	101	0	48
9	Apex (supplied both N and S) and TSP	113	40	101	0	41
10	Urea treated with EXCELIS MAXX; and TSP	111	40	101	0	46
	MEAN	**109**	**39**	**101**	**0**	**49**
	C.V. (%)	6.0	7.0	-	-	17.1
	PR>F	0.5100	0.5100	-	-	0.1800
	SE	1.0	0.4	-	-	1.3
	LSD (0.05)	NS	NS	-	-	NS

Notes:
a Letter codes not displayed for the means were not affected by the treatments (P>0.05)
b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)
AS: Ammonium Sulphate
TSP: Tripple Superphosphate

4.3.3 Evaluation of Gypsum and Ammonium Sulphate as Sources of Sulphur (S) for Barley, Canola and Pea Residual Effect on Wheat Production

PLANTING DATE: May 26, 2020
FERTILIZERS: 74 kg N/ha (152 kg/ha 46-0-0, 39 kg/ha 11-52-0) 20 kg P_2O_5/ha (39 kg/ha 11-52-0) 20 kg K_2O/ha (34 kg/ha 0-0-60)
HERBICIDE: None
HARVEST DATE: September 10, 2020
PREVIOUS CROP: As per treatments
VARIETY: Prosper

FACTOR A X B			.....YIELD.....				
MAIN PLOT	SUB PLOT	GRAIN♣ [a] kg/kg NUTRIENTS	GRAIN [a]	STRAW [a]	BIOMASS .....(MT/ha).....	HARVEST INDEX (%)	1000 K WT.(g)
Barley (Boroe)	No Sulphur	4.6	0.53	0.77	1.30	40.2	40
Barley (Boroe)	Gypsum @ 19.5 kg S/ha♠	8.0	0.91	1.06	1.97	44.5	38
Barley (Boroe)	AS @ 19.5 kg S/ha*	8.3	0.95	1.31	2.26	42.1	41
Canola (L252)	No Sulphur	6.7	0.77	1.19	1.96	38.8	37
Canola (L252)	**Gypsum @ 19.5 kg S/ha♠**	**8.8**	**1.01**	**1.23**	**2.24**	**44.1**	**39**
Canola (L252)	AS @ 19.5 kg S/ha*	8.6	0.99	1.46	2.44	39.3	39.0
Pea (Sorrento)	**No Sulphur**	**8.8**	**1.01**	**1.23**	**2.24**	**42.1**	**42**
Pea (Sorrento)	**Gypsum @ 19.5 kg S/ha♠**	**8.8**	**1.00**	**1.26**	**2.26**	**44.7**	**42**
Pea (Sorrento)	AS @ 19.5 kg S/ha*	5.0	0.57	0.76	1.33	42.8	38
MEAN		**7.5**	**0.86**	**1.14**	**2.00**	**42.1**	**40**
C.V. (%)		52.3	52.3	42.2	45.0	15.5	-
PR>F - A		0.7545	0.7545	0.3862	0.5406	0.6335	-
PR>F - B		0.4510	0.4510	0.7860	0.6406	0.2822	-
PR>F - (A x B)		0.3027	0.3027	0.2462	0.2478	0.9863	-
SE		0.66	0.075	0.080	0.150	1.08	-
LSD (0.05)		NS	NS	NS	NS	NS	-

Notes:
♣Indicates nutrients utilization efficiency
♠ Placed in the seed row
*AS stands for Ammonium Sulphate
a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.3.3 Evaluation of Gypsum and Ammonium Sulphate as Sources of Sulphur (S) for Barley, Canola and Pea Residual Effect on Wheat Production…Cont'd from Previous page

FACTOR A	GRAIN♣ [a] kg/kg NUTRIENTS	YIELD (MT/ha) GRAIN	STRAW	BIOMASS	HARVEST INDEX (%)	1000 K WT.(g)
Barley	7.0	0.80	1.05	1.84	42.2	40
Canola	**8.1**	**0.92**	**1.29**	**2.21**	**40.7**	**38**
Pea	7.5	0.86	1.08	1.94	43.2	41
MEAN	**7.5**	**0.86**	**1.14**	**2.00**	**42.1**	**40**
SE	0.66	0.075	0.080	0.150	1.08	-

FACTOR B	GRAIN♣ [a] kg/kg NUTRIENTS	YIELD (MT/ha) GRAIN	STRAW	BIOMASS	HARVEST INDEX (%)	1000 K WT.(g)
No Sulphur	6.7	0.77	1.07	1.83	40.3	40
Gypsum @ 19.5 kg S/ha♠	**8.5**	**0.97**	**1.18**	**2.16**	**44.4**	**40**
Ammonium Sulphate @ 19.5 kg S/ha	7.3	0.83	1.18	2.01	41.4	39
MEAN	**7.5**	**0.86**	**1.14**	**2.00**	**42.1**	**40**
SE	0.66	0.075	0.080	0.150	1.08	-
Following were seeded as guards and did not get any sulphur:						
Barley (Synosolis)	7.2	0.82	0.95	1.77	48.3	36
Canola (L140P)	8.2	0.93	1.17	2.10	46.3	36
Pea (Polstead)	**9.0**	**1.03**	**1.25**	**2.28**	**44.1**	**39**
MEAN	**8.1**	**0.93**	**1.12**	**2.05**	**46.2**	**37**
PR>F	0.6400	0.6410	0.5100	0.5280	0.7770	-

Notes:

♣Indicates nutrients utilization efficiency

♠Placed in the seed row

a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

4.3.3 Evaluation of Gypsum and Ammonium Sulphate as Sources of Sulphur (S) for Barley, Canola and Pea Residual Effect on Wheat Production

Soil Test Results (Spring 2020)

CROP	Organic Matter %	Phosphorus Bicarbonate ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	pH pH	pH Buffer
Barley (Boroe)	4.4	15 L	126 M	447 H	2300 M	34 M	6.1	6.6
Canola (L252)	4.1	19 L	126 M	435 H	2210 L	29 L	6.0	6.5
Pea (Sorrento)	4.1	20 M	135 M	485 H	2550 L	35 M	6.2	6.5

CROP	CEC meg/100g	Percent Base Saturation % K	% Mg	% Ca	% H	% Na	Sulphur S ppm	Zinc Zn ppm
Barley (Boroe)	20.4	1.6	18.2	56.2	23.2	0.7	9 VL	1.8 L
Canola (L252)	21.1	1.5	17.2	52.4	28.2	0.6	7 VL	1.7 L
Pea (Sorrento)	23.2	1.5	17.4	54.9	25.6	0.7	7 VL	1.7 L

CROP	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Saturation %P	Aluminum Al ppm	Saturation %Al	K/Mg Ratio	ENR
Barley (Boroe)	10 L	93 VH	1.4 H	0.5 L	4 M	1009	0.4 G	0.09	56
Canola (L252)	8 L	93 VH	1.3 H	0.4 L	3 L	1032	0.4 G	0.09	53
Pea (Sorrento)	10 L	96 VH	1.4 H	0.3 VL	3 L	1060	0.3 G	0.09	53

Note: VL = Very low, L = Low, M = Medium, H = High, VH = Very high, G = Good

4.3.3 Evaluation of Gypsum and Ammonium Sulphate as Sources of Sulphur (S) for Barley, Canola and Pea
Residual Effect on Wheat Production
Averaged Over 2018 - 2020

FACTOR A X B			YIELD					
MAIN PLOT	SUB PLOT	GRAIN♣ kg/kg NUTRIENTS	GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K WT.(g)	TEST WT.‡ (kg/hl)
Barley (Boroe)	No Sulphur	26.8	3.31	3.08	6.38	40.2	40	74.6
Barley (Boroe)	Gypsum @ 19.5 kg S/ha♠	28.6	3.44	3.10	6.54	41.5	40	75.4
Barley (Boroe)	AS @ 19.5 kg S/ha*	28.2	3.30	3.20	6.50	40.4	41	76
Canola (L252)	**No Sulphur**	**29.8**	**3.94**	**3.42**	**7.36**	**42.3**	**40**	**76**
Canola (L252)	**Gypsum @ 19.5 kg S/ha♠**	**29.9**	**3.83**	**3.24**	**7.06**	**43.6**	**40**	**76**
Canola (L252)	**AS @ 19.5 kg S/ha***	**30.0**	**3.65**	**3.19**	**6.83**	**40.9**	**41**	**76**
Pea (Sorrento)	No Sulphur	29.5	3.52	3.18	6.70	40.5	41	76
Pea (Sorrento)	Gypsum @ 19.5 kg S/ha♠	28.8	3.60	3.45	7.06	42.6	42	76.2
Pea (Sorrento)	AS @ 19.5 kg S/ha*	26.8	3.23	2.87	6.10	41.3	38	76.2
MEAN		**28.9**	**3.57**	**3.23**	**6.80**	**41.5**	**41**	**76**
C.V. (%)		69.1	68.3	64.2	65.9	28.1	-	-
PR>F - A		0.9180	0.7440	0.9560	0.8560	0.8690	-	-
PR>F - B		0.9890	0.9240	0.9380	0.9300	0.8210	-	-
PR>F - (A x B)		0.9980	0.9990	0.9850	0.9970	0.9980	-	-
SE		1.99	0.243	0.206	0.445	1.17	-	-
LSD (0.05)		NS	NS	NS	NS	NS	-	-

Notes:
♣Indicates nutrients utilization efficiency
♠Placed in the seed row
*AS stands for Ammonium Sulphate
‡Test wt. was only recorded in 2018-2019

4.3.3 Evaluation of Gypsum and Ammonium Sulphate as Sources of Sulphur (S) for Barley, Canola and Pea Residual Effect on Wheat Production…Cont'd from Previous page
Averaged Over 2018 - 2020

FACTOR A	GRAIN♣ kg/kg NUTRIENTS	YIELD GRAIN (MT/ha)	YIELD STRAW (MT/ha)	YIELD BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K WT.(g)	TEST WT.‡ (kg/hl)
Barley	27.9	3.35	3.13	6.48	40.7	41	75
Canola	**30.0**	**3.82**	**3.27**	**7.09**	**42.6**	**41**	**76**
Pea	28.8	3.52	3.22	6.74	41.2	40	76
MEAN	**28.9**	**3.56**	**3.21**	**6.77**	**41.5**	**41**	**76**

FACTOR B	GRAIN♣ kg/kg NUTRIENTS	YIELD GRAIN (MT/ha)	YIELD STRAW (MT/ha)	YIELD BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K WT.(g)	TEST WT.‡ (kg/hl)
No Sulphur	28.7	3.59	3.23	6.82	41.0	40	76
Gypsum @ 19.5 kg S/ha♠	**29.1**	**3.62**	**3.26**	**6.89**	**42.6**	**41**	**76**
Ammonium Sulphate @ 19.5 kg S/ha	28.3	3.39	3.08	6.48	40.9	40	76
MEAN	**28.7**	**3.54**	**3.19**	**6.73**	**41.5**	**40**	**76**
Following were seeded as guards and did not get any sulphur:							
Barley (Synosolis)	24.4	2.73	2.80	5.52	41.2	35	75
Canola (L140P)	26.8	2.82	2.84	5.66	40.0	35	77
Pea (Polstead)	**24.4**	**3.00**	**3.15**	**6.15**	**40.0**	**37**	**76**
MEAN	**25.2**	**2.85**	**2.93**	**5.78**	**40.4**	**36**	**76**

Notes:
♣Indicates nutrients utilization efficiency
♠Placed in the seed row
‡Test wt. was only recorded in 2018-2019

Forages

4.4.1 Comparative Performance of Gypsum and Lime for Galega Production

PLANTING DATE: May 14, 2018
FERTILIZER: 45 kg N/ha (150 kg/ha 21-0-0-24 and 29 kg/ha 46-0-0 for Treatment 1; 98 kg/ha 46-0-0 for Treatments 2-7)
90 kg P_2O_5/ha (200 kg/ha 0-45-0)
50 kg K_2O /ha (83 kg/ha 0-0-60)
HERBICIDE: May 22, 2020; Venture L @ 2 L/ha
HARVEST DATES: June 18, 2020
PREVIOUS CROP: Fallow

	DRY MATTER YIELD (kg/ha) [a]			FRESH MATTER YIELD (kg/ha) [a]		
	2019	2020	2019-2020	2019	2020	2019-2020
TREATMENTS	TOTAL	1st CUT	TOTAL	TOTAL	1st CUT	TOTAL
1 Check: No Lime or Gypsum	2532	1105	3637	14870	6287	21157
2 Gypsum @ 1.25 MT/ha	**2404**	**1255**	**3659**	**12846**	**7429**	**20275**
3 Gypsum @ 2.5 MT/ha	**3042**	**1294**	**4336**	**15942**	**6872**	**22814**
4 Gypsum @ 3.75 MT/ha	2418	1055	3473	12268	5537	17805
5 Lime @ 1.07 MT/ha	2974	1185	4159	16176	6533	22709
6 Lime @ 2.14 MT/ha	**3084**	**1510**	**4594**	**16126**	**7683**	**23809**
7 Lime @ 3.21 MT/ha	2585	1202	3787	13661	6821	20482
MEAN	**2720**	**1229**	**3949**	**14556**	**6737**	**21293**
C.V. (%)	21.7	26.6	-	21.5	25.9	-
PR>F	0.1816	0.4410	-	0.1847	0.7120	-
SE	292.7	61.7	-	1544.1	329.3	-
LSD (0.05)	NS	NS	-	NS	NS	-

Notes:
Pre seeding soil analysis 0-15 cm (ppm): pH: 5.9; Ammoniacal N: 1, Nitrate N: 20, Total N: 21, and S: 28
The treatments had no significent effect on the yield
A second cut was not taken in 2020 due to poor regrowth
a Letter codes not displayed for the means not affected by the treatment (P>0.05)

…Cont'd from previous page

	DRY MATTER YIELD (kg/ha) [a]			FRESH MATTER YIELD (kg/ha) [a]		
	2019	2020	2019-2020	2019	2020	2019-2020
GYPSUM (MT/ha)	TOTAL	1st CUT	TOTAL	TOTAL	1st CUT	TOTAL
0	2794	1250	4044	15208	6831	22039
1.25	2404	1255	3659	12846	7429	20275
2.50	**3042**	**1294**	**4336**	**15942**	**6872**	**22814**
3.75	2418	1055	3473	12268	5537	17805
MEAN	**2665**	**1214**	**3878**	**14066**	**6667**	**20733**
C.V. (%)	21.7	26.6	-	21.5	25.9	-
PR>F	0.1694	0.4640	-	0.0879	0.3230	-
SE	297.4	61.7	-	1537.4	329.3	-
LSD (0.05)	NS	NS	-	NS	NS	-

	DRY MATTER YIELD (kg/ha) [a]			FRESH MATTER YIELD (kg/ha) [a]		
	2019	2020	2019-2020	2019	2020	2019-2020
LIME (MT/ha)	TOTAL	1st CUT	TOTAL	TOTAL	1st CUT	TOTAL
0	2599	1177	3776	13982	6531	20513
1.07	2974	1185	4160	16176	6533	22709
2.14	**3084**	**1510**	**4594**	**16126**	**7683**	**23809**
3.21	2585	1202	3787	13661	6821	20482
MEAN	**2811**	**1269**	**4079**	**14986**	**6892**	**21878**
C.V. (%)	21.7	26.6	-	21.5	25.9	-
PR>F	0.2330	0.3890	-	0.2880	0.4710	-
SE	300.3	61.7	-	1596.9	329.3	-
LSD (0.05)	NS	NS	-	NS	NS	-

Note:

The treatments had no significent effect on the yield

A second cut was not taken in 2020 due to poor regrowth

a Letter codes not displayed for the means not affected by the treatment (P>0.05)

4.4.1 Comparative Performance of Gypsum and Lime for Galega Production…Cont'd from previous page
Quality Parameters on Dry Matter Basis: First Cut

TREATMENTS	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Check: No Lime or Gypsum	17.4	35.8	1.91	36.7	37.5	43.2	66.3	1.50	0.73	1.30	129
Gypsum @ 1.25 MT/ha	16.4	35.8	2.04	36.7	38.2	45.6	65.8	1.49	0.71	1.28	121
Gypsum @ 2.5 MT/ha	17.8	35.8	1.88	36.7	37.5	45.7	65.2	1.48	0.73	1.30	121
Gypsum @ 3.75 MT/ha	15.4	36.1	1.28	36.5	36.2	42.7	67.2	1.53	0.75	1.33	132
Lime @ 1.07 MT/ha	17.0	35.8	1.70	36.7	36.4	42.7	67.5	1.53	1.47	1.33	132
Lime @ 2.14 MT/ha	15.5	36.0	1.47	36.6	37.3	43.8	66.9	1.52	0.73	1.30	127
Lime @ 3.21 MT/ha	17.1	35.8	1.75	36.7	35.8	43.0	67.1	1.52	0.77	1.35	132
MEAN	**16.6**	**35.9**	**1.72**	**36.6**	**37.0**	**43.8**	**66.6**	**1.51**	**0.84**	**1.31**	**128**

TREATMENTS	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Check: No Lime or Gypsum	0.33	3.62	0.28	1.05	0.43	0.27	11.8	25.9	181	47.2	0.04
Gypsum @ 1.25 MT/ha	0.37	4.66	0.28	1.36	0.46	0.27	10.2	23.7	182	31.1	0.03
Gypsum @ 2.5 MT/ha	0.35	3.37	0.26	1.02	0.42	0.28	12.4	26.7	159	28.8	0.03
Gypsum @ 3.75 MT/ha	0.31	3.34	0.25	1.02	0.36	0.35	9.7	24.6	172	30.4	0.02
Lime @ 1.07 MT/ha	0.34	3.62	0.29	1.08	0.46	0.29	11.2	25.0	154	34.4	0.04
Lime @ 2.14 MT/ha	0.31	3.46	0.28	0.98	0.39	0.32	11.6	27.9	249	29.6	0.02
Lime @ 3.21 MT/ha	0.34	3.70	0.30	1.14	0.44	0.28	10.9	24.0	179	32.1	0.06
MEAN	**0.34**	**3.68**	**0.28**	**1.09**	**0.42**	**0.29**	**11.1**	**25.4**	**182**	**33.4**	**0.03**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

4.4.1 Comparative Performance of Gypsum and Lime for Galega Production…Cont'd from previous page

Quality parameters on dry matter basis: First cut 2019-2020 average

TREATMENTS	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Check: No Lime or Gypsum	14.2	36.0	1.40	34.3	37.8	52.1	64.5	1.46	0.72	1.29	109
Gypsum @ 1.25 MT/ha	16.2	35.7	1.95	34.4	39.3	47.2	63.3	1.43	0.69	1.26	115
Gypsum @ 2.5 MT/ha	16.6	35.8	1.73	34.4	38.2	47.2	63.4	1.44	0.71	1.28	117
Gypsum @ 3.75 MT/ha	15.5	36.0	1.53	34.3	37.1	44.0	65.6	1.49	0.73	1.31	127
Lime @ 1.07 MT/ha	16.3	35.8	1.72	34.4	37.2	44.0	65.0	1.47	1.09	1.31	111
Lime @ 2.14 MT/ha	15.5	35.9	1.51	34.3	37.3	44.5	65.4	1.49	0.73	1.30	125
Lime @ 3.21 MT/ha	16.3	35.7	1.69	34.4	37.8	45.5	64.6	1.46	0.72	1.30	122
MEAN	**15.8**	**35.9**	**1.64**	**34.4**	**37.8**	**46.4**	**64.5**	**1.46**	**0.77**	**1.29**	**118**

TREATMENTS	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Check: No Lime or Gypsum	0.32	3.17	0.23	0.74	0.30	0.47	9.0	21.9	145	44.6	0.05
Gypsum @ 1.25 MT/ha	0.34	3.89	0.26	1.20	0.42	0.34	12.1	26.5	177	35.8	0.05
Gypsum @ 2.5 MT/ha	0.33	3.16	0.24	0.95	0.37	0.34	12.0	37.0	228	30.8	0.05
Gypsum @ 3.75 MT/ha	0.32	3.25	0.27	1.05	0.36	0.41	11.2	26.2	183	35.6	0.07
Lime @ 1.07 MT/ha	0.33	3.17	0.24	0.75	0.32	0.48	8.7	21.5	132	38.2	0.05
Lime @ 2.14 MT/ha	0.32	3.31	0.27	0.92	0.37	0.38	11.8	27.4	217	31.2	0.06
Lime @ 3.21 MT/ha	0.35	3.58	0.28	1.04	0.41	0.36	11.4	25.7	160	34.4	0.07
MEAN	**0.33**	**3.36**	**0.26**	**0.95**	**0.36**	**0.39**	**10.9**	**26.6**	**177**	**35.8**	**0.06**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients, NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

4.4.2 Maximizing Yield and Quality of Galega

PLANTING DATE: May 23, 2018
FERTILIZER: As per treatment
HERBICIDE: None
HARVEST DATES: June 15, 2020
PREVIOUS CROP: Winter cereals

						DRY MATTER YIELD (kg/ha)				FRESH MATTER YIELD (kg/ha)		
	NUTRIENT RATES (kg/ha)					2019 [b]	2020 [a]		2019-2020	2019 [a]	2020 [b]	2019-2020
Trt	N	S	B	Zn	Mn	TOTAL	1st CUT		TOTAL	TOTAL	1st CUT	TOTAL
1	0	0	0	0	0	2750	1104	*b*	3854	12742 *b*	7019	19761
2	45	0	0	0	0	3655	1576	*ab*	5231	22625 *a*	10349	32974
3	45	24	0	0	0	3832	1422	*ab*	5254	20024 *ab*	8414	28438
4	45	24	1	0	0	2720	1369	*ab*	4089	18037 *ab*	8520	26557
5	45	24	1	7	0	3618	1567	*ab*	5185	22029 *a*	9652	31681
6	**45**	**24**	**1**	**7**	**2**	**3615**	**1690**	***ab***	**5305**	**20607 *ab***	**8567**	**29174**
7	45	36	2	7	2	2921	1531	*ab*	4452	17756 *ab*	8863	26619
8	**45**	**36**	**3**	**7**	**2**	**3781**	**1625**	***ab***	**5406**	**21795 *a***	**9805**	**31600**
9	45	36	4	7	2	3339	1387	*ab*	4726	17227 *ab*	8462	25689
10	**60**	**36**	**2**	**7**	**2**	**3477**	**1853**	***a***	**5330**	**20698 *ab***	**9821**	**30519**
MEAN						**3371**	**1512**		**4883**	**19354**	**8947**	**28301**
C.V. (%)						25.4	27.9		-	25.7	26.3	-
PR>F						0.1424	**0.0150**		-	**0.0176**	0.2400	-
SE						429.8	66.7		-	787.9	372.0	-
LSD (0.05)						NS	436		-	6289	NS	-

Notes:
*Trt stands for Treatment
Pre seeding soil analysis 0-15 cm (ppm): pH: 5.9; Ammoniacal N: 1, Nitrate N: 20, Total N: 21, and S: 28
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

Quality Parameters on Dry Matter Basis: First Cut

	NUTRIENT RATES (kg/ha)					CRUDE PROTEIN	SOLUBLE PROTEIN	ADF-CP	UIP	ADF	NDF	TDN	NEL	NEG	NEM	RFV
Trt	N	S	B	Zn	Mn	%	% of CP	%	% of CP	%	%	%	.....Mcal/kg.....			
1	0	0	0	0	0	19.3	35.7	2.46	36.7	34.2	45.0	66.6	1.51	0.80	1.38	129
2	45	0	0	0	0	17.9	35.8	2.51	36.7	36.9	45.5	66.0	1.50	0.75	1.32	123
3	45	24	0	0	0	18.1	36.0	2.40	36.6	35.8	44.2	69.5	1.58	0.77	1.35	129
4	45	24	1	0	0	17.0	35.9	2.04	36.6	35.0	44.9	66.9	1.52	0.79	1.37	128
5	45	24	1	7	0	19.2	35.8	3.48	36.7	38.9	48.6	66.3	1.50	0.69	1.26	112
6	45	24	1	7	2	16.4	36.2	1.47	36.5	34.6	43.9	69.2	1.58	0.79	1.37	131
7	45	36	2	7	2	16.9	35.9	2.00	36.6	34.4	46.7	67.2	1.53	0.80	1.38	124
8	45	36	3	7	2	19.6	35.6	2.48	36.8	34.9	46.0	66.5	1.51	0.79	1.37	125
9	45	36	4	7	2	17.6	35.8	2.22	36.7	35.0	43.8	67.0	1.52	0.79	1.37	131
10	60	36	2	7	2	17.9	36.0	1.88	36.6	34.2	44.9	66.7	1.51	0.80	1.38	129
MEAN						**18.0**	**35.9**	**2.29**	**36.7**	**35.4**	**45.3**	**67.2**	**1.53**	**0.78**	**1.36**	**126**

	NUTRIENT RATES (kg/ha)					P	K	S	Ca	Mg	Cl	Cu	Zn	Fe	Mn	Na
Trt	N	S	B	Zn	Mn	%	%	%	%	%	%	ug/g	ug/g	ug/g	ug/g	%
1	0	0	0	0	0	0.40	2.87	0.23	1.24	0.50	0.21	13.2	28.7	118	39.8	0.08
2	45	0	0	0	0	0.37	2.97	0.23	1.27	0.57	0.22	13.1	28.3	107	38.2	0.08
3	45	24	0	0	0	0.36	2.84	0.39	1.11	0.51	0.24	13.4	31.9	108	46.0	0.04
4	45	24	1	0	0	0.32	2.4	0.34	1.17	0.54	0.26	12.7	27.3	108	34.8	0.04
5	45	24	1	7	0	0.44	4.17	0.35	1.14	0.51	0.20	14.8	39.4	131	47.2	0.04
6	45	24	1	7	2	0.36	2.79	0.34	0.86	0.44	0.30	12.7	37.5	93	38.1	0.05
7	45	36	2	7	2	0.32	2.80	0.35	0.96	0.46	0.28	11.3	35.2	92	40.2	0.05
8	45	36	3	7	2	0.36	2.94	0.32	1.18	0.51	0.18	12.3	36.2	130	46.4	0.04
9	45	36	4	7	2	0.35	2.83	0.48	1.20	0.56	0.24	13.4	40.8	172	48.1	0.10
10	60	36	2	7	2	0.34	2.62	0.31	0.86	0.44	0.28	12.0	33.8	133	50.5	0.04
MEAN						**0.36**	**2.92**	**0.33**	**1.10**	**0.50**	**0.24**	**12.9**	**33.9**	**119**	**42.9**	**0.06**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

Quality Parameters on Dry Matter Basis: First Cut 2019-2020 Average

	NUTRIENT RATES (kg/ha)					CRUDE PROTEIN	SOLUBLE PROTEIN	ADF-CP	UIP	ADF	NDF	TDN	NEL	NEG	NEM	RFV
Trt	N	S	B	Zn	Mn	%	% of CP	%	% of CP	%	%	%	.....Mcal/kg.....			
1	0	0	0	0	0	17.5	35.8	1.75	36.8	33.1	45.2	67.5	1.53	0.83	1.41	130
2	45	0	0	0	0	17.1	35.7	1.99	36.8	37.3	45.5	65.9	1.50	0.74	1.31	122
3	45	24	0	0	0	17.5	35.8	1.82	26.7	34.3	43.6	68.6	1.56	0.81	1.45	133
4	45	24	1	0	0	17.3	35.7	1.72	36.7	34.3	42.7	67.8	1.54	0.81	1.39	136
5	45	24	1	7	0	17.8	35.7	2.32	36.7	36.8	47.4	66.4	1.51	0.74	1.32	118
6	45	24	1	7	2	16.3	35.9	1.29	36.7	34.6	44.8	68.1	1.55	0.79	1.37	129
7	45	36	2	7	2	17.3	35.8	1.66	36.7	34.4	45.2	67.2	1.53	0.80	1.38	128
8	45	36	3	7	2	17.7	35.6	1.98	36.8	36.6	46.6	65.8	1.49	0.75	1.33	121
9	45	36	4	7	2	16.9	35.8	1.56	36.7	33.4	44.8	67.2	1.53	0.83	1.41	130
10	60	36	2	7	2	18.6	35.8	1.72	36.7	34.1	44.3	67.0	1.52	0.81	1.39	131
MEAN						**17.4**	**35.7**	**1.78**	**35.7**	**34.9**	**45.0**	**67.1**	**1.52**	**0.79**	**1.37**	**128**

	NUTRIENT RATES (kg/ha)					P	K	S	Ca	Mg	Cl	Cu	Zn	Fe	Mn	Na
Trt	N	S	B	Zn	Mn	%	%	%	%	%	%	ug/g	ug/g	ug/g	ug/g	%
1	0	0	0	0	0	0.38	2.89	0.21	1.12	0.44	0.33	11.8	29.0	108	44.8	0.06
2	45	0	0	0	0	0.36	3.26	0.21	1.27	0.56	0.34	11.7	25.5	109	47.2	0.08
3	45	24	0	0	0	0.35	2.71	0.32	1.07	0.47	0.32	11.3	29.1	115	43.4	0.04
4	45	24	1	0	0	0.33	2.79	0.35	1.27	0.58	0.33	12.8	34.2	162	39.3	0.05
5	45	24	1	7	0	0.41	3.78	0.37	1.20	0.54	0.29	13.4	41.3	122	61.2	0.05
6	45	24	1	7	2	0.35	2.87	0.31	0.96	0.45	0.35	11.9	37.0	87	46.7	0.04
7	45	36	2	7	2	0.33	3.05	0.32	1.02	0.45	0.36	10.9	36.2	84	55.5	0.06
8	45	36	3	7	2	0.36	3.16	0.34	1.20	0.50	0.30	11.6	37.4	117	60.9	0.05
9	45	36	4	7	2	0.35	2.79	0.37	1.08	0.48	0.30	11.6	35.4	139	49.0	0.07
10	60	36	2	7	2	0.36	3.09	0.33	1.01	0.48	0.38	11.0	44.2	253	65.1	0.07
MEAN						**0.36**	**3.04**	**0.31**	**1.12**	**0.49**	**0.33**	**11.8**	**34.9**	**129**	**51.3**	**0.06**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

5. Other Agronomic Practices

Treatment Details

Trt #	CROP	PRODUCT	CROP STAGE/TIME OF APPLICATION
1	Spring Wheat	None	No fungicides sprayed
2	Spring Wheat	Stratego	Stratego sprayed at tillering
3	Spring Wheat	Stratego + Prosaro	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering)
4	Spring Wheat	Stratego + Prosaro + Caramba	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering) + Caramba sprayed one week later
5	Malthing Barley	None	No fungicides sprayed
6	Malthing Barley	Stratego	Stratego sprayed at tillering
7	Malthing Barley	Stratego + Prosaro	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering)
8	Malthing Barley	Stratego + Prosaro + Caramba	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering) + Caramba sprayed one week later
9	Spring Oats	None	No fungicides sprayed
10	Spring Oats	Stratego	Stratego sprayed at tillering
11	Spring Oats	Stratego + Prosaro	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering)
12	Spring Oats	Stratego + Prosaro + Caramba	Stratego sprayed at tillering + Prosaro sprayed at heading (20% flowering) + Caramba sprayed one week later

PRODUCT	RATE OF APPLICATION
Stratego	572 ml/ha
Prosaro	800 ml/ha
Caramba	1.02 L/ha

CROP	VARIETY
Spring Wheat	AAC Wheatland
Malthing Barley	CDC Bow
Spring Oats	AC Rigodon

Notes:

Trt: Treatment

This research was part of Anmol Rana's MSc. Thesis

PLANTING DATE: May 5, 2020
FERTILIZERS: 95 kg N/ha (152 kg/ha 46-0-0, 38 kg/ha 11-52-0, 100 kg/ha 21-0-0-24)
20 kg P_2O_5/ha (38 kg/ha 11-52-0)
20 kg K_2O/ha (33 kg/ha 0-0-60) 24 kg S/ha (100 kg/ha 21-0-0-24)
HERBICIDES: Logic M @ 1.25 L/ha applied June 1, 2020
HARVEST DATES: Oats and Barley August 12, 2020; Wheat August 16, 2020
PREVIOUS CROP: Canola

				……YIELD……..					
			SEED ♣	GRAIN [b]	STRAW [a]	BIOMASS [b]	HARVEST	HEIGHT	PLANTS
Trt	CROP	TREATMENT	kg/kg NUTRIENTS [b]	...……...(MT/ha)…...……..			INDEX (%) [b]	(cm) [a]	/m^2 [a]
1	Spring Wheat	None	26.4	4.07	2.82 *b*	6.90	61.6	68 *bc*	489 *bcd*
2	Spring Wheat	Stratego	26.8	4.12	4.24 *ab*	8.36	48.9	72 *bc*	533 *abcd*
3	Spring Wheat	Stratego + Prosaro	28.0	4.32	4.74 *ab*	9.05	47.8	66 *c*	524 *abcd*
4	Spring Wheat	Stratego + Prosaro + Caramba	23.9	3.68	3.44 *ab*	7.13	51.7	68 *c*	373 *d*
5	**Malthing Barley**	**None**	**30.0**	**4.62**	**5.22 *a***	**9.84**	**47.3**	**63 *c***	**830 *abc***
6	Malthing Barley	Stratego	25.6	3.94	4.23 *ab*	8.17	48.4	60 *c*	963 *a*
7	Malthing Barley	Stratego + Prosaro	24.3	3.75	4.34 *ab*	8.09	46.2	58 *c*	873 ***abc***
8	Malthing Barley	Stratego + Prosaro + Caramba	27.8	4.28	5.52 *a*	9.81	43.8	59 *c*	916 ***ab***
9	**Spring Oats**	**None**	**28.6**	**4.40**	**3.84 *ab***	**8.24**	**53.6**	**82 *ab***	**330 *d***
10	Spring Oats	Stratego	26.7	4.11	3.46 *ab*	7.57	54.2	83 *ab*	443 *abcd*
11	Spring Oats	Stratego + Prosaro	27.5	4.23	4.15 *ab*	8.38	50.4	85 *ab*	453 *bcd*
12	**Spring Oats**	**Stratego + Prosaro + Caramb**	**29.1**	**4.48**	**3.94 *ab***	**8.43**	**53.3**	**88 *a***	**400 *cd***
		MEAN	**27.1**	**4.17**	**4.16**	**8.33**	**50.6**	**71**	**594**
		C.V. (%)	14.8	14.8	24.7	16.8	13.4	16.3	47.6
		PR>F	0.7300	0.7300	**0.0252**	0.1200	0.0960	**<0.0001**	**<0.0001**
		SE	0.62	0.096	0.159	0.217	1.05	1.8	43.8

Notes:
♣ Indicates nutrients utilization efficiency.
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

Cont'd from previous page

Trt	CROP	TREATMENT	……DAYS TO…… HEAD [a]	MATURE [a]	LODGING♠ (0-9)	1000 K WT.(g)	TEST WT. (kg/hl)
1	Spring Wheat	None	52 *b*	89 *a*	0	39	80
2	Spring Wheat	Stratego	51 *b*	89 *a*	0	42	80
3	Spring Wheat	Stratego + Prosaro	54 *b*	88 *a*	0	43	81
4	Spring Wheat	Stratego + Prosaro + Caramba	52 *b*	89 *a*	0	39	81
5	**Malthing Barley**	**None**	**60 *a***	**87 *a***	**0**	**51**	**66**
6	Malthing Barley	Stratego	60 *a*	87 *a*	0	54	64
7	Malthing Barley	Stratego + Prosaro	60 *a*	86 *a*	0	53	57
8	Malthing Barley	Stratego + Prosaro + Caramba	60 *a*	87 *a*	0	54	61
9	**Spring Oats**	**None**	**54 *b***	**87 *a***	**0**	**37**	**53**
10	Spring Oats	Stratego	54 *b*	85 *a*	0	40	52
11	Spring Oats	Stratego + Prosaro	54 *b*	86 *a*	0	42	52
12	**Spring Oats**	**Stratego + Prosaro + Caramb**	**54 *b***	**86 *a***	**0**	**42**	**52**
		MEAN	**56**	**88**	**0**	**46**	**69**
		C.V. (%)	11.1	1.8	-	-	-
		PR>F	**<0.0001**	**0.0049**	-	-	-
		SE	0.9	0.3	-	-	-

Notes:

a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

♠ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

Cont'd from previous page

			……DISEASES*……..					
Trt	CROP	TREATMENT	BYDV	SEPTORIA [a]	TAN SPOT	SPOT BLOTCH [a]	RUST [b]	FHB
1	Spring Wheat	None	0	5 *a*	0	0 *b*	0	**0**
2	Spring Wheat	Stratego	0	4 *a*	0	0 *b*	0	**0**
3	Spring Wheat	Stratego + Prosaro	0	1 *c*	0	1 *b*	0	0
4	Spring Wheat	Stratego + Prosaro + Caramba	0	1 *c*	0	0 *b*	0	0
5	**Malthing Barley**	**None**	**0**	**0 *c***	**0**	**4 *a***	**0**	**0**
6	Malthing Barley	Stratego	0	0 *c*	**0**	5 *a*	1	**0**
7	Malthing Barley	Stratego + Prosaro	0	0 *c*	0	1 *b*	0	0
8	Malthing Barley	Stratego + Prosaro + Caramba	0	0 *c*	0	1 *b*	0	0
9	**Spring Oats**	**None**	**0**	**5 *a***	**0**	**0 *b***	**0**	**0**
10	Spring Oats	Stratego	0	4 *ab*	0	0 *b*	0	0
11	Spring Oats	Stratego + Prosaro	0	2 *bc*	0	0 *b*	0	0
12	**Spring Oats**	**Stratego + Prosaro + Caramb**	**0**	**0 *c***	**0**	**0 *b***	**0**	**0**
		MEAN	**0**	**2**	**0**	**1**	**0**	**0**
		C.V. (%)	-	122.0	-	178.7	393.5	-
		PR>F	-	**<0.0001**	-	**<0.0001**	0.5900	-
		SE	-	0.3	-	0.3	0.1	-

Notes:

a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

CROP	SEED ♣ kg/kg NUTRIENTS [b]	YIELD (MT/ha) GRAIN [b]	YIELD (MT/ha) STRAW [a]	YIELD (MT/ha) BIOMASS [b]	HARVEST INDEX (%) [a]	HEIGHT (cm) [a]	PLANTS /m^2 [a]	1000 K WT.(g) [a]	TEST WT. (kg/hl) [a]
Spring Wheat	26.2	4.04	3.85 *b*	7.89	52.1 *ab*	68 *b*	467 *b*	41 *b*	80 *a*
Malthing Barley	27.0	4.16	4.82 *a*	8.98	46.6 *b*	60 *c*	897 *a*	53 *a*	62 *b*
Spring Oats	**28.1**	**4.33**	**3.85 *b***	**8.18**	**52.9 *a***	**85 *a***	**404 *b***	**40 *b***	**52 *c***
MEAN	**27.1**	**4.18**	**4.17**	**8.35**	**50.6**	**71**	**589**	**45**	**65**
C.V. (%)	14.8	14.8	24.7	16.8	13.4	16.3	47.6	13.9	18.4
PR>F	0.4900	0.4900	**0.0150**	0.1100	**0.0260**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
SE	0.62	0.096	0.159	0.217	1.05	1.8	43.8	1.0	1.8

TREATMENT	SEED ♣ kg/kg NUTRIENTS [b]	YIELD (MT/ha) GRAIN [b]	YIELD (MT/ha) STRAW [b]	YIELD (MT/ha) BIOMASS [b]	HARVEST INDEX (%) [b]	HEIGHT [b] (cm)	PLANTS [b] /m^2	1000 K WT.(g)	TEST WT. (kg/hl)
None	**28.5**	**4.39**	**4.07**	**8.46**	**53.5**	**72**	**555**	**43**	**65**
Stratego	26.3	4.04	4.00	8.05	50.3	71	716	46	65
Stratego + Prosaro	26.8	4.12	4.44	8.56	48.1	69	585	46	65
Stratego + Prosaro + Caramba	26.9	4.14	4.19	8.33	50.1	73	531	44	65
MEAN	**27.1**	**4.17**	**4.18**	**8.35**	**50.5**	**71**	**597**	**45**	**65**
C.V. (%)	14.8	14.8	24.7	16.8	13.4	16.3	47.6	13.9	18.4
PR>F	0.6200	0.6200	0.8000	0.8700	0.3500	0.9100	0.5300	0.5700	1.0000
SE	0.62	0.096	0.159	0.217	1.05	1.8	43.8	1.0	1.8

Notes:

♣ Indicates nutrients utilization efficiency.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

Cont'd from previous page

CROP	DAYS TO HEAD [a]	DAYS TO MATURE [a]	LODGING♠ (0-9)	BYDV	DISEASES* SEPTORIA [a]	DISEASES* TAN SPOT	DISEASES* SPOT BLOTCH [a]	DISEASES* RUST	DISEASES* FHB
Spring Wheat	52 *c*	89 *a*	0	0	3 *a*	0	0 *b*	0	0
Malthing Barley	60 *a*	87 *b*	0	0	0 *b*	0	3 *a*	0	0
Spring Oats	**54 *b***	**86 *b***	**0**	**0**	**3 *a***	**0**	**0 *b***	**0**	**0**
MEAN	**55**	**87**	**0**	**0**	**2**	**0**	**1**	**0**	**0**
C.V. (%)	11.1	1.8	-	-	122.0	-	178.7	393.5	-
PR>F	**<0.0001**	**<0.0001**	-	-	**0.0005**	-	**<0.0001**	0.2840	-
SE	0.9	0.3	-	-	0.3	-	0.3	0.1	-

TREATMENT	DAYS TO HEAD [b]	DAYS TO MATURE [b]	LODGING♠ (0-9)	BYDV	DISEASES* SEPTORIA [a]	DISEASES* TAN SPOT	DISEASES* SPOT BLOTCH [b]	DISEASES* RUST	DISEASES* FHB
None	**56**	**87**	**0**	**0**	**3 *a***	**0**	**1**	**0**	**0**
Stratego	56	87	0	0	2 *ab*	0	2	0	0
Stratego + Prosaro	56	87	0	0	1 *b*	0	0	0	0
Stratego + Prosaro + Caramba	55	87	0	0	0 *b*	0	0	0	0
MEAN	**56**	**87**	**0**	**0**	**2**	**0**	**1**	**0**	**0**
C.V. (%)	11.1	1.8	-	-	122.0	-	178.7	393.5	-
PR>F	0.7200	0.9500	-	-	**0.0021**	-	0.0900	0.3800	-
SE	0.9	0.3	-	-	0.3	-	0.3	0.1	-

Notes:

a Letter codes not displayed for the means were not affected by the treatments (P>0.05)

b Letter codes not displayed for the means that were not affected by the treatments (P>0.05)

* Diseases are rated on the scale 0-9, where 0 = free from infection and 9 = 89 % infection.

♠ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

5.2 Winter Rye Date of Seeding

PLANTING DATE: As per Treatments

FERTILIZERS: 120 kg N/ha (173 kg/ha 46-0-0; 91 kg/ha 44-0-0) 5.6 kg S/ha (35 kg/ha 0-0-0-16-20)
50 kg P_2O_5/ha (111 kg/ha 0-45-0) 7 kg Zinc/ha (35 kg/ha 0-0-0-16-20)
20 kg K_2O/ha (33 kg/ha 0-0-60) 1 kg Boron/ha (7 kg/ha 0-0-0-15)

HERBICIDE: Refine SG @ 30 g/ha + 0.2% v/v surfactant; applied on September 23, 2019

HARVEST DATE: August 12 , 2020

PREVIOUS CROP: Fallow

VARIETY: Hazlet

	…….YIELD…….					
	GRAIN ♣ [a]	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST	DAYS TO
	kg/kg NUTRIENTS	.....(MT/ha).....			INDEX (%) [b]	MATURE [a]
August 25, 2019	19.5 *ab*	3.97 *ab*	5.75 *a*	9.72 *a*	40.8	336 *a*
September 05, 2019	**21.0 *a***	**4.28 *a***	**5.86 *a***	**10.13 *a***	**42.2**	**327 *b***
September 15, 2019	**26.5 *a***	**5.40 *a***	**6.84 *a***	**12.24 *a***	**44.1**	**320 *c***
September 25, 2019	**23.8 *a***	**4.86 *a***	**5.98 *a***	**10.83 *a***	**44.7**	**308 *d***
October 05, 2019	20.7 *ab*	4.22 *ab*	5.29 *ab*	9.51 *ab*	43.8	300 *e*
October 15, 2019	12.3 *b*	2.51 *b*	3.91 *b*	6.42 *b*	39.2	296 *f*
MEAN	**20.7**	**4.21**	**5.60**	**9.81**	**42.5**	**314**
C.V. (%)	26.8	26.8	19.9	22.1	8.3	4.7
PR>F	**0.0015**	**0.0015**	**0.0010**	**0.0006**	0.2000	**<0.0001**
SE	1.13	0.230	0.228	0.443	0.7	2.3
LSD (0.05)	5.6	1.10	1.10	2.10	NS	1

TREATMENTS	LODGING▼ (0-9)	PLANTS & TILLERS /m^2 [a]	HEIGHT (cm) [a]	1000 K WT.(g)	TEST WT. (kg/hl)
August 25, 2019	0	650 *a*	122 *a*	31	66
September 05, 2019	**0**	**353 *ab***	**120 *a***	**32**	**67**
September 15, 2019	**0**	**407 *ab***	**126 *a***	**37**	**67**
September 25, 2019	**0**	**383 *ab***	**111 *a***	**37**	**67**
October 05, 2019	0	380 *ab*	107 *a*	37	67
October 15, 2019	0	273 *b*	108 *a*	39	66
MEAN	**0**	**408**	**116**	**36**	**66**
C.V. (%)	-	41.7	9.5	-	-
PR>F	-	**0.0220**	**0.0500**	-	-
SE	-	34.7	2.3	-	-
LSD (0.05)	-	201	14	-	-

Notes:

♣ Indicates nutrients utilization efficiency

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

5.2 Winter Rye Date of Seeding…Cont'd from previous page

Averaged over 2018-2020

TREATMENTS	GRAIN kg/kg ♣ [a] NUTRIENTS	…….YIELD……. GRAIN [a]	STRAW [a]	BIOMASS [a] (MT/ha)	HARVEST INDEX (%) [a]	1000 K WT.(g) [a]	TEST WT. (kg/hl) [a]	DAYS TO MATURE [a]	HEIGHT (cm) [a]
August 25	**36.3 *ab***	**5.62 *abc***	**6.99 *a***	**12.61 *ab***	**40.3 *b***	**32.4 *c***	**69 *ab***	**348 *a***	**122 *a***
September 05	**38.7 *a***	**6.36 *ab***	**7.42 *a***	**13.78 *ab***	**43.9 *ab***	**34.9 *b***	**71 *a***	**341 *ab***	**121 *a***
September 15	**40.0 *a***	**7.25 *a***	**7.82 *a***	**15.07 *a***	**49.8 *a***	**37.7 *a***	**69 *ab***	**336 *abc***	**121 *a***
September 25	33.5 *ab*	5.40 *bc*	6.23 *ab*	11.62 *bc*	43.7 *ab*	38.3 *a*	70 *ab*	328 *abc*	106 *b*
October 05	28.8 *ab*	4.23 *cd*	4.81 *bc*	9.03 *cd*	41.5 *b*	39.1 *a*	69 *ab*	324 *bc*	104 *b*
October 15	22.1 *b*	2.97 *d*	4.01 *c*	6.98 *d*	37.6 *b*	39.0 *a*	67 *b*	320 *c*	107 *b*
Mean	**33.2**	**5.30**	**6.21**	**11.52**	**42.8**	**36.9**	**69**	**333**	**113**
C.V. (%)	43.4	38.2	30.7	33.7	15.7	8.0	3.7	6.0	10.8
PR>F	**0.0168**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0001**	**<0.0001**	**0.0440**	**0.0013**	**<0.0001**
SE	1.7	0.239	0.225	0.457	0.79	0.3	0.3	2.3	1.5
LSD (0.05)	11.0	1.20	1.10	2.30	4.7	1.4		15	8

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means were not affected by the treatments (P>0.05)

5.3 Winter Rye Date and Rate of Seeding

PLANTING DATE: As per Treatments

FERTILIZERS: 120 kg N/ha (173 kg/ha 46-0-0; 91 kg/ha 44-0-0)
50 kg P_2O_5/ha (111 kg/ha 0-45-0)
20 kg K_2O/ha (33 kg/ha 0-0-60)
5.6 kg S/ha (35 kg/ha 0-0-0-16-20)
7 kg Zinc/ha (35 kg/ha 0-0-0-16-20)
1 kg Boron/ha (7 kg/ha 0-0-0-15)

HERBICIDE: Refine SG @ 30 g/ha + 0.2% v/v surfactant; applied on September 23, 2019

HARVEST DATE: August 12, 2020

PREVIOUS CROP: Fallow

VARIETY: Hazlet

				…….YIELD…….		
SEEDING DATE	SEEDING RATE	GRAIN ♣ kg/kg NUTRIENTS	GRAIN [a]	STRAW [a] .....(MT/ha).....	BIOMASS [a]	HARVEST [b] INDEX (%)
September 25	**1×**	**19.4 *a***	**3.95 *a***	**4.82 *a***	**8.77 *a***	**45**
October 05	1.25×	12.8 *ab*	2.61 *ab*	4.62 *a*	7.22 *ab*	35
October 15	1.25×	10.5 *ab*	2.13 *ab*	2.91 *b*	5.37 *bc*	40
October 25	1.5×	7.4 *b*	1.51 *b*	2.03 *b*	3.54 *c*	43
MEAN		**12.5**	**2.55**	**3.59**	**6.23**	**40.6**
C.V. (%)		49.3	49.3	39.5	41.0	19.3
PR>F		**0.0166**	**0.0170**	**0.0008**	**0.0029**	0.3900
SE		1.55	0.315	0.355	0.638	1.96
LSD (0.05)		6.9	1.40	1.20	2.40	NS

SEEDING DATE	SEEDING RATE	1000 K WT.(g)	TEST WT. (kg/hl)	PLANTS & TILLERS /m^2 [b]	HEIGHT (cm) [a]	DAYS TO MATURE [a]
September 25	**1×**	**39**	**67**	**517**	**118 *a***	**308 *a***
October 05	1.25×	39	68	467	111 *a*	302 *b*
October 15	1.25×	39	67	450	103 *a*	297 *c*
October 25	1.5×	38	68	373	98 *a*	295 *d*
MEAN		**39**	**67**	**452**	**108**	**300**
C.V. (%)		-	-	24.4	10.2	1.7
PR>F		-	-	0.3800	**0.0560**	**<0.0001**
SE		-	-	27.6	2.8	1.3
LSD (0.05)		-	-	NS	14	1

Notes:

♣ Indicates nutrients utilization efficiency

a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)

b Letter codes not displayed for the means not affected by the treatments (P>0.05)

5.3 Winter Rye Date and Rate of Seeding...Cont'd from previous page

Averaged over 2019-2020

SEEDING DATE	SEEDING RATE	GRAIN ♣ kg/kg NUTRIENTS	……YIELD……. GRAIN (MT/ha)	STRAW (MT/ha)	BIOMASS (MT/ha)	HARVEST INDEX (%)	1000 K WT.(g)	TEST WT. (kg/hl)
September 25	**1×**	**72.0**	**4.16**	**4.64**	**8.80**	**47**	40	68
October 05	1.25×	39.9	2.48	3.48	5.96	43	38	68
October 15	1.25×	27.5	1.85	2.51	4.52	40	42	68
October 25	1.5×	14.3	1.13	1.51	2.64	44	39	68
MEAN		**38.4**	**2.40**	**3.04**	**5.48**	**43.5**	**40**	**68**

SEEDING DATE	SEEDING RATE	HEIGHT (cm)	DAYS TO MATURE
September 25	**1×**	**112**	**317**
October 05	1.25×	103	310
October 15	1.25×	98	302
October 25	1.5×	92	297
MEAN		**101**	**306**

Notes:

♣ Indicates nutrients utilization efficiency

▼ Lodging is rated on the scale 0-9, where 0 = standing and 9 = flat.

5.4 Effect of Winter Rye Cover Cropping on Spring Crops

PLANTING DATE: June 6, 2020

FERTILIZERS: **Flax, Spring Wheat and Spring Barley:**
70 kg N/ha (152 kg 46-0-0), 20 kg P_2O_5/ha (44 kg 0-45-0), 20 kg K_2O/ha (33 kg/ha 0-0-60)
Canola:
180 kg N/ha (391 kg 46-0-0, 100 kg 21-0-0-24), 20 kg P_2O_5/ha (44 kg 0-45-0), 20 kg K_2O/ha (33 kg/ha 0-0-60)
24 kg S/ha (100 kg 21-0-0-24)
Soybean and Lentils:
45 kg N/ha (98 kg 46-0-0), 20 kg P_2O_5/ha (44 kg 0-45-0), 20 kg K_2O/ha (33 kg/ha 0-0-60)

HERBICIDE: Roundup @ 3 L/ha applied pre - emergent; June 5, 2020

HARVEST DATE: October 27, 2020

PREVIOUS CROP: Annual Forage

…….FACTOR A X B…….

FACTOR A	FACTOR B	BIOMASS (MT/ha) [b]
Winter Rye with Fertilizer	Spring Wheat	0.56
Winter Rye with Fertilizer	Spring Barley	3.39
Winter Rye with Fertilizer	**Canola**	**5.11**
Winter Rye with Fertilizer	Soybean	0.22
Winter Rye with Fertilizer	Lentils	1.03
Winter Rye with Fertilizer	**Flax**	**4.67**
Fallow	Spring Wheat	1.11
Fallow	Spring Barley	3.67
Fallow	Canola	4.11
Fallow	Soybean	2.00
Fallow	Lentils	1.56
Fallow	Flax	3.69
Winter Rye without Fertilizer	Spring Wheat	0.75
Winter Rye without Fertilizer	Spring Barley	3.58
Winter Rye without Fertilizer	**Canola**	**8.78**
Winter Rye without Fertilizer	Soybean	1.42
Winter Rye without Fertilizer	Lentils	0.81
Winter Rye without Fertilizer	Flax	0.03
MEAN		**2.85**
C.V. (%)		132.3
PR>F - (A x B)		0.3618
SE		0.407
LSD (0.05)		NS

Notes:
♣Indicates nutrients utilization efficiency
Pre seeding soil analysis 0-15 cm (ppm):
Winter Rye with Fertilizer: Ammoniacal N: 7, Nitrate N: 17, Total N: 24
Winter Rye with No Fertilizer: Ammoniacal N: 7, Nitrate N: 9, Total N: 16
Fallow: Ammoniacal N: 7, Nitrate N: 19, Total N: 26
Only biomass was recorded because the crops didn't reach maturity
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

Cont'd from Previous page

FACTOR A	BIOMASS (MT/ha) [b]
Winter Rye with Fertilizer	2.60
Fallow	**2.67**
Winter Rye without Fertilizer	2.56
MEAN	**2.61**
C.V. (%)	132.3
PR>F - A	0.9917
SE	0.407
LSD (0.05)	NS

FACTOR B	BIOMASS (MT/ha) [a]
Spring Wheat	0.81 *b*
Spring Barley	4.02 *ab*
Canola	**6.00 *a***
Soybean	0.92 *b*
Lentils	1.13 *b*
Flax	2.80 *ab*
MEAN	**2.61**
C.V. (%)	132.3
PR>F - B	0.0003
SE	0.407
LSD (0.05)	2.47

Notes:
♣Indicates nutrients utilization efficiency
Only biomass was recorded because the crops didn't reach maturity
a Means followed by the same letter codes were not significantly different based on Tukey's test (P=0.05)
b Letter codes not displayed for the means were not affected by the treatment (P>0.05)

5.5 Optimizing Seeding Rate in Kernza and Comparing its Grain Production Potential with Perennial Rye and in Mixture with Alfalfa

PLANTING DATE: July 10, 2017
FERTILIZER: 70 kg N/ha (153 kg/ha 46-0-0)
20 kg P_2O_5/ha (45 kg/ha 0-45-0)
20 kg K_2O/ha (34 kg/ha 0-0-60)
HERBICIDE: None
HARVEST DATE: August 31, 2020
PREVIOUS CROP: Soybean

		…….YIELD…….				
TREATMENTS	GRAIN ♣ [a] kg/kg NUTRIENTS	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST [a] INDEX (%)	HEIGHT [a] (cm)
		.....(MT/ha).....				
Kernza @ 70 seed/m^2	1.9	0.21	8.94	9.14	2.1	136
Kernza @ 90 seed/m^2	1.7	0.19	8.84	9.02	2.1	133
Kernza @ 110 seed/m^2	**3.3**	**0.36**	**10.41**	**10.77**	**3.3**	**133**
Kernza @ 130 seed/m^2	2.7	0.30	9.81	10.11	2.8	136
Ace 1 @ 250 seed/m^2	N/A	N/A	N/A	N/A	N/A	N/A
MEAN	**2.4**	**0.26**	**9.50**	**9.76**	**2.6**	**134**
C.V. (%)	47.2	58.4	12.6	13.5	47.2	4.1
PR>F	0.1921	0.1921	0.1022	0.0823	0.3343	0.6760
SE	0.35	0.038	0.300	0.328	0.31	1.4
LSD (0.05)	NS	NS	NS	NS	NS	NS

Notes:
Ace 1 perennial rye produced seed only in 2018 and didn't survive thereafter!
a Letter codes not displayed for the means were not affected by the treatment (P>0.05).

5.5 Optimizing Seeding Rate in Kernza and Comparing its Grain Production Potential with Perennial Rye and in Mixture with Alfalfa

Average Over 2018-2020

	…….YIELD…….					
	GRAIN ♣ [a]	GRAIN [a]	STRAW [a]	BIOMASS [a]	HARVEST	HEIGHT
	kg/kg NUTRIENTS	.....(MT/ha).....			INDEX (%) [a]	(cm) [a]
TREATMENTS						
	5.5	1.18	11.87	13.06	8.1	143
Kernza @ 70 seed/m^2	5.1	1.09	11.88	12.97	7.7	140
Kernza @ 90 seed/m^2	**6.2**	**1.30**	**12.86**	**14.15**	**8.5**	**142**
Kernza @ 110 seed/m^2	5.5	1.16	12.60	13.76	7.7	141
Kernza @ 130 seed/m^2	9.2	1.75	6.26	8.01	21.6	121
Ace 1 @ 250 seed/m^2 *						
	5.6	**1.18**	**12.30**	**13.49**	**8.0**	**142**
MEAN	47.3	57.7	25.9	27.0	60.5	9.8
C.V. (%)	0.7700	0.9200	0.7390	0.7900	0.9600	0.9300
PR>F	0.38	0.098	0.426	0.489	0.76	1.9
SE	NS	NS	NS	NS	NS	NS
LSD (0.05)						

Notes:

*Ace 1 perennial rye produced seed only in 2018 and didn't survive thereafter!

a Letter codes not displayed for the means were not affected by the treatment (P>0.05)

5.6 Alternate Forage Legumes

PLANTING DATE: June 11, 2018
FERTILIZER: 45 kg N/ha (52 kg/ha 46-0-0, 100 kg/ha 21-0-0-24)
20 kg P_2O_5/ha (44 kg/ha 0-45-0) 24 kg S/ha (100 kg/ha 21-0-0-24)
60 kg K_2O/ha (100 kg/ha 0-0-60) 1 kg B/ha (7 kg/ha 0-0-0-15)
HARVEST DATE: June 19 and August 13, 2020
PREVIOUS CROP: Annual forages

	DRY MATTER YIELD (kg/ha)					FRESH MATTER YIELD (kg/ha)			
	2019	….....2020.....			2019-2020	2019	….....2020.....		
TREATMENTS	TOTAL[a]	1st CUT[a]	2nd CUT[b]	TOTAL[a]	AVERAGE[a]	TOTAL[a]	1st CUT[a]	2nd CUT[b]	TOTAL[a]
Alfalfa	**2459 *ab***	**2245 *a***	**1199**	**3444 *a***	***2952 a***	**12850 *b***	**11959 *a***	**3841**	**15800 *a***
Galega	641 *e*	1280 *b*	574	1854 *ab*	*1248 b*	3187 *e*	6817 *b*	2322	9139 *bc*
Red Clover	3135 *a*	1958 *a*	981	2939 *ab*	*3037 a*	21527 *a*	12085 *a*	3569	15654 *a*
Birdfoot Trefoil	1527 *cd*	1810 *a*	575	2385 *ab*	*1956 b*	8398 *cd*	12082 *a*	2265	14347 *ab*
Sainfoin seeded @ 20 kg/ha	965 *de*	946 *b*	521	1467 *b*	*1215 b*	4724 *de*	4925 *b*	1652	6577 *c*
Sainfoin seeded @ 30 kg/ha	1427 *cd*	942 *b*	951	1893 *ab*	*1660 b*	7335 *cd*	5633 *b*	3492	9125 *bc*
Sainfoin seeded @ 40 kg/ha	1381 *cd*	1034 *b*	847	1881 *ab*	*1631 b*	7131 *cd*	5466 *b*	2816	8282 *bc*
Sainfoin seeded @ 50 kg/ha	1939 *bc*	1050 *b*	490	1540 *b*	*1739 b*	10433 *bc*	6187 *b*	1779	7966 *c*
MEAN	**1684**	**1408**	**767**	**2175**	**1930**	**9448**	**8144**	**2717**	**10861**
C.V. (%)	48.4	36.8	34.3	32.1	36.4	59.8	40.2	31.0	34.6
PR>F	**<0.0001**	**<0.0001**	0.6600	**0.0100**	**0.0280**	**<0.0001**	**<0.0001**	0.76	**<0.0001**
SE	156.5	183.3	93.0	246.9	248.0	828.8	1157.5	298	1328.8
LSD (0.05)	457	320	NS	998	587	2419	1848	NS	3923

Notes:
a Means with the same letter were not statistically different according to the Tukey-Kramer test (P=0.05)
b Letter codes not displayed for the means not affected by the treatment (P>0.05)

5.6 Alternate Forage Legumes
Quality Parameters on Dry Matter Basis: First Cut

VARIETIES	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL .....Mcal/kg.....	NEG	NEM	RFV
Alfalfa	18.8	35.7	1.71	36.3	33.4	45.0	65.7	1.49	0.82	1.40	130
Galega	13.4	36.1	1.71	36.5	38.5	46.8	65.4	1.48	0.70	1.27	117
Red Clover	19.1	35.8	2.05	36.7	33.0	48.1	66.3	1.51	0.83	1.41	122
Birdfoot Trefoil	19.6	35.7	1.84	34.8	34.2	45.1	65.7	1.49	0.80	1.38	128
Sainfoin seeded @ 20 kg/ha	19.6	35.7	1.84	34.8	34.2	45.1	65.7	1.49	0.80	1.38	128
Sainfoin seeded @ 30 kg/ha	14.7	35.9	2.04	36.6	37.0	47.2	65.6	1.49	0.74	1.31	118
Sainfoin seeded @ 40 kg/ha	12.7	36.2	2.01	36.5	39.1	445.1	65.4	1.48	0.70	1.25	121
Sainfoin seeded @ 50 kg/ha	13.2	36.1	2.00	36.5	37.3	46.4	65.7	1.49	0.73	1.30	120
MEAN	**16.4**	**35.9**	**1.90**	**36.1**	**35.8**	**96.1**	**65.696**	**1.49**	**0.77**	**1.34**	**123**

VARIETIES	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa	0.28	2.05	0.34	2.11	0.47	0.26	12.2	32.7	127	28.4	0.13
Galega	0.29	2.49	0.37	1.24	0.49	0.28	11.5	33.5	135	35.3	0.11
Red Clover	0.26	2.01	0.18	1.68	0.55	0.24	12.0	32.9	164	40.7	0.04
Birdfoot Trefoil	0.31	2.87	0.25	1.19	0.39	0.29	10.6	31.2	135	33.0	0.12
Sainfoin seeded @ 20 kg/ha	0.26	2.37	0.23	1.19	0.44	0.30	9.2	34.4	266	32.3	0.08
Sainfoin seeded @ 30 kg/ha	0.27	2.40	0.30	1.46	0.51	0.23	10.9	33.3	176	29.1	0.07
Sainfoin seeded @ 40 kg/ha	0.25	2.72	0.23	1.12	0.43	0.27	9.6	24.1	133	33.8	0.08
Sainfoin seeded @ 50 kg/ha	0.25	2.39	0.37	1.51	0.46	0.25	10.4	34.6	132	25.3	0.06
MEAN	0.27	2.41	0.28	1.44	0.47	0.27	10.8	32.1	158	32.2	0.09

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.
Note: Quality parameters on dry matter basis were not analyzed for the second cut due to poor growth

5.7 Galega Establishment - Planted in 2018

PLANTING DATE: As per treatment in 2018

FERTILIZER: 45 kg N/ha (62 kg/ha 46-0-0, 79 kg/ha 21-0-0-24); 1 kg B/ha (7 kg/ha 0-0-0-15); 24 kg S/ha (79 kg/ha 21-0-0-24, 35 kg/ha 0-0-0-16-20); 7 kg Zn/ha (35 kg/ha 0-0-0-16-20)

HERBICIDES: As per treatments

HARVEST DATE: First cut: June 15, 2020

PREVIOUS CROP: Spring Cereals

		DRY MATTER YIELD (kg/ha)			FRESH MATTER YIELD (kg/ha)	
		2019	2020	2019-2020	2019	2020
	TREATMENTS	TOTAL[a]	1st CUT[a]	AVERAGE 1st CUT[d]	TOTAL[a]	1st CUT[a]
1	Alfalfa seeded at 15 kg/ha (check)	4166 *a*	2570 *a*	2217	24525 *a*	14789 *a*
2	Galega seeded in spring as early as possible	2594 *ab*	2052 *ab*	1858	14251 *abc*	13596 *ab*
3	Allow weeds to come out in spring kill the weeds and then seed galega [b]	3149 *ab*	1424 *b*	1899	17804 *abc*	7670 *b*
4	Galega seeded after barley harvested at boot stage [c]	2873 *ab*	1489 *b*	1689	13481 *bc*	9138 *ab*
5	Galega seeded mid-July after killing the weeds	2981 *ab*	1426 *b*	1767	14902 *abc*	9190 *ab*
6	Galega seeded after pre-plant incorporation of Rival (trifluralin) @ 3L/ha	3784 *ab*	2008 *ab*	2369	21236 *ab*	10774 *ab*
7	Galega seeded after pre-plant incorporation of Sencor @ 475g/ha	1826 *b*	1458 *b*	1472	9125 *c*	7829 *b*
8	Galega sprayed with Sencor @ 275 g/ha post-emergent	2355 *ab*	1849 *ab*	1525	13382 *bc*	11523 *ab*
9	Galega sprayed with Basagram Forte @ 1.75L/ha post-emergent	3664 *ab*	1573 *ab*	1952	21040 *ab*	8743 *ab*
10	Galega sprayed with Pursuit @ 210 ml/ha + Ag-Surf @ 0.25% v/v post- emergent	3533 *ab*	1792 *ab*	2272	19501 *abc*	10407 *ab*
	MEAN	**3093**	**1764**	**1902**	**16925**	**10366**
	C.V. (%)	33.3	23.4	21.2	35.2	24.9
	PR>F	**0.0138**	**0.0550**	0.8600	**0.0009**	**0.0250**
	SE	437.9	117.2	97.1	2230.3	750.8
	LSD (0.05)	1491	618	NS	8617	3814

Notes:

Treatments 2 - 10 were seeded with Galega at 30 kg/ha

Herbicide treatments were only applied in planting year (2018)

Phosphorus and potassium levels were high in soil and were not applied in 2019

A second cut was not taken in 2020 due to poor growth

a Means with the same letter were not statistically different according to the Tukey-Kramer test (P=0.05)

b Seeded June 14, 2018

c Barley harvested July 9, 2018

d Letter codes not displayed for the means not affected by the treatment (P>0.05)

5.7 Galega Establishment - Planted in 2018
Cont'd from previous page
Quality Parameters on Dry Matter Basis: First Cut

TREATMENT	CRUDE PROTEIN %	SOLUBLE PROTEIN % of CP	ADF-CP %	UIP % of CP	ADF %	NDF %	TDN %	NEL	NEG	NEM	RFV
								.....Mcal/kg.....			
Alfalfa seeded at 15 kg/ha (check)	20.4	36.0	1.57	36.6	33.1	41.8	68.8	1.57	0.83	1.41	141
Galega seeded in spring as early as possible	20.4	35.7	3.32	36.7	37.6	50.4	67.1	1.52	0.73	1.30	110
Allow weeds to come out in spring kill the weeds and then seed galega	20.1	36.0	2.51	36.6	35.9	46.9	69.4	1.53	0.76	1.34	121
Galega seeded after barley harvested at boot stage	20.3	35.9	2.81	36.6	34.2	45.8	70.2	1.60	0.80	1.38	127
Galega seeded mid-July after killing the weeds	19.6	35.9	3.10	36.6	36.9	49.2	67.7	1.54	0.74	1.31	114
Galega seeded after pre-plant incorporation of Rival (trifluralin) @	19.4	36.0	2.77	36.6	35.5	45.1	69.8	1.59	0.78	1.36	126
Galega seeded after pre-plant incorporation of Sencor @ 475g/ha	17.3	36.1	2.20	36.5	37.2	47.2	67.9	1.54	0.74	1.31	118
Galega sprayed with Sencor @ 275 g/ha post-emergent	17.8	36.1	2.53	36.5	36.0	47.6	68.3	1.55	0.76	1.34	119
Galega sprayed with Basagram Forte @ 1.75L/ha post-emergent	20.2	35.8	2.78	36.7	35.4	46.9	69.2	1.58	0.78	1.36	122
Galega sprayed with Pursuit @ 210 ml/ha + Ag-Surf @ 0.25% v/v post- emergent	20.3	35.7	3.01	36.7	36.9	48.2	69.2	1.57	0.74	1.32	116
MEAN	**19.6**	**35.9**	**2.66**	**36.6**	**35.9**	**46.9**	**68.8**	**1.56**	**0.77**	**1.34**	**121**

UIP = Bypass Protein, ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, TDN = Total Digestible Nutrients,
NE = Net Energy, L = Lactation, M = Maintenance, G = Gain and RFV = Relative Feed Value.

5.7 Galega Establishment - Planted in 2018
Cont'd from previous page
Quality Parameters on Dry Matter Basis: First Cut

TREATMENT	P %	K %	S %	Ca %	Mg %	Cl %	Cu ug/g	Zn ug/g	Fe ug/g	Mn ug/g	Na %
Alfalfa seeded at 15 kg/ha (check)	0.33	2.80	0.29	1.47	0.37	0.38	11.2	39.7	111	48.1	0.10
Galega seeded in spring as early as possible	0.36	3.54	0.27	1.27	0.47	0.19	13.7	41.6	149	58.3	0.05
Allow weeds to come out in spring kill the weeds and then seed galega	0.38	3.01	0.31	1.01	0.51	0.27	16.4	31.6	129	52.8	0.05
Galega seeded after barley harvested at boot stage	0.36	3.29	0.28	1.09	0.45	0.26	12.8	34.2	101	46.8	0.03
Galega seeded mid-July after killing the weeds	0.34	3.39	0.28	1.00	0.43	0.24	14.1	36.0	113	56.7	0.02
Galega seeded after pre-plant incorporation of Rival (trifluralin) @	0.35	3.45	0.25	1.12	0.47	0.25	13.8	36.9	94	54.9	0.02
Galega seeded after pre-plant incorporation of Sencor @ 475g/ha	0.36	3.50	0.26	0.89	0.36	0.29	14.0	36.3	128	48.0	0.04
Galega sprayed with Sencor @ 275 g/ha post-emergent	0	0	0	0.00	0.00	0.27	0.00	0.0	0	0.0	0.00
Galega sprayed with Basagram Forte @ 1.75L/ha post-emergent	0.41	3.32	0.32	1.11	0.49	0.22	16.2	38.6	110	57.8	0.04
Galega sprayed with Pursuit @ 210 ml/ha + Ag-Surf @ 0.25% v/v post- emergent	0.40	3.72	0.28	1.07	0.43	0.21	16.0	45.6	122	65.6	0.04
MEAN	**0.33**	**3.00**	**0.25**	**1.00**	**0.40**	**0.26**	**12.8**	**34.1**	**106**	**48.9**	**0.04**

6 Abstracts of Reseach Papers

Environmentally Smart Nitrogen (ESN) – Potential for Improving Modern Crop Production and N-Use Efficiency

Tarlok Singh Sahota*

*Lakehead University Agricultural Research Station, 5790 Little Norway Road, Thunder Bay, Ontario, Canada P7B 5E1 (e-mail: tssahota@lakeheadu.ca)

ESN is polymer coated urea that could release N matching with crop requirements. I was the first to initiate research on ESN in field crops in Ontario, Canada in 2006; initially on timothy, spring wheat and winter wheat and later (till date) on bromegrass, grass mixtures (timothy, bromegrass, orchardgrass), other forages (barley, silage corn, oat, MasterGraze corn and sorghum sudangrass) feed barley and canola. In winter wheat, in 3 out of 6 years ESN gave ~0.6 MT/ha higher grain yield than urea. In spring wheat, in a relatively warmer year with well spread rainfall, ESN produced 1 MT/ha higher grain yield than urea; averaged over 3 years, 2/3rd N from urea and 1/3rd N from ESN could be recommended. Two third N from urea and 1/3rd N from ESN gave ~1 MT/ha extra seed yield than urea alone @ 180 kg N/ha in 2016 and 2017. Entire N from ESN in winter/spring wheat could be applied in seed rows at seeding without any detrimental effect. Highest barley grain and forage yields were recorded by urea @ 50 kg N/ha + ESN @ 20 kg N/ha; that recorded 1.2 MT/ha more forage yield than urea. Partial substitution of N from urea with ESN improved forage dry matter yield of timothy and MasterGraze corn (100 kg N/ha from urea + ESN (3:1 N) equaled that with urea @ 150 kg N/ha in yield, % protein and RFV!), but not that of winter cereals for forage, silage corn and sorghum sudangrass. At equal rates of N, single/fall application of ESN in timothy and bromegrass gave equal yield to urea applied in two splits in spring/summer. Spring wheat grain yields were the same with fall/or spring application of ESN. ESN/or urea + ESN (3:1 N) increased the grain/forage protein content in almost all crops by 1-2 % points at an extra cost of only $ 6.0-10.5/ha. The results indicate that ESN could improve both crop yields and quality, make better use of N/and increase N-use efficiency. The presentation summarizes results from over 10 years and the results could be applicable globally under situations of high N losses from readily available N sources such as urea!

Paper presented at the International Horticulture Conference February 26-28, 2020, Punjab University Lahore, Pakistan.

Research on New Crops*

Dr. Tarlok Singh Sahota CCA
Director LUARS Thunder Bay, Canada
tssahota@lakeheadu.ca

Research on new crops is important for adaption of a crop to new areas and for the much needed crop diversification. Over twenty new crops (grain, forage, oilseed and specialty crops) were evaluated for their production potential at the Lakehead University Agricultural Research Station, Thunder Bay, Ontario, Canada during the past 15 years. These included Camelina, Canola, Sainfoin, Kernza, Galega, MasterGraze Corn, Sorghum Sudangrass, Perennial Rye, Frosty Berseem, Tonic Plantain, Choice Chicory, Fixation Blansa, Quinoa, Hemp, Switchgrass, Winter Barley, Winter Triticale, Winter Rye, Winter Wheat, Durum Wheat and Spring Triticale. Crops that showed good production potential were; Kernza for forage (4.40 MT DMY/ha) and straw (14-15 MT/ha) production, Galega for higher and better quality forage production (5.52 MT DMY/ha ~1 MT/ha higher than that from alfalfa), MasterGraze corn for forage production (8.40 MT DMY/ha in ~80 days; better production than barley), Sorghum Sudangrass for forage production (8.80 MT DMY/ha in ~80 days), Perennial Rye for straw/biomass production (24 MT straw/ha), Frosty berseem for forage production (3.85 MT DMY/ha) and for building soil N fertility, Switchgrass for biomass production on marginal lands (6.30 DMY/ha), winter cereals (Triticale, Rye and Wheat) for forage (10-12 MT DMY/ha), grain (up to 8 MT/ha) and straw (8-10 MT/ha) production, and Durum Wheat that produced as good grain yield (over 6 MT/ha) as the conventional wheat and gave higher straw yield (over 8 MT/ha) than the conventional wheat. Crops that were grown locally are Winter Wheat/and Rye, Durum Wheat, Sorghum Sudangrass, MasterGraze Corn and Canola. Galega had a Province wide trial cultivation and also in a few Provinces outside Ontario. MasterGraze Corn found its place in the outskirts of Calgary, Alberta. Addition of new crops help to diversify cropping systems on farms, help meeting the challenge of climate change, protect and build soils and improve farm income.

**Paper presented at the International Conference "Smart Plantation an Ultimate Solution to Climate Change (ICSP 2020)" March 2-4, 2020; organized by the Department of Botany, LCWU Lahore, Pakistan*

Effect of time of seeding and stage of harvesting on MasterGarze corn in Northwestern Ontario

T. S. Sahota[1]

[1]Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, Canada (tssahota@lakeheadu.ca)

Abstract

MasterGraze corn could produce 8 Mg ha^{-1} dry matter yield (DMY) in 80 days and has been reported to increase milk and butter fat yield in dairy cows. However, its optimum time of seeding and stage of harvesting was not known in the Northwestern Ontario. Therefore an experiment was conducted at LUARS Thunder Bay during 2016 and 2017 in RCBD replicated four times. Treatments included all combinations of four seeding dates (May 15, May 25, June 5 and June 15) and three stages of harvesting (initiation of tasseling, 50 % tasseling and 100 % tasseling). The crop was raised with optimum production practices. DMY was recorded and feed samples for taken for feed quality analyses. The data from the two years were subjected to pooled analysis of variance. The results revealed that the highest DMY (9.13 Mg ha^{-1}) was obtained with June 5 seeding, which was 1.95 Mg ha^{-1} higher than May 15 seeding and 1.57 Mg ha^{-1} higher than May 25 seeding. June 15 seeding gave the lowest DMY (5.39 Mg ha^{-1}). DMY yield increased linearly with delay in harvesting from initiation of tasseling (5.55 Mg ha^{-1}) to 50 % tasseling (7.35 Mg ha^{-1}) and to 100 % tasseling (9.03 Mg ha^{-1}). Protein content was maximum (14.9 %) with June 15 seeding that was 13 % with June 5 seeding. Other feed components (ADF, NDF and TDN) didn't seem to vary with the seeding dates. Stage of harvesting didn't have much effect on protein content (13.4 % at full tasseling and 13.9 % at initiation of tasseling). RFV was highest (113) with seeding on May 15 and harvesting at initiation of tasseling. It may be concluded that June 5 was the optimum time of seeding MasterGraze corn and 100 % tasseling the optimum stage for its harvesting in Northwestern Ontario!

Paper prepared for presentation at the International Conference on Crop Sciences, University of Saskatchewan, SK, June 2020 that was cancelled due to COVID-19!

Evaluation of spring wheat varieties for their production potential and diseases incidence in Northwestern Ontario

T. S. Sahota[1]

[1]Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, Canada (tssahota@lakeheadu.ca)

Abstract

Crop production is determined primarily by three factors; weather, genetics and management. There is nothing much we can do about the weather, but we can choose good genetics. However, what is good for one area may not be good for another. Therefore 29 varieties (21 aestivum and 8 durum) from all over Canada were evaluated for their production potential and diseases incidence at LUARS Thunder Bay during 2016 to 2018 in a RCBD replicated four times. All varieties were seeded at the same time in May and harvested in September every year and received uniform package of practices. The data were subjected to pooled analysis of variance. The results indicated that the grain yield ranged from 4.86 Mg ha^{-1} (AAC Raymore - durum) to 8.69 Mg ha^{-1} (Easton - HRW), and the straw yield ranged from 5.93 Mg ha^{-1} (AAC Penhold - CPSR) to 9.70 Mg ha^{-1} (Easton). The next best grain yielding varieties were AAC Chiffon-SW (7.55 Mg ha^{-1}) and SY Rowyn - CPSR (7.33 Mg ha^{-1}). The second and third best straw yielding varieties were Easton - HRW (9.70 Mg ha^{-1}) and Furano - HRW (8.69 Mg ha^{-1}). Durum varieties produced lower grain yields (4.86 Mg ha^{-1} in AAC Raymore to 6.36 Mg ha^{-1}in CDC Alloy) than aestivum varieties (4.99-8.69 Mg ha^{-1}). The straw yields from durum varieties (7.24-8.35 Mg ha^{-1}) were not too bad as compared to aestivum varieties (5.93-9.70 Mg ha^{-1}). Grain protein content was higher in Easton (13.8 %) than in AAC Chiffon (12.3 %). All varieties matured between 113 to 119 days. None of the varieties had Septoria or Rust infection, and the infection from other diseases (BYDV, Spot Blotch and FHB) was negligible. Aestivum varieties gave higher grain yield than the durum varieties and the top three grain yielding varieties were Easton, AAC Chiffon and SY Rowyn.

Paper prepared for presentation at the International Conference on Crop Sciences, University of Saskatchewan, SK, June 2020 that was cancelled due to COVID-19!

Evaluation of spring barley varieties for their production potential and diseases incidence in Northwestern Ontario

T. S. Sahota[1]

[1]Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, Canada (tssahota@lakeheadu.ca)

Abstract

Crop production is determined primarily by three factors; weather, genetics and management. There is nothing much we can do about the weather, but we can choose good genetics. However, what is good for one area may not be good for another. Therefore 16 varieties (5 two row and 11 6 row) from all over Canada were evaluated for their production potential and diseases incidence at LUARS Thunder Bay during 2016 to 2018 in a RCBD replicated four times. All varieties were seeded at the same time in May and harvested in September every year and received uniform package of practices. The data were subjected to pooled analysis of variance. The results indicated that the grain yield in two row barley ranged from 4.70 Mg ha^{-1} (CDC Coalition) to 5.79 Mg ha^{-1}) (CDC Austenson) and that from 6 row barley ranged from 5.24 Mg ha^{-1} (AAC Mirabel) to 6.95 Mg ha^{-1} (Chambly). Boroe (6.78 Mg ha^{-1}) was as good as Chambly in grain yield. The next best varieties in grain yield were, Oceanic (6.42 Mg ha^{-1}) and Synasolis (6.09 Mg ha^{-1})/ Rhea (6.08 Mg ha^{-1}). Straw yields were highest in Encore (6.38 Mg ha^{-1}), Chambly (6.21 Mg ha^{-1}) and Rhea (6.13 Mg ha^{-1}). None of the varieties were infested with Septoria, BYDV incidence on the scale of 0-9 was low (1.6 in Canmore to 3.7 in Oceanic) and Spot Blotch (0.6-1.3) and FHB infestation (0-0.3) was negligible. Six row varieties gave higher grain and straw yield than the two row varieties. Considering both grain and straw yield, Chambly was the best variety followed closely by Boroe!

Paper prepared for presentation at the International Conference on Crop Sciences, University of Saskatchewan, SK, June 2020 that was cancelled due to COVID-19!

Evaluation of malting barley varieties for their production potential and diseases incidence in Northwestern Ontario

T. S. Sahota[1]

[1]Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, Canada (tssahota@lakeheadu.ca)

Abstract

Crop production is determined primarily by three factors; weather, genetics and management. There is nothing much we can do about the weather, but we can choose good genetics. However, what is good for one area may not be good for another. Therefore 10 varieties from all over Canada were evaluated for their production potential and diseases incidence at LUARS Thunder Bay during 2016 to 2018 in a RCBD replicated four times. All varieties were seeded at the same time in May and harvested in September every year and received uniform package of practices. The data were subjected to pooled analysis of variance. The results indicated that the grain yield was highest with CDC Bow (6.49 Mg ha^{-1}) followed closely by CDC Kindersley (6.06 Mg ha^{-1}). CDC Copeland (5.75 Mg ha^{-1}) was the next best variety. Straw yield was highest in CDC Bow (9.15 Mg ha^{-1}) followed by CDC Copeland (7.03 Mg ha^{-1}). Considering both grain and straw yields CDC Bow proved to be the best! Crop maturity ranged from 102-107 days. Septoria and Rust were absent. BYDV infection was low (1.8 AC Newdale) to medium (4.6 CDC Kindersley) on the scale of 0-9. Spot Blotch infestation was negligible (0.1-0.8). CDC Bow that had the highest grain and straw yields could be recommended for cultivation on farms!

Paper prepared for presentation at the International Conference on Crop Sciences, University of Saskatchewan, SK, June 2020 that was cancelled due to COVID-19!

Evaluation of oat varieties for their production potential and diseases incidence in Northwestern Ontario

T. S. Sahota[1]

[1]Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, Canada (tssahota@lakeheadu.ca)

Abstract

Crop production is determined primarily by three factors; weather, genetics and management. There is nothing much we can do about the weather, but we can choose good genetics. However, what is good for one area may not be good for another. Therefore 23 varieties from all over Canada were evaluated for their production potential and diseases incidence at LUARS Thunder Bay during 2016 to 2018 in a RCBD replicated four times. All varieties were seeded at the same time in May and harvested in September every year and received uniform package of practices. The data were subjected to pooled analysis of variance. The results indicated that the grain yield was highest with OA 1357-2 (7.21 Mg ha^{-1}) followed closely by AAC Roskens (7.09 Mg ha^{-1}), AAC Bullet (7.06 Mg ha^{-1}), OA 1395-1 (6.92 Mg ha^{-1}) and AAC Noranda (6.87 Mg ha^{-1}). Straw yield was highest with OA 1395-1 (8.86 Mg ha^{-1}) followed by OA 1342-1 (8.73 Mg ha^{-1}), OA 1347-2 (8.57 Mg ha^{-1}), OA 1357-2 (8.30 Mg ha^{-1}), and OAC Nicolas (8.26 Mg ha^{-1}). Most varieties matured in 92 days. All varieties were free from Septoria or Spot Blotch incidence. BYDV infestation was low (1.6-2.6 on the scale of 0-9) and Rust incidence was negligible (0.1-0.7). Considering the grain yield, AAC Roskens, AAC Bullet and AAC Noranda could be recommended for cultivation on farms.

Paper prepared for presentation at the International Conference on Crop Sciences, University of Saskatchewan, SK, June 2020 that was cancelled due to COVID-19!

7. Extension and Outreach

7. Extension and Outreach

Lakehead University Agricultural Research Station (LUARS), Thunder Bay, apart from conducting on-station research was also actively involved in the following important Extension and Outreach activities, largely through its Director Dr. Tarlok Singh Sahota CCA:

7.1 Invitations/Honours:

- Dr. Sahota was invited as a Key Note Speaker at two International Conferences; (i) International Horticulture Conference, Punjab University Lahore, Pakistan, February 26-28, 2020, and (ii) International Conference on Smart Plantation an ultimate solution to Climate Change, Women College University, Lahore, Pakistan, March 2-4, 2020.
- Dr. Sahota was also invited to deliver International Seminars at the Departments of Botany in the University of Education, Lahore, Pakistan and GC University Lahore, Pakistan in the first week of March 2020.
- Dr. Sahota was invited for participation in presentations on "Balanced Fertilizer Application in Wheat" organized by Pakistan Agricultural Scientists Form (PAS) in collaboration with Pakistan Academy of Science, on zoom on September 12, 2020.
- Dr. Sahota was appointed Editor of the Journal Plantarum, Women College University Lahore, Pakistan.

7.2 Farm Advisory Services:

7.2.1 Contributions to the Northwest Link/TBFA Website and Ontario Farmer:

Dr. Tarlok Singh Sahota contributed the following articles to the Northwest Link-a newsletter of the TBSCIA Thunder Bay, and Ontario Farmer for the benefit of the farming community in Ontario in general and Northwestern Ontario in particular. The articles help farmers to get much needed advice on important aspects of crop production and nutrient management at pertinent times and make informed decisions.

Northwest Link/TBFA Website:

1. Sahota, Tarlok S. 2020. LUARS has some extremely good alfalfa varieties. http://tbfarminfo.org/luars-has-some-extremely-good-alfalfa-varieties/. June 27, 2020.
2. Sahota, Tarlok S. 2020. Post Seeding Tasks: June 4, 2020; https://tbfarminfo.org/post-seeding-tasks-dr-tarlok-singh-sahota-cca/ Was also published by CCA Ontario at: http://ccaontario.com/uploads/pdfs/PostSeedingTasks.pdf
3. Sahota, Tarlok S. 2020. Last Minute Tips: May 15, 2020; https://tbfarminfo.org/last-minute-tips-dr-tarlok-singh-sahota-cca/
4. Sahota, Tarlok S. 2020. Tips to get Maximum Economic Yields. April 6, 2020. http://tbfarminfo.org/tips-to-get-maximum-economic-yields-dr-tarlok-singh-sahota-cca/ (See also at http://ccaontario.com/uploads/pdfs/TipstogetMaximumEconomicYields.pdf).
5. Sahota, Tarlok S. 2020. It pays to use multiple sources of Nitrogen for crop production! March 26, 2020. https://tbfarminfo.org/it-pays-to-use-multiple-sources-of-nitrogen-for-crop-production/
6. Sahota, Tarlok S. 2020. LUARS 2020 – Research Results from Forage Experiments. Northwest Link March 2020, Pages 2-4.
7. Sahota, Tarlok S. 2020. LUARS Research 2019 – Results from the Fertilizer Experiments. February 20, 2020; https://tbfarminfo.org/luars-research-2019-results-from-the-fertilizer-experiments/

8. Sahota, Tarlok S. 2020. LUARS Research 2019 – High yielding crop varieties. January 19, 2020; https://tbfarminfo.org/luars-research-2019-high-yielding-crop-varieties/

Ontario Farmer/Others:

Apart from direct publications by Dr. Sahota in Ontario Farmer (through CCA Ontario Board), he was quoted in/or interviewed by Ontario Farmer, Thunder Bay Television and Chronicle Journal for the following articles/reports:

1. Sahota, Tarlok S. 2020. It pays to use multiple sources of nitrogen for crop production. Ontario Farmer, February 11, 2020, Page 17B*.
2. Sahota, Tarlok Singh. 2020. Tips to get Maximum Economic Yields. http://ccaontario.com/ontario-farmer-articles- (April 2020).
3. Peter Reschke. 2020. Crop production for max return. Ontario Farmer, April 21, 2020, Page B10.
4. Peter Reschke. 2020. Diamondback moth feeding damage in canola. Ontario Farmer, July 7, 2020, Page B3.
5. Peter Reschke. 2020. New alfalfa varieties put to test at Lakehead. Ontario Farmer, July 14, 2020, Page B3.
6. Jackie Clark. 2020. Lakehead welcomes farmers to research station. The Agricultural Research Station brings together researchers, students and farmers to optimize crop production in Thunder Bay. https://www.farms.com/ag-industry-news/lakehead-welcomes-farmers-to-research-station-507.aspx (July 234, 2020).
7. Jodi Lundmark. 2020. Research station keeps tour going. Chronicle Journal Thunder Bay, July 28, 2020, Pages A1 and A3. See also at: https://www.chroniclejournal.com/news/local/station-always-tries-something-new/article_2d7f99fc-d078-11ea-b389-a3d5fd275365.html
8. Peter Reschke. 2020. There are lots of reports of multi-cob corn plants this year. But have you ever seen with five? Ontario Farmer, August 4, 2020, Page B2.
9. Ontario Farmer. 2020. Northern wheat success. Ontario Farmer, August 25, 2020, Page A5.
10. Peter Reschke. 2020. Natural Control (of Grasshopper). Ontario Farmer, August 25, 2020, Page B3.
11. Peter Reschke. 2020. Thunder Bay-area spring wheat yields 2.4 tonnes per acre. Ontario Farmer, September 8, 2020, Page B5.

*Articles published through CCA Ontario Board!

7.2.2 Papers Presented at Scientific and Farmers' Conferences: Dr. Tarlok Singh Sahota made the following presentations in the local, regional, national and International conferences and meetings:

1. Sahota, Tarlok S. 2020. LUARS Research 2019 Highlights presentation made to the TBARA member farmers at Rosslyn Hall on February 20, 2020.
2. Sahota, Tarlok S. 2020. Environmentally Smart Nitrogen (ESN) – Potential for Improving Modern Crop Production and N-Use Efficiency. Paper presented at the International Horticulture Conference, Punjab University Lahore, Pakistan, February 26-28, 2020*.
3. Sahota, Tarlok S. 2020. Research on New Crops. Paper presented at the International Conference on Smart Plantation an ultimate solution to Climate Change, Women College University, Lahore, Pakistan, March 2-4, 2020*.

4. Amanda Diochon, Paul Hazlett, Steve Kinrade, Nancy Luckai, Dave Morris, Tarlok Singh Sahota, Lisa Venier, Martin Kwiaton, Alissa Ramsay, Robin Sevean, Magali Furlan Nehemy, Evalisa McIllfaterick, James Salter, Erin Wepruk. 2020. Amending soils with wood ash: Effects on soils and vegetation in long term trials. Presentation made to the Faculty of Natural Resources Management, Lakehead University, Thunder Bay, March 4, 2020.

**Invited Paper; See also Section 7.1!*

7.2.3: Other Important Conferences/Meetings/Programs attended by Dr. Tarlok S Sahota:

- Participated in CCA Annual Conference, January 15-16, 2020 at London, ON*.
- Participated in over 55 webinars*; (i) ASA Webinar Taking a 4R Approach when Applying Iron to Crops on January 23, 2020, (ii) Top Crop Manager webinar, Fungicide resistance management: Best practices in pome fruit, on February 6, 2020, (iii) ASA Webinar 'Policy and Science - Our Current Nitrogen Landscape' on February 12, 2020, (iv) ASA Webinar Seeking Net Neutral: *Energy Efficiency in the U.S. Rice Industry on February 18, 2020, (v) Top Crop Manager webi*nar Optimizing Spring Nitrogen Application on February 20, 2020, (vi) Top Crop Manager webinar Pre-seed tank mixing for yield & weed resistance management on March 11, 2020, (vii) ASA Webinar Phosphorus and Agriculture: Optimizing Production and Minimizing Environmental Issues on March 19, 2020, (viii) ASA Webinar Lessons Learned from Technology Adoption: Moving into the Digital Age of Farming on March 24, 2020, (ix) Top Crop Manager webinar Managing waterhemp, Canada fleabane and kochia in corn and soybeans on March 25, 2020, (x) ASA Webinar Strip Tillage: Research Lessons on How to Make a Good System Even Better on April 8, 2020, (xi) Top Crop Manager webinar What to consider when looking at cover crops? on April 8, 2020, (xii) ASA Webinar U.S. Rice: Sustaining Communities and Looking to the Future on April 9, 2020, (xiii) Timac Agro Canada Webinar Phosphorus and Top-Phos on April 9, 2020, (xiv) Timac Agro Canada webinar on Biostimulants on April 23, 2020, (xvi) Scouting potato diseases by Eugene Banks on May 21, 2020, (xvii) Scouting potato insects by Eugene Banks, (xviii) Physiological Disorders and Injuries in potato by Eugene Banks on May 28, 2020, (xix) Research Round Table Webinar organized by Dr. Andrew Dean on May 29, 2020, (xxx) Developing insights of Variable Rate Nitrogen by Aaron Breimer on June 4, 2020, (xxxi) Tissue Testing Made Easy by the Canadian Fertilizer Institute (CFI) on June 18, 2020, (xxxii) Ontario Hoppenings Lunch and Learn, a webinar on hops on June 29, 2020, (xxxiii) New Frontiers in Research Fund (NFRF) Exploration NOI, July 7, 2020, (xxxiv) Is fungicide a smart investment or a foolish money pit? On July 9, 2020, (xxxv) Cover Crops on July 13, 2020, (xxxvi) Measures of Soil Water Cycling on July 21, 2020, (xxxvii) Using Data to Identify Where to Take Tissue Samples for Micronutrient Crop Needs on August 5, 2020, (xxxviii) ASA Webinar The Future of Foliar Disease Identification, Quantification, and Impact Determination on August 11, 2020, (xxxix) SSSA Webinar "Measures of Soil Carbon Cycling and Storage" on August 13, 2020, (xxxx) 4Rs and Conservation Practices - Opening Carbon Credit Markets, (xxxxi) Is there enough time to use the data collected in 2020 for variable rate applications in 2020?, August 26, 2020, (xxxxii) How can placement of nitrogen fertilizer impact productivity, profitability, and sustainability? on August 28, 2020, (xxxxiii) Deveron Webinar "Powerful Wheat Insights from 2020" on September 10, 2020, (xxxxiv and xxxxv) Capturing the variability of your field fertility and "Measures

of Soil Nitrogen Cycling"; both on September 17, 2020, (xxxxvi) Optimum Strip-till Placement: Soil, Nutrient, and Crop Considerations on September 22, 2020, (xxxxvii) Find out how to make the most of your manure, on September 23, 2020, (xxxxviii) How can placement of nitrogen fertilizer impact productivity, profitability, and sustainability?, (xxxxix) Evaluating 2020 in-field testing data on October 2, 2020, (xxxxx) Fertilizer and the Farm on October 13, 2020, (xxxxxi) CityAge webinar Connected Farms on October 15, 2020, (xxxxxii) Liquid manure distribution and application uniformity: Getting the most from your manure on October 21, 2020, (xxxxxiii) Practical Measures of the Soil Microbiome: How do Crop Advisors Use the Data?" on November 17. 2021, (xxxxxiv) The Forgotten R in 4R Nutrient Management on November 19, 2020, (xxxxxv) Standard Measurements for Soil Health on December 8, 2020, and (xxxxxvi) Active Carbon and Soil Protein: New Frontiers for Monitoring Soil Health and Quality on December 17, 2020.

Participated in several meetings:

- Met Brian McLaren and Jannat Chauhan (Master's student Faculty of NRM) on January 10, 2020 to discuss about Chauhan's Master's research.
- Had a meeting with two Master's students Keshav Menon and Anmol Rana along with Brian McLaren and Don Henne on January 13, 2020 to discuss about students' Master's research.
- Met Gert Brekveld to provide farm advisory services to him on January 27, 2020.
- Met Jannat Chauhan Master's student on February 5, 2020 for discussion on her proposed Master's research.
- Attended a presentation, An Embarrassment of Riches: We now have better topography for the ice on Earth than the land, by Paul Morin, Director, Polar Geospatial Center, University of Minnesota, St. Paul on February 10, 2020.
- Met Karen Davies, Secretary TBARA on February 13, 2020 to discuss relationship between LUARS and TBARA and TBARA's expectations from LUARS.
- Met Fred Breukelman to provide farm advisory services to him on March 13, 2020.
- Met Thunder Bay Co-op staff (Darren Fisk, Christina Mol and Jason Buitenhuis) to know about the ongoing seeds/and fertilizer sales.
- Participated in several Teleconferences with Adrian Unc and Team for the NFRF Project - Northern food-security through integrated boreal and arctic agricultural research during May to July 2020.
- Participated in OMAFRA's Northern Ontario Agribusiness Breakfast Meetings (over zoom) by Christine O'Reilly on May 20, June 3 and June 17, 2020.
- Zoom meeting with Muditha Heenkenda, Department of Geography, Lakehead University on Remote Sensing on May 28, 2020.
- CCA Research and Innovation Committee Teleconference on June 5, 2020.
- I was interviewed by Kristy Tasala TBDHU on climate change (June 16, 2020).
- Participated in virtual CSA Annual General Meeting via zoom on June 22, 2020.
- I was interviewed by the media on LUARS Summer Tour in small groups; July 21 by Thunder Bay TV, Farms.Com on July 24 and Chronicle Journal on July 27, 2020.
- Participated in Thesis Defence of Amber Fredenburg on zoom on September 10, 2020; Fredenburg worked on "Diversity, phernology, and host association of wild bees (Hymenoptra:Anthophilla in Thunder Bay, Ontario)" at LUARS for her Master's Degree.

- Invited for and participated in presentations on "Balanced Fertilizer Application in Wheat" organized by Pakistan Agricultural Scientists Form (PAS) in collaboration with Pakistan Academy of Science, on zoom on September 12, 2020.
- Participated in CCA Research and Innovation Committee Meeting on September 28, 2020.
- Underwent Zoom Training with TSC Multimedia on September 30, 2020.
- Participated in EDI workshop on October 7, 2020.
- Participated in Annual General Meeting of the TBSCIA on December 8, 2020 via Zoom.

**Participation in these programs, meetings or events were meant for Networking and Professional Development!*

In addition, Dr. Sahota participated in numerous formal and informal meetings at Thunder Bay with member farmers and colleagues/researchers from other organizations.

7.2.4 Field Tours/Visits:

LUARS Annual Summer Tour: Annual Summer Tour at the Lakehead University Agricultural Research Station (LUARS), Thunder Bay, ON, has been an important yearly event as a means to demonstrate and disseminate innovative crop production and soil and nutrient management technologies to the area producers and participants from other organizations from within and outside Thunder Bay. Due to COVID-19, the tour this year was held in small groups from July 21 to August 6, 2020, was well appreciated despite thin attendance and was very well covered by the Media;

Thunder Bay Television, July 21:
https://www.youtube.com/watch?time_continue=833&v=41aUgYjL0W0&feature=emb_title.

Farms.Com (Jackie Clark), July 23: https://www.farms.com/ag-industry-news/lakehead-welcomes-farmers-to-research-station-507.aspx.

Chronicle Journal (Jodi Lundmark), July 27:
https://www.chroniclejournal.com/news/local/station-always-tries-something-new/article_2d7f99fc-d078-11ea-b389-a3d5fd275365.html.

Dr. Sahota, Director LUARS led the tours and showed the participants diverse research plots, including various trials on about two dozen crops such as canola (Clearfield, Liberty, Roundup and Truflex), alfalfa, sainfoin, trefoil, red clover, winter rye, peas, various varieties of wheat (winter and spring), feed and malting barley and oats, edible beans, soybean, flax, galega, Kernza, and lentils, plus many more crop varieties and different fertilizers (ammonium sulphate, urea, ESN, NK21, urea SuperU, and two new fertilizers - Top Phos and Apex) and new Biostimulants (FA starter, IRYS, FL Gold and Genea) experiments. The large acreage and beautiful sunny location proved, as always, an exceptional area to view the crops at and spend the mornings learning more about the field trials that our local research station has been working hard on in the past few months, especially when it is so relevant to our area growers. Following is a list of the participants; listed alphabetically by the first name:

- Allan Mol, Dairy Farmer and Past President OSCIA and TBARA
- Dr. Andrew Dean*
- Anmol Rana*

- Bill Meyers, Dairy Farmer
- Dr. Don Henne*
- Dr. Gautam Das*
- Howard Hancock, Farmer
- Karen Davies, Secretary TBARA
- Kelly Fettes*
- Martin Schep, Dairy Farmer
- Melissa Burton*
- Muditha Heenkenda*
- Peggy Brekveld, Dairy Farmer and Vice President OFA
- Taylor Gynane*
- Tom Loghrin, a Retired Farmer
- Trevor Pennings (a farmer from near London, Ontario)
- William (Bill) Maloney*

*Officials, Researchers or Staff from the Lakehead University, Thunder Bay.

The participants were amazed at the quantum and quality of work done at LUARS with only a few staff. The visitors were treated to some refreshments by LUARS.

Mid/Late Summer Tours: Dr. Sahota gave tour of LUARS research plots and to DeBruin Greenhouse to a group of First Nations from Mobert (400 km away from Thunder Bay) lead by Victoria (Vicky) Desmoulin on August 14, 2020:

- Victoria (Vicky) Desmoulin
- Randal Desmoulin
- Hannah Desmoulin
- Judie Desmoulin
- Chris Banish, and
- Eli Bananish

Fall Tours: Dr. Sahota gave tour of LUARS research plots in fall 2020 to:

- Dillon Brian Muldoon and his father Joe Dillon Muldoon who came from Lakefield, Ontario on September 22, 2020. Muldoons were impressed by the breadth and depth of ongoing research at LUARS!
- Thora Cartlidge Regional Manager Bioenterprise Corporation on October 2, 2020. Thora Cartlidge commented as follows after the tour: "Tarlok, thank you so much for the informative walking tour of the LUARS field plots last week. I learned much about the growing potential of new and familiar crops for this region. Experiencing the Research Station through your eyes was akin to visiting a city of diverse neigbhourhoods, block by block, each with its own characteristics!"
- Riley Verhelst, the new Director Terminal Operations Richardson International Limited Thunder Bay on October 20, 2020. Verhelst has replaced Gerry Heinrichs with whom LUARS has very good professional relations. Verhelst assured of continued support to LUARS.

Farm Calls and Visits: Dr. Tarlok Singh Sahota, as a part of the 'Farm Advisory Services' of the LUARS, attended to farmers' phone calls, called most of them (on phone) and made frequent visits to their fields, held one to one meetings with the area growers and helped them in selection

of high yielding crop varieties and planning for efficient crop, soil and nutrient management practices. In addition, Dr. Sahota wrote dozens of emails to the member farmers and compiled and shared Tech Info from LUARS with them on biweekly basis to keep them informed on the latest production technology, challenges, opportunities and developments in farming. *Dr. Sahota also attended to queries from other parts of the Province/and from other Provinces most of which were on Galega, a new perennial forage legume from Scandinavian countries, researched and introduced for cultivation on farms by TBARS/LUARS.*

7.2.5 Impact on farms:

LUARS, through its research, extension and outreach activities, have made a significant impact for the betterment of the agricultural industry particularly through 'Crop Diversification' and adoption of 'Beneficial Nutrient Management Practices'. Area farmers continued to diversify their cropping systems, adding new crops, clearing land and tile drainage. The impact of our Extension and Outreach activities could be seen in the form of favourable changes as follows:

- Thunder Bay Co-op brought in 88 MT of CDC Bow barley, some Maverick, a Truck load of Brandon, lots of different corn, 7 MT of Akras soybean, L252, L233P (most popular) and L255PC canola, a bit of alfalfa from General Seeds, a few 4010 peas and barley mix.
- Fritz Jaspers: Seeded 190 acres Brandon wheat (tested at LUARS), 100 acres corn under biodegradable plastic mulch, 210 acres canola (160 acres Liberty 233P and 50 acres Liberty 255PC), 90 acres Synasolis barley under seeded with alfalfa and timothy, and 40 acres soybeans (Akras and Elite). Fritz Jaspers created a new record by getting 2.4 MT grains and 90 small straw bales/acre from his 90 acre Brandon wheat field grown after canola. Wheat at LUARS was found to give higher yield after canola than after other crops! He had a record 1.7 MT/acre seed yield from a 53 acres canola field. His overall canola seed yield averaged at ~1.6 MT/acre. His silage corn (20 MT/acre) and soybean grain (1.23 MT/acre) yields too were good!
- Fred Breukelman seeded 170 acres canola and obtained 1.5 MT seed yield/acre. Fred Breukelman also grew Sorghum Sudangrass, tested at and recommended by LUARS in 40 acres.
- Ed Breukelman: Seeded 150 acres CDC Bow barley (out of which 50 acres under seeded with alfalfa and 40 acres after winter rye that had significant winter kill), 90 acres corn under biodegradable plastic mulch, and 50 acres of Liberty 233P canola. Ed Breukelman got ~2 MT/acre average grain yield from barley and 1.5 MT/acre from canola. Almost all area growers got at least 1.5 MT/acre seed yield from canola this year.
- Bernie Kamphof: Planted 205 acres of corn, 165 acres of Austenson barley and 60 acres of alfalfa – all for forage/feed.
- Evan Grootenboer: Applied wood ash in 121 acres, seeded Tabasco Fababeans in 16 acres.
- Mark Veurink: seeded 25 acres winter wheat, 150 acres corn, 100 acres AAC Penhold spring wheat, 95 acres canola and 140 acres barley 2 row. Mark Veurink created a new record by getting a very high grain (2.8 MT/acre) and straw (6 large scale bales/acre) yield from winter wheat. His barley and wheat grain yields were ~2 MT/acre and he got 1.5 MT/ha seed yield from canola.
- Gerrit Cramer seeded Bono hybrid winter rye (tested at LUARS) first time in 90 acres. He has applied ESN to winter rye in the seed row. He also seeded 300 acres under cover crop (a mixture of turnip, barley and peas) for the first time.

- Allan and Henry Mol seeded canola for the first time this year in 64 acres and recorded 90 MT seed production, which equaled ~1.5 MT/acre seed yield. Mols also seeded winter wheat (variety AAC Gateway recommended by LUARS) in 42 acres for the first time this year.
- Henry and Peter Aalbers seeded winter rye in 25 acres for the first time.
- Land clearing and tile drainage on farms continued!
- Farmers continued to use multiple sources of N (urea, ESN and ammonium sulphate) for crop production. Farmers have also started applying ESN in the seed row; a practice recommended by LUARS. One producer applied ESN in seed row in over 400 acres for spring wheat, canola, barley, and corn production! Research at LUARS has proved that use of multiple sources of N instead of a single source was conducive to high yields.
- Inspired by research at TBARS/LUARS dairy farmers around Calgary continued to expand their acreage under MasterGraze corn. TBARS pioneered in research on MasterGraze corn that produces 8 MT dry matter yield/ha in 80 days. Its feeding to dairy cows improved milk yield by 3l/cow/day and butter fat yield from 3.93 % to 4.40 %.
- Richardson International Limited procured 12,926 tonnes grains/seeds from local producers as at November 25, 2019 at a value of ~3.8 million dollars from Thunder Bay and Rainy River Districts. This is 4,126 tonnes more than that in 2019 and over 7,100 tonnes more than that in 2018. I believe at least one more Grain Elevator procured grains from the area as well (volumes not known). This is in addition to some malting barley procured by the Canada Malting Company from our area.

Thunder Bay remains the only place in Ontario, where Millhouse (hulless food) barley is grown!

Thunder Bay producers are continuing to renovate, expand/or make additions to their fields and dairy operations! At least one dairy farmer installed a super modern Robot Milk Barn!

7.4 Visitors to LUARS/Dr. Sahota's office:

Because of COVID-19 there were hardly any visitors to LUARS this year. We had only the following two visitors:

- Andrew Brekveld Dairy Farmer, and
- Harjit Dillon Past Technician TBARS

7.5 Networking:

Dr. Tarlok Singh Sahota, Director LUARS, continued to further expand and strengthen LUARS's network and shared an excellent rapport with the researchers/research organizations, ministry officials/specialists, funding agencies, private companies, etc. not only in the province of Ontario, but also in the other provinces of Canada and the USA. Part of this is done by participating in the conferences/meetings (this year mostly by Zoom) within the Province/country and out of country. One of the new contacts includes Adrian Unc, Memorial University of Newfoundland. LUARS is a part of the LOI (Integrated research to accelerate development of adapted Northern cropping systems) submitted by Adrian Unc for funding from "New Frontiers in Research Fund" in collaboration with 15 others from all over Canada and one from Finland (Maren Oelbermann, University of Waterloo, Kyle Bobiwash, University of Manitoba. Douglas Cattani, University of Manitoba, Joann Whalen, McGill University, Sina Adl, University of Saskatchewan, Atanu Sarkar, Memorial University of Newfoundland, Matthew Bakker, University of Manitoba, Sylvie Quideau, University of Alberta, Cynthia Kallenbach, McGill University, Pedro Madeira Antunes, Algoma University, Joshua Nasielski, University of Guelph

David Thompson, Sault Ste. Marie Innovation Centre, Ashlee Cunsolo, Memorial University of Newfoundland, Rachel Pugh, Yukon University, Nils Borchard, Natural Resources Institute Finland).

LUARS successfully completed a three year project on malting barley in collaboration with NOFIA and RAIN and further strengthened its relations with NOFIA and other northern agricultural research stations by submitting a LOI for a Pan Northern research project on sunflower (New Crop for Northern Ontario: Sunflower Yield and Management Trial). LUARS enjoyed good relations with RAIN and completed a three years project on 'Alternate Forage Legumes' jointly with RAIN and also got funding approval from CAP for a research project on Alfalfa row spacing and S in collaboration with RAIN/and other northern research stations.

LUARS was able to get seeds for all its experimental plots free of cost because of its good relations with the seed companies and the Plant Breeders in the universities and the AAFC (see also Acknowledgement!). Continued good relations with the industry led to ~$33,500.00 contribution this year from 4 organizations (GFO, Richardson International, Canada Malting Company, NWO Innovation Centre and Timac Agro). Thunder Bay Co-op not only donated $1,000.00 to LUARS but also agreed to store our pesticides over winter free of charge! Good relations with FedNor Thunder Bay helped get funding for a Research and Extension Intern at LUARS.

LUARS Annual Reports are highly appreciated by all researchers in North America/and by our colleagues in OMAFRA and OSCIA at 1 Stone Road Guelph and elsewhere! Sharing of LUARS Annual Reports is one of the excellent means for extension and outreach by LUARS. Often people are surprised to see so much output with so little manpower (see comments from a colleague in OMAFRA in the TBARS Annual Report 2016 and comments by Dr. Glenn Coulter, Calgary in TBARS Annual Report 2015).

7.6 Training of Students/Interns:

- Dr. Sahota was/is a co-guide or member of the advisory committee for some Lakehead University (LU) PhD (PaulGonzalo BenalcazarVergara from Ecuador) and MSc students (Anmol Rana and Jannat Chauhan) – all from the Faculty of Natural Resources Management.
- Dr. Sahota and Blaine Tomeck trained an Intern Dillon Brian Muldoon and the following MSc Students/Part Time Help Workers from LU in small plot field plot research:
    - Anmol Rana who also did her Master's Research at LUARS
    - Karan Karan
    - Parneet Kaur, and
    - Shyam Bechra

7.7 Media Attention/Coverage:

LUARS, because of its excellent ongoing research and extension activities continued to attract media attention during 2020 as well. The media personnel came to LUARS at a short notice. See media news reports in Section 7.2.4.

The media has always helped the research station to spread the good work done by it not only among the farming community, but also to the consumers and the general public at large. As a result, research station has always had a strong public support for continuity of its development oriented and economically rewarding research and extension activities!

8. Contact Information of Seed Companies

8. Contact Information of Seed Companies/Suppliers

Varieties	Companies/Suppliers	Contact information
Spring Wheat		
SY Obsidian, SY TORACH	Syngenta Canada Inc.	Box 104, Oakville, MB, Canada R0H 0Y0 Tel: (204) 871-5774
AAC Magnet, CDC Adamant, AAC Succeed, AAC Viewfield, AAC Russell VB, CDC Reign	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-1045, Fax: (877) 791-1046
Raven, Easton	C&M Seeds	6180 5th Line, Palmerston, ON, Canada N0G 2P0 Tel: (519) 343-2126, Email: esparry@redwheat.com
AAC Crossfield, AAC Connery, AAC W1876, CS Jake, CS Accelerate, CS Tracker, CDC Credence	Canterra Seeds	1475 Chebrier Blvd R&PD Suite 201, Winnipeg, MB, Canada R3T 1Y7. Tel: (204) 988-9760, Email: info@canterra.com
AAC Penhold, Minnedosa, AAC Tisdale, AAC Goodwin, AAC Starbuck, AAC Wheatland VB, AAC Alida, AAC Brandon, AAC Redstar	SeCan Association	400 – 300 Terry Fox Drive Kanata, ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
AAC Warman VB	SeCan Association	SeCan, Box 30, Elstow,SK S0K 1M0, Canada
Dakosta	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe, QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381, Email: Christian.Azar@sollio.ag Website: www.lacoop.coop
Prosper	Seed Depot Corp.	Box 208 Pilot Mound, MB Canada R0G 1P0. Tel: (204) 825-2000, Fax: (204) 825-2758
AAC Prevail VB	Alliance Seed Corporation	24th Floor, 333 Main Street, Winnipeg, Manitoba R3C 4E2. Tel: 1-877-270-2890, Email: info@allianceseed.com

Varieties	Companies/Suppliers	Contact information
Winter Wheat		
Gallus, JDC 78, Keldin	C & M Seeds	RR#3 6180 Line Minto 5 Palmerston, ON Canada N0G 2P0 Tel: (519) 343-2126, Fax: (519) 343-3792, Email:
AAC Goldrush, AAC Icefield	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-
CDC Falcon, Moats	SeCan Association	400 – 300 Terry Fox Drive Kanata, ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
AAC Gateway	Seed Depot Corp.	Box 208 Pilot Mound, MB Canada R0G 1P0 Tel: (204)
AAC Elevate, AAC Wildfire	Stamp Seeds	9 Center Street Box 3030 Enchant, AB Canada T0K0V0 Tel: (403) 739-2233, Fax: (403) 739-2167, Email:
CDC Buteo	Trawin Seeds	Box 267 Melfort, SK Canada S0E 1A0 Tel: (306) 752-
Spring Oat		
CDC Arborg	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-
Akina	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe, QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381, Email: Christian.Azar@sollio.ag, Website: www.lacoop.coop
AAC Bullet, AAC Roskens, AC Rigodon, Ore 3541M, Ore 3542M, CDC Skye, AAC Douglas	SeCan Association	400 – 300 Terry Fox Drive Kanata, ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
AAC Noranda	Semican Atlantic Inc.	366 Rang 10 Plessisville, QC Canada G6L 2Y2
Vitality	Synagri	5175 boulevard Laurier East Saint-Hyacinthe, QC Canada J2R 2B4 Tel: (450)799-3225, Fax: (450) 799-3229, Email:

Varieties	Companies/Suppliers	Contact information
Malting Barley		
AAC Synergy, AC Newdale, Bentley	Semican Inc.	366 10e Rang Plessisville, QC, Canada G6L 2Y2. Tel: (819) 362-8823, Fax: (819) 362-3385
AAC Connect	Semician Recherche	1290 116 RTE O Princeville, QC, Canada G6L 4K7. Tel: (819) 364-2001
CDC Fraser, CDC Copeland, CDC Kindersley, CDC Bow	SeCan Association	192038 GD TWP Rd. 572, Lamont, AB, Canada T0B 2R0. Tel: (780) 887-3639, Email: seed@secan.com
OAC 21	Cribit Seeds	265 Katherine St. S, West Montrose, ON, Canada N0B 2V0. Tel: (519) 664-3701, Email: seeds@cribit.com
Lowe, AB Brewnet	Alberta Agriculture and Forestry	Field Crop Development Centre 5030 - 50'th Street Lacombe, AB Canada T4L 1W8, Tel: (403) 782-4641
AAC Goldman	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe, QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381, Email: Christian.Azar@sollio.ag, Website: www.lacoop.coop
Two-Row Spring/Malting Barley		
AB Tofield, AB Wrangler, TR18647	AAFC Lacombe	6000C AND E TRAIL, Lacombe, AB T4L 1V7, Tel: (403) 782-8100
AAC Ling and AAC Bell	AAFC Ottawa	960 Carling Ave, Central Experimental Farm, Ottawa, ON K1A 0C6, Tel: (613) 759-1307, Email: raja.khanal@canada.ca
CDC Bow, CDC Churchill	SeCan Association	192038 GD TWP Rd. 572, Lamont, AB, Canada T0B 2R0 Tel: (780) 887-3639, Email: seed@secan.com
AAC Goldrush	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe, QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381, Email: Christian.Azar@sollio.ag, Website: www.lacoop.coop

Varieties	Companies/Suppliers	Contact information
Malting Barley		
Six-Row Spring Barley		
AAC Bloomfield, Alyssa, Boroe	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe, QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381, Email: Christian.Azar@sollio.ag, Website: www.lacoop.coop
Amberly	PRO Seeds	595570 Hwy 59 N PO Box 20039 Woodstock, ON Canada N4S 8X8 Tel: (519) 533-0370, Fax: (519) 533-0773, Email: info@proseeds.ca
Encore, AB Advantage	SeCan Association	400 – 300 Terry Fox Drive Kanata, ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
Chambly	Semences Prograin Inc.	145 Bas-de-la-rivière Nord Saint-Césaire, QC Canada J0L 1T0 Tel: (450) 469-5744, Fax: (450) 469-4547
Oceanik, Synasolis	Synagri	5175 boulevard Laurier East Saint-Hyacinthe, QC Canada J2R 2B4 Tel: (450)799-3225, Fax: (450) 799-3229, Email: synagri@synagri.ca
AB CATTELAC	Alliance Seeds	333 Main St 22nd Floor, Winnipeg, MB R3C 4E2, Tel: 877-270-2890
Winter Rye		
Bono, Brasseto	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-1045, Fax: (877) 791-1046, Email: ssingh@fpgenetics.ca
Guttino	Stamp Seeds	9 Center Street Box 3030 Enchant, AB Canada T0K0V0 Tel: (403) 739-2233, Fax: (403) 739-2167, Email: Office@stampseeds.com, Website: www.stampseeds.com
Hazlet	SeCan Association	400 – 300 Terry Fox Drive Kanata, ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com

Varieties	Companies/Suppliers	Contact information
Perennial Rye		
Ace-1	AAFC Lethbridge	5403 1st Avenue South Lethbridge, AB Canada T1J 4B1 Tel: (403) 327-4561, Email: AAFC.LethbridgeRDC@agr.gc.ca
Canola		
L234PC, L255PC, L230, L241C, L252, L345PC, L352C, LR344PC	BASF Agricultural Solutions	Site 600, Box 117 Saskatoon, SK, Canada S7K 3J9 Tel: (306) 477-9400, Email: kent.hall@agro.basf-se.com
BY 6204TF	BrettYoung	Box 99 St Norbert Postal Stn, Winnipeg, MB R3V 1L5, Tel: (204) 478-2240, Email: Rene.Mabon@brettyoung.ca
B3010M	Brevant™ Seeds	Call (800) 667 3852; Got the seed through Richardson International - see address in Our Collaborators
CS2300	Canterra Seeds	1475 Chebrier Blvd R&PD Suite 201, Winnipeg, MB,
PV 585GC	Nutrien Ag Solutions	3735 East Quance St. Regina, SK S4V 3A4. Tel: 1 (855) 569-9444
Spring Peas		
AAC Carver, AAC Comfort	Canterra Seeds	1475 Chebrier Blvd R&PD Suite 201, Winnipeg, MB, Canada R3T 1Y7. Tel: (204) 988-9760, Email: info@canterra.com
AAC Chrome, Sorrento, AAC Profit	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-1045, Fax: (877) 791-1046, Email: ssingh@fpgenetics.ca
Gold Harvest	Salt Spring Seeds	P.O. Box 444 Ganges Salt Spring Island, BC Canada V8K 2W1, Tel: (250) 537-5269
CDC Forest, CDC Spruce, CDC Spectrum, CDC Canary, CDC Lewochko	SeCan Association	400 – 300 Terry Fox Drive, Kanata ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com

Varieties	Companies/Suppliers	Contact information
Mustard		
AAC Brown 120	AAFC Saskatoon	107 Science Place Saskatoon, SK Canada S7N 0X2 Tel: (306) 385-9273
AC 200 (oriental)	Sundwall Seed	Farm, Govan, SK Canada S0G 1Z0 Tel: (306) 484-2010
AAC Adagio (yellow), AC Vulcan (oriental)	AAFC Saskatoon	107 Science Place Saskatoon, SK Canada S7N 0X2 Tel: (306) 385-9358
Flax		
Topaz	Alliance Seed Corporation	22nd Floor, 333 Main Street Winnipeg, MB Canada R3C 4E2 Tel: (204) 272-2892, Fax: (204) 272-2893, Email: jkarlowsky@allianceseed.com
ND Hammond	North Dakota Crop Improvement & Seed Association	1360 Albrecht Blvd, Fargo, ND 58102, United States.Tel: 701-231-8067
FP2566, FP2567, FP2573, FP2589, FP2590, FP2591, FP2592, FP2593, FP2594, FP2595	FP Genetics Inc.	426 McDonald Street Regina, SK S4N 6E1 Tel: (877) 791-1045, Fax: (877) 791-1046, Email: ssingh@fpgenetics.ca
CDC Glas, AAC Bright, CDC Rowland, AAC Prairie Sunshine, CDC Bethune, CDC Buryu	SeCan Association	400 – 300 Terry Fox Drive, Kanata ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
CDC Dorado, CDC Marvelous,	Stamp Seeds	9 Center Street Box 3030 Enchant, AB Canada T0K0V0 Tel: (403) 739-2233, Fax: (403) 739-2167, Email: Office@stampseeds.com, Website: www.stampseeds.com
Lentils		
CDC Rosetown	Thompsons Limited	2 Hyland Drive, Blenheim, ON, Canada N0P 1A0. Tel: (403) 327-4561, Fax: (519) 676-3185
CDC Impulse CL, CDC Lima	SeCan Association	400 – 300 Terry Fox Drive, Kanata ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com

Varieties	Companies/Suppliers	Contact information
Edible Beans		
AAC Expedition	AAFC Lethbridge	5403 1st Avenue South, Lethbridge, AB, Canada T1J 4B1. Tel: (403) 327-4561
AAC Scotty	AAFC Morden	101 Route 100, Morden, MB, Canada R6M 1Y5. Tel: (204) 822-7556
AAC Argosy, AAC Nautica, AAC Shock	Hensall District Co-operative	1 Davidson Drive, P.O. Box 219, Hensall, ON, Canada N0M 1X0 Tel: (519) 262-3002, Fax: (519) 262, 2317
Earlired	University of Guelph, Parent Seed Farm Ltd.	Department of Plant Agriculture Crop Science Building Guelph, ON Canada N1G 2W1 Box 36 St. Joseph Manitoba, ON Canada R0G 2C0 Tel: (204) 737-2625, Fax: (204) 737-2248
AAC Whitehorse, AAC Whitestar, AAC Y012, AAC Y015	Viterra Inc.	Viterra Inc. 74041 Highway 845 Lethbridge, AB T1K 8G9 Tel: (403) 317-1746, Email: lethbridge@viterra.com

Varieties	Companies/Suppliers	Contact information
Soybeans		
S006-M4X, S0009-M2, S006-W5, S003-Z4X, S007-Y4	Syngenta Canada Inc.	Box 104, Oakville, MB, Canada R0H 0Y0 Tel: (204) 871-5774
LASSA R2X, Vidar R2X, Karpo R2	BrettYoung	51134 Hwy 330, Winnipeg, MB, Canada R3V 1L5. Tel: (240) 261-7932
NSC Redvers RR2X, NSC Sperling RR2X, NSC Newton RR2X, NSC Greenridge RR2Y, NSC Starbuck, NSC Tilston RR2Y, NSC Watson RR2Y, NSC Redvers RR2X, NSC Culross RR2X	NorthStar Genetics	3493 Pembina Hwy, Winnipeg, MB R3V 1A4 Tel: (204) 262-2425, Email: contact@northstargenetics.com
Lono R2, Mani R2X, Amirani R2, Renuka R2X, Akras	BrettYoung	Box 99 St Norbert Postal Stn, Winnipeg, MB Canada R3V 1L5 Tel: (800) 665-5015
PekkoR2, PodagoR2	Elite Seeds (La Coop Fédérée)	19235 Avenue St-Louis Saint-Hyacinthe , QC Canada J2T 5J4 Tel: (450) 799-2326, Fax: (450) 773-3381 Website: www.lacoop.coop
Bourke R2X, Mahony R2,	SeCan Association	400 – 300 Terry Fox Drive, Kanata ON Canada K2K 0E3 Tel: (613) 592-8600, Fax: (613) 592-9497, Email: seed@secan.com
PV16 S004 RR2X, PV15 S0009 RR2X	Nutrien Ag Solutions	3735 East Quance St. Regina, SK S4V 3A4. Tel: 1 (855) 569-9444

Note: For older varieties, see past LUARS Annual Reports or visit www.GoForages.ca or visit www.inspection.gc.ca/plants/variety-registration/eng/1299175847046/1299175906353

9. Acknowledgements by the Research Team

9. Acknowledgements by the Research Team

On behalf of Blaine Tomeck, Dillon Brian Muldoon and myself, I would like to take this opportunity to thank all our collaborators and:

1. Dr. Andrew Dean Vice President Research and Innovation for his support for smooth functioning of LUARS; which wouldn't be possible without funding in part by OMAFRA through an agreement with the ARIO.
2. Members of TBARA Thunder Bay for putting faith in the Research Team at LUARS.
3. FedNor for funding Research and Extension Intern position at LUARS
4. A & L Lab, Canada Malting Company and all others for their in kind contributions.
5. All farmers who spared time for me to visit their fields alone/or with others and for sharing information on farm operations, crop varieties/practices and yields.
6. All organizations that funded research projects/trials at LUARS; see Our Collaborators.
7. All visitors to LUARS from within and outside Thunder Bay who showed interest in our work.
8. Andrew Brekveld for providing alfalfa seed free of cost and for dropping lentil harvest samples at LUARS.
9. Henry Aalbers for contributing corn seed free of cost.
10. Gert Brekveld for on farm cultivation of lentils.
11. Karen Maa and Margot Ross for sending invoices to our collaborators and Human Resources LU for staff payments on time.
12. Chronicle Journal Thunder Bay, Thunder Bay TV, Ontario Farmer, Northwest Link and TBFA for coverage of LUARS research and development activities.
13. Physical Plant LU for opening and winterizing LUARS and for some repairs at LUARS.
14. NOFIA and RAIN for working on joint research proposals on malting barley and Galega/Alternate Forages.
15. Thunder Bay Co-op for donating $1,000.00 for research at LUARS.
16. Dr. Ulf Runesson for sparing 2 MSc students to complete part of their Summer Intern Term at LUARS this year and the students (Karan Karan and Parneet Kaur).
17. Anmol Rana and Shyam Bechra for working as Part Time Help at LUARS from September to November, 2020; without whom it wouldn't be possible to complete the Annual Report.
18. Various seed suppliers for supply of cost free seeds; as listed in Contact Information of Seed Companies/Suppliers part of this report. Trent Whiting (SeCan), Ellen Sparry (C&M Seeds), Natalie Campbel (BASF), Marc Brown (Syngenta), Surjit Bawa (Canterra Seeds), Jodee Karlowsky (Alliance Seeds), Cynthia Deitz (Nutrien) and some AAFC and Field Crop Development Centre Lacombe Scientists (Raja Khanal, Robert Graf and Patricia Juskiw) deserve special mention.
19. And, above all to the Omnipresent/Omnipotent Lord who helped us to successfully complete another year of Development Oriented Research. I bow to you 'O Lord!

I would like to place on record my appreciation for Blaine Tomeck for his consistent hard/and dedicated work and Dillon Brian Muldoon for his hard work and dedication.

Dr. Tarlok Singh Sahota CCA

10. Abbreviations used in Annual Report

10. Abbreviations used in the LUARS Annual Report 2020

AAFC: Agriculture and Agri-Food Canada
ASA: American Society of Agronomy
ARIO: Agricultural Research Institute of Ontario
CAP: Canadian Agricultural Partnership
CCA: Certified Crop Advisor
CEC: Cation Exchange Capacity
CHU: Corn/Cumulative Heat Units
CSA: Canadian Society of Agronomy
EDI: The Economic Development and Innovation office, LU
ESN: Environmentally Smart Nitrogen (Brand name for polymer coated urea)
FHB: Fusarium Head Blight
GDD: Growing Degree Days
GFO: Grain Farmers of Ontario
LOI: Letter of Intent
LU: Lakehead University
LUARS: Lakehead University Agricultural Research Station
MOU: Memorandum of Understanding
MT: Metric Tonne
NFRF: New Frontiers in Research Fund
NRM: Natural Resources Management
NOFIA: Northern Ontario Farm Innovation Alliance
NWO: Northwestern Ontario
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
OSCIA: Ontario Soil and Crop Improvement Association
RAIN: Rural Agri-Innovation Network
TBARA: Thunder Bay Agricultural Research Association
TBARS: Thunder Bay Agricultural Research Station
TBDHU: Thunder Bay District Health Unit
TBFA: Thunder Bay Federation of Agriculture
TBSCIA: Thunder Bay Soil and Crop Improvement Association
TbTv: Thunder Bay Television
TSC: Technology Services Centre

L to R: Two LU MSc Students/Part Time Workers — Anmol Rana and Shyam Hasmukh Bechra and Dillon Brian Muldoon Intern LUARS; without whom it would not be possible to complete LUARS Annual Report 2020!

Proud Sponsor of LUARS Annual Report 2020!