2. Summary of Research Results 2019

√2.1 Thunder Bay Weather Analysis (2003-2018):

- Thunder Bay weather has not been consistent.
- The number of rainy days/year varied widely from 35 to 104, the total seasonal rainfall varied from 285 mm to 498 mm/year.
- Rainfall of 350-400 mm seemed to be optimum for wheat (variety Sable) grain yield.
- At times, day temperature has been above 29℃ and night temperature exceeded 16℃. Such temperatures result in flower abscission and drying of young pods in canola.
- The number of days with temperature ≥ 10℃ appeared to decline over time (2003-2018) with some exceptions. However, it seems that August has become hotter since 2006.
- Risk of frost in June and killing frost in the first ten days of September couldn't be ruled out.
- The CHU ranged from 1,204 in 2004 to 2,239 in 2016 (average over 2013-2018: 1900).
- The GDD ranged from 994 in 2004 to 1441 in 2006; with an average value of 1220.
- It seems that CHU and GDD didn't matter much for crop production in Thunder Bay.
- Of late, there have been two main concerns; (i) cold and wet springs delaying seeding and (ii) wet falls, challenging harvesting.
- However, despite these odds and with our short growing season at Thunder Bay, we have been able to successfully raise crops without any crop failure in any of the years!

2.2 Screening of crop varieties:

2.2.1 Spring Cereals:

√*Wheat Varieties:*

- Twenty four varieties were evaluated; 16 of which were CWRS (mostly new).
- Highest grain yield (6.44 MT/ha) was obtained with *AAC Wheatland*. The next best two varieties in grain yield were *AAC Crossfield* (5.99 MT/ha) and *Prosper* (5.98 MT/ha).
- Grain yield from *AAC Penhold* (CPSR; year 2016's highest yielding variety), cultivated on farms in Thunder Bay, was only 4.59 MT/ha. It's time to replace *AAC Penhold* with other high yielding varieties!
- Highest straw (7.24 MT/ha) and biomass (12.62 MT/ha) yields were obtained with *AAC Warman* that gave 5.39 MT/ha grain yield.
- Grain protein content in the high yielding varieties was; *AAC Viewfield* 19.1 %, *AAC Wheatland* 17.8 %, *AAC Goodwin* and *AAC Crossfield* 16.9 %, *Prosper* 16.6 % and *AAC Penhold* 16.1 %.

√*Barley Varieties:*

- Ten high yielding barley varieties (2 two row and 8 six row) were compared for their production potential.
- Order of grain yield in the three top yielding varieties was *Boroe* (7.65 MT/ha) = *Synasolis* (7.64 MT/ha) ≥ *Oceanik* (7.30 MT/ha).
- Among the 2 row varieties, *AAC Goldman* (6.78 MT/ha) recorded higher grain yield than *CDC Bow* (5.40 MT/ha).
- *Encore* with a grain yield of 6.55 MT/ha), produced the highest straw (7.66 MT/ha) and biomass (14.20 MT/ha) yields.

√*Malting Barley Varieties:*

- Eleven varieties were evaluated. *AAC Goldman* was the new variety added this year.
- Three top grain yielding (6.00 MT/ha) varieties were *Lowe*, *CDC Copeland* and *AAC Connect*. *CDC Bow* that has been producing the highest grain yield in the past lagged behind in grain yield (4.80 MT/ha) this year. It seems that late seeding didn't suit *CDC Bow* and it didn't like the heat during July-August this year. *OAC 21* had the lowest grain yield (2.71 MT/ha).
- Grain yield of other varieties ranged from 5.34 MT/ha (*Bentley*) to 5.95 MT/ha in *CDC Kindersley*.

- Averaged over 2017-'19, *CDC Bow* produced the highest grain (6.54 MT/ha), straw (9.51 MT/ha) and biomass (16.05 MT/ha) yields. And, two second best varieties in grain yield were *CDC Kindersley* (6.03 MT/ha) and *AAC Synergy* (5.92 MT/ha).
- *Lowe* recorded the highest straw yield (8.37 MT/ha) followed by *AAC Goldman* (7.67 MT/ha) and *AAC connect* (7.22 MT/ha).
- Biomass yield was in the order of *Lowe* (14.40 MT/ha) ≥ *Bentley* (13.26 MT/ha) ≥ *AAC Connect* (13.21 MT/ha).
- Malting quality parameters tested last year indicated an excellent quality! Grain protein content was within limits for all varieties except OAC 21 (14.1 %) and Newdale (13.7 %). Plumpness of grains was acceptable; above 90 % in all varieties except OAC 21 and Newdale (> 80 %, which is acceptable!). Chitted seeds from 0-0.5, and wheat seeds, wild oats seeds, green seeds and Ergot were zero in almost all varieties (except OAC with high 40 score). There was hardly any dockage or stained seeds.
- 2019 results revealed that *OAC21* had the highest grain protein content (15.1 %). Two out of other varieties tested for grain protein content had higher than 13 % protein (*Copeland* 13.4 % and *AAC Goldman* 13.8 %). Grain protein in other varieties ranged from 12.1 to 12.5 %.

√*Oat Varieties:*

- Nine oat varieties were evaluated for their yield potential.
- *AC Rigodon* (6.04 MT/ha) and *CDC Arborg* (5.96 MT/ha) produced the highest grain yield.
- Grain yield from the two new milling oat varieties *Ore 3541M* and *Ore 3542M* was 4.74 and 4.86 MT/ha, respectively.
- *AAC Bullet* registered the highest straw yield (7.00 MT/ha).
- Biomass yield (≥ 11.8 MT/ha) was highest with *AC Rigodon*, *CDC Arborg*, and *AAC Bullet*.

2.2.2 Winter Cereals:

√*Winter Wheat Varieties (seeded on September 5, 2018):*

- 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.
- *Keldin* (8.18 MT/ha), *Gallus* (7.67 MT/ha) and *AAC Gateway* (6.66 MT/ha) were the three highest grain yielding varieties.
- *CDC Buteo* recorded the highest straw yield (10.84 MT/ha), followed by *AAC Wildlife* (9.57 MT/ha) and *Keldin* (9.09 MT/ha).
- *Keldin* (17.26 MT/ha) and *Gallus* (16.62 MT/ha) had the highest Biomass yields. These two varieties had a total winter kill in the previous year.
- However, the grain, straw and biomass yield differences between the varieties was not statistically significant.
- *JDC 78* was the most dwarf (85 cm tall) and *Swainson* the tallest variety (114 cm). *AAC Gateway* with a height of 96 cm was a medium variety

√*Late seeded Winter Wheat Varieties (seeded on September 12, 2018):*

- Out of the three varieties (*JDC 78, Lexington and CDC Falcon*), *JDC 78* produced the highest grain (7.05 MT/ha) and biomass yield (14.55 MT/ha), and *Lexington* the highest straw yield (7.48 MT/ha). The yield differences were not significant though.
- *JDC 78* was the most dwarf (86 cm tall) and *Lexington* the tallest variety (99 cm).

2.2.3 Grain Legumes and Oil Seeds Varieties:

√*Soybean Varieties:*

- Twenty one varieties were compared for their grain production potential.
- *Lono R2* like last year gave the highest gain yield (2.12 MT/ha) though the yield this year was much less than that in the last year (4.54 MT/ha); most likely because we were late to seed this year (on

June 3). Other four varieties which gave equally good grain yield (1.99 to 2.11 MT/ha) to *Lono R2* were *NSC Tilston RR2Y*, *PV16 S004 RR2X*, *S006 - M4X* and *NSC Sperling RR2X*.

- Grain yield in other varieties ranged from 0.90 MT/ha (*S0009 - M2*) to 1.94 MT/ha (*S006 - W5*/and *NSC Greenridge RR2Y*).

√*Edible Bean Varieties:*

- Ten edible bean varieties from different classes and of different colours (mostly new) were evaluated for grain yield.
- *AAC Shock – Navy beans* (2.62 MT/ha), *AAC Scotty – Cranberry beans* (2.61 MT/ha), *AAC Argosy – Navy beans* (2.57 MT/ha) and *AAC Whitestar – Great Northern* (2.53 MT/ha) gave better grain yield than all other varieties (1.54-2.39 MT/ha).
- *Earlired* that gave 2.9 MT/ha grain yield last year and had been on top in edible bean variety yields in the past several years produced 2.39 MT/ha grain yield this year. Overall the edible beans grain yield this year was less than that in the previous years.

Edible beans if they fetch a good price in the market could be an integral part of the cropping systems in northwestern Ontario!

√*Pea Varieties:*

- Nine field pea varieties (5 yellow, 3 green and 1 brown/specialty pea) were evaluated.
- Seed set was extremely poor (probably due to excessive heat in July-August); therefore only biomass yield was recorded.
- *CDC Canary* produced the highest biomass yield (5.50 MT/ha), followed by *CDC Spruce* (4.84 MT/ha) and *CDC Forest* (4.41 MT/ha).
- Last year too, there was hardly any seed set in field peas, which seem to be more sensitive to excessive heat than even canola.

√*Lentil varieties:*

- Three lentil varieties (two yellow and one green) were evaluated.
- Grain yield was in the order of *CDC Impulse CL* (green; 3.66 MT/ha) ≥ *Lima* (3.55 MT/ha) > *CDC Rosetown* (2.52 MT/ha). All varieties matured in 116 days.
- Straw yield depicted a trend similar to the grain yield and was 5.65 MT/ha in *CDC Impulse CL*, 4.85 MT/ha in *Lima* and 4.70 in *Rosetown*.

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

- Twenty varieties/biotypes (10 varieties and 10 biotypes) were compared.
- Deer ate the flax (we were caught unaware because this never happened before) and hence the seed yield was very low; ranging from 0.72 to 1.46 MT/ha. We failed to get the realistic seed yield.
- Flax is a relatively low input crop and could be added to diversify the existing cropping systems!

√*Liberty Canola Varieties:*

- Five varieties were evaluated.
- *L252* recorded the highest seed (5.74 MT/ha), straw (7.72 MT/ha) and biomass (13.46 MT/ha) yields. Seed yield from other varieties ranged from 4.12 MT/ha in *L234PC* to 4.86 MT/ha in *L230*. Seed yield from *L241C*, last year's top yielding variety, was 4.81 MT/ha.
- Seed yield this year was lower than that during the previous years, likely due to excessive heat at flowering (July-August).
- *P stands for 'Shatter Reduction' and C for Club Root resistance.*

√*Other Canola Varieties (seeded late on June 7, 2019):*

- Three varieties were compared; one each from Roundup, Clearfield and Liberty category.
- Seed yield was in the order of *L241C* (4.04 Mt/ha) ≥ *PV 585 GC* (3.96 MT/ha) > *2028 CL* (2.79 MT/ha). Seed yields were low because of late seeding.
- Straw yield followed a similar trend to the seed yield; *L241C* (8.41MT/ha) = *PV 585 GC* (8.46 MT/ha) > *2028 CL* (5.55 MT/ha).
- Harvest index (33-34 %) was the same in all varieties.

√*Mustard Varieties:*

- *AC 200* (Oriental mustard; 2.33 MT/ha) and *AC Vulcan* - Oriental mustard (2.15 MT/ha) produced higher seed yield than other varieties (*AAC Brown 120*; 1.65 MT/ha and *Adagio*; 1.41 MT/ha).
- Straw and biomass yields followed more or less a similar tend to the seed yield with Adagio recording the highest straw yield (4.81 MT/ha) and *AC 200* recording the highest biomass yield (6.98 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!

2.2.4 Forage Crops/Varieties:

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

- Dry matter yields from Galega seeded in 2011 @ 25, 35 or 45 kg seed/ha and alfalfa seeded @ 13 kg/ha were similar this year. However, averaged over 2012-2019, Galega seeded @ 35 kg/ha produced significantly higher dry matter yield (5,523 kg/ha) than alfalfa (4,660 kg/ha).
- Protein content in Galega seeded @ 35 kg/ha was 1.7 % point higher in the first cut and 4.5 % point higher in the second cut as compared to alfalfa seeded @ 13 kg/ha.
- Protein content in Galega @ 35 kg/ha, averaged over 2016 to 2019, was 1.3 % point higher in the first and 2.2 % point higher in the second cut than that in alfalfa.
- Galega had lower mineral content (K, Ca, Mg, Cu, Zn, Mn and Na) than alfalfa in the first cut (averaged over 2016 to 2019). In the second cut, Mg, Cu, and Mn were higher in Galega than in alfalfa. Galega contained higher amounts of iron (Fe) than alfalfa in both the cuts.
- *Higher yield and higher protein content in Galega than in alfalfa, could make Galega a better fodder than alfalfa!*

√*New Annual Forage Crops:*

- Ten annual forage crops (some at different seed rates) were compared for their production potential. Belle Red Clover, Frosty Berseem (@ 13 kg seed/ha), Fixation Balansa, Italian ryegrass, Choice Chicory and Tonic Plantain had very poor growth and were not worth harvesting.
- *Forage peas* produced the highest dry matter yield (5,079 kg/ha). *Union Ultimate Blend* (30 % Hairy Vetch, 25 % Italian Ryegrass, 15 % Sorghum, 10 % Crimson Clover, 10 % Winfred, 5% Hunter, and 5% Graza) + *CDC Coalition* gave the second highest dry matter yield (4,842 kg/ha).
- Dry matter yield from *Berseem*, *Frosty Berseem* (at 16 kg/ha) and *All Brassica Blend* (alone or in mixture with Berseem) was very poor and ranged from 644 to 1,365 kg/ha.
- *Frosty Berseem*, *All Brassica Blend alone* @ 4kg seed/ha or in mixture with *Berseem* had higher protein content (21.1-22.5 %) than *Berseem* (19.7/8), Forage Peas (14.4 %) and *Union Ultimate Blend + CDC Coalition* (9.9 %).
- Highest RFV (163) was obtained with *All Brassica Blend* @ 2 kg seed/ha + *Berseem* @ 13 kg seed/ha. In other forages, RFV ranged from 114 (*Union Ultimate Blend + CDC Coalition*) to 144 (Frosty Berseem @ 16.25 kg seed/ha).

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

- Optimum seed rate of *Kernza* appeared to be 90 seeds/m^2. At this rate, it produced 3,141 kg/ha dry matter yield, which equaled dry matter yield from *Kernza* at other populations (70, 110 1nd 130 seeds/m^2) as also with *alfalfa + Ace 1* (*Perennial Rye*) 80:20 mixture. However, *Ace 1* did not survive beyond winter 2018-2019 and *alfalfa + Ace 1* was virtually alfalfa alone.
- *Alfalfa* + *Kernza* (80:20 mixture) recorded the highest dry matter yield (4,259 kg/ha).
- In the first cut, protein content was higher in *alfalfa + Kernza/or Ace 1* (80:20) mixtures (16.6 %) than *Kernza* at varying populations (70-130 seeds/m^2) by 2.6-3.2 % points. In the second cut, the protein content in *Kernza* ranged from 11 % (130 seeds/m^2) to 13.9 % (70 seeds/m^2); Protein

content was 3.2-6.1 % point higher with *alfalfa + Kernza* (80:20 mixture; 17.1 % protein) than *Kernza* alone (13.3-14.1 %).

- RFV was higher in both the cuts with *alfalfa + Kernza* (80:20 mixture) than with Kernza alone.

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

- Dry matter yield from the two cuts ranged from 662 kg/ha (*Sainfoin* variety *Glenview*) to 4,486 kg/ha (RR Alfalfa variety *Mission HVXRR*).
- Though 135 alfalfa had the lowest dry matter yield (4,030 kg/ha), it was statistically at par with all other alfalfa varieties including *Mission HVXRR*. In other words the dry matter yield differences between alfalfa varieties were not significant!
- *Perennial Rye* (*Ace 1*) couldn't sustain itself to the second cut and had a low dry matter yield (1,459 kg/ha). Dry matter yield from *Chicory* (1,042 kg/ha) and *Sainfoin* (*Glenview* 662 kg/ha; *Mountainview* 1,104 kg/ha) were lower than even that of *Perennial Rye*.
- Dry matter yield from *Kernza* (4,328 kg/ha) equaled alfalfa yield(s).
- Protein content in the first cut ranged from 20.5 % (*135*) to 21.9 % in alfalfa (*WL354HQ*), 20.9 % in *Chicory*, 16.9-18 % in *Sainfoin*, 16.4 % in *Perennial Rye* (*Ace 1*) and 13.5 % in *Kernza*.
- RFV was highest (142) in *Sainfoin* (*Glenview*) and *Chicory*! It ranged from 112 (*135*) to 129 (*WL319HQ*) in other forage types.

Considering the dry matter yield, protein content and RFV, RR Alfalfa could be recommended for cultivation on farms!

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

2.3.1 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).
- Grain yield continued to increase with both urea and urea + ESN up to 105 kg/ha (with each increment of N from zero to 105 kg/ha) though the increase with each increment of N was more with urea + ESN than with urea alone.
- Grain yields from urea and urea + ESN (3:1 on N basis) @ 105 kg N/ha, without S, were 5.38 MT/ha and 6.48 MT/ha, respectively (1.08 MT/ha higher grain yield with urea + ESN than with urea alone).
- Urea + ESN (3:1 on N basis) @ 105 kg N/ha, without S, produced the highest straw (8.18 MT/ha) and biomass (14.66 Mt/ha) yields.
- Malting barley didn't respond to S application; available S at seeding was 9 ppm (= 36 kg/ha). It seems that above average heat during the months of July and August transformed the native soil S to available form.
- Quality parameters analyzed last year indicated excellent malting quality irrespective of the treatments; grain protein (10.5 % in zero N and 16 kg S/ha to 12.2 % with ESN @ 105 kg N/ha + 8 kg S/ha), plumpness (96.6-98.6 %), Chitted grains (0.5-6.0; least with ESN and more with S), zero wheat, wild oats, green seeds or Ergot and negligible dockage (0.1 in all treatments) and stained seeds (1.5-2.0 %).
- In 2019, all of the N and S treatments had grain protein contents within limits and it ranged from 9.21 % (urea @ 70 kg N/ha and no S) to 11.62 % (urea + ESN @ 105 kg N/ha + 16 kg S/ha).

√*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 + (urea + ESN) were compared at 4 rates of N; 0, 40, 80 and 120 kg/ha (applied at seeding).
- Application of N irrespective of its source or blend increased the grain yield (by 0.77 MT/ha to over 1.10 MT/ha). Grain yield increased up to 80 kg N/ha with urea + ESN and tended to decline

thereafter, whereas with fish waste and fish waste + (urea + ESN) it continued to increase up the highest rate of N (120 kg N/ha).

- Grain yield was in the order of urea + ESN (2.99 MT/ha) ≥ fish waste + (urea + ESN) – 2.80 MT/ha ≥ fish waste (2.46 MT/ha). Straw yield followed the same trend as the grain yield. Low yield was due to late seeding (June 7) and relatively poor fertility in the area in which the trial was conducted.
- Averaged over sources of N, grain yield continued to increase with each successive rate of N from 0 to 120 kg N/ha.

√*Winter wheat survival:*

- Effect of agrochemicals spray at tillering and soil applied potassium (recommended rate and double the recommended rate) on winter wheat survival and yield was studied. However, winter wheat survived very well in all treatments and the treatments' effect on grain and straw yield was non-significant.
- Grain yield was highest (7.19 MT/ha) with Seaweed extract spray with recommended rate of K_2O, followed closely by fungicide + insecticide seed treatment with double the K_2O rate without any spray (7.02 MT/ha) and no fungicide + insecticide seed treatment/or agrochemicals spray at double the K_2O rate (6.93 MT/ha).
- Doubling the rate of K_2O appeared to lower the grain yield with Headline and Seaweed extract sprays. Averaged over agrochemicals, there was no difference in the grain yield between the two rates of K_2O application.
- Straw yield was the highest (10.66 MT/ha) with double the rate of K_2O without any seed treatment/or chemical spray; 1.92 MT/ha higher than that at the recommended rate of K_2O without any seed treatment/or chemical spray. This means doubling the rate of K_2O didn't increase the grain yield but improved the 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 *Hazlet* (4.45 MT/ha) = *Brasetto* (4.44 MT/ha) ≥ *Bono* (4.26 MT/ha) ≥ Guttino (4.06 MT/ha). Straw yield followed a similar trend with *Brasetto* and *Hazlet* producing the highest straw yield (10 MT/ha in both the varieties).
- Lowering the seed rate or rate of NPK fertilizers application lowered the grain, straw and Biomass yields. Highest grain yield (6.37 MT/ha) was obtained with 100 % of recommended seed rate/and NPK fertilizers followed closely by 75 % of recommended seed rate and full rate of NPK fertilizers (5.39 MT/ha). Grain yield at recommended seed rate with 50 % of recommended fertilizers rate was 4.93 MT/ha and was only 3.27 MT/ha without fertilizers application.
- Straw (7.22 MT/ha) and Biomass (13.58 MT/ha) yields were highest with 100 % of recommended seed rate/and fertilizers rate.
- Spring barley kept as a check treatment yielded 4.37 MT grain and 3.53 MT straw/ha. However, we were late to seed barley because of cold and wet spring.

√*Residual effect of winter rye cover crop – Different seeding and NPK fertilizer rates on canola*:

- Winter rye cover crop was seeded in the fall 2018 at different seed and NPK fertilizers rates with a check (fallow plot without seeding rye) and its effect was studied on canola in 2019.
- The canola seed yield was not affected by the cover crop treatments and ranged from 5.13 to 6.41 MT/ha. The seed yield in the fallow (check) plot was 6.25 MT/ha; not less than any of the other treatments.
- 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 9.90 MT/ha in the fallow to 11.18 MT/ha with 100 % seed rate and 50 % NPK fertilizers to winter rye.
- Soil analyses data in spring 2019 indicated that winter rye cover crop at any of the seed or fertilizers rates didn't improve the soil health index, CEC or available nutrients (by and large), including the

mineralizable N, organic matter and the biological activity in the soil. However reactive carbon improved up to 5.67 % by the winter rye cover cropping.

2.3.2 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 and MOP (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 2.50 MT/ha with NK21 @ 42 kg N/ha + 42 kg K_2O/ha to 3.27 MT/ha at equal rates of N and K_2O from urea and MOP (0-0-60). The two fertilizers at any of the rates of N and K_2O didn't exert a significant influence on the grain yield. In other words, soybeans could be grown without N and K_2O application at Thunder Bay.
- *However, NK21 has the advantage of applying two nutrients from one source*.

√Response of canola (L241C) 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 and urea superU + ESN (2:1 ratio on N basis) significantly improved the canola seed yield Maximum seed yield response at the lowest level of N (90 kg/ha) was obtained with urea (1.62 MT/ha) and the least with urea superU + ESN (0.46 MT/ha).
- Application of 360 kg N/ha (2/3rd as urea and 1/3rd as ESN) resulted in maximum seed (6.16 MT/ha), straw (9.17 MT/ha), and biomass (15.33 MT/ha) yields. The other two treatments that statistically equaled this treatment in seed, straw and biomass yields were urea superU @ 360 kg N/ha and urea superU + ESN (2:1 ratio on N basis) @ 180 kg N/ha; the latter treatment indicated 50 % saving of N (= 180 kg N/ha).
- Averaged over sources of N, seed yield increased almost linearly up to 180 kg N/ha (5.49 MT/ha) and tended to decline/or level off thereafter at the higher rates of N (240 and 360 kg N/ha).
- Averaged over N rates, different N sources/or their combinations didn't exhibit any significant difference in seed yield; though urea + ESN appeared to give the highest (5.54 MT/ha) and urea superU + ESN the lowest seed yield (4.94 MT/ha).
- But for the heat and moisture stress at times during July-August seed yields could be better!

√Evaluation of Ammonium Sulphate and Gypsum as Sources of Sulphur (S) for Canola Production:

- Ammonium sulphate and Gypsum were compared at 5 rates of S application; 0, 12, 24, 36 and 48 kg/ha.
- Maximum seed yield (6.01 MT/ha) was recorded with ammonium sulphate @ 36 kg/ha, which was 1.68 MT/ha higher than the check (No S application) and 1.07 MT/ha higher than Gypsum at the same rate of S.
- Straw yield seemed to be a bit higher with ammonium sulphate @ 48 kg/ha (6.74 MT/ha) than that @ 36 kg/ha (6.49 MT/ha).
- Averaged over rates of S application, Gypsum and ammonium sulphate didn't differ in seed or straw yield.
- Averaged over 2017 to 2019, highest seed yield was obtained with 36 kg S/ha and the highest straw yield was recorded with 48 kg S/ha; irrespective of S source. Gypsum and ammonium sulphate didn't vary significantly with each other in seed/or straw yield.

√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!):

- Seed (4.61 MT/ha) and straw (6.46 MT/ha) yields from canola were better than the grain (3.69 MT/ha) and straw (2.44 MT/ha) yields from barley. There was hardly any pod formation in peas due to excessive heat in July-August and the straw/or biomass production by peas was 1.77 MT/ha.
- There was hardly any response to S either as ammonium sulphate or as Gypsum; may be because of low yields (late seeding on May 31?).

- Residual effect of crops grown and Gypsum and ammonium sulphate applied in 2018 was studied on the spring wheat in 2019 (no S was applied). Wheat grain yield seemed to be higher when grown after canola (3.66 MT/ha) than after barley (3.17 MT/ha) or pea (3.32 MT/ha). Ammonium sulphate (3.54 MT/ha) appeared to be a bit better than Gypsum (3.21) in wheat grain yield. However, the effects of the crops and the sources of S on grain yield were not significant; maybe because of late seeding (June 10).
- Soil analysis in spring 2019 indicated that the organic matter, P, K, Ca, CEC, were in the order of canola > pea > barley. Whereas, nitrate N, pH, S, Zn, Cu, B, and soluble salts seemed to be unaffected by the previous crops.
- Soil Health Index was a little bit higher after canola (30) than after barley (29) or peas (28).

√*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).
- Application of N or S didn't help in increasing lentils grain yield and the maximum grain yield (3.48 MT/ha) was obtained without application of N and S. The pre seeding soil analysis indicated unbelievably high amounts of ammoniacal N (35 ppm) and S (58 ppm).

√*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).
- 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 (up to 2.60 MT/ha) due to late seeding (May 30, 2019).
- From the two nutrient management experiments on lentils, it appears that the lentils can be grown without application on N, P, K and S!

2.3.3 Forages:

Galega:

√*Comparative performance of gypsum and lime for Galega production:*

- Lime @ 1.07 or 2.14 – 3.21 MT/ha and gypsum @ 2.5 MT/ha produced similar dry matter yield of Galega (around 3,000 kg/ha); ~500 kg/ha higher than the check/and gypsum @ 1.25 MT/ha! However, these yield differences were statistically not significant.
- Both the amendments increased the first cut protein content by 4 % point or more as compared to the check (no lime/or gypsum application).
- Mineral content in Galega was also improved by lime and gypsum application.

√Maximizing yield and quality of galega:

- Maximum dry matter yield of Galega (3,832 kg/ha) was obtained with the application of 45 kg N + 24 kg S/ha. Addition of other nutrients (B, Zn and Mn)/or increasing rates of N and S application didn't help in improving the dry matter yield further.
- Protein content in the first cut was highest (19.2 %; 3.4 % point higher than the check-no nutrient application) at the higher rates of N (60 kg/ha) and S (36 kg/ha) supplemented with B, Zn and Mn.

2.4 Other Agronomic Practices:

√*Winter Rye (Cultivar Hazlet) Date of Seeding:*

- Winter rye was seeded at 10 days interval from August 25 to October 25.
- Grain (8.16 MT/ha), straw (8.43 MT/ha) and biomass (16.59 MT/ha) yields were highest with September 5 seeding. The delay in each consecutive seeding from September 5 to October 25 decreased the yields. Even seeding at October 5 with only 2.65 MT/ha grain yield wasn't worth it.
- Averaged over 2018-2019, September 15 seeding produced the highest grain (8.18 MT/ha), straw (8.31 MT/ha) and biomass (16.49 MT/ha) yields.

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

- *Ace 1* (perennial rye) didn't survive/and grow well to produce any grain yield.
- *Kernza* grain/and straw production was not affected significantly by the seeding rates. Though both the grain (1.93 MT/ha) and the straw (15.29 MT/ha) yields appeared to be highest at a seeding rate of 130 seed/m^2.

√*Cross seeding grasses:*

- Cross seeding (at half seed rate in one direction and half seed rate at 45 degree angle to the first seeding) gave 703 kg/ha less dry matter yield as compared to conventional (unidirectional) seeding. In the previous years, cross seeding has given higher yield than the conventional seeding.
- Averaged over 2017-'19, cross seeding gave 645 kg/ha/year extra dry matter yield as compared to conventional seeding.
- Cross seeding resulted in 0.8 % point higher protein content than conventional seeding both in the first and the second cut. However, averaged over 2017-2019, conventional seeding gave 1.7 % point higher protein content than cross seeding in the first cut, whereas in the second cut protein content was the same (12.4 %) with the two methods of seeding.
- Crop species covered the ground in both seeding methods and No weeds were observed.

√*Optimum Seeding Rate of Quinoa:*

- The experiment was a failure because the quinoa didn't set the seeds.

√*Galega Establishment under Weed Pressure:*

- Top dry matter yields of Galega were obtained by seeding Galega after pre plant incorporation of Rival (Trifluralin) @ 3L/ha (3,784 kg/ha) or by post emergence spraying of either Basagram Forte @ 1.75L/ha (3,664 kg/ha) or Pursuit @ 210 ml/ha + Ag-Surf @ 0.25% v/v (3,533 kg/ha). These yields fell a bit short of dry matter yield from alfalfa (4,166 kg/ha). The Galega and alfalfa yield differences mentioned here were not significant.
- First cut protein content was the same in alfalfa (21.5 %) and early seeded Galega (21.8 %). All other treatments had relatively lower protein content.

√*Optimum Seeding Rate for Galega Seed Production:*

- Maximum seed yield (49.7 kg/ha) was achieved with seeding galega @ 4 kg/ha at 24" row spacing.
- Increasing seed rate from 4 to 12 kg/ha didn't seem to improve Galega seed production. However, increasing row spacing from 12" to 24" increased the seed production by almost 4 folds.

√2.5 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). There is hardly any farm magazine/journal in Ontario in which LUARS wasn't mentioned at least once. The impact of our Extension and Outreach activities could be seen in the form of favourable changes as follows:

- Truckloads of seeds of new crops/varieties (50 MT of *CDC Bow* barley, 25 MT of *AAC Penhold* wheat, 10 MT of *Brandon* wheat, some *Tradition* barley, a lot of Pioneer and Pride Seeds corn, and considerable quantities of L233P and L255P canola) were brought in by Thunder Bay Co-op. Sale of fertilizers including micronutrients at Thunder Bay was maintained at the same level as last year.
- Thunder Bay Co-op brought in and sold 10,350 MT of lime this year!
- Canola, with an estimated produce value of over half a million dollars, has established itself as one of the main crops in the area with a single producer growing 210 acres in 2019. With canola fields scattered here and there, Thunder Bay farmland looked like mini Alberta!
- Use of multiple sources of N (urea, ESN and ammonium sulphate) for crop production is becoming a popular practice with a single producer applying ESN in the seed row in 200 acres for spring wheat production and in 210 acres under canola!

- Thunder Bay producers obtained bin bursting yields this year breaking their previous records! Fritz Jaspers obtained 2.25 MT/acre average wheat grain yield from 200 acres under AAC Penhold; last year he got 2.0 MT/acre from the same acreage! He got a record 3.05 MT/acre barley grain yield from cultivar Synasolis. Silage corn harvested by him yielded 25 MT/acre (fresh yield with ~65 % moisture). In this case too, he broke his previous record of 20-25 MT/acre corn silage yield last year. Average canola seed yield obtained by Fritz Jaspers from 210 acres was 1.6 MT/acre; the yield peaked 2.0 MT/acre in good spots. Other growers got 1.3 to 1.5 MT/acre canola seed yield. Fred Breukelman got very good yield from silage corn. He said he had abundant forage with all his bunkers and bags full of corn for silage. Aaron Breukelman recorded 2.5 MT/acre barley grain yield. Similar grain yields of wheat and barley were obtained by Mark Veurink.
- Land clearing and tile drainage on farms continued!
- *Sale of Galega seed continued this year too. Thunder Bay Feeds sold 3 MT of Galega seed this year, which went mostly to southern Ontario and some 20 bags of seed to western Canada. TBARS/LUARS is credited for the province wide introduction of Galega, a new perennial forage legume crop from the Scandinavian countries!*
- A local Grain Elevator procured ~ 8,800 MT grains this year (nearly 3,000 MT higher than last year) as at November 25, 2019 at a value of ~2.0 million dollars from Thunder Bay and Rainy River Districts. 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.

Dr. Tarlok Singh Sahota CCA **November 25, 2019**
Director of Research and Business