

2. Summary of Research Results 2018

2.1 Screening of crop varieties:

2.1.1 Spring Cereals:

Wheat Varieties:

- Thirty five varieties were evaluated; 9 of which were durum wheat and the rest mostly hard red.
- Two varieties that gave >10 MT/ha grain yield were *AAC Chiffon* (soft white; 10.6 MT/ha) and *Easton* (HRS; 10.3 MT/ha). Second best group of varieties in grain yield was *AC Foray VB* (CPRS; 8,756 kg/ha), and *Furano* (HRS; 8,075 kg/ha).
- *AAC Penhold* (CPSR; year 2016's highest yielding variety), cultivated on farms in Thunder Bay, at 7,654 kg grains/ha, gave 2,665 kg/ha less grain yield than *Easton* this year!
- Highest straw (11.9 MT/ha) and biomass (22.2 MT/ha) yields were obtained with *Easton*.
- Among the durum wheat varieties, *CDC Alloy* recorded the highest grain yield (6,801 kg/ha), *AAC Raymore* the highest straw yield (9,853 kg/ha) and *Enterprise* the highest biomass yield (15,868 kg/ha).
- Averaged over three years (2016-'18), highest grain (8,687 kg/ha), straw (9,701 kg/ha) and biomass (18.4 MT/ha) yields were obtained with *Easton*! *AAC Chiffon* (7,551 kg/ha) and *SY Rowyn* (7,334 kg/ha) were the next best varieties in grain yield.
- Grain protein content in the high yielding varieties was; *Furano* 16.6 %, *AAC Penhold* and *Minnedosa* 15.6 %, *Easton* 14.4 %, and *AAC Chiffon* 13.6 %.

Barley Varieties:

- Seventeen high yielding barley varieties (5 two row and 12 six row) were compared for their production potential.
- Three top grain yielding varieties were *Chambly* (7,586 kg/ha), *Oceanik* (~7,000 kg/ha) and *Rhea* (6,784 kg/ha).
- *Encore* (6,694 kg/ha), *Austenson* (6,612 kg/ha) and *Boroe* (6,567 kg/ha) formed the second best group in grain yield. You may recall that *Boroe* has been the highest yielding variety during 2016 and 2017.
- Straw yield was highest with *Rhea* (8,583 kg/ha); followed by *Encore* (7,572 kg/ha) and *Chambly* (7,362 kg/ha).
- Averaged over 2016-'18, three top grain yielding varieties were *Chambly* (6,949 kg/ha), *Boroe* (6,783 kg/ha) and *Oceanik* (6,421 kg/ha). *Encore* (6,378 kg/ha), *Chambly* (6,211 kg/ha) and *Rhea* (6,125 kg/ha) were the best for straw production!

Malting Barley Varieties:

- Ten varieties were evaluated. *New Dale* was almost a failure; hence the results are reported for 9 varieties only.
- *CDC Bow* produced the highest grain (7,854 kg grains/ha), straw (11,424 kg/ha) and biomass yield (19.3 MT/ha). Grain yield from *CDC Bow* was ~800 kg/ha higher than that from than *AAC Synergy* (7,074 kg/ha); one time the best (yielding) variety.
- *CDC Kindersley* (7,699 kg grains/ha) and *CDC Copeland* (7,586 kg grains/ha), were not far behind *CDC Bow* in grain yield. However, the straw yield from these two varieties was significantly lower than that from *CDC Bow*.
- Grain yield of other varieties ranged from 5,924 kg/ha (*Lowe*) to 7,478 kg/ha in AAC Connect.
- Averaged over three years (2016-'18), *CDC Bow* maintained its supremacy over other varieties in grain, straw and biomass yield.
- Malting quality parameters 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.

Older Barley Varieties Demonstration (Single Replication):

- Grain yield from *Brucefield* and *Chapais* was low (4,850 kg/ha in both) and moderate to reasonable in *AC Klinck* (5,847 kg/ha) and *Cyane* (6,439 kg/ha).

Hulless Barley and Oat Varieties Demonstration (Single Replication):

- Among three hulless barley varieties *AAC Azimuth* gave the highest grain yield (6,183 kg/ha). Grain yield of *Black Barley* was very low (2,052 kg/ha).
- The two hulless oat varieties (*Navaro* and *Gehl*) had similar grain yields (~3,800 kg/ha).

Black (Hulless) Barley is a specialty crop and can be eaten like rice (boiled)! It may be of interest to gardeners/and organic producers.

Oat Varieties:

- Twenty three oat varieties were evaluated for their yield potential.
- *Akina* (milling oat) produced the highest grain yield (8,882 kg/ha) and biomass (17,347 kg/ha) yields. Highest straw yield (9,338 kg/ha) was obtained with *Bolina* (also milling oat) that had low grain yield (6,278 kg/ha).
- *AAC Bullet* (8,072 kg/ha) and *OA 1367-3* (8,001 kg/ha) were the second best group of varieties with good grain yields!
- *AAC Noranda* was reasonably good in both grain (7,378 kg/ha) and straw (9,034 kg/ha) yields!
- Grain yields of *AC Rigodon* and *AC Jordon*, formerly high yielding varieties with stable yields till 2015, were 6,426 and ~6,600 kg/ha only.

2.1.2 Winter Cereals:

Winter Wheat Varieties (seeded on August 23, 2107):

- Nine winter wheat varieties from the west and east of Canada, including *Gallus*, *AAC Elevate* and *AAC Wildfire*, were compared for their production potential.
- *Moats* recorded the highest grain (8,518 kg/ha), straw (~10,000 kg/ha) and biomass yields (18,500 kg/ha).
- *AAC Gateway* with grain, straw and biomass yields of 6,541 kg/ha, 7,250 kg/ha and 13,792 kg/ha, respectively, was the next best variety.
- *Gallus* and *Keldin*, the two Ontario varieties, had a total winter kill and hence no yield data could be obtained from these varieties.

Late seeded Winter Wheat Varieties (seeded on September 23, 2107):

- *JDC 78* and *AAC Goldrush*, two new varieties, were compared with two old varieties (*Gallus* and *AAC Gateway*).
- *AAC Gateway* gave the highest grain yield (7,819 kg/ha) and *JDC 78* the highest straw (10,626 kg/ha) and biomass (17,905 kg/ha) yields; though not significantly higher than that from *AAC Gateway*.

Winter Rye Varieties and Lime/Woodash:

- Four winter rye varieties were evaluated.
- *Hazlet* (11,086 kg/ha) recorded the highest and *Brasetto* (4,328 kg/ha) the lowest grain yield. This was a reflection of winter survival; highest (81 %) in *Hazlet* and lowest (25 %) in *Brasetto*.
- Grain yield of *Guttino* was ~9,000 kg/ha and that of *Bono* was ~8,000 kg/ha.
- Neither wood ash nor lime applied three years ago improved grain yield of winter rye this year.
- *Winter rye could be a good option for grain (feed or malt)/and straw production!*

2.1.3 Grain Corn:

- Nine corn varieties (3 from DuPont Pioneer, 2 from Pride Seeds, 3 from Maizex and 1 from Brett & Young) were evaluated for grain production.

- Grain yield ranged from 7.62 MT/ha (*P7211HR – 2050 CHU*) to ~22.0 MT/ha (*E44H12 R – 2100 CHU*); the latter gave consistently high grain yield during the past years (2016 and 2017) too.
- *P7005AM* (2000 CHU - 19.0 MT/ha) and *MZ 1340DBR* (2150 CHU – 18.0 MT/ha) stood next to *E44H12 R (2100 CHU)* in grain yield.
- Stover yield was highest (16.1 MT/ha) with *P7005AM* followed closely by *E44H12 R* (15.8 MT/ha) and *MZ 1340DBR* (15.2 MT/ha).

2.1.4 Grain Legumes and Oil Seeds Varieties:

Soybean Varieties:

- Thirteen varieties were evaluated for grain production.
- *Lono R2* gave the highest grain yield (4,543 kg/ha). Three other varieties with good grain yields were *Sunna R2X* (3,913 kg/ha), *Pekko R2* (3,886 kg/ha) and *NSC Sperling RR2Y* (3,860 kg/ha).
- Grain yield in other varieties ranged from 2,562 kg/ha (*NSC Moosomin RR2Y*) to 3,688 kg/ha (*NSC Starbuck RR2Y*).
- Based on two to three years' (2016-'18) average grain yields, three top yielding varieties were *NSC Watson RR2Y*, *Podago R2*, and *Pekko R2* (4,000 kg/ha or more).

Edible Beans Varieties:

- Six white and 2 red edible bean varieties were compared for their grain yield.
- Only three varieties produced nearly 3 or more than 3 MT grain yield/acre; *Fathom* (3,010 kg/ha), *Earlired* (2,900 kg/ha) and *Lighthouse* (2,870 kg/ha).
- Based on three years average (2016-'18), *Earlired* maintained its lead in grain yield at 3,162 kg/ha. *Yeti* (2,872 kg/ha) and *Bolt* (2,670 kg/ha) were the next best varieties.

Edible beans could be an integral part of the cropping systems in northwestern Ontario!

New Edible Beans Varieties:

- Five white and two yellow edible bean varieties were compared with *Earlired* (time tested high yielding check variety) for their grain yield. None of the varieties gave higher grain yield than *Earlired* (2,463 kg/ha).
- *AAC Whitehorse* (2,166 kg/ha) and *AAC Argosy* (1,923 kg/ha) white bean varieties had better grain yield than other white or yellow beans varieties (~1,200-1,842 kg/ha).
- Unless white beans are sold at a higher price they cannot compete with the red beans.

Flax Varieties:

- Six varieties were evaluated for their production potential.
- Varieties that gave >2,500 kg/ha seed yield were: *CDC Glas* (2,750 kg/ha), *Prairie Sapphire* (2,589 kg/ha), *CDC Sorrel* (2,532 kg/ha) and *CDC Plava* (2,527 kg/ha).
- Straw yield was highest with *CDC Sorrel* (5,255 kg/ha) followed closely by *CDC Plava* (5,169 kg/ha) and *CDC Buryu* (5,039 kg/ha). Straw yield of *CDC Glas* was 4,669 kg/ha).
- Highest biomass yield (7.8 MT/ha) was obtained with *CDC Sorrel*.

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

- Twenty six biotypes were compared; including 12 standard/named varieties.
- In the standard varieties, three varieties that gave >3,300 kg/ha seed yield were: *CDC Glas* (3,581 kg/ha), *CDC Buryu* (3,394 kg/ha) and *AAC Bright* (3,393 kg/ha).
- In the new lines, seed yield ranged from 2,873 kg/ha (*FP2566*) to 3,504 kg/ha (*FP2585*)
- Flax is relatively a low input crop and could be added to diversify the existing cropping systems!

Liberty Canola Varieties:

- Seven varieties were evaluated.
- *L241C*, a Club Root resistant variety, recorded the highest seed yield (6,050 kg/ha); 582-658 kg/ha more than *L233C* and *L252*. Straw (~10 MT/ha) and biomass (16 MT/ha) yields were also highest with *L241C*!
- Seed yield from other varieties ranged from 4,268 kg/ha (*L255PC*) to 5,363 kg/ha (*L230*).

- Due to expected threat from Club Root in Ontario, LUARS would recommend *L241C* for cultivation on farms.
- *P* stands for ‘Shatter Reduction’ and *C* for Club Root resistance.

Round Up Ready/Clearfield Canola Varieties:

- Four varieties were compared.
- Seed yield from two varieties (*6086 CR* and *5545 CL*) was ~4,300 kg/ha and 3,842/3,943 kg/ha from the other two varieties (*6074 RR/6080 RR*). Round Up wasn’t sprayed to avoid drift to Clearfield variety plots and weed control with Rival didn’t seem to be all that effective. This may account for relatively low seed yield from RR canola varieties.
- Straw yield was in the order of *6074 RR* (8,043 kg/ha) \geq *5545 CL* (7,832) $>$ *6086 CR* (7,331 kg/ha) $>$ *6080 RR* (~6,000 kg/ha).

Mustard Varieties:

- *AC 200* (Oriental mustard) recorded the highest seed (1791 kg/ha), straw (3,775 kg/ha) and biomass yields (5,566 kg/ha). Straw yield from *Adagio* (Yellow; 3,682 kg/ha) equaled that from *AC 200*.
- Seed yields from the other two varieties were 1,346 kg/ha (*AC Vulcan* - Oriental mustard) and 1,191 kg/ha (*Adagio*).
- Compared to canola, mustard is a low input crop, is used for culinary purposes, can be sold in retail and fetches higher market price than canola!

2.1.5 Quinoa Varieties:

Quinoa Varieties Demonstration (Single Replication):

- Quinoa made good vegetative growth, but didn’t set seeds.
- Ten different varieties were tested in a single replication. After the seeding only seven emerged and three that did not emerge.
- Dry matter yield was in the order of CP-1-17 (8,953 kg/ha) $>$ AG-2-15 (6,292 kg/ha) $>$ RIL-28-16 (2,593 kg/ha) $>$ BC-1-15 (2,075 kg/ha).

2.1.6 Forage Crops/Varieties:

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

- Galega seeded in 2011 @ 25 kg seed/ha gave significantly higher dry matter yield (~500 kg/ha) than alfalfa seeded @ 13 kg seed/ha only in the first cut. Higher than 25 kg/ha seed rates in Galega didn’t prove beneficial in 2018 (unlike last year).
- Protein content in Galega seeded @ 25 kg/ha was 1 % point higher in the first cut and 2.6 % point higher in the second cut as compared to alfalfa seeded @ 13 kg/ha.
- Galega had lower mineral content (K, Ca, Mg, Cu, Zn, Mn and Na) than alfalfa in the first cut (averaged over 2016 to 2018). In the second cut, Mg, Zn and Mn were higher in Galega than in alfalfa. Galega contained higher amounts of iron (Fe) than alfalfa in both the cuts.
- Averaged over 2012 to 2018, Galega seeded @ 25 and 35 kg seed/ha produced 600 kg/ha and 1,000 kg/ha higher total dry matter yield (from 2 cuts) than alfalfa.
- Protein content in Galega @ 25 kg/ha, averaged over 2016 to 2018, was 3.6 % point higher than in the first and 2.7 % point higher in the second cut than that in alfalfa.
- *Higher yield and higher protein content in Galega than in alfalfa, will make Galega a better fodder than alfalfa!*

Forage Production Potential of Different Annual Forage Crops:

- *Silage corn* produced the highest dry matter yield (28.2 MT/ha – 7.5 % protein content). *Oats/Oats +Berseem* registered the 2nd highest dry matter yield (13.4/~13.0 MT/ha – 8.6/10.0 % protein). Among other crops/or crop combinations (*Barley, Berseem, Barley + Peas/or Berseem, Sorghum Sudangrass, Soybean, and Fababeans*), *MasterGraze corn* had the highest dry matter yield (7.9 MT/ha – 9.9 % protein).

- *Berseem/and Soybean* forage had the highest RFV (155/152)! Second highest RFV was found in *Oats + Berseem/or Peas* (134/131).
- Averaged over 2016-2018, dry matter yields of *Silage corn, Oats, MasterGraze corn* and *Oats + Berseem* were 34.8, 8.72, 8.55 and 8.47 MT/ha, respectively. Protein content in these crops was 8.0, 8.1, 10.3 and 13.4 %, respectively. RFV was highest in *Fababeans* (177) followed by 150 in *Berseem*. Higher RFV could be indicative of a higher milk yield.

Dairy producers could add berseem crop to their cropping systems as an intercrop with barley/or oat!

New Annual Forage Crops:

- *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 highest dry matter yield (5,031 kg/ha – 13.1 % protein) for the 2nd consecutive year! Second and third highest dry matter yields were obtained with *frosty berseem* seeded @ 13 kg/ha (4,047 kg/ha – 20.5 % protein) and *Italian Ryegrass* (Crusader; 3,901 kg/ha – 14.5 % protein).
- Protein content was highest in *conventional berseem* (23.6 %) that yielded 1.5 MT/ha lower than the *frosty berseem*.
- Dry matter yield of other crops (*Choice Chicory, Tonic Plantain, Fixation Blansa, Peas all Brassica Blend* and *Belle Red Clover*) ranged from 2,070 kg/ha to 3,017 kg/ha. Protein content in these crops ranged from 16.2 % to 20.8 %.
- Highest RFV was recorded in *Peas* (163) followed by *conventional Berseem* (159).
The new forage crops will be good for grazing/or feeding small ruminants!

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

- Optimum seed rate of *Kernza* was found to be 90 seeds/m². At this rate, it produced 4,943 kg/ha dry matter yield, which was 2,300 kg higher than dry matter yield of *Ace 1* (perennial rye), 982 kg/ha than *alfalfa + Ace 1* (80:20) mixture and 801 kg/ha than *alfalfa + Kernza* (80:20) mixture.
- In the first cut, protein content was higher in *alfalfa + Kernza* (80:20) mixture (17.0 %) than in *alfalfa + Ace 1* (80:20) mixture (15.5 %), and pure stands of *Kernza* (12.8-14.3 % at seed rates of 70-130 seeds/m²) and *Ace 1* (13.3 %). In the second cut, the trend was same; though the protein content increased to 20.1-21.2 % in alfalfa cereals mixtures, because of drastic reduction in the cereals stand after the first cut!
- In the first cut, RFV was higher with alfalfa perennial cereals mixtures (136-138) than *Kernza* (93-100) or *Ace 1* (91) alone. In the second cut, RFV came down to 122 in alfalfa + *Kernza* and 129 in *alfalfa + Ace 1*, but remained unaffected in the pure stands of *Kernza* and *Ace 1*.

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

- Dry matter yield from the two cuts ranged from 735 kg/ha (*Chicory*) to 5,101 kg/ha (RR Alfalfa variety *WL319HQ*).
- *WL319HQ* yield was significantly higher than the two other RR Alfalfa varieties (*WL354HQ* and *Mission HVX*), but not significantly higher than the two conventional alfalfa varieties (*I35* and *Instinct*).
- Among the perennial cereals, *Kernza* recorded higher dry matter yield (4,518 kg/ha) than *Ace 1* Rye (3,179 kg/ha).
- Two *Sainfoin* varieties had poor yields; *Mountview* 2,259 kg/ha and *Glenview* 1,967 kg/ha.
- Protein content in the first cut was in the order of *Choice Chicory* > *Alfalfa* > *Ace 1* > *Kernza* > *Sainfoin*. In the second cut, *Alfalfa* had the highest protein content, and *Glenview* (*Sainfoin*) exceeded *Mountview/Kernza* in protein content by 2.5/2.3 % points and *Ace 1* by 3.8 % points.
- RFV was highest in *WL319HQ* in the 1st (164) as well as in the 2nd cut (136)!
Considering the dry matter yield, protein content and RFV, WL319HQ RR Alfalfa could be recommended for cultivation on farms!

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

2.2.1 Cereals:

Winter rye cover crop – seeding and NPK fertilizer rates:

- Winter rye seeded on August 24, 2017 at 50 % recommended seed and NPK rates gave the highest grain yield (4,848 kg/ha) among all treatments (50-100 % seed rates/and NPK), which statistically equaled grain yield from spring barley (5,034 kg/ha) without winter rye cover crop in the fall/winter. However, this was a single replication demonstration.
- Soybean seeded after winter rye cover crop was damaged by the deer and hence no grain yield could be recorded or reported.

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, 16 and 24 kg S/ha).
- Grain yield with urea leveled off/or declined above 70 kg N/ha, whereas with urea + ESN the grain yield continued to increase up to 105 kg/ha (with each increment of N from zero to 105 kg/ha) though the response followed the Law of Diminishing Returns.
- Grain yields from urea and urea + ESN (3:1 on N basis), without S, were 6,573 kg/ha and 7,005 kg/ha, respectively.
- Malting barley didn't respond to S application even though available S at seeding was only 7 ppm. It seems that above average heat during the summer transformed the native soil S to available form.
- Grain yield from urea @ 35 kg/ha + 16 kg S/ha (6,816) statistically equaled grain yield from urea (6,693 kg/ha)/or urea + ESN (6,618 kg/ha) @ 70 kg/ha.
- Straw yield was highest with urea @ 70 kg N/ha + 8 kg S/ha (5,989 kg/ha) followed closely by urea @ 105 kg/ha/or urea + ESN (3:1 on N basis) @ 70 kg/ha (~5,910 kg/ha).
- Quality parameters 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 %).

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 significantly increased the grain yield (by 870 kg/ha to over 1,000 kg/ha).
- Grain yield was in the order of urea + ESN (7,632 kg/ha) \geq fish waste + (urea + ESN) – 7,593 kg/ha > fish waste (7,042 kg/ha). Straw yield followed the same trend as the grain yield. Low yield from fish waste is attributed to low plant stand in fish waste plots (450/m² as compared to 482/m² in urea + ESN), which means that the fish waste had a deleterious effect on the emerging wheat seedlings.
- Grain yield with urea + ESN @ 80 kg N/ha (8,630 kg/ha) equaled that with fish waste + (urea + ESN) @ 120 kg N/ha (8,657 kg/ha). The latter produced the highest straw yield (5,605 kg/ha).
- Urea + ESN @ 80 kg N/ha resulted in highest grain protein content (15.4 %)!

2.2.2 Grain Legumes and Oil Seeds:

Effect of P and bio-ag products on soybean grain yield:

- Soybean was damaged by the deer and hence no grain yield could be recorded or reported.
- Neither application of Quickroots a microbial (*Bacillus amyloliquefaciens* and *Trichoderma virens* based) nor Jumpstart (*Penicillium bilaii*; a fungus providing better access to soil and applied P) seed inoculants increased the soybean dry matter yield.

- Application of 20 kg P₂O₅ gave the maximum (2,238 kg/ha) dry matter yield

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 % K₂O) was compared @ 21, 42, 63 and 84 kg/ha N and K₂O with urea and MOP (0-0-60) at equal rates of N and K₂O along with three checks (No N, No K₂O and No N or K₂O).
- Grain yield increase at rates higher than 21 kg N + 21 kg K₂O/ha from NK21 was marginal, whereas with urea + MOP, there was 509 kg/ha increase in grain yield with increasing rates of N and K₂O from 21 to 63 kg/ha. Grain yield from NK21 @ 21 kg N + 21 kg K₂O/ha (3,836 kg/ha) was only marginally lower than that from urea + MOP @ 63 kg N + 63 kg K₂O/ha (4,030 kg/ha).
- Averages for main factors revealed that grain yield response (increase over check) to (i) N @ 21, 42 and 63 kg/ha was 754, 879 and 978 kg/ha and (ii) K₂O @ 21, 42 and 63 kg/ha was nil, 320 and 419 kg/ha. Grain yield declined at rates higher than 63 kg/ha N or K₂O. Grain yield with NK21 was ~350 kg/ha more than that with urea + MOP.
- *NK21 has the advantage of applying two nutrients from one source and may therefore be preferred over urea and MOP.*

Maximizing canola (L252) yield with nitrogen and other nutrients and fungicides/growth retardant:

- Nutrients (N, S, B, Zn and Mn) effect on canola yield was assessed over uniform recommended rates of P and K. The seed yield this year with hot summer was less than last year.
- Application of N @ 150 kg/ha increased the canola seed yield by more than 1 MT/ha. Addition of S with N raised the seed yield further by 738 kg/ha. Addition of B and Zn along with N and S improved the seed yield by 240 kg/ha (as compared to N + S). Peak seed yield (4,329 kg/ha) was recorded when nutrient (N, S, B, and Zn) supply was supported by Proline spray (@ 315 ml/ha) at 25 % flowering.
- Neither Mn (@ 2 kg/ha) nor Manipulator 620 (@ 1.8 l/ha) spray improved the seed yield.
- Straw yield was highest (6,651 kg/ha) without application of secondary and micronutrients/or fungicide and growth retardant.
- Averaged over 2016-'18, maximum seed (5,340 kg/ha), straw (8,254 kg/ha) and biomass (13,593 kg/ha) yields were obtained when N was supplemented with secondary and micronutrients (S, B, Zn and Mn) with or without Proline spray. As you may note from the next experiment, 150 kg N/ha is not enough to maximize economic yield of canola!

Maximizing canola (L252) yield with nitrogen and growth retardant:

- Application of N @ 60,120, 180 and 240 kg/ha from urea/or urea + ESN (2:1 ratio on N basis) significantly improved the canola seed yield and the maximum seed yield in both cases was obtained with 240 kg N/ha (6,530/6,452 kg/ha). Straw yield was also highest at 240 kg N/ha; 7,572 kg/ha with urea and 7,687 kg/ha with urea + ESN.
- Application of N @ 240 kg N/ha as urea and urea + ESN increased the seed yield over 180 kg N/ha by 1,214 kg/ha and 643 kg/ha, respectively. At 180 kg N/ha, urea + ESN gave ~500 kg/ha extra seed yield than urea.
- Averaged over N rates, without Manipulator spray, urea + ESN (2:1 ratio on N basis) gave somewhat higher seed yield than urea. This was true for straw yield too.
- Averaged over 2016-'18, at 180 kg N/ha, urea + ESN @ 180 kg N/ha gave 742 kg/ha extra seed yield than urea.
- Manipulator 620 spray appeared to lower the seed yield.
- Averaged over 2016-'18, it was found that (i) the seed and straw yields were highest at the highest rate of N (240 kg/ha), (ii) at 180 kg N/ha, urea + ESN gave 742 kg/ha extra seed yield than urea and (iii) Manipulator 620 spray tended to lower the seed yield.

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. Seed yield continued to increase up to 36 kg S/ha with every increase in S from 0 to 36

kg/ha and declined thereafter. However, increase in yield from 24 to 36 kg/ha S with Gypsum wasn't significant.

- Maximum seed yield (6,079 kg/ha) was recorded with ammonium sulphate @ 36 kg/ha, which was 2,080 kg/ha higher than the check (No S application). Straw yield too was highest (8,029 kg/ha) with ammonium sulphate @ 36 kg/ha.
- Averaged over rates of S application, Gypsum didn't give significantly higher seed or straw yield than ammonium sulphate, which is the prevalent S source with the area producers.
- Averaged over 2017 and 2018, highest seed yield was obtained with 36 kg S/ha irrespective of S source and Gypsum seemed to be a better source than ammonium sulphate.
- It may be advisable to increase the rate of S application to canola from 24 (current) to 36 kg/ha in 2019 and Gypsum could be preferred in fields deficient/or marginal in available calcium.

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!):

- Barley grain yield (5,810-6,213 kg/ha) was better than canola seed yield (4,501-4,822 kg/ha). Whereas, straw yield in canola (6,258 kg/ha) was higher than in barley (4,162 kg/ha). It shows that canola (a cool loving crop) was affected by excessive heat this year. Even in other experiments, we didn't get as high seed yield in canola this year as last year.
- Excessive heat this year led to crop failure in peas (grain yield up to 500 kg/ha only).
- Ammonium sulphate, which resulted in 403 kg/ha extra grain yield in barley and 311 kg/ha more seed yield than Gypsum, appeared to be a better source of S for crop production than Gypsum! At low canola yield, response to S would be low too.
- Residual effect of crops grown and Gypsum and ammonium sulphate applied in 2017 was studied on the spring wheat in 2018 (no S was applied). Wheat grain yield was significantly higher when grown after canola (6,802 kg/ha) than after barley (6,037 kg/ha) or pea (6,143 kg/ha). Gypsum and ammonium sulphate exerted a negative residual influence on wheat grain yield (probably due to higher yield and nutrient removal in the previous year leaving the soil a bit poor).

Effect of nitrogen and growth regulator on flax seed yield:

- Application of N @ 35 kg/ha increased the flax seed yield significantly (by 348 kg/ha). Each unit increase in N from 35 to 105 kg/ha improved the yield only marginally; unless 1/3rd N in 105 kg N/ha was replaced from urea with ESN (356 kg/ha higher seed yield than that at 35 kg N/ha)!
- Straw yield (2,960 kg/ha) was highest with N @ 105 kg (2/3rd from urea and 1/3rd from ESN).
- The experiment was not on a relatively poor site and hence the yield in this experiment was poor.
- Manipulator spray did not improve seed or straw yield.
- Averaged over 2016-'18, application of urea N @ 105 kg/ha and growth regulator (Manipulator 620) spray produced the highest seed (2,535 kg/ha), straw (4,424 kg/ha) and biomass (~7,260 kg/ha) yields.

Effect of P and K on flax seed yield:

- Treatments included all combinations of 3 rates of P₂O₅ and 3 rates of K₂O application (both @ 0, 20 and 40 kg/ha).
- Application of 40 kg P₂O₅/ha, but not 20 P₂O₅/ha, (without application of K₂O) improved the seed yield significantly from 3,051 kg/ha (check – No P₂O₅) to 3,415 kg/ha, which was also the maximum seed yield.
- Straw yield (~5,300 kg/ha) was highest with 40 kg P₂O₅/ha + 40 kg K₂O/ha; though this wasn't significantly higher than the straw yield with 40 kg P₂O₅/ha alone (5,120 kg/ha).
- Without application of P, application of 40 kg K₂O/ha, but not 20 K₂O/ha, increased the seed yield significantly by 313 kg/ha.
- Averaged over K rates, P didn't exert any significant influence on seed yield, which was true for K when the seed yield was averaged over P rates. This was true for averages over 2016-'18.

- From the three nutrient management experiments on flax for three years, it appears that flax can be grown with application on N alone!

Effect of sulphur on flax seed yield:

- Application of S @ 10, 20 or 30 kg/ha didn't increase seed yield of flax, which ranged from 3,103 kg/ha without S to 3,281 kg/ha with 30 kg S/ha.
- Straw yield ranged from 4,594 kg/ha without S to 8,195 kg/ha S @ 20 kg/ha.

2.2.3 Forages:

Galega:

Comparative performance of gypsum and lime for Galega production:

- Galega seeded in 2017 was infested badly with pineapple weed, had a scanty stand and produced low dry matter yield from two cuts (up to 3,356 kg/ha).
- Neither lime (@ 2.14 – 6.28 MT/ha) nor gypsum (@ 2.5 -7.5 MT/ha) helped to improve dry matter yield of Galega in the first harvest year! However, both the amendments increased the protein content by 1 % point or more.

2.3 Other Agronomic Practices:

Mid June Seeding Options:

- Six spring crops (wheat, barley, oat, canola, pea and flax) were evaluated for their success of cultivation and production potential when seeded during mid June.
- Mid June seeding of cereals could give reasonably good yields. Grain yields from mid June seeding of cereals was in the order of *oat* (5,937 kg/ha) \geq *barley* (5,717 kg/ha) $>$ *wheat* (5,009 kg/ha). Oat produced the highest straw yield (9,227 kg/ha) and barley and wheat equaled in straw yield (~5,900 kg/ha).
- This was the first year when *canola* and *flax* completed their crop cycle; though the seed yields were poor (*canola* 2,123 kg/ha and *flax* 623 kg/ha). *Pea* grain yield (~3,800 kg/ha) was average.
- Averaged over 2016-'18, among the three cereals, oat (5, 268 k/ha) produced the highest and wheat (4,093 kg/ha) the lowest grain yield; barley grain yield (4,866 kg/ha) was medium.

Winter Rye (Cultivar Hazlet) Date of Seeding:

- Winter rye was seeded at 10 days interval from August 25 to October 15 and wasn't winter killed in any of these seeding dates.
- Grain yield increased with delay in seeding from August 25 to September 15 and declined with delay in seeding later than mid September. Highest grain (9,158 kg/ha), straw (9,267 kg/ha) and biomass (18,424 kg/ha) yields were obtained with mid September seeding!
- Mid October seeding registered the lowest grain yield (4,704 kg/ha).

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

- Ace 1 (perennial rye) grain yield (1,748 kg/ha) was highest compared to Kernza seeded at different seed rates.
- Kernza seeded at (130 seed/m²) was the most economical rate when it comes to both grain and straw yield.
- Kernza seeded at (130 seed/m²) gave a grain yield of (1,667 kg/ha) which was only ~80 kg/ha less than Ace 1.
- Comparing straw yield; Kernza seeded @ 130 seed/m² gave a straw yield of (13,593 kg/ha) which was more than double (7,335 kg/ha) the straw yield of Ace 1.

Cross seeding grasses – at LUARS and at a farmer's field:

- Cross seeding (at half seed rate in one direction and half seed rate at 45 degree angle to the first seeding) gave ~80 kg/ha extra dry matter yield as compared to conventional (unidirectional) seeding at LUARS and ~150 kg/ha extra yield at farmer's field.
- Averaged over 2017-'18, cross seeding gave ~ 1,300 kg/ha extra dry matter yield as compared to conventional seeding at LUARS and 380 kg/ha extra yield at farmer's field.

- Cross seeding resulted in 2.1 % point lower protein content than conventional seeding at LUARS in the first cut and 1.2 % point lower protein content in the second cut. Cross seeding also lowered the protein content by 1.5 % point at farmer's field.
- Crop species covered the ground in both seeding method and No weeds were observed.

All Quinoa trials made good vegetative growth, but didn't set seeds!

Optimum Seeding Rate of Quinoa:

- Dry matter yield in 2018 was maximum (6,989 kg/ha) at the second highest seed rate (8.97 kg/ha = 8 lb/ac). Averaged over 2017-'18, same seed rate gave the maximum dry matter yield (5,210 kg/ha). Highest seed rate was 11.2 kg/ha = 10 lb/ac.

Optimum Quinoa Seeding Date:

- Dry matter yield was maximum (2,515 kg/ha) when Quinoa was planted on May 5, 2018.

Optimum Row Spacing for Quinoa Production:

- Dry matter yield was maximum (4,329 kg/ha) at the narrowest row spacing of 6 Inch.

Galega Establishment under Weed Pressure in the Seeding Year:

- Crop yield is not reported this year since, this is the establishment year and forage crops are not generally harvested in the planting year. Next year is when the true evaluation of the 10 different establishment methods will be shown.
- Galega seeded after barley forage crop, mid-July after killing weeds, and sprayed with Basagram Forte had 0 weed pressure compared to check (alfalfa) and galega seeded in spring (as early as possible).
- Even though, Basagram Forte provided the best weed control compared to other herbicides. It also damaged/set back the crop.
- The main weed pressure was from: Canada thistle, Lambs Quarter, and Sheperd Purse.

Optimum Seeding Rate for Galega Seed Production:

- In 2017, TBARS seeded Galega for seed production and to examine what is the optimal rate of seeding galega for seed production is.
- The maximum yield was achieved from seeding galega at 48 kg/ha which gave the yield of (21 kg/ha).

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). There is hardly any farm magazine/journal in Ontario in which LUARS wasn't mentioned at least once. 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 (25 MT each of Bow Barley from Regina and CDC Coalition barley from Pilot Butte Alberta, respectively, 21.5 MT AAC Penhold wheat from Manitoba, a lot of Pioneer and Pride Seeds corn, and considerable quantities of other crop varieties such as Alyssa, Amberly, Boroe and Synasolis barley and L233P and L255P canola - all tested at and recommended by the research station) were procured by Thunder Bay Co-op to meet farmers' orders. Sale of some fertilizers at Thunder Bay Co-op went up by 10-13 % and that of micronutrients (zinc and boron) by 25-50 % as compared to last year.
- Thunder Bay Co-op brought in and sold 10,350 MT of lime this year!
- In the vicinity of LUARS, acreage under canola rose from 500 acres in 2017 to 700 acres this year (estimated produce value of ~\$600,000.00). Canola is one of the main crops in the Thunder Bay district, which with canola fields scattered here and there, 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 for the second year!

- Thunder Bay producers obtained bin bursting yields this year breaking their previous records! Fritz Jaspers obtained 2 MT/acre average wheat grain yield from 200 acres under AAC Penhold for the second year! He got a record 3 MT/acre barley grain yield from cultivar Synasolis (under seeded with alfalfa in 36 acres. He surpassed his previous record of 2.65 MT/acre barley grain yield from 65 acres with the same variety. Silage corn harvested by him from a small acreage yielded 20-25 MT/acre (fresh yield with ~65 % moisture). In this case too, he broke his previous record of 19 MT/acre corn silage yield. Fred Breukelman obtained 1.5 MT/ac canola seed yield. Ed Breukelman got 1.6 MT/acre grain yield from wheat Cardale (53 acres) with 14-15 % grain protein that was sold @ \$270/acre. Despite low yield compared to AAC Penhold he felt that he made up with the good price he got. Ed grew Alyssa barley in 30 acres and got 2.8 MT/acre grain! He obtained 20 MT/acre silage corn yield at 65 % moisture from 50 acres, 182 bushels grain corn from 25 acres, and 2.1 MT/acre winter rye (cultivar Hazlet) grain yield and 10 large bales of straw/acre from 40 acres.
- Land clearing and tile drainage on farms continued!
- *Sale of Galega seed has been on the rise. 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 6,000 MT grains (1,400 MT higher than last year) at a value of ~2.0 million dollars this year 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.

For details, refer to the Chapter on Extension and Outreach (Pages 162 – 173).

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