2. Summary of Research Results 2014

2.1 Screening of crop varieties:

2.1.1 Spring Cereals:

New western wheat varieties (2014):

- Thirteen new western hard red spring wheat varieties were compared with *Sable*.
- Three varieties that gave higher grain yield than *Sable* (5,485 kg/ha) and ≥ grain yield of *WR859CL* (6,416 kg/ha) were *AAC Ryley* (6,786 kg/ha), *CDN Bison* (6,594 kg/ha) and *GP097* (6,455 kg/ha).
- Grain protein content was highest in Sable (16.1 %) followed by *CDN Bison* (15.6 %), *WR859CL* (15.4 %) and *AAC Ryley* (14.6 %).
- Highest grain N removal (165 kg/ha) was recorded in *WR859C*/ and *AAC Ryley*.
- Only *AAC Chiffon* and *AAC Prevail* produced ≥ 8,850 kg/ha straw. Straw yield in high grain yielding varieties ranged from ~7,500-7,800 kg/ha.
- *AAC Chiffon* registered the highest biomass production (15,166 kg/ha) followed by *CDN Bison*, *AAC Ryley* and *WR859CL* (all three ≥ 14,200 kg/ha).

New western wheat varieties (2013):

- Ten newly registered varieties were compared with *Sable* and *WR859CL* as checks.
- Highest grain yields were obtained with *HY1312* (6,231 kg/ha), *AAC Innova* (5,937 kg/ha) and *AAC Proclaim* (5,857 kg/ha); same trend as last year! Grain yields of *Sable* and *WR859CL* were 5,649 kg/ha and 5,809 kg/ha, respectively.
- *AAC Innova* produced the highest straw (9,023 kg/ha) and biomass (14,960 kg/ha) yields; same trend as last year! *AAC Innova* was the only variety that recorded higher straw yield than *Sable* (8,071 kg/ha).
- Grain protein content was 16 %/or ~16 % in *BW931*, *AAC Redwater* and *AAC Bailey*. Varieties that had 15 %/or ~15 % grain protein were *Sable*, *BW931*, *HY1312*, *AAC Innova* and *WR859CL*.
- Producers may consider adding *AAC Innova* and *HY1312* to their cropping systems.

Durum wheat/Triticale:

- Ten durum wheat, three triticale and two spring wheat (as checks) varieties were evaluated.
- Triticale grain yields (5,811 kg/ha in *Taza* to 6,072 kg/ha in *Bumper*) were higher than the durum wheat varieties (3,514 kg/ha in *Eurostar* to 4,429 kg/ha in *Enterprise*). *AAC Current* was the only other durum wheat that gave >4,000 kg/ha grain yield. Grain yield of *Hallmark*, the only Ontario durum wheat, was low (3,743 kg/ha).
- Grain yield of *Sable* (5,850 kg/ha) was ~700 kg/ha higher than that of *Helios*. *Sable* produced ~1,400 kg/ha more straw than *Helios*. *AAC Raymore* (durum) produced the highest straw yield (9,463 kg/ha).
- Grain protein content was highest (16.2 %) in *AAC Marchwell* followed by 15 .9 % in *AAC Raymore* and 15.3 % in *AAC Current/and AAC Durafield,* was 13.6 % in *Sable*, 14.5 % in *Helios* and ranged from 10 8 % (*T-200*) to 11.9 % (*Bumper*) in triticale. *Bumper* recorded the highest biomass yield (14,265 kg/ha).
- Highest grain N removal (127 kg/ha) was recorded in *Sable*.

Canadian/US Wheat Varieties:

- Seven selected high yielding varieties were compared.
- Three varieties that gave higher grain yield than the standard checks (*Sable*: 5,682 kg/ha; *WR859CL*: 5,842 kg/ha) were *Minnedosa* (6,430 kg/ha), *Prosper* (6,404 kg/ha) and *Megantic* (6,215 kg/ha).
- *Megantic* produced the highest straw yield (7,584 kg/ha).
- Grain protein was more than 14 % in *Sable*, *CM 9004* and *Barlow* and above 13 % in other varieties.

Older Wheats:

- Older wheat varieties (*Pembino, Saunders, Thatcher, Marquis, AC Michael, Red Fife, AC Mimi, Garnet* and *Kamut*) were compared with *Sable* and *Amber* (a dwarf wheat).
- In the older varieties, grain yield ranged from 2,964 kg/ha (*Garnet* that produced the highest grain yield last year) to 4,758 kg/ha (*AC Michael*). Straw yields from *Marquis* (7,923 kg/ha), *AC Michael* (7,325 kg/ha) and *Pembino* (7,254 kg/ha) were higher than those from other varieties (6,070 kg/ha in *AC Mimi* to 7,108 kg/ha in *Thatcher*).
- Grain yields of *Sable* (5,329 kg/ha) and *Amber* (5,214 kg/ha) were similar; though the straw yield was higher with *Sable* (7,320 kg/ha) than that with *Amber* (6,549 kg/ha).

Additional Wheat Varieties Demonstration:

- Out of 6 varieties, *CM9004*, which gave the highest grain (4,764 kg/ha) and straw (8,623 kg/ha) yield, had the lowest grain protein content (13.8 %).
- Highest grain protein content (18.9 %) was found in *Sable*, which had the lowest grain yield (~3,000 kg/ha) in this demonstration trial.

Eastern Barley Varieties:

- Six high yielding barley varieties were evaluated.
- Three varieties (*Amberly*, *Cyane* and *Oceanik*) produced ≥ 6,200 kg/ha grain yield and the other three (*Chambly*, *Synasolis* and *Encore*) up to/< 5,800 kg/ha grain yield. However, the yield differences between the varieties were non-significant.
- Highest grain protein content (10.1-10.3 %) was found in *Chambly*, *Encore* and *Oceanik*.
- Straw yield ranged from 5,061 kg/ha in *Synasolis* to 6,922 kg/ha in *Chambly*.

Specialty Barley Varieties:

- Twelve barley (food, malting and feed) varieties were compared.
- *CDC Austenson* (7,612 kg/ha), *AAC Synergy* (6,745 kg/ha), and *Merit 57* (6,904 kg/ha) were the three top grain yielding varieties. *Celebration* recorded 6,636 kg grain yield/ha.
- In the food barley, *Roseland* grain yield (6,046 kg/ha) was ~1,200 kg/ha > *Millhouse*.
- *Black barley* (16.1 %), but not *Millhouse* (12.8 %) had the highest grain protein content. Grain protein ranged from 8.8 % to 11.1 % in other varieties.
- *Millhouse* produced the highest straw (6,775 kg/ha) and *CDC Austenson* the highest biomass (14,045 kg/ha) yield. Two other varieties that gave >6,400 kg/ha straw yield were *CDC Austenson* and *Roseland*.
- Grain N removal was the highest by *Celebration/CDC Austenson* (117/116 kg/ha).

Additional Barley Varieties Demonstration:

- Six high yielding barley varieties were demonstrated. *Synasolis* produced the highest grain yield (6,904 kg/ha) and *Encore* the highest straw yield (~9,000 kg/ha).
- *Amberly* was the second best variety for grain (6,103 kg/ha) as well as straw (8,547 kg/ha) production.
- Grain protein content was highest in *Amberly* (13.2 %)/and *Oceanic* (13.1 %) and ranged from 11.1 % (*Synasolis*) to 12.2 % (*Cyane*) in other varieties.

Older Barley Varieties Demonstration:

- *Chapais*, *Brucefield*, *AC Klinck*, *Binscarth* and *Cyane* were compared for grain and straw yields. *Chapais* (5,954 kg/ha) out yielded all other varieties in grain production! The next best varieties in grain yield were *Cyane* 5,371 kg/ha) and *Brucefield* (~5,300 kg/ha).
- *Binscarth* that had the poorest grain yield (~3,400 kg/ha) produced the highest straw yield (~7,200 kg/ha). *Cyane* (6,715 kg/ha) was the second best variety in straw production.

Hulless Barley Varieties/Blue Tinge Ethiopian Emmer Wheat Demonstration:

- Grain yield from *Millhouse* (standard check) was poor (2,660 kg/ha) as compared to two new six row hulless varieties (*CH2226N-3*: 7,255 kg/ha and *AAC Azimuth*: 7,220 kg/ha).
- Black barley was too slow/late to mature with the poorest grain yield of 1,202 kg/ha.
- Grain yield of *Blue Tinge Ethiopian Emmer wheat* wasn't too bad (3,183 kg/ha; 17.4 % grain protein). The grains from this wheat could be eaten the same way as rice grains.
- *Millhouse* registered the highest straw production (13,046 kg/ha); almost double than the straw yield from the new six row hulless varieties.

Malting Barley Varieties:

- *AAC Synergy* (7,147 kg/ha) and *Bentley* (6,817 kg/ha) were the two highest grain yielding varieties out of the 7 varieties evaluated. Grain yield of *Newdale*, one of the check varieties, was only 5,926 kg/ha.
- Straw yield was also higher with *AAC Synergy* (~6,000 kg/ha) and *Bentley* (~5,700 kg/ha kg/ha) than with other varieties (4,852 – 5,461 kg/ha).
- Grain malting quality was more or less similar with all varieties; with plump grains ranging from 96 % (*Newdale*) to 98 % (*AAC Synergy and Bentley*), except that the sprouted grains were highest (6 %) in *CDC Meredith*.

Barley Varieties for Silage:

- Seven six row and eight two row barley varieties from the east and the west of Canada were compared with a new forage oats variety (*CDC Haymaker*), which wasn't the top yielding variety this year (7,455 kg/ha) as was the case last year.
- Forage dry matter yield ranged from 5,048 kg/ha (*Amberly*) to 6,810 kg/ha (*Oceanik/and Sundre*) in 6 row barley and from 5,542 kg/ha (*Taylor*) to 8,849 kg/ha (CDC Coalition) in 2 row barley.
- Averaged over varieties, forage dry matter from two row barley varieties was 1,313 kg/ha more than that from six row barley varieties.
- Protein content ranged from 7.5 % (*Cyane*) to 12.6 % (*Synasolis*) in six row barley varieties and from 7.3 % (*CDC Coalition*) to 11.4 % (*Taylor*) in two row barley varieties. Averaged over varieties, Protein content in six row barley varieties was ~2 % point higher than in the two row barley varieties.
- RFV ranged from 81 (*Cyane*) to 100 (*Synasolis*) in six row barley varieties and from 83 (*Taylor*) to 108 (*CDC Coalition*) in the two row barley varieties.
- *Research in the past at TBARS has indicated that CDC Coalition was a good dual purpose variety (for silage as well as grain production).*

Western Oat varieties:

- Fourteen varieties, including some Ontario varieties as checks, were evaluated.
- *Stride* gave the highest grain yield (7,728 kg/ha). The next best varieties in grain production were *Summit* (7,373 kg/ha) and *Vitality* (7,293 kg/ha). Grain yield of *AC Rigodon,* a standard check, was relatively low this year (6,723 kg/ha).
- In the hulless oats, *Navaro* (5,190 kg/ha) had better grain yield than *Gehl* (3,744 kg/ha).
- *Navaro* produced the highest straw (8,680 kg/ha) and *Stride* the highest biomass (14,922 kg/ha) yield.
- Grain protein content ranged from 9.4 % in *Stride*/and *Vitality* to 15.1 % in *Gehl*. Most other varieties had 10-11 % grain protein.

2.1.2 Winter Cereals:

Ontario Winter Wheat Varieties:

- *Princeton, AC Morley* and *Keldin* had the poorest winter survival (up to 15 %) and consequently the poorest grain yields (3,072-3,957 kg/ha).
- Highest grain yield was recorded by *CDC Falcon* (8,019 kg/ha). Other varieties that produced > 7,000 kg/ha grain yield were *Stanford* (7,323 kg/ha), *Priesley* (7,132 kg/ha) and *Whitebear* (7,001 kg/ha).
- *Keldin* had the highest grain protein content (14 %). Grain protein content in all other varieties (12.6-13.6 %) was above an acceptable level.
- Grain N removal was the highest (>150 kg/ha) in *CDC Falcon* and *Stanford*.
- *Stanford* produced the highest straw yield (8,885 kg/ha) ~900 kg/ha > *CDC Falcon* and *Priesley*.
- Highest biomass yield (16,208 kg/ha) was recorded with *Stanford*; followed closely by *CDC Falcon* (16,025 kg/ha).

Manitoba Winter Wheat Varieties:

- Twelve varieties were evaluated.

- *Swainson* (8,975 kg/ha), *CDC Falcon* (8,560 kg/ha) and *CDC Chase* (8,526 kg/ha) produced the highest grain yields. Grain N removal by these varieties was ≥160 kg/ha.
- Grain protein content was highest (15.5 %) in *CDC Chase*, and was similar in *CDC Falcon* (11.6 %) and *Swainson* (11.4 %).
- Only two varieties, *CDC Chase and Swainson*, had over 10 MT/ha straw yield and over 19 MT/ha biomass yield.

Winter Rye Varieties:

- Fifteen winter rye varieties (including 10 hybrids) were compared.
- Grain yield ranged from 7,558 kg/ha (*Guttino*) to 10,391 kg/ha (*AC Rifle*) and the straw yield ranged from 5,948 kg/ha (*KWS-H 127*) to 10,015 kg/ha (*KWS-H 132*).
- Three top grain yielding varieties that produced more than 10.2 MT grain yield/ha were *AC Rifle*, *KWS-H 132* and *Hazlet*. Same three varieties registered the highest straw (9.5-10.0 MT/ha) and the biomass yields (≥20 MT/ha).
- Grain protein content in high grain yielding varieties was 7.8 % (*AC Rifle*), 8.4 % (*KWS-H 132*) and 11.1 % (*Hazlet*).
- *Winter rye could be a good option for feed grain/and straw production!*

2.1.3 Grain Legumes and Oil Seeds Varieties:

Soybean Varieties:

- Out of 36 soybean varieties evaluated, only three (*Bishop R2*, *P001T34R* and *P002T04R*) matured by the time of killing frost on September 18.
- Highest grain yields were obtained with *NSC Tilston RR2Y* (2,503 kg/ha), *McLeod* (2,500 kg/ha) and *NSC Reston RR2Y* (2,327 kg/ha).

Camelina Varieties:

- Only three out of the six varieties evaluated gave > 1,000 kg/ha seed yield; *Orovata*: 1,337 kg/ha, *Glacier*: 1,086 kg/ha and *Jasper*: 1,027 kg/ha.
- Last year's highest yielding variety (*Calena*) had the lowest yield (429 kg/ha) this year.

Flax Varieties:

- Six varieties were evaluated for their production potential.
- *CDC Glas* gave the highest seed (3,845 kg/ha), straw (8,151 kg/ha) and biomass (12,000 kg/ha) yields. Seed yields in other varieties ranged from 2,906 kg/ha (*CDC Sorrel*) to 3,345 kg/ha (*CDC Bethune*).
- Seed oil content was highest (42.5 %) in *CDC Bethune*/and *Lightning*.

2.1.4 Forage Crops Varieties:

Alfalfa Varieties and Cutting Management OFCC 2012:

- Six varieties were compared for 2 and 3 cuts. In the two cuts, *GS-11-08* (8,626 kg/ha), *GS-11-03* (8,444 kg/ha) and *GS-11-9* (8,430 kg/ha) were the three top yielding varieties in the total dry matter yield during 2013 and 2014.
- In the three cuts, *GS-11-03* (11,418 kg/ha), *GS-11-08* (10,871 kg/ha), and *55V48* (10,490 kg/ha) were the three top ranking varieties in the total dry matter yield during 2013 and 2014.

Alfalfa Varieties OFCC 2013:

- *GS-13-06 M* recorded the highest dry matter yield (6.617) from the two cuts. However, this wasn't significantly higher than the dry matter yield from *GS-13-08 SC* (6,197 kg/ha) or that from the two check varieties (*55V48*; 5,873 kg/ha and *OAC Superior*; 5,987 kg/ha).

Red Clover Varieties OFCC 2012 (Reseeded in 2013; first harvest in 2014):

- Dry matter yield of 4 varieties were statistically similar (*Belle*; 4,121, *GS-11-02*; 4,014, *AC Endure*; 3,957 and *Tempus*; 3,662 kg/ha).

Tall Fescue Varieties OFCC 2012:

- *Courtenay* (13,478 kg/ha), *Carnival* (12,803 kg/ha) and *Tower* (11,992 kg/ha) had statistically similar (two years total) dry matter yields.

Orchardgrass Varieties OFCC 2012:

- Two years total dry matter yields were ≥11,110 kg/ha in *Dividend VL, Okay* and *Proper*, and <10,400 kg/ha with *Echelon*. The yield differences were however non-significant.

Forage grasses heading dates 2013:

- In orchardgrass, *AC Killarney* (June 11) and *Okay* (June 12) were earlier to bloom than *Dividend VL* (June 16), which was reported to be an early blooming variety. *Echelon* and *Proper* were the last to head (June 23).
- In Timothy, all varieties bloomed between June 22 (*Richmond*) and June 26 (*Climax*).

Alternate Forages:

Comparative Performance of Annual and Perennial Forage Legumes:

- Highest total dry matter yield of 16,756 kg/ha (over 2011-'14) was obtained from Galega, a perennial forage legume from the Scandinavian countries, seeded @ 25 kg/ha. This was 2,630 kg/ha (~20 %) higher than the dry matter yield from alfalfa.
- Increasing seed rate of galega from 25 to 45 kg/ha didn't help in increasing its yield.
- Inter seeding berseem in galega and berseem/or red clover in alfalfa didn't help in improving the forage yields.
- Dry matter yield of Fenugreek (one cut only) was only 59 % and 56 % of that from alfalfa and Galega, respectively.
- First cut protein content in galega @ 25 kg seed/ha (26.1 %) was higher than that in alfalfa (22 %). In the 2nd cut, protein content in Galega at different seed rates was either similar or somewhat better than alfalfa.
- Alfalfa + berseem in the first cut (141) and berseem alone in the second cut (179) recorded the highest RFV.

Berseem, Barley, Oat and Fenugreek for Forage and Grain production:

- Highest forage dry matter yield (8,801 kg/ha; 1,213 kg/ha higher than barley alone) was recorded with berseem clover (full seed rate + barley @ 50 % seed rate).
- Intercropping berseem with oats didn't improve the forage dry matter yield, but increased the grain production by ~1,700 kg/ha @ 50 % seed rate of oats and by 2,560 kg/ha @ 70 % seed rate of oats.
- Barley + berseem intercropping didn't increase the grain yield of barley as compared to its pure crop.
- Forage dry matter yields from berseem (4,018 kg/ha) and fenugreek (3,660 kg/ha) were significantly lower from those from oats (7,285 kg/ha)/or barley (7,588 kg/ha).
- Forage protein content was in the order of berseem (17.9 %; first cut) > fenugreek (10.5 %) ≥ oats/and berseem + barley @ 70 % seed rate (10 %) > barley (9.2 %).
- In the second cut (berseem), protein content was ≥ 20 % in all treatments except berseem + oats @ 50 % seed rate (17.8 %).

Cereals/Flax Intercropping (seeded in the same rows) for Silage and Grain:

- Forage dry matter yields from pure crops of wheat, barley, oats and flax were 11,613, 11,338, 10,866 and 10,042 kg/ha.
- Intercropping oats and flax @ 50 % seed rate of each crop raised the forage dry matter yield to 13,307 kg/ha (2,441 kg/ha than oats alone).
- Intercropping wheat and flax (wheat @ 75 % seed rate and flax @ 50/or 75 % seed rate) increased the forage dry matter yield to ~12,200 kg/ha (~600 kg/ha more than wheat alone). Intercropping barley and flax didn't help in increasing the forage yield.
- Protein content in flax forage (12.3 %) was higher than that in the cereal forages (9.8-10.8 %)/or the cereals flax intercropping systems (6.8-11.1 %) except wheat flax intercropping @ 50 % seed rate of each; which had 12.8 % protein and also the highest RFV (145).
- Grain yield of pure crops of wheat, barley, oats and flax were 5,217, 6,354, 8,158 and 3,183 kg/ha, respectively. In the previous years too we have seen that oats will out yield other cereals in wet years (as was the case this year).

- Intercropping wheat and oats, but not barley, with flax significantly lowered the cereals grain yields. However, total grain/seed productivity from barley flax intercropping @ 50 % seed rate of each crop was ~600 kg/ha greater than barley alone. At the same population mix of wheat and flax, grain productivity was ~330 kg/ha than wheat alone.

Wheat/Flax Intercropping (alternate rows) for Silage and Grain:

- Pure crops of wheat (8,922 kg/ha) and flax (8,015 kg/ha) produced higher forage dry matter yields than their intercropping in different proportions; except the intercropping with 50 % seed rate of both the crops that gave almost as much dry matter yield (7,857 kg/ha) as pure flax. Forage protein content (~11 %), in these treatments, exhibited the same trend as the dry matter yield.
- Individual crops' grain yields were higher (wheat: 4,085 kg/ha; flax: ~3,000 kg/ha) than the grain yield of the two crops in the intercropping systems.
- Protein content in flax seed (24.6 %) was higher than grains from pure (19.3 %) or intercropped wheat (18.4-18.7 %).

2.2 Evaluation of Pulses:

2.2.1: Spring pulses:

Chickpea varieties:

- Four Kabuli and two Desi varieties were compared. Due to cold and wet year, the chickpea in this trial didn't mature fully and the grain yields weren't worth reporting.
- Straw yield was highest with Desi *CDC Corinne* (6,124 kg/ha) followed by Kabuli *CDC Orion* (5,311 kg/ha).
- *CDC Corinne* recorded the highest grain protein content (25.9 %).

Effect of different herbicide on late (July 10) seeded chickpea:

- Pre-emergence application of Sencor @ 925 g/ha gave perfect control of weeds and resulted in 4,511 kg/ha biomass yield of chickpea.
- Rival applied as pre plant incorporation @ 2.3 l/ha wasn't better than Sencor in weed control; though it equaled Sencor in biomass yield (4,580 kg/ha).
- Pursuit applied as pre or early post emergence @ 310 ml/ha wasn't effective in weed control and had low biomass yield (2,436 or 3,254 kg/ha). Tank mixing Basagran Forte @ 1.5 l/ha with Pursuit @ 210 ml/ha for early post emergence didn't improve efficacy of Pursuit in weed control/or improving the biomass yield.
- The vegetative biomass of chickpea had 22.6 % protein content. Late seeded chickpea (which wasn't killed by the normal killing frost) could therefore be used as a forage/or a cover crop.

Lentil varieties:

- Five lentil varieties were tested for their production potential.
- Only two varieties could give some reasonably good grain yield in a cold year (*Redberry*: 2,307 kg/ha and *CDC Viceroy*: 2,067 kg/ha).
- *CDC Viceroy* had higher grain protein content (31.7 %) than *Redberry* (26.1 %).
- *Lentils offer a protein rich alternate food to vegetarians!*

Field pea varieties:

- *CDC Treasure* produced the highest grain yield (~6,000 kg/ha). Two next best varieties in grain yield were *CDC Hornet* (5,090 kg/ha) and *Sorento* (4,940 kg/ha). Grain protein in these varieties varied from 20.1 % to 22.4 %.
- *Gold Harvest Bush Pea*, a specialty pea variety with golden grains and chestnut flavour, grain yield was ~2,800 kg/ha and it had high protein content (25.4 %). This variety could be good for growing in the gardens for home/or local consumption.

Edible beans varieties:

- Five edible beans varieties were evaluated for their production potential.
- Highest grain yield (3,876 kg/ha) was recorded with *Earlired*. The next best varieties in grain yield were *Pintoba* (3,480 kg/ha) and *Carman* (3,209 kg/ha).
- As in the previous years, *Pintoba* recorded the highest grain protein content (24.1 %); though *Earlired* with a grain protein content of 23.8 % was equally good.

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

2.2.2: Winter Pulses (peas and lentils):

- Winter peas and lentils (seeding dates in peas/lentils and pea varieties) were winter killed.

2.3 Introduction of New Cover Crops:

Effect of cover crops in/after spring barley for silage in 2013 on soybean in 2014:

- Cover crops or the soybean didn't receive any fertilizers.
- Soybean grain yields were too low (776-1,217 kg/ha), due to cold wet weather to express any significant effect from the cover crops/or to make any meaningful conclusions.
- However, higher soybean grain yields were obtained with/after buckwheat, turnips and red clover as cover crops than with the other cover crops (winter rye, tillage radish, berseem clover, forage peas or mixture of the cover crops).
- Grain nutrients contents didn't seem to differ much with the different cover crops.
- Post-harvest soil analyses indicated that pH and available micronutrients contents were not affected by the cover crops. However, some of the cover crops seemed to reduce the available P and K (see details in the report).

Optimizing population for spring barley + winter wheat for silage; seeded in spring 2013:

- In western Canada, the recommended practice is to seed spring barley and winter wheat each @ 75 % population. Our results indicated that spring barley + winter wheat (75 %:85 % recommended seed rate) produced ~1,400 kg/ha extra dry matter yield than the 75 %:75 % mix of the two crops. However the practice didn't give higher yield than the pure crop of barley. The trend in dry matter yield was similar over the average of two crop cycles even though the magnitude of yield differences varied.

Winter wheat co seeded with barley could serve as a good cover crop and could be left for fall grazing/or for forage/grain production in the next spring.

2.4 Fertilizer Management Practices:

2.4.1 Spring Cereals:

Comparative efficiency of urea and ESN for grain and forage production of barley:

- Application of 70 kg N/ha through urea/or ESN with or without supplementing part N (10 kg/ha) with ammonium sulphate significantly increased the grain yield of barley as compared to no N (1,720 kg/ha increase with urea @ 70 kg N/ha).
- Grain yield with urea @ 70 kg N/ha (normal practice) was 6,535 kg/ha; none of the other N fertilizer treatments/blends gave higher grain yield than this treatment.
- Straw yield (7,035 kg/ha) and total N removal (183 kg/ha) was highest with ESN @ 60 kg N/ha + ammonium sulphate @ 10 kg N/ha.
- Grain protein (trial mean 10.8 %) didn't vary much with the N fertilizers/blends. Though the grain protein content was highest (11.2 %) with ESN @ 70 kg N/ha.
- Application of urea/or ESN @ 70 kg N/ha with or without supplementing 10 kg N/ha from ammonium sulphate increased the forage dry matter yield as compared to no N by 1,275-3909 kg/ha.
- Highest dry matter yield (8,903 kg/ha) and RFV (111) was obtained with application of 50 kg N/ha as urea and 20 kg N/ha as ESN; as against 7,406 kg/ha dry matter yield and 97 RFV with urea @ 70 kg N/ha.
- In a straight comparison @ 70 kg N/ha, ESN didn't prove better than urea.
- Forage protein content was the highest (12.8 %) when N was supplied from the three fertilizers (urea @ 40 kg N/ha, ESN @ 20 kg N/ha and ammonium sulphate @ 10 kg N/ha). The protein content with urea @ 70 kg N/ha (standard practice) was 9.6 %.

Fall vs. spring application of N fertilizers (urea and ESN) for spring wheat production:

- The experiment was conceived in the late fall last year and the fall application of N was made at the end of the fall (almost winter time). Hence the N from urea and ESN wouldn't have transformed to the nitrate form.
- Maximum grain yield (5,048 kg/ha) was obtained with the fall application of N @ 80 kg N/ha; in two equal halves from urea and ESN. This wasn't significantly higher than the grain yield with spring application of N at the same rate either from urea alone or from the two fertilizers each applied @ 40 kg N/ha (~4,800 kg/ha in both cases).
- Averaged over different treatments, grain yield appeared to be higher with spring than with the fall application of N, and there was no significant difference in the yield between the two N fertilizers (urea and ESN).
- Grain protein content ranged from 12.8-15.3 % and was highest with the spring applied ESN @ 80 kg N/ha, which recorded the highest grain N removal (114 kg/ha). *This means that the ESN had the higher N use efficiency than urea!*
- Application of N increased the grain Zn content (desirable from human health point of view). Highest grain Zn content (40 ppm) was registered with spring application of the two fertilizers; each applied @ 40 kg N/ha (total 80 kg N/ha).
- Spring applied urea @ 80 kg N/ha produced the highest straw yield (~6,000 kg/ha).

Response of organic and conventional wheat varieties to phosphorus (P) application:

- Application of P_2O_5 @ 20 kg/ha didn't increase grain, straw or total biomass yields of any of the conventional (*Unity VB, Goodeve,* and *Stettler*) or organic/older wheat varieties (*Spelt*, *Red Fife* and *Kamut*) significantly. Even though, application of P appeared to improve grain yields of *Unity VB*, *Stettler* and *Kamut*.
- *Spelt* (4,087 kg/ha) and *Unity VB* (3,956 kg/ha) recorded the highest grain yields.
- Straw (5,916 kg/ha) and biomass (9,872 kg/ha) yields were the highest with *Unity VB*.
- Grain protein content was higher in *Stettler* (19 %) and *Kamut* (18.3 %) than in the other varieties (12.8 % in *Spelt* to 17.5 % in *Goodeve VB*).
- Soil P tests came down by 1.7 ppm without application of P.
- Nutrients removal per MT by straw is given in the report.

Effect of copper (Cu) and boron (B) on spring wheat:

- Application of Cu or Cu + B didn't increase the grain, straw or biomass yield of wheat significantly. Maximum increase in grain yield (365 kg/ha) was observed with application of Cu @ 2.5 kg/ha.
- Grain protein content was ~1 % point higher with Cu @ 5 kg/ha or Cu @ 5 kg/ha + B @ 1 kg/ha as compared to the check (no Cu or B).
- DON level in grains was below detectable limits in almost all treatments.

Effect of sugar (C, H & O) on spring wheat:

- Application of sugar @ 50 or 100 kg/ha at seeding had no significant effect on wheat grain, straw or biomass yield; there was only a marginal increase in grain yield (127 kg/ha) with sugar application @ 50 kg/ha.

2.4.2 Winter Wheat:

Comparative performance of urea, ESN and their blends in winter wheat: Urea/or ESN alone or their blends @ 120 kg N/ha applied at seeding were compared with the recommended practice of applying urea @ 10 kg N/ha at seeding and 110 kg N/ha in early spring.

- Urea @ 120 kg N/ha applied at seeding gave a little higher grain yield (6,180 kg/ha) than the OMAFRA recommended practice of applying 10 kg N/ha at seeding and 110 kg N/ha in early spring (5,960 kg/ha).
- ESN applied at seeding @ 120 kg N/ha produced nearly 400 kg/ha extra grain yield as compared to urea applied at the same rate and time.
- Grain yields from blends of urea and ESN at 25 % and 50 % N from urea and the rest from ESN equaled in grain yield from ESN alone that had the maximum grain protein content (13.3 %).
- Straw (7,121 kg/ha) and biomass (13,682 kg/ha) yields were highest with ESN @ 120 kg N/ha.

Optimum Rate of Sulphur Application for Winter Wheat and Winter Barley:

- Application of S @ 24 kg/ha improved only the winter wheat grain yield by ~700 kg/ha. Averaged over winter wheat and barley, increase in grain yield by S was insignificant. Grain protein content in the two crops was unaffected by S application.
- Winter barley grain yield was only about 44 % of the winter wheat grain yield (~6,500 kg/ha). Low yield of winter barley is ascribed to poor/scanty stand in some of the plots.
- The experiment may be repeated in winter wheat in 2015.

2.4.3 Grain Legumes and Oil Seeds:

Frequency of application of Lime and Wood ash (3 harvest years of alfalfa-3 years barley-3 years soybean – 1st year canola):

- Lime/and wood ash were applied in spring 2004 (seeding year) and in falls of 2006, 2008 2010 and 2012 in the 'after every two years' frequency of application treatments. In falls 2008 and 2012, wood ash/and lime were applied in the 'after every 4 years' frequency of application treatments as well. Treatments with lime/and wood ash 'after every 6 years' and 'after every 8 years' received second application of the amendments in the falls 2010 and 2012, respectively. Canola was the test crop in 2014.
- Frequency of wood ash/and lime application had no significant effect on canola seed yield; though the 2 and 4 years frequency of application appeared to out yield the 6 and 8 years' frequencies.
- Averaged over frequencies of application, lime alone didn't improve the canola seed yield as compared to the check (no lime/or wood ash application).
- *Application of wood ash increased the canola seed yield by 411kg/ha*. Combined application of lime and wood ash (50:50 proportion) increased the seed yield only marginally by 100 kg/ha.
- Soil analyses for heavy metals after 10 years of the start of the experiment didn't show higher heavy metals contents in the soil with wood ash than that with lime, except Arsenic. However the Arsenic content with wood ash was lower than that in the check treatment (no wood ash/or lime application).

Manure, wood ash and fertilizer nutrients (3 harvest years of alfalfa-3 years barley-3 years soybean – 1st year canola):

- Solid dairy manure was applied in the springs of 2004 and 2007, and falls of 2008, 2010 and 2012; wood ash was applied in spring 2004 and in the falls of 2006, 2008, 2010 and 2012. The fertilizer nutrients were applied every year.
- Manure/or manure + wood ash had a larger impact on canola seed yield than wood ash alone and increased the seed yield by 2,500 kg or more/ha.
- Seed yield increase by wood ash alone was 1,310 kg/ha (statistically significant).
- Among the fertilizer nutrients, S had the biggest impact on canola seed yield (yield improvement of ~1,130 kg/ha). Increase in the seed yield by the application of N, P and K was 816, 231 and 150 kg/ha, respectively.
- Highest seed yield of 4,002 kg/ha was obtained with the application of N, P, K and S.

Effect of N and liquid zinc (sprayed @ 4.5 l/ha at 50 % flowering) on canola yield:

- Increasing the rate of N application from zero to 80, and from 80 to 120 kg/ha increased the seed yield significantly. Seed yield at 120 kg N/ha was 5,488 kg/ha.
- On the contrary, liquid zinc spray didn't bring any yield improvement.
- Nutrient removal per MT of straw was 9.7 kg N, 1 kg P (2.3 kg P_2O_5), 13.4 kg K (16.1 kg K_2O), 3.2 kg S, 8.9 kg Ca, 2.5 kg Mg, 5.6 kg Na (sodium), 9.8 g B, 9.5 g Zn, 7.5 g Mn, 56.8 g Fe (iron) and 1.5 g Cu (copper). While baling straw, farmers may wish to replenish the essential nutrients removed by the straw.

P and S requirements of chickpea:

- Due to cold and wet year, the chickpea in this trial was prematurely hit by a killing frost.
- Application of P @ 20 kg P_2O_5 seemed to improve the biomass yield that remained unaffected by the application of S @ 8, 16 or 24 kg/ha.

Effect of sugar (C, H & O) on soybean:

- Application of sugar @ 50 or 100 kg/ha at seeding had no significant effect on soybean grain yield; there was only a marginal increase in grain yield (81 kg/ha) with sugar application @ 50 kg/ha.

2.4.4 Forages:

Alfalfa:

Fertilizing for persistence and maximum yield of alfalfa:

- OMAFRA recommended practice of applying only P and K to alfalfa resulted in the lowest dry matter yield (3,483 kg/ha) in the ninth harvest year. Application of N and S in addition to P and K improved the dry matter yield by ~1,250 kg/ha.
- Treatments that produced >5,000 kg/ha dry matter yield were N, P, K, S, B & Zn or N, P, K, S, B, Zn & Mn with manure/or wood ash or both (applied only two out of the past 10 years). These treatments resulted in a total productivity of ~50 MT dry matter/ha in 9 harvest years (5.56 MT/ha/year, which is pretty good in the long run!).
- Highest protein content (18.1 %) in the first cut was recorded with the application of N, P & K and with application of N, P, K, S, B, Zn & Mn with wood ash (2 out of 10 years) in the second cut (20.2 %).
- RFV was highest with N, P, K, S, B & Zn in the first cut (137) and with N, P, K, S, B, Zn & Mn in the second cut (153).
- *Thus for sustained yield of high quality alfalfa, over a longer period, regular application of N, P, K, S, B & Zn and application of manure/or wood ash once in a while is required!*

Effect of elemental and sulphate forms of sulphur on alfalfa:

- Elemental S @ 112 kg/ha produced the highest dry matter yield (6,079 kg/ha) of alfalfa. This wasn't significantly better though from the dry matter yield without S (5,838 kg/ha). S @ 28 kg/ha from ammonium sulphate produced almost as much dry matter yield (5,305 kg/ha) as 56 kg S/ha from sulphate of potash (5,531 kg/ha).
- None of the S treatments had higher protein content (20.5 %) than in the no S treatment in the first cut. In the second cut, elemental S @ 112 kg/ha gave 1.2 % higher protein content than the check (no S or K) treatment.

Grasses:

Residual effect of urea and ammonium sulphate blends applied to timothy in 2008-2011:

- In 2008-2011, urea, ammonium sulphate and their blends were evaluated for yield and quality of timothy. Last two years and this year, except the check (no N), urea @ 105 kg N/ha was applied to all treatments; thus yield difference in N treatments this year could be due to S applied in the previous years.
- Application of 105 kg N/ha increased the timothy dry matter yield by 662 kg/ha only where ammonium sulphate @ 105 kg N/ha was applied during 2008-'11.
- Protein content (16.8 %) was highest with urea @ 84 kg N/ha + ammonium sulphate @ 21 kg N/ha applied during 2008-'11.

Cost of S application could therefore be spread beyond the years of its application!

Fall vs. spring application of N to grasses (timothy and bromegrass); residual effect 2014:

- This year/or previous fall no N was applied in this experiment to study the residual effect of N applied as ESN and urea in the fall or spring in the previous 6 years regularly.
- None of the treatments produced higher dry matter yield than the check (No N treatments in the two grasses). In other words, there was no residual effect of N applied to the grasses during the previous years!

Effect of urea and its blends with ESN and ammonium sulphate on forage grasses mixture - Timothy (Itasca) 50 %, Bromegrass (Peak) 42.5 %, and Orchard grass (Dividend) 7.5 %:

- Application of N as urea @ 105 and 140 kg N/ha significantly increased the grasses dry matter yield by ~2,000 kg/ha or more as compared to the check (No N/or S).
- Increasing the rate of urea N application from 105 to 140 kg/ha improved the dry matter yield only marginally by ~200 kg/ha.

- Application of 140 kg N/ha from blends of urea (84.5 kg N/ha), ESN (35 kg N/ha) and ammonium sulphate (20.5 kg N/ha) brought in an additional 1,050 kg dry matter yield/ha as compared to 105 kg N/ha from urea and 861 kg/ha as compared to 140 kg N/ha applied from urea.
- In the first cut, protein content was highest (19.4 %) with 140 kg N/ha (105 kg N/ha from urea and 35 kg N/ha from ESN); same as last year. In the second cut, urea applied @ 140 kg N/ha resulted in the similar protein content (13.6 %) to that obtained by the same amount of N applied from the blends of urea and ESN (105 kg N/ha from urea and 35 kg N/ha from ESN).
- *The yield gain from additional 35 kg N/ha (over the recommended 105 kg N/ha) from the blends of the three N fertilizers will more than compensate extra cost of N from ammonium sulphate and ESN in the blend!*

Effect of potassium (K) and sulphur (S) on forage grasses mixture - Timothy (Itasca) 50 %, Bromegrass (Peak) 42.5 %, and Orchard grass (Dividend) 7.5 %:

- Significant effect of K and S on dry matter yield was recorded in the first cut only. The dry matter yield of grasses with the application of 70 kg K_2O/ha + 24 kg S/ha (6,010 kg/ha) equaled that from 140 kg K_2O/ha (recommended rate as per soil test) without S (6,132 kg/ha). The trend was more or less similar in the total dry matter yield from the two cuts.
- With the application of 24 kg S/ha, increasing rates of K application beyond 70 kg K_2O/ha didn't increase the dry matter yield. Rate of N, as also P, application was the same in all treatments.
- High protein content (17.5 % in the first and 13.8 % in the second cut) was registered by the application of 70 kg K_2O/ha. Only this treatment had higher RFV than the check (No K or S) and that too in the second cut only. In other words, RFV didn't seem to be influenced by K or S!

Spring and Winter Cereals:

Lime and Wood ash (first year; barley for silage):

- There was no significant effect of lime (Garden Treat Grow Lime/or Spanish River Carbonatite) and wood ash on dry matter yield of barley; though the highest dry matter yield was obtained with wood ash (4,440 kg/ha).
- Soil tests after the treatments application didn't show any differences between the treatments either.
- Spanish River Carbonatite resulted in the highest protein content (18.1 %) and RFV (101)!

Fertilizer requirements of spring barley + winter wheat (75 %:75% population) – Year 2; seeded in spring 2013-winter wheat forage production 2014 and total production from barley and wheat (2013 & 2014):

- The crop mixture was seeded in 2013 with different fertilizer combinations. Spring barley was harvested last year and barley (check treatment)/and winter wheat in 2014.
- Highest forage dry matter yield from the two crops (12,908 kg/ha) was obtained with spring barley and winter wheat seeded together at normal rates of N, and 1.25 times recommended rates of P and K application. This was ~40 % higher than the check (spring barley alone during both the years.
- Feed analysis was not done this year. Last year's results indicated that (i) RFV was highest (108) with barley + winter wheat at normal N and 1.25 times normal P and K; followed closely (106) by pure crop of barley after barley, and (ii) Protein content was highest in winter wheat (16 %) seeded as a pure crop after barley. In all other treatments, protein content ranged between 11-13 %.

Fertilizers requirements of spring barley + winter wheat seeded together; each @ 75 % of the recommended seed rate (averaged over 3 crop cycles):

- The practice of growing spring barley + winter wheat together gave ~1,100 kg/ha extra dry matter yield as compared to growing barley – barley alone in a two year crop cycle.

Increasing rates of N, P and K application above the recommended rates didn't help in increasing the dry matter yield. While N was applied every year, P and K were applied only in the first year. This amounts to saving of P and K for one crop year.

- When winter wheat alone was grown after a pure crop of barley, dry matter yield was 1,253 kg/ha higher than the two crops grown together (first year two crops, next year only winter wheat would be left).

Winter Cereals for Silage:

- Winter cereals (wheat, rye and triticale) were harvested for forage at flag leaf stage. When N was applied as urea, highest dry matter yield in winter wheat (1,441 kg/ha) was obtained @ 150 kg N/ha, and @ 100 kg N/ha in winter rye (3,081 kg/ha) and triticale (2,779 kg/ha). Substituting 25 % of N from urea with ESN improved the dry matter yield only in wheat (by 566 kg/ha) supplied with 100 kg N/ha. However, partial substitution of urea N with N from ESN improved the protein content up to 2.2 % points.
- Averaged over the winter cereals/and N sources, application of N @ 50 kg/ha increased the dry matter yield significantly by ~500 kg/ha. Further increase in the rate of N application to 100 or 150 kg/ha increased the dry matter yield only marginally, if any. Protein content was highest (20.2 %) at the highest rate of N (150 kg/ha).
- RFV was in the order of wheat (125) > rye (111) > triticale (99).
- *Cultivation of winter cereals will cover and protect the soils in fall/winter, help to cover risk of forage shortage in the event of winter kill of perennial forage crops and vacate the fields in time for another forage crop; such as sorghum Sudangrass, MasterGraze corn barley/oats, barley/or oats + peas mixture. Producers may wish to add winter cereals, to their cropping systems!*

Silage Corn/Sorghum Sudangrass:

Effect of sources and rates of N on MasterGraze corn and sorghum Sudangrass: MasterGraze is a forage corn variety that produces tillers and is harvested at tasseling stage (before silking)!

- Application of urea N increased the dry matter yield of MasterGraze corn linearly up to 150 kg N/ha and exhibited a law of diminishing returns thereafter. However, with 25 % substitution of urea N with N from ESN the yield improved somewhat further from 150 to 200 kg N/ha.
- Dry matter yield of MasterGraze corn with urea was highest (8,306 kg/ha) @ 150 kg N/ ha. Substitution of part N at this rate didn't help in yield improvement.
- Application of N @ 200 kg/ha improved the sorghum Sudangrass yield over its lower rate (150 kg/ha) by 672 kg/ha only when 25 % of the total N was applied as ESN.
- At the same rates of N dry matter yield from MasterGraze corn was 8,249 kg/ha and that from sorghum Sudangrass was 7,952 kg/ha. N removal by the two crops was the same (~200 kg/ha).
- Protein content in sorghum Sudangrass (16.4-22.9 % in the first cut and 23.1-26.2 % in the second cut) was higher than that in MasterGraze corn (9.5 % - 16.3 %). Protein content in MasterGraze corn increased with the increasing rates of N from 50 to 200 kg/ ha (11.3-17.6 %).
- Averaged over N rates, RFV in MasterGraze corn (111) equaled that in sorghum Sudangrass (112).

2.5 Other Experiments:

Effect of tillage on soybean after oat-barley-soybean-barley-soybean-barley-soybean-barley-soybean-barley:

- Eleven tillage treatment plots in each replication were split into two halves after 10 year; one half was plowed in the fall and the other left the way it was.
- Due to cold/wet year, grain yields of soybean in all treatments were too low (1,032-1,636 kg/ha) to exhibit any treatment effect. In other words, plowing after 10 years/or other tillage treatments didn't affect the grain yield of soybean significantly.

Forest Tree Research:

- Experiments to optimize afforestation of fast growing conifer tree species (Norway Spruce, White Spruce, Red Pine and European Larch) were initiated during spring 2005.
- Since the trees growth rate is too small, it was decided not to record growth observations this year.

Wild Blueberries:

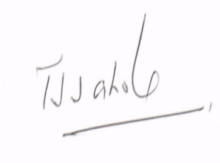
- Wild blueberry plants, collected from different places, were planted at TBARS in the fall 2010. Only one picking was done this year. Fresh fruit yield varied from 8-108 kg/ha (0.8-10.7 g/plant) with a mean value of 38 kg/ha (3.8 g/plant).
- *V. augustifolium var nigrum* from Black Sturgeon Lake had the highest yield (108 kg/ha).

2.6 Extension and Outreach:

A proactive approach to extension and outreach activities was adopted by TBARS 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 TBARS wasn't mentioned at least once. Impact of our Extension and Outreach activities could be seen in the form of favourable changes on farms. High yields in wheat and canola were especially noteworthy. Increasing number of canola growers in Thunder Bay and intercropping in forages attracted attention of Ontario Farmer. A unique feature this year at TBARS, used as a tool for effective extension and outreach, was maintenance of a separate 'Demonstration Block' to demonstrate high yielding varieties of different crops and beneficial management practices, where farmers/visitors didn't have to see a large number of plots to see recommended varieties and practices by TBARS. In recognition of my expertise in conducting summer tours, I was interviewed by Marc Zienkiewicz, Issues Ink Winnipeg, Manitoba (on conducting the summer tours) in May 2014. For details, refer to the section on Extension and Outreach in the main report.

2.7 Additional Information:

- Total nutrients (both macro and micro) removal as well as nutrients removal per MT of grains, straw and forage dry matter by various field crops is given in the report.
- Canada Malting Barley was pleased with the excellent quality of malting barley grown at TBARS.
- Based on several years winter wheat research data provided by TBARS to AGRICORP, Northern Ontario (the districts of Algoma, Cochrane, Kenora, Muskoka, Parry Sound, Rainy River, Sudbury, Thunder Bay, Timiskaming and the county of Haliburton) was covered for winter wheat Crop Insurance by the AGRICORP.



Dr. Tarlok Singh Sahota CCA **December 5, 2014**
Director of Research and Business