2. Summary of Research Results 2013

2.1 Screening of crop varieties:

2.1.1 Spring Cereals:

Specialty Wheat:

- Eleven varieties of wheat (mostly hard red from the western Canada) were compared.
- *Minnedosa* (4,896 kg/ha), *NRG010* (4,417 kg/ha), and *Enchant,* a midge tolerant variety (4,088 kg/ha), topped in grain yield and nutrient use efficiency. Grain yield of *WR859CL* was 4,066 kg/ha and that of *Sable* was 3,836 kg/ha.
- *NRG010* produced the highest straw (~6,400 kg/ha) and biomass (10,810 kg/ha) yields, followed closely by *Enchant* (straw 6,057 kg/ha; biomass 10,145 kg/ha).
- Grain protein content ranged from 14.7 % in *Minnedosa* to 19.3 % in *WR859CL/*and *Stettler*. Other varieties that had 18 % or more grain protein content were *Sable, Waskada, Goodeve, Enchant and BW901*.

New western wheat varieties:

- Ten newly registered varieties were compared with *Sable* as a check.
- Highest grain yields were obtained with *HY1312* (4,421 kg/ha), *AAC Innova* (4,300 kg/ha) and *AAC Proclaim* (4,214 kg/ha). Grain yield of *Sable* was 3,836 kg/ha.
- *AAC Innova* produced the highest straw (6,793 kg/ha) and biomass (11,093 kg/ha) yields followed closely by *Enchant VB* (straw 6,653 kg/ha; biomass 10,700 kg/ha).
- Grain protein content was higher in *Sable* (19.4 %), *HY1312* (19.1 %) and *AAC Bailey* (18.9 %) than other varieties (15.4 % in *AAC Proclaim* to 18.6 % in *AAC Redwater*).

Older Wheats:

- In a demonstration trial, older wheat varieties (*Pembino, Saunders, Thatcher, Marquis, AC Michael, Red Fife, AC Mimi, Garnet* and *Kamut*) were compared with *Sable*.
- *Garnet* produced the highest grain yield (3,845 kg/ha; 22.6 % higher than *Sable*). *Kamut* had the lowest grain yield (1,442 kg/ha).
- Highest straw yields were recorded with *Thatcher* and *Garnet* (6,872 & 6,834 kg/ha) and the highest biomass yield with *Garnet* (10,678 kg/ha).

Durum wheat/Triticale:

- Out of 6 durum wheat varieties compared, *Enterprise* (4,158 kg/ha) produced the highest grain (~500 kg/ha higher than Ontario's *Hallmark*), straw (9,400 kg/ha) and biomass (13,557 kg/ha) yields.
- Grain protein content (20.4 %) too was highest in *Enterprise* (2.6 % points more than *Hallmark*) though only marginally higher than *Sable* (19.8 %) and *AC Avonlea* (19.9 %).
- *T-200* gave the highest grain yield (6,131 kg/ha) among the 3 triticale varieties tested, whereas, straw (9,462 kg/ha) and biomass (14,553 kg/ha) yields were highest with *Taza* that also recorded the highest grain protein content (16.2 %).

Ontario Wheat Varieties:

- Twenty two spring wheat varieties were evaluated.
- In grain yield, *CM9004* (4,723 kg/ha), *HY 162-HRF* (4,400 kg/ha), and *Megantic* (4,260 kg/ha) were the three top yielding varieties. Grain yield from *Sable* was only 3,476 kg/ha.
- *CM9004* had the highest straw (7,436 kg/ha) and biomass (12,160 kg/ha) production.
- *AW625* (17.9 %) and *Sable* (17.5 %) had the highest grain protein content. *Megantic*, *HY 162-HRF* and *CM9004* had similar grain protein contents (15.6-16 %).

US HRS Wheat Varieties:

- There was no significant difference in grain yield of four varieties tested; though *Prosper* (4,629 kg/ha) and *WR859CL* (4,527 kg/ha) appeared to have higher grain yields than *Sable/ Barlow* (4,331/4,305 kg/ha). The trend was similar in 2012 as well.
- *Sable* produced the highest straw (6,833 kg/ha) and biomass yields (11,163 kg/ha).
- Grain protein in *WR859CL* was 19.1 % (highest) and 18.3-18.9 % in other varieties.

Ontario Barley Varieties:

- Twenty six barley varieties/lines were evaluated; 7 of which were 2 row barley.

- *Chambly* (6,010 kg/ha; 13.5 % protein), *Amberly* (5,884 kg/ha; 11.3 % protein) and *Synasolis* (5,800 kg/ha; 11.3 % protein) produced the highest grain yields. Grain yield of *Oceanik* was 5,004 kg/ha (13.9 % protein).
- *Bentley, a 2 row barley,* recorded the highest straw (6,128 kg/ha) and *Amberly* the highest biomass yield (11,810 kg/ha).
- Highest grain protein content was found in *Pandora* (17.6 %) followed by *GB092001* (16.8 %). *AC Kings*, *Harmony* and *Bornholm* had similar protein contents (15.3-15.6 %).

Specialty Barley:

- Contrary to last year, grain yield (2,924 kg/ha) from *HB 122*, a new hulless barley, was lower than that from *Millhouse* hulless barley (3,718 kg/ha).
- *AAC Synergy* (4,620 kg/ha), *CDC Austenson* (4,444 kg/ha), and *CDC Troy* (4,261 kg/ha) were the three top grain yielding varieties. *Celebration* recorded 4,214 kg grain yield/ha.
- *AAC Synergy/CDC Troy* produced higher straw (6,310/6304 kg/ha) and biomass (10,930/10,564 kg/ha) yields than all other varieties.
- *Merit 57* (17.5 %), but not *Millhouse* (13.4 %) had the highest grain protein content followed by *Quest* (*M122;* 15.1 %). AAC Synergy and CDC Coalition had similar grain protein contents (12.5/12.4 %).

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 recorded the highest forage dry matter yield (7,316 kg/ha).
- Forage dry matter yield ranged from 5,463 kg/ha (*Cyane*) to 6,851 kg/ha (*Oceanik*) in 6 row barley and from 6,097 kg/ha (*Bentley*) to 7,284 kg/ha (*TR 06294*) in 2 row barley.
- Forage dry matter yields from *TR 06294* (7,284 kg/ha), *Conlon* (7,203 kg/ha), and *CDC Coalition* (7,109 kg/ha) equaled that from *CDC Haymaker* (7,316 kg/ha). From our past experience we know that *Conlon* does well only in cold years such as 2013.
- Protein content was highest (15.7 %) in *Cyane* and *Amberly* (2 % point higher than in *TR 06294*, and 0.8 % point higher than in *Conlon*).
- *TR 06294* recorded the highest RFV (128), followed closely by *Cyane* (122), *CDC Coalition* (122) and *Conlon* (120).

Ontario Oat Varieties:

- Twenty six varieties/lines of oats were compared with each other.
- Amongst registered varieties, highest grain yields were obtained with *Vitality* (5,750 kg/ha), *AC Rigodon* (5,430 kg/ha), and *Robust* (5,410 kg/ha).
- *Idaho* (hulless) produced 48 % higher grain yield than *Navaro,* another hulless variety.
- *Cantal* recorded the highest straw (9,000 kg/ha) and biomass yields (13,500 kg/ha).
- Grain protein content was highest in *Robust* (15.9 %), medium in *Vitality* (13 %) and low in *AC Rigodon* (11.8 %).

Western Oat varieties:

- *Dieter* gave the highest grain yield (5,707 kg/ha). *AC Rigodon* (5,019 kg/ha), *Bradley* (5,082 kg/ha) and *Stride* (5,101 kg/ha) equaled in grain yield.
- *AC Rigodon* produced the highest straw (7,730 kg/ha) and biomass (12,750) yields. *AC Rigodon* could therefore be preferable to other varieties, if straw is required as well.
- Between the two hulless varieties, *Gehl* (3,831 kg/ha) appeared to give more grain yield than *Navaro* (3,314 kg/ha). The straw yields (~6,800 kg/ha) from the two varieties were more or less the same, though *Gehl* produced 5 % higher biomass yield than *Navaro*.
- Grain protein content was highest (18.6 %) in *Gehl,* followed by 17.3 % in *Bradley, Stride* and *Badger*.

2.1.2 Winter Cereals:

Ontario Winter Wheat Varieties:

- *Keldin* (6,859 kg/ha) produced the highest grain yield, though the grain yields from *Priesley* (6,397 kg/ha) and Princeton (6,356 kg/ha) were not significantly lower than that from *Keldin.* Grain protein content (~14 %) in these 3 varieties was similar.
- As also in 2012, *CDC Falcon* had the highest straw yield (7,738 kg/ha).
- Highest biomass yield (14,205 kg/ha) was recorded with *Keldin*.
- *Whitebear*, a relatively new hard white wheat variety, had the lowest grain yield (3,640 kg/ha), but the highest grain protein content (16.2 %).
- Grain protein content in all other varieties (13.9-15.9 %) was above an acceptable level.

Manitoba Winter Wheat Varieties:

- Eleven varieties were evaluated.
- *Moats* registered the highest grain (6,130 kg/ha; 2,200 kg/ha higher than *CDC Falcon*), straw (9,128 kg/ha) and biomass (15,258 kg/ha) yields and grain N removal (151 kg/ha).
- Grain protein content ranged from 13.4 % in *Sunrise* to 15.4 % in *Moats* to 16.2 % in *CDC Falcon*.

Winter Rye Varieties:

- Fifteen winter rye varieties (including 10 hybrids) were compared.
- Among registered non-hybrid varieties, *Guttino* gave the maximum grain yield (9,209 kg/ha; with 10.4 % protein). Hybrids that equaled/or seemed to be better than *Guttino* in grain yield were *KWS-H 129*, *KWS-H 119*, *KWS-H 133* and *KWS-H 131* (9,203-9,450 kg grains/ha; with 9.7-10.4 % protein).
- *Hazlet* produced the highest straw (10.2 t/ha) and biomass (18.7 t/ha).

2.1.3 Soybean/Camelina Varieties:

Soybean Varieties:

- Twenty-five RR2 soybean varieties were evaluated. Grain yields ranged from 1,479 kg/ha (*P001T34R*) to 3,091 kg/ha (*TH33003R2Y*). Second best group of varieties with over 2,600 kg/ha grain yield were *TH33005R2Y, LS002R24N and LS002R23*.

Camelina Varieties:

- Six selected varieties of camelina were evaluated.
- Seed yield ranged from 680 kg/ha in *Glacier* to 1,727 kg/ha in *Calena*.

2.1.4 Forage Crops Varieties:

Alfalfa Varieties and Cutting Management OFCC 2011:

- *OAC Superior, 55H94, 55V50 and Starbuck* were compared for two and three cuts.
- Totaled over 2012 and 2013, *55V50* recorded the highest dry matter yield in two (6,823 kg/ha) as well as in three cuts (10,027 kg/ha). However, the yield difference between the varieties was not significant.

Alfalfa Varieties and Cutting Management OFCC 2012:

- Six varieties were compared for 2 and 3 cuts. In the two cuts, *GS-11-08* (3,463 kg/ha), *GS-11-9* (3,425 kg/ha) and *GS-11-03* (3,411 kg/ha) were the three top yielding varieties.
- In the three cuts, *GS-11-03* (5,381 kg/ha), *GS-11-08* (5,378 kg/ha), and *55V48* (5,078 kg/ha) were the three top ranking varieties.

Late Timothy Varieties:

- *Normax* (7,441 kg/ha), *Treasure* (6,808 kg/ha), and *Itasca* (6,643 kg/ha) were the three top yielding varieties out of nine varieties tested in 2013. However, in total yield over 2012 and 2013, *Normax*, *Express* and *Itasca* were the three top ranks.

Tall Fescue Varieties:

- *Courtenay* (6,143 kg/ha), *Carnival* (5,900 kg/ha) and *Tower* (5,863 kg/ha) had similar dry matter yields.

Orchardgrass Varieties:

- Highest dry matter yield (5,025 kg/ha) was obtained with *Proper*. The yield of other three varieties (*Echelon, Okay* and *Dividend VL*) ranged from 4,339 kg/ha to 4,471 kg/ha.

Forage grasses heading dates:

- In orchardgrass, *AC Killarney* (June 9) and *Okay* (June 10) were earlier to bloom than *Dividend VL* (June 14), which was reported to be an early blooming variety.
- In Timothy, all varieties bloomed between June 22 (*Toro* and *Treasure*) and June 25 (*Climax* and *Itasca*).

2.2 Evaluation of Pulses:

2.2.1: Spring pulses:

Chickpeas:

- Due to cold and wet year, the chickpea in this trial was prematurely hit by a killing frost.

Lentils:

- Five lentil varieties were tested for their production potential.
- Grain yield ranged from 1,632 kg/ha (*Plato*) to 3,802 kg/ha (*Redberry*).
- *Rosetown* (2,935 kg grains/ha) and *Viceroy* (2,755 kg grains/ha) did reasonably well.
- Grain protein content ranged from 28 % (*Plato*) to 31 % (*Viceroy*); grain protein content in Meteor, Redberry and Rosetown was the same (30 %).
- *Lentils offer a protein rich alternate food to vegetarians!*

Field peas:

- Due to deer damage, the grain yield results weren't valid/or worth reporting.
- Grain protein content in the 4 pea varieties (*Hornet*, *Treasure*, *Fusion* and *Sorento*) ranged from 24.6 % to 25.6 %.

Edible beans:

- Highest grain yield (3,818 kg/ha) was recorded with *Winmore*. The next best varieties in grain yield were *Pintoba* (3,400 kg/ha) and *Earlired* (3,264 kg/ha).
- As in the previous years, *Pintoba* recorded the highest grain protein content (19.4 %); though *Portage* with a grain protein content of 19.1 % was equally good. Grain protein content in *Winmore* and *Earlired* was 18.3 % and 17.3 %, respectively.

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

2.2.1: 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 wheat in 2012 on Barley for Silage in 2013:

- No fertilizers were applied in this experiment to cover crops or to the following barley crop for silage.
- Only tillage radish appeared to increase the dry matter yield of barley as compared to the fallow (no cover crop seeding) treatment. All other cover crops tended to reduce the dry matter yield of barley, which ranged from 3,012 kg/ha in winter rye seeded with spring wheat to 5,030 kg/ha in fallow and 5,383 kg/ha in tillage radish.
- Winter rye @ 85 % seed rate co-seeded with spring wheat @ 75 % seed rate produced barley for silage with the highest protein content (10.7 %); followed by barley grown after a mixture of cover crops (9.7 %).
- Barley after turnip/ forage peas had the highest RFV (108/107). Barley after winter/spring cereals had the lowest RFV (79-81).

Effect of cover crops in/after spring barley for silage in 2012 on soybean in 2013:

- Cover crops or the soybean didn't receive any fertilizers.
- Soybean grain yields were too low (1,087-1,498 kg/ha), due to cold wet weather to express any significant effect from the cover crops.
- Red clover, tillage radish and turnip and berseem clover appeared to have some favourable effect on the soybean grain yield.

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

- Co-seeding spring barley and winter wheat each @ 75 % seed rate (standard check) gave somewhat less dry matter yield (7,615 kg/ha) as compared to barley alone at 100 % seed rate (8,256 kg/ha).

- Highest forage dry matter yield (~9,400 kg/ha) was obtained by co seeding spring barley at 60 % and winter wheat at 90 % of the recommended seed rate.
- Forage protein content was highest (14 %) with co seeding of spring barley and winter wheat each @ 75 % seed rate (standard check); 2 % point more than pure barley.
- RFV (95-109) was highest (109) with co-seeding of spring barley @ 75 % and winter wheat @ 85 % seed rates.

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.
- At equal N rate (70 kg N/ha), ESN produced 362 kg/ha higher grain yield than urea.
- Maximum grain (8,383 kg/ha) and biomass (14,470 kg/ha) yields, grain protein content (13.8 %) and grain N removal (184 kg/ha) were recorded with 50 kg N/ha from urea and 20 kg N/ha from ESN.
- Highest straw yield (7,650 kg/ha) was obtained with 60 kg N/ha from ESN and 10 kg N/ ha from ammonium sulphate.
- 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 600-800 kg/ha. Yields from urea and ESN each @ 70 kg N/ha were 5,050 & 5,236 kg/ha.
- Replacing 10 kg N/ha from urea/or ESN with ammonium sulphate improved the forage dry matter yield by nearly 1,000 kg/ha/or 700 kg/ha.
- Blend of the three N fertilizers (urea, ESN and ammonium sulphate) produced the highest dry matter yield (6,184 kg/ha), though this wasn't statistically higher than the yield with a blend of the any two N fertilizers (5,919-6,073 kg/ha).
- Crude protein content was highest (15 %) when urea/or ESN were applied alone. RFV was highest (94) with ESN @ 60 kg N/ha plus ammonium sulphate @ 10 kg N/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 varieties (*Spelt*, *Red Fife* and *Kamut*). In fact yields in *Kamut* (an ancient wheat variety) with application of P tended to decline.
- In the conventional varieties, *Unity VB* (a midge resistant variety) gave the highest grain (3,338 kg/ha), straw (6,313 kg/ha) and biomass yields (9,652 kg/ha), whereas in organic wheats, *Red Fife* produced the highest grain yield (2,500 kg/ha; about the same as *Spelt* and only 280 kg/ha higher than *Kamut*), and *Spelt* the highest straw (7,814 kg/ha) and biomass yields (10,286 kg/ha).
- Grain protein content ranged from 16.3 % in *Red Fife* to 19.1 % in *Stettler*. Grain protein in the two midge resistant varieties (*Unity VB* and *Goodeve VB*) and *Spelt* was 18-18.5 %.

2.4.2 Winter Wheat:

Effect of sources and methods of N application on winter wheat:

- Urea @ 120 kg N/ha side banded at seeding was the only treatment which gave higher grain yield (4,384 kg/ha) than the check (no N) treatment (3,650 kg/ha).
- Straw (6,436 kg/ha) and biomass (10,820 kg/ha) yields were also highest with urea @ 120 kg N/ha side banded at seeding. It seems that exceptionally low temperature at grain development didn't properly translate the total biomass to grain yield.
- It was safe to apply 120 kg N/ha as ESN with the seed.

- Grain protein ranged from 13.8 % with ESN @ 40 kg N/ha side banded at seeding to 16.1 % with ESN @ 80 kg N/ha side banded at seeding. Grain protein in the no N treatment was 14.3 % and that with urea @ 120 kg N/ha side banded at seeding was 15.1 %.
- Grain N removal (106 kg N/ha) was highest with urea @ 120 kg N/ha side banded at seeding, which was 22 kg N/ha higher than the check (no N) treatment.

Comparative performance of urea, ESN and their blends on 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.

- Even though grain yield was highest (4,878 kg/ha) with 120 kg N/ha applied at seeding (90 kg N/ha from urea and 30 kg N/ha from ESN), the yield (4,551-4,878 kg/ha) differences between the treatments (sources/time of N application) were not significant.
- Increasing the proportion of N as ESN from 30 to 90 kg/ha in the urea ESN blends raised the grain protein content to 15.9 % (as compared to 14.1 % from urea alone).
- Grain N removal with blends of urea and ESN was 9-16 kg/ha higher than that with the recommended N practice. Thus ESN blends improved N use efficiency.
- Straw and biomass yields were not affected by the N treatments.

2.4.3 Grain Legumes and Oil Seeds:

Maximizing economic yield in soybean:

- Seed treatment with *Vitaflow 280,* and application of P and K at recommended rates without *Rhizobium* inoculant or N, produced the highest grain yield (2,070 kg/ha).
- Application of higher than recommended rates of P or K or additional nutrients (S or B) or fungicide (*Stratego*) spray did not bring any additional benefit as compared to the Vitaflow treatment with P and K at recommended rates, though some of these treatments improved grain yield over the check treatment (no seed treatment, fungicide or NPK).

Lime and Wood ash (soybean after 3 harvest years of alfalfa-3 years barley-3rd year soybean):

- Lime/and wood ash were applied in spring 2004 (seeding year) and in falls of 2006, 2008 and 2010 in the 'after every two years' frequency of application treatments. In fall 2008, 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 first application of the amendments in fall 2010 and 2012, respectively. Soybean was the test crop in 2013.
- Wood ash/and lime, irrespective of frequency of application, significantly increased soybean grain yield.
- Lime alone every 6 years (lime applied in 2010) recorded the highest grain yield (1,537 kg/ha; low yield due to cold and wet year).
- Averaged over frequencies of application of lime and wood ash, lime seemed to produce higher grain yield and protein content than wood ash.
- Mid season soil analysis indicated that both lime and wood ash brought the soil pH to 6.5; availability of P, K, Mg, Zn and Mn was more with wood ash than that with lime. Reverse was true for soil Ca.
- Details of soil analyses, at the end of 10 year period, are given in the main report.

Manure, wood ash and fertilizer nutrients (3 harvest years of alfalfa-3 years' barley-3rd year soybean):

- Solid dairy manure was applied in the springs of 2004 and 2007, and falls 2008 and 2010; wood ash was applied in spring 2004 and in falls of 2006, 2008 and 2010, whereas fertilizer nutrients were applied every year.
- Due to cold and wet year, manure wood ash or nutrients couldn't express any significant effect on grain yields (trial mean 1,824 kg/ha); both manure and wood ash increased soybean grain yield marginally by ~120 kg/ha and 343 kg/ha, respectively.
- None of the nutrients (N, P, K or S) helped to increase the soybean grain yield.
- Grain protein content appeared to be unaffected by any of the treatments.
- Mid season soil tests revealed that the availability of K was more with manure than that with wood ash. Whereas, available P, Ca, Zn, Mn and B were higher with wood ash than

with manure. Soil pH was 6.6-6.8 with wood ash and 5.6-5.9 with manure. Organic matter was in the order of manure+ wood ash (7.1 %) > manure (6.7) ≥ wood ash (6.6 %) > no manure or wood ash (5.3 %).

- Application of fertilizer nutrients (N, P, K and S) increased availability of P, K and S, and marginally lowered the soil pH from 5.8 to 5.6.
- Effect of manure, wood ash and fertilizer nutrients on pH, organic matter and macro and micro nutrients after a 10 year period are detailed in the main report.

P and S requirements of chickpea:

- Due to cold and wet year, the chickpea in this trial was prematurely hit by a killing frost.

Response of spring canola to sulphur (S):

- Four rates of S application (0, 11.1, 22.2 and 44.4 kg/ha) were compared.
- Application of S @ 22.2 kg/ha produced the highest seed yield (6,148 kg/ha).

Effect of preceding crops (canola, flax and wheat) on N and S response to canola (2nd year):

- Canola seed yields after canola were the lowest (2,086 kg/ha); 2,703 kg/ha after flax and 2,523 kg/ha after spring wheat. Flax equaled wheat in straw production (~4,300 kg/ha).
- Application of N without S didn't increase canola seed yield.
- On an average, application of S @ 15 kg/ha improved the canola seed yield by ~700 kg/ha. Increasing the rate of S from 15 to 30 kg/ha didn't increase the yield further.
- Canola supplied with 100 kg N + 15 kg S/ha resulted in a seed yield of 2,720 kg/ha, which was only marginally lower than the seed yield (2,835 kg/ha) with 150 kg N + 30 kg S/ha/or with 150 kg N + 15 kg S/ha (2,911 kg/ha).
- Well fertilized canola produced 4,200-4,600 kg straw/ha.
- The margin of response to S in canola was higher after flax and wheat than after canola.

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

- Application of N @ 80 kg/ha significantly increased the canola seed yield. The margin of yield increase was higher with zinc spray (1,113 kg/ha) than without it (675 kg/ha).
- Increasing the rate of N from 80 to 120 kg/ha didn't significantly increase the seed yield.
- Averaged over all N rates, zinc spray increased the seed yield by 261 kg/ha.

2.4.4 Forages:

Alfalfa:

Fertilizing for persistence and maximum yield of alfalfa:

- OMAF & MRA recommended practice of applying only P and K to alfalfa resulted in the lowest dry matter yield (2,525 kg/ha) in the eighth harvest year.
- Addition of N along with P and K improved the alfalfa dry matter yield by over 1,500 kg/ha. Adding S to the NPK mix further raised the yield by 600 kg/ha.
- Highest dry matter yield (5,132 kg/ha) in the nutrients alone treatments was obtained with the combined application of N, P, K, S, B & Zn. *It may be noted that application of Zn becomes critical for high yield as the alfalfa stands get older!*
- Application of manure and wood ash, once in five years, without adjusting the nutrient supply from the manure and wood ash in the fertilizer program and bi-directional seeding at 1.5 times seed rate was better (at 5,479 kg/ha) than the best nutrient alone treatment.
- Highest protein content (18.7 %) in the first cut was recorded with the application of N, P, K, S & B. Application of wood ash/or manure along with macro and micro nutrients further improved the protein content by 0.3-0.8 % points. In the second cut, protein content was up to 2 % points higher with the combined application of nutrients and manure/or wood ash than the nutrients alone.
- RFV was highest with N, P, K, S & B in the first cut (157) and with all nutrients plus wood ash without adjusting nutrients contribution from the wood ash.
- *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!*
- Details of soil analyses from each treatment this year are given in the main report.

Optimizing rates and timing of ammonium sulphate application in older stands of alfalfa:

- Only one cut was taken in this experiment.
- As in 2012, maximum alfalfa dry matter yield (2,573 kg/ha) was obtained with early spring application of ammonium sulphate @ 150 kg/ha (=36 kg S/ha). At this rate, ammonium sulphate gave over 600 kg/ha higher yield and 2.1 % point higher protein content as compared to its lower rate (100 kg/ha = 24 kg S/ha).
- Split application of ammonium sulphate (100 kg/ha in early spring and 50 kg/ha after first cut) didn't affect the alfalfa yield, but improved the protein content by 1.5 % point.
- At equivalent rates of S, alfalfa yield was ~700 kg/ha lower with potassium sulphate than that with ammonium sulphate; though the protein content was similar (~17 %) with the two fertilizers. However, RFV was highest (173) with potassium sulphate.

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 year 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 623-1358 kg/ha. Protein content in the first, but not in the second cut, was higher with N than without it.
- Residual effect of S (from ammonium sulphate) was quite apparent; at equal N rate, dry matter yield from ammonium sulphate was ~500 kg/ha more and N removal 21 kg N/ha higher than that with urea.
- Ammonium sulphate didn't seem to increase the protein content.

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):

- Application of N significantly increased dry matter yield of bromegrass and timothy (up to 1,500 kg/ha). Bromegrass (3,591 kg/ha) and timothy (3,711 kg/ha) yields were similar; however 81 % of yield from timothy came from the first cut, whereas bromegrass yield between the two cuts (46:54) was more or less balanced.
- In the first cut, bromegrass had 3.1 % point higher protein content than timothy, whereas in the second cut, timothy had 4.4 % point higher protein than bromegrass.
- As before, grasses dry matter yield from fall applied ESN (3,850 kg/ha) equaled that with urea applied in the fall (September 25; 3,776 kg/ha)/or in the spring (3,845 kg/ha).
- Both in the first and the second cut, application of urea in the fall, especially in the late fall, resulted in higher grasses protein content than the spring applied urea.
- Bromegrass had 12 % higher RFV than timothy. ESN/urea treatments didn't seem to improve the RFV as compared to the check (no N).
- While application of N improved protein content (more in the first than in the second cut), fall applied ESN and fall/or spring applied urea had similar protein content in the first cut. In the second cut, protein content was in the order of fall applied ESN > fall applied urea > spring applied urea.
- *Application of entire N to perennial forage grasses from ESN in the fall could save one operation and widen the window of N application with extra protein content as a bonus!*

Effect of urea and its blends with ESN and ammonium sulphate on forage grasses mixture (timothy, bromegrass and orchardgrass):

- Application of N as urea @ 105 and 140 kg N/ha significantly increased the grasses dry matter yield. Increasing the rate of N application from 105 to 140 kg/ha improved the dry matter yield by over 1,000 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 910 kg dry matter yield/ha as compared to the 140 kg N/ha applied from urea alone.
- In the first cut, protein content was highest (19.2 %) with 140 kg N/ha (105 kg N/ha from urea and 35 kg N/ha from ESN). In the second cut, urea applied @ 140 kg N/ha resulted in the highest (17.1 %) protein content.

It is clear that the optimum rate of N application to grasses is higher than the OMAF & MRA recommended optimum rate of N (105 kg N/ha) for forage grasses in Ontario.

Spring and Winter Cereals:

Fertilizer requirements of spring barley + winter wheat (75 %:75% population) – Year 2; seeded in spring 2012-winter wheat forage production 2013 and total production from barley and wheat (2012 & 2013):

- The crop mixture was seeded in 2012 with different fertilizer combinations. Spring barley was harvested last year and barley (check treatment)/and winter wheat in 2013.
- Highest forage dry matter yield from the two crops (8,025 kg/ha) was obtained with pure crops of barley after barley at normal rates of N, P and K application. This was 23.6 % higher than spring barley + winter wheat mixed cultivation.
- Increasing the rates of N, P and K application in barley + winter wheat cropping appeared to improve the dry matter yield of the cropping system.
- 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 %.
- 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. .

Fertilizers requirements of spring barley + winter wheat seeded together in spring 2013; each @ 75 % of the recommended seed rate:

- Spring barley + winter wheat supplied with normal N and 1.25 times normal P and K (for barley) resulted in the highest dry matter production (8,403 kg/ha; 28 % higher than barley alone). Protein content in the highest yielding treatment was 13.1 %.
- Protein contents (15.0/15.1) in the pure barley or barley + winter wheat at normal NPK rates were similar. Increasing the rates of NPK application by 1.5 times increased the protein content by only 1 % point.
- RFV was highest (104) with barley + winter wheat at 1.25 times normal rates of NPK, which was 4 points more than the pure barley crop.

Winter Cereals for Silage (and Grain):

- Forage dry matter yield from winter cereals harvested at flag leaf stage were in the order of triticale (2,620-3,080 kg/ha) > wheat (2,170-2,290 kg/ha) > rye (2,780-2,980 kg/ha). Beneficial effect of blending urea with ESN (3:1 N) was noticed only in triticale. Increasing rates of N application increased forage dry matter yield linearly up to 100 kg N/ha, and tapered off at 150 kg N/ha.
- When harvested at flag leaf stage, each increment of 50 kg N/ha from zero to 150 kg N/ ha raised the winter cereals protein content by 1 % point. Blending urea with ESN (3:1 on N basis) increased the forage protein content in all winter cereals by at least 1 % point. Protein content with the blend of two N fertilizers in winter rye (*Hazel*), winter wheat (*CDC Falcon*) and winter triticale (*Fridge*) was 19 %, 16 % and 17 %, respectively. RFV in winter rye (137 with urea and 128 with urea ESN blend) was higher than in winter wheat/or triticale (97-104).
- Maximum dry matter yield (4,026 kg/ha) in the second cut from the regrowth after the first cut (that wasn't affected by N rates) was recorded in triticale with urea alone. Protein content in regrowth in winter cereals ranged from 8.7-9.4 % and RFV from 87 to 97.
- In the total forage dry matter yield (15.7-18.4 t/ha in triticale, 16.9-17.9 t/ha in wheat and 12.8-13.6 t/ha in rye), urea ESN blend proved beneficial only in triticale and resulted in 2,750 kg/ha increase in yield as compared to urea alone. Response to N was linear up to 100 kg N/ha and exhibited a diminishing trend at 150 kg N/ha.
- Grain yield from regrowth after harvesting at the flag leaf stage was higher with winter wheat (1,729 kg/ha) and triticale (1,671) than with rye (872 kg/ha). Highest straw (6,060 kg/ha) and biomass (8,108 kg/ha) yields from the regrowth were recorded in winter triticale that received N from urea ESN blend.

Producers may wish to add winter cereals, especially Fridge triticale, to their cropping systems!

Silage Corn/Sorghum Sudangrass/Spring Cereal Forages:

Effect of ESN, urea and their blends (150 kg N/ha) *applied to corn in 2012 on forage oats (2013):*

- Highest forage dry matter yield was recorded with ESN (7,180 kg/ha) though it was only ~200 kg/ha higher than that from urea. Blends of ESN and urea (applied to corn) didn't help increasing the oats dry matter yield as compared to the two fertilizers applied alone.
- RFV (105) and protein content (7.6 %) in oats was highest when 25 % N to corn was applied from urea and 75 % N from ESN.
- Response to direct application of N @ 35, 70 and 105 kg N/ha to oats was linear; highest N rate recorded the highest dry matter yield (8,368 kg/ha) and protein content (8.2 %).
- Application of N to oats didn't help to improve the RFV.

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 only at its highest rate (200 kg N/ha) brought in a significant increase (of over 2,000 kg/ha) in MasterGraze corn dry matter yield.
- N applied @ 100 kg N/ha from a blend of urea and ESN (3:1 ratio on N basis) resulted in the similar yield (8,565 kg/ha) as urea @ 200 kg N/ha (8,593 kg/ha).
- Dry matter yield of sorghum sudangrass @ 150 kg N/ha from urea ESN blend was ~7,200 kg/ha. Increasing the rate of N to 200 kg/ha either as urea alone or urea ESN blend didn't affect the sorghum sudangrass yield.
- Protein content in MasterGraze corn varied from 8.2 % to 18.2 % with urea N rates from 50-150 kg/ha and from 17.8 % to 14 % at the same rates of N from urea ESN blend. N @ 200 kg/ha didn't improve the protein content further in either case. Protein content in sorghum sudangrass at 150 kg N/ha from urea ESN blend was 13.9 %, which increased to 15.4 % at 200 kg N/ha from urea and to 16.1 % at 200 kg N/ha from urea ESN blend.
- Highest RFV (129) was recorded in MasterGraze corn supplied with 150 kg N/ha from urea ESN blend. At equivalent N rates, mineral content in MasterGraze forage was higher with urea ESN blends than that with urea alone.

Soil Nitrogen Supply in Corn:

- Corn (for silage) dry matter yield with (urea @ 150 kg N/ha) or without N was the same (10.7 t/ha). Indication from the other experiment on corn is that more than 150 kg N/ha was probably required to produce a significant response to N in corn this year.
- Cobs contributed 36.9 % of the total dry matter yield without N and 38.4 % of the total dry matter yield with N @ 150 kg/ha.

2.5 Other Experiments:

Efficient Cropping Systems:

- An experiment with 10 potential cropping systems, including forage and grain legumes, other forages and cereals, spread over 10 years, was initiated during 2004 with alfalfa as the first crop. Alfalfa crop cycle ended in 2007 and it followed different crops thereafter.
- Winter wheat for silage was the test crop in 2013 in all treatments. Winter wheat forage dry matter yields were higher with rotations that included corn-barley (~4,900 kg/ha) for silage/or soybean (grain)-barley (4,660-4,700 kg/ha) than other crops (spring cereals and Italian ryegrass) in rotation.
- Winter wheat in rotations including ryegrass produced the lowest dry matter yield (3,500-3,600 kg/ha)
- Protein content in winter wheat was highest (12.1 %) in rotation with soybean, oat and barley. RFV was highest (112) with rotations involving barley and Italian ryegrass.
- Comparison/details of soil analyses in the beginning and at the end of the 10 year cropping cycle are given in the main (data) section of the report.

Tillage in barley (after Oat-Barley-Soybean-Barley-Soybean-Barley-Soybean-Barley- Soybean):

- Zero tillage resulted in the lowest barley grain yield (3,005 kg/ha).
- In the alternate tillage systems, highest grain (4,403 kg/ha), straw (3,823 kg/ha) and biomass (8,226 kg/ha) yields were recorded with disking in the fall and spring followed

by cultivation. These yields were not significantly lower than those obtained with the conventional tillage (fall plowing, spring disking and cultivation).

- Disking in the fall and spring followed by cultivation consumed 32 % less time and 53 % less fuel as compared to the conventional tillage.
- Details of soil analyses from each treatment at the end of 10 years period are given in the main report.

Alternate Forages:

Comparative Performance of Annual and Perennial Forage Legumes:

- Galega, a perennial forage legume from the Scandinavian countries, produced over 600 kg/ha higher dry matter yield than 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.
- First cut protein content in galega @ 25 kg seed/ha (25.5 %) was higher than that in alfalfa (21.1 %). In the 2nd cut, there was no difference between the protein contents in galega and alfalfa.
- Galega/or alfalfa + berseem had the highest RFV (122/123) in the first cut, whereas, in the 2nd cut, galega + berseem/or alfalfa + red clover had the highest RFV (156/157).

Biomass/Bioenergy Production:

Temperate grasses varieties for biomass/bioenergy production:

- High yielding varieties of temperate grasses (tall fescue, orchardgrass, reed canarygrass, timothy and bromegrass) were compared with two switchgrass varieties (*Dacotah* and *Sunburst*) for biomass/bioenergy production.
- Reed Canary grass (*Rival*), and tall fescue (*Kokanee*), produced ~1,800 kg/ha and ~200 kg/ha higher biomass yield than switchgrass (Sunburst; 4,992 kg/ha). Biomass yield from orchardgrass (*Okay)* was as good as that from switchgrass.
- Over a 3 year (2011-2013) period, reed canarygrass produced 1.4 times and tall fescue 1.2 times higher biomass than switchgrass.
- Averaged over all grasses, harvesting in fall resulted in 720 kg/ha extra biomass yield than harvesting in spring this year. However, over a 3 year period, there was no significant difference between fall and spring harvesting.

Forest Tree Research:

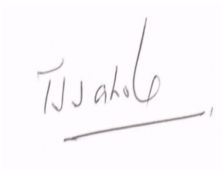
- Experiments to optimize afforestation of fast growing conifer tree species (Norway Spruce, White Spruce, Red Pine and European Larch) were initiated during spring 2005.
- Since the trees growth rate is too small, it was decided to record growth observations after every 2-3 years. No data were recorded 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 11-55 kg/ha (1.1-5.4 g/plant) with a mean value of 34 kg/ha (3.3 g/plant).
- *V. augustifolium* from Nipigon had the highest yield (55 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 no 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. Record breaking yields in barley and canola were especially noteworthy, which attracted attention of Ontario Farmer. For details, refer to the section on Extension and Outreach in the main report.



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