

## 2. Summary of Research Results

### 2.1 Spring Cereals – Variety Evaluation:

#### *Specialty Wheat:*

- Sixteen varieties of different types of wheat (hard red, durum, soft white, hard white, and old Kamut wheat) from the east and west of Canada were compared.
- *Sable* (6,715 kg/ha; ~1,200 kg/ha higher than hard white *Snowstar*), *AC Andrew* (6,576 kg/ha; last year's best yielding) and *Superb* (6,297 kg/ha) were the three top (grain) yielding varieties.
- Grain yield of *Strongfield* (4,911 kg/ha), western durum variety, gave ~1,300 kg/ha lower grain yield than Ontario's durum variety (*Hallmark*: 6,177 kg/ha); the two varieties were at par with each other last year. However, *Strongfield* had higher grain protein content (21%) than *Hallmark* or hard red *Sable* (17% in both).
- New hard red (*AC Crystal*, *Kanata*, *AC Cadillac*) or hard white (*Snowbird*) spring wheat varieties from the west (3,920-5,138 kg/ha) were nowhere near *Sable* in grain yield.
- Highest straw yield (6,394 kg/ha) was obtained with *Snowbird*, and highest biomass yield (12,888 kg/ha) with *Sable*.
- Grain protein content ranged from 14% (*AC Andrew*) to 20% (*Strongfield*, *Kane*, *Kanata*, *AC Cadillac* and *Harvest*).

#### *Organic wheat (with clover green manuring and application of liquid dairy manure):*

- Grain yields were in the order of *Superb* (6,069 kg/ha)  $\geq$  *Sable* > *Kamut* = *Red Fife* (3,553 kg/ha).
- Seed treatment with mycorrhizal fungi appeared to improve the grain yield of *Sable*; overall (mean over varieties), however, there was no significant increase in grain yield by mycorrhizal seed treatment.
- *Superb* had the highest straw (7,399 kg/ha) and biomass (13,467 kg/ha) yields.
- Grain protein content (unaffected by mycorrhiza) was 15% in both *Superb* and *Sable* (2-3 % point higher than *Red Fife* and *Kamut*).

#### *Old Wheats:*

- Eight old wheat varieties, including *Marquis* and *Kamut*, were evaluated along with *Sable*. Old wheat varieties did well during 2009 with grain yield as high as nearly 6,000 kg/ha with *Thatcher* and over 5,300 kg/ha with *Garnet*.
- *AC Mimi* had the highest straw (6,328 kg/ha) and biomass (11,161 kg/ha) yield.
- Grain protein content was lowest in *Kamut* and *AC Mimi* (16%) and highest in *Pembino*, *Marquis*, and *AC Michael* (19% in all).

#### *Wheat Performance:*

- In grain yield, *Hoffman* (7,673 kg/ha), *Batiscan* (7,054 kg/ha), and *BS02-126* (6,824 kg/ha) were the three top yielding varieties amongst the 29 wheat entries. *Sable* produced 6,309 kg grains/ha (~ 550 kg/ha higher than *Waskada* one of the three top yielding varieties last year). *Hoffman* has been topping in grain yield only during the cold years.
- *Snowstar*, a hard white wheat variety, lagged behind *Sable* in grain yield by ~700 kg/ha.
- *Hoffman* (15,970 kg/ha) and *Batiscan* (15,480 kg/ha) maintained their top ranks in biomass production as well.
- Straw yield from *Batiscan* (8,626 kg/ha) was ~330 kg/ha higher than that from *Hoffman*. *Batiscan* may therefore be worth trying on farms during 2010!

#### *Barley Performance:*

- Twenty five barley varieties/lines were evaluated.
- *Oceanik* (7,148 kg/ha), *GB046001* (7,059 kg/ha) and *Encore* (6,712 kg/ha) produced the highest grain yields. Last year too, *Oceanik* had topped in grain yield.

- Grain yield of *Cyane* (5,495 kg/ha) was below expectation, but that from *Brucefield* (6,227 kg/ha) was not too bad.
- *Amberly* produced the highest straw (7,898 kg/ha) and biomass yield (14,314 kg/ha) though only marginally higher than *Encore*.
- *Farmers may wish to add Oceanik to their barley portfolio during 2010 season!*

*Barley – silage and grain:*

- Eleven high yielding varieties from the east and the west of Canada were compared.
- *Bentley*, a two row malting variety from Alberta, had the highest (7,642 kg/ha) forage yield followed by *CDC Coalition* - also two row (7,235 kg/ha) and *Binscarth* (6,371 kg/ha) – a six row silage barley. *Bentley could be worth trying on farms during 2010!*
- Protein content in the forage was in the order of *Chapais* (13%) > *CDC Battleford* = *Brucefield* = *Trochu* = *Chigwell* (12%) > *all other varieties* (10-11%).
- In grain yield, *CDC Coalition* (6,405 kg/ha), *Chapais* (6,375 kg/ha), and *Trochu* (6,115 kg/ha) were at the top. *Cyane* had the lowest grain yield (5,021 kg/ha).
- Grain yields from *Binscarth*, *AC Klinck* and *Brucefield* were close to 6,000 kg/ha.
- There was no significant difference in the straw or biomass yield amongst the varieties.

*Oats Performance:*

- Seventeen varieties/biotypes of oats were compared with each other.
- Amongst known varieties, highest grain yields were obtained with *Bia* (7,987 kg/ha), *AC Rigodon* (7,667 kg/ha), and *Synextra* (7,407 kg/ha).
- Highest biomass yield was recorded with *Dieter* (14,185 kg/ha) followed by *Bia* (13,966 kg/ha) and *Synextra* (13,167 kg/ha). *Synextra* is good for both biomass and grain production.
- *Navaro* (7,429 kg/ha), a hullless variety, and *Dieter* (7,041 kg/ha) topped in straw yields.

*Milling Oat varieties from the west:*

- Three new oat varieties (*AC Morgan*, *AC Jordan* and *AC Ronald*) from the west were compared with our standard high yielding variety (*AC Rigodon*).
- Grain yields were *AC Jordan* (7,895 kg/ha) = *AC Morgan* (7,842 kg/ha) > *AC Rigodon* (7,283 kg/ha) > *AC Ronald* (6,758 kg/ha).
- *AC Jordan* produced the highest straw (5,568 kg/ha) and biomass yield (13,463 kg/ha).
- Grain protein content was highest in *AC Rigodon* (14.2%), and lowest (11.3/11.5%) in *AC Jordan/ AC Morgan*. Grain N removal (165 kg/ha) was also highest in *AC Rigodon*.

## **2.2 Spring Cereals – Other Experiments:**

*Response of barley + pea intercropping to N:*

- Application of N @ 80 kg/ha, but not 40 kg N/ha, to barley (alone) significantly increased the grain yield as compared to the check (No N).
- No significant yield response to N application (20 or 40 kg/ha) was recorded in peas.
- Increase in grain yield with application of 20-40 kg N/ha in barley + peas (alternate rows/or same row) fell short of the level of significance.
- Grain yields were in the order of peas (7,501 kg/ha) > barley + peas (alternate rows; 4,837 kg/ha) > barley + peas (4,327 kg/ha) > barley (3,923). Economic value of the produce from peas or barley + peas would be higher than that from barley.
- Peas alone produced the highest biomass (over 15,000 kg/ha); straw yield was higher when barley + peas were grown in the same rows than in the alternate rows. The two treatments didn't differ in the total biomass yield though.

*Nitrogen requirements of spring wheat as affected by previous crops in the rotation:*

- Pre spring wheat seeding nitrate N was equal (13 ppm) and higher after alfalfa, silage corn and soybean than after barley or wheat (8 ppm in both cases). Ammonia N was highest after alfalfa (12 ppm; as compared to 6-8 ppm after other crops).
- Spring wheat (*Sable*) grain yield after different crops, in the rotation, was in the order of alfalfa (5,156 kg/ha) ≥ soybean (5,088 kg/ha) > silage corn (4,717 kg/ha) > barley (4,406 kg/ha) > wheat (3,963 kg/ha). *This means wheat after wheat produced the lowest yield!*
- Straw (5,235 kg/ha) and biomass (10,323 kg/ha) yield was highest after soybean.
- Response to N in spring wheat varied with the previous crops. Wheat after soybean, applied with 120 kg N/ha (highest rate of N application) gave significantly (~1,000 kg/ha) higher grain yield than the lower rates of N application (0, 40 & 80 kg/ha), which resulted in similar grain yields. Wheat after alfalfa had a marginal increase in grain yield, but wheat after barley had a significant increase in grain yield with increasing rate of N application from 40 to 80 kg N/ha; the highest rate (120 kg N/ha) produced only about as much grain yield as 80 kg N/ha after alfalfa/or barley. Wheat after silage corn didn't depict any significant response to N application. Wheat after wheat produced the highest grain yield at 80 kg N/ha. Overall, wheat grain yield increased with increasing rates of N application from 0-120 kg N/ha, though 80 kg N/ha appeared to be the economic optimum rate.
- Application of 120 kg N/ha to wheat after soybean recorded the highest straw (6,240 kg/ha) and biomass (12,053 kg/ha) yield. The treatment also resulted in highest N removal by grains (152 kg N/ha).
- Grain protein content was higher in wheat after soybean (15 %)/or alfalfa (14.4 %) than after barley, corn or wheat (13.8 % in all cases).

*Comparative performance of urea and polymer coated urea (ESN) @ 40, 80 and 120 kg N/ha in spring wheat: wheat was seeded in the same plots as last year without changing the layout.*

- Grain yield was low (trial mean 1,800 kg/ha) in this trial.
- Application of 40 kg N/ha, through either of the two fertilizers, didn't increase grain yield as compared to the check (No N). N @ 120 kg/ha seemed to have higher grain yield than its lower rate (80 kg/ha) only in ESN.
- Overall, ESN wasn't significantly better than urea in grain, straw and biomass yield.
- Grain protein content was 1% point higher with urea than that with ESN.
- On an average, spring wheat removed 88 kg N/ha; 45 kg/ha by grains and 43 kg/ha by straw, which is low because of the low yield.
- Post harvest total mineral N (0-30 cm soil) was 30% higher with urea than that with ESN. N at 80 kg/ha left more residual mineral N than its lower or higher rate of application. Overall, ~70% of residual N was in nitrate form and 30% in ammoniacal form.

*Effect of tillage on barley after oats-barley-soybean-barley-soybean:*

- No till direct seeding that gave the highest (soybean) grain yield last year, resulted in the lowest barley grain yield this year (over 1,000 kg/ha lower than the conventional tillage).
- One disking in fall followed by (one) disking, cultivation and seeding in spring recorded the highest barley grain yield (6,346 kg/ha) closely followed by chisel ploughing in fall followed by disking, cultivation and seeding in spring (6,262 kg/ha)/and no fall tillage, two disking in spring followed by cultivation and seeding (6,051 kg/ha). The latter treatment produced the highest straw (5,684 kg/ha)/and biomass yield (11, 736 kg/ha).
- Two disking in spring followed by seeding without cultivation (with grain yield of 5,964 kg/ha) was the least time and fuel consuming, whereas fall ridging after disking followed by spring disking and cultivation before seeding was the most time and fuel consuming.

### 2.3 Dates of Seeding Winter Wheat/Barley/Rye:

#### *Winter Wheat:*

- Delay in seeding winter wheat (*CDC Buteo*) from August 25 to September 5 resulted in over 1,000 kg/ha increase in grain yield, which declined drastically with delay in seeding beyond September 15. Maximum grain (6,417 kg/ha) and biomass (16,731 kg/ha) yield were obtained with September 5 seeding. The straw yield (10,800 kg/ha) was highest with August 25 seeding.
- Application of sulphur @ 24 kg S/ha improved the grain yield of only September 25 seeded winter wheat (by over 1,100 kg/ha). Effect of manganese on the winter wheat grain yield wasn't discernible.
- Grain protein content was marginally higher with late seeding (September 15/or 25) as compared to timely seeding (August 25/September 5). Application of S/or Mn didn't appear to improve the grain protein content (overall mean ~12.6%).

#### *Winter Barley:*

- Winter barley seeded on August 15 harvested for forage before snowfall, produced 2,000 kg/ha dry matter yield with 28% protein without affecting the grain yield that was low because of poor winter survival.
- Harvesting winter barley seeded on August 25 before snowfall not only gave poor forage yield (~800 kg/ha), but also decreased grain yield by nearly by a tonne/ha. Seeding winter barley on August 25 otherwise resulted in the highest grain yield (2,644 kg/ha).

#### *Winter Rye:*

- Highest grain (5,179 kg/ha), straw (9,725 kg/ha), and biomass yields (12,821 kg/ha) were obtained with September 5 seeding, whereas grain protein content (17%) was highest with August 25 seeding.

### 2.4 Winter wheat/rye varieties:

#### *Ontario Winter Wheat Varieties:*

- Survival (flooding due to speedy snow melting in spring) of winter wheat varieties in this trial was very poor (4-21 %), and consequently the grain (mean 2,500 kg/ha), straw and biomass yields were very poor.

#### *Manitoba Winter Wheat Varieties:*

- *AC Radiant* that didn't perform so well in normal years (with respect to grain yield) produced the highest grain (7,210 kg/ha), straw (8,242 kg/ha) and biomass (15,452 kg/ha) yields. Members may recall, that the variety produced ~18 tonne biomass/ha in 2004-'05.
- *CDC Ptarmigan*, a new hard red winter wheat variety from the west, was the second best in grain yield (6,102 kg/ha).
- *AC Raptor* recorded the highest grain protein content (16.1%) followed closely by *McClintock* (15.9%); Grain protein content in *CDC Falcon* was 13.2%.

#### *Manitoba Winter Rye Varieties:*

- *AC Hazlet* registered the highest grain yield (6,743 kg/ha; over 5,100 kg/ha higher than Ontario's *Common No. 1*), followed closely by *AC Rifle* (6,607 kg/ha); whereas *Prima* gave the highest straw (~9,500 kg/ha) and biomass (~15,600 kg/ha) yields. Low yield from *Common No. 1* was due to its poor winter survival (25%).
- Grain protein content ranged from 12 % in *AC Rifle* to 16 % in *Common No. 1*.

### 2.5 Winter wheat N management:

#### *Split application of N:*

- Highest grain yield (~7,800 kg/ha) was obtained with application of urea @ 30 kg N/ha at seeding supplemented with urea @ 90 kg N/ha in the early spring. The yield differences fell short of the level of significance as compared to no N application.

- Application of entire N (120 kg/ha) through urea in spring resulted in highest straw (11,232 kg/ha) and biomass (18,653 kg/ha) yields.
- ESN @ 90 kg N/ha applied in the fall equaled in grain yield from ESN and urea applied in the fall @ 120 kg N/ha.
- Post harvest soil mineral N ranged from 9 to 19 ppm; the highest amount was from urea @ 120 kg N/ha applied in the fall.
- Grain protein content was lowest (10.8%) without application of N and highest (13.9%) when a small portion of N was applied through ammonium sulphate. The protein content in treatments with urea applied @ 90 kg N/ha or higher in the spring resulted in 13.0-13.2 % grain protein. Grain protein content in treatments with a part or entire N applied in the fall as ESN ranged from 11.2% (all N as ESN) to 12.6% (N from both urea and ESN).
- Part or entire application of N in spring appeared to improve grain protein content.
- N removal by grains followed the same trend as grain yield.
- In the early spring, nitrate and ammoniacal N in 0-30 cm soil were 22% higher from urea applied at seeding @ 120 kg N/ha than N applied through ESN at the same rate and time.
- Residual mineral N, in 0-90 cm soil, after harvest was highest (19 ppm) with urea applied at seeding @ 120 kg N/ha; 73% higher than the residual mineral N (0-90 cm soil) from ESN applied at seeding @ 120 kg N/ha.

*Blends of N fertilizers (CDC Falcon):*

- When the total N supply (120 kg/ha) was from a single N fertilizer, grain yields were in the order of ESN (4,347 kg/ha) > ammonium sulphate (3,956 kg/ha) > urea (2,998 kg/ha).
- Highest grain yield (4,830 kg/ha) was, however, recorded with 90 kg N/ha from urea and 15 kg N/ha each from ESN and ammonium sulphate. The treatment also produced the highest straw (4,214 kg/ha) and biomass (9,044 kg/ha) yields.
- Post harvest nitrate N content (~80 % of total in 0-60 cm), at all soil depths (0-30, 30-60 & 60-90 cm), followed the pattern of urea > ESN > ammonium sulphate. Ammonia N in the soil in the early spring was too low and didn't differ with the fertilizers.
- Post harvest soil analysis indicated that ammonium sulphate doubled the sulphate sulphur content in the soil as compared to urea/or ESN.
- None of the treatments resulted in higher grain protein content than the check (15%) and the protein content, with 1-2 exceptions, was 14-15% in all treatments.

*Comparative performance of urea and polymer coated urea (ESN) @ 40, 80 and 120 kg N/ha:*

- Urea and ESN resulted in similar grain yield, but ESN had an edge over urea in straw and biomass yield.
- Response to N in both the fertilizers increased with the increasing rates of N from 40 to 120 kg N/ha. At a low rate of 40 kg N/ha, the fertilizers didn't increase grain yield as compared to the check (no N).
- Flag leaf N content (3.1-3.2%) and grain protein content (13%) were highest at the highest rate of N (120 kg/ha). N at this rate increased grain protein content by 3% points over control (No N).
- Post harvest residual mineral N (nitrate, ammoniacal or total) at any of the soil depths (0-30, 30-60 and 60-90 cm) didn't vary much with the type of fertilizer or the rate of N application.
- Winter wheat grains on an average removed ~120 kg N/ha.

## **2.6 Soybean:**

*Varieties and population:*

- In the soybean varieties trial, grain yield ranged from as low as 1,439 kg/ha in 90A06 and 1,579 kg/ha in *Montcalm* to 4,079 kg/ha with *NSC Warren RR*. Grain yield from most other varieties was between 2,500-3,000 kg/ha.

- Highest soybean grain yield was obtained with a population of 280,000 per acre (population ranging from 120,000 to 360,000).

*Effect of row spacing and direction on soybean:*

- In the unidirectional seeding, seeding at 6 inch row spacing resulted in the highest grain yield (~2,878 kg/ha), whereas in bi-directional seeding, 12 inch row spacing produced the highest yield (3,370 kg/ha; 17.5 % higher than 6 inches unidirectional row spacing). In fact the actual spacing/area per plant in these two treatments will be the same.
- The mean grain yields over two seeding patterns indicated that the yield increased with increase in row spacing from 6 to 12 inches and declined thereafter (with 30 inch row spacing producing the lowest yield).

*Effect of zinc and manganese on soybean (residual effect of the nutrients applied to spring wheat last year):*

- No residual effect of the zinc and manganese applied to spring wheat in 2008 was observed on soybean this year may be because the grain yield had been low (trial mean 2,100 kg/ha).

## **2.7 Field Pea – Variety Evaluation:**

- Six shortlisted varieties out of 27 varieties/biotypes (tested last year) were evaluated.
- *Polstead* that produced the highest grain yield last year didn't do well this year. *Cutlass* had the highest grain yield (6,515 kg/ha) followed by *CDC Trucker* (5,877 kg/ha) and *Fusion* (5,869 kg/ha). Last year too, *CDC Tucker* and *Fusion* were the second best in grain yield.
- *Field pea could be an integral part of the cropping systems in the Thunder Bay district!*

## **2.8 Fall Vs. Spring Canola:**

- Winter canola (cultivars *Kronos* and *Californium*) seeded on August 15, September 5, and September 15 didn't survive the 2008-2009 winter. Hence spring canola wasn't even tried in this experiment.
- Our success rate in winter canola so far is two out of five years.

## **2.9 Forages:**

### **2.9.1 Grass Varieties:**

*OFCC 2007: Dry matter yields in Orchard grass, Bromegrass and Meadow Fescue depicted the same trend as last year!*

- *Orchard grass: Okay* gave the highest (2,917 kg/ha) and *QS 23* the lowest dry matter yield (855 kg/ha).
- *Bromegrass: Bravo, Peak* and *Big Foot* had similar dry matter yield (over 5,500 kg/ha).
- *Meadow Fescue: Mimer, Epic* and *Pardel* didn't differ in dry matter yield (over 4,270 kg/ha).
- *Tall Fescue: Carnival* gave the highest (3,235 kg/ha) and *Kokanee* the lowest yield (2,570 kg/ha).
- *Late Timothy (one cut only): Itasca* recorded the highest (2,778 kg/ha) and *Barpenta* the lowest yield (1,443 kg/ha).
- *Perennial ryegrass:* There was no significant difference in the yield of 4 entries; though *GO-ABZ* had the highest (2,900 kg/ha) and *GO-ABM* had the lowest yield (2,300 kg/ha).

*OFCC 2008:*

- *Perennial ryegrass:* There was no significant difference in the dry matter yield of *Lactal*, *Citadel*, *Bastion*, and *Condesa* though the yield ranged from 2,213 kg/ha (*Condesa*) to 2,623 kg/ha (*Citadel*).

- *Tall Fescue: Courtney* produced the highest (5,314 kg/ha) and *PST-5CAN* the lowest (3,837 kg/ha) dry matter yield.

**2.9.2 Grasses Nutrition:** Only one cut was taken during 2009, because the regrowth, after first cut, was too poor to take a second cut.

*Comparative performance of urea and polymer coated urea (ESN) @ 35, 70 and 105 kg N/ha in timothy:*

- Increasing rates of N application, from zero to 105 kg/ha significantly increased the dry matter yield of timothy almost linearly up to 105 kg/ha with urea. With ESN, the yield tended to level off after 70 kg N/ha. On an average, timothy yield was better with urea than that with ESN probably due to the cold and dry spring/summer.
- Protein content in timothy was highest without application of N (due to poor yield).
- There was no significant difference in the protein content between sources or rates of N.
- Soil analysis in the fall indicated that residual nitrate N was more or less the same with urea and ESN, but urea left a higher amount of ammoniacal N than ESN, which it seems didn't hydrolyze well due to cold and dry season till timothy harvest.

*Blends of ESN and urea:*

- In the experiment on blends of urea and ESN, 75% N from urea and 25% N from ESN was at par with 100 % N from urea in dry matter yield of timothy. Increasing the proportion of N from ESN, in the total N application to timothy, tended to reduce the dry matter yield. Total residual mineral N (0-30 cm soil) in the early spring, before fertilizer application, was the same (14 ppm) with the two fertilizers.
- Protein content in timothy was higher with the blends of the two fertilizers than with the fertilizers applied alone/separately.
- Mineral N in the soil in the fall was highest (40 ppm; 50% in 0-30 cm, 30% in 30-60 cm and 20% in 60-90 cm) when ESN was applied alone. Eighty percent of total mineral N was in ammoniacal form and 20% in nitrate form with ESN.

*Urea and ammonium sulphate blends in timothy:*

- Application of N significantly improved dry matter yield of timothy. Ammonium sulphate and urea, when used alone/separately, @ 105 kg N/ha, didn't differ in first cut timothy yield, but ammonium sulphate gave higher second cut yield than urea.
- Blends of the two fertilizers appeared to improve the dry matter yield of timothy; application of 21 kg N/ha from ammonium sulphate and 84 kg N/ha from urea that produced the highest yield (6,012 kg/ha) could be the best economic option. N removal by timothy with this treatment was ~150 kg/ha.
- Protein content in the first cut of timothy was highest with urea (18 %; 2-3% points higher than ammonium sulphate/or blends of the two fertilizers). In the second cut, blends of the two fertilizers, on an average, gave > 1% point higher protein content than urea.

*Fall vs. spring application of N to grasses (timothy and brome grass):*

- Brome grass gave 2,125 kg/ha higher yield than timothy.
- In timothy, fall application of ESN @ 105 kg N/ha produced the highest dry matter yield (4,600 kg/ha), which is ~630 kg/ha higher than application of same amount of N from urea; 70 kg/ha applied in early spring and 35 kg N/ha applied after the first cut, and over 900 kg/ha higher than urea applied @ 70 kg N/ha in the fall (2008) and 35 kg N/ha applied after the first cut.
- In brome grass, fall application of ESN @ 105 kg N/ha produced as much dry matter yield (6,200 kg/ha) as urea @ 105 kg N/ha applied in two splits; 70 Kg N/ha applied in the fall/or early spring and 35 kg N/ha applied after the first cut.
- Optimum window for fall application of urea was September 25 to October 25!

- Soil mineral N content in early spring was lower when N was applied on September 25 as compared to N application at other times. This shows, as also evident from the protein content, that more N was taken up by grasses from the September 25 applied N as compared to N application on later dates.
- First cut protein content in timothy was highest (16.4%) when urea @ 70 kg N/ha was applied on September 25; the treatment was second best in bromegrass in which highest protein content was attained with ESN @ 105 kg/ha applied on September 25.
- Protein content in timothy in the second cut (35 kg N/ha applied to all treatments, after the first cut, except the check and ESN treatments), was highest (20.3%) when 70 kg N/ha was applied as urea on October 10 or when ESN was applied @ 105 kg/ha on September 25. In bromegrass, protein content was highest (20%) when urea @ 70 kg N/ha was applied on September 25 or November 10.

*Application of entire N to perennial forage grasses from ESN in the fall could therefore save one operation and widen the window of N application. Even application of urea to grasses in the fall rather than in the spring is another option with a fairly wide window of application.*

### **2.9.3 Corn for silage:**

*Partial substitution of urea with ESN and ammonium sulphate x zinc application in silage corn:*

- Comparison of each treatment combination revealed that application of urea @ 100 kg N/ha + Zn @ 7kg/ha produced the highest silage corn dry matter yield (12,267 kg/ha). However, the treatments effect on the yield was not significant.
- Main effects of the treatments indicated that partial (21%) substitution of urea N with N from ammonium sulphate/or ESN didn't significantly influence the dry matter yield of silage corn as compared to urea alone.
- Highest protein content in corn was obtained with urea without any substitution of N by ammonium sulphate/or ESN. Corn getting part N (21%) as ammonium sulphate had the lowest protein and ADF contents.
- Zinc had no favourable effect on protein content of corn.

### **2.9.4 Alfalfa Varieties:**

- *In OFCC 2007 trial*, alfalfa dry matter yield (total over 2008 and 2009) from the two cuts was in the order of *Oneida VR* ≥ *DS 723* > *OAC Superior*, though the yield differences were not statistically significant.

### **2.9.5 Alfalfa Nutrition:**

*N x B: N and B were not applied during 2009 (or 2008); the results indicate a residual effect from the N and B fertilizers applied during 2004- '07.*

- Maximum alfalfa yield from two cuts (5,014 kg/ha; over 1,200 kg/ha higher than that of the mean yield from the three checks) was registered with ammonium sulphate @ 30 kg N/ha + 2.25 kg B/ha.
- Ammonium sulphate was distinctly superior to urea and ammonium nitrate in its residual effect on alfalfa yield.
- Residual effect of N fertilizers on protein content in the first and the second cut was more or less similar.
- Residual effect of N @ 30 kg/ha on protein content was no better than N @ 15 kg/ha.
- Protein content increased by 1% point in both the cuts with increase in boron rate from 1.125 kg/ha to 2.25 kg/ha.

**N x S:** Supplement sulphur (S) in this experiment in the urea treatments was applied as elemental S; two-third of the total S (equivalent to the amounts supplied by different rates of ammonium sulphate) in the seeding year and one-third in the first harvest year.

- Application of urea @ 20-40 kg N/ha increased alfalfa dry matter yield as compared to the no N (check), though the differences were marginally short of the level of significance. Highest dry matter yield (5,217 kg/ha from two cuts-1.5 times higher than that from the check) was obtained with urea @ 40 kg N/ha + elemental S @ 46 kg S/ha.
- When compared over mean of three rates of S (23-69 kg/ha) and N (20-60 kg/ha) application, alfalfa yield from urea was a bit better than that from ammonium sulphate.
- Ammonium sulphate + urea on equal N and S basis @ 40 kg N /ha gave higher yield than either of the two fertilizers applied alone at the same level of N/and S.
- However, without supplementing S, alfalfa yield from urea was lower than that from ammonium sulphate at the same rate of N.
- *The results indicate that urea supplemented with elemental S could be agronomically and economically better than ammonium sulphate for alfalfa production.*
- Protein content in the first cut alfalfa was the highest with ammonium sulphate @ 60 kg N/ha; 2 % point higher than urea @ 60 kg N/ha supplemented with equal rate of S. In the second cut, however, the two treatments matched in the protein content (25%). In fact, overall in the second cut, urea supplemented with S had a distinct edge over ammonium sulphate in the protein content.
- Feed mineral content, especially Zn, Fe and Mn, appeared to be higher with ammonium sulphate as compared to urea (with or without supplementing S matching with supply from ammonium sulphate) more so in the first cut.

**P:** OMAFRA recommendation on P application to alfalfa was compared with P application at 50, 100 and 150% of P removal at 8 tonnes dry matter yield/ha and a check (No P).

- None of the treatments produced higher dry matter yield of alfalfa than the check.
- Application of P based on OMAFRA recommendations produced lower yield than the check.
- Application of P improved the protein content in both the cuts. In general, P application based on its removal increased first cut protein content as compared to P application as per OMAFRA recommendations. No such difference was observed in the second cut.

**K:** OMAFRA recommendation on K application to alfalfa was compared with K application at 50, 100 and 150% of K removal at 8 tonnes dry matter yield/ha and a check (No K).

- Application of K @ 50% of K removal gave the highest dry matter yield of alfalfa, followed closely by K application as per OMAFRA recommendations.
- Application of K @ 150 % of K removal or application of K @ 100 % of K removal (three years requirement applied at once in the fall of seeding year) tended to impact the alfalfa yield.
- Application of K improved alfalfa protein content by 2 % points in the first cut and by ~3 % points in the second cut. Application of K matching with 50 % of K removal at 8 tonnes dry matter yield/ha, resulted in the highest protein content (22 % in the first cut, and 25 % in the second cut).

*These experiments indicate that N, K and S are more critical for alfalfa than P.*

#### **2.9.6 Studies on Galega:**

- Galega was compared with alfalfa in pure stands and also in mixtures with timothy and orchard grass.
- Dry matter yield from galega was ~80 % of that from alfalfa.
- Legume grass mixtures appeared to improve dry matter yield as compared to legumes alone. Maximum yield (5,543 kg/ha) was obtained with alfalfa + orchard grass (80:20).

- First cut, but not the second cut, feed quality was better with galega than that with alfalfa. Galega had 3 % point higher protein content than alfalfa in the first cut; ADF and NDF were low, and TDN, energy values, and some minerals (K, Ca, B, Zn and Fe) were higher in galega as compared to alfalfa.

## 2.9.7 Forage Cereals:

### Varieties:

- *Barley: Xena* (6,823 kg/ha) and *Champion* (6,506 kg/ha) were the two (out of 8) top yielding varieties. *Vivar*, *CDC Mindon*, and *AC Ranger* (12-13% protein) had an edge over other varieties in protein content (10-11%); *though AC Ranger seemed to have the best overall feed quality.*
- *Oats: AC Ranger* (a check barley variety used for comparison) produced the highest dry matter yield (5,181 kg/ha; over 1,000 kg/ha higher than the next best *AC Jordan*). There was hardly any difference in the feed quality parameters in the oats varieties.
- *Triticale: AC Ranger* (a check barley variety used for comparison) resulted in highest dry matter yield (5,736 kg/ha); the other three varieties (*Tyndal*, *Bunker* and *T196*) were at par with each other in dry matter yield and also in feed quality.
- *Proso Millets:* Dry matter yields from three proso millets (*Green Crown Millet*, *Yellow AC Prairie Gold* and *Red Cerise*) were in a narrow range of 1,637 – 1,826 kg/ha. *Green Crown Millet*, *Yellow AC Prairie Gold* had 4% point higher protein content than *Red Cerise*.
- *Foxtail Millet: Black Millet* (2,329 kg/ha) had the highest dry matter yield, and *Golden German Millet* the highest protein content (20%) amongst the three varieties compared.

### Alternate forages:

- Spring cereals, corn, barley + peas and spring barley + winter wheat (all seeded in spring) were compared for their relative forage yield.
- *Corn* produced the highest dry matter yield (12,280 kg/ha).
- Amongst other crops/crop combinations, *CDC Lophy-I* (low phytate barley) and *Millhouse* (hullless food barley) gave the highest dry matter yield (over 6,700 kg/ha in both cases). *CDC Lophy-I appeared to have the best feed quality.*
- Out of three spring cereals, *Triactor*, a new variety of oats gave the highest grain yield (6,000 kg/ha).

### Residual effect of N fertilizers applied to winter wheat @ 120 kg N/ha on forage oats (2009):

- If there was any treatment that left any residual effect on oats yield it was urea. None of the other fertilizer treatments, ammonium sulphate alone or ESN alone or their blends with urea in different proportions, applied to winter wheat last season, gave higher oats yield than the check (no N application).
- Protein content in forage oats was higher with ESN/and ammonium sulphate (12%) than that with urea (8%); the protein content in the rest of the treatments (various blends of the three N fertilizers) was in between these two extremes.

## 2.10 Long Term Experiments:

### 2.10.1 Lime and Wood ash (barley after 3 harvest years of alfalfa-barley):

- Lime/and wood ash were applied in spring 2004 (seeding year) and in fall 2006 in the 'after every two years' frequency of application treatments. In fall 2008, wood ash/and lime were applied again in the 'after every two years' and 'after every four years' frequency of application treatments.
- Both lime and wood ash, applied singly or in conjunction with each other, appeared to improve grain yield of barley. There was hardly any difference in the grain yield between

the main effects of wood ash/or lime, though wood ash + lime recorded the highest grain yield, especially when lime + wood ash were applied after every two years. This treatment also resulted in the highest straw and biomass yield. However, lime alone, but not wood ash alone, applied after every two years appeared to have a depressing effect on grain yield as compared to its application after every four years.

- Mid season soil tests indicated that application of wood ash, but not lime, raised the soil pH to 7.0-7.1 from 6.1 in the check. Both lime and wood ash applied after every 2 or 4 years increased available Ca in the soil, as compared to the check, but only wood ash applied after every 2 years increased available K in the soil. Available P in the soil appeared to be higher with lime than that with wood ash, whereas the reverse was true for Zn, Mn, and B. In fact application of wood ash doubled the Mn content in the soil. Lesser the time for reapplication of wood ash better the contents of available nutrients in the soil.
- *End of the season soil tests in fall 2008 indicated that application of wood ash has not increased heavy metals content in the soil after five crop seasons.*

#### **2.10.2 Manure, wood ash and fertilizer nutrients (barley after 4 years alfalfa-barley):**

- Solid dairy manure was applied in the springs of 2004 and 2007, and fall 2008; wood ash was applied in spring 2004 and in falls of 2006 and 2008, whereas fertilizer nutrients were applied every year. Barley grain yields were similar with application of manure alone or wood ash alone or manure + wood ash. Wood ash + manure followed by manure alone produced the highest straw and biomass yield.
- Application of N (70 kg/ha) appeared to increase the barley grain yield, but significant increase in grain yield with fertilizer(s) application was obtained only when P/or P + K were also applied with N. However, grain yield differences between NPK treatments were only marginal.
- Application of N alone resulted in significant increase in straw and biomass yield. Application of K, but not P, improved the straw and biomass yield further (though without any corresponding increase in grain yield).
- Interactions between manure/wood ash and nutrients were not significant, which means that the nutrient effects were not influenced by manure/wood ash and vice versa.
- Application of wood ash/or manure had no effect on the grain protein content, which increased by over 1 % points with the application of N (with or without P and K).
- Mid season soil tests (2009) revealed that wood ash (with or without manure), but not manure raised the soil pH to 7.2 (6.3 in manure and 5.9 in check plots). Both wood ash and manure improved the soil organic matter; manure did more than the wood ash. Calcium and micronutrients (Zn, Mn, Cu and B) availability was more with wood ash than that with manure; the reverse was true for K and Mg.
- *Contrary to the common belief, especially with respect to manure, available soil sulphur was not at all affected by the application of manure/or wood ash.*
- Fertilizer nutrients improved the soil organic matter and available P and K, but lowered the soil pH, as compared to the check plots (without fertilizers).

#### **2.10.3 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 in 2008 and 2009.
- Soybean grain yield was highest after silage corn (2,361 kg/ha) and lowest after wheat (1,451 kg/ha). Soybean grain yield after ryegrass, barley and oats ranged between 1,700-1,800 kg/ha). Nutrient removal followed the same trend as yield.

- Wheat grain yield (2,043 kg/ha) in this experiment, after barley, was only about half of barley grain yield (4,094 kg/ha) after barley.
- Silage corn dry matter yield (after barley) was low at 3,556 kg/ha.
- Macro and micronutrients contents and removal by different crops, through grains or straw or total biomass were analyzed and are reported. Soybean removed more nitrogen, potassium, boron and copper as compared to cereals.

#### **2.10.4 Alfalfa Persistence/Maximum Yield (seeded in 2005):**

- Sulphur appeared to be the single most important nutrient for increasing alfalfa dry matter yield (by over 1,200 kg/ha in two cuts).
- Addition of zinc, boron and manganese to NPKS didn't significantly increase alfalfa yield.
- Wood ash and manure applied only once in fall 2004, and application of N, P, K, S, B, Zn and Mn produced similar yield (over 5,500 kg/ha), which was ~500 kg/ha higher than all these nutrients without manure/or wood ash.
- *Adjusting nutrient contribution from manure/or wood ash in the fertilizer program lowered alfalfa yield.*
- Protein content in alfalfa supplied with NPKS was 21 % in the first cut and 22 % in the second cut. Addition of B and Zn/or B, Zn and Mn to NPKS increased protein content further by 1 % point in the second cut only.

#### **2.10.5 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 therefore recorded this year.

#### **2.11: Medicinal Plants:**

- A Medicinal Plants Garden with over two dozen species was established in 2005 to study their survival, growth and the quantity and quality of active constituents in the natural environment. The plants survived and grew well during 2005-08. Details may be seen TBARS Annual Report 2008 (contribution by Professor Lada Malek of Lakehead University, Thunder Bay).
- Systematic small plot research was initiated on *Arctium lappa* and *Scutellaria laterifolia* during 2008.
- Closer row spacing (15 cm x 15 cm in *Scutellaria laterifolia* and 30 cm x 30 cm in *Arctium lappa*) produced higher leaf, stem and total plant biomass yields than wider row spacings.
- Total biomass yields from the two species, at optimum spacings (11,533 and 12,317 kg/ha, respectively) were at ~7% variance.

