YUKON AGRICULTURE RESEARCH & DEMONSTRATION

2005 PROGRESS REPORT

Yukon

Energy, Mines and Resources

Preface

This document is a record of agricultural trials, experiments, and studies conducted in the Yukon. This is a yearly testimony of new and accumulated data and information set out to assist growers and researchers with future endeavors related to northern agriculture.

The target audience for this document is commercial agriculture producers, growers, and those interested in northern agronomic research.

Acknowledgments

The authors would like to thank all agricultural producers who participated and contributed with site locations, data collection, and field monitoring and observations. Recognition is also extended to the Forest Management Branch of the Department of Energy, Mines and Resoucres, as well as Environment Canada for contributing valuable climate data. In addition, the Agriculture Branch would also like to thank Manfred Hoefs of AMBOCA Ecological Services for his contribution with the elk nutrition study, and Leigh MacMillan, the 2005 S.T.E.P. student (Student Training Employment Program), for his hard work and enthusiasm.

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Table of Contents

Tables, Graphs, and Photographs

FRONT COVER

Main photo: Alfalfa nodulation trial.
Inserts (left-right): 1) brome grass trial, 2) fruiting raspberry cane, and 3) brome grass

TABLES

GRAPHS

PHOTOS

1.0 Introduction

The Yukon Agriculture Branch conducts a variety of research and demonstration work to enhance the knowledge base of agriculture North of 60°. Agriculture research has been taking place in the Yukon for almost one-hundred years and is an important aspect of the development of the industry.

As thousands of people entered the Yukon during the Klondike Gold Rush there was a necessity for people to produce their own food. In 1915, the Dominion Department of Agriculture began conducting co-operative research with interested producers in the Yukon. In 1917, the Department established an experimental sub-station at Swede Creek near Dawson City. The results of this research carried out at the station confirmed that a variety of crops could be grown successfully at a latitude of 64° north, with yeilds and quality of produce comparing favourably with those obtained in agricultural areas a thousand miles to the south. The Swede Creek station closed in 1925.

In 1944, after the completion of the Alaska Highway, the Government of Canada conducted soil surveys in the Yukon and established a new experimental farm at Mile 1019 of the Alaska Highway near Haines Junction. A variety of vegetables, forages and livestock were grown without difficulty. The station closed in 1968.

Key studies were undertaken in the 1970s to determine the climate classification and soil capability. A large scale soil mapping exercise was completed in 1977.

The Yukon government began conducting their own research through the 1980s. A number of studies and reports were published through the 80s and 90s examining fertilizer rates, soil organisms, forage varieties, management techniques, etc. In 1998 the Yukon government established a small research site at the Gunnar Nilsson and Mickey Lammers research forest. The mulitude of research projects conducted at this site have since lead to a number of variety and management practice recommendations.

The mandate of the extension and research arm of the Agriculture Branch is to provide advice to farmers in all aspects of farm management, production, marketing, conservation techniques, new farm technology, and farm financing.

It is with this mandate that we move forward and look at new crops and techniques that can advance Yukon agriculture.

During the 2005 growing season the branch increased the research area at the Gunnar Nilsson and Mickey Lammers research forest and teamed up with co-operators for on farm trials.

The focus of research at the research farm was to continue work on the input management trials initiated in 2002, to implement an alfalfa study and establish a new forage demonstration trial.

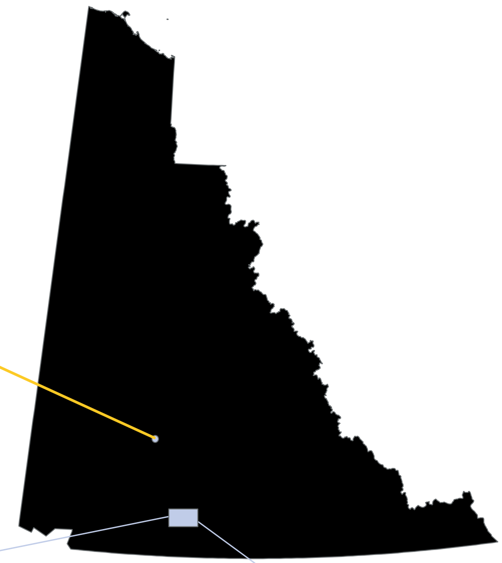
New co-operator trials were initiated this year in conjunction with the alfalfa study looking at alfalfa establishment within existing forage stands.

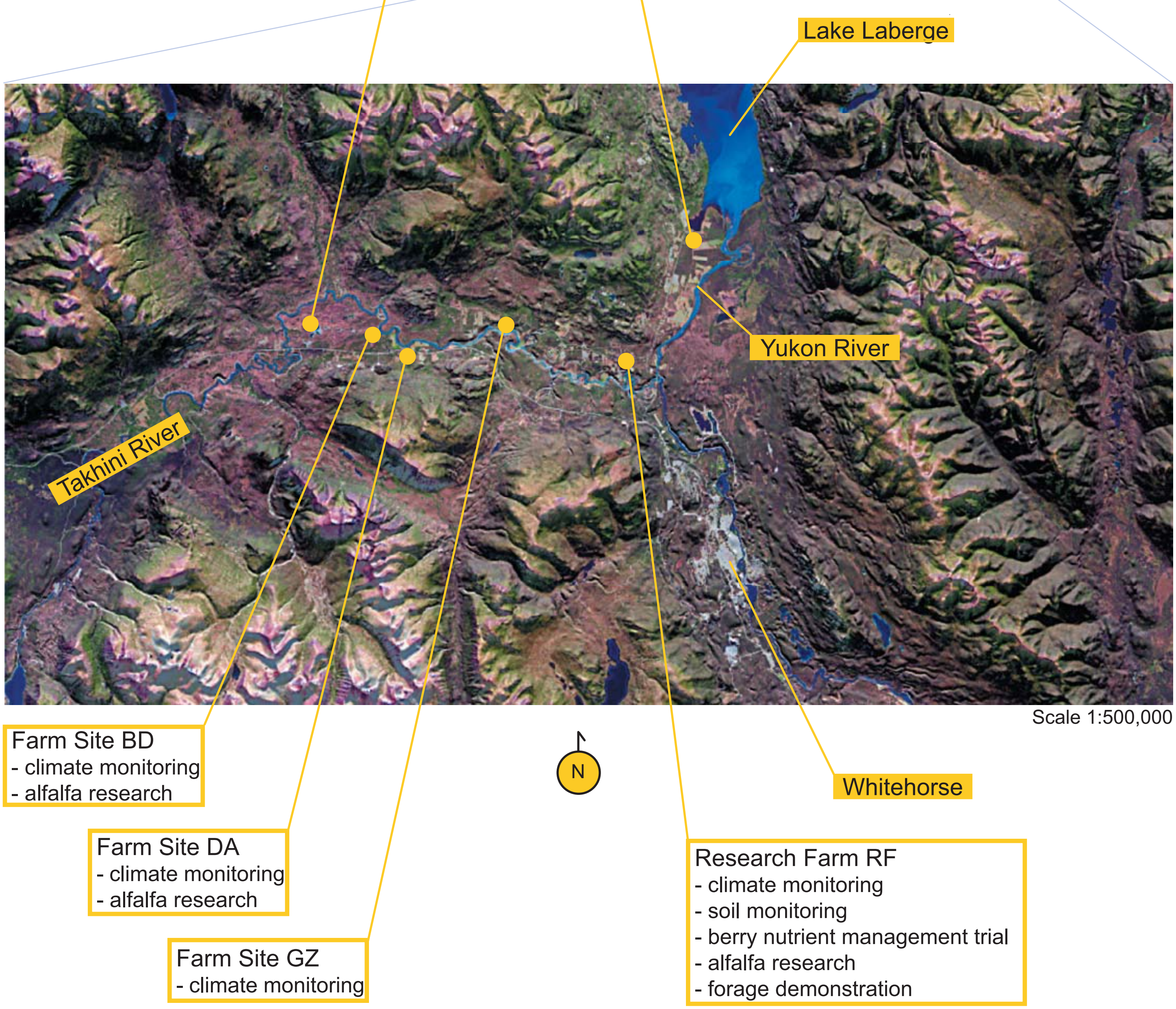
2005 also saw an increase in the number of collection sites for agroclimatic data. Five climate stations were setup in the southern and central Yukon, collecting air temperatures to help understand microclimate variations and to calculate agroclimatic ratings.

Photo 1: New forage demonstration. September 22, 2005

1.1 Map of 2005 Research Areas

This map delineates the areas currently used for agricultural research in Yukon. This derives from a Landsat 7 composite image created in 2004. It was modified with a natural colour shaded relief derived from a 90 meter Digital Elevation Model. This highlights the geography that limits agriculture in the Whitehorse area.





1.2 Site Descriptions

Research Farm: This site is located on 1.3 hectares (3.2 acres) near the northeast corner of the Gunnar Nilsson and Mickey Lammers Research Forest. This Research Forest is situated south of the junction of the Klondike Highway and the Takhini Hotsprings Road. The fine textured soils at the demonstration plot vary from silt loam to sandy loam, and their potential for agricultural production is rated as fair to good. These soils belong to the Lewes soil association and are characterized as loam, with an average particle size breakdown of 42% sand, 47% silt and 11% clay throughout the four fields that atre there. The average soil pH in these plots is approximately 7.0 (neutral) and is trending downwards, or morer acidic over the years. Average soil organic matter is as low as 2%.

The Research Farm is located on a level field surrounded by forest providing shelter from winds, consequently creating a frost pocket. The soil, landscape and climatic properties of the site are typical of those encountered at many farms in the southwest region of the Yukon. The elevation of this site is 660 m (2160 feet) amsl.

BD Farm Site: This location is on a flat alluvial terrace beside the Takhini river. Soils are classified as loams with a pH between 7 – 7.5, which have a low electrical conductivity around 1.5 dS/m. This site has some low lying wetter areas with undulating terrain due to thawing of ice lenses (thermokarst) which spans over a large clearing of approximately 130 acres. The elevation is 670 m (2200 feet) amsl.

DA Farm Site: This is located on a gently north facing slope. The glaciolacustrine soils are classified as loam with a pH around 7.7 and high 3% or greater level of organic matter. Electrical conductivity is under 1 dS/m. The aspect of the slope allows for the maintenance of higher moisture over the summer providing a better regime for decomposition, in turn increasing the amount of organic matter. This location has a large cleared area of approximately 200 acres. The elevation is 700 m (2300 feet) amsl.

GZ Farm Site: Location GZ is on an alluvial terrace next to the Takhini river on a slightly sloping, south face. Soils are classified as loam to clay loam with an average pH of 8.2 and very high organic matter between 5 – 10%. Electrical conductivity ranges below 1 dS/m to upward of 3.7 dS/m resulting in areas of poor growth. This is a small cleared area with poor frost drainage. The elevation of this site is 640 m (2100 feet) amsl.

SM Farm Site: This location is on a flat alluvial terrace next to the Yukon river. Soils are sandy loam to loamy sand with an average pH of 7.2. The electrical conductivity is below 1 dS/m and organic matter is approximately 2-3%. There is a large cleared area of over 100 acres. Elevation is 640 m (2100 feet) amsl.

Carmacks Farm Site: This is the location of the field where vegetable crops are produced for the Little Salmon Carmacks First Nation. There is a small cleared area approximately four acres on the edge of the Yukon river. The pH is around 7.3 and electrical conductivity below 0.5 dS/m. Elevation 520 m (1700 feet) amsl.

Photo 2: Looking north across the BD Farm Site. Alfalfa trial is in the foreground

2.0 Agroclimatology

Climate is the major limiting factor to agriculture in the Yukon due to a short frost free period and lack of heat units during the growing season. Agroclimatic capability ratings are a measure of the degree of limitation imposed by climate on agricultural production. These ratings are derived from 30-year normal data collected by the Meteorological Service of Environment Canada.They represent a measure of the amount of heat available to crops during the growing season. The agroclimatic rating is modified to account for local climate patterns, such as frost occurrences, which affect the length of the growing season. As shown in Table 2.0, agroclimatic classes range from Class 1 (no restrictions) to Class 7 (unable to be used for any agricultural purpose).

The number of Growing Degree Days (GDD) are calculated beginning the fifth consecutive day of the year with daily mean temperatures above 5°C, and terminated the day of the first killing frost (-2.2°C) occuring after July 15. This killing frost temperature does not need to occur as a daily mean temperature, but rather at any moment of a day. For example, if the daily mean temperature is 10°C, the GDD total is 5. Similarly if the daily mean temperature is 16°C, GDD equals 11. However, in the instance that a mean temperature is 5°C or lower, GDD would equal 0.

Research Farm

During the 2005 growing season the Research Farm recorded 659 GDD. This temperature factor is adjusted upward by 18% to account for the boost plants receive from the long hours of daylight north of 60° latitude. As you head further north the GDD is adjusted incrementally higher (Dawson City is adjusted by 22%). Therefore, the 659 GDD recorded in 2005, becomes 778 Effective Growing Degree Days (EGDD) at the Research Farm. The first killing frost occurred on August 1. Hence, the agroclimatic rating for 2005 was a Class 5 (700-900 GDD); the most common agricultural classification for the Yukon. Such lands have severe limitations that restrict the range of crops to forages, improved pastures and cold-hardy vegetables. This data is summarized in Table 2.1.

Although the first killing frost occured August 1, and is recorded to have lasted from 3:00 - 5:00 am, such a frost does not occur again until one month later; specifically on September 1. GDD computation based on the September 1 killing frost drastically alters the growing season's results to a total of 1054 EGDD, which corresponds to a Class 3 in the Capability Classification (Table 2.2).

Table 2.3 shows the weather data summary for the Research Farm from 1995 to 2005.

Table 2.0: Definitions and operational constraints of land capability classes for cultivated agriculture in the Yukon Territory (Tarnocai *et al*. 1988)

Class 1 1400-1600 GDD	These lands have no significant limitations that restrict the production of the full range of common Canadian agricultural crops (none in Yukon).
Class 2 1200-1400 GDD	These lands have slight limitations that restrict the range of some crops but still allow the production of grain and warm season vegetables (none in Yukon, based on a 30 year average).
Class 3 1050-1200 GDD	These lands have moderate limitations that restrict the range of crops to small grain cereals and vegetables (in a few localized areas in Yukon).
Class 4 900-1050 GDD	These lands have severe limitations that restrict the range of crops to forage production, marginal grain production and cold-hardy vegetables (valleys of central Yukon).
Class 5 700-900 GDD	These lands have very severe limitations that restrict the range of crops to forages, improved pastures and cold-hardy vegetables (the most common class of agricultural land in Yukon).
Class 6 <700 GDD	These lands have such severe limitations for cultivated agriculture that cropping is not feasible. These lands may be suitable for native grazing.
Class 7	These lands have no capability for cultivated agriculture or range for domestic animals.

Table 2.1: Agroclimatic data for the 2005 growing season at the Research Farm

Table 2.2: Season extension

Climate Factor	April	May	June	July	August	Total	August	September	Modified Total
Max Temp	21.8	22.5	26.9	25.4	29.6		29.6	17.3	
Min Temp	-14.2	-9.3	-2.2	-2.1	-2.7		-2.7	-8.8	
Mean	2.73	9.74	12.87	13.59	12.56		12.56	7.17	
Total Rainfall (mm)	24.86	14.46	62.87	34.98	36.97	173.94	36.97	21.52	195.46
30 year normal	1.3	13	29.7	41.4	38.5	123.9	38.5	29.3	153.2
Growing Degree Days	5.81	150.54	236.13	266.43		658.91	234.38		893.29
Effective Growing Degree Days	6.86	177.64	278.63	314.39		777.51	276.57		1054.08
Frost Free Period			9-Jun	5-Jul		25 Days			25 Days
Killing Frost Free Period (-2.2)		31-May	-	-	1-Aug	61 Days	-	1-Sep	92 Days

* 30 year normals are derived from the Whitehorse Airport weather station 1971-2001.

** The temperature factor is adjusted upward by 18% to account for the boost plants receive from the long hours of daylight north of 60° latitude.

*** Whitehorse Airport records a 30-year mean frost free period of 87 days. This is longer than most frost free periods recorded at the Research Farm. The airport site regularly receives winds which tend to keep the temperature above freezing, while the forest sheltered nature of the Takhini Valley Research Farm site reduces air movement, making frosts more common.

Table 2.3: Growing season weather data summary for the Research Farm: 1995-2005

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
EGDD	859	595	901	972	957	784	838	729	758	1253	778
Land Capability Class	Class 5	Class 6	Class 4	Class 4	Class 4	Class 5	Class 5	Class 5	Class 5	Class 2	Class 5
Frost Free (days)	44	25	45	35	50	50	51	18	40	18	25
Killing FF (days)	67	50	74	81	85	68	77	51	54	88	61
Precipitation (mm)	107	162	125	57	145	179	159	98	98	94.89	174
Max Temp (°C)	31.1	29.6	28.7	34.1	33.2	35.0	30.8	27.3	27.3	34.1	29.6

Photo 3: Looking north across the berry nutrient management trial. Strawberries in the foreground, raspberries in the background

2.1 Agroclimatic Data Comparison

Historical climate data comparisons between the Research Farm and the Whitehorse Airport have shown interesting contrasts between growing degree day (GDD) values. These differences are mainly attributed to site profiles; namely elevation, slope, aspect, and wind. In 2004, the Agriculture Branch set out to record temperatures at various farm sites in the Yukon, particularly in the Takhini river valley in order to assess their Agroclimatic Capability Classification, as well as to compare and contrast microclimates of these different agricultural settings. In 2005, additional temperature data loggers were deployed at other farm sites in order to expand on this comparitive analysis.

Methodology

Data loggers used to record ambient temperature throughout the growing season were placed at five different locations: three within the Takhini river valley and two within the Yukon river valley. These small battery operated sensors called HOBO's (manufactured by Onset Computer Corporation) were fixed approximately two meters (six feet) above ground on a steel bar using Stevenson screens, or plastic protective plates for solar shielding. This height was used in order to avoid stagnant air movement at ground level, where boundary layers tend to occur. Furthermore, this height factor could adjust for non-uniform terrain common at some of the chosen sites, hence resulting in more representative air temperature samples.

The recording period started in early to mid May, depending on the site, and lasted until late August to early September. Since temperatures recorded at the Research Farm indicated heat units relevant to GDD computation prior to and after the recording period for the farm sites, a correction was made using linear regression. Values outside the recording period were established based on temperature trends found at the Research Farm.

Results and Discussion

Micro-climate variations, as with other weather phenomena, are difficult to predict. Distributing small data loggers through the Takhini valley has lead to some interesting findings. Two sites adjacent to each other (BD and DA), with different aspects, but similar management practices have almost identical growing seasons. These two sites fall in a Class 3 climate, capable of small grain cereals and horticulture.

Farm Site GZ always records lower than average temperatures because of the sheltered, low lying position on a flood plain of the Takhini River.

Results for all the sites are summarized in Tables 2.3 to 2.7.

Table 2.4: BD Farm Site 2005, 670m amsl, flat terrain

Climate Factor	April	May	June	July	August	September	Total
Max Temp	21.22	22.09	28.7	27.12	33.59	20.19	
Min Temp	-11.26	-7.21	-1.06	0.29	-1.06	-7.85	
Mean	3.97	10.31	13.37	13.86	13.02	7.17	
Growing Degree Days	23.95	165.31	250.88	273.03	248.69	0.46	962.32
Effective Growing Degree Days	28.26	195.07	296.04	322.18	293.45	0.54	1135.54
Frost Free Period			8-Jun	-	1-Aug		53 days
Killing Frost Free Period (-2.2)		22-May	-	-	-	3-Sep	103 days

Did you know ?
As you move towards central Yukon (eg: Carmacks and Dawson) the change to a more continental climate results in a longer growing season with more heat units. This also means it is typically colder in the winter!

Table 2.5: DA Farm Site 2005, 700m amsl, north aspect

Climate Factor	April	May	June	July	August	September	Total
Max Temp	20.08	22.48	24.4	27.12	31.12	17.52	
Min Temp	-8.35	-5	-0.61	1.17	0.29	-6.82	
Mean	4.93	10.48	12.96	13.68	13.09	7.26	
Growing Degree Days	27.39	169.95	238.86	268.99	250.69	0.45	956.33
Effective Growing Degree Days	32.32	200.54	281.85	317.41	295.81	0.53	1128.47
Frost Free Period			8-Jun	-	1-Aug		53 days
Killing Frost Free Period (-2.2)		22-May	-	-	-	3-Sep	103 days

Table 2.6: Carmacks Farm Site 2005, 520m amsl, flat terrain

Climate Factor	April	May	June	July	August	September	Total
Max Temp	21.12	24.01	25.56	27.12	27.42	17.58	
Min Temp	-7.96	-4.13	-0.16	-4.33	1.33	-3.24	
Mean	5.6	11.35	13.89	15.69	13.67	9.46	
Growing Degree Days	41.03	196.95	266.68	298.52	268.66	2.74	1074.58
Effective Growing Degree Days	48.42	232.40	314.68	352.25	317.02	3.23	1268.00
Frost Free Period		28-May	-	-	21-Aug		84 days
Killing Frost Free Period (-2.2)		19-May	-	-	-	3-Sep	106 days

Photo 4: Weather station at farm site BD

Table 2.7: GZ Farm Site 2005, 640m amsl, south aspect

Climate Factor	April	May	June	July	August	September	Total
Max Temp	20.6	24.01	25.17	25.17	30.71	18.66	
Min Temp	-12.94	-8.5	-1.97	-0.16	-1.51	-8.03	
Mean	2.8	9.3	12.31	12.93	12.18	6.7	
Growing Degree Days	5.21	135.21	219.37	245.79	222.63	0	828.21
Effective Growing Degree Days	6.15	159.55	258.86	290.03	262.70	0.00	977.29
Frost Free Period			8-Jun	29-Jul			50 days
Killing Frost Free Period (-2.2)		28-May	-	-	-	3-Sep	97 days

Table 2.8: SM Farm Site 2005, 640m amsl, flat terrain

Climate Factor	April	May	June	July	August	September	Total
Max Temp	20.52	24.01	25.95	25.17	29.1	17.9	
Min Temp	-7.93	-4.5	0.29	1.17	0.73	-4.01	
Mean	5.37	10.77	13.34	14.47	13.1	8.27	
Growing Degree Days	36.68	178.72	250.34	293.62	251.19	1.91	1012.46
Effective Growing Degree Days	43.28	210.89	295.40	346.47	296.40	2.25	1194.70
Frost Free Period		23-May	-	-	1-Aug		69 days
Killing Frost Free Period (-2.2)		19-May	-	-	-	3-Sep	106 days

2.2 Soil Temperature & Moisture

Soil temperature and moisture measurements are important in order to understand plant growth. In cold soils microbial activity is reduced, minimizing the cycling of bio available nutrients in the soil matrix. Cold soils can also reduce plant performance and reduce yields.

Prior to this experiment, soil temperature data for the North had been collected in context to permafrost. For this experiment three sites had their soil temperature values recorded: the agriculture research site, farm site BD, and farm site DA. In contrast to the permafrost data, these sensors were deployed at root zone depths, 0-10 cm deep.

When soil temperature probes were initially buried in the early part of the growing season, the recorded values appeared higher than expected.

Soil Temperature

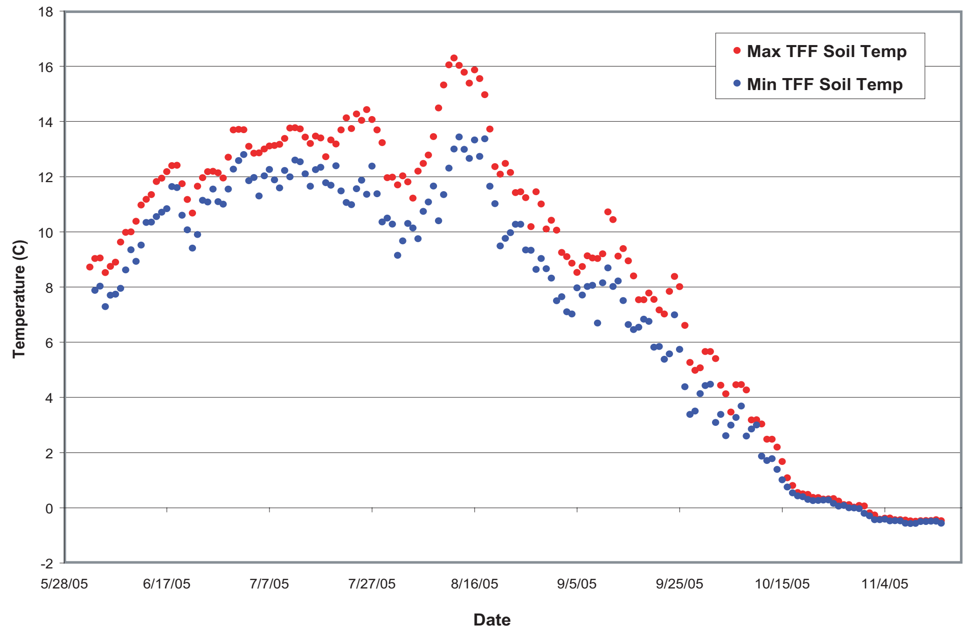
Graphs 1 to 3 represent the minimum and maximum soil temperatures at the research site, farm site BD and farm site DA. At the research site data was collected well into the fall to monitor soil freezing, which occurred October 28, 2005.

Due to the difference between the soil temperature probes and the difference in depths that were being monitored, it was difficult to compare the soil temperature at the research site with the farm sites, therefore no direct comparisons were inferred.

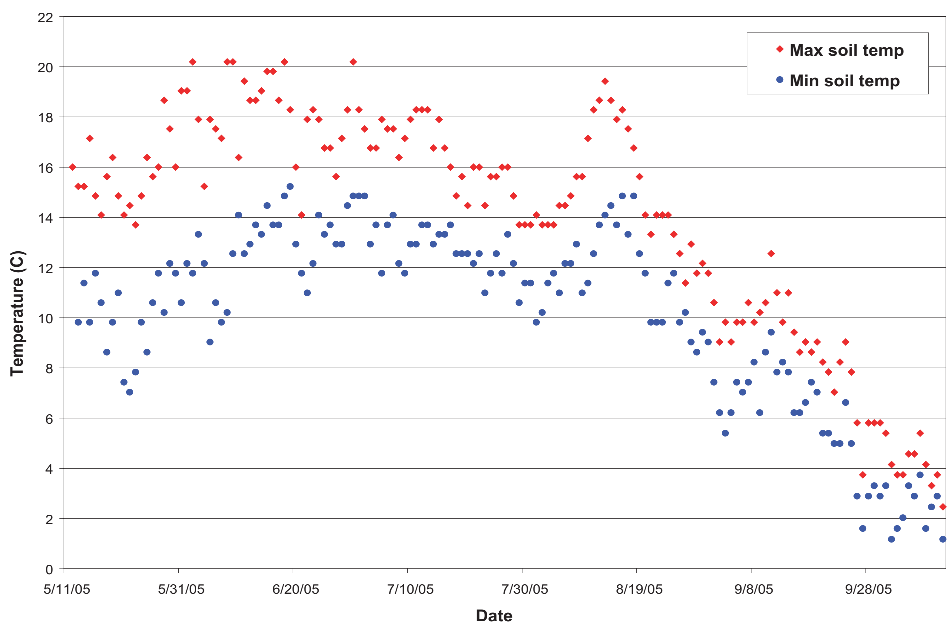
At the research site the three metre long Aquaflex sensors were inserted into the soil at 15 cm depth. The data capture started late into the spring, in early June the soil temperature at this depth was only around 8°C with little variability between minimum and maximum values.

At the farm sites the maximum daily soil temperatures at the beginning of May were already over 10°C from 0-10 cm. For rhizobia, the critical temperature for nitrogen fixation is a minimum 10°C (Rice *et al*, 1995). The variability between the minimum and maximum temperatures at this depth and location was more pronounced. The soil temperatures reached up to 20°C in early June through to early July and then another spike in mid-August.

Graph 1: Soil temperature at research site RF



Graph 2: Soil temperature at Farm Site BD



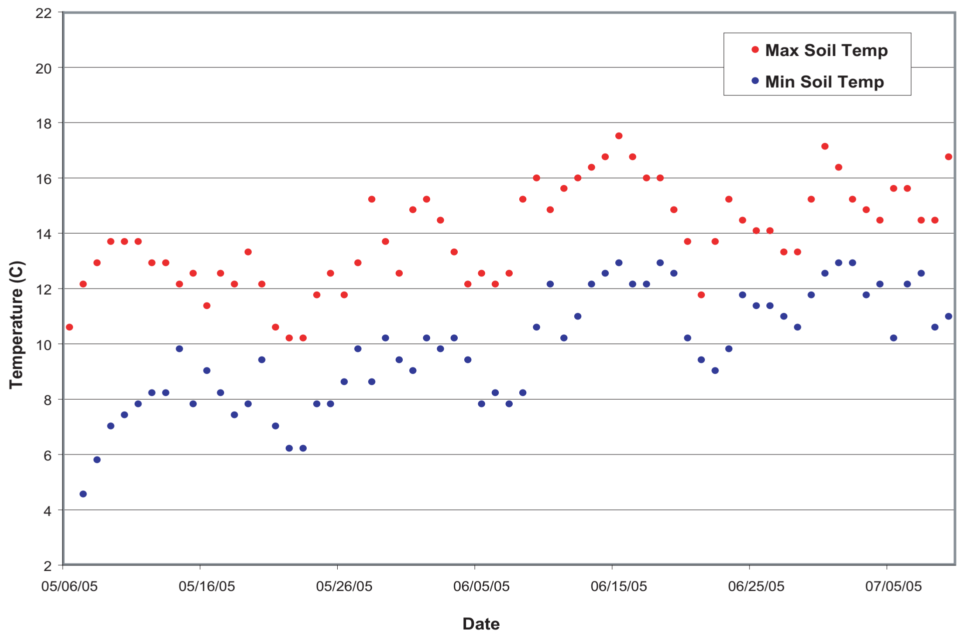
The soil sensor at farm site DA was damaged during harvest July 10. Soil temperature maximums were not as high as at farm site BD, with temperatures through June never quite reaching 20°C but still providing adequate temperature for nodulation.

Soil Moisture

Time domain reflectrometry (TDR) measurements were used to compute the volumetric moisture content (VMC) of the plots at the Research Farm. Graph 4 highlights the moisture variability within each block. Samples were taken randomly throughout the fields at various time intervals over the summer. Ten measurements were averaged for each data point shown on the graph.

Three plots were monitored in all. The brome plot showed consistently higher moisture than the other two plots. This was because it was irrigated up to 50% more for the purpose of monitoring nutrient fluxes in the root zone.

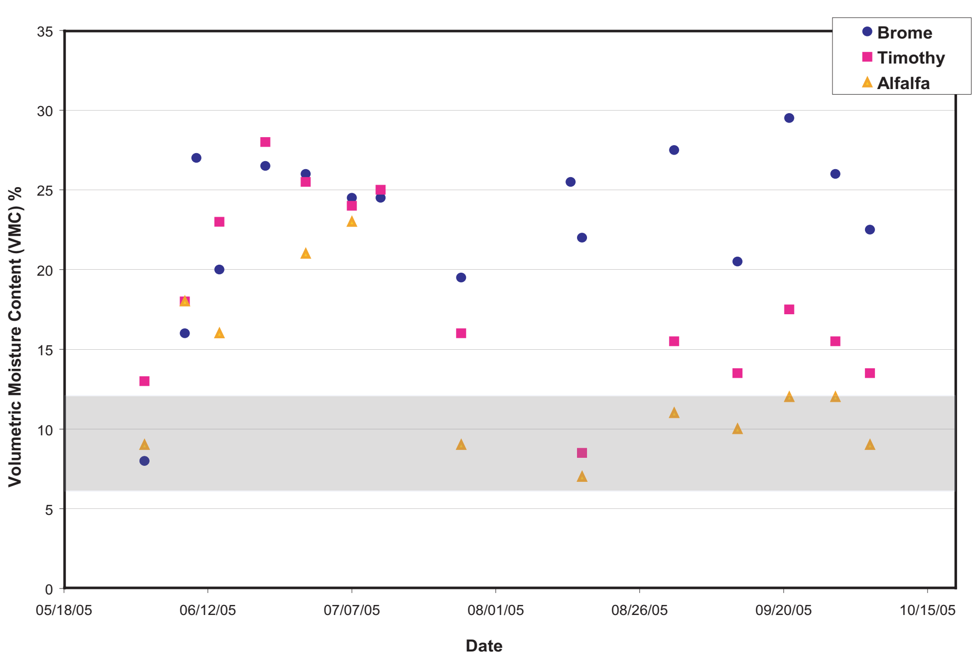
Graph 3: Soil temperature at Farm Site DA



The permanent wilting point (PWP) is the point at which plants can no longer draw water from the soil. The deficiency in the soil moisture results in stress for plants exhibited as wilt. Based on a series of moisture retention curves developed in 2003, the PWP for the silt loam soil at the Research Farm is 9-12% for 0-6 cm depth, and 6-9% for 6-12 cm depth (identified by the shaded area on the Graph 4).

There are 11 points on the graph that fall within the range of the identified permanent wilting point. Particularly of concern is the frequency of occurrence of low moisture in the alfalfa plot. This is demonstrated by the eight points in the PWP shaded area of the graph. Observations in the field noted wilting vegetation only on a couple of occasions - not as frequently as the graph suggests. The difference between the observational notes and the TDR data can likely be attributed to the dry upper root zone. The TDR probe calculates one moisture level value for 0-20 cm depth. Since this value represents the average for the area, it is not always representative of moisture content at a specific depth (eg: moisture readings at 20 cm depth and 5 cm depth can differ substantially). Therefore skewed averages resulting from dry upper soils would not account for moisture that is accessible by plants deeper in the root zone.

Graph 4: TDR volumetric moisture content at the research site TFF



3.0 Agriculture Research Farm Berry Trials

The input management trial was initiated in 2002 with collaboration from the Pacific Agri-Food Research Centre in Summerland, BC. The purpose of the trial is to examine best management practices for fertilizing and irrigating Yukon crops. The idea being to apply only as much water as is needed. This not only conserves water resources, but it reduces the risk of nitrate leaching below the root zone.

The key to minimizing water use is to have a clear understanding of how much moisture is used by the plant, how much is transpired through the leaves and how much is lost through the soil.

Using various crop monitoring technologies information on soil moisture and evapotranspiration (ET) is computed and water is automatically delivered as required. This trial will also help determine the usefulness of new technologies in Yukon applications. Crop management experience was gained during the Small Fruit Variety Trial initiated in 1998 that was incorporated into this new trial. Our hope is that some of these new techniques could be applied to other Yukon field crops such as potatoes, grains and forages.

Strawberry harvest was low in 2005, declining in both years subsequent to 2003, due to significant winter mortality. This was the first year with a successful raspberry harvest.

Photo 5: Fruiting raspberry cane

3.1 Berry Trial - Raspberries

The raspberry orchard was established at the Research Farm site in 2002 and took until 2005 before the orchard was mature enough to produce a meaningful harvest. Work on the orchard began as soon as the snow melted in early May of 2005, with thinning and pruning taking place, and florocanes being tied to trellis wires on the outside of the rows. A light application of *Princep-9T* herbicide was applied to the rows prior to new shoot emergence. This was done to reduce weed growth within the rows, where cultivation would not be possible after the leaves came out.

Photo 6: Agrologist Tony Hill harvesting data

As mentionned in the agroclimate section (2.0), on the early morning of August 1 the site had two hours of killing frost, -2.7ºC, creating concern that this would kill the blossoms producing immature fruits. Fortunately, little damage occurred and the next killing frost did not happen until September 9.

Harvest began on August 17 starting on the lower branches of the Alaskan variety Kiska. The harvest peaked for both Kiska and the Canadian variety Souris on

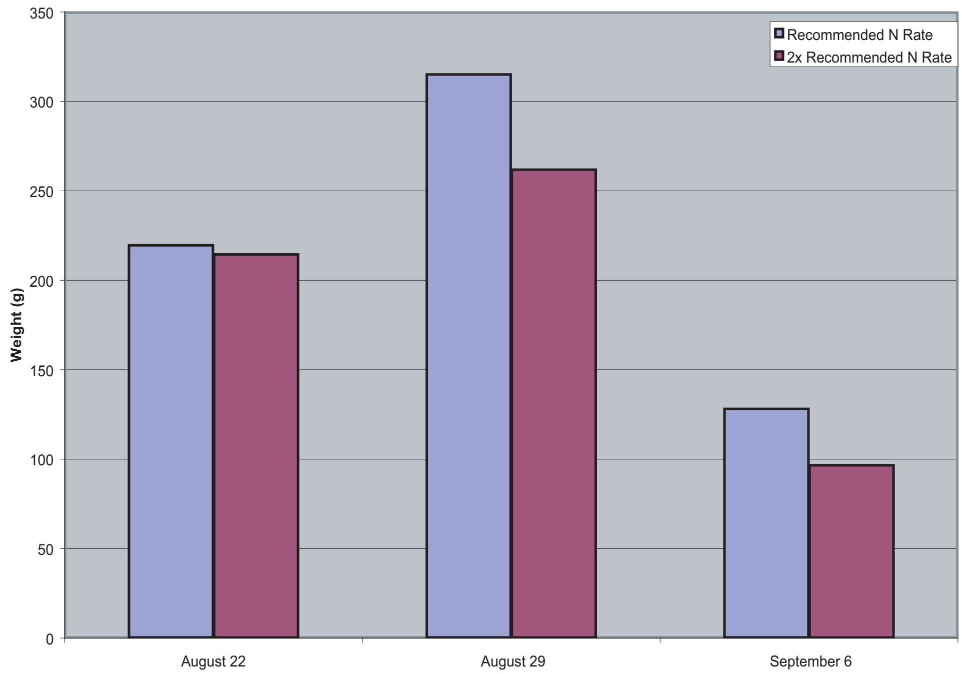
August 29. By September 6 Kiska was almost finished and Souris was beginning to slow down in production. The harvest was over due to killing frost on September 9 that destroyed any remaining berries.

Total harvest for the site was 21.7 kilograms. Mean production per plot was highest on August 29 for the treatment with the recommended nitrogen fertilizer rate with Kiska .

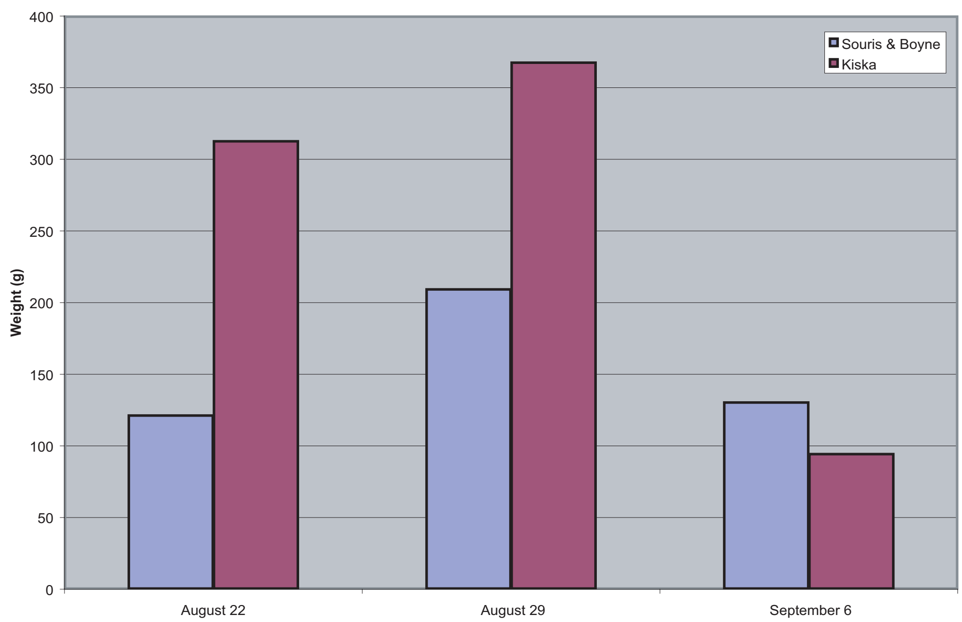
Graphs 5 and 6 demonstrate the 2005 results

Photo 7: Trellis system in raspberry row (see insert)

Graph 5: Raspberry nitrogen treatments for three harvests



Graph 6: Raspberry variety treatments for three harvests



The design of a trellis system can vary in the materials used. The stuctures set up at the Research Farm consist of wooden posts shaped as crosses with metal wires running horizontally from one post to the next. The objective of the system is to separate, support, and direct growing plants. Every season the healthiest and most productive floral canes are selected by pruning off the rest; roughly 15 canes per plant base are selected. By training the floral canes to the outside of the trellis, fruits can easily be picked during harvest. Also, this allows for light to reach the new growing canes at the plants base. Since canes produce fruit only one season, the old canes can then be pruned the following year, repeating the process of selecting only the healthiest floral canes for fruit production.

3.2 Berry Trial - Strawberries

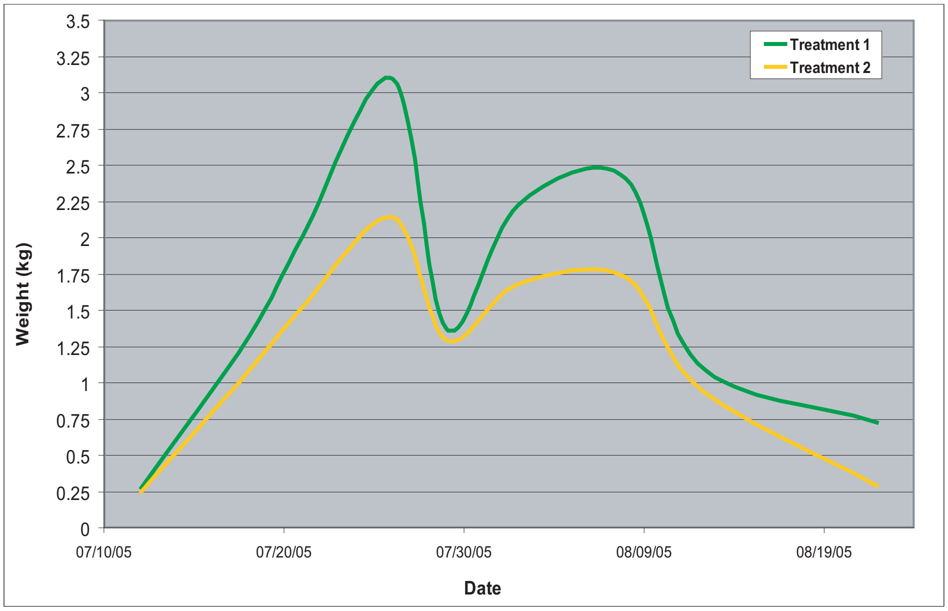
On labour day weekend 2004, a very cold frost of -8ºC froze and broke the irrigation system headworks. This resulted in no irrigation taking place from September 1, 2004 until freeze up 6-8 weeks later. Since the strawberry rows were covered with an IRT poly mulch, any precipitation that occurred during September and October drained to the sides of the rows where runners had set, but did not benefit the strawberries under mulch. In late September 2004, all rows were covered with a generous layer of barley straw.

In early May 2005, the straw mulch was removed and the extent of the winterkill was noted. Up to 50% of the plants were completely dead, with all remaining plants under the plastic displaying some level of winterkill. Damage occurred on both Kent and Cavendish to such an extent that it was not possible to estimate that one variety survived any better than the other. All of the runner plants produced in 2004 that had rooted beside the rows survived in good condition due to precipitation draining off the raised beds with poly mulch and these were used to replace the mother plants that had died in the rows.

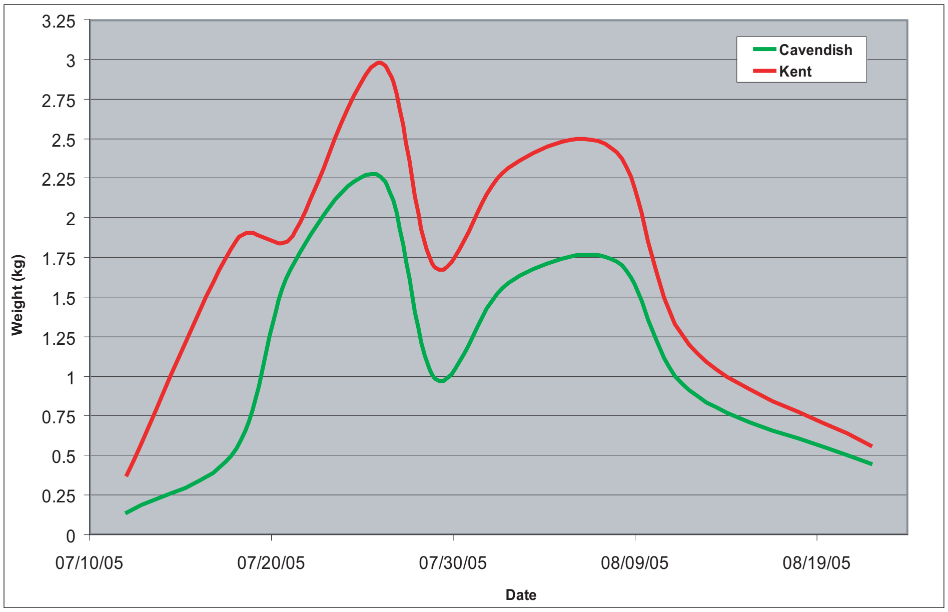
Transplanting of runner plants was completed by May 27, 2005. High winds during the following weeks delayed the installation of the floating row covers to the point that they were not used at all. Another reason the row covers were not installed was due to a very warm May with the mean temperature averaging close to 3ºC above normal, causing the strawberry transplants to flower sooner than usual. By June 20, the strawberries were in full flower and western flower thrips were observed on the blossoms in small numbers.

Harvest started on July 12 and continued until August 22 with peak harvest weights being reached on July 26. The harvest was light, due to the large number of replacement plants. Culled fruit in the early part of the season was largely due to damage caused by *Otiorhynchus ovatus*, commonly referred to as the Alaskan snout beetle, birds, primarily robins and grey jays and later in the season by a resident red fox that developed a taste for ripe strawberries. There was also a high number of misshapen, smaller berries likely due to flower bud damage on winter stressed plants and thrip damage on the blossoms during fruit set. See Graphs 7 and 8.

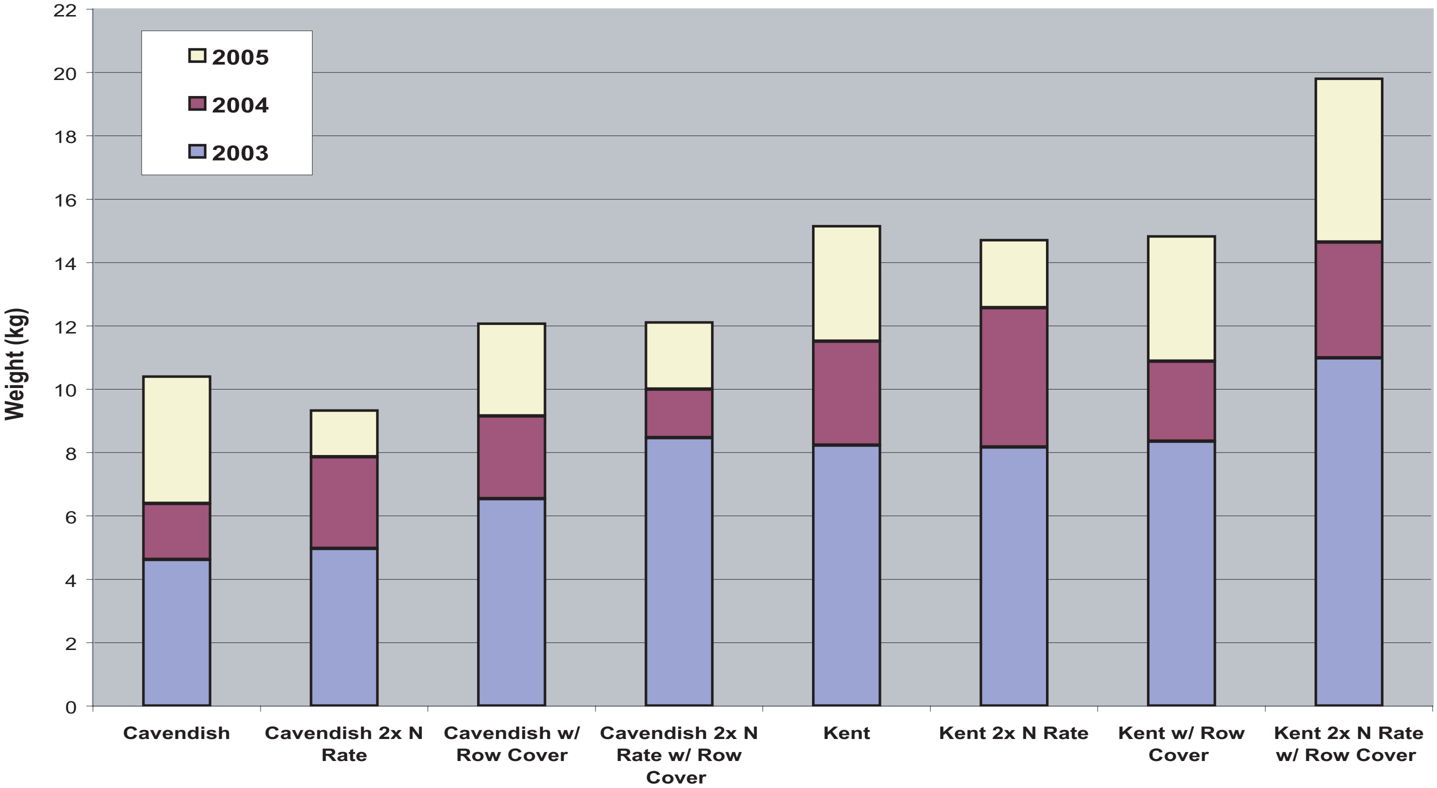
Graph 7: Strawberry fertilizer treatments and fruit producttion weight



Graph 8: Strawberry varieties and fruit production weight



Graph 9: 2003-2005 Strawberry Weights

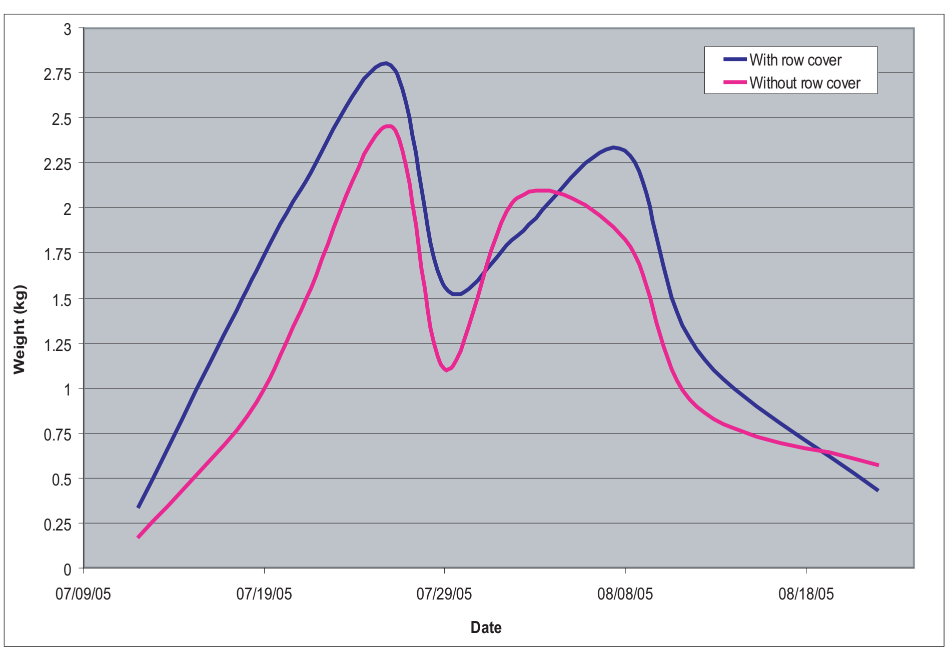


An analysis of the data for the past three years show that the Kent variety with row cover and twice the recommended nitrogen rate consistently produce higher yileds during the fruiting period.

Regardless of the treatment used, the Kent variety always has better results (Graph 9).

The row covers, added for the first week in June, increased the production and reduced the time to peak production. Throughout the harvest the rows that were covered for only a short time in the spring resulted in higher production (Graph 10).

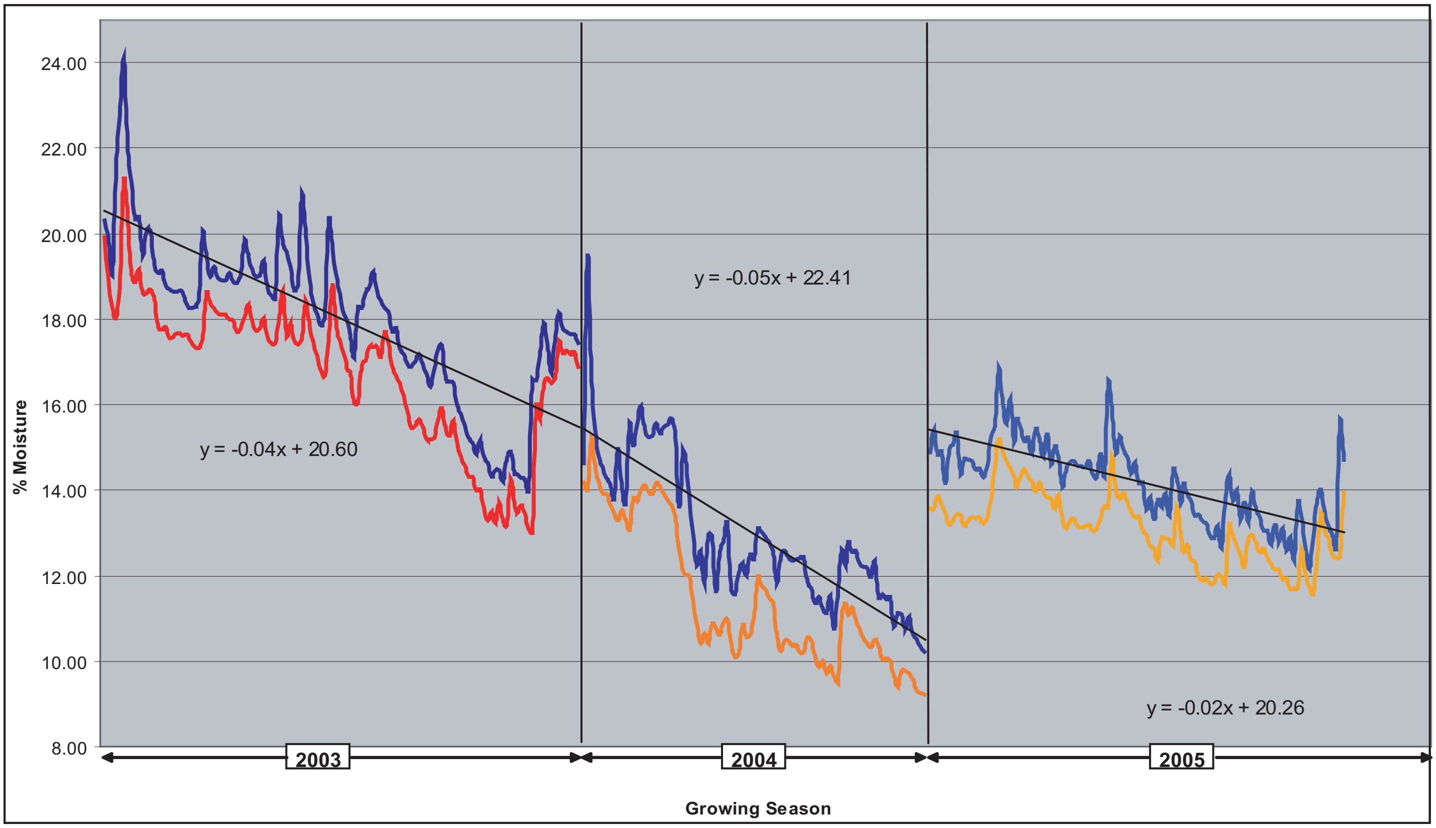
Graph 10: 2005 results of strawberry weight with and with out row cover



Soil Moisture Trend

After a detailed analysis of the soil moisture data from 2003 and 2004 it was apparent that there was a drying trend beneath the IRT mulch (Graph 11). As mentionned above, the measured Permanent Wilting Percentage (PWP) for the silt loam soil at the TFF is 6 – 12%. The moisture values shown on this graph are dangerously low. In 2004, with above average temperatures through the growing season, the moisture level dipped far below acceptable levels. This provided poor conditions for dormancy and likely increased winter kill. In spring 2005 we increased the irrigation run times

Graph 11: Soil moisture trend under the IRT mulch 2003-2005



for the strawberry trial by 25% to compensate for this trend. The results for 2005 are encouraging, with the moisture level decreasing throughout the summer, but at a much reduced negative slope. The ideal situation would be to see a flat line for the trend. Since we are attempting to manage the watering to match the plant withdrawal, having a negative slope through the growing season is acceptable if the moisture doesn't drop near the PWP.

Photo 8: IRT poly mulch used in strawberry rows

4.0 Alfalfa Research

This was the first field season of a two year experiment testing the establishment of alfalfa in Yukon. The project goal is to reduce the chemical fertilizer use on forage crops.

Research focus is on augmenting the available nitrogen and phosphorus in the soil under irrigated grass hay stands through the use of soil organisms. Research will focus on establishing and managing the symbiotic relationship that is formed between the rhizobia *Sinorhizobium meliloti* and alfalfa *Medicago sativa Peace* and the synergism added by the free-living, phosphorus solubilizing fungi *Penicillium bilaii*.

Three hypotheses are being tested:

H_1: Establishment of alfalfa inoculated with a specific strain of *Sinorhizobium meliloti* within existing grass hay stands with reduced fertilizer application will increase forage yield and protein levels.

H_2: Amending Yukon soils with *Penicillium bilaii* will lead to increased phosphorus availability and increased nodulation.

H_3: Limiting nitrogen fertilization will increase the rate of nodulation and reduce the competitiveness of the bromegrass.

In order to test these hypotheses four trials in three locations were established for the 2005 season (see map page 5). Two co-operator sites on forage production farms (BD and DA) and the Research Farm were used, all located near Whitehorse, Yukon. All three sites are located within the Takhini valley and have experienced similar soil formation processes. Even with similar formation, there are differences between all sites because of site profile and historical management.

A Truax FLX-812 seeder was used to plant alfalfa within existing forage stands.

Alfalfa was inoculated onsite with a peat based rhizobia inoculant and/or a powder based fungal inoculant.

The farm site trials were designed to provide a yield and protein comparison between the high fertilizer rate historically applied (ranging from 100 to 170 kg/ha) to the grass stand and a low fertilizer rate combined with inoculated alfalfa.

At the research site the trial with alfalfa planted into preexisting grass hay stands was set up to look at the difference in growth between the different treatments when no fertilizer was used versus a small amount of N (25 kg/ha). Two plots were used for this trial, one brome and one timothy. The trial is set up in a split plot completely randomized design with the seed treatment split by the fertilizer (see diagram right), and three replications of each treatment. A yield control was included in this trial at 170 kg/ha actual N to determine efficiency of nitrogen uptake. These plots were hand fertilized for even coverage.

Another trial was initiated at the research site, a pure stand of Peace alfalfa either inoculated or not and a comparison trial of three varieties to determine which performs best in Yukon's climate. The pure stand was designed to determine the timing of nodulation and the rate of nitrogen fixation for Peace alfalfa over the first year of establishment. Nitrogen fixation was planned to be determined using the total plant nitrogen difference method. Eight plots 2 x 2 m with one meter spacing were laid out in a completely randomized design with the treatments being dual inoculated seed (PB-50 and NRG-34) vs control with no inoculant. Seed was hand sown in rows with 20 cm spacing (same spacing as the no-till seeder).

Alfalfa growth and nodulation was successful on all but one of the locations. All data has been collected and a portion has been analyzed.

Soil temperatures reached 10°C by early May at the farm sites and by early June at the research site providing a good temperature regime for rhizobial activity. Most results have yet to be thoroughly statistically analyzed. Results include soil nutrient levels, using standard soil tests and PRS-resin probes (Western Ag Innovations Inc); nodulation assessments; vegetation composition, weight, protein and moisture; weed incidence; soil bulk density, moisture and temperature conditions; and climate conditions.

PRS-probes (Western Ag Innovations Inc.) were used to monitor nutrient availability on the brome plot.

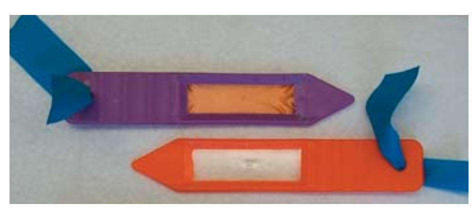


Photo 9: PRS probes, approximately 15cm long (orange - anion, purple - cation)

Photo 10: Nodule formation on pure alfalfa sample from the inoculated plot trial, August 8, 2005

A pair of probes (one cation and one anion) were placed within the root zone 2.5 cm from a row of alfalfa down to a depth of 15 cm at four different locations within each experimental unit. Probes were incubated for 48 hours during a period of irrigation. This was repeated four times throughout the summer, starting the beginning of June, followed by incubations in early July, August and September.

Results to date, with limited statistical analysis, show that the combination of the low fertilizer rate with the Tag Team (Philom Bios) inoculant provides similar results to the NRG-34 inoculant and these treatments provide the highest yield of alfalfa in all trials.

There is an inverse relationship between the alfalfa yield and the grass yield. Where there is lower grass yield the alfalfa has better establishment and yield, regardless of the treatment. Within the timothy stand where the stand is sparse the alfalfa production reached almost 1400 kg/ha.

The addition of only 25 kg/ha of actual nitrogen provided 79% higher yield in smooth bromegrass and with 170 kg/ha actual N the increase is upward of 325%. With 170 kg/ha actual N the mean dry matter production of the bromegrass totalled over 10,000 kg/ha. This figure is astoundingly high, at the extreme of Yukon production, and can be attributed to the optimum conditions and late sampling (which occurred one month after most forage harvests).

In the pure stand the weights were compared using analysis of variance at p=0.05 resulting in a significant difference between the treatments. Results from this first year will be compared to other results from across northern regions. The alfalfa production on the inoculated treatments reached 2800 kg/ha dry matter yield with sampling very late in the season.

This season's data is very promising. Soil temperatures are perfectly adequate at shallow depth for nodulation, good nodulation was found on specified treatments as expected and there was no incidence of brown root rot.

Regrowth was monitored into the fall. NRG-34 inoculated treatments both with and without the PB-50 showed the best alfalfa regrowth compared to the other treatments. The height and colour of the NRG-34 and Dual trials was generally as good or better than the regrowth of the brome in the straight nitrogen trial.

Trials will be continued through 2006 with more field scale projects and more focused sampling.

Photo 11: Block 1 on farm site DA. Control (left) and NRG-34 inoculated (right), August 27, 2005

5.0 Elk Nutrition Studies


Photo 12: Game farm elk from the Ford Elk Farm

In early 2005, the Agriculture Branch hired AMBOCA Ecological Services (Manfred Hoefs) to produce a report that summarized available information on elk nutrition and habitat. The report was based on a literature review, the experience of the report author and consultation with resource people. The report evaluated the potential of Yukon native plant associations to support elk and outlined an experimental design to determine grazing and browsing capacity of Yukon native range for elk.

This report, titled "Nutritional and Habitat Requirements of Elk and the Capacity of Yukon's native range to provide them," outlines the nutritional requirements of elk during various life stages such as maintenance, growth and reproduction. It states that the diet of Yukon elk includes grass, forbs and browse. The important Yukon vegetation communities for elk are grassy south-facing slopes, fire-created areas with aspen regeneration, mature aspen forests, areas of willows, sedge meadows and grass meadows. Different vegetation types are used by elk during different times of the year. Over winter, snow depth and hardness are important factors in determining habitat use. The determination of elk grazing and browsing capacity includes sampling of ground vegetation, sampling of shrubs and trees within reach of elk, and sampling of leaf hay, which is leaves that have fallen to the ground.

In the summer of 2005, the Agriculture Branch contracted AMBOCA Ecological Services to carry out the experimental design outlined in the earlier study to determine the elk grazing and browsing capacity of a grassy south-facing slope and a fire-created area with aspen regeneration. The complete results of this study are included in a report titled, "Biomass Production of a Grassland and an Aspen forest in the Takhini River Valley of southwestern Yukon." In the autumn of 2005, Agriculture Branch staff determined the elk grazing capacity for leaf hay in an aspen forest. These findings are covered in a report titled, "Elk grazing capacity for leaf hay in a regenerating aspen forest." All three of these reports are available at the Agriculture Branch office.

Following is a summary of the elk grazing and browsing studies:

The sites selected for the elk study were representative of the habitats currently used by Yukon's wild elk herds, but the sites showed little evidence of use by elk or horses. The grassland was a ridge extending in an easterly direction from the Takhini River towards the Ibex River near Km 1468 of the Alaska Highway. The aspen forest was located north of the Alaska Highway at Km 1464 to Km 1465.

Grassland site: Ten transects 50 metres apart were established from the top of the ridge downhill in a southerly direction. Plots were located at five metre intervals. Fifteen plots were selected using a random number list. Plots size was 2 x 2 m. Vegetation was clipped and separated into species. A species list was compiled. Vegetation samples were dried in an oven for 24 hours, then weighed.

Aspen forest: Twenty transects 50 metres apart were established extending a distance of 100 metres from a cut-line near the Alaska Highway. Plots were located 20 m apart. Sixteen plots were randomly selected using a random number list. Plots were 2 x 5 m. A vegetation list was compiled. Three layers of forest vegetation were harvested: 1.) ground layer of herbs and grasses, 2.) shrub layer (foliage and twigs), and 3.) tree cover (foliage and twigs up to 2.5 m). Vegetation samples were oven dried for 24 hours, then weighed.

Leaf hay study: Five study enclosures were established at random locations within a large area of aspen forest. The enclosures were 2.5 x 2.5 m. Enclosures were constructed by establishing corners with rebar and wiring a one metre high strip of geotech cloth around the rebar. Branches lower than 2.5 m within the enclosures were cut off using a tree trimmer, and all old leaves were removed within the enclosures before leaf drop began. The study area was visited three times during the autumn leaf drop and all fallen leaves were picked up. Leaves were oven dried and weighed.

In all three studies, the average biomass production per plot was determined from the oven-dried vegetation. This production rate was used to estimate elk grazing and browsing capacity of the area. The average weight of an elk was assumed to be 225 kg, and an elk's average monthly forage consumption was assumed to be 150 kg dry weight.

In the grassland, palatability of available plants was assumed to be 90% and a safe use rate of 50% was used to estimate grazing capacity to be 0.56 ha/ AUM (1.8 AUM/ha). In the aspen forest, palatability was estimated at 90%, and deadfall in the area reduced the availability of forage by 10%. The safe use rate for foliage was 50% and for browse it was 60%. The aspen forest had an elk grazing capacity of 0.75 ha/AUM for foliage (1.3 AUM/ha) and 2.75ha/AUM (.36 AUM/ha) for browse.

When determining leaf hay production, palatability was assumed to be 100%. There was no deduction for safe use because consumption of fallen aspen leaves does not affect plant survival. Long term effects of leaf decomposition on soil properties is not known for this area. A 10% deadfall deduction was applied to the data. Elk grazing capacity for leaf hay was determined to be .14ha/AUM or 7.14 AUM/ha.

6.0 Forage Demonstration Trials

Forage Demonstration

A series of plots were set up on the south side of the research site for a demonstration of forage species. Four varieties of legumes were included in this trial: Peace, 2065 MF, AC Nordica, and Ram Red Clover. Twelve varieties of grasses were also seeded: Carleton Smooth Brome, Kirk Crested Wheatgrass, Fleet Meadow Bromegrass, Boreal, Richmond Timothy, Bellevue Reed Canarygrass, Russian WidRye, Violet Wheatgrass, Kentucky Bluegrass, Tufted Hairgrass, Slender Wheatgrass, OKAY Orchardgrass.

The plots were laid out July 28, and the seeding occured August 9.

Fertilizer mixture used on the legumes was:

0.6 kg 11-51-0
0.6 kg 0-0-60

and the same mixture plus 1.0 kg 34-15-0 was applied to the grasses.

Germination was observed by late August. By late September the stands were healthy and well established. Further assessment will be done in spring 2006.

Plant growth will be monitored and compared along with production yield next year (2006).

Photo 13: RF variety performance trials, September 22, 2005

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Appendix

Strawberry Variety Descriptions

Cavendish – Developed by Agriculture Canada in 1990, it is a cross between Glooscap and Annapolis. This variety produces high yields of very large, medium firm to firm fruit. Flavour is good but berries are prone to excessive darkening when overripe and colour can be variable with white blotches evident under some conditions. Plants show low to medium vigour so planting densities should be increased. Resistant to red stele (A-6) but susceptible to powdery mildew and green petal. Suited to PYO or limited shipping.

Kent – Developed by Agriculture Canada it is a cross between Redgauntlet, Tioga and Raritan. Produces very high yields of large, bright red fruit. Berry flesh is firm but skin may be weak in hot weather. Flavour is fair to good. Has shown some tolerance to red stele (A-6) in some fields. Suited to PYO and limited shipping. Kent is the most widely grown strawberry variety in eastern Canada.

Raspberry Variety Descriptions

Boyne – Developed at the Agriculture Canada Research Station at Morden, Manitoba and introduced in 1960, it is a combination of Chief and Indian Summer. It is the hardiest and most consistently productive cultivar for the Prairies; and the main cultivar for commercial production in all colder regions of Canada and the United States. Canes are medium in height, thick, erect and stocky, with many lateral branches. Fruit is medium sized, dark red, firm, juicy, aromatic and tart.

Kiska – Developed by Dr. Arvo Kallio at the Agricultural and Forestry Experiment Station, Fairbanks Alaska. Kiska raspberries have thin, willowy canes. Under optimum fertility and moisture, canes may easily reach 6-8 feet in height. These canes tend to bend outward and downward making harvesting difficult.

Souris – Developed by Agriculture Canada Research Station, Morden Manitoba. An improved selection of Boyne because it is better tasting, a heavier producer of fruit and it has 15% better spider mite resistance.

Glossary

Above Mean Sea Level (AMSL) - Refers to the elevation (on the ground) or altitude (in the air) of any object, relative to the average sea level.

Atmometer - An instrument used to measure evaporation.

CR-10 - Campbell Scientific programmable datalogger used to measure soil moisture, soil temperature, and water flow, also used to compute irrigation run times.

DeciSiemens per metre (dS/m) - Salt tolerances are usually given in terms of the stage of plant growth over a range of electrical conductivity (EC) levels. Electrical conductivity is the ability of a solution to transmit an electrical current. To determine soil salinity EC, an electrical current is imposed in a glass cell using two electrodes in a soil extract solution taken from the soil being measured (soil salinity). The units are usually given in deciSiemens per metre (dS/m).

Effective Growing Degree Days (EGDD) - An upward adjustment made to the GDD value to account for the boost plants receive from the long daylight hours at northern latitudes.

Evapotranspiration (ET) - The combined water loss from soil evaporation and plant transpiration.

Field Capacity - The water content of the soil where all free water has been drained from the soil through gravity.

Growing Degree Days (GDD) - Can be calculated in a number of ways, Agriculture branch calculates them by beginning the fifth consecutive day with mean temperatures above 5^{o}C, and terminating the day of the first killing frost (-2.2^{o}C) which occurs after mid-July.

Irrometer - Ceramic tipped soil water sampling device.

Management Allowable Depletion (MAD) - The percentage of water at field capacity which can be removed from the soil by the plant prior to reaching the wilting point, at which time irrigation should occur.

Permanent Wilting Point (PWP) - The soil moisture content at which the plant will wilt and die. Any remaining water in the soil is insufficient to meet the plant requirements.

pH - A measure of a solution's acidity or alkalinity based on it's activity of hydrogen ions (H^+).