A study of

Legume Growth

On

Yukon Organic Farms

A research proposal

Prepared by

Garret Gillespie HND AgrE, MSc AgrE.

On behalf of

Growers of Organic Food Yukon

(A chapter of Canadian Organic Growers)

Contents

1.0 Introduction

The use of legumes as forage and soil building crops is widely documented. Legumes form an intregral part of crop rotations on organic farms. In the Yukon, obstacles to successful legume culture are often believed to be due to the climate, cold soil temperatures, and poor varietal adapatation. Successful perennial legume production has remained elusive in the Yukon and Alaska and it is widely attributed to the factors mentioned above.

The purpose of this research is to examine several issues affecting legume culture under organic conditions in the Yukon. The general paramiters of the research are as follows.

1. When used as a green manure crop, how is plant material best incorporated to facilitate decomposition?

2. What are the limiting factors of decomposition within the soil?

3. How resiliant are rhizobacteria to the soil environment commonly found in the Yukon?

4. What is the relationship between soil nutrient balance and perennial legume survival?

There is a common denominator running through all these questions that forms the basis of this research: Soil nutrient balance. Inadequate soil nutrition will impair decomposition of organic materials due to a sparse microbial population. If the conditions are not conducive for microbes, rhizobacteria will be no different.

2.0 Background

Red clover, and to a lesser extent, white clover formed the back bone of North American forage and soil impovement crops up until the first world war (6,7). This was due to the high quality protein content of these crops. The reliability of these crops began to wane from this point, and the gap was filled by alfalfa and soybeans. This was because the nutrient demands of clovers are high and they were depleting soil reserves of nutrients. On the other hand alfalfa and soybeans have woodier growth compared to clover and will tolerate poorer soil conditions. Despite bulky growth on soils where clovers did not fare well, overall protein content was much lower (8). Albrecht found that when starved of protein forming nutrients, legumes and other plants increase their carbon content at the expense of protein levels. He found that a balance of calcium to phosphorous (8) and adequate trace elements were essential for protein (amino acid) production (9). It follows that if these conditions are met in the soil, optimum conditions are available for the nitrogen fixing bacteria (10, 11).

Albrecht (3) pointed out that soil microbes get to eat first out of all the creatures that depend on the soil for food, including humans. Every nutrient that passes into a plant is as a result of microbial life. The Liebig theory of soluble fertiliser chemistry does not recognise the involvement of soil microbes in feeding plants, and has been the prevailing thought for many years. However, more recently scientists are recognising the flaws in this theory (5). Microbes require a balance of carbon and protein-forming elements in their diets to remain healthy. If there is not an adequate supply of nutrients, or it is imbalanced, the microbes will starve or will not function healthily.

Albrecht and others (17) have showed that legumes will not do well on poor soil. The logic of growing a legume to improve a poor soil's nutrition is similar to trying to treat acne by eating fries. Like the soil, the acne sufferer will feel well fed in the short term on a diet of fries, the long term effects will see a continued decline in health and a worsening of the situation. Successful legume growth presupposes the balanced availability of at least 11 known macronutrients and a similar number of known micronutirents. When these conditions are met, the plant is strong enough to supply the huge energy needs of the nitrogen fixing bacteria, and then free nitrogen can be fixed and made available to the plant and rhizosphere.

3. Yukon, Alaska, and Northern Alberta research

Trials of legumes have been conducted in the Yukon, Alaska, Northern BC and Alberta dating back 100 years. Studies have looked at nitrogen fixation (12, 13), bacteria survival and functioning in cold conditions (14), and legume winterhardiness (15, 16).

3.1 Soil Nutrition factors

Little or no attention has been given to adequate soil nutrition as a limiting factor to legume growth. For example Haines Junction Experimental Farm found that alfalfa could survive and persist well, were it not for being attacked by *Plenodomus meliloti* or brown root rot, which is apparently prevalent in the Yukon (16). This suggests two things. One is that alfalfa could be an important legume for the Yukon. The other is that the soil nutrient level is high enough to support legume growth, but not balanced enough to make for healthy growth. There is a linkage between a balanced suite of macronutrients and a plants ability to draw in trace elements. In this case the balance of calcium to phosphorous plays a pivotal role in a plant's ability to take up copper from the soil (9). Copper is used by plants, animals and humans as an antibiotic to prevent fungal attack. Similarly, boron is required to prevent fungal attack (17), however, Yukon soils are known to be deficient in this element (1).

Studies in Alaska similarly paid little attention to nutrient balance. Reported persistence was poor as were yields and measured crude protein (15). These too would suggest that soil conditions may have played a bigger role in the poor growth and persistence of legumes. Kinsey reports that soils in Alaska and The Yukon tend to have low amounts of available potassium in relation to calcium and magnesium. Potassium and phosphorous are essential for developing winterhardiness in alfalfa, and other legumes (17). Inadequate plant nutrition may play as a large role in legume persistence as climatic and varietal factors.

3.2 Climatic Factors

Perhaps the most extensive studies of legume persistence have been conducted in Alaska. Klebesadel (15) reports that success has been minimal in Southcentral Alaska. He cites several reasons for the lack of success: 1. Method of establishment, 2. Lack of winter snow cover, 3. Inadequate varietal adaptation to high latitudes.

The first two points are interrelated in their linkage to climatic factors.

1. Method of establishment. Klebesadel admits that legumes are normally undersown into a nurse crop in that area to aid establishment. This helps protect tender legume

seedlings from harsh winds, conserves moisture, and supresses weed competition (2). However, the methods employed were to sow directly onto cultivated ground with no nurse crop. Timing of sowing was mid summer.

2. Lack of winter snow cover. The site of the experiments is subject to strong winter winds that remove snow cover from fields. This exposes plant crowns to freeze-thaw cycles, and is belived to be the main reason for winterkill.

It may be that early sowing of the legume into a rapidly growing nurse crop such as oats or barley will allow the legume to become well established before the first winter. The nurse crop could be mowed mid or late season to create a stubble about one foot high. This will help trap snow and maintain ground cover during the winter (2).

Anecdotal observations by this author would further suggest that temperature is not the major limiting factor. The first evidence comes from our own farm, where three year old plants of white and red clover began to grow more vigourously than chickweed in early May. The area in question is low lying and always wet and cold. At the time of observation the ground was still frozen at about six inches in this area. The second observation comes from examination of the soil at Wheaton River Gardens and CSA, run by Shiela Alexandrovich. Here, the gardens are shaded by spruce trees, and there is discontinuous permafrost in the vicinity of the beds. However, the visual appearance of the soil suggested intense microbial activity, despite cool soil temperatures at the end of May. In both cases rock powders, composts, and other organic ammendments are used to improve soil fertility.

3.3 Species and varietal Factors

Klebesadel and others (15) suggest that transferring cultivars and species from southern latitudes to northern latitude present serious problems in terms of the plants ability to adapt to changes in photoperiod. They have found that even though the region of origin may have more severe winters than Alaska, lack of adaptability is related to photoperiod. The critical period for the plant is at the close of the growing season where the cycles of light and dark periods trigger physiological changes in preparation for winter. In Alaska, it was found that introduced plants were inadequately exposed to shortening day length to complete the necessary physiological changes before the onset of severely cold weather. This in turn affects their ability to overwinter successfully. Alaskan research suggests that latitudinal differences of several hundred miles can significantly impair a plant's overwintering abilites, despite similar climate (15).

Personal observation and experimental observation as reported by Bisset (16), contradict this view. Varieties and species of clover and alfalfa originating in the Peace region have been observed to overwinter well in the Yukon. The Peace region straddles the 56th parallel, approximately 1000 kilometres south of Whitehorse. Land classification of the experimental sites in Alaska are classed between 1 and 3. Most areas of the Yukon are classed no higher than class 4 (18). Despite an inferior land classification in comparison to Alaska, observation would suggest that legume adaptation to the Yukon climate is more successful than Alaska. Even though climates are similar, and plant resources are brought in from similarly long distances, the soil resources must play a larger role in adaptation than has previously been investigated.

4.0 Research Proposal

The hypothesis of this work is:

> *Soil nutrient balance and adequate fertility are the primary limiting factors to successful legume culture in the Yukon.*

To test this hypothesis, it is proposed that a five year study examining legume response to soil treatments on a number of Yukon farms be carried out. A selection of annual and perennial legume species known to grow satisfactorily in the Yukon will be grown in a randomised block design with two treatments. No replications are included in the block design on each site for the sake of simplicity, however, a degree of replication will occur between partcipating farms. The treatments are (a) no soil treatment, (b) additions of soil amendments as per soil audit. Plants will be allowed to grow all season to see if plants will set viable seed. At the end of each season soil samples will be taken from each plot and analysed by Kinsey Agricultural Services. The ensuing recommendations will be applied to the plots that are to receive ammendments. Soil samples will also be taken to assess changes in microbial populations using key species as identifiers. The collected data will be compiled in an annual interim report. A final report will present the findings of the study.

4.1 Research Technician

Growers of Organic Food Yukon shall engage a research technican to implement the experiment protocol and collect primary data. The requirements of the technician are as follows:

1. Access to vehicle and telephone
2. Technician will need to arrange for seed purchase, and will be responsible for maintaining and ensuring seed integrity.
3. Technician will obtain/ purchase/borrow the following equipment: hand held seeder, precision seeder, soil thermometer, measuring tape, string line, accurate weighing scales, rake, gas powered weed eater, and other simple tools as the need arises.
4. The technician will purchase enough simple rain gauges and clip boards for each plot, so that each farm has one rain gauge and one clipboard per plot. The rain gauge will be mounted as set out below.
5. Technician shall help identify a suitable piece of land with each farmer, and coordinate cultivation and planting work with the farmer.
6. The farmer shall be responsible for providing a cultivated site.
7. The technician will be responsible for setting out the plot as detailed below. The farmer may voluntarily help the technician in this endeavour if it suits.
8. The technician shall record the following at the time of planting for each plot on the provided clipboard: Weather conditions, soil temperature at six inches, seed bed

conditions (dry, moist, etc). The clipboard will remain at each farm in an accessible weatherproof, childproof, animalproof location.

9. The technician will ensure that each farmer is able to read a rain guage. The technician will develop a simple sheet for recording precipitation events, which the farmer will be responsible for maintaining. This record sheet will be attached to the clipboard.
10. The technician will visit each test site at least twice during the growing season to control nurse crop growth, record competitive weeds, assess presence and condition of root nodules, record soil temperature at six inches and observe overall performance of the legumes. All observation and recording to be reported on the clipboard.
11. After the first killing frost, the technician shall collect a sample of seed if available from each legume. A soil sample shall be collected, one from each pair of treatments.
12. The technician will remain in contact with the project manager during the course of the season, and will assist the manager with data entry and recording.
13. Ideally, the same technician will be available for the duration of the experiment.

4.2 Site selection

Any farm in the Yukon is welcome to participate in the study provided they are either certified organic or eligible for certification. This will exclude land that has had applications of chemical fertilisers or agrochemicals in the previous three years. The site will ideally be easily accessed by road, and will be fenced or otherwise free of grazing animals. The research plot will run for 5 seasons, and therefore participants will not be able to use the plot area for other purposes for the duration of the study.

4.3 Plant Selection

It is proposed to use seed that is commercially available through local seed merchants. The rationale is there is little point in using experimental varieties of seed that are difficult to obtain, even for this experiment, let alone for farmers wishing to plant relatively large areas. Commercially available seed is easily obtained in Whitehorse. Local seed merchants also know what does well partly because of feedback from customers, and partly because certain varieties or strains may sell better than others.

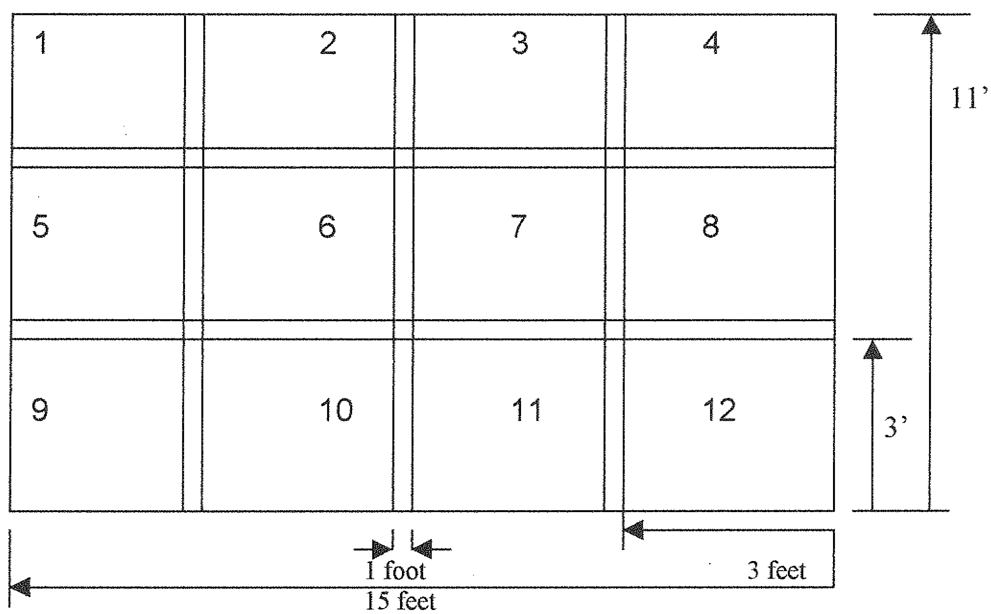
With this in mind, the selection of crops is narrowed down to:

Perennials	**Annuals**
Alfalfa	Field peas
White clover	Fava beans
Red Clover	
Alsike clover	
Sweet clover	

It is desireable to buy organic seed as per certification standards, however it is very difficult to find adapted varieties of organic seed at an affordable price.

4.4 Plot layout and plant culture

The minimum plot dimensions and plot layout are shown below.



The overall plot dimensions are 15 feet by 11 feet. Each plot is 3 feet by 3 feet square. The plots are separated by a 1 foot buffer strip, which also serves as a walkway. The plot should be situated so that it can receive irrigation from whatever source is available. Each plot shall be equipped with a rain guage, which shall be situated in the centre of the plot and mounted approximately 3 feet off the ground.

Ideally the plots will have been cleared of plant materials and plowed or otherwise cultivated to produce a firm, clean seedbed. If the plot has been rototilled it will be important to recompact the soil by rolling or other means. Once the plot has been cultivated, the block layout may be measured out using string lines and stakes. The corners of each plot shall be marked and each plot numbered and labelled 1 to 12, as shown in the diagram.

The legumes shall be each be allocated a letter in alphabetical order from A to F as follows:

Perennials	**Annuals**
Alfalfa (A)	Field peas (F)
White clover (B)	
Red Clover (C)	

Alsike clover (D)
Sweet clover (E)

Each letter is randomly allocated two block numbers as follows:

A 1 and 7; B 4 and 9; C 2 and 11; D 6 and 8; E 3 and 10; F 5 and 12.

All seed shall be treated with the relevant, OMRI listed innoculant prior to planting. The alfalfa and clovers may be broadcast sown using a small hand-held spreader, and then lightly raked. The sowing rate will be approximately 25 lbs per acre or 0.08 ounces per block. In metric that is 2.34 grams per 3 foot square block. Oats shall be sown at the same rate and in the same manner as the alfalfa and clovers. This is to provide ground cover, thus preventing weeds during the slow establishment period. Care should be taken to ensure that the buffer strips are seeded with oats.

The peas shall be sown using a precision garden seeder at ¾ inch depth with 8 inches between the rows, with no nurse crop.

If the red clover and sweet clover fail to set seed they will likely die out after the second season. This will be dealt with when the issue arises. It would be unwise to repeatedly plant peas in the same plots year after year even if the plants set viable seed. It is hoped to be able to alternate plantings of peas with fava beans, or other non related legume. At the time of writing no commercial source of fava beans have been found. It is anticipated that a source of suitable seed will be found in time for the 2006 season.

4.5 Plot Maintenance

It is hoped that the participating farmers will have enough time to observe the plots on a daily basis. This only requires a brief inspection of the rain gauge and recording of any precipitation. Also a brief inspection of the plants to ensure they are not being eaten or trampled. This daily chore need only take a few minutes. The farmer should call the technician if there are any concerns. The farmer should ensure adequate soil moisture by irrigating if possible. The technician will be responsible for making the more involved observations and recordings, as well as controlling any weeds or nurse crop growth. The buffer strips should be kept trimmed to a minimum of six inches. The oats in the plots may be trimmed back to the upper height of the legumes if it is deemed necessary. It will be the responsibility of the technician to ensure uniform plot maintenance at each site.

4.6 End of Season

The farmer will inform the technician when there has been a killing frost on their farm. The technician will visit the site and collect any samples of seed that may have been set by the plants. Soil samples will also be collected under the guidance of the project manager from each site for each treatment. In the first year there will be no variable between the treatments. However, the second growing season will begin with the addition of any recommended nutrients, and will introduce the only variable to the experiment.

The plots will be left for the winter with the plants standing. This will help protect the crowns of the plants from winter stresses. In the spring, prior to reemergence the plant material will be cut and allowed fall and act as a mulch.

4.7 Soil Sampling and testing

The soil samples will be sent to Kinsey Agricultural Services in Missouri for analysis. Kinsey's make fertilser recommendations according to the Albrecht principles of soil balancing. It is hoped that whatever nutrients are required may be found locally in the form of indigenous rocks. Soil samples will also be examined for key microorganism communities, as an overall indicator of soil vitality. The project manager will be responsible for arranging the procurement of any fertilising materials.

4.8 Reporting

The project manager will write an annual report detailing the observations of the previous season(s). At the end of the experiment a final report will be generated.

4.9 Estimated project costs

See appendix A for detailed costs.

5.0 References

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Appendix A

Estimated 2005 operating costs.

Costs are estimated on the participation of five farms; four within one hour of Whitehorse, and one near Dawson City. It is assumed that the technician will visit all farms once at planting time, three times during the growing season, and once at the end of the growing season. The project manager will be responsible for supervising the project budget. The budget projection will be updated annually

Expense items for 2005 are as follows:

Seed	$ 600
Supplies	$ 600
Technician (40 days at $200 per day)	$8,000
Travel (8400 km from Whitehorse @ 25 cents/km)	$2,100
Soil testing	$3,360
End of season report (project manager)	$3,750
Total expenses for 2006 season	**$18,410**

Final report

February 24th 2005

A study of Legume Growth on Yukon Organic Farms

Research proposal

Please find attached a copy of the research proposal. This proposal calls for a study lasting for five years that looks at soil nutritional barriers affecting successful legume culture in the Yukon.

Growers Of Organic Food Yukon (GOOFY) will submit an application for funding shortly to cover the 2005 costs of this project as outlined in this proposal.

This report is submitted in fulfillment of my contractual obligations with the Yukon Agricultural Association.

Sincerely

Garret Gillespie