Pilot Project:

The production of rock powder fertilizers using quarried Yukon gravel

Final report

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Prepared by:

Garret Gillespie HND AgrE, MSc AgrE
with Growers Of Organic Food Yukon

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1.0 Abstract

This project was completed in two parts:

1. Research and identify agronomically important series and occurrences of rock in the southern Yukon, collect samples, and submit them for mineral assay.
2. Process in a ball mill rocks types that show agronomic potential. The efficiency of this mill was evaluated in relation to its ability to produce high quality powder for use as agricultural soil amendment.

2.0 Introduction

The rationale is summarized by the following points:

- There is a growing awareness and need among local farmers and growers to find effective fertilizers that will enhance production in a sustainable way.
- It is more sustainable to reduce costs of production by sourcing those fertilizers as close to the farm as possible, thus reducing transportation and environmental costs.

Rock powders have been used for millennia by many cultures around the world to build, maintain and enhance soil fertility. In Canada, there used to be government programs that subsidized and promoted the use of calcitic and dolomitic limestone, phosphatic rocks, and gypsum as primary fertilizers on Canadian farms. These public supports ceased in favour of the promotion of chemical fertilizers after the Second World War. Today, there are very few agricultural mineral prospectors and few sources of naturally produced agricultural minerals.

As a result, Yukon farmers must import required fertilizers at very high unit and transportation costs due to the bulky nature of the amendments. This seems an unnecessary and expensive option when it is considered that many important agricultural minerals occur in easily accessible sites in the southern Yukon. However, the main problem has been the ability to process the raw material into high quality, agricultural grade powder.

For a rock to become useful in a soil it must be ground fine enough to allow and facilitate biochemical processes within the soil that, in turn, make nutrients available to plants and thus promote growth and plant health.

3.0 Method

The most commonly used machine to produce consistently fine material is a ball mill. A ball mill was located near Burwash Landing. In June of 2006, the ball mill was rented and transported to Wild Blue Yonder Family Farm in Tagish.

Samples were collected and assayed from three quarry sites: Whitehorse Copper Belt, White Mountain and Caribou Mountain in the early spring of 2006. After considerable research, these sites were selected as potential sources of high quality magnesium, calcium and phosphorous respectively.

The project was delayed by a late spring, highway weight restrictions, and unsuitable road conditions from the highway to the project site. This made it difficult to move equipment and materials on site in a timely manner.

The original plan was to bring several rock samples on site and to assess ball mill efficacy at processing rock of varying types and hardness. However the pressing nature of the Yukon growing season in combination with a late start meant that only one example of rock was hauled to the farm from nearby White Mountain.

There are two types of ball mill: dry process and wet process. The ball mill that was obtained had been used for wet processing, and it was unknown if it could be used dry. The benefit of dry processing allows the processed material to be immediately handled and used. Wet processed material must be first stock piled and dried before it can be used in conventional distribution equipment. The initial setup of the ball mill, therefore, was to run dry. However, after several mechanical problems had been overcome it was obvious that the machine could only wet process. At this point, Garret Gillespie could devote no further time to the project for the remainder of the season.

Work resumed in May 2007 to set the machine up to wet process. After some initial adjustments to feed rates and so on, the ball mill produced a consistently high quality material. The milling quality was assessed continually by collecting samples of the milled slurry as it exits the machine. The samples were then washed through a 60 mesh screen. The commonly used guide for agricultural limestone is that 50% of the material should pass through a 60 mesh screen. The feed rate of unprocessed material and water were then adjusted to maintain output within the specifications.

The milled slurry flowed from the machine to a settling lagoon, where the water was allowed to drain away. The material become dry enough to move with a loader in about three days and was spread over about 15 acres using a special kind of manure spreader capable of handling semi solid material. In total about 60 metric tons of calcitic limestone were processed and spread in June 2007 at Wild Blue Yonder Family Farm.

4.0 Results

The maximum rate of milling was found to be in the region of 6 metric tonnes per hour using the material from White Mountain ground to the specifications described previously. The rate of milling varies according to the relative hardness of the material being ground, the quantity and size of balls in the machine, and the dwell time of the material in the machine. There are currently about 3.5 metric tones of balls in the machine, with room for more. This increases the horsepower requirement, but also increases the rate of milling.

The way the machine was set up and operated proved to be very functional, but required a considerable amount of mechanical aptitude, time and supervision to ensure that the ground material stayed within specifications.

5.0 Discussion

This project has clearly demonstrated the potential of producing agricultural fertilizers in the Yukon. Primarily due to time constraints, only three rock samples were taken and sent for analysis. There are still quite a few sites within the Whitehorse area that deserve further investigation. The rocks contained within these sites contain specific minerals needed in large quantities by certain local soils to amend inherent deficiencies. Examples of these minerals include calcium, magnesium, copper, iron, zinc, boron, sulphur, potassium, phosphorus, nitrogen and cobalt. The three samples assayed as part of this project revealed interesting initial findings. The copper belt in Whitehorse is a very high quality magnesium source with good traces of sulphur, copper and iron, and virtually no calcium. This find is exciting because it almost perfectly matches the requirements of specific local soils as recommended by Kinsey Agricultural Services as part of the multi-year legume study.

The sample from White Mountain is a good source of relatively pure calcium and low in magnesium which was similarly recommended by Kinsey.

The sample from Carcross could be used as a general amendment for soils low in a wide range of minerals, while not exacerbating any existing excesses.

The limestone that was ground by the ball mill was quite hard because much of the rock is marbleized. Despite this, the ball mill was able to mill at about 6 tonnes per hour. This rate could be improved by adding more balls and by improving the feed hopper/ water blending system. The consistency of the milled material could be improved by using a device such as a spiral concentrator which would feed oversized material back into the machine for further processing.

For the purposes of this project a simple lagoon was constructed with a basic weir structure to allow settlement of material and separation of water by gravity. This worked fine, but would need to be improved upon because it does not allow for rapid drying of the material and creates further handling issues that are difficult to overcome using basic farm equipment. The other main problem with gravity settlement is that the settling material stratifies leaving the largest particle size at the bottom and the finest at the top. This has to be carefully mixed together prior to spreading on the land to ensure evenness of particle distribution. As well, the water that runs from the lagoon contains some very fine suspended material which is lost.

6.0 Conclusions

Despite some delay and mechanical difficulties, the ball mill project was successful. The ball mill project enabled the identification and milling of a limestone from White Mountain, which was then spread on 15 acres at Wild Blue Yonder Family Farm near Tagish. The limestone addressed a major calcium deficiency which was limiting production and quality. Farm owners Heidi Marion & Garret Gillespie were delighted with this year's vegetable crops which are unprecedented in yield, health and quality.

The legume study has highlighted the fact that there are other farms in the Yukon with similar deficiencies that limit legume survival and overall productive capacity. The ball mill project clearly shows tremendous potential to address these fertility issues by processing locally found materials on farm. The cash savings to the farmer are huge as demonstrated by the following price comparison between locally milled limestone and trucked in limestone from the nearest developed agricultural source which near Edmonton.

Cost per tonne	White mountain	Edmonton
Trucking	6.78	450.00
Material	0.00	250.00
Processing (labour & fuel)	5.00	
Total cost per tonne	11.78	700.00

Note: The cost of trucking from Edmonton is out of date by one year and assumes a full B train load of 28 tonnes. Invariably it will be higher now. The cost of processing does not include equipment costs in this case as it is assumed the farmer will already have the equipment on hand. However if the equipment were hired for the occasion it would add an additional cost of about $33.00 per tonne, bringing the grand total for the local option to $44.78 per tonne.

The above table shows that even if local trucking costs were higher i.e. rock source were further from the farm, the cost per tonne would still be considerably less than trucking it in from any source outside the Territory. This low cost could induce more farmers to address major nutritional imbalances within their soils thereby increasing profitability and overall production in the Territory.

7.0 Recommendations

Results from this project indicate that further work should be done in this area in the interests of cutting costs of production, increasing profitability, increasing environmental sustainability, cutting greenhouse gas emissions, increasing production and crop quality. Locally milled rock powder amendments are a key component of increasing food production and sustainability in the Yukon. Local production will also help shield farmers from the continually rising costs of buying and trucking fertilizers in from outside the Territory.

For these reasons, the following recommendations are made.

- Further prospecting for agricultural minerals should occur. The results from this work could be compiled in a database so that farmers can easily identify key local and accessible sources of nutrients needed on their land as shown by soil analysis.
- The ball mill should be mounted on a low-bed semi-trailer and set up with a better hopper system, perhaps a spiral concentrator, a centrifugal dewaterer, and a conveyor system. The system would be run using its own power source rather than using a tractor power take off. A set up like this would allow the mill to be moved from farm to farm with minimum hassle. It would also enable the machine to be run using minimum training, experience, or supervision. Potentially, the hopper could be loaded in the morning and it would contain enough material to last for a day of milling. The dewatering system would present a semi-dry cake to a conveyor that would pile the milled material to facilitate drying.
- Many farmers do not possess the appropriate distribution equipment for larger acreages of more than about 3 acres. A small trailed lime spreader (in the 4 tonne capacity range) could be supplied to farmers with the ball mill to facilitate distribution.

8.0 Pilot project budget

Item		**Budgeted**	**Actual**
Ball mill transport (Burwash to Tagish)		$1200.00	$1341.25
Ball mill rental	(in kind)	1000.00	1000.00
Ball mill set up (materials and labour)	(in kind)	1200.00	1200.00
Sourcing and testing rock samples (travel)		500.00	500.00
Lab analysis ($20/sample x 20)	(in kind)	400.00	400.00
Shipping cost for samples ($5/sample x 20)	(in kind)	100.00	100.00
Shipping rock to mill		800.00	786.00
Milling ($200/hr x 5 hours)		1000.00	1000.00
Reports and administration		600.00	600.00
Total cost of project		6800.00	6927.25