Title:

Effect of Fine Cement Sand and Zeolite on Rye (*Secale cereal)* Biomass Accumulation in Two Local Soils

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i. Objective

Evaluated winter rye response to a range of rock dust and zeolite application rates in two different soils from farms managed by KPU. Tested for interactions between amendment, application rate, and soil type.

ii. Introduction

Soil amendment with mineral additives is a common cultural practice in agriculture, whether it is used to change soil pH or add nutrition. Finding available and affordable sources for mineral amendments can be challenging. The fine concrete sand in this study is a by-product of gravel production from the Orca Sand & Gravel Pit located in Port McNeill, British Columbia and the zeolite comes from a mining operation in Princeton, British Columbia. There is considerable interest in using rock dusts as a soil amendment, but results of its use can vary, depending on weathering, soil type, and soil microbiology.

Aluminosilicate, ferromagnesian silicate and accessory minerals of rocks contain varying concentrations of essential plant nutrients (Harley and Gilkes, 2000). Different minerals provide a varying array of nutrients to plants and soils. Quartz, which is a major component of the sand being studied, is resistant to weathering. Another large component is feldspars such as plagioclase and orthoclase, which can provide calcium and potassium (Harley and Gilkes, 2000). Nutrient availability of rock dust has been studied in many countries and from many mineral sources. Sanz Scovino and Rowell (1988) explored potassium sources in feldspars. In Norway, several mineral sources including amphibolite (5.9% of the fine concrete sand (Rothstein, 2017)) were investigated by Baerug (1991a). The same study found evidence of magnesium sources (Baerug, 1991b). Feldspars are the most common igneous structural rocks and alkali aluminosilicate, and, moreover, potential sources of calcium and sodium (Harley and Gilkes, 2000).

Rock dusts have also been studied for their nutrient limiting capabilities. A variety of rock dusts were studied by Campbell (2009), and were observed to decrease the concentration of a few nutrients in soils that they were applied. Counter to this, a 2013 study found that in a loamy sand soil environment rockdust provided magnesium, iron, and phosphorous (Ramezanian, 2013). In the scope of nutrient availability, pH greatly influences the accessibility of elements as fertilizers. In Spain, a study found that granite powder could neutralize acidity in soils (Barral Silva et al., 2005). The fine cement sand also is 2.9% limestone (Rothstein, 2017), which is known to aid in raising the pH of soils. Ramezanian (2013), however, did not see any significant change in pH or carbon and nitrogen levels in soils observed in their rock dust trials.

Factors that affect nutrient availability from rock dusts include soil type and weathering. Pulverized rock and granite can act as a slow release fertilizer (Gillman, 1980; Leonardos et al., 1987; Sanz Scovino and Rowell, 1988; Chesworth et al., 1989; Bockman et al., 1990; Weerasuriya et al., 1993; Coroneos et al., 1996; Hinsinger et al., 1996; Harley and Gilkes, 2000). Amendment with silicate rock powder can increase nutrient levels in poor soil (Sans Scovino and Rowell, 1988; Hinsinger et al., 1996). As in all nutrient cycles, mineral breakdown and uptake requires a biological element to aid in the process, as emphasized by Manning (2010) and Ramezanian (2013). Nutrient levels could be improved in poor soils by rock mineral application and biological associations. Microorganisms in low nutrient soils have been found to populate and dissolve feldspars with limiting nutrients (Rogers and Bennett 2004). Another study similarly concluded the possibility that ground silicate rock would work for soil amelioration with yearly applications, amending cation exchange capacity and acid neutralization of poor soils (Blum et al., 1989b). Loamy sand soils showed greater benefit from rock dust applications than clay or peat soils (Ramezanian, 2013).

Providing nutrients to the soil is no more important than a crop's capacity to utilize them. Applications of up to 20 t/ha silicate rock powder produced encouraging plant responses in several glasshouse pot experiments (Leonardos et al, 1987; Baerug, 1991a, b; Coroneos et al., 1996; Hinsinger et al., 1996). Similar responses were observed in field experiments done by Sans Scovino and Rowell (1987). Quartz and silicate minerals are also commonly used in biodynamic agriculture. Specifically, preparation 501 (also called BD501 or horn silica 501) is finely ground quartz buried for a period of time with other preparations and then used as an aerial spray. Preparation 501 has been found to increase dry matter accumulation in cereals (Kjellenberg and Grandstedt, 2005) and phenolic compounds in potatoes (Jariene et al, 2015). Treatment of poor soil with ground granite increased wheat biomass (Hinsinger et al.,1996). Conversely, a 2000 study by Bollard and Baker stated that a granite dust amendment of 2 t/ha did not affect grain yield in the application year. Ando et al.

(1996) found no significant increase in rice dry matter regardless of the nitrogen fertilizer conserved in the soil.

Plant nutrients are made available by the weathering and dissolution of rock minerals, thus the efficacy of mineral grounds and dust are dependant on particle size (Ramezanian, 2013). The release of potassium, a key plant nutrient, was found to be faster from <60 µm size particles but leveled out with larger grain sizes of up to 350 µm, after six weeks (Niwas et al., 1987). Particle size of the Orca fine cement sand ranges from 75 µm to 4.75 mm, with the largest portion of the material being 150 µm (Rothstein, 2017).

This research examined the response of fall rye grass (*Secale cereale)* to a range of application rates of Orca fine cement sand and clinoptilalite zeolite applied as a soil amendment to a sandy loam and a silty clay loam. The experimental design allowed for an evaluation of any effects of application rate, amendment type and soil type on crop dry matter accumulation, and tested for interactions between these factors.

iii. Methods

Sixty pots arranged in a completely randomized factorial design were arranged in a row along the south-facing terrace at KPU richmond campus at 8771 Lansdowne Road. Orca fine cement sand from a sand and gravel quarry in Port McNeill, BC was tested at application rates of 0, 2, 4, 8, and 16 g/L (~0-25 t/ha equivalent) and Canadian zeolite from a quarry near Princeton, BC was tested at rates of 0, 274, 547, 1094 or 1641 g/L (Fig. 1). The zeolite was measured in percent of weight basis at 1, 2.5, 5, 10, and 15% of the top 15 cm of soil based on research done by Lim et al (2016). Two soil types used in the experiment were a sandy mineral loam from the Garden City Lands at Garden City and Lansdowne Roads and a silty clay loam from the KPU Orchard at the corner of Gilbert and Dyke Road. Fall rye (*Secale cereale)* cover crop was used as the indicator plant. The two amendment types each with five application rates in two soil types were replicated three times. The pots were twenty-five litres (6.5 gal.) each and were filled with either the Garden City Lands (GCL) or Orchard (orch) soils and then amended with the respective application rates of rock dust or zeolite. The amendment was then mixed in the top 15 cm of soil to mimic farm application. Fall rye was direct seeded in three clumps of four seeds each. All application and seeding was done on Sept 11, 2018. The pots were weeded and monitored for two months and the above and below plant matter were harvested on November 6, 2018. The plant material was washed free of soil and oven dried for 72 hours at 75°C. The biomass was weighed and analyzed using a general linear model in R.

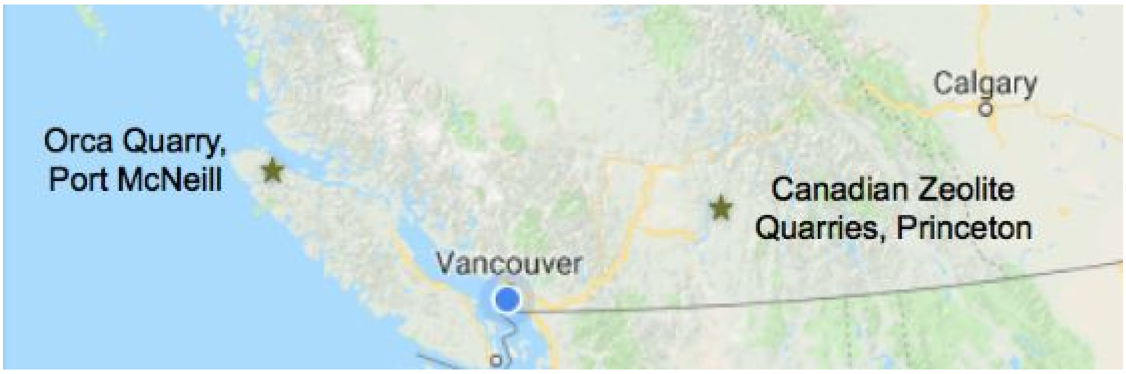

Fig. 1. Locations of each of the amendments in relation to study site. The fine cement sand was from Orca Quarry in Port McNeill and zeolite is from a quarry in Princeton, BC.

iv. Results

None of the experimental factors had any detectable effect on rye biomass production, and no interactions were found between the factors tested. Both rock dust and zeolite have been previously reported to neutralize acid soils and increase soil cation exchange capacity. These properties may not have offered benefits in the tested soils because they were not acidic, and they had high cation exchange capacity due to their clay content. No difference was observed in the biomass between the GCL or orch soil or of either amendment type or application rate (Fig. 2, Fig. 3).

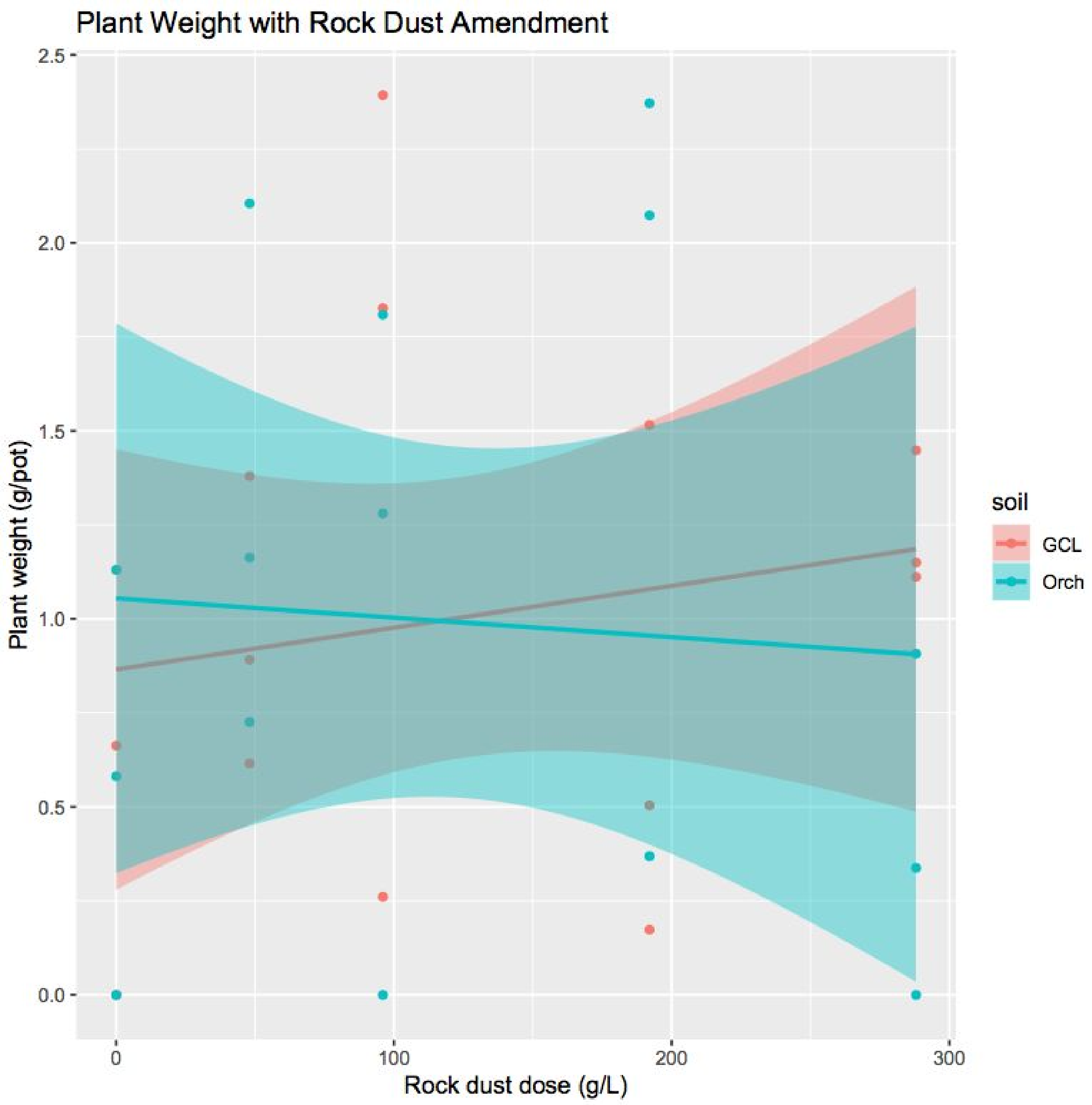

Fig. 2. Rye dry weight over a range of rock dust amendment rates in organic silty clay loam soil from the KPU Orchard (blue) or sandy clay loam from the Garden City Lands (red). Shaded areas show 95% confidence interval around lines.

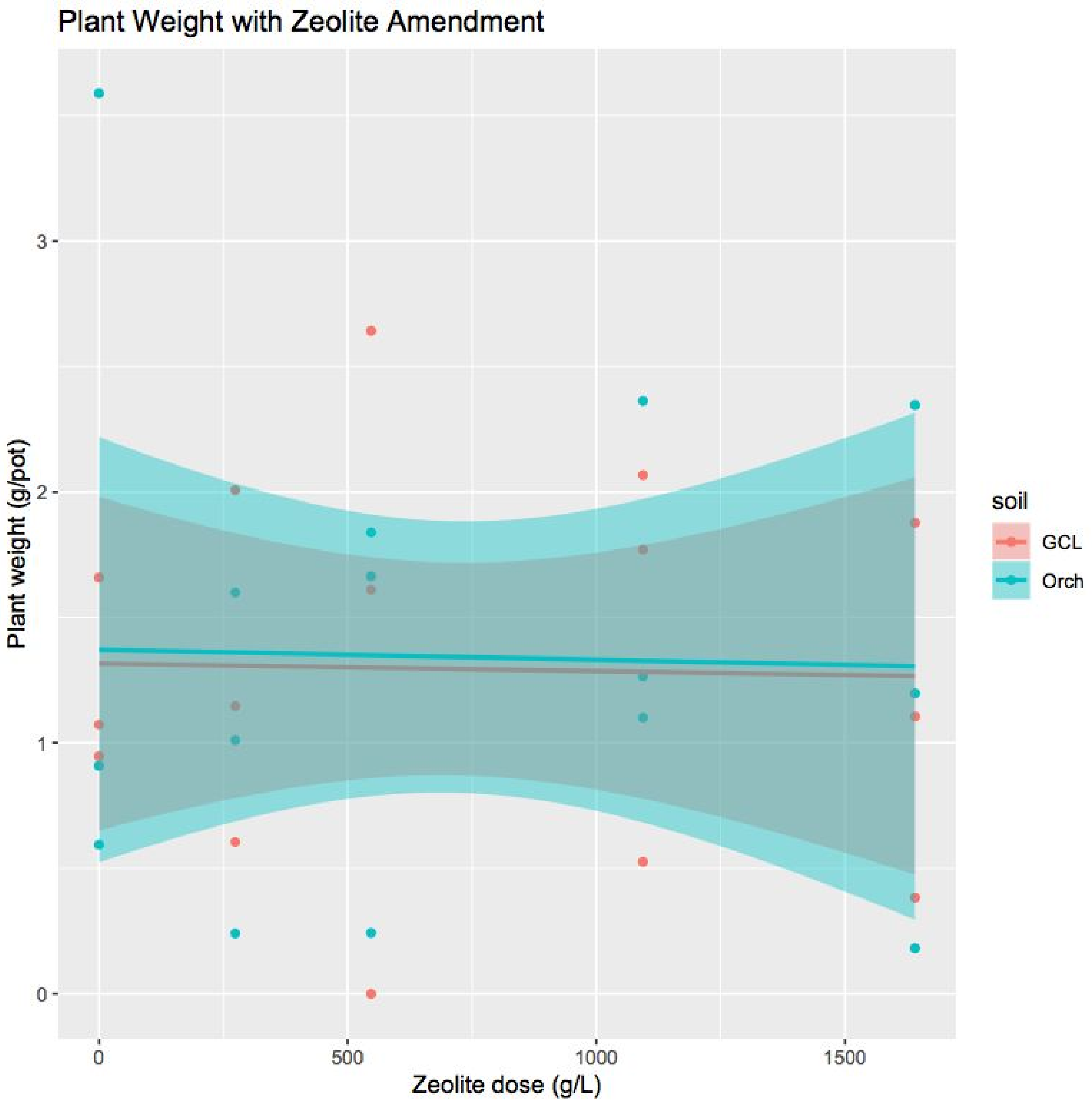

Fig. 3. Rye dry weight over a range of Zeolite amendment rates in organic silty clay loam soil from the KPU Orchard (blue) or sandy clay loam from the Garden City Lands (red). Shaded areas show 95% confidence interval around lines.

v. Discussion

Soil amendments were expected to have the greatest impact in the soil from the Garden City Lands because it had a much lower organic matter and nitrogen content than the Orchard soil. Even without amendment, rye biomass production did not differ between these soils, This suggests that winter rye is tolerant of adverse conditions, and may not be a suitable test crop. It is surprising that no effect was observed in soil type as organic matter content is a well known advantage for crop growth. The GCL soil has an organic matter content of ~1%

and the orch soil has an organic matter content of ~11%. An earlier iteration of this study looked at multiply crop types with above and below growth habits and harvestable produce. These growth habits could provide more information of mineral utilisation in the future as the nutrient requirements for each crop type may show different results. In this experiment no soil testing was done but future studies may explore the nutrient content within the growing medium. Plant tissue analysis may be another tool to assess the nutrient availability in rock dusts. As seen in many of the research cited in the introduction rock dusts and mineral amendments may require a longer length of examination to assess their potential. The fine cement sand used in this study has a large portion that is resistant to weathering, this adds to the need for longer study duration in order to fully understand the capabilities of this product. Zeolite has other applications beyond soil amendment and further exploration is needed to ascertain how to effectively utilise this local resource. In summary further studies are needed to evaluate possible benefits of soil amendment with fine cement sand or zeolite.

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