

MSc Dissertation Project Proposal

ACE8121

Name of Student:

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Name of Principal Supervisor:

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Name of second Supervisor:

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Proposed Title:

Assessment of the impact of Gypsum application on soil quality physical indicators and earthworm populations in a Conservation Agricultural System

Introduction:

Increasingly, there is greater concern for food security globally (Rosegrant and Cline, 2003). Over the years, agriculture has been intensifying to ensure greater production to feed the growing global population. However, it has now been understood that past and current practices have been environmentally damaging, and more sustainable methods of agriculture should be promoted (Doran and Zeiss, 2000). The aim of sustainable intensification is to increase agricultural yields without damaging the environment or converting more land to agricultural use (Pretty and Brarucha, 2014). Through this there has been increased concern for soil quality due to its importance for food production.

Soil quality can be defined simply as the ability the soil has to function, reflecting the soils living and dynamic nature (Karlen *et al.*, 1997). Soil quality is measured using biological, physical and chemical indicators. Physical indicators include bulk density, aggregate stability and porosity to name a few (Environment Agency, 2006). Earthworm population is a biological indicator, providing understanding of the life in the soil. Soil quality properties can be interlinked and impacted by management and climatic factors (EC, 2012; Schröder *et al.*, 2016). Specifically, in the UK, soil quality is damaged by compaction, measured by bulk density, poor nutrient and water retention, and poor soil biota. It was found by Natural England (2012) that generally across the UK soil biota was poor due to management practices. However, due to the greater awareness and concern for soil quality, land management practices have been tailored to encourage soil quality (Schröder *et al.*, 2016).

Conservation agriculture ensures agricultural productivity through the management of agro-ecosystems and preservation of resources and the environment (FAO, 2015). Conservation agriculture involves diverse crop rotations, along with minimum or no tillage, and ensuring permanent soil cover (Hobbs, 2007; FAO, 2015). Research has found that by implementing conservation agriculture, benefits to soil quality can be seen (Kassam *et al.*, 2009; Kertész and Madarász, 2014).

Gypsum (calcium sulfate dihydrate: $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is non-toxic waste solid with the primary use for decoration and construction (UNEP, 2003; Gypsum Association, 2018). Gypsum is a relatively common substance which is found in two forms, natural and the waste version FGD. Gypsum can be used as a soil conditioner aided by the high proportion of calcium. Research has suggested that

gypsum is beneficial to soil quality, including soil physical properties, soil nutrients (calcium and sulphur) and water infiltration (SEPA, Not dated). However, gypsum has not been researched in detail, especially from field investigations.

Gypsum is a waste product, which makes it relatively cheap to apply, and doesn't require specialist equipment (Wallace, 1994), due to the suitability of application with fertiliser spreader. However, there are restraints on application due to being a waste product with a maximum application being 1t/ha in a 12 month period, based on PAS 109:2013 and Standard Rules Permit SR2010 No.4 (Mobile plant for land spreading) (Environment Agency, 2010; NFU, 2015)

Studies that suggest gypsum has an impact on soil physical properties, including soil colloid flocculation, impacting aggregate size and stability. A study by Lebron *et al.* (2002) found that soil aggregates break down was prevented by the incorporation of gypsum in the soil columns. Furthermore, there was a direct correlation between the amount of gypsum added and the proportion of aggregates broken down. This result was explained as being due to gypsum reducing the exchangeable sodium percentage and the sodium adsorption ratio, along with encouraging sodium replacement with calcium (Lebron *et al.*, 2002).

Soil compaction is a major issue for soils under agricultural practice. Soil compaction reduces pore spaces, water infiltration and root penetration. Gypsum inputs have been found to correlate with reduction of soil compaction (Lebron *et al.*, 2002) suggesting gypsum restructures the aggregates, and improves their size and stability. The combination of gypsum and ripping was found by Hamza and Anderson (2003) to be the best long term method for reduction of compaction, as the ripping removes compaction and the gypsum helps restructure the soil.

Gypsum as a conditioner has benefits for infiltration rate and soil stability which reduces soil erosion, providing benefits to the environment. Yu *et al.* (2002) produced results supporting the benefit gypsum has on water infiltration rate and soil erosion. Gypsum at the rate of 4Mg ha⁻¹ doubled the infiltration rate when compared with the control and provided a greater benefit than when compared with 2Mg ha⁻¹, furthermore, greater differences were found with soil of higher clay content (Yu *et al.*, 2002), which has also been found by WRAP (2007) and Hamza and Anderson (2003).

Lebron *et al.* (2002) found a positive effect of gypsum on soil physical properties, however these were found at a laboratory scale, therefore, it will be interesting to investigate the impact gypsum quantities have on poor soils field scale. Studies suggest that increasing rate of gypsum applied provided greater soil physical improvements. Therefore, it will be interesting to analyse differences in application rate on soil quality in this project, whilst analysing whether current recommended application rates are appropriate to create changes in soil quality.

There are fewer studies on the impact gypsum has on soil macrofauna. The Durham farmers highlighted the change in macrofauna population across the farm with respect to good and poor quality fields, and want to improve the populations. Therefore, this project will be useful to provide evidence for the impact gypsum has on soil macrofauna.

Four farms in Northumberland, north Durham, have adopted conservation agriculture for many years. The farmers have detected differences in the soil and crop response to conservation agriculture across their farms, with some good and some bad quality fields. Therefore, this project will investigate the impact gypsum has on poor fields as a strategy to improve soil quality. They will be compared with better quality fields.

The investigation will produce results which will be provided further information on the use of gypsum, furthermore, there will be benefits to the Durham farmers which should aid their management decisions to ensure greater soil quality across their farms.

During this project, four Durham farmers will be involved, along with the Soil Association and BASE-UK.

Aim:

The aim of the project is to assess the contribution of varying rates of gypsum has on improving soil quality.

Objectives

1. To determine the effect various rates of gypsum has on soil physical properties (bulk density, aggregate stability and infiltration rate).
2. To investigate the impact of gypsum on earthworm populations.
3. To provide management advice for gypsum application in a conservation agricultural system.

Research question

1. How does different rates of gypsum application impact soil quality?

Hypothesis:

There will be no impact on soil quality from the application of gypsum

Proposed method:

Gypsum will be applied using the standard fertiliser spreader owned by each farm. This will provide an even coverage of Gypsum at the required rate.

Three trials will be included in this study:

Trial A: Impact of a high rate of gypsum application on soil quality indicators

On one farm the gypsum will be applied as a blanket application at a rate of 3t/ha. The application will occur on two fields which are divided into a poorer and better soil quality sections. The testing will occur before and after application, allowing for an assessment of a high application rate. The field will be divided into four zones, consisting of similar soil types, including two in high quality soil and two in the poorer soil quality. In each zone 5 subsamples will be taken randomly across the area. These subsamples will be mixed into a bucket to create 4 samples from the field, two from the poor soil quality and two from good soil quality section. Total samples taken is 16 for this trial.

The trial will have gypsum applied at 3t/ha and then will be planted with the spring crop. The second sample will be taken late spring, to ensure the crop is not too tall, soil is easily accessible and least damage to the crop is caused.

Trial B: Impact of a low rate of gypsum application on soil quality indicators

The other three farms will apply the gypsum by strip application across the fields. The strip will be the width of one pass by the tractor and the length of the field, spreading the gypsum using the farmers' fertiliser spreader. The following application rates will be applied: a control consisting of no gypsum and 1t/ha as the recommended rate of application, with one replicate in each field. This will

be repeated over 6 fields, two on each farm. This will provide evidence on the impact gypsum, at the standard rate, has on soil quality compared with standard conservation agriculture systems.

From each treatment, one sample will be taken consisting of 4 subsamples along the treatment plot, creating total of 12 samples. The soil samples will be taken late spring, after the planted spring crop has time to develop, to ensure least damage and ease of access.

Trial C: Impact of different rates of gypsum application

Nafferton research farm will be used to compare application rates. These will be applied through strip application and at the following rates: 0, 1, 2, 3t/ha, replicated 4 times (16 plots). Plot size will be 10x10m suiting the trial fertiliser spreader at Nafferton. The design will be randomised block design. Each plot will be subsampled 4 times to create one sample for each plot.

Trial C will be set up and gypsum applied on bare ground, this provides the opportunity to mix the gypsum into the soil surface using a disc. The gypsum will be applied early spring to allow for a spring crop of wheat to be planted. Wheat was chosen due to the importance it has as a UK commodity market (AHDB, 2015).

Analysis

The soil analysis will look at soil physical properties including bulk density, soil aggregation, and infiltration rate and along with earthworm population. These were chosen due to being key indicators of biological health and physical soil quality (Environment Agency, 2006).

Soil samples will be taken with a 15cm core sampler, this depth was selected due to minimum tillage (SAC, 2003), which is implemented on the test sites, most soil changes will occur close to the surface. The soil samples will then be taken to the laboratory to measure bulk density and aggregation. Samples should be taken on the same day, to avoid influence of the weather.

Soil Bulk Density

Bulk density is measured by taking a soil sample, weighing the sample, then dry and reweigh to calculate the moisture content. Calculations include (USDA, 1999):

Soil water content (g/g) = (weight of moist soil - weight of oven dry soil)/ weight of oven dry soil

Soil bulk density (g/cm³) = oven dry weight of soil/volume of soil

Soil Aggregation

Aggregate stability can be measured using a wet sieving apparatus, measuring the resistance soil structure has against either mechanical or physico-chemical destructive forces, causing unstable aggregates to breakdown easily (Eijkelkamp, 2008). The standard method produced by Eijkelkamp (2008) will be used.

Aggregate stability index calculated by dividing weight of stable aggregated over total aggregate weight (Eijkelkamp, 2008).

Infiltration Rate

SATURO Dual-head Infiltrometer will be used to collect infiltration data for each treatment. For each treatment in all trials one reading will be taken per treatment, due to the time taken to collect the data. The method will follow the standard method produced by Metergroup (2017).

Earthworm Population

Earthworm population should be recorded by digging a square foot plot, 12 inches deep (USDA, 1999). Then break the soil down to locate all the earthworms present. The worms will be categorized into adults and juveniles and then split into species. Deep burrowing worms can be calculated by pouring 2L of mustard solution into the hole and waiting 5 minutes. In the 2L solution, 2 tablespoons of mustard powder (USDA, 1999).

Plots will be dug in Trial A and B, 4 samples taken, using random sampling strategy. For Trial C, the hole will be dug and the mustard solution will be used for each treatment.

Statistical analysis

Mixed methods will be used to statistically analyse the data from each trial. Initially descriptive analysis will be used to provide initial understandings. The data produced is categoric and will be parametric. Trial 1 involves comparing between before and after treatment, with two treatment, therefore two-way anova will be used. Trial 2 produces data for two treatments with six replicates, therefore, Two-Way Anova will be used. Trial 3 will use One Way Anova, comparing each treatment and its impact on soil physical and biological quality.

All the tests will be carried out using the programme SPSS.

Schedule of Work:

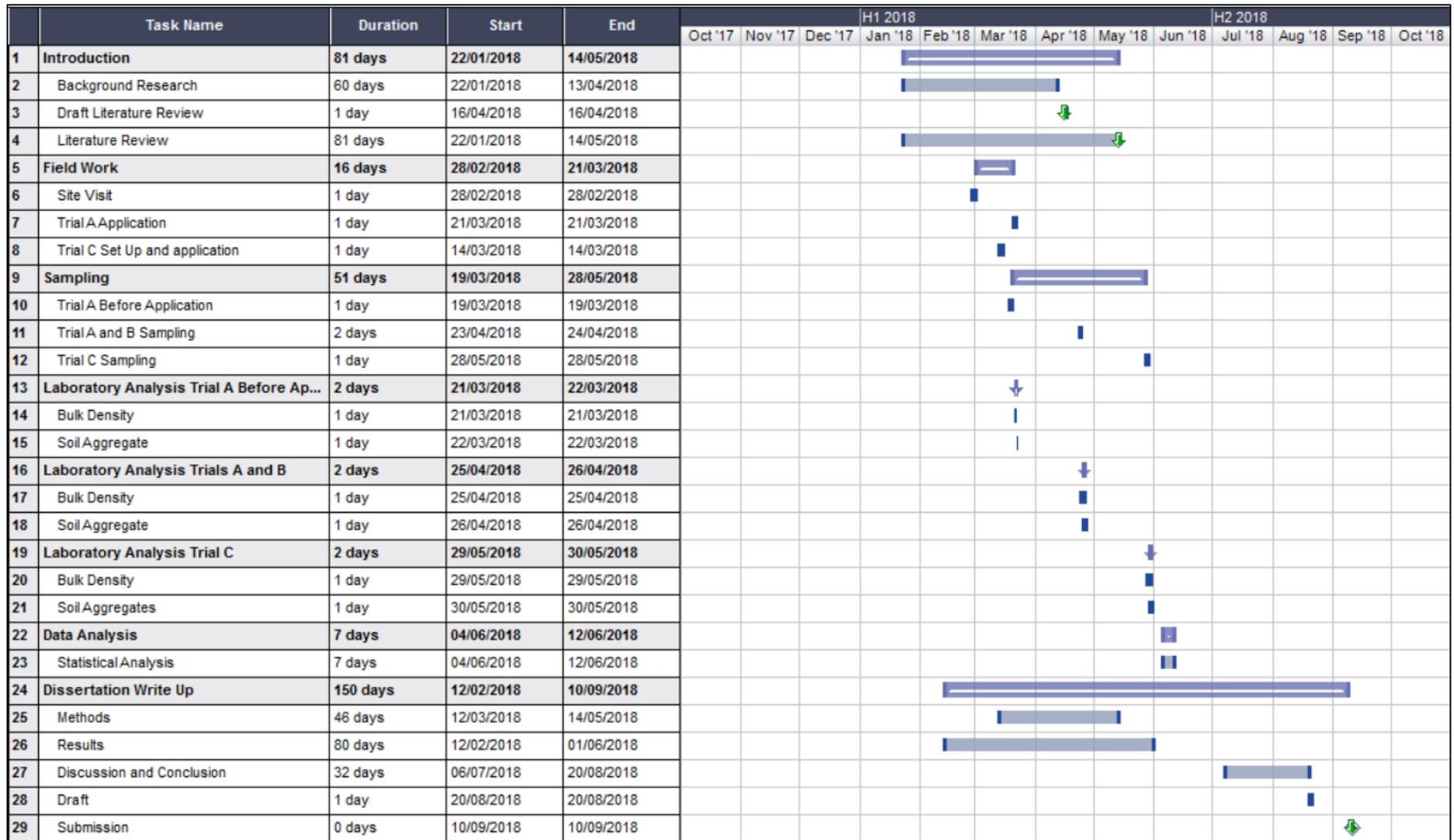


Figure 1: Gantt Chart representing schedule of work

Budget:

Table 1: Project Budget

Component	Price per Unit (£)	Quantity	Total (£)
Car Hire	70 ¹	6 days	420
Fuel	0.45	150 miles	67.5
Sample collection bags	0.15	44	6.6
Mustard	7.27/1kg ²	2	14.54
Gypsum	21.19/25kg ³	3	63.57
Total			572.21

Car hire will be required for several days due to the differences in sampling timing over the project. As hire cars will be used, the fuel will be required, which is increased due to the number of site visits and distances to each site. Gypsum needs to be purchased to allow for application in trial C. Trial A and B will have the gypsum applied and purchased by the farmers. The mustard purchase will be required to analyse the impact gypsum has on the deep burrowing earthworms.

The student budget for the Masters Dissertation is £500, the budget for the project has been calculated as over the masters allocation. The supervisors' research fund will provide the excess money to complete the project.

¹ Average from Hire Car Companies

² Whole Foods (2016)

³ Amazon (2017)

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Student Surname... SAUNDERS

Supervisor Name... JULIA COOPER

SCHOOL OF AGRICULTURE, FOOD AND RURAL DEVELOPMENT
APPLICATION COST SUMMARY FOR MSc and STAGE 4 UNDERGRADUATE PROJECT COSTS

Please note you will not be able to claim any money back/place any orders until your form has been approved

Provide breakdown of expected costs

Description	Amount	Office Use Only	
		Approved	Processed
Airfare	-		
Mileage (round trip .45p 1 st 200 miles, .25p thereafter)	150	67.5	
Public Transport (rail fare, taxis, bus, metro)	-		
Accommodation	-		
Consumables* (web req to be done by a technician or supervisor)	504.71		
Are you able to contribute personally to your project?	00		
Total	572.21		

The School supports projects to a maximum total of £500, the above total should not exceed this

External Sponsorship

If you have sponsorship from an external source, you must include written confirmation with this form

Statement by the applicant - I understand that I am not to make any orders or claim any costs until I have received confirmation that my application has been approved.

Signature... ASaunders Date... 15/01/18

Name... ABIGAIL SAUNDERS Student Number... 13130534145

Degree Programme... Msc Sustainable Agriculture + Food Security

Statement by the project supervisor/DPD/appropriate staff member - I confirm that I have discussed this application with the student and agree these costs are justified.

Signature of Supervisor... Julia Cooper Date... 12/01/2018

***Breakdown of consumables**

Item	Expected cost
CARS HIRE	420.0
SAVUE COLLECTION BAGS	66
MUSTARD	14.54

(Continue overleaf if needed)

This form **MUST** be signed by both the student and academic staff member before handing it in.

Please return this form to Susan Davies via the reception, School Office, 2nd floor Agriculture building.

Students will be emailed a copy of this form back when the costs have been approved

Notes (office use only)

Student Surname SANDERS

Supervisor Name JULIA COOPER

Gypsum

63.57