Super Soil – Why is soil so important?

Teaching Resource for Key Stages 3 / 4 students

This resource is aimed at Key Stage 3 students, (with extension activities for Key Stage 4 learners).

The resource contains an introduction to "the importance of soils", which is best delivered in the classroom.

Following the introduction, there are 7 activities that can be undertaken whilst on a farm visit. These activities assess the properties and quality of the soil.

The introduction could be delivered as a standalone session and it is not necessary to carry out all 7 of the soil assessments. Depending on time, resources, group sizes, the season etc it may be preferable to do some but not all of the 7 activities.

Farmers may find it useful to carry out a selection of the soil assessments as part of a **"Farmer Time"** session. https://leafuk.org/farmertime/home

The series of activities in this resource will allow students to:

- Understand the importance of soil
- Understand how we can measure soil health through a series of activities / experiments
- Understand how farmers use information on soil health to improve their soil
- Understand how farmers use information on soil health to plan what they can grow on their farm

This resource forms a set of teacher notes with tasks, practical activities and questions for students. Each is marked as follows:

 Student Task

 Student Activity

 Student question (answers provided in italics)

Contents

Before the Farm Visit

Before the farm visit it is worth spending some time looking at

- What is soil?
- Is soil important?

It would be useful to ascertain the prior knowledge and understanding your students have.

What do the students think? What do they already know about soil? Why is it so important?

Have a look at this short video from Lancaster University, relating to the importance of soil
https://www.youtube.com/watch?v=PAlZBUckaRM

Key ideas for students to understand;

- **Soil Security**: it can take 10,000 years to produce 30 – 40cm of soil. We can think of soil as a non renewable resource. So if we damage soil, it doesn't recover quickly. We need to think of using soil more sustainably.
- **Food:** soil provides the basis for almost all the food we eat. We therefore need to protect soil.

Soil is one of a farmer's most important raw materials. On arable farms it is used for producing crops. On livestock farms it supports grass for grazing animals.

What did the students have for their last meal?

Where did that food come from / grow? *The soil on the farm.*

But how much soil have we available to use for farming?

Have a look at this You Tube video; https://www.youtube.com/watch?v=v9WXCAwk4_c&t=42s

So, we have a very small amount of soil we can use to feed a growing population. This means we have to look after and manage our soil.

A third of the planet's land is severely **degraded** and fertile **soil** is being lost at the rate of 24bn tonnes a year, according to the United Nations

What does "degraded" mean?

*"**Soil degradation** is the decline in soil condition caused by its improper use or poor management, usually for agricultural, industrial or urban purposes. It is a serious environmental problem. Soils are a fundamental natural resource, and are the basis for life. Avoiding soil degradation is crucial to our well-being".*

Based on what they have learnt so far, can your students identify the key points?

- *Soil takes a long time to form.*
- *We need to look after it. If it becomes damaged, we can't replace it.*
- *Soil is the basis for food.*
- *Soil is essential for life!*

Stretch and challenge for the more able student.

"With increasing pressure on the world's natural environment and resources, it is essential that we develop farming systems that have a low impact on the environment and are also highly productive in meeting the needs of a growing global population. Land, water and nature are all under pressure and competition.

Getting the balance right to ensure economic prosperity, environmental sensitivity and social gain are critical.

Land degradation will remain high on the international agenda. This is due to its impact on world food security and quality of the environment". (LEAF Simply Sustainable Soils publication)

"The nation that destroys its soil destroys itself" Franklin D Roosevelt

Can your students think of any other issues that pose a risk to the stability of our soils?

Climate change: within the UK we are predicted to get warmer, hotter, drier summers and milder, wetter winters. Intense extreme weather events plus rising sea levels all present a higher risk to the stability of soils.

Farmers and scientists must work together to predict changes and formulate strategies to protect our soils and ensure a sustainable food supply.

Have a look at Syngenta's Good Growth Plan as an example of farmers and scientists working together
https://www.youtube.com/watch?v=H_YXEh0eQD4&feature=emb_rel_pause

Read the article, "Soil, the beginning of everything" https://www.cropscience.bayer.com/people-planet/natural-resource-conservation/a/soil-beginning-everything

Who are the FAO and what did they create in 2012?

What are the FAO's predictions for the next 25 years in terms of global food production and food prices?

On The Farm

By now your students should understand the importance of soil and why we need to look after it.

But how do farmers assess the quality of the soil on their farm?

The following activities are often used by farmers to assess soil type and quality. This in turn allows them to make decisions on how to improve their soil and what crops are best grown in particular fields.

Time, group size and availability of equipment will dictate how many activities are carried out. Some may need to be demonstrated by the farmer with the students observing and discussing. Others, could be carried out by the students.

Results of each test should be entered into the **Soil Record Sheet** that can be copied from the handout section at the end of this resource. If time allows, it would be useful to carry out the same tests in different locations across the farm, allowing students to see different soil types.

Soil Testing Activities

1. The soil texture / type
2. The structure of the soil
3. Drainage of the soil
4. Compaction of the soil
5. Organic Matter in the soil
6. pH and nutrients in the soil
7. Earthworms, living organisms and plant residues found in the soil

Stretch and challenge for the more able student

 Which of the above tests measure the:

- physical health of the soil? *(soil structure, drainage, compaction)*
- nutrient balance and exchange? *(organic matter, pH and nutrient levels)*
- biological health of the soil? *(earthworms, living organisms and plant residues)*

Test 1, Soil Texture / Type

All soil contains sand, silt and clay particles; but in different proportions. Sand particles are the biggest, then silt, then clay.

Sandy soil is free draining but cannot hold on to nutrients.

Clay soil holds water well but can become waterlogged when wet and it doesn't hold on to nutrients.

Silty soil holds on to water and can be hard to drain. It can only hold limited nutrients.

Soil also contains 35 – 40% air and water. Air allows the plant roots and animals to "breathe". Water binds soil particles and is taken up by plant roots.

Soil also contains organic matter (manure, leaf mould and compost) which provides nutrients as it rots. Insects, bacteria and earthworms then help to break down dead materials.

Soil Texture Test – easy

- Take a handful of soil and wet it
- Squeeze out the water
- Make the shapes below in order
- When you can't make your shape you have your soil type

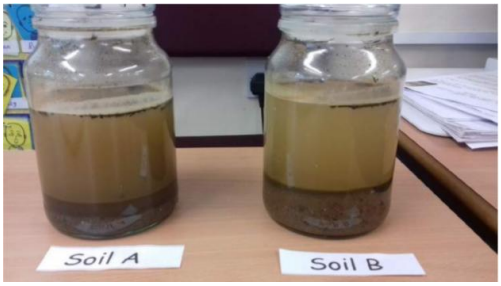
				
Cone	**Ball**	**Straight worm**	**Bent cracked worm**	**Bent smooth worm**

Shapes you can make	Soil Type
Cone only	Sandy
Cone and ball	Loamy sand
Cone, ball and straight worm	Loam
Cone, ball, worm and bent worm with cracks	Clayey loam
Cone, ball, worm and bent smooth worm	Clay

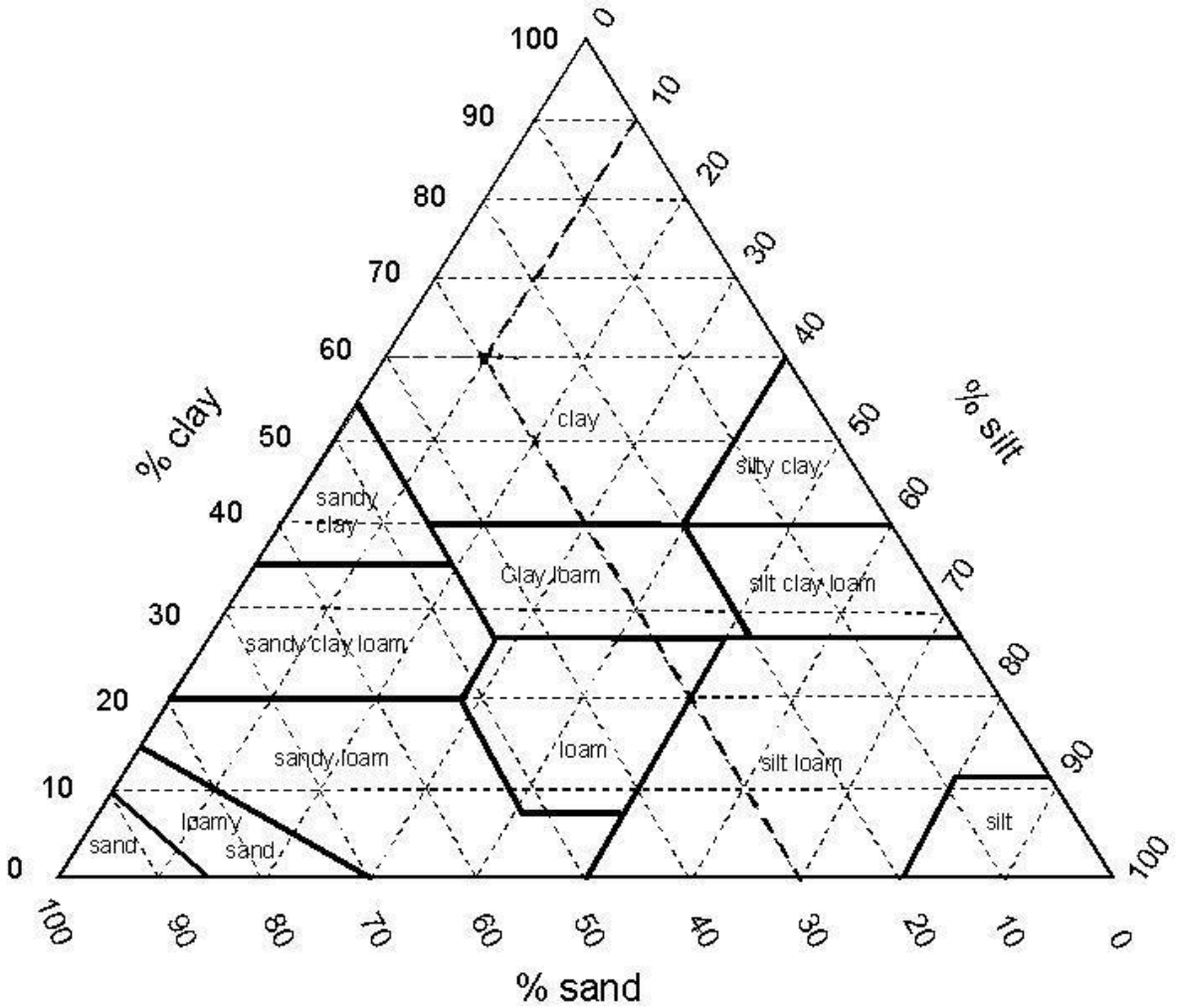
Loam soil has almost equal proportions of sand, silt and clay.

Soil Texture Test – bit harder!

Take a sample of soil and put in a clean, clear jar or measuring cylinder. Add water to cover the soil and put a lid on your container. Leave the sample to settle. The heaviest, biggest particles sink first (sand). The smallest, lightest sink last (clay). Floating on top might be organic matter. This is best done as a demonstration using a sample left to settle the day before.



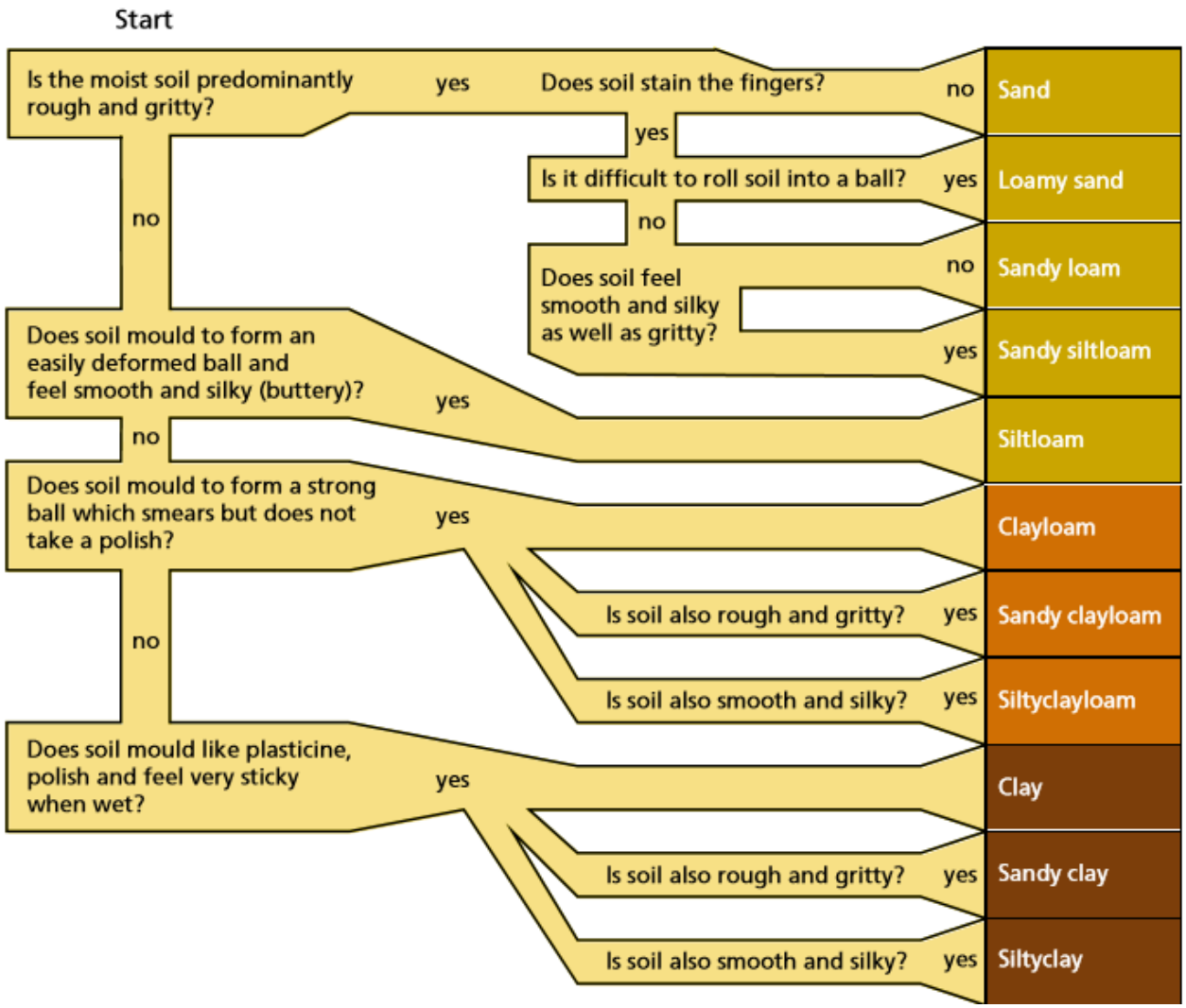
Using a **Soil Texture Triangle,** work out the soil type depending on the estimated percentage of the layers in the settled samples in the jar.



Soil Texture Test – harder!

Take a dessert spoonful of soil. If it is dry add some water and rub between your fingers and thumbs until it crumbles. Use the chart below to decide what soil you have. A copy of the ID chart is available in the handout section of this resource.

Once students have completed one of the above tests, they should enter the soil texture / type for their sample into the **Soil Record Sheet.**



Test 2, Soil Structure

You will need: a spade, plastic container (approx 35cm by 35cm by 20cm deep) and a heavy-duty plastic bag.

Farmers would normally carry this test out in spring.

- Dig a 20cm cube of top soil
- Drop the sample a maximum of 3 times from waist height into the plastic container
- Lay the sample out on the plastic bag, grading the pieces with the biggest at one end and the finest at the other end.

Which picture, (below) does the sample look most like?

Students should enter the score into their **Soil Record Sheet**

Poor (0)	**Medium (1)**	**Good (2)**
Lots of lumps of coarse soil and not much crumbly soil	Sample is approx 50% lumps of coarse soil and 50% crumbly soil	Lots of crumbly soil. Not many clumps of soil

Stretch and challenge for the more able student

Why is a soil with a score of 2 the best for growing crops?

Why is a soil with a score of 0 the worst for growing crops?

The size, shape and arrangements of soil particles and air spaces are important in order to maximise the potential for aeration, root development and drainage.

Good soil has well formed particles that can be easily broken down between the fingers. This allows roots to grow into the soil as well as maintain structure.

Poor soil has hard and sharp edged particles which are more difficult to break up. This restricts root development and growth.

Test 3, Drainage

If soils drain well, water can pass through easily. This prevents waterlogging.

Waterlogged soil is so wet it cannot absorb any more water. Once the soil becomes saturated, a layer of water remains on the surface of the soil.

Why is waterlogging bad for soil? *Waterlogging can lead to less air in the soil which can restrict plant growth.*

It may be useful at this point for the farmer to show any photographs he or she may have of fields that have been waterlogged on their farm; particularly in the areas where you are carrying out your soil tests.

The colour of soil is a useful indication of soil drainage.

Brown / black = good drainage

Grey mottles = potential drainage issues

To test the soil, dig a 20cm cube of topsoil. It may be best for the farmer to dig the sample and then the pupils discuss what they see.

Compare your sample to the pictures below.

Which picture does your sample match the best? What score will you give your sample? Copies of the pictures below are available in the handout section.

Add the scores to the **Soil Record Sheet**.

Poor (0)	**Medium (1)**	**Good (2)**
Grey, blue, purple or green soil colour occurs due to waterlogging for prolonged amounts of time	Some colour change due to moderate waterlogging	Dark coloured soil indicating good aeration and organic matter due to well draining soil.

Stretch and challenge for the more able students

Why might the soil change colour when it has been waterlogged for prolonged amounts of time? *The change in colour is called "Gleying". Waterlogged soils have less oxygen which allows anaerobic microbes to flourish. This leads to a reduction in iron and manganese in the soil which results in the grey colour change*.

Test 4, Compaction

Compaction is where the soil has been squashed and made more solid.

What might cause compaction? *Animals, machinery*

Why is compaction detrimental to the soil? *Compacted soil restricts the movement of air, water and nutrients. This leads to poor root growth.*

As a demonstration activity

1. Have a clear container / jar ¾ full of soil
2. Pour a small amount of water over the soil. Watch how quickly it absorbs / drains into the soil.
3. Use a pencil or stick to push into the soil. How easy was it to push in?
4. Now.... push the soil sample down as much as possible in the container (compacting the soil).
5. Repeat steps 2 and 3 above. Was there any difference? Does the soil look any different?

Now to test on the farm...

Ask the farmer to dig a hole about 50cm in depth.

Are there any obvious changes in soil structure?

Can you see any roots? Are they just in the top layer or do they extend down into the soil?

Can you see any evidence of moisture?

Try the water and stick test from the above demonstration activity.

So..... what score would the students give to the field sample?

0 = little evidence of roots, looks and feels solid, little water absorption
1 = some roots, water runs through sample slowly, firm but not hard
2 = deep roots, water runs through soil, easy to push stick in ground

Enter the score on the **Soil Record Sheet**.

Test 5, Organic Matter

Organic matter in soil is made up of:

- Dead organisms
- Plant matter
- Other organic material

All of the above can be at various stages of decomposition.

Can students state why **organic matter** is important for good soil health? *Organic matter helps create a good growing environment for plants by improving soil structure and providing plant nutrients and water.*

Some farmers choose to send soil samples to laboratories in order to get accurate organic matter results. However, it is possible to assess organic matter visually.

Black / brown soil tends to have high organic matter levels

Light brown soil tends to have low levels of organic matter

So..... what score would the students give the field sample?

0 = light brown soil.

1 = brown soil

2 = dark brown soil

Enter the score on the **Soil Record Sheet**

Test 6, Soil pH and Nutrients

Every 3 to 5 years farmers will test soil for pH and nutrient levels.

NPK are the three essential macronutrients plants need to grow.

Do the students know what N, P and K are?

N – Nitrogen

P – Phosphorus

K – Potassium

The NPK levels must be at the correct levels in soil in order to grow healthy plants.

NPK can be tested by sending samples off to a laboratory (provides accurate and detailed results) or by using a test kit.

Farmers need to know the NPK levels of their soil so that they can alter any deficiencies by adding the right type and amount of fertiliser. Adding the correct amount and type of fertiliser will save the farmer time and money.

It is useful at this point if the farmer can provide NPK values for the area of field the pupils are testing.

The availability of NPK is affected by soil pH. Acidity affects how plants take in nutrients (NPK). Having the right soil pH is therefore important.

What can your students tell you about pH?

- *pH is measured on a scale of 1 to 14*
- *pH 7 is neutral*
- *below pH 7 is acidic*
- *above pH is alkaline*

Most soil is between pH 5 – 8

Over time soil can become acidic so the farmer would add lime to raise the pH

What is the pH of the soil the students are sampling?

Use an electronic soil acidity meter or pH testing kit. Both available from garden centres.

To obtain accurate readings, farmers would normally take 25 samples of soil whilst walking a “W” track in the field. The farmer would use an auger / soil corer.

The samples would be combined and sent to the laboratory.

Use the table below to work out the soil pH and nutrient score for the Soil Record Sheet

	Score 0	**Score 1**	**Score 2**
pH value	pH too low or high	pH slightly low or high	pH 6 - 7
Nutrient (NPK) value (from farmer)	low	Needs some adjustment	Correct levels

Add your pH score to your nutrient score. Then divide by 2.

 This is the value needed for the **Soil Record Sheet**.

Test 7, Earthworms, Living Organisms and Plant Residues

Farmers will look for insect activity, number of beetles and plant residue in their soil as these are good indicators of the biological health of the soil.

But the best way to assess the biological health is to look at the number of earthworms in a sample!!!!

So let's have a "Worm Charming" competition!!!

Split the students into small groups / pairs. You will need a watering can full of water for each group. Each group needs a designated area ($1m^2$).

Pour the water over the area and count how many worms come to the surface. Allow 15 – 20 minutes.

Which group found the most?

Why do the worms come to the surface? *Worms need air, (they don't have lungs but absorb oxygen through their skin). When the ground is wet, they can't take oxygen in so they have to come to the surface.*

What other methods could be used to "charm the worms"? ***S**tamping or anything vibrating on the ground might work.*

10 – 15 worms in a $1m^2$ would be a good indicator of soil health

Scores for the **Soil Record Sheet**

0 = 0 – 5 worms

1 = 6 – 10 worms

2 = 11 – 15 worms

Do pupils know why worms are a good indicator of soil health?

- *Earthworms create tunnels by burrowing. This helps soil structure, which in turn helps aerate the soil and drain water.*
- *Worms fertilize the soil with their poo!! (worm casts). Their castings contain recycled nutrients from the plant remains and soil organic matter that they eat.*

A Lovely Worm Cast!!

So, how healthy is the soil?

Add up the scores on your **Soil Record Sheet**.

Total Scores:

Poor Soil	**0 – 4**
Medium Soil	**5 – 8**
Good Soil	**9 - 12**

Have the students sampled poor soil, medium soil or good soil?

Using this Knowledge to Improve the Soil

What does good soil look like?

- *Drains well and soaks up rain*
- *Correct pH and nutrient levels*
- *Stores air and water*
- *Not compacted*
- *Lots of organic matter and worms!!*

If the students have poor or medium soil can they explain how they would improve their soil? Discuss the options available with the famer. Are there any examples on the farm? Maybe the farmer has before and after pictures?

Stretch and challenge for the more able student.

Print copies of the poster on the link below and laminate so they can be used on the farm or back in the classroom. Using the poster, their soil record sheet and discussions with the farmer, can students come up with suggestions on how to improve the soil they have been testing?

https://www.nfuonline.com/cross-sector/environment/soil/how-farmers-improve-soil-health-all-year-round/

What would you choose to grow at this farm?

Once farmers know the health status of the soil, they must decide what crop is best suited to each field.

Farms are businesses, so it is important farmers maximise yields, (and therefore profits) whilst maintaining the fertility of the soil.

Different crops prefer different soil types and take different nutrients from the soil.

Farmers will use a **crop rotation** system so that the same crop isn't growing in the same field each season and therefore depleting the soil of one set of nutrients. Crop rotation is also useful in reducing pests and weeds.

Using pictures of crops growing at the farm, can students discuss with the farmer what should be grown in each field and why?

Stretch and challenge for the more able students

Using information provided by the farmer about the nutrient needs of each crop, can the students devise a crop rotation plan which will maximise yield but maintain the fertility of the soil?

Alternatively, students can try the **"Crop Rotation"** game on page 12 of the **"Rocks and Soils"** resource which can be found on the Countryside Classroom website:

https://www.countrysideclassroom.org.uk/resources/1214

You will need to print off and laminate the cards contained in the pack for your students to use.

Planning a farm visit

You may have organised farm visits for your students before, but if you feel you need a little bit of help have a look at:

"How to plan curriculum linked and safe visits to farms: A handbook for teachers" available on the Countryside Classroom website at https://www.countrysideclassroom.org.uk/resources/1416 .

This should give you all the information you need. If you would like further support, don't hesitate to contact your LEAF Education Regional Consultant (details in the handbook or on the LEAF Education website www.educationleafuk.org)

Health and Safety

An extensive risk assessment is contained in the handbook mentioned above. However, pay particular attention to;

- Poisonous plants on farm walk
- Pupil / staff allergies
- Cover cuts / skin abrasions
- Soil blowing into eyes
- Tetanus status
- Hands MUST be washed as per guidance in handbook

LEAF Education

LEAF Education is a charity working throughout England and Wales to inspire future generations about food, farming and the countryside. The team of experienced Regional Education Consultants work closely with teachers and farmers to facilitate links and learning opportunities.

LEAF Education is part of LEAF (Linking Environment and Farming). LEAF is the leading global organisation delivering more sustainable food and farming. LEAF works with farmers, the food industry, scientists and consumers to inspire and enable sustainable farming that is prosperous, enriches the environment and engages local communities. LEAF promotes Integrated Farm Management, a whole business approach that delivers sustainable farming. LEAF also organises LEAF Open Farm Sunday, the farming industry's annual open day for the public.

This resource has been adapted from the "Simply Sustainable Soils" brochure produced by LEAF.

Useful Websites

Countryside Classroom	www.countrysideclassroom.org.uk Rocks and Soils resource https://www.countrysideclassroom.org.uk/resources/1214 BBSRC Science on the Farm Poster – Soils https://www.countrysideclassroom.org.uk/resources/1233
Soil Net	www.soil-net.com Lots of information in the teacher and parent section.
Opal	https://www.opalexplorenature.org/soilsurvey
Field Studies Council	https://www.field-studies-council.org/shop/publications/aidgap/earthworms-2nd-edition/
Soil Association	https://www.soilassociation.org/our-campaigns/save-our-soil/
British Society for Soil Science	https://www.soils.org.uk/young-soil-explorers
RHS Campaign for School Gardening	https://schoolgardening.rhs.org.uk/Resources/Find-a-resource?so=0&pi=0&ps=10&f=1,7:&page=1
LandIS, Soil Scape Viewer	http://www.landis.org.uk/services/soilscapes.cfm Interactive online soil map for England and Wales
The Royal Society	https://royalsociety.org/topics-policy/projects/ Soil structure and its benefits. The summary slide pack is particularly useful

Curriculum Links

This resource pack links well to **Key Stages 3 / 4 Geography**

- Rocks, Weathering and Soils
- Rural Environments
- Understand how human and physical processes interact to influence and change landscape, environment and climate
- Geography skills and fieldwork; use fieldwork in contrasting locations to collect, analyse and draw conclusions

Links can also be made to **Key Stages 3 / 4 Science**

- Ecosystems
- Cycles
- Plant transport
- Working scientifically; experimental skills and investigation; analysis and evaluation

The section for more able students in the “Introduction to Soils” may also be used with Key Stage 4 pupils studying **sustainability topics**

Soil Record Sheet

Test	Sample 1 Location.....	Sample 2 Location.....	Sample 3 Location.....
Soil Type / Texture			
Soil Structure			
Drainage			
Compaction			
Organic Matter			
pH and Nutrients			
Worm Score!!!!			
Total Score			
Soil Rating (poor, medium or good)			

Total Scores

Poor Soil 0 – 4
Medium Soil 5 – 8
Good Soil 9 - 12

Soil Texture

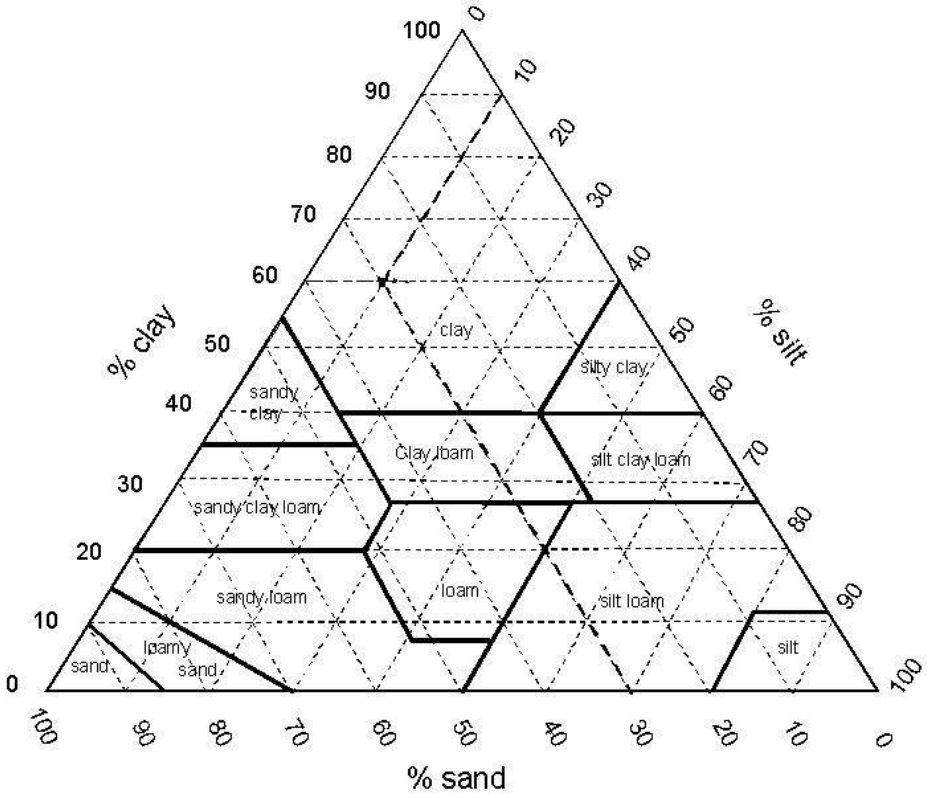
What shape can you make with your soil sample?

				
Cone	**Ball**	**Straight worm**	**Bent cracked worm**	**Bent smooth worm**

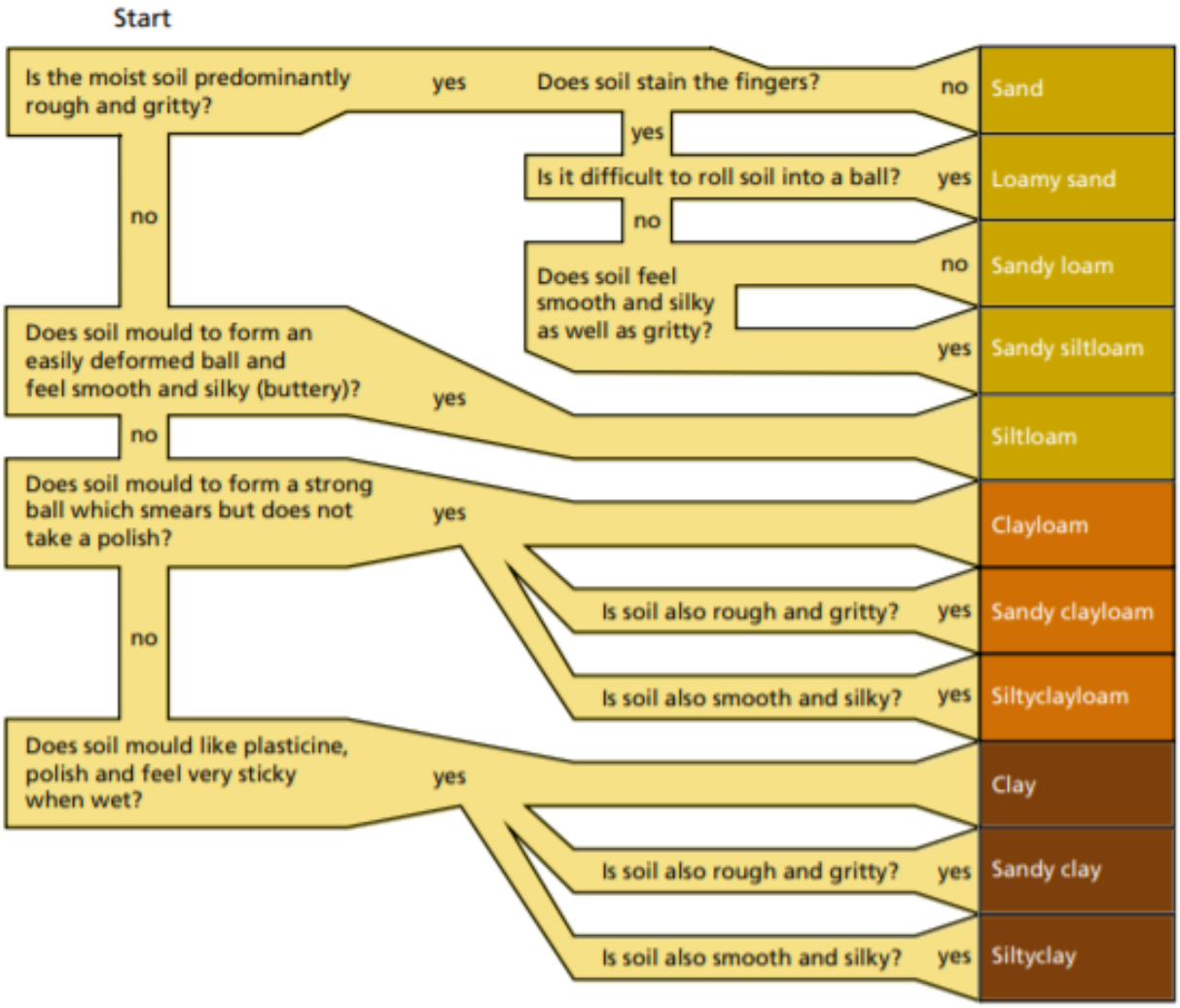
Shapes you can make	Soil Type
Cone only	Sandy
Cone and ball	Loamy sand
Cone, ball and straight worm	Loam
Cone, ball, worm and bent worm with cracks	Clayey loam
Cone, ball, worm and bent smooth worm	Clay

Soil Texture Triangle

Use the soil texture triangle to work out what soil you have if you are using the jar settling method.



Soil ID Flow Chart



Soil Drop Test Images

Poor (0)
Lots of lumps of coarse soil and not much crumbly soil

Medium (1)
Sample is approx 50% lumps of coarse soil and 50% crumbly soil

Good (2)
Lots of crumbly soil. Not many clumps of soil

Soil Drainage Images

Poor (0)
Grey, blue, purple or green soil colour occurs due to water logging for prolonged amounts of time

Medium (1)
Some colour change due to moderate water logging

Good (2)
Dark coloured soil indicating good aeration and organic matter due to well drained soil