Soil and nutrient management

Soil management
FSA19, 21

Compaction and erosion management
FSA20, 22

Nutrient management
FSA23, 24, 25, 28,29

Organic manure and sludge
FSA26, 27

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Compiled by : NIAB

Soil Management

Best practice :

Be aware of good soil management and how to apply it on your farm.

Carry out soil analysis on a regular basis, following good agricultural practice and local and national laws and requirements.

FSA21 To improve the productivity of your soil, do you take measures to conserve and improve soil health?

FSA19 Do you carry out periodic soil sampling to monitor the changes in soil condition, and do you keep the sampling records?

Background

How to answer YES

Further information

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Soil Management

Good soil management is important to ensure a farm's continued profitability and to protect long-term soil sustainability.

The first step is to make a realistic assessment of the land. By exceeding the limitations of agricultural land, soil can be lost or damaged, reducing nutrient and water holding capacity. This may mean inputs are more easily lost to the atmosphere or water, causing unacceptable damage to the environment.

A healthy soil will have high levels of microbial activity, higher levels of organic matter, and a good structure. There are a ways to retain, build or restore soil health, including: no-till or reduced tillage; cover cropping; mulching; nutrient management; keeping the soil covered as much as possible; reducing soil disturbance; ensuring year-round plant cover; and using an appropriate crop rotation combined with cover crops.

A soil management plan can identify the soil characteristics, enabling the development of suitable strategies to manage and improve that soil's health.

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Soil Management

- Develop a soil management plan based upon a map of the farm, including:
  - field layout
  - crops grown
  - areas of differing soil characteristics (e.g. soil type, slope, aspect etc.)
  - where soil testing has been undertaken with links to test results
  - application of organic matter
  - areas prone to erosion
  - compacted areas
  - cultivation type
  - sites of conservation.
- Match the intended use of each field with the capability of the land to minimise environmental risks.
- Use a spade to check the soil structure in each field, or part-field, aiding decisions on appropriate cultivations and the need for soil loosening or sub-soiling. Consider additional actions to improve the organic matter content of the soil. Soil sampling.
- During the year, check land during and after rain, identifying areas of poor drainage and where run-off or erosion may be occurring from fields, or other parts of the farm such as roads and tracks.
- Manage the soil organic matter/organic carbon as it is important for soil water and nutrient management. A decline in organic matter generally makes crops and pasture more vulnerable to drought and reduces fertiliser/nutrient use efficiency.

How to answer YES

Ensure that all staff and contractors are aware of the soil management plan to conserve and improve soil health (FSA21).

Consider both soil and weather conditions and the short-term weather forecast. Be prepared to suspend work, including that of contractors, until conditions improve (FSA21).

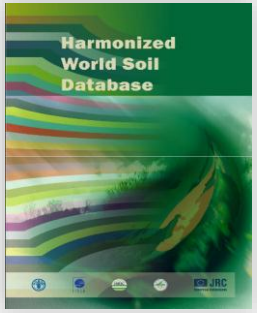
Have management practices in place that maintain or enhance soil organic carbon/ organic matter (FSA21).

Show soil analyses are carried out regularly to assess soil health. The frequency should be determined by good agricultural practice and national, or local, laws or requirements. Always take samples at the same time of year (FSA19).

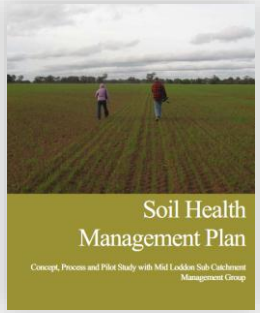
Have a soil management plan which includes:
- identification of the major risks to the soil
- suitability of the land for its intended purpose
- performing periodic soil sampling
- a strategy to maintain and improve soil health (FSA19).

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Soil Management



FAO: Harmonised world soil database



Victoria State Government, Australia: Soil Health Management Plan

Case study: Using soil testing to increase potato yields in Pune, India.

Developing a soil management plan.

Further reading and examples:

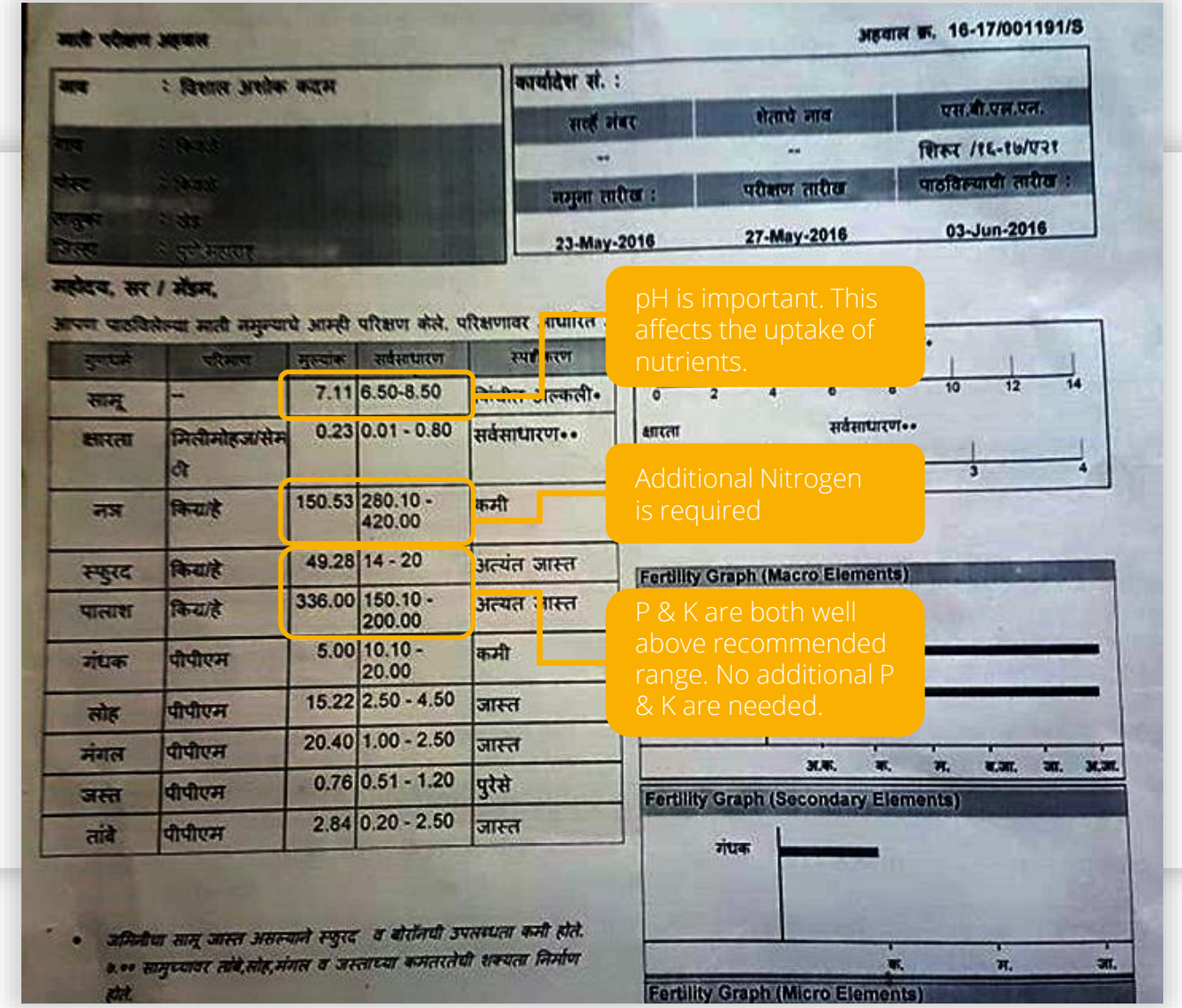
- Soil Association: Seven ways to save our soil
- NFU, UK: Check sheet for soil management
- Campaign for the Farmed Environment, UK: Soil management for your farm business
- Aglearn, Croplife International: Soil fertility
- Manitoba Agriculture, Food and Rural Initiatives, Canada: Soil management guide
- New South Wales Agriculture, Australia: Soil management for dairy and beef cattle grazing

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Using Soil Testing To Increase Potato Yields

Kalis from Kivale, Pune

Soil testing identified incorrect fertiliser use, saving 2,000–3,000 INR (28-42 USD) and increasing potato yields by 2.5 t/ha due to better agronomy practices.



सामू	–	7.11	6.50-8.50	
क्षारता	मिलीमोहज/सेमी	0.23	0.01 - 0.80	सर्वसाधारण••
नत्र	किग्रॅ/हे	150.53	280.10 - 420.00	कमी
स्फुरद	किग्रॅ/हे	49.28	14 - 20	अत्यंत जास्त
पालाश	किग्रॅ/हे	336.00	150.10 - 200.00	अत्यंत जास्त
गंधक	पीपीएम	5.00	10.10 - 20.00	कमी
लोह	पीपीएम	15.22	2.50 - 4.50	जास्त
मंगल	पीपीएम	20.40	1.00 - 2.50	जास्त
जस्त	पीपीएम	0.76	0.51 - 1.20	पुरेसे
तांबे	पीपीएम	2.84	0.20 - 2.50	जास्त

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Soil Management Plan

The observations made as part of the soil management plan can be recorded in a table an example is presented below:

Field id	Characteristics including: Run off, macro & micronutrient levels, organic matter,			Issue- based on testing, observations	Corrective action based on goals & soil testing	Observations during the season (e.g. run off, erosion, poor growth, compaction)
	Physical	Chemical	Biological			
Faraway field	Good soil structure, low risk for erosion and run off. Penetrometer readings good	pH 6, N okay P, a little low K okay	Lower levels of organic matter observed	1)Lower P than required 2)Reducing organic matter observed	1)Apply P 2)Consider cover crop as green manure 3) Keep field preparation methods	
F26	Near road, silty soil, run off risk, Penetrometer-inconsistencies	Low micronutrients Higher salinity yr/yr		1)Risk run off 2) Concerns regarding compaction	1) Loosen tramlines 2) Short term green manure, to increase organic matter 3) Mark on risk map of farm for run off/ erosion	Observed erosion during irrigation last year

Soil Sampling

A soil test is only meaningful if it is a representative soil sample of the field. Sampling should be carried out at the rate of one sample for, ideally, every two hectares, or up to a maximum area of five hectares.

How and when to sample

1. If one crop is cultivated in a year, then soil testing once every three years is sufficient. Under more intensive cropping, e.g. up to three crops per year, then sampling should carried out every year prior to sowing of the first crop of the given sequence.
2. Collect the soil sample during the fallow period or, if in the standing crop, collect samples between rows. Avoid sampling soon after fertiliser or manure applications.
3. Take samples at several locations in a zig-zag pattern to ensure homogeneity.
4. Collect separate samples from fields that differ in colour, slope, drainage, past management practices like liming, gypsum application, fertilisation, cropping system etc.
5. Avoid sampling in dead furrows, wet spots, areas near main bund, trees, manure heaps and irrigation channels.
6. For shallow rooted crops, collect samples up to 15cm depth. For deep rooted crops, collect samples up to 30cm depth. For tree crops, collect profile samples.

Sampling Procedure

Soil Sampling

Sampling procedure

Divide the field into different homogenous units based on visual observation and farmer's experience.

1. Remove the surface litter at the sampling spot.
2. Use a spade to dig a small hole about 20 cm deep
3. From the side of the hole take a vertical, rectangular slice of soil 15cm deep and about 5cm thick. This will ensure the sample is the same width at the top and bottom of the slice and the same amount of soil is collected from all depths; important as soil properties can vary with depth.
4. Remove any plant material from the top of the sample and put the sample into the collection tray or bucket.
5. Repeat steps 1 to 3, collecting at least 10 to 15 samples from representative locations each sampling area and place in a bucket or tray.
6. Mix the samples thoroughly and remove foreign materials such as roots, stones, pebbles and gravel.
7. Reduce the bulk to about ½ to 1 kilogram by quartering or compartmentalisation.
    a) Quartering is done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters are discarded and the remaining two quarters are remixed and the process repeated until the desired sample size is obtained.
    b) Compartmentalisation is done by uniformly spreading the soil over a clean hard surface and dividing into smaller compartments by drawing lines along and across the length and breadth. From each compartment a pinch of soil is collected. This process is repeated till the desired quantity of sample is obtained.
8. Collect the sample in a clean cloth or polythene bag.
9. Label the bag with information useful in identification and assessment, e.g. farmer name, farm location, survey number, previous, current and future crop grown, date of collection, sampler name etc.

Compaction And Erosion Management

Best practice :

Be aware of the risks of soil erosion and be able to identify areas where erosion may be a problem.

Be aware of actions that can be used to prevent soil erosion.

Know how soil compaction can occur and undertake measures to avoid it.

FSA20 Do you take measures to avoid soil erosion?

FSA22 Do you avoid soil compaction from farm machines or livestock?

Compaction And Erosion Management

Soil compaction

Compacted soils have less space between soil particles. They hold less air and water and have less space for the plant roots to develop, causing the crop to have shallow roots and be more susceptible to drought.

Although animals and people can cause significant soil compaction, the most serious problems are caused by farm machinery.

Soil erosion

Each year, an estimated 10 million hectares are lost due to soil erosion[1]. Soil erosion can be avoided by using land within its capability and considering field position, soil type and slope.

Soil erosion can have direct short-term costs as seeds, young plants and applied fertilisers may be washed away with the soil; or young plants may be damaged or inundated by wind-borne soil. As the topsoil is eroded, the ability of the soil to hold nutrients and water is lost and so becomes unproductive.

Surface cover is a major factor in erosion control. It reduces the impact of raindrops falling on bare soil and wind removing soil particles. It also reduces the speed of water flowing over the land.

1. Soil erosion threatens food production Agriculture 2013, 3, 443-463

Compaction And Erosion Management

- Develop a soil management and conservation plan. It should identify the major risks to soil and the suitability of the land for its intended use, based on soil and topography, slope length and gradient, organic carbon levels, risk of erosion, compaction and salinisation/ desertification. Specifically note areas that already show signs of erosion.
- If wind erosion is going to be a problem, consider the wind direction at the most vulnerable period and the crop density/ ground cover.
- Consider using methods for limiting the effects of erosion, such as:
  - wind-breaks
  - intercropping
  - cover cropping
  - leaving field stubble and mulching
  - terracing
  - under-drainage systems.
- Understand which areas of the farm are susceptible to compaction and manage them appropriately.
- If soils are at risk of crusting, slaking, or hardpan development, the risks should also be assessed, mapped and managed.
- If travelling on wet soils, reduce the loading with low ground pressure set-ups, or set tyre pressures at the lowest compatible with the load and tyre type.

How to answer YES

Be aware of areas at risk of soil erosion, and be able to identify these on land maps (FSA20).

Be able to describe efforts being taken on farm to control erosion (FSA20).

Be able to describe measures that can be used to control soil compaction and how you apply those methods on your farm (FSA22).

Compaction And Erosion Management

NRCS – USDA, USA: The science of soil health: compaction

Government of Western Australia: Subsoil compaction - causes, diagnosis and management

World Bank: No-till agriculture prevents soil erosion

Soil erosion demonstration

Exercise: Soil erosion risk mapping

Case study: Cover cropping helping to increase yields in Kivale, India

Further reading and examples:

- Queensland Government, Australia: Soil conservation planning in cropping lands
- Alberta Agriculture and Forestry, Canada: An introduction to wind erosion control
- Government of Western Australia: Water erosion in the agricultural region of Western Australia
- University of Wisconsin, USA: Soil compaction: Causes, concerns, and cures

Soil Erosion Risk Mapping

The risk of runoff and erosion depends on the physical features of the farm, the soil type and your approach to soil management.
Draw a map of your farmland and assess the risk of soil erosion in each field. To do this you will need to know the soil type in the field and make a decision on how steep the slope is. For assessment purposes large fields might be sub-divided if slope, soils or topography differ significantly, but for whole field assessment the worst scenario should generally be mapped. Field entrances should be marked on the map where they may influence erosion by channelling water movements into or out of a field. Using the information in the field below, colour in each field to show the level of risk and also mark on the map the direction of any observed erosion/ water flow.

Soil	Steep slope (steeper than 15% or 8o)*	Moderate slope (9 - 15% or 5 - 8o)	Gentle slope (2 - 9% or 1 - 5o)	Level ground (0 - 2% or 0 - 1o)
Sandy and light silty soil	Very high	High	Medium	Low
Medium and calcareous soils	High	Medium	Low	Low
Heavy soils	Low	Low	Low	Low

Standard slope descriptors

Are there areas on your farm that are at high risk of erosion, if so, what are you going to do to reduce the risk? The 2 main principles to control erosion are to:

- Use land according to its capability: The land's position, soil type and slope determine how vulnerable it will be to erosion. It may not be suitable for agriculture, or suitable only for an activity which limits erosion.
- Protect the soil surface with some form of cover: Surface cover is a major factor to control erosion because it reduces the impact of raindrops falling on bare soils and wind removing soil particles. It also reduces the speed of water flowing over the land.

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Case study: Cover cropping helps to increase yields

Balashheb, and his neighbours from Kivale, agree that cover cropping with jute before planting potatoes can increase potato yields by 10-15 % during Kharif season.
The cost of jute seed is 9,880 INR/ha; however, as it is ploughed back into the soil before planting potatoes, it acts as a fertiliser. No other inputs are required.
It also maintains good soil structure and reduces water logging which can happen during monsoon.

Please note: Whilst cover crops can have significant benefits it is important to take some time to consider what is the best crop for your situation. The selection of the wrong crop could introduce new problems. If unsure seek some guidance.

Costs vs Benefit

Costs : 9,880 INR/ha
Benefit : 10-15% increase in yield of 12.35 t/ha (1.2-1.9 t/ha extra) 12–30 INR received per kg.
Extra profit/ha = 14,820 INR – 55,575 INR

Nutrient management

Best practice :

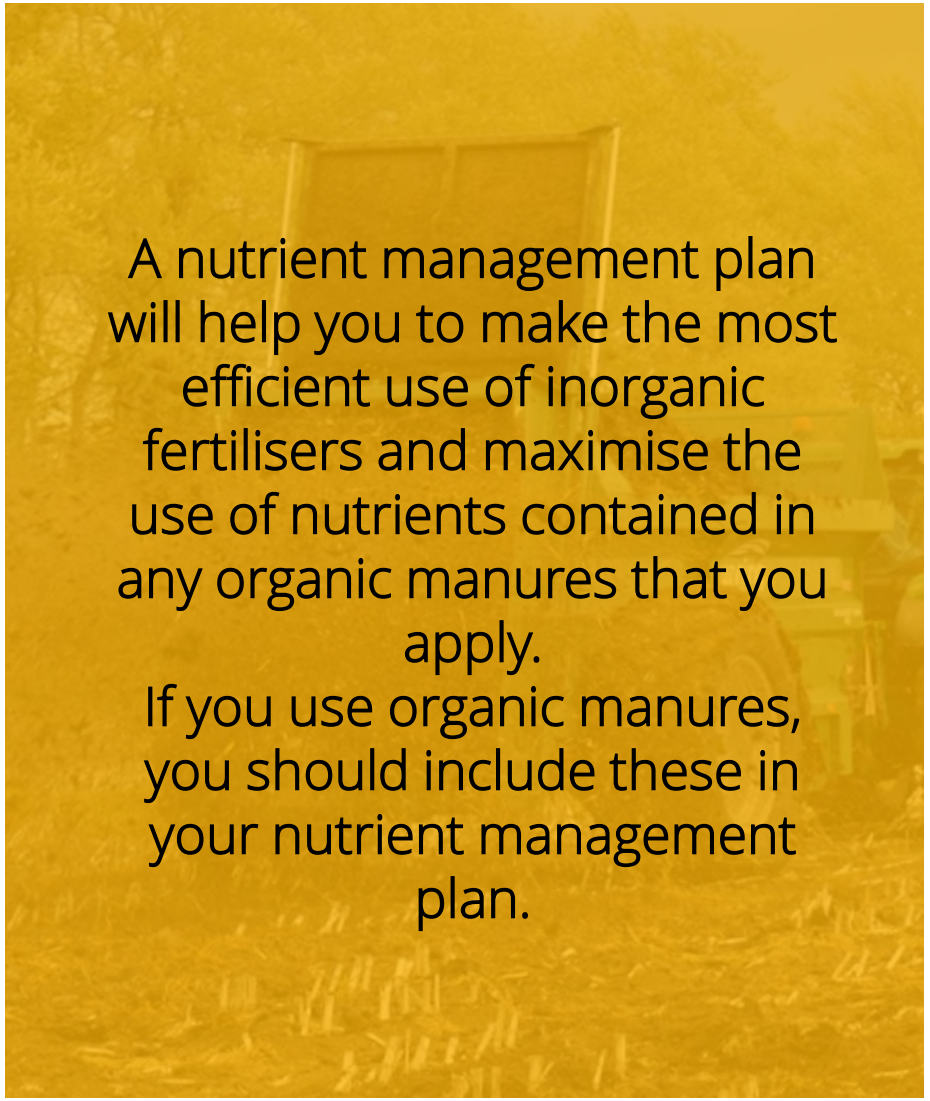
- Have a nutrient management plan and records of fertiliser application.
- Know the type, quantity and application method used to apply fertilisers on the farm.
- Able to show consideration of increasing nutrient efficiency whilst reducing negative environmental and social impacts.
- Be aware of the source of the fertilisers used on farm.
- Store fertilisers so risks to the environment and human health are minimised

FSA23	Do you choose fertiliser type, quantity and application method according to crop needs whilst reducing environmental impacts?
FSA25	Have you obtained your organic and inorganic fertilizers from a trustworthy source to ensure it is of a high quality?
FSA28	Do you keep records of organic and inorganic fertilizer applications in accordance with local legislation?
FSA29	Do you store fertilizer in a safe and secure way for humans and environment?
FSA24	Do you have a nutrient management plan?

Nutrient management

Managing nutrients properly offers both economic and environmental benefits. Efficient use of nutrients from inorganic fertilisers, manure or other sources reduces input costs for crop production and minimises the risk of nutrient loss to ground and surface water. High inorganic fertiliser prices and concerns for environmental stewardship, means that sound nutrient management is increasingly important for the sustainability of crop production.

Applying excessive amounts of organic and inorganic fertiliser can exceed the crops requirements (for some crops reducing the quality of the product) and result in the build up of nutrients in the soil. Some of the nutrients can be carried downward through the soil by excess water and enter the watercourse causing water pollution, eutrophication and the contamination of drinking water sources. The excess nutrients can also have a negative impact on biodiversity that thrives in nutrient-poor environments and be released from the soil as greenhouse gases.



Nutrient management

- Optimise application rates by making use of historical application records, combined with estimates of nutrient losses to the environment and take-off in harvested crops.
- Know what you are applying to your fields, be sure to know:
  - The source (Product name and vendor etc. Is there an application manual?),
  - Chemical composition and concentration, are they going to meet the crop requirements?
- Develop a crop nutrient management plan to optimise all nutrient applications. Components for consideration are:
  - Map or aerial photograph of field(s);
  - A current/planned crop production sequence/rotation;
  - Results of analyses of soil, plant, water, manure or organic by-product samples;
  - Realistic yield potentials for crops to calculate nutrient input/output balance;
  - A listing of all nutrient sources;
  - Recommended nutrient rates, timing, form, and method of application.
- Store fertilisers appropriately and a safe distance from:
  - Sensitive areas (water bodies, drains etc.)
  - Houses and the property boundary
  - Ignition sources
  - The risk of flooding
  - Other hazardous chemicals, such as crop protection products.

How to answer YES

Be able to demonstrate how you determine the type, quantity and application method for all fertilisers and manures applied (FSA23, 25).

Have good awareness of the type of fertiliser used and the impacts of applying too much fertiliser (FSA23).

Keep records of all fertiliser and manure applications made. Recording the type of fertiliser and quantity used to demonstrate compliance with local legislation, where applicable (FSA28).

Keep records of where fertilisers used on the farm are sourced (e.g. product name and vendor) (FSA25).

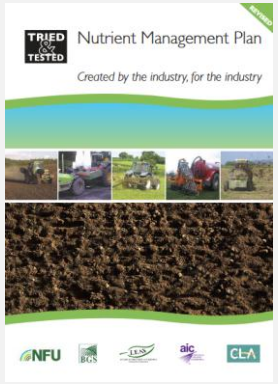
Show that you store all fertilisers and manures safely following any legislative requirements and guidelines (FSA29).

Have a nutrient management plan (FSA24).

Show management plans are reviewed regularly and updated when circumstances change (FSA24, 29).

Nutrient management

- AHDB, UK: Nutrient Management Guide (RB209)
- Section 2 Organic materials
- Section 3 Grass and forage crops
- Section 4 Arable crops
- Section 5 Potatoes
- Section 6 Vegetables and bulbs
- Section 7 Fruit, vines and hops



NFU, UK: Nutrient management plan

Developed for UK but has a template for a nutrient management plan that may be adapted to your needs

Macronutrients

Further reading and examples:

- International Plant Nutrition Institute, USA: Nutrient removal calculator
- USDA, USA: Nutrient and pest management, Nutrient management plan
- Fertilizers Europe: Guidance For Safe and Secure Storage of Fertilizers on Farms
- NFU: A guide to manure management
- FAO: Fertilizers as water pollutants
- OCI Agro: Good storage and handling practices for nitrogen fertilizers

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Macronutrients

Macronutrients		Absorbed Form	Function	Deficiency Indicators
Nitrogen	N	NO_3^-, NH_4^+	Protein and enzyme component	General yellowing of leaves, stunted growth, often older leaves affected first.
Phosphorus	P	HPO_4^-, HPO_4^{2-}	Membranes, energy, DNA	Difficult to visualize until severe. Dwarfed or stunted plants. Older leaves turn dark green or reddish-purple.
Potassium	K	K^+	Osmotic balance	Older leaves may wilt or look burned. Yellowing between veins begins at the base of leaf and goes inward from the leaf edges.
Calcium	Ca	Ca^{2+}	Cell structure	Fruit/flower and new leaves are distorted or irregular. When severe, leaves will be necrotic near the base. Leaves can be cupped downward. Occurs more often at low pH.
Magnesium	Mg	Mg^{2+}	Chlorophyll, enzyme activation	Older leaves will turn yellow and brown around the edge of the leaf leaving a green centre. May appear puckered. Occurs more often at low pH.
Sulphur	S	SO_4^{2-}	Protein and enzyme component	Yellowing leaves starts with younger leaves.

Organic Manure And Sludge

Best practice :

- No untreated sludge is applied to the land
- All treated sludge, slurry and manure is tested to avoid:
  - Pollution of ground and surface water
  - Health risks to workers, the community and customers
  - Contamination of the crop, water and soil with heavy metals
- Treated sludge, slurry and manure is not applied to a crop after flowering.

FSA26 Do you prevent using untreated sewage sludge on your field?

FSA27 Do you ensure that the composition and application of organic manure and treated sludges, treated sludge water and /or industrial waste residues are not harmful?

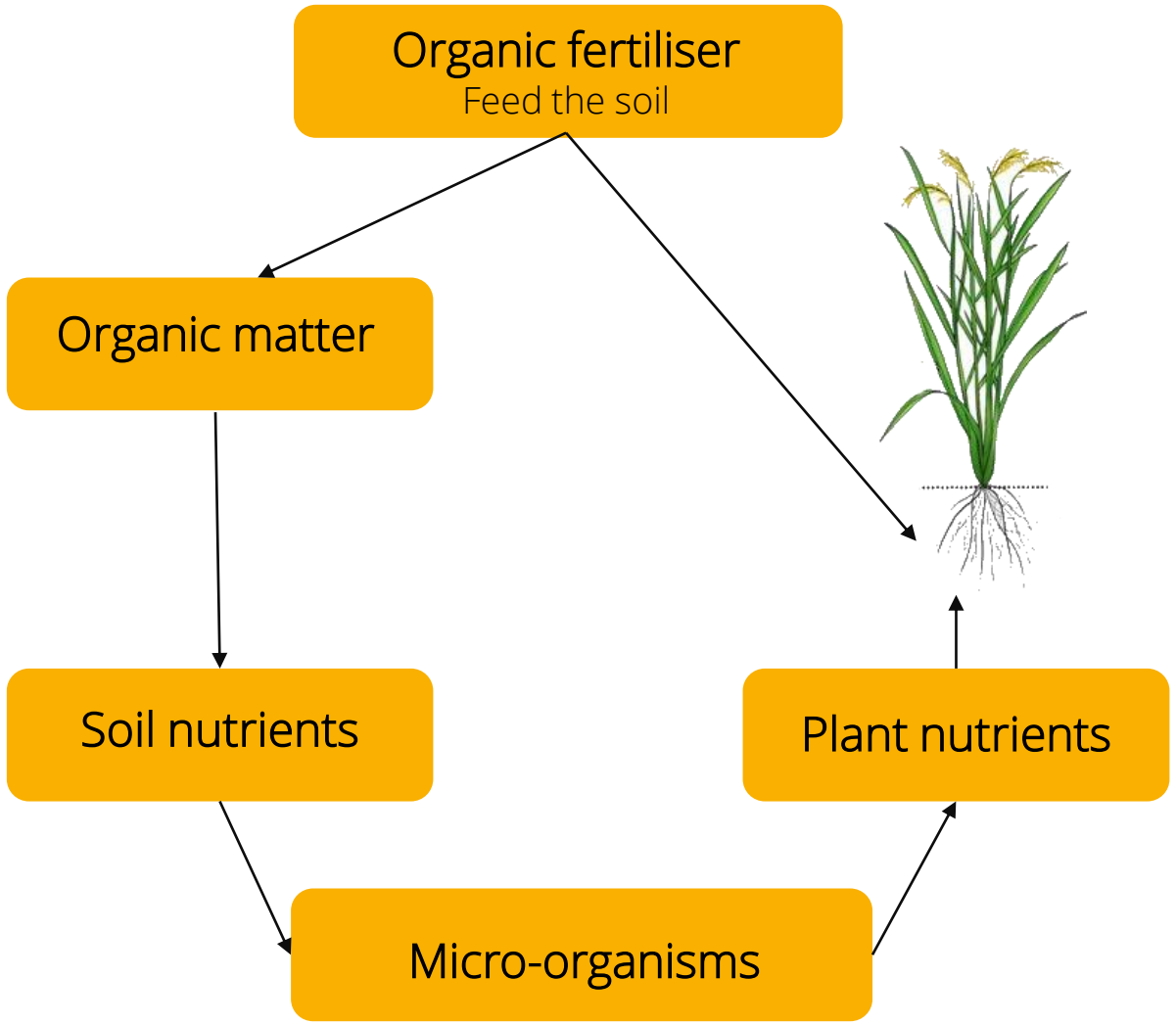
Organic Manure And Sludge

Organic manure and certain treated materials are valuable sources of nutrients and also help build organic matter which can improve the physical structure and stability of soils. The correct application of such materials, as part of a nutrient management plan, will help reduce inorganic fertiliser costs and reduce the risk of water pollution.

However, improper management can have a negative impact on environmental quality and human health. Risks that need to be managed include:

- Potential for human pathogens to be introduced to the production system (worker and food safety), especially if human waste is involved
- Potential for heavy metal introduction, especially with sewage sludge (sometimes known as bio-solids)
- Problems handling the volume of manure required for effective nutrition if not complemented by other inputs
- Introduction of new weed seeds with the manure
- Uncertainty about the nutrient content of the applied manure
- Pollution arising from over-application of organic manures or other waste materials, applied as a form of waste-disposal.

These risks must be properly managed. This generally means all manures need to be composted well and sewage sludge must be carefully processed before use. Ready-to-eat crops - such as salads, fruits and vegetables, which are unlikely to be cooked before consumption, are particularly vulnerable to microbiological contamination and organic manures or sewage sludge should not be used unless they have had enhanced or advanced treatment that is capable of virtually eliminating all pathogens.



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Organic Manure And Sludge

Sludge originates from the process of treatment of waste water (sewage). It tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses, bacteria etc.). It is however, rich in nutrients such as nitrogen and phosphorous.
The aim is to make sure that when organic fertilisers are used in agriculture there is no risk to human, animal or plant health and no harmful effects on soil.

- Every effort should be made to assess the available nutrient content of organic fertilisers used on the farm. This can be done using one of the following:
    - For slurry, using an on-farm assessment tool, such as a slurry hydrometer or N-content assessment kit
    - By having samples analysed in a laboratory
    - If volumes are low or laboratory assessments impractical, by looking up average values in tables
- The inclusion of organic fertilisers into your farm management plan needs to be taken into account when scheduling your inorganic fertiliser requirements
- Care must be taken when using organic fertilisers to ensure they are not likely to have a negative impact on the product because of contaminants such as heavy metals or pathogenic bacteria. As untreated sludge has not undergone any appropriate processing to reduce the risk of pathogenic bacteria it must not be used on the land.

How to answer YES

Have up to date records which can confirm that no untreated sewage sludge is applied to the field (FSA26).

You have evidence of testing treated sludge, treated sludge water and industrial waste if applicable (FSA27).

Correct personal protective equipment is available for all working with organic fertilisers (FSA27).

Ensure you are aware of the correct procedures for handling and applying organic fertilisers to the field (FSA27).

FSA FARM SUSTAINABILITY ASSESSMENT BY SAI PLATFORM

Organic Manure And Sludge

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

FAO: Agricultural use of sewage sludge

Further reading and examples:

- Cornell University, USA: Manure value calculator (Excel workbook)
- Government of Manitoba, Canada: Calculating Manure Application Rates
- European Commission: Sewage Sludge
- NFU, UK: Check Sheet for Organic Manure management
- Water UK: Safe sludge matrix