

# Pack 105, Item 9

# Type: Backgrounder

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**Backgrounder on soil fertility**

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***Introduction***

**Soil fertility** has been defined as “*the capacity of soil to supply sufficient quantities and proportions of essential nutrients and water required for optimal growth of specified plants as governed by the soil’s chemical, physical, and biological attributes.”*

Agriculture is the main source of both food and income for the majority of the population of sub-Saharan Africa (SSA). Poor soil fertility is a major constraint to increasing the production of food, feed, and fibre. There is limited use of agricultural inputs in SSA. With reductions in the size of farms because of increasing population pressure, and with the disappearance of fallow lands, applying agronomic practices which maintain soil fertility is key.

***Key facts***

* Over 70% of the population in SSA relies on agriculture for their livelihood, mainly through growing crops.
* Over 50% of the agricultural lands in SSA are degraded, mainly due to depletion of soil nutrients.
* There are methods for maintaining good soil fertility, but most are not widely used because of barriers to uptake, including financial constraints, policies which make uptake difficult, lack of knowledge, and lack of access to knowledgeable extension services.

***Big challenges of maintaining proper soil fertility***

* Poor access to appropriate fertilizers and organic amendments (e.g., manure)
* Soil acidification or salinization (because of, for example, irrigation with salty water)
* Lack of capacity to properly diagnose the status of soil fertility, which could pinpoint the main constraints to crop production
* Soil erosion
* Poor water management

***Misinformation about soil fertility***

* Mistaken perception of mineral fertilizers: For example, diammonium phosphate (DAP) is a common fertilizer, but when continuously applied on the same plot over seasons, it can cause soil acidification. But when properly used—for instance, in rotation with non-acidifying fertilizers—it will not negatively affect soil fertility. Farmers who have had a negative experience with DAP might generalize and say that fertilizers are bad for soil fertility, regardless of the type of fertilizer and the techniques of use.
* Misleading claims on fertilizer labels: For example, the actual nutrient content may be much lower than the amount shown on the fertilizer label or package.

***Gender aspects of maintaining proper soil fertility***

*Financial inability to purchase agricultural inputs* (e.g., fertilizers and liming materials). In small-scale farming families, resources are generally controlled by men, including the family budget. Even when a woman thinks it is important to spend on agricultural inputs, she may not be allowed to by her spouse, especially when there is competing priorities.

* *Responsibility for managing specific crops and fields*: Men tend to control the relatively more fertile plots close to the homestead, while women mainly work on less fertile plots relatively farther away. In combination with women’s poorer access to financial resources, the less fertile plots become more and more degraded.
* *Time spent managing soil fertility on the family farm:* Women (including girls) spend more time on faming activities than men (including boys), and use minimal resources to manage soil fertility. Thus, they have fewer opportunities to look for off-farm jobs to increase their income, which limits their ability to purchase agricultural inputs.

***Predicted impact of climate change on soil fertility***

* Extreme weather events which cause drought, flooding, and abrupt temperature fluctuations could alter soil properties, as well as the availability of water and air in the soil.
* Predicted shifts in the dynamics of soil processes—for example, the processes which make minerals and other plant nutrients available from organic matter.
* Predicted shift in the types of crops grown, and in their requirements for soil nutrients.

***Key information about maintaining proper soil fertility***

1. **Soil erosion**

Water and wind erosion result in the loss of the surface layers of the soil, which contain nutrients and organic matter. Erosion can be reduced by:

* minimizing deforestation or cropping on marginal lands;
* covering the soil, including by mulching;
* using physical barriers such as terraces and vegetated buffer strips to control erosion on sloping land; and
* using vegetative barriers such as trees and shrubs to reduce wind velocity.

For further information, see *Resource List* below: 1, 2, 4, & 5.

1. **Soil organic matter**

Soil organic matter is critical for maintaining the important functions of the soil, including its capacity to hold water, its capacity to reduce soil compaction, the diversity of microbial life in the soil, and for preventing the loss of important plant nutrients.

Soil organic matter can be improved by:

* leaving crop residues in the field after harvest, and
* applying external organic inputs like manure and compost.

Organic inputs can significantly improve the amount of soil organic matter in the soil. But to ensure that the essential nutrients in organic inputs are available to plants and to minimize nitrogen immobilization, it’s important to add organic inputs that have less than 25 units of organic carbon for each equivalent unit of nitrogen. For instance, if an organic input contains 1% nitrogen, the organic carbon content should be less than 25%. In general, mature compost can meet this condition. Hence, it is important to compost organic residues and use the compost to maintain soil fertility.

For further information, see *Resources* 1, 2, 3, 4 & 5.

1. **Soil nutrient balance**

The essential soil nutrients include nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, iron, zinc, copper, manganese, boron, chloride, molybdenum, and nickel. Other elements are beneficial for specific crops or plants, including cobalt for legume crops, sodium for sugar beets, and silicon for cereals and grasses. Essential nutrients need to be available in a sufficient amount either naturally (which is rare) or through applying fertilizer (chemical or organic). They must also be available in the right balance to ensure good crop yields while minimizing losses, particularly losses of nutrients like nitrogen and phosphorus.

For further information, see *Resources* 2*,* 3, 4 & 5.

1. **Soil acidification**

Poor agronomic practices—such as continuous application of fertilizers that contain ammonium on the same field or mono-cropping of specific crops without recycling of crop residues—can make the soil too acidic. Atmospheric deposition of nitrogen and phosphorus can also contribute to soil acidification. Also, some soils are naturally acidic (for example, acid sulphate soils), and poor drainage can worsen acidification. Soil acidification reduces fertility and the production capacity of most agricultural soils by increasing the availability of toxic aluminum.

To minimize acidification, farmers should:

* use the right type of fertilizer and balanced fertilization (seek the guidance of a qualified crop advisor), and
* apply lime.

Spot application of high quality manure can also temporarily alleviate soil acidity.

For further information, see *Resources* 2 & 4.

1. **Soil salinization**

Some soils are naturally saline (for example, in coastal areas). Agriculture can cause salinization when irrigation water is not managed properly, especially when the water contains significant amounts of sodium, calcium, and magnesium. Soil salinization decreases plant growth because less water is available to plants. Efficient drainage is required to prevent accumulation of salt.

To minimize evaporation, irrigation water should be applied to the soil and not to leaves. Gypsum is also recommended to control salinity, particularly for sodic soils.

For further information, see *Resource* 2.

1. **Soil biodiversity**

When environmental conditions are favourable, the biological processes in the soil are mainly controlled by soil organisms. These processes include transforming the minerals in soil organic matter into forms that plants can use, transforming soil organic matter into humus, improving plant access to phosphorus, and improving soil structure. The diversity of soil organisms can be disturbed by poor agronomic practices, including practices that lead to acidification and salinization, indiscriminate use of pesticides, and depletion of soil organic matter.

The most practical way to maintain soil biodiversity is to diversify crop production, for example, through intercropping and rotations, and to ensure that sufficient amounts of organic inputs are applied to the soil.

For further information, see *Resources* 2, 3, & 5.

1. **Soil compaction**

Compacted soil slows down water drainage, reduces water infiltration, causes severe run-off, and decreases soil aeration. This degrades soil structure and affects the development of root systems, especially for annual crops. Soil compaction can be reduced by:

* proper use of organic amendments,
* preventing overgrazing on rangeland,
* reducing farm vehicle traffic, and
* growing agroforestry plants with deep tap roots.

For further information, see *Resources* 1, 2 & 4.

1. **Soil water management**

Good soil allows water to infiltrate rapidly, has sufficient capacity to hold water, and drains efficiently when saturated. Too little or too much water in the soil results in poor crop performance, due either to poor root development and growth (in the case of waterlogging) or poor access to water and nutrients (drought). If there is too little water, covering the soil with mulch can minimize evaporation. When there is too much water, drainage practices such as creating open trenches is crucial to facilitate water run-off.

For further information, see *Resources* 1, 2, 4 & 5.

***Selected resources on maintaining proper soil fertility***

1. Thomas Fairhurst, editor, 2012. *Handbook for integrated soil fertility management*. CAB International. <http://www.tropcropconsult.com/downloads_files/Fairhurst2012.pdf> (25,047 KB)
2. FAO and ITPS, 2015. *Status of the World’s Soil Resources (SWSR) – Main Report*. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy. <http://www.fao.org/3/a-i5199e.pdf> (26,864 KB)
3. Sutton M.A., Bleeker A., Howard C.M., Bekunda M., Grizzetti B., de Vries W., van Grinsven H.J.M., Abrol Y.P., Adhya T.K., Billen G., Davidson E.A, Datta A., Diaz R., Erisman J.W., Liu X.J., Oenema O., Palm C., Raghuram N., Reis S., Scholz R.W., Sims T., Westhoek H. & Zhang F.S., with contributions from Ayyappan S., Bouwman A.F., Bustamante M., Fowler D., Galloway J.N., Gavito M.E., Garnier J., Greenwood S., Hellums D.T., Holland M., Hoysall C., Jaramillo V.J., Klimont Z., Ometto J.P., Pathak H., Plocq Fichelet V., Powlson D., Ramakrishna K., Roy A., Sanders K., Sharma C., Singh B., Singh U., Yan X.Y., & Zhang Y., 2013. *Our Nutrient World: The challenge to produce more food and energy with less pollution*. Global Overview of Nutrient Management. Centre for Ecology and Hydrology, Edinburgh, on behalf of the Global Partnership on Nutrient Management and the International Nitrogen Initiative. <http://www.unep.org/gpa/documents/publications/ONW.pdf> (9,777 KB)
4. B. Vanlauwe, K. Descheemaeker, K. E. Giller, J. Huising, R. Merck, G. Nziguheba, J. Wendt, and S. Zingore, 2015. *Integrated soil fertility management in sub-Saharan Africa: unravelling local adaptation. SOIL*, Volume 1, pp 491-508. <http://www.soil-journal.net/1/491/2015/soil-1-491-2015.pdf> (1,403 KB)
5. B. Vanlauwe, D. Coyne, J. Gockowski, S. Hauser, J. Huising, C. Masso, G. Nziguheba, M. Schut, and P. Van Asten, 2014. Sustainable intensification and the African smallholder farmer. *Current Opinion in Environmental Sustainability* 2014, Volume 8, pages 15–22. <http://humidtropics.cgiar.org/wp-content/uploads/downloads/2014/12/Sustainable-intensification-and-the-African-smallholder.pdf> (938 KB)
6. Laura van Schöll and Rienke Nieuwenhuis, 2007. *Soil fertility management*. Agrodok 2; Agromisa Foundation, Wageningen, 2007. (2,155 KB) <http://publications.cta.int/media/publications/downloads/185_PDF.pdf>
7. FiBL, 2012. *African Organic Agriculture Training Manual: A Resource Manual for Trainers*, Chapter 2: Soil Fertility. <http://www.organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Manual_M02.pdf> (4,160 KB)
8. FiBL and Tanzania Organic Agriculture Movement, 2012. Mwongozo wa Mafunzo ya Kilimo-Hai: Afrika Mwongozo kwa Wakufunzi. <http://www.organic-africa.net/fileadmin/documents-africamanual/training-manual/Swahili/M02_Soil-Fertility_Swahili-lr.pdf> (1,611 KB) (Swahili version of Resource #7.)

***Key definitions***

1. **Acid sulphate soil:** soils containing iron sulfides, most commonly pyrite. Whenexposed to air, the iron sulfides react with oxygen and water to produce sulfuric acid and other iron compounds. The process could be accelerated by soil bacteria. (for a fuller explanation, see Government of Western Australia, Department of Environment and Conservation, undated. *What are acid sulfate soils?*) <https://www2.landgate.wa.gov.au/c/document_library/get_file?uuid=5dc8c72e-68da-48b6-8fd4-4583af6b14de&groupId=10136>)
2. **Humus:** the organic component of the soil formed by the decomposition of plant or animal material mainly by soil microorganisms; it does not include plant or animal material that are not decomposed or their partial decomposition products, and soil microbial biomass. In principle, it is the dark-brown organic matter. [Josée Fortin (2003) ‘Biochemistry of humus’, Teaching material, University Laval, Québec, Canada.]
3. **Loss of soil organic carbon**: the decline of organic carbon in the soil affecting fertility and the soil’s capacity to regulate climate change. (Resources 2)
4. **Nutrient imbalance**: an excess or a lack of nutrients (mainly nitrogen, phosphorus, and potassium) in the soil as a consequence of bad land use and management. Nutrient imbalances may result in soil contamination when there are excess nutrients, and in loss of fertility when nutrients are depleted or “mined.” (Resources 2)
5. **Sodic soil:** soil containing exchangeable sodium percentage greater than 15% of the soil cation exchangeable capacity (CEC) ([http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex13200](http://www1.agric.gov.ab.ca/%24department/deptdocs.nsf/all/agdex13200))
6. **Soil acidification**: the lowering of the soil pH because of the buildup of hydrogen and aluminum in the soil and the leaching of minerals such as calcium, magnesium, potassium, and sodium. (Resources 2)
7. **Soil biodiversity loss**: a decline in the diversity of micro- and macro-organisms in the soil. This reduces the ability of the soil to provide critical ecosystem services like organic carbon retention and nutrient cycling among others. (Resources 2)
8. **Soil cation exchangeable capacity**: number of cations that the soil clay and organic matter particles can hold. The most common soil cations include: calcium, magnesium, potassium, sodium, ammonium, and hydrogen (https://www.extension.purdue.edu/extmedia/ay/ay-238.html)
9. **Soil compaction**: the increase in density and a decline of macro-porosity in the soil. Soil compaction impairs the functions of both topsoil and subsoil, and impedes root penetration and water and gaseous exchanges due to reduced air and water pockets. (Resources 2)
10. **Soil erosion**: the removal of topsoil from the surface of the land by running water, wind, ice, or gravity. Soil erosion can be accelerated by human activities such as tillage, by and animals (Resources 2)
11. **Soil salinization**: an increase in water-soluble salts in the soil which reduces the ability of plants to take water from the soil and could lead to toxicity to plants. (Resources 2)
12. **Soil structure:** the arrangement of soil particles in a variety of recognized shapes and sizes (Resources 2)
13. **Waterlogging**: an excess of water on top of and/or within the soil. Waterlogging leads to reduced availability of air in the soil for long periods. (Resources 2)

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