HELVETAS Swiss Intercooperation | AFGHANISTAN

Nutrient Management

Proper nutrient management is an important component of sustainable farming. Poor soil fertility and low soil nutrient contents are often a major constraint on increased yields in small-scale agriculture. Soils in Afghanistan have shown low levels of nitrogen and micronutrients deficiencies for iron, zinc, copper, and boron (USDA&UC Davis, 2013). Proper nutrient management is therefore crucial to improve nutrient inputs, reduce nutrient losses and recycle nutrients on-farm.

Box 1: Liebig's law of the minimum

Yield is controlled not by the total amount of nutrients available but by the scarcest nutrient, known as the limiting factor.

Source: Wikipedia

Macro- and micronutrients

The three most important nutrients for plant growth are nitrogen (N), phosphorous (P; P_2O_5) and potassium (K; K_2O), mostly abbreviated to NPK. Other important macronutrients include calcium (Ca), magnesium (Mg) and sulphur (S). The main micronutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn), all of which are also necessary for plant growth, but in small quantities (ILEIA, 2010).

If one nutrient is missing or deficient, plant growth will be poor, even if the other nutrients are abundant. The deficiency of any one nutrient delays plant development. Once supply of that nutrient is no longer the limiting factor, there is no benefit to increasing its supply. Another element will then be in low supply and thus the limiting factor. This rule is known as Liebig's law of the minimum, which is presented in Box 1 (Pami, 2014).

Nutrient cycling

Nutrients are found in the **soil**, and come from decomposing plant residues, animal remains, soil minerals and soil microorganisms. Nutrients can also be applied to the soil in the form of **organic fertilisers** (manure, compost, green manure) or as **chemical fertilisers**. Nitrogen can also be fixed through **nitrogen fixation**.

Nutrient uptake and loss

Uptake: Nutrients are taken up by plants through their roots. The presence of water enables plants to absorb nutrients, in particular nitrogen. Soil moisture thus plays an important role in nutrient uptake. For plants to be able to absorb essential nutrients from the soil, the nutrients must be available in their soluble, inorganic form; nutrients from organic sources must first be mineralised by soil microorganisms from the organic to the inorganic form.
Loss: Conversely, nutrients can be lost, e.g. directly from the soil through erosion, runoff, leaching or volatilisation (evaporation).
Nutrients taken up by plants are removed with the harvest of crops or through animals grazing. Nutrient losses increase when crops residues or livestock manure are not returned to the soil, but nutrient inputs should always balance nutrient outputs so as to maintain soil nutrients and thus soil fertility.

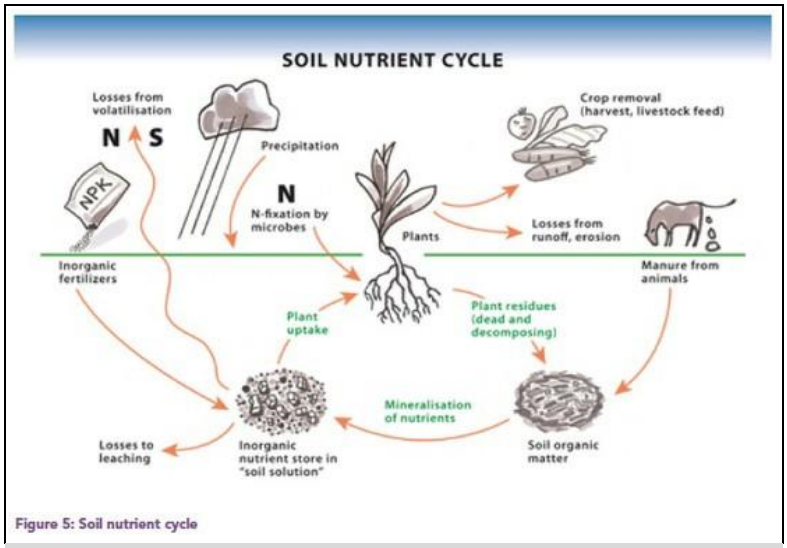

Figure 1: The soil nutrient cycle with nutrient sources and losses (ILEIA, 2010)

Nutrients can also be a source of **environmental contamination** when they reach lakes, rivers and ground-water (ILEIA, 2010).

Organic and chemical fertilisers

Fertilisers need to be applied in agricultural production, as nutrients deplete in the soil over time. Fertilisers can either be of organic or of chemical origin. Chemical fertilisers are usually available in a soluble and inorganic form, which distinguishes them from organic fertilisers such as farmyard manure or compost. Organic fertilisers are mineralised by soil organisms to their inorganic form before being taken up by plants (see Figure 1). Chemical fertilisers can be taken up immediately after application and are therefore faster-acting in terms of plant nutrition. Thus chemical fertilisers are often referred to as "feeding the plant", whereas organic fertilisers "feed the soil", as they contribute substantially to increase soil organic matter. Table 1 shows the advantages and disadvantages of organic and chemical (inorganic) fertilisers.

Table 1: Advantages and disadvantages of organic and chemical fertilisers

Chemical fertilisers		Organic fertilisers	
Advantages	Disadvantages	Advantages	Disadvantages
• Act fast • Specific and known nutrient composition • Easy application	• High costs • Water contamination • Health hazards • Loss in biodiversity • Contribution to Green House Gases	• Recycling of farm material • Cheap • Multiple nutrient composition • Improve soil organic matter • Improve the soil in the long-term	• Labour-intensive • Time-consuming • Knowledge-intensive • Transport

Organic fertilisers are key in sustainable agriculture, and chemical fertiliser use must be limited in order to reduce the impact on human health and the environment. As most of the cropping systems in Afghanistan are mixed farming systems, farmyard manure represents the most important organic fertiliser.

Farmyard manure

Farmyard manure is the best available organic fertiliser in mixed farming systems. Farmyard manure should be collected and recycled back into agricultural production to close nutrient cycles and improve soil fertility. The amount of farmyard manure produced depends on which animals are kept on the farm. Farm animal excrement contains up to 90% of the nutrients that the animals have taken up with the fodder. It is a multiple nutrient fertiliser that contains nutrients such as NPK as well as Mg, Ca and many micronutrients. Manure is therefore a cheap and efficient fertiliser. Cattle manure is better than donkey and horse manure, while goat and sheep manure is considered better than cattle manure. Chicken manure is considered the best of all, as it is nitrogen-rich. (SSMP; ICIMOD, 2008) The following aspects have to be considered with regard to manure:

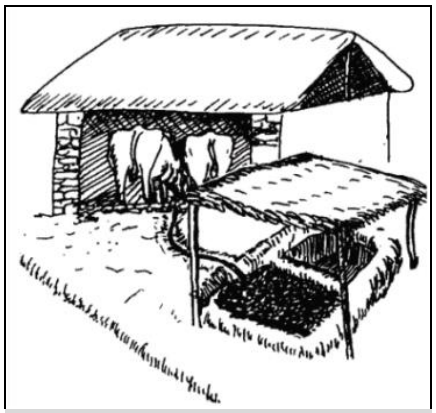

Figure 2: Farmyard manure and urine collection in a stable (SSMP; ICIMOD, 2008)

Collection: Manure is best collected mixed with litter such as straw or other plant residues. They absorb nutrients that would otherwise be lost. A high proportion of litter generates more solid manure, whereas water mixed with little litter results in more liquid manure (slurry). The best option for absorption is chopped and mashed straw. Manure collection is easiest to perform when animals are kept in stables. However, the collection of dried dung from grazing lands is also important.

Storage: There are different possibilities for storing manure. Manure is either stored directly in the stable, or outside the stable in heaps or pits (see Figure 3). One simple rule is to avoid sun, wind, rain and stagnant water. Roof cover or a tree can provide good protection. It is also preferable to choose a site on a slight slope, which allows the liquid manure to flow out and be caught in a slurry pit. The best base is compressed soil (clay) or concrete.
Sheep, goat or horse/donkey dung has to be watered or urine can be

poured on it. White threads or points indicate too dry storage; a yellow-green colour is a sign for overly wet manure. When correctly stored, manure has an even brown-to-black colour. Manure should not be stored for too long: most manure is mature in about four months. (Forster, 2001)

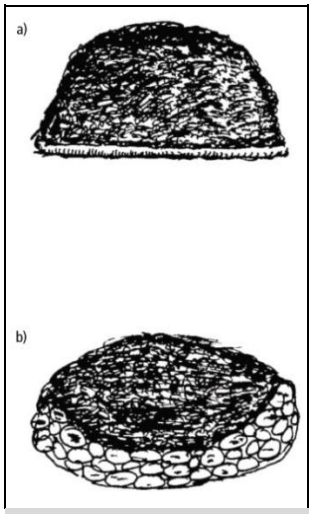

Figure 3: Store manure in a) heaps and b) pits (SSMP; ICIMOD, 2008)

Application: The dry manure is carried to the field where it is incorporated into the soil. It is important to carry the manure to the field on the day it is worked into the soil so as to avoid losses through on-field evaporation. Figure 4 shows two methods for applying manure, either by distributing manure in small heaps or as one big heap at the edge of the field.

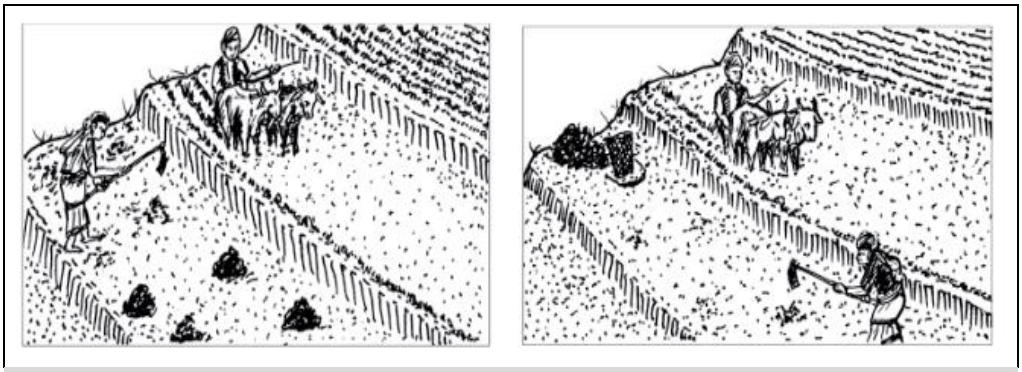

Figure 4: Incorporation of manure into the soil (SSMP; ICIMOD, 2008)

Urine: Animal urine is a very good source of nitrogen, because 60% of the nitrogen excreted is found in urine and only 40% in manure. As few as two cattle can save the cash equivalent of purchasing about 100kg of urea per year. Urine can be applied directly as liquid fertiliser (WOCAT, 2008). Urine collection should be promoted in Afghanistan to tackle soil nitrogen deficiencies. Urine is best collected in a urine pit inside the stable.

Other organic fertilisers

Besides farmyard manure and urine there are several other organic fertilisers which feed the soil and help to improve soil nutrients (FiBL, 2011):

Diversification: The availability of soil nutrients can be made available by diversifying cropping systems. Crops require different amounts of the various nutrients, so a diversified system balances nutrient requirements. Crop rotation, intercropping and multi-layer systems are all sustainable ways of using different crops, shrubs and trees to optimise plant growth and improve soil nutrients.

Compost: Compost is made from plant residues and animal manure. During the composting process microorganisms decompose plant and animal material to humus. Composting is the best management option to maximise nutrient availability; it also ensures that the concentration of nutrients is not too high for crops. When properly managed, composting will also kill off harmful pathogens and weed seeds. **Vermi-compost**: Same process as compost, but worms are used to decompose plant residues and animal manure to humus.

Green manure: Green manures are plants grown to accumulate nutrients for the main crops. Legumes are ideal for green manure due to their ability to fix nitrogen.

Liquid manures: These can be made using fresh plant material (plant tea), compost (compost tea) or fresh animal manure (manure tea). Manure tea and plant tea are both rapid sources of nitrogen, while compost tea is a more nutritionally balanced liquid fertiliser. **Plant tea**: Fresh and green material is soaked in water for several days or weeks to undergo fermentation. Nutrient- or nitrogen-rich material should be used.

Ashes: The ashes of burnt organic material are often also used as organic fertiliser. Ash provides a rapid supply of phosphorous; however burning organic material also includes a loss of other nutrients and thus has severe long-term consequences.

Human faeces and urine: Human faeces and urine can also be used as an organic fertiliser. Using human faeces in agricultural production does need special attention to hygiene and sanitation, however, and requires an additional treatment stage.

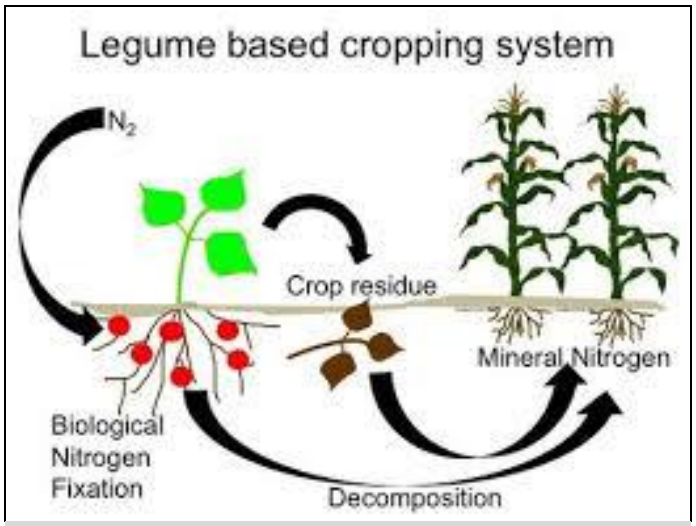

Figure 5: Nitrogen fixation via Rhizobia in the root nodules of legumes (http://www.extension.org)

Nitrogen fixation

Nitrogen fixation is the process by which nitrogen is converted into ammonium. The ammonium is further converted into nitrates, which can then be taken up by plants. We distinguish between nitrogen-fixing **soil bacteria** that fix nitrogen from the air directly to form ammonium, and nitrogen-fixing bacteria in legume root nodules.

One finds symbiotic bacteria called Rhizobia in the root nodules of **legumes**. These bacteria fix nitrogen from the air. When the plant dies, the fixed nitrogen is released into the soil and converted to nitrates; the nitrogen can then be taken up by other plants.

A cropping system including legumes is therefore advantageous in terms of nitrogen supply. Legumes can be incorporated into the cropping system as intercrops, relay crops, improved follow or as part of an agro-forestry system (leguminous trees). Legumes integrated into cropping systems for their ability to fix nitrogen are referred to as green manures.

Crop nutrient requirement

Crops require different amounts of nutrients for optimal plant growth. For details of the nutrient requirements of various crops (wheat, potatoes, vegetables, fruit and nuts) please refer to the information provided by USDA&UC Davis on: http://afghanag.ucdavis.edu/afghanag

Nutrient deficiencies

If a crop does not receive enough nutrients it will not growth properly, and one nutrient will also be the limiting factor. This kind of nutrient deficiency often becomes visible on the green parts of the plant, and mainly on the leaves. It is important to be able to detect major nutrient deficiencies to be able to react and tackle nutrient deficiencies efficiently. The following links show the nutrient deficiency symptoms of wheat, potatoes, fruit and vegetables:

Wheat: http://repository.cimmyt.org/xmlui/bitstream/handle/10883/1141/26347.pdf
Potatoes: http://nbsystems.co.za/potato/index_13.htm
Fruit and vegetables: http://www.extension.umn.edu/garden/fruit-vegetable/nutrient-management-for-commercial-fruit-and-vegetables-in-mn/docs/5886_31-32.pdf

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Further reading and references

- FibL, 2011: African Organic Training Manual, Module 2, Soil fertility management, available at: http://www.organic-africa.net/1311.html?&L=0
- Forster, D., 2001: Compost production: Ways to improve, Rural Advisory and Development Centre RADC, Jalal Abad Oblast, Kyrgyzstan.
- ILEIA, 2010: Learning AgriCultures Module 2, Soil and water systems, available at: http://www.agriculturesnetwork.org/resources/learning/mod2
- SSMP Notes, ICIMOD 2008, available at: http://www.icimod.org/?q=10300
- Pami, 2013: http://pami.ca/resources/other-information/law-of-minimums/
- USDA&UC Davis, 2013: Afghan Agriculture Portal, available at: http://afghanag.ucdavis.edu/

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