Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual

2.2.4 SUB-MODULE 4: MANAGEMENT OF PROBLEMATIC SOILS

Problematic or problem soils refer to soils that possess characteristics that make them uneconomical for the cultivation of crops without adopting proper reclamation measures. There are three major types of problem soils.

- Physical problem soils
- Chemical problem soils
- Biological problem soils

Soils with Physical Problems for Agricultural Production

Physical problematic soils have physical properties with some limitations. They include impermeable soils, soil surface crusting and sealing, subsoil hardpan, shallow soils, highly permeable soils, heavy clay soils and fluffy paddy soils slow permeable soils/ impermeable soils.

Slow permeable soils have very high clay content which restricts the infiltration rate and encourages runoff, erosion and nutrient removal from the top layers of soil. Such soils have very poor drainage, aeration and suffer from reducing conditions.

Impermeable soils can be managed by adoption of the following practices:

- Addition of organic matter such as farmyard manure (FYM), compost, composted coir pith and press mud improves physical properties leading to improved water retention capacity.
- Ridges and furrows within the farm provide adequate root zone aeration.
- Broad/cumbered beds reduce the amount of water retained in black clay soils during the first days of rainfall. The beds should be formed either along the slope or across the slope with drainage furrows in between broad beds.
- Provision of open or subsurface drainage to reduce waterlogged conditions.
- Huge quantity of sand /red soil application to change the texture contour /compartmental bunding to increase the infiltration. Application of soil conditioners like vermiculite to reduce runoff and erosion

Soil Surface Crusting and Sealing

Soil sealing and hard setting or soil capping are common problems in most soils in sub-humid and semi-arid tropics. Soil sealing refers to the formation of a thin impermeable layer on dry soils due to the impact of raindrops while surface crust refers to the formation of a compact layer within a few millimetres to a few centimetres' depths. The crusts are formed by either physical forces such as livestock trampling or traffic by agricultural machinery and other off-loading vehicles or chemically by the presence of colloidal oxides of iron and aluminium that binds soil particles together in wet soils. Such soils may have the following problems:

- Poor seed germination or retarded root growth
- Poor infiltration rates and high runoff rates
- Poor aeration within the rhizosphere
- Poor biological nitrogen fixation due to poor nodule development in legumes.
- Soils with surface seal or crusting problems can be managed by the following practices:
- Application of organic matter to improve soil physical properties
- Ploughing to break the seal and surface crust.
- Scraping the surface soil by tooth harrow.
- Bold grained seeds may be used for sowing on the crusted soils.
- More seeds/hill may be adopted for small, seeded crops.
- Sprinkling water regularly.
- Resistant crops like cowpea can be grown.
- Lime or gypsum may be uniformly spread before ploughing in severely crusted soils.

Sub Soil Hard Pan

This refers to a compacted subsurface soil layer. The compact layer is formed by accumulation of clay below the surface causing the subsoil to be dense, difficult for roots and water to penetrate hence leading to reduced water and nutrient uptake and low crop yields. Such soils are also susceptible to soil erosion. Subsoil hardpan can be managed by the following practices:

Deep cultivation

Ploughing with a chisel plough at 50 cm intervals in both directions. Chiseling helps to break the hardpan in the subsoil besides it ploughs up to 45 cm depth.

Application of organic matter

Application of farmyard manure or compost or composted coir pith helps in improving the soil physical properties.

Shallow Soils

Shallow soils are less than 50 cm depth. Soils having a depth of 50-100 cm are referred to as moderately deep soils while soils with a depth greater than 100 cm are referred to as deep soils. Most shallow soils are found on high mountains and valleys, and they basically occur in areas where soils are not well formed. Shallow soils restrict root elongation, spreading, water and nutrient holding capacity and crop uptake. Shallow soils can be managed through growing shallow-rooted crops and frequent soil fertility or water management practices.

Highly permeable soils (sandy soils)

Sandy soils containing more than 70% sand fractions are referred to as highly permeable. Such soils have poor nutrient and water retention capacity, very high hydraulic conductivity and infiltration rates. The soils normally lack the finer particles, poor organic matter and living organism population; have poor temperature regulation, weak aggregate stability and very poor soil structure. These soils have poor soil fertility, nutrients and water added is subject to loss through deep infiltration which does not benefit the target crops.

Sandy soils can be managed by adoption of the following practices:

- Application of organic matter such as farmyard manure or compost or slurry to improve soil aggregation.
- Crop rotation with green manure crops.
- Frequent irrigation with low quality water.
- Frequent split application of fertilisers.
- Uniform ploughing.
- Application of clay soil depending on availability of clay materials.

Heavy Clay Soils

Clay soils are those whose particles are less than 0.002 mm in diameter. These soils have poor permeability, but their permeability differs with clay content. Most soils are classified as clay soils when they are made up of about 40% clay particles. An example of a heavy clay soil is Vertisols.

Soils with chemical problems for Agricultural production.

Soils with chemical problems for Agricultural production include acid soils and salt affected soils.

Acid soils

Soil with a pH of less than 7 are generally referred to as acid soils. The acidity level however increases pH decrease from 7 towards zero with pH levels lower than 5.5 being strongly acidic and pH of less than 4.75 being extremely acidic.

Acidity i

n soils can be caused by the mineralogy of parent material, organic matter accumulation, leaching of base cations (calcium, magnesium, potassium, and sodium), and management practices such as continuous use of acid forming fertilisers, application of elemental sulphur which undergoes reactions forming sulphuric acid, tillage practices and soil pollution.

At pH levels less than 5.5 most micronutrients are abundant and soluble except molybdenum. Some of the abundant micronutrients are toxic to plant roots and soil microorganisms. Oxides and hydroxides of some micronutrients like aluminium (Al) and iron (Fe) form insoluble complexes with important nutrients like phosphorus hence making them unavailable for plant and microorganisms' uptake. At pH less than 5.5, some base cations such as calcium and magnesium are also low, which adversely affects the base saturation levels.

Soil acidity can be managed by application of organic amendments such as manure. Organic matter is a strong buffering agent that buffers the soil against drastic changes in pH on top of replenishing soil nutrients. Application of pulverised limestone or dolomitic limestone (which has magnesium in addition to calcium carbonate that makes up regular lime) is one the fastest ways to increase soil's pH or reduction of soil acidity. Liming materials should be added periodically depending on the nature and level of acidity in particular soils. Basic slag obtained from the iron and steel industry can be substituted for lime because it contains 48-54%CaO and 3-4%MgO. Calcium ammonium phosphate fertilisers, citrate soluble phosphate fertilisers and potassium sulphate are suitable sources of N, P and K respectively in acidic soils.

Saline Soils

Saline soils are non-sodic. They contain sufficient soluble salt to adversely affect the growth of most crop plants with a lower limit of electrical conductivity of the saturated extract (ECe) being 4 Deci Siemens / meter (dS/m), which is equivalent to a value of 4 mmhos/cm. These salts might originate from the parent rock from which the soils were formed or from seawater in low lying areas along the coastal strip. A very common source of salts in irrigated soils is the irrigation water. Most irrigation waters contain some salts. After irrigation, the added water is used by the crop or evaporates directly from the soil then salt is left behind. If not removed, the salts accumulate over time in a process called salinization. Salty underground water may also contribute to salinity when the water table rises. For example: irrigation without proper drainage may cause salty groundwater to rise to the upper layers thus supplying salts to the root zone. Very salty soils are sometimes recognizable by a white layer or dry salt on the soil surface.

The reclamation of saline soils involves basically the removal of salts from the root zone soil through the processes of leaching with water and drainage. Provision of lateral and main drainage channels 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils. Sub-surface drainage is an effective tool for lowering the water table, removal of excess salts and prevention of secondary salinization.

Irrigation of Saline Soils

Proportional mixing of good quality (if available) water with saline water and then using it for irrigation reduces the effect of salinity. Alternate furrow irrigation favours the growth of plants rather than flooding. Drip, sprinkler and pitcher irrigation have been found to be more efficient than the conventional flood irrigation method since a relatively lesser amount of water is used under these improved methods.

Fertiliser Management for Saline soils

Addition of extra dose of nitrogen to the tune of 20-25% of recommended level will compensate for the low availability of N in these soils. Addition of organic manures like FYM, compost, etc. Helps in reducing the ill effect of salinity due to release of organic acids produced during decomposition. Green manuring and green leaf manuring also counteracts the effects of salinity.

Sodic Soils

Sodic soils contain sufficient exchangeable sodium to adversely affect the growth of most crop plants. They have high levels of exchangeable sodium (Na) and low levels of total salts caused by natural presence of minerals producing sodium carbonate (Na2CO3) or sodium bicarbonate (NaHCO3) upon weathering. They contain an exchangeable sodium percentage greater than 15% and a pH of 8.2 or more. Extreme cases may have a pH of above 10.5. These soils tend to occur within arid to semi-arid regions and are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability and ultimately plant growth. Sodic soils may impact plant growth by a) sodium toxicity to sodium sensitive plants; b) Nutrient deficiencies or imbalances; c) High pH of > 8.0 and d) soil structure destruction or dispersion or flocculation of clay minerals.

Sodic soils can be reclaimed or managed using several approaches, they include:

- Establishment of sodic tolerant crops
- Application of organic manures
- Application of chemical amendments such as soluble calcium salts (gypsum, calcium chloride), acids or acid forming substances (sulphuric acid, iron sulphate, aluminium sulphate, lime-sulphur, and pyrite) or calcium salts of low solubility like ground limestone. The compounds in the salts or acids react with the sodium carbonate (Na2CO3 or NaHCO3) forming a leachable compound.
- Agronomic management such as planting at the edge of hills, leaching and crop rotation among others.

Alkaline Soils

Alkaline soils are clay soils with high pH, poor soil structure and low infiltration capacity. Often, they have a hard calcareous layer at 0.5 to 1 metre depth. The causes of alkaline soils are natural or can be man-made. Natural causes are the presence of minerals producing sodium carbonate (Na2CO3) or sodium bicarbonate (NaHCO3) upon weathering.

Alkaline soils with solid CaCO3 can be reclaimed with grass cultures, organic compost, waste hair and feathers, organic garbage, etc. Ensuring the incorporation of much acidifying materials (inorganic or organic material) into the soil and enhancing dissolved Ca in the field water by releasing CO2 gas. Deep ploughing and incorporation of the calcareous subsoil into the topsoil also helps.

Soils with Biological Problems for Agricultural Production

These are soils whose biological properties have undesirable biological properties like low organic matter content and harmful macro and microorganisms. Bacterial wilt, Fusarium wilt and nematodes are some of the unfavourable biological soil pathogens.

Biological properties of soils - Soil organisms break down organic matter and while doing so make nutrients available for uptake by plants. The nutrients stored in the bodies of soil organisms prevent nutrient loss by leaching. Microbes also maintain soil structure while earthworms are important in bioturbation in the soil. Biological degradation of soil is the impairment or elimination of one or more "significant" populations of microorganisms in the soil, often with a resulting change in biogeochemical processing within the associated ecosystem