AN EXTENSION MANUAL ON SOIL NUTRIENT MANAGEMENT FOR SUSTAINABLE CROP PRODUCTION




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FOREWORD

Sustainable agriculture revolves around the principles of successful management of soil, water and nutrients resources for crops production. Maintaining soil quality is therefore essential for sustained crop production to meet growing demand of food. However, the skills of the Ghanaian farmer in the successful management of soil nutrients resources for crops production under changing climatic conditions is very low. Therefore there is the need for an accurate and easy to understand information on management of soil nutrients for sustainable crops production to enhance the skills of our farmers. This limitation was identified as a priority at the National Research – Extension – Farmer Linkage Committee (RELC) Planning Session.

The Modernizing Agriculture in Ghana (MAG) Project, funded by the Global Affairs Canada, is therefore partnering CSIR-Soil Research Institute by providing funding for developing this communication material to build capacity and help transfer improved soil nutrient management technologies for sustainable and increased crop production.

This extension manual provides practical solutions to sustainable soil nutrient management for increased and sustainable crop production. It covers almost all the basic practices and strategies on soil, water and nutrient management. It is intended to serve as a guide to agricultural extension officials, farmers, FBOs and other interest groups.

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1.0 INTRODUCTION

1.1 Current situation of soils in Ghana

Productivity of Ghana's cropland remains low and continues to reduce due to several factors. Some of these include:

- Inherent low soil fertility status
- Bad adoption of soil management practices (e.g. low/excessive use of fertilizers, deep ploughing, ploughing along the slope, complete burning of farm waste, etc.)
- Untimely performance of field operations
- Bush burning
- Reduction in fallow periods.

1.2 How to Improve Soil Productivity

Soil productivity can be improved through the adoption of one or more of the following:

- Prudent and effective soil management practices (selecting suitable soils, good conservation measures, etc.)
- Improved and effective water management practices (mulching, bunding, ridging across slopes, etc.)
- Improved and effective nutrient management (use of inorganic/organic fertilizers, appropriate farming /cropping systems, etc.) practices
- Soil conditioners (e.g. biochar)
- Periodic soil testing to assess fertility status, identification of limiting nutrients and pollutants.

1.3 Effect of Climate Change and Variability on Soil Fertility/Productivity

- Climate change is resulting in changes in rainfall patterns and intensity (drought and floods)
- Climate change is resulting in high temperatures
- Such changes invariably affect the soil and its ability to support crop growth.

1.4 Measures to Mitigate/Adapt to Effects of Climate Change

- Farmers must adopt effective soil, water and nutrient management strategies that can improve crop production (e.g. mulching, bunding, ridging, suitable crop varieties, good agronomic practices, etc.)
- Reliance on Agro-meteorological information and other early warning systems

- Practice conservation agriculture (cover cropping, rotations, relay cropping, etc.)
- Early warning systems emergency preparedness

2.0 EFFECTIVE SOIL AND WATER MANAGEMENT PRACTICES FOR CROPLANDS

Some recommended ways in which the soil must be managed to ensure continuous and sustainable use are:

(i) Proper site selection for crop production

- Consider that soils in Ghana vary in properties and potentials to support crop production.
- Agro-ecological zones in Ghana have different environmental and climatic characteristics, thus affecting soil properties
- Various crops have specific soil requirements and at different degrees for a successful production.
- For most crops, soil that are deep, well-drained and gentle sloping are most suitable.

Note: Farmers are encouraged to seek advice from nearest extension offices or consider the above factors in selecting the cropping sites.

(ii) Land preparation

- All land preparation practices should not expose the soil to severe erosion and removal of top soil (e.g. Ploughing across slopes);
- Constant use of heavy machinery causes sub-soil compaction and/or increased erosion
- Land preparation practices must be undertaken early enough during the cropping season

Considerations for good land preparation

- Adoption of no or limited burning (always maintain some vegetative cover)
- Slashing and de-stumping are recommended for areas with thick vegetative cover.
- The use heavy machinery such as bulldozers to clear land including topsoil removal is never recommended under any circumstances for agricultural land preparation.

- Levelling may be required when/where necessary (should only be done within the topsoil to create uniformity on soil surface)
- Avoid deep ploughing in shallow soils
- Practice minimum tillage
- Plough across the slope and not along it
- Minimize the use of heavy equipment in land preparation where it cannot be avoided.

(iii) Management and Maintenance of Croplands

Croplands must always be protected and nurtured to provide a very conducive environment for the sustainable growth of the crops.

Strategies for good Cropland Management

- Always maintain adequate vegetative cover (preferably dry material as mulch)
- Apply adequate plant nutrients at the right time
- Adopt practices that improve soil organic matter content (e.g. mulching, application of organic manures, crop rotations, etc.)
- Adopt practices that improve water conservation (e.g. strip cropping, bunding, terracing, mulching)
- Adopt effective weed control measures.
- Adopt recommended erosion control measures.
- Drain off standing/stagnant water where not needed
- Protect the cropland from strong winds by creating wind breaks
- Protect and stabilise the banks of water courses in and around the cropland

Note: Minimal or macro levelling may be necessary to prevent/reduce water collection at particular points under upland conditions

3.0 SOME SIMPLE IRRIGATION PRACTICES FOR SMALLHOLDER CROPLANDS

The amount, duration and frequency of water applied to a specific crop field must be based on the crop's requirement, soil conditions and other environmental factors.

Famers may ensure adequate water availability to their fields through the following measures:

- Grow water intensive crops in the valleys (e.g. dry season vegetable farming)

- Construct dykes/weirs and associated channels to manage water resources for agriculture
- Create hand dug wells/ponds to harvest flood/rain water for crops
- Adopt bunding, terracing, strip cropping, agroforestry etc. to conserve soil moisture

3.1 EFFECTIVE SOIL NUTRIENT MANAGEMENT FOR CROPLANDS

Providing adequate soil nutrients in the required forms, quantities and at the right time is essential for good crop growth and optimum yields

4.0 WHAT IS A PLANT NUTRIENT?

- Plant nutrient is any natural or artificial substance containing chemical elements (e.g. N, P, K, Ca Mg. etc.) that improve crop growth.
- Some of these nutrients can be supplied by natural means (existing within the soil) while others may have to be supplied through artificial additions (fertilizers).
- Others may be supplied through effective cropping systems

4.1 Why add Plant Nutrients to the Soil?

- They are needed because plants depend on them to grow and provide good yields (food for mankind).
- In general, fertility status of soils in Ghana is inherently low and any successful crop production effort must be supported by the addition of adequate nutrients.
- There is low fertilizer use (< 15kg ha^{-1}) in crop production in Ghana, causing soil nutrient mining (removal without replacement).
- The end result is low crops yield, shortage of food, hunger and rural poverty.

4.2 Types of Plant Nutrients

There are several types of plant nutrients.

These can be broadly grouped into three categories depending on the quantities required by plants for normal growth and yield:

(i) Macro nutrients - required in large quantities (N, P, K)

(ii) Secondary nutrients - required in medium quantities (Ca, Mg, Na, S)

(iii) Micro nutrients – required in very small quantities (Zn, B, Fe, Mn, etc.)

4.3 Sources of Plant Nutrients

Crop nutrients can come from several sources. Notably among these are

(i) Natural sources (in the parent materials/rocks that formed the soil)

(ii) Organic sources (farm and domestic residues, natural vegetation) and

(iii) Inorganic sources (mineral fertilizers)

5.0 NATURAL SOURCES TO IMPROVE/MAINTAIN SOIL FERTILITY

Basically, these are nutrients supplied by parent material during weathering of rocks

5.1 Organic Fertilizer Sources to Improve/Maintain Soil Fertility

Most plant and animal residues are great sources of plant nutrients that can be harnessed to support crop production. In addition, several systems can also help improve soil fertility. Some of these include:

- Composting
- Mulching
- Green manuring
- Crops rotation,
- Relay cropping
- Intercropping
- Strip cropping (*see plate 1*)
- Farm yard manure (FYM)

Plate 1: Cowpea - cassava strip cropping

- Direct application of plant residue (straw from rice, maize, sorghum, etc.)

    - Apply about 3-5 t/ha plant residue depending on availability and quality
    - Apply plant residue both in the raw form or when decomposed
    - The commonest farm residues in Ghana are rice and maize straw.
    - These materials are rich in plant nutrients.

Plate 2: Heap of decomposing rice straw

***Advantages of adding farm residues to soil*:**

- Increase the soil's ability to hold water and makes the soil easier to till
- Help soil to retain more of the plant nutrients.
- Supply most of the nutrients needed by crops.
- Help to reduce the adverse effects of excessive alkalinity, acidity, or the excessive use of chemical fertilizer.
- Aid in preventing soil erosion by keeping the soil covered.
- Help in controlling the growth of weeds.

5.2 Inorganic Fertilizer Sources to Improve/Maintain Soil Fertility

These are mostly mineral fertilizer materials synthetically manufactured for crop production. There are several types based on their composition and make. Some of these include:

- Straight/single fertilizers (e.g. urea, sulphate of ammonia, super phosphates, muriate of potash, sulphate of potash)
- Compound fertilizers (e.g. NPK of various combinations)

6.0 FERTILIZER APPLICATION TECHNIQUES/METHODS

Fertilizers may be applied in several ways or methods based on type and form.

For Organic Sources,

- work material into soil during land preparation (cereals, roots, tubers, legumes, tree crops)
- place materials around and/or at the base of growing crop (vegetables, tree crops)
- foliar application
- through irrigation water

For Inorganic Sources

- broadcast (spread uniformly on soil surface or field e.g. lowland rice)
- band placement (place around growing crops and cover e.g. maize)
- deep placement (place deep inside soil using special tools/equipment)
- Within the plant hole
- Foliar application
- Through irrigation water

Fertilizer Application Rates

- Application rates are normally based on a recommendation rate which has been scientifically established through field experimentation.
- Each crop has a specific recommendation based on its requirement and growing environment
- As such, fertilizer recommendations must be specific based on soil type and growing environment (agro-ecology)
- Blanket recommendations for all crops across agro-ecological zones does not provide for crops to give optimum yields.
- Some current recommendation rates are:

  Maize: 100-40-40 N-P_2O_5-K_2O kg per hectare for savanna ecology

  Equivalent to 4 bags NPK + 3 Bags Urea):

  90-60-60 (N-P_2O_5-K_2O) kg per hectare for transition ecology,

Equivalent to 6 bags NPK + 2 bags Urea.

Rice: 90-60-60 (N-P_2O_5-K_2O) kg hectare for lowland ecology

Equivalent to 6 bags NPK + 2 Bags Urea

7.0 INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) FOR CROPLANDS

This is the management of soil fertility to enhance and sustain cropland productivity through the adoption/application of two or more soil fertility management practices:

e.g. mineral fertilizer application + manure application + suitable cropping systems + suitable crop variety (considering local conditions).

Suggested options of ISFM for selected crops

a. ***Maize***

- Adopt minimum tillage for land preparation (slash and mulch or use of herbicides)
- Avoid deep ploughing
- Apply compost/farmyard manure during land preparation (4-6 tons per hectare) if available
- Select the most suitable maize variety for your ecological zone
- Apply mineral fertilizer at a rate of 100-40-40 kg N-P_2O_5-K_2O per hectare in the Savannah ecology and 90-60-60 kg N-P_2O_5-K_2O ha^{-1} in the Transition ecology
- Apply the recommended inorganic fertilizers as basal (NPK 15-20-20) at 6 bags per hectare and also top dressing using urea
- Ensure adequate soil cover (mulch) where possible
- Practice crop rotation using legumes

Note: The use of Sulphate of Amonia is discouraged in upland croplands because it causes soil acidity

b. Rice

- Slash (use herbicides), plough and bund field
- Apply compost/farmyard manure during land preparation (4-6 tons per hectare) if available

- Select the most suitable rice variety for your ecological zone
- Apply the recommended inorganic fertilizers as basal (NPK 15-20-20) at 6 bags per hectare
- Top dressing using Sulfate of Ammonia at 3 bags hectare (lowlands) and Urea at 1.5 bags per hectare (uplands)
- Practice crop rotation using legumes/vegetables where possible

3. Yam

- Slash or use herbicides before mounding/ridging
- Avoid burning if possible
- Apply compost/farmyard manure during mounding/ridging (4-6 tons per hectare) if available
- Select the most suitable yam variety for your ecological zone
- Apply mineral fertilizer at the rate of 30-40-40 kg N-P_2O_5-K_2O per hectare.
- Apply the recommended inorganic fertilizers as basal (NPK 15-20-20) at 4 bags per hectare
- Practice crop rotation using legumes where possible

  Note: Farmers are encouraged to adopt ISFM in soil management systems

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