Managing acid soils for reclaiming livelihoods in Ethiopia

Why it is critical

41% of cultivated land in Ethiopia is affected by soil acidity.

28% of cultivated land is highly acidic (3.5 million ha).

9 billion birr* per year is lost in foregone wheat production i.e. 17,000 birr every single minute.

Crop diversity is reduced as farmers restrict to acid-tolerant crops such as barley and potatoes.

Abandoning of land and migration has been observed in areas of extreme acidity.

Cost of inaction can be high impacting food security and income of smallholder farmers adversely.

What are the benefits

Increased yield (In cereals)

30-40% increase with liming alone

50-100% increase when combined with ISFM

Healthier soils and crops

Increased nutrient availability

Improved grain quality

Improved soil microbial activity

Reduced fertilizer costs

Decreased Aluminum and Magnesium toxicity

Greater pesticide effectiveness

How it can be addressed

3 complementary approaches are often employed in the management of acid soils:

- **Liming** – application of calcium and magnesium-rich materials from local sources
- **Integrated Soil Fertility Management (ISFM)**
- **Acid-tolerant crops and varieties**

The approach is dictated by rainfall patterns, soil properties as well as economic considerations.


Soil acidification is the result of a complex set of processes caused both naturally and by human activity. It limits plant growth because of conditions that increase base element deficiencies, Phosphorus-fixation and toxicities of Aluminum, Manganese and Hydrogen ions. Acid parent material

SOILS LOW IN LIME: Soils derived from weathered granite are likely to be more acidic than those derived from shale or limestone.

MINERAL TOXICITY: The principal hydrous oxides of the soils are Al and Fe. When soil pH decreases, these oxides through step-wise hydrolysis release Hydrogen (H+) ions resulting into further acidification.

Use of ammonium fertilizer

HYDROGEN ION TOXICITY: Transformation of some Nitrogen fertilizers into nitrate (NO₃⁻) releases Hydrogen ions (H+) to create soil acidity.

REMOVAL OF BASE ELEMENTS: In effect, nitrogen fertilizer increases soil acidity by increasing crop yields, thereby increasing the number of basic elements being removed.

Decomposing organic matter

HYDROGEN ION TOXICITY: Soil organic matter or humus contains reactive carboxylic, enolic and phenolic groups that behave as weak acids. During their dissociation they release H⁺ ions. The formation of Carbon dioxide and organic acids during the decomposition also result in replacement of bases on exchange with H⁺ ions.

Symptoms of soil acidity in crops

- Poor plant vigor
- Uneven crop growth
- Poor nodulation of legumes
- Stunted root growth
- Persistence of acid-tolerant weeds
- Yellow/red leaf discoloration
- Increased disease incidence

Extent of soil acidity in Ethiopia

>80% of the landmasses originating from Nitisols are acidic

Examples of well-known areas severely affected include:

- Oromia
  - Gimbi
  - Hosaena
  - Nejo
  - Sodo
- SNNPR (Southern Nations, Nationalities and Peoples’ Region)
  - Endibir
  - Chencha
- Amhara
  - Hagere-Mariam
  - Awi Zone

Steps taken by the Ethiopian Government and partners

GTP (Growth & Transformation Plan)

The lime initiative laid the foundation for much broader dissemination and impact of agricultural lime in Ethiopia through:

- Groundwork
  - Successfully created awareness of, and demand for, agricultural lime among smallholder farmers in acid soil areas of the highlands.
- Capacity building
  - Trained development agents and district agricultural experts in critical skills of soil sampling, lime application and in conducting demonstrations and popularizations.
- Infrastructure
  - Establishment of lime crushers in selected locations. There are currently five lime crushers in three locations, with a total annual capacity of just under 20,000 tons.

Goal for 2020

226,000 ha of acid soils to be treated

Plan for next five years

450,000-900,000 tons of lime needs to be produced, distributed and applied to acid soils to meet the goal

Benefits of liming

- Increases soil pH and availability of Phosphorus, Molybdenum and Nitrogen
- Eliminates toxicity of Aluminum and Manganese.
Diagnosing soil acidity

Periodic soil testing is needed when growing high-yielding crops. Testing identifies soil acidity early enough to change the pH.

Steps include:
1. Soil sampling
2. Monitoring soil pH
3. Reaching target pH

What the pH score says

ACIDIC | NEUTRAL | ALKALINE

Liming acidic soils calls for application of calcium- and magnesium-rich materials to soil in the form of:
- Marl
- Chalk
- Limestone
- Hydrated lime

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Liming acidic soils

Calcium- and magnesium-rich materials are applied to soil in the form of:
- Marl
- Chalk
- Limestone
- Hydrated lime

Determine the amount of lime:
Application of 2-5 tons of lime per hectare annually has been reported to be adequate to maintain the level of Ca and Mg in the soil under continuous cropping.

Determine the frequency of liming:
At higher rates, residual effects of liming are expected to last for five to seven years. When a high rate of lime is recommended, (>6 tons/ha) biennial application may suffice.

Purity determines rate of application:
If the purity of liming material is 80%, then recommendation rate must be adjusted by multiplying by 100 and dividing by 80.

Smaller-size material acts faster:
The finer the lime material, the faster is the correction of soil pH.

Soil type determines the lime amount:
Clay soils, particularly nitisols, need more lime to correct the pH. Due to high organic matter they have a larger reservoir than sandy soils.

For effective reclamation of acid soils:

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**Complementary strategies**

Integrated soil fertility management: In acid soils, where Phosphorus (P) fixation is a problem, application of Farm yard manure (FYM) releases a range of organic acids that can form stable complexes with Aluminum and Iron thereby blocking the P retention sites and releasing P.

Tolerant crop and pasture species
In extreme acidic soils Triticale rye with hybrid wheat was found to be producing a good crop.

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**Decision guide for soil acidity management**

<table>
<thead>
<tr>
<th>Farms in high rainfall areas can be</th>
<th>Extremely acidic (&lt;4.5pH)</th>
<th>Moderately acidic (4.5-5.5 pH)</th>
<th>Slightly acidic (5.5-6.5 pH)</th>
</tr>
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<td>Abandoned farms</td>
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<td>Productive farm</td>
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<td>Rarely grows barley, potato or wheat; only weeds like Rumex spp grow</td>
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<td>Stunted crops with low-yield</td>
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<td>Moderately fertile and wet (Nitisols, Luvisols, Acrisols, Alisols and Ferralsols)</td>
<td>Deep clay or loam (Mostly Nitisols, Alisols, Gleysols, Cambisols, Planosols and Ferralsols are also found)</td>
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**Indicators checklist**

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<th>Type of farm</th>
<th>Crop system</th>
<th>State of crop</th>
<th>Crop symptoms</th>
<th>Soil indicators</th>
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**What can be done**

- **System shift**
  - Shift to pasture/livestock systems
  - Liming with high rates ( >6 ton / ha) (To be done after all the other interventions)
  - Liming as a single application (about 1.5 t/ha)
  - Liming as rotation (about 1 t/ha)
  - Maintenance, rotational application of lime (about 2 t/ha)

- **Lime**
  - Whole farm application of lime (4-5 t/ha), repeat every 5 years, OR rotational application of lime, row application (about 2.5 t/ha)

- **Fallowing + legumes**
  - Fallowing with deep-rooted legume trees (e.g. Acacia decurrens; Erythrina spp; Sesbania spp)
  - Short season fallow with deep rooted legumes (e.g. Alfalfa, Lupin)

- **Water guide**
  - Proper drainage

- **Fertilizer usage**
  - Avoid ammonium-based fertilizers

**Reverse the condition by:**

- Shift to pasture/livestock systems
- Liming with high rates ( >6 ton / ha) (To be done after all the other interventions)
- Liming as a single application (about 1.5 t/ha)
- Liming as rotation (about 1 t/ha)
- Maintenance, rotational application of lime (about 2 t/ha)

**Manage the soil by:**

- Whole farm application of lime (4-5 t/ha), repeat every 5 years, OR rotational application of lime, row application (about 2.5 t/ha)
- Fallowing with deep-rooted legume trees (e.g. Acacia decurrens; Erythrina spp; Sesbania spp)
- Short season fallow with deep rooted legumes (e.g. Alfalfa, Lupin)

**Maintain and improve the soil by:**

- Proper drainage
- Avoid ammonium-based fertilizers
GTP II targets: Reclaim 226,000 hectares of acidic soil
For every 1birr invested today, a NPV* return of 5.2 birr is projected

Business model for acid soil management

Five-year plan for achieving GTP II targets

Results of farmer field demonstrations across the Ethiopian Highlands (Amhara, Oromia, SNNPR and Tigray)

<table>
<thead>
<tr>
<th>Year</th>
<th>N*</th>
<th>Grain yield (t/ha)</th>
<th>ISFM + lime</th>
<th>Minus lime</th>
<th>Increase (%)</th>
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<tr>
<td>2016</td>
<td>100</td>
<td>2.2 1.3 10</td>
<td>4.4 2.5 80</td>
<td>7.5 4.7 59</td>
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<tr>
<td>2017</td>
<td>100</td>
<td>5.4 3.3 63</td>
<td>8.8 5.7 55</td>
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<tr>
<td>2018</td>
<td>58</td>
<td>5.0 2.9 73</td>
<td>8.7 4.8 80</td>
<td></td>
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<tr>
<td>Total/ weighted average</td>
<td>244</td>
<td>4.9 2.8 71</td>
<td>8.2 5.0 63</td>
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*Number of experiments; Minus lime=farmer practice (without lime)
Recommendations

- **Need for a National Movement in Reclaiming Acid Soil:** This mission needs to be taken up with urgency as part of the solution for wheat import replacement and enhanced productivity.

- **Lime Production, Supply and Distribution:** Excavation, production, distribution and application of lime should be more consistent with current GTP II targets and the need for greater supply to meet the needs of the full acid soil problem should be developed (public-private partnership is strongly recommended).

- **Farmer Awareness and Support:** Development of enhanced government services that facilitate farmer awareness, acid soil diagnosis, access to local acid soil experts and availability of training packages and local demonstrations, assistance with last-mile delivery and the availability of financing and credit to smallholder farmers for lime procurement and application.

- **The Need for Targeted Application:** Refinement of a comprehensive acid soil treatment and management package (lime, improved seeds, fertilizers, organic matter management, improved agronomy).

- **Comprehensive Acid Soil Policy:** Beyond just targets (as included in GTP II), a fully developed government policy that addresses the needs of an efficient and sustainable acid soils reclamation strategy as well as complimentary services (research support, inputs, credit, etc.) is needed.

- **Lime Delivery Business Model:** Develop an efficient and sustainable lime delivery system that balances cost effectiveness with widespread farmer adoption and job creation.

Suggested next steps

- National campaign for lime promotion
- Minimize free distribution of lime, except for demonstrations
- Continue farmer demand creation for lime, particularly in the most-affected regions
- Develop sustainable lime delivery mechanisms (Proactive Task Force)
- Agree on pricing mechanism (subsidy/credit for lime) – Policy decision is needed.

References

Getachew Agegnehu, Chilot Yirga and James Warner. 2018. Soil acidity in Ethiopia, cause, effects, management and policy consideration. IFPRI, EIAR.

James Warner, Chilot Tizale, Sam Gameda, and Tadiwos Zewdie. 2018. A pilot program to rehabilitate and enhance the productivity of acid soils in Ethiopia. IFPRI, GIZ, EIAR and CIMMYT.


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