On-farm yield response of chickpea \([Cicer arietinum (L)]\) to inoculation and phosphorus fertilizer application, at Damote Gale district in Ethiopia

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By:
Endalkachew Wolde-meskel and Team
Introduction

Chickpea, *Cicer arietinum* (L.)

- World’s 3rd most important food legume next to common bean and soybean
- Widely cultivated pulse crop by smallholders of the semi-arid tropics
Introduction
Putting nitrogen fixation to work for smallholder farmers in Africa

Why chickpea

Major African chickpea producing countries & their share of total production (FAOSTAT 2011)

Total production volume (in 10^5 tons) for eight selected grain legumes (CSA 2013)
Putting nitrogen fixation to work for smallholder farmers in Africa

...Why chickpea

Export share of 346 million US$ in 2013 (ERCA, 2013)

BNF of a number of legumes (CGIAR, 2012)

- Common bean: 60%
- Chickpea: 18%
- Soybean: 11%
- Faba bean: 60%

Export share of 346 million US$ in 2013 (ERCA, 2013)
…Why chickpea

Major Dietary Protein

Nutritious chickpea products

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Constraints

- Important crop, BUT low productivity:
  - Average yield in Ethiopia = 1.5 t/ha
  - Potential yield: 3 ton ha⁻¹

- Main Constraint
  - Poor soil fertility (low N & P availability)

Table 1. Average nutrient balance of N, P and K (kg/ha/yr) of the arable land for some East and southern African countries (after Stoorvogel et al., 1993)

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>0</td>
<td>−2</td>
<td>−1</td>
<td>0</td>
<td>−7</td>
<td>−26</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>−41</td>
<td>−47</td>
<td>−6</td>
<td>−7</td>
<td>−26</td>
<td>−32</td>
</tr>
<tr>
<td>Kenya</td>
<td>−42</td>
<td>−46</td>
<td>−3</td>
<td>−1</td>
<td>−29</td>
<td>−36</td>
</tr>
<tr>
<td>Malawi</td>
<td>−68</td>
<td>−67</td>
<td>−10</td>
<td>−10</td>
<td>−44</td>
<td>−48</td>
</tr>
<tr>
<td>Rwanda</td>
<td>−54</td>
<td>−60</td>
<td>−9</td>
<td>−11</td>
<td>−47</td>
<td>−61</td>
</tr>
<tr>
<td>Tanzania</td>
<td>−27</td>
<td>−32</td>
<td>−4</td>
<td>−5</td>
<td>−18</td>
<td>−21</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>−31</td>
<td>−27</td>
<td>−2</td>
<td>−2</td>
<td>−22</td>
<td>−26</td>
</tr>
</tbody>
</table>

Inorganic fertilizer?
Biological Nitrogen fixation

- BNF reduces dependence on mineral N fertilizer

Fig.: Symbiotic effectiveness of selected indigenous isolates on Chickpea, 45 days
On farm trials conducted in Southern Eth (45 farmer’s plots)

Objectives:

- Determine rhizobial population size compatible to Chickpea, MPN
- Examine effects of +I, +P and +I+P on yield and yield components of chickpea in two different soil types, black and red soils
- Across farm response variations to the treatments

<table>
<thead>
<tr>
<th>Soil type</th>
<th>PH</th>
<th>OC (%)</th>
<th>TN (%)</th>
<th>Av. P (mg/Kg)</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>6.7</td>
<td>0.96</td>
<td>0.09</td>
<td>13</td>
<td>Clay loam</td>
</tr>
<tr>
<td>Black</td>
<td>6.4</td>
<td>1.4</td>
<td>0.12</td>
<td>23</td>
<td>Loam</td>
</tr>
</tbody>
</table>
On farm trial conducted in Southern Eth.

Inoculation with Rhizobium (I) and Phosphorous fertilization (P)

- **T1**
  - Improved Seed
  - without inputs

- **T2**
  - Improved seed with
  - inoculation only

- **T3**
  - Improved seed with P

- **T4**
  - Improved seed with
  - inoculation & P

**Observations:**
- MPN, Growth and Yield, Symbiotic effectiveness, N Content, HH economic benefits
Results

Tab. 2: Rhizobial population size (g⁻¹ of soil), MPN, in black and red soils at some farms in the study area

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Farm number</th>
<th>Rhizobia Population (g⁻¹ of soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Black</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Black</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Black</td>
<td>20</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Red</td>
<td>4</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Red</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Red</td>
<td>13</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Red</td>
<td>17</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

- The low rhizobia population number warrants response to inoculation
Results

Soil types affect nodulation, growth, and yield of chickpea (*Cicer arietinum* L.) (n=40)

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Nodule score PP at 23 DAS</th>
<th>Plant ht. (cm)</th>
<th># of branches PP</th>
<th># pods PP</th>
<th>Days to maturity</th>
<th>Yield (t/ha)</th>
<th>Grain</th>
<th>T. biomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black soil</td>
<td>3.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>108&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Red soil</td>
<td>3.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Means followed by the same letter(s) in a column are not significantly different at P = 0.05 (Duncan's Multiple Range Test).

*Rhizobium* inoculation and/or Phosphorus fertilization improves nodulation in chickpea.
Putting nitrogen fixation to work for smallholder farmers in Africa

Results

- Rhizobium inoculation and/or phosphorus fertilization affects the phenology and growth of Chickpea (*Cicer arietinum* L.)(n = 20)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>SFWt at 45 DAS (g/plant)</th>
<th>Days to maturity</th>
<th># Branches</th>
<th>Plant height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>101&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inoculation</td>
<td>8.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>104&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>8.5&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>103&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>42&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inoculation + P</td>
<td>9.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>104&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>43&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Effects of Inoculation & Phosphorus on Chickpea Grain yield in different cropping seasons, Damot Gale, Ethiopia (n=20 ;45)

![Graph showing chickpea grain yield with P and/or I (t/ha) for 2012 and 2014]
...Results

Total biomass yield (t/ha) of chickpea as affected by Inoculation & Phosphorus fertilization, Damot Gale, Ethiopia

![Chart showing total biomass yield with and without P and I treatments.]

Chickpea straw total N uptake (Kg/ha) & total nitrogen content (STN, %) as influenced by Inoculation & P fertilizer

![Chart showing chickpea straw total N uptake and content with and without P and I treatments.]

Cattle feeding chickpea residues, Damot Gale, Wolyta, SNNPRS

Putting nitrogen fixation to work for smallholder farmers in Africa
on the majority of farms (>80%) positive effects due to inoculation

Farmers are missing out the benefit of applying P with out N being sufficient
Inoculation is strongly recommended to improve the productivity of chickpea in this area (*Rhizobium* concentrations of \(<10^2 \text{ g}^{-1}\) of soil are insufficient to establish effective symbiosis).

Application of I, P, and I+P increased grain yield by 26%, 19% and 33% respectively.

Assuming a ¼ ha chickpea plot, each household will benefit 63, 33, and 63 USD for I, P and I+P, respectively.

However, lack of efficient input supply and output market access are important constraints.
Central Partnership Cluster for Chickpea

- Designing & Facilitation of partnerships
- Technical support
- M&E
- Grants & leverage resources

- Evidence generation
- M&E, communication
- Technical support
- Develop extension materials
- Liaise with other VC partners

- Trainings on legume business, accounting & financing
- Support technology dissemination,
- Facilitate the use of MIS,

- Supply inoculants
- Trainings on inoculant applications, handling, storage & distribution
- Multiply effective strains

- Grain buyer,
- Seed access (ACOS variety)
- Support trainings on grain quality & grading
Thank You
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BNF of a number of legumes (CGIAR, 2012)

Protein provided by legumes per US$ (Monitor Group, 2012)