Evaluation report

Season 2013

A mission within the project:

Rock dust based Bio- fertilizers: A better life for farmers and mine workers in Ethiopia.

Addis Abbeba, Rema, Holeta and Arsi Negele, Ethiopia

Nov 12th–December 12th 2013

Rubén Borge Robles
Almere, februari, 2014

Concept VERSION 1-2-14
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About the Author

The expert on this mission is Mr. Rubén Borge Robles. Rubén has worked over ten years in studying and simplifying appropriate technology to create healthy local food and energy production systems and regenerate exhausted soils. He works with local communities in Europe, Africa and South America.

He gives farming families better access to information and skills to regenerate their farms, soils and communities. He combines techniques to increase the retention of water and nutrients and grow healthy plants. All the techniques are easily accessible to any producer in any country. His trainings include specific examples regarding the elaboration and use of compost, bio-fertilizers, and mineral additives based on local rock dust. He also coaches farming families to record and share their experiences within their own communities and build up local knowledge centers.
Summary of the results and recommendations

Ethiopian farming lands are decreasing in fertility, due to erosion and unbalanced fertilizer strategies; while farmers have limited access to information how to direct local resources as fertilizer inputs. Chemical fertilizer technologies are not affordable and/or not available to the average farmer and their environmental and socio-economic effects on the long term are questionable. The integration of local rock dust in the composting process of farm site offers an affordable powerful instrument to poor farmers to increase soil fertility, improve harvest quality and move one step further towards food security.

Goal: The aim of this mission is to assess the performance Bocashi and Bio-fertilizer in the Ethiopian cultural and agro-ecological context at three levels:

a. Physical: based on performance indicators and farmer interviews (qualitative and quantitative) for in soil and crop and seed.

b. Social: assess the participation of the trained farmers in the production and application of rock dust based fertilizers. Identify the critical barriers that stop farmers from producing and using the Bio-fertilizers.

c. Economic identify the cost and benefits from using bio-fertilizers.

Crop performance indicators and farmer interviews. As general conclusion we can state that the performance of bio-fertilizers is positive for the crop development.

- The performance of the bio-fertilizers depends greatly of the quality of the products, the correct doses, timing of application.

- The crop performance was higher in the fields where a combination of Bocashi, Bio-fertilizer and ash was used taking into account the crop phases. Bocashi during the land preparation, bio-fertilizer as seed inoculator, at least 3 applications of bio-fertilizer during the crop development stages until flowering. Ash solution after flowering.

- Significant improvements of crop performance have been achieved in demonstration fields where compost was applied during the land preparation and with at least 3 applications of liquid bio fertilizer Rema Arsi and Holeta. In demonstration field where did not apply Bocashi the crop performance was comparable to the controls.

- The application of Bio-fertilizer is not optimal when are applied to bad drained crops (Solulta).

- The application of bio-fertilizer to inoculate the seed had a positive performance on early development in sorghum. (Rema).

- The application of bio-fertilizer is sub-optimal when applied in the water

- The direct application of Rock dust in combination with liquid fertilizers had no response in teff in Holeta (bad soil condition) but did improve the performance (biomass and yield) of teff in Arsi.
• The direct application of basalt rock dust (up to 2 ton/ha) in degraded clay soils had no positive /negative effect on the performance (Holeta, Solulta).

• The quantitative performance of Bocashi can be compared with the compost from the bio-digester. An addition of low doses (0.5-1%) rock dusts or ashes in the bio-digesters can potentially improve microbiological activity resulting in a) more biogas production and b) higher quality fertilizer (rich in trace elements).

• Visual Soil Assessment has not been carried out as the soil was too dry to be evaluated. In the future the soil assessment will need to be done at the beginning of the rainy season. As changes in the soil happen a few years, the soil assessment will be done in year 3 and 4. Indirectly we can conclude that the most fertile soils leave more harvest but also more biomass that improve the soil. Hence, more biomass means higher organic matter in soils.

• The application of bio-fertilizer impacted positively in the quality of the seed. In teff, fields treated with bio-fertilizer had whiter teff seed more value in the market.

• Seed conservation was also affected by bio-fertilizer. In sorghum, the seed from bio-fertilizer was less affected by fungal attack than the chemically fertilized seed.

Social assessment

The application of bio-fertilizer to feed the plant is not effective if not combined with soil amendments (Bocashi). The crop response is proportional to the soil condition. Hence this should still be the focus for the farmer at the long term.

During the field visit it is clear that farmers are aware about this technology and they make different use of it. The implementation of this Some apply some bio-fertilizer, some train farmers and local extension workers in producing local rock dust enriched fertilizer. The training shows how to process locally available many vegetable wastes and rock dust from mining wastes to produce high value organic fertilizers. The second goal is to train the trainers in developing demonstration fields where the produced rock dust fertilizer products can be tested in teff, wheat and sorghum systems, and be optimized during 4 cropping seasons.
Chapter 1. Introduction and preparation of the mission

Background

80 million inhabitants make Ethiopia the second most populated country in Africa. With 83 percent of Ethiopians living in rural areas agriculture is the main source of income in Ethiopia; both in terms of exports and employment (46% of GDP).

Despite the growth of agricultural production the last years, food security remains fragile. Reasons are the rain-fall depend nature of agriculture, low fertility of farming soils, primarily being caused by non-circular nutrient flows (cow dung disposed of being sold at markets dried as fuel, crop residues being burned or fed to cows).

Mission Objectives

The main objective of this mission is to evaluate the three pilot projects to produce, apply rock dust enriched bio-fertilizer and to develop dissemination strategy. This objective can be divided in the following targets:

1. Assess the performance of the bio-fertilizers and mineral solutions in the Ethiopian context in particular the capacity of Bocashi to increase the soil structure and restore the soil physically, chemically and biologically, in the long term.

2. Assess the performance of Liquid bio fertilizer to feed the plants and increase production from the first season and the capacity of Mineral solutions to raise the quality of the final product while protecting crop from insects and diseases, in the short term.

3. Identify the bottlenecks to integrate bio-fertilizers in the local context and research the availability of local resources to scale up the project at regional level.

4. the level adoption of the bio-fertilizer technology in different Ethiopian institutions local NGO’s, governmental extension workers and model farmers to define appropriated strategy for dissemination.
Methodology of the project

The smallholder project tests self-produced bio-fertilizers in small holder farms during 4 seasons. Each year

Phase 1. Producing their own inputs (March-May)

During the training samples of all preparations were made at each site. To execute the demonstration, more products are needed and this means that the farmers will have to collect ingredients themselves and produce the bio fertilizers. Farmers get technical assistance (coaching) during the production phase.

Phase 2. Applying the products during growing season (June-October)

Although the first training gave information over application doses, timing and other details, hand-outs handed to the course participants give also information about the application. The visit in June will make more emphasis in application of the product and data collection during the growing and harvest season.

Phase 3. Evaluating results (December—January)

After the first season, the data need to be analyzed and used to prepare the strategy and the action-plan for the second season. Communication with the people in the field is crucial to get the right data and context.

Phase 4. Re-design (February)

This is a pilot project meant to demonstrate, learn and improve. The recommendations from phase 3 are used as input to correct the approach and ensure progression and learning. Each season will serve to adapt the bio-fertilizer technology to the Ethiopian context.
Methodology for the evaluation phase

To achieve the proposed evaluation the following methodology is used:

Demonstration plots are evaluated on a basis of comparing the performance of the fields with bio-fertilizers with the control fields. The evaluation also will assess the capacity of the farmers to produce and apply the fertilizers to achieve optimal performance. The evaluation cover the project sites Rema, Holeta, Solulta, Ziway and Arsi Negele.

The evaluation consists in interviews with the farmers responsible to keep the fields, direct data gathering from the field according to structured forms with key performance indicators for soil, plant and seed. See Annex 1. Crop performance indicators

Moreover this evaluation will assess the level of involvement of the community in awareness, or participation within the project. By community we mean different local institutions such as: model farmers, local entrepreneurs, extension workers of NGO’s, local agricultural extension officers, training of trainers and model farmers, vocational schools directors.

<table>
<thead>
<tr>
<th>Location</th>
<th>Host organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rema</td>
<td>Getaw Mekonnen mixed farm</td>
</tr>
<tr>
<td>Holeta and Solulta</td>
<td>Holeta Agricultural research center</td>
</tr>
<tr>
<td>Arsi Negele</td>
<td>ANCEDA, Vocational Training Centers</td>
</tr>
<tr>
<td>Ziway</td>
<td>SEDA and RCWDO</td>
</tr>
</tbody>
</table>

Table1. Host organizations location projects
Chapter 2. Activities of the mission

Field visits
The two day field visits to each demonstration site had the purpose to meet different actors involved in the maintenance of the field and evaluate the status identify bottlenecks, give technical advice and implement corrective measures if needed.

During the field visits the following activities were performed:

1. Visual inspection of the demonstration sites. (photo)
2. Measurement of the soil and plant performance indicators (photo)
3. Interview the farmers about the activities undertaken during the season, the application rates, doses and their general impression about the season including incidents. The purpose of this interview is to detect incidents and contexts that can influence the results of the pilot and gain information about specific observations during the different development stages of the crop. ( photo)
4. Collection of seed samples to measure seed performance indicators later at the office.
Chapter 3. Results and findings of the mission

For each demonstration site, the results are described as follows. Firstly layout of the site is described then the results are presented in a table. Afterwards the results are interpreted followed by on incidences, conclusions and recommendations.

Hoeveel boeren zijn getrained hoeveel impact opbrengst impact op ???

Rema, 2013

1. Plot layout:

The plot layout consists in 6 parcels of 10x20m following the design as given in the Table 1

<table>
<thead>
<tr>
<th>B1</th>
<th>C1</th>
<th>P1</th>
<th>B2</th>
<th>C2</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x spray</td>
<td>No</td>
<td>100 kg/ha DAP</td>
<td>3x spray</td>
<td>No</td>
<td>100 kg/ha DAP</td>
</tr>
<tr>
<td>Bio-fertilizer</td>
<td>treatment</td>
<td></td>
<td>Bio-fertilizer</td>
<td>treatment</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 design plots Rema

2. Crop performance indicators:

<table>
<thead>
<tr>
<th>Sorghum</th>
<th>B1 and B2</th>
<th>C1 and C2</th>
<th>P1 and P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>150birr</td>
<td>0</td>
<td>1500 birr</td>
</tr>
</tbody>
</table>

- Fungal in 3 weeks after harvesting stored in recipients (see Figure 1)
3. **Incidences:**

**Manure in C1 and P1:** There is presence of cow manure in fields C1 and P1 that may affect the results of the first repetition. A few months after the lay out of the plot, the farmers realized that the cows used to sleep in the near upstream of C1 and P1, leaving manure behind in this place. During the rainy season the runoff wash the manure and contaminate C1 and P1 fertilizing these plots and showing relatively better performance for these plots. To assess these fields sampling was collected from the area’s most far away from the cows sleeping place to minimize the possible effects of the contamination in the results. However it is difficult to assess the impact of this contamination in the end results for the C1 and P1 Areas. We expect therefore a higher performance of these plots due to this contamination.

**Storm.** Farmers reported a big storm with intense rain and hard southeast winds caused damage to the crops, 5 weeks before the harvest the intensity of the winds vary per plot. This storm brought near 50% of the sorghum down.

**Striga:** Especially the west side of the plots was affected by Striga (*Striga hermonthica*). This affected severely the crop density and also the production per plant. The infestation affected most the plots B1 and B3 C3 and P3.

4. **Assessment on producing the bio-fertilizers**

Not all the farmers product fertilizers. Only one farm took the initiative to product and
experiment and it now is starting to sell products and services to the community.

The limiting factor for this area is the supply of fine rock dust. This resource

5. **Interviews with the farmers**

From the 12 trained farmers one farmer started producing bio-fertilizer and Bocashi and applied regularly. Also started the distribution of bottles with fertilizer (free samples to introduce the product). As a result a dozen of farmers tried the product and the demand for product and training now increases. There is a lot of interests of farmers about this project. At least 10 farmers at the community are trying the bio-fertilizers at their own farms and gardens in Teff, Maize, Okra, faba beans, potato Garlic. Also there is expectation at fruit farms trying in Onions, tomato and papaya and they are very positive about the results. The community chiefs and the extension workers are organizing meetings to follow and evaluate the results. On 2014 they will organize a new training in the village where at least 40 farmers are expected.

![Figure 3 Teff in Rema without bio-fertilizer (left) and with bio-fertilizer (right)](image)

![Figure 4 other experiences in Rema Papaya Farm in Rema with bio-fertilizer (left); Abere reported increases in yield of 300% in beans and 150% barley with bio-fertilizer and Bocashi (right)](image)
6. Conclusions:

At Rema (Amhara Region) Bocashi was tested in the production of sorghum. In all cases farmers reported increase of yield and biomass. In Sorghum, the yields in 10x20m plots for (B) Bio-fertilizer, (C) control and (P) DAP were 55, 38 and 49 kg respectively. The production of biomass is 3% higher in the fields with Bocashi + Bio-fertilizer than in the control. The farmer is scaling production of Bocashi and bio-fertilizers in farm up to grow 190 ha in the coming years of organic production. In Barley the farmer Abere reported an increase of the production in 150% in barley after a treatment of 1 t/ha of Bocashi as compared to the same farm in last years. Abere increased yield of beans in 300%.

In 2013 a total of 12 farmers were trained in Rema. These farmers applied some of the technologies at their family farm. In 2014 80-100 farmers have shown interest in getting the training. The second year the experienced farmers will share their experiences with the new and a new training session will be organized in collaboration with the regional agricultural extension office. The good results achieved help to spread the dissemination phase.

7. Recommendations:

In general we can conclude that the plots with bio fertilizers have more yields, better quality than the control plots. When compared to the use of the DAP sorghum with bio-fertilizer yield more, have better quality and cost less 10x less than the industrial fertilizer. We recommend to the farm to:

1. Scale up the use of bio-fertilizer to the farm progressively.
2. Protect the crops from strong winds with windbreaks
3. Harvest rainwater (mulching and soil organic content management)
4. To process all cow manure and crop rests to produce Bocashi and increase the soil organic content.

Figure 5 The community at Rema meets with the local leaders to discuss the preliminary results and plan a second season with the training of 80-100 more farmers in 2014 with the participation of the local agricultural extension office WOREDA.
Holeta

1. Plot layout:

The plot layout consists in 3x16 parcels of 10x10m following the design as given in the Table 2

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NP+Co</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>2</td>
<td>NP+Co</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>3</td>
<td>NP+Co</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>4</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>5</td>
<td>RD</td>
<td>RD</td>
<td>RD</td>
</tr>
<tr>
<td>6</td>
<td>RD</td>
<td>RD</td>
<td>RD</td>
</tr>
<tr>
<td>7</td>
<td>RD</td>
<td>RD</td>
<td>RD</td>
</tr>
<tr>
<td>8</td>
<td>RD</td>
<td>RD</td>
<td>RD</td>
</tr>
<tr>
<td>9</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>10</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>11</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>12</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>13</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
<td>RD</td>
</tr>
<tr>
<td>14</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
<td>RD</td>
</tr>
<tr>
<td>15</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
</tr>
<tr>
<td>16</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
<td>RD+Bio</td>
</tr>
</tbody>
</table>

Table 2 design Holleta Faba beans (green) and teff black

<table>
<thead>
<tr>
<th>NP+Co</th>
<th>NP</th>
<th>RD+Bio</th>
<th>RD+Bo+Bio</th>
<th>RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 kg/ha DAP</td>
<td>100 kg/ha DAP</td>
<td>1x spray Bio-fertilizer</td>
<td>1x spray Bio-fertiliser</td>
<td>1t/ha basalt fine grained rock dust</td>
</tr>
<tr>
<td>Compost 1t/ha</td>
<td>Compost 1t/ha</td>
<td>1t/ha basalt fine grained rock dust</td>
<td>Bo 1t/ha</td>
<td>1t/ha basalt fine grained rock dust</td>
</tr>
</tbody>
</table>

Table 3 tests in Holeta
2. Crop performance indicators:

<table>
<thead>
<tr>
<th>Plant Seed</th>
<th>Cost (birr/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP+Co</td>
<td>NP 1500</td>
</tr>
<tr>
<td>NP</td>
<td>RD 400</td>
</tr>
<tr>
<td>RD+Bio</td>
<td>RD 400</td>
</tr>
<tr>
<td>avB13</td>
<td>av-C5</td>
</tr>
<tr>
<td>av-B16</td>
<td>av-C8</td>
</tr>
<tr>
<td>RD+bo+bio</td>
<td>avA6</td>
</tr>
<tr>
<td>RD</td>
<td>av-B6</td>
</tr>
<tr>
<td>Bio 150birr</td>
<td>RD 400</td>
</tr>
<tr>
<td>Bo 250</td>
<td>RD 400</td>
</tr>
<tr>
<td>Bio 150</td>
<td></td>
</tr>
</tbody>
</table>

### Yield and biomass Teff, Holleta

<table>
<thead>
<tr>
<th>Yield (t/ha)</th>
<th>Biomass (m*100 plant/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>avA1</td>
<td>avB-10</td>
</tr>
<tr>
<td>av B13</td>
<td>av-B16</td>
</tr>
<tr>
<td>av C5</td>
<td>av-C8</td>
</tr>
<tr>
<td>avA6</td>
<td>av-B6</td>
</tr>
<tr>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 4 Teff performance in Holleta

The Fields with NP and compost performed a bit better than in those fields with NP. However, the field fertilized with DAP produce relatively more straw than grain and when compost is added the field produce more grain. (see A1 and B-b10 in Table 4)

The performance of RD as well as RD+bio is far less than the other tests. The reason being might be in the lack of organic matter in the soil. Fields with addition of organic compost or bio fertilizer yield two times more yield.

The application of Rock dust or Rock dust with only one application of Bio-fertilizer seems to be insufficient to improve the performance of the teff in the tests. In this design there is not control. Therefore we cannot say if Rock dust improves the productivity of teff when compared with a no fertilized crop.
Faba Beans

<table>
<thead>
<tr>
<th>Plant Seed</th>
<th>Cost (birr/ha)</th>
<th>Yield and biomass beans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NP 1500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RD 400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RD 400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bo 250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bio 150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bio 150</td>
<td></td>
</tr>
</tbody>
</table>

The faba bean on chemical fertilizer (A11 and C10) got similar yield as the organic plots A15 and A16. However the plots with chemical fertilizer got a bit more biomass in relation to grain.

In faba, as well as in teff, the application of only Rock dust gets less yields than the organic or the chemical plots. Spraying Biofertilizer once shows here, as well as in teff no difference C13 and C15, with the rock dust fields (A13 and A14).

With these results it is interesting to consider that bocachi (and 1x biofertilizer) gets similar yields than chemical fertilizer at half of the costs.
3. Incidences

Instructions for the preservation product were not followed. Insufficient application of the products: Bio-fertilizer only one application. Application rates were not followed. Bocashi and bio fertilizers were too old (4-8 months).

Changing faces Field officer The field officer in charge of the field got another job and a new person was appointed for this function. The appointed person did not assist to the training about bio-fertilizers.

The contact persons at this locations hire other farmers to do the job (this people didn’t necessary follow the training) and have no control about what they do. Therefore there is no logbook about the activities carried out.

Teff treated with DAP was also applied compost. When compost is applied in combination with DAP the performance of the crop cannot be pointed to DAP nor to the compost. (it is not clear whether the compost applied with the DAP was a Bocashi)
4. **Assessment on producing the bio-fertilizers**

No self-production of bio-fertilizers. The products used for the demonstration were de samples made during the training.

5. **Interviews with the farmers**

Besides the demonstration site, a model farmer is testing the products at his own. It was not possible to meet him. No other farmer was interviewed, only the extension officers from the WOREDA.

Availability of resources all resources to make fertilizers are abundant in the surroundings.

Field visits were organized to show 200 local farmers this experiment. It is not clear what information did these farmers get. And also it not clear how many farmers will get trained (and from whom) to carry disseminate the knowledge.

The fields were not well maintained. Anonymous source pointed out that maintenance of the fields stopped in the half of the growing season.

Communication between field officers and MetaMeta office manager weren’t content based and mostly addressed finances and payments.

6. **Conclusions:**

In Holeta, (Oromia Special Zone), the Bocashi was tested in beans (vicia faba). The Rock dust fields of vicia faba yielded an average 4.5t/ha where the fields with Bocashi and bio-fertilizer yielded an average of 9.2/ha (90%). The biomass production increased in 37% with bio-fertilizer and Bocashi due to higher plants, with better developed root systems and more plants per m². A third group of fields was fertilized only with bio-fertilizer with no significant improvements, indicating that the soil condition was the bottleneck to increase performance.

For faba bean and for teff it has been observed that when Rock-dust is applied in combination with Bocashi en bio fertilizer, the crop performance increases. The effects of Rock dust are not visible in the fields. These effects are expected to be visible in the long term.

When bio-fertilizer is preserved in bad conditions¹ (it is too old and bad preserved it can have negative effects on the performance of the crops. That is why training is fundamental to manage these products.

With only one bio-fertilizer application in teff there is not result visible. Therefore the results of B13 and B16 are cannot be used for the evaluation of the product. Expected improvements are expected at 3 applications at least.

The fields with Bocashi C5 and C8 perform under NP but better than the other fields. Better than the fields with only rock-dust, although there are large differences in their performance that cannot be explained.

In the case of Faba beans have shown good response to the combination of the Bocashi and Bio-fertilizer. This positive response was not achieved in the fields where Rock dust only was applied. Therefore we can attribute the better performance to the organic fertilizers. this differences can be possible due to the capacity that faba has to fix atmospheric nitrogen.

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¹ Field visit in June was observed that the digester was opened and the product has exposed to air (oxygen several times)
1. **Recommendations:**

Lack of communication mismatch expectations about results are the main sources that lead to lack of results. The trained peoples are not the people that implement the demonstration site. Therefore the risk is high that untrained people will achieve the results. The situation is even worse by changing faces of the trained people assigned to follow this course.

Look for direct contact with farmers and less with extension workers as they act solely intermediaries (not farmers). Extension officers have shown an economic motivation to carry the research. Working with farmers offers more continuity for the than the officers at the WOREDA officers because WOREDA officers are often changing in the organization.

Give skills to direct beneficiaries (farmers) who have interests in achieving results from the fields and will care for them out of their own personal interest (WIN-WIN).
Solulta

1. Plot layout:

The plot layout consists in 24 where 4 different fertilization scenarios were tested in barley and wheat. The fertilization plans were: (1) Rock dust, (2) DAP, (3) Rock dust + Bio fertilizer and (4) no treatment in parcels of 10x10m following the design as given in the Table 1

<table>
<thead>
<tr>
<th>LAYOUT SULULTA</th>
<th>Barley</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rep 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 NT</td>
<td>2 RD</td>
<td>3 DAP</td>
</tr>
<tr>
<td><strong>Rep 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 DAP</td>
<td>10 RD+BIO</td>
<td>11 NT</td>
</tr>
<tr>
<td><strong>Rep 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 RD+BIO</td>
<td>18 NT</td>
<td>19 RD</td>
</tr>
</tbody>
</table>

Table 6 design plots Solulta (blue arrow are drains)

<table>
<thead>
<tr>
<th>NT</th>
<th>RD</th>
<th>RD+Bio</th>
<th>NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment</td>
<td>1t/ha basalt fine grained rock dust</td>
<td>1x Bio-fertilizer in root irrigated 1t/ha basalt fine grained rock dust</td>
<td>100 kg/ha DAP</td>
</tr>
</tbody>
</table>

Table 7 fertilization program in solulta
2. Crop performance indicators:

<table>
<thead>
<tr>
<th>Plant</th>
<th>Seed</th>
<th>Cost (birr/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Solulta</td>
<td>0</td>
</tr>
</tbody>
</table>

The results obtained are not representative of the fertilization done in the plots. The results obtained do not correlate within the treatments. The plots with the best results are at the lower part of the parcel where all runoff accumulates. (see desing the situation of the drains. Therefore the plots 17 untill 20 obtain relatively higher results than their repetitions.
### Wheat

#### Plant

#### Seed

![performance wheat solulta](image)

See Annex 1. Crop performance indicators

<table>
<thead>
<tr>
<th>Cost (birr/ha)</th>
<th>0</th>
<th>RD 400</th>
<th>RD 400</th>
<th>NP 1500</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

#### 3. Incidences:

Application rates were not followed. Bocashi and bio fertilizers were too old (4-8 months).

Application was done with a Watering can in a moment where there was waterlogging in the field. Therefore this application could barely reach the plant.

Insufficient application of the products: Bio-fertilizer only one application. No Bocashi was applied as recommended.

Location of the plot is not appropriated for a comparative study. There are differences among the plots in the fertility and the parcel tends to accumulate nutrients around the lower parts plots 17- until 20. And

#### 4. Assessment on producing the bio-fertilizers

No self-production of any bio-fertilizers. The products used for the demonstration were de samples made during the training.

#### 5. Interviews with the farmers

Besides the demonstration site, a model farmer is testing the products at his own. It was not possible to meet him. No other farmer was interviewed, only the extension officers from the WOREDA.

Availability of resources all resources to make fertilizers are abundant in the surroundings.

Field visits were organized to show (around 100 farmers) local farmers this experiment. It is not clear what information did these farmers get. And also it not clear how many farmers will get trained (and from whom) to carry disseminate the knowledge.
Fields were not well maintained. Anonymous source pointed out that maintenance of the fields stopped in the half of the growing season.

Communication between field officers and MetaMeta office manager weren’t content based and mostly addressed finances and payments.

When compost is applied in combination with DAP the performance of the crop cannot be pointed to DAP nor to the compost. (it is not clear whether the compost applied with the DAP was a bocachi)

6. **Conclusions:**

For faba bean and for teff it has been observed that when Rock-dust is applied in combination with Bocashi en bio fertilizer, the crop performance increases.

The effects of Rock dust are not visible in the fields. These effects are expected to be visible in the long term.

When bio-fertilizer is preserved in bad conditions\(^2\) (it is too old and bad preserved it can have negative effects on the performance of the crops. That is why training is fundamental to manage these products.

7. **Recommendations:**

-Idem as in Holeta-

Provide training and transfer skills to direct beneficiaries (farmers) who have interests in achieving results from the fields and will care for them out of their own personal interest.

Dissemination is not possible when there is lack of field experience in the field.

\(^2\) Field visit in June was observed that the digester was opened and the product has exposed to air (oxygen several times)
Arsi Negele

1. Plot layout:

The plot layout consists in 6 parcels of 10x20m following the design as given in the Table 1.

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x spray Bio-fertilizer</td>
<td>100kg/ha</td>
<td></td>
</tr>
</tbody>
</table>

*Table 8 design plots Rema*

2. Crop performance indicators:

<table>
<thead>
<tr>
<th>Maize</th>
<th>RD</th>
<th>DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 t/ha basalt rock dust</td>
<td>100kg/ha</td>
<td></td>
</tr>
<tr>
<td>3x biofertilizer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Plant | No data | No data |
| Seed | | |

Yield corn grain Arsi Negele tons/ha

<table>
<thead>
<tr>
<th></th>
<th>Yield [tons/ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>av RD+ bio</td>
<td>9.15</td>
</tr>
<tr>
<td>av DAP</td>
<td>8.10</td>
</tr>
</tbody>
</table>

| Cost/ benefit (birr/ha) | RD 500 birr | 1500 birr / |
| Bio 150 birr |

*Table 9 performance maize in year 1. Arsi Negele*

3. Incidences:

Farmers reported a sudden change in color in the maize leaves. He pointed to some sickness (or probably lack of nutrient not determined) after one application with biofertilizer, the test field recovered and got an intense green color.

3 Yield was calculated by stablisching the following parameters: plants/ ha
Harvest was done before our visit. Therefore, no field data is available. We could see the piles of cobs that were collected and kept apart. We took samples and visited the field to evaluate the roots and from the cobs from which we calculate the yields for the test with rock dust and the control with DAP. Therefore we only estimate the yield though not the biomass.

![Image of corn cobs](image1)

**Figure 8** comparing corn cobs of maize of Arsi Negele. Above, length of the cobs. Bellow, RD + bio-fertilizer show better health and filling the grains at the top of the cob. NP field had difficulty to fill the grains at the top and was often infested by fungi.

![Image of corn cobs](image2)

Teff cannot be reported as it was harvested before our visit. The visited field had better crop density and the plants had more seed per plant and whiter color (more quality and quantity) therefore we inferred that the performance of bio-fertilizer in teff better was than the control crop. The interviews with the field staff confirms these observations.

![Image of teff plants](image3)

**Figure 9** comparing plant density in Teff at vocational school in Arsi. (Left control plot: 40%) and (right Bocashi + bio-fertilizer plot: 80%).
4. **Assessment on producing the bio-fertilizers**

Arsi Negele was able to produce Bocashi and apply it to teff. The production was too late and the maize trial did not get Bocashi. There is still room for improvement in the preparation, and conservation of the products.

5. **Interviews with the future farmers**

Demonstration fields were maintained by the schools staff. This staff did not get directly the training but was well instructed by the local contact person in Arsi.

The students were good informed about the experiment and were up to date with all the development phases of the crop, problems and incidences. This counts for the primary school as well as for the vocational school.

The demonstration sites were near the school and the teachers visited the sites with the students regularly and discussed the progress of the crop and got feedback from the staff that maintained the sites. Teachers at the basic school want to incorporate the making of organic fertilizers as a part of a subject and integrate in the curriculum of the school.

![Figure 10 Visit to Arsi Negele at the basic school (up) assessing the root development of the maize with the students. (Down discussing on the maize performance with organic self-made fertilizers)](image-url)
6. Conclusions:

The performance of the organic fertilizers in Arsi Negele was higher than the control plots. When compared to DAP, the use of the bio-fertilizers is up to 10 times lower than the commercial ones. The abundance of local resources in the area guaranties the supply system for the local market. Attention must be paid to development of the local mineral market -crash and use the local volcanic rocks, (mainly scoria and tuffs and mix them with Local Zeolite)- and avoid dependence from basalt crashers that are around 70 km far north.

The higher performance of organic fertilizers, together with their lower costs makes them competitive with commercial imported fertilizers. Organic local fertilizers are therefore especially interesting for farmers with low incomes as well as for the commercial farmers.

5 Recommendations:

Arsi Negele (Ethiopia) Bocashi was tried in Teff with an application of 1ton/ha in the test plots. After harvest the control plots had land coverage of 40-60% whereas the plots with Bocashi had cover rate of 80%. The production of biomass in Teff is between 20 and 40% higher than in the control fields.
About the products

**Bocashi** means fermented compost. It is produced through aerobic fermentation of diverse vegetable rests, forest earth and soil microorganisms in presence of minerals from rock dust. Bocashi is known for its capacity to regenerate exhausted soils. I adapted the receipt to integrate teff wastes and other farm waste. Making compost means sometimes conducting repetitive tasks. This allows building routines and making time to reflect. While making the products, participants were talking among them, discussing about the best way to proceed.

**Bio fertilizer** is a product that results from the anaerobic fermentation of fresh cow manure and minerals of the rock dust. During this process bacterium enzymes attack minerals from rock dust making them bio-available for the crops. Bio-digesters at the three sites showed bacterial activity within 24 hours. We analyzed what are the most common causes for failure in the process of producing bio-fertilizers.

**Ash solution** is a preparation that dissolves ash in water and makes minerals from the ash, available to plants. The composition of the ash depends on the original material used. Ash from wood is rich in K and Si. In Ethiopia it is common to use cow dung in the kitchen as fuel. The chemical composition of the ashes cow dung may vary from cow to cow and from the origin the cow is fed and with over the time (it has to do with different development stages of the grasses along the season). The same account for the trees. One can expect bigger differences in the ashes from cow dung and

**Soil management techniques** facilitate the retention of nutrients and keep the optimal soil moisture. After perceiving concerns from the organizations on water, soil moisture and erosion management, we decided to address this issue and discuss some strategies that increase moisture and nutrient retention in the soil.
Chapter 4 Conclusions and General Recommendations

• Combine always with compost/ Bocashi. Bio-fertilizer will nourish the plant and act on the short term. Compost nourish the soil and create the long term solution. Relying on bio-fertilizer is a labor intensive that makes plant dependent of the farmer.

• Best results have seen when bio-fertilizer is applied for more than 3 times during the growing season and in combination with other minerals.

• Rock dust alone does not increase the performance of exhausted soils if not combined with organic matter and conditions to enable the activity of microbiology.

• Increase mulching and organic matter growing at the farm. Think about beans to get food and fix nitrogen, if possible during the soft raining season.

• Instead of using herbicide to avoid competences, increase the plant density because shadow kills weed seedlings. If some weeds still grow, chop them to increase mulch and therefore, litter.

• Use variety of green manures, if possible indigenous legumes such as (i.e. Crotolaria ochroleuca G. (sunhemp), Mimosa invisa L.(Colla), Cassia obtusifolia L.(Sicklepod) Sesbania. Other common legumes are Sesbania Rostrata.

• Superimposed with bio-fertiliser or rock dust as fertilizer to increase land cover, infiltration, de-compaction, mulch, water retention and nutrient storage and control other weeds. Green manures increase organic matter, fix the nutrients, enables life and grows on site, avoiding need for transport and labor on fertilization.

• Plant trees to create shadow and windbreaks Calliandra calothyrsus, Acacia Mearnsii (wind can damage directly but also increase evaporation and erosion).

• Implement poly-cultures integrating animals. The use of animals like chicken to pasture the green manures, disinfects from larvae and insects and fertilizes too and generates extra income.

• Never use chemical fertilizers/ pesticides of any kind as they also kill what makes soils fertile= life.

• Facilitate the supply of seed for green manures: Consult the nearest seed bank for the availability of forages. To species consult like : http://www.tropicalforages.info

• Support with Oromiya Special Zone Department to integrate the Bocashi Composting technique in their composting outreach program.

• Encourage the local entrepreneurs to purchase a mobile unit of stone crusher to get fine stuff to supply the increasing demand to be expected in the coming year. Transport of one or two machines will be more effective than transport of basalt material. Moving the scarce things.
Chapter 6. Work plan for follow-up

1. Select organisations that as closed as possible to the farmers. (end users and end beneficiaries)

2. Split this 4 year project in two phases⁴:
   a. Test (adoption) where the target is a limited number of farmers (1st part: 2 seasons)
   b. Dissemination where tested technology can be disseminates (2nd part: 2 seasons)

3. Select organisations by their intrinsic motivation to improve their land (interest in production)

4. Train the farmers or (hands-on extension officers) with determination to adopt this technology and invest in time and effort.

5. Do not pay DSA for extension officers, only transport costs and lunch in case transportation is needed. And announce it like this during the promotion.

6. Manage the expectations of the

7. Select demonstration plots with more homogeneity in soil and exposition to weather special wind, rain and logging.

8. Match the payment to the deliverables (rapport) logical steps:

9. production fertilizers with own resources

10. application, as indicated (demo plot, application intervals, dosis)

11. Intensify the communication with the field contact people in order to early warning system to correct problems as soon as possible.

<table>
<thead>
<tr>
<th>Farmers reached</th>
<th>Rema</th>
<th>Holleta</th>
<th>Solulta</th>
<th>Arsi</th>
<th>Total aware</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>trained</td>
<td>aware</td>
<td>trained</td>
<td>aware</td>
<td>trained</td>
</tr>
<tr>
<td>2013</td>
<td>12</td>
<td>80</td>
<td>15</td>
<td>200</td>
<td>15</td>
</tr>
<tr>
<td>2014 - expected-</td>
<td>100</td>
<td>400</td>
<td>40</td>
<td>400</td>
<td>80</td>
</tr>
</tbody>
</table>

With the difference of Rema where the test phase is achieved in one season and the community demands naturally the dissemination. Here we can create a real community of practice where test and dissemination go integrated.
Annexes

1. Crop performance indicators
2. Derived indicators


1.1 (beans) (Vicia Faba)
- distance between rows (sowing) [m]
- distance between plants [m]
- number of plants per m survived until harvest
- number of plants with diseases per m
- plant length (cm)
- overall plant aspect [0/1/2]
- overall root aspect [0/1/2]
- number of pods per plant
- number of grains per bean
- Weight of 50 seeds (productive elements)

1.2 (Grains) Sorghum, Wheat and Barley
- distance between seed lines (sowing)
- sowing density (kg seed/ha)
- diseases [0/1/2]
- tillers harvested per plant
- number of tillers/m
- plant height [m]
- lodging [0/1/2]
- overall plant aspect [0/1/2]
- overall root aspect [0/1/2]
- brix juice from plant/root/seed (if applicable)
- weight of 5ml grain [g] (only for teff)
- weight of seeds of 50 plants [g] (only for teff)
- number of grains per plant
- weight of 100 grains [g] (general for grains)
- number of rows with grain per inflorescence (barley and wheat)

\(^5\) average of 5 measures
Annex 2. Derived indicators

Yield:
The yield is calculated as follows

\[ Yield = P \times N \times Wav \]

Where:
\( P \): number plants/ha that survived until harvesting
\( N \): is the number of productive elements per plant (edible part or product)
\( Wav \): is the average weight per productive element

Biomass index
There are two possibilities to measure biomass:
1. Biomass index
The biomass is calculated as an index. Biomass is proportional to the number of plants and the length of them. With these two parameters, we estimated an index to measure indirectly differences on production of biomass. The index is the number of meters of plants (excluding root). We choose this index this season because we did not have the chance to weight the crop rests. We recommend next year to weight of the crop rests. This season we compared performance in biomass production with this index:

\[ Biomass = L \times N \]

Where:
\( L \): is the average length in (m) per rests of the crop per plant after harvesting the productive element.
\( N \): is the number of tillers per m (furrow)

Now used this season but for the next season the biomass will be calculated in tons/ha.

\[ Biomass = W'_{av} \times N \]

Where:
\( W'_{av} \): is the average weight per rests of the crop per plant after harvesting the productive element.
\( N \): is the number of productive elements per plant (edible part or product)