



## Demonstration of maize-soybean (*Glycine max* (L) Merrill ) rotations in promotion for sustainable cropping system in Southwest Ethiopia

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### Abstract

Maize-soybean crop rotation system has positive impacts on the key indicators chosen for ecology, food and nutrition, and socioeconomic conditions of smallholder farmers. The study was conducted at Omonada, and Bedele districts of south west Ethiopia during 2017 and 2018 cropping season. Forty-nine farmers were selected in two districts with the land holding of 20mX20m (400m<sup>2</sup>). Suitable varieties for each crop were selected and sown based on agro-ecological features of the areas. Four cropping scenarios were arranged viz., Maize-after maize, Soybean after soybean, Soybean after maize and maize after soybean in the two years period. The results of study revealed that, mono-cropping of maize gives a minimum yield (7.84 and 6.98 t/ ha) as compared to Maize after soybean rotation (8.38 and 9.14 t/ha) in Omonada and Bedele districts respectively, which means that crop rotating maize after soybean produced yield benefit of 3.33 and 15 percent in the respective districts respectively. Net average revenue from maize production after soybean (66,330 birr) was more economical than the profit obtained from maize monoculture (54,002 pair). The focus group discussion was made with the farmers on their perceptions on maize-soybean rotation. They responded that soybean after maize has the advantage for increasing yield, limits concentration of pests and diseases, reduces the stress of weeds and improves the soil fertility and structure. Generally, maize after soybean farm is profitable business and both yield and profit obtained are above breakeven. Therefore possible measures for adoption and expansion of this cropping system should get priority in the country.

**Keywords:** soybean, Maize, Crop-Rotation, Economically viable.

### Introduction

In spite of the continues development and release of improved agricultural technologies by research institutions and other organizations, the contribution of agriculture to food and nutritional security remains negligible in Sub-Saharan Africa including Ethiopia (FAO,2015). The current agriculture system in Ethiopia, particularly in southwest Ethiopia is dominated by cereal based monoculture system. A few cereal crops like maize and other horticultural crops constitute the staple diets of a majority of the population in west and southwest Ethiopia. These crops are rich in carbohydrates but not meet the recommended dietary allowance for proteins, and other vitamins as well as minerals necessary for nutritional security.

Monoculture which neglects pulse crops; causes negative impacts on the environment and ecosystem services through reduction of soil fertility and aggravating incidence of pests and diseases pressures (IPES-Food, 2016). Regarding to this,

several failures have been reported because of mono-cropping practices in different crops across the world that includes the damages of rice crop by brown plant hopper in Indonesia in 1970s and destruction of citrus industry by citrus greening disease in USA in 1980s (WCMC, 1992). Therefore, a shift from monoculture to crop rotation and diverse agro –ecological farming can be an alternative pathway as this system promotes sustainable agricultural intensification and provides multiple benefits and ecosystem services from the uses of the same piece of land (Tsfai *et al.*, 2019). Crop rotation is a practice of rotating /changing the type of crops in field each season or year. It is a key principal of conservation agriculture because it improves the soil structure and fertility and it also helps to decrease the infestation and outbreak of diseases and pests (Broker *et al.*, 2015). Switching from monoculture to a rotation with legume crops is reported to stimulate the accumulation of 0.5 to 1.0 t/ha of soil organic carbon annually, with the legume component in the

cropping sequence contributing up to 20% of the carbon gain (Wu *et al.*, 2003).

Soybeans occupy a premier position as a world crop because of their high and virtually unrivalled, protein content (40%) and also are a rich source of high-quality edible vegetable oil (20%). Nowadays, Soybean is emerging as the most important strategic crop for small holder farmers' in terms of reducing malnutrition, improving soil fertility and as a source of income. As illustrated by different authors, soybean has become an important for sequential cropping systems with cereal crops in the world (Peoples *et al.*, 2008; Okogun *et al.*, 2005; Jagadamma *et al.*, 2008; Alves *et al.*, 2003). Erickson (2008) reported that, the rotation of soybean has a yield benefit for maize by 7.8%. In a wheat-soybean-wheat sequence, it was noted that wheat planted after soybean produced a higher grain yield than grown before soybean (Kumbhar *et al.*, 2007). Nitrogen fixation has a large role in meeting the nitrogen requirements of the soybean as well as, to some extent, those of the succeeding crop in the system. Ennin and Clegg (2001) found evidence for soybean nitrogen fertilizer replacement values in Nebraska of up to 46 kg N ha<sup>-1</sup> in rotation with maize. Nitrogen fixed by the soybean crop, its roots, leaves shed during crop growth and residue at harvest contribute greatly to improving the chemical, physical and biological properties of soil. The biological properties of soil have been reported to be influenced by soybean cultivation (Adeboye and Iwuafor, 2007; Bhattacharyya *et al.*, 2008). Important for pest control maize grown after soybean has been found to have lesser *Strigahermonthica* parasitism as compared with maize grown after sorghum (Carsky *et al.*, 2000).

Considering the current societal problems, such as malnutrition and soil fertility problem faced due to frequent cultivation of maize, the adoption of crop rotation of soybean is good alternative option. While, maize can serve as a major source of the daily calorie intake of the large majority of rural community, soybean need to be integrated in the cropping system to meet their essential amino acids that children need to grow, but it also serves as a good source of essential micronutrients, such as folic acid, vitamins B1, B2 and E, zinc, iron, magnesium and calcium to the diet. Therefore, the study was initiated to demonstrate and adopt soybean-maize crop rotation system for sustainable production through enhancing biological nitrogen fixation in southwestern Ethiopia.

## Material and Methods

The study was conducted at Omonada, and Bedele districts of south west Ethiopia. Forty-nine farmers were selected in two districts each year based on interest and willingness of farmers to provide land and technology adoption experience. Suitable soybean and maize varieties were selected and planted/sown based on agro-ecological features of the areas. The selected farmers were arranged in the four cropping scenarios, i.e., Maize-after maize, Soybean after soybean, Soybean after maize and maize after soybean in the two years period of 2017 and 2018. Each demonstration site embraces two side by side plots: rotating plot and non-rotating plot. The size of each plot was 20m\*20m (400m<sup>2</sup>). All improved agronomic practices were implemented as per the recommendations for each of maize and soybean crops.

**Data Collection:** Grain yield of maize and soybean yield and yield component were collected. A total field cob weight was taken from each plot and converted to grain yield by the conversion factor (0.83). Finally, grain yield was adjusted to standard moisture contents of maize, 12.5% as described in the adjusted yield = Actual yield x100-M/100-D, where D is the measured moisture content. Similarly, soybean yield was measured from the 20x20m plots, then converted to the standard moisture content i.e.12.5%. Yield, some other agronomic and economic data (production and marketing) data were collected and analyzed using descriptive and inferential statistics and the result was reported and documented. Changes associated with farmer's attitude towards the importance of rotation of maize with soybean and household consumption of soybean was assessed using semi-structured questionnaire.

## Results and Discussions

The results of this study revealed that, mono-cropping of maize gives lowest yield (7.84 and 6.98 t/ ha) as compared to Maize after soybean rotation (8.38 and 9.14 t/ha) in Omonada and Bedele districts respectively, which means that crop rotating maize after soybean produced an average yield benefit of 3.33 and 15 percent in Omonada and Bedele districts respectively. Increased productivity of the succeeding crop represents the sum total of all beneficial effects of previous soybean. At the same time, the soybean after soybean cropping scenario in both locations showed that there was a yield decrement trend (Table 1). After an experiment to study the residual effect of soybean on the succeeding crop of maize, Osunde *et al.* (2003) reported significantly greater plant height, shoot biomass, grain yield and nitrogen uptake of maize in

plots previously sown to soybean than in previously fallow plots.

**Operational costs of Maize after soybean production (Soybean maize rotation):** Maize-soybean rotations gives maximum maize and soybean yields than mono-cropping of the crops. The yield of maize in an annual soybean-maize rotation was significantly different from maize after maize rotations in all sites of the experiment. As shown in the following table (1) the result shows that first-year, maize after one year of soybean yielded more than maize in the soybean-maize rotation, and soybean after soybean also shows that higher yields than soybean after maize.

The result is also economically viable in case that the net average revenue from maize production after soybean was 66,330 birr which is higher than the profit obtained from maize after maize which was 54,002 birr respectively. Average price of 1kg of maize and soybean were 10 birr and 12 birr respectively during data collection. The result is further supported by the focus group discussion made by the farmers on their perceptions on maize after soybean rotation. They reported that the yield

of maize after one year soybean is significantly high and even they said that soybean after maize has the advantage of increasing soil fertility, reduce soil erosion, limits concentration of pests and diseases, reduces the stress of weeds and improves the soil structure.

**Demonstration, popularization:** In these demonstrations, researchers helped the farmers and other stakeholders in imposing the nutrient management options at the time of soybean sowing and then stepped back to allow the farmers to take up other pest and weed management practices as per their schedule. The importance of rotating maize with soybean was demonstrated on forty-nine farmers in the two districts. The performance of both maize and soybean was, generally, very good. Exceptionally, the performance of maize after soybean was very good. Field day was organized, and a total of 174 stakeholders from Zonal and Woreda Bureau of agriculture (BoA), Union and Primary cooperatives representatives, and farmer's representatives attended the field day.

**Table 1. Mean yield (t/ha) of maize, soybean rotation at two locations in the year 2018.**

| N <sup>o</sup> | Woreda  | Crop    | 2017         | 2018    | Crop sequence and yield |
|----------------|---------|---------|--------------|---------|-------------------------|
|                |         |         | Yield (t/ha) | Crop    |                         |
| 1.             | Omonada | Maize   | 8.69         | Maize   | 7.84                    |
|                |         | Maize   | 8.60         | Soybean | 2.54                    |
|                |         | Soybean | 4.49         | Maize   | 8.38                    |
|                |         | Soybean | 4.49         | Soybean | 3.14                    |
| 2.             | Bedele  | Maize   | 6.72         | Maize   | 6.98                    |
|                |         | Maize   | 6.72         | Soybean | 2.72                    |
|                |         | Soybean | 3.76         | Maize   | 9.14                    |
|                |         | Soybean | 3.80         | Soybean | 2.26                    |

**Table 2: Operational costs of soybean -maize rotations**

| Inputs                              | Average Costs of operation per hectare(Ethiopian Birr) |                   |
|-------------------------------------|--|-------------------|
|                                     | Maize after soybean                                    | Maize after Maize |
| Labor cost for land clearing        | 400  | 400               |
| Labor cost for chemical application | 400  | 400               |
| Labor cost for first plowing        | 752  | 728               |
| Labor cost for second plowing       | 752  | 728               |
| Labor cost for third plowing        | 752  | 728               |
| Labor cost for sowing               | 1,320  | 1,320             |
| Labor cost for hoeing               | 1,090  | 1,090             |
| Labor cost for first weeding        | 1,240  | 1,240             |
| Labor cost for second weeding       | 1,080  | 1,080             |
| Labor cost for third weeding        | 800  | 800               |
| Labor cost for harvesting           | 1,160  | 1,160             |
| Labor cost for transporting         | 760  | 760               |
| Labor cost for threshing            | 1,600  | 1,600             |
| Cost of seed                        | 864  | 864               |
| Cost of DAP                         | 2,400  | 2,400             |
| Cost of UREA                        | 2,100  | 2,100             |
| Growth yield (ton/hectare)          | 8.380  | 7.140             |
| <b>Total average cost</b>           | <b>17,470</b>  | <b>17,398</b>     |
| <b>Average Revenue</b>              | <b>83,800</b>  | <b>71,400</b>     |
| <b>Net average revenue</b>          | <b>66,330</b>  | <b>54,002</b>     |

**Note:**1\$USD=28.34 ET.BIRR, during data collection



**Figure 1: Pictorial description Soybean + Maize rotation for the year at Asendabo, Omonada district 2018.**

## Conclusions and Recommendations

Legume based farming system provides multipurpose ecosystem services and can play tremendous role in addressing future global food and nutritional security problem. Soybean is one of the most legume crop which gives vital role in human nutrition, especially in the dietary pattern of low-income households in developing countries and vegetarians. Soybean based crop rotation system with maize showed positive impact on improving and amending soil physico-chemical property, food and nutrition, the ability to break life cycles of pests and diseases and socioeconomic conditions of smallholder farmers. However, adoption and expansion of soybean-based cropping systems is generally limited in Ethiopia. This is due to weak agricultural extension, and less attention given by the government. Hence, in order to more scale up this important farming system, due attention should be given to have tough agricultural extension and advisory services, appropriate policies, and strong institutional arrangements which will facilitate the improvement of this technology. The result indicates maize-soybean rotations gives maximum maize and soybean yields than mono-cropping of the crops. The yield of maize in an annual soybean-maize rotation was significantly different from maize after maize rotations at all sites of the experiment and economically viable. In the future, demonstrating maize –soybean rotation in the different potential production area is highly encouraged.

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