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Demonstration and Promotion of Improved Maize *(Zea mays)* Varieties for Green Ear Production: Evidence from the Central Highlands of Ethiopia

Abenezer Abebe [a*], Endashaw Girma [a] and Mamaru Tesfaye [b]

[a] Department of Crop Science Research, Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, Holetta, Ethiopia.
[b] Department of Agricultural Extension and Communication Research, Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, Holetta, Ethiopia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Maize is the third most consumed cereal in the world and an important source of carbohydrates, making it an energy-producing food source. The main objective of this study was to demonstrate and promote the use of improved maize varieties for green ear production. Participatory action research was employed as the research design. Sites and farmers are selected purposefully based on maize production potential and farmers' willingness to allocate their land and labor to implement the activity. Two improved maize varieties, Jibat and Ambo, were demonstrated and promoted using their full recommendation package. Green maize production has increased significantly

**Corresponding author: E-mail: abentef2012@gmail.com;*

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because of its profitability. To ensure food security and revenue for urban and semi-urban populations, maize green ear production work was demonstrated and promoted in kebeles such as Mede Gudina, Birbirsa Siba, and Sademo on a land area of 0.6 ha. As a result, the findings of this study revealed that maize green ear production provided significant income and a high return for farmers. The production cost of maize green ear harvested at the dough stage in Mede Kebele is 38,610.80 ETB, but the income is 345,389.20 ETB. This shows that the maize green ear production business is profitable and feasible. However, production can be constrained by several factors, such as the time of harvest, fertilizer, irrigation requirements, variety selection, and disease. Therefore, the findings of this study suggest that future research and interventions should pay special attention to the factors mentioned earlier. Overall, expanding the green ear business to other study areas and similar agroecological regions can contribute to food security, income generation, and job opportunities, ultimately alleviating poverty.

Keywords: Demonstration; green ear; improved; income; maize; production.

1. INTRODUCTION

Maize *(Zea mays)* is the third-most consumed cereal in the world and is considered an important source of carbohydrates, thus constituting an energy-producing food source. It is the leading cereal in terms of production volume and is set to become the most widely grown and traded crop in the coming decade [1]. Maize is intended for "green maize," and grain production is one of the most important crops in Ethiopia.

Maize green ear production is the practice of harvesting maize ears before they reach full maturity and drying them for later consumption or sale [2]. Castro, Silva [3] also stated that green maize is the name for ears harvested when the grain moisture content is between 70 and 80%. In Ethiopia, green maize is a common food that street vendors boil and sell to customers as "takeaway food [4]. It also sold four to six uncooked cobs bundles for home preparation. According to Rinaldi, Mahaputra [5], farmers would substantially increase their net income by selling green maize cob and using green stover for their cattle. The green maize meal is more nutritious than processed products because the milling process removes most of the germ and fiber [6]. Bhandari [7] reported that dry stover is low in nutrients (e.g., 3.7% crude protein compared to 8.8% in green stover), and is less palatable and unsuitable for conserving silage. In contrast, green and fresh stover are more nutritious and palatable to the livestock.

The production of green maize has increased significantly because of its profitability, as green maize has greater commercial value than dry maize grains [1]. It can be cultivated through irrigation and rain; however, irrigation could be more advantageous because of the high market demand and declining supply. Van Averbeke [6]described those farmers growing green maize for marketing as attractive and beneficial because the value is higher than that of maize grain. Green cobs gave about 2.5 times more money than grains of the same size. Street traders apply quality criteria, such as long and attractive cobs, large cob size, high number of grain rows and kernels per cob, complete kernel fill, absence of insect and disease damage, sweet taste, and good roasting quality. These quality standards meet consumer preferences and ensure the marketability of green maize. To harvest the maximum green maize cob yield, it is important to ensure that the maize plants are well supplied with water and nutrients, spaced far apart to allow for optimal growth, and harvested at the early dough stage, approximately three weeks after flowering [8] [9]. This stage is typically at least one month before the grain reaches maturity, ensuring that the green maize is harvested at a profitable stage.

While the green maize ear is a valuable agricultural product, its yield can be affected by several factors, including nutrient management, spacing, and the timing of harvesting. This requires careful management of these factors and optimization of the yield and quality of green maize cobs, meeting the criteria set by street traders, and maximizing profitability. Green maize ear production can increase smallholder farmers' incomes and food security, especially in developing countries where maize is a staple food crop [1]. In Ethiopia, farmers in the Oromia region of the Meta Robi District were involved in green maize cob production and explained its profitability from both green cobs and stover. This study should be expanded and promoted under both irrigation and rainfed conditions.

Therefore, the demonstration and promotion of maize green ear production activity were initiated to ensure food security and income in urban and semi-urban societies, promote maize technologies, and encourage women and youth to engage in this business.

2. MATERIALS AND METHODS

Demonstrations and promotion of maize green ear activity were carried out in the Wolmera district at three kebeles, namely Mede Gudina, Arada, and Sadamo, by the 2023 cropping season. Seven farmers were involved, and a total of 0.62 hectares of land was covered. Two improved highland maize varieties, Ambo and Jibat, were used for demonstration and promotion. The Highland Maize Research Program of the Holeta Agricultural Research Center provided support for inputs such as seeds, fertilizers, labor during planting, and pre-emergence herbicides. Frequent follow-up and technical advice were provided to the farmers to benefit them from green ear production. The land was plowed twice, and the seeds were planted in a third plow. Planting was performed using 75 cm and 25 cm inter- and intra-spacing, respectively. NPS and urea fertilizers were applied at 121 and 150 kg/ha, respectively. Premagram Gold herbicide was sprayed three days after planting as pre-emergence weed control. Farmers have also sprayed insecticides to control fall armyworms. The crops were kept in the field from mid-May to mid-October.

2.1 Data Collection and Analysis

Qualitative data were collected through the participatory rural appraisal technique by employing focus group discussion, personal observation, and key informant interviews. Quantitative data for the input and output of maize green ear production harvested at the dough were recorded with a data sheet.

The collected quantitative data was analyzed using a partial budget analysis to determine the income and feasibility of maize farming. The formulas are as follows:

$$\text{I (income)} = TR - TVC = (Qy \times Py) - (Qi \times Pi) \quad [10]$$

Where:

I = Income or gross margin TR = Total revenue (1) TVC = Total variable costs (sum of the costs of labor and other variable inputs, i.e., seeds, fertilizers, and chemicals) Qy = Yield of maize per ha (kg) Py = Price of maize per kg (Ethiopian Birr - ETB) Qi = Number of inputs (unit) Pi = Price of inputs per unit (ETB)

The feasibility of maize farming was calculated using the revenue cost ratio (R/C ratio) formula [10]. The revenue-cost ratio determines the profitability or efficiency of maize farming [11].

$$\text{R/C ratio} = TR / TVC$$

Where:

R/C ratio = Revenue cost ratio TR = Total revenue TVC = Total variable costs R/C ratio > 1, implies maize farming is profitable and efficient R/C ratio < 1, implies maize farming is not profitable and not efficient R/C ratio = 1, implies maize farming is in the break-even point.

3. RESULT AND DISCUSSION

3.1 Income of Maize Green Ear Farming

The farmers in Mede Gudina, Birbirsa Siba, and Sademo Kebele of Wolmera district cultivate an average maize planted area of 0.6 hectares. The highland area is not well known for maize cultivation; therefore, the area covered is large. Pratiwi and Canon [12] reported that land area has a positive and significant effect on maize farmers' income. Yasin and Syam [13] stated that seed quality is pivotal for increasing maize production and productivity. The cultivation of improved maize varieties is an essential part of maize production technology because maize has the potential to provide food, feed (maize stover), and industrial raw materials. Likewise, for demonstration and promotion, improved maize varieties with quality seeds were used.

The analysis of maize green ear production indicated that the average production facility cost incurred was 10930.8 ETB, which comprises maize seeds, inorganic fertilizer, herbicides, and insecticides. In addition to the use of production facilities, there was also the use of labor, which farmers entirely carried out. The labor cost of maize green ear farming was 27,680.00 ETB for planting a land area of 0.6 ha, which is 2.5 times higher than the production facility costs. Similarly, Rinaldi [5] and Siagian et. al [14] stated that labor cost has a significant effect on production costs. The production cost of maize green ear harvested at the dough stage in Mede Gudina, Birbirsa Siba, and Sademo Kebele was 38, 610.80 ETB per 0.6 ha of land area (Table 2). The high labor cost was attributed to the high

costs of tillage, harvest, guard, hoeing, and fertilization (36.4, 21.7, 17.3, and 14.5, respectively). Widarma and Setiawina [15] found that production and labor costs in maize farming in the study area had a positive and significant effect on farmers' production. However, maize green ear production has increased at the farm level. The current study also signifies the findings of previous studies that green ear production provides a good return on the costs incurred by farmers.

Maize green ear farming harvested at the dough stage resulted in a revenue of 384, 000.00 ETB per 0.6 ha from the sale of green ears (Table 2). Farmers also used green maize stalks for their cattle. Niu, Liu [16] stated that green maize stover is a valuable farmer resource. Maize straw is a highly nutritious and palatable alternative feed source[17] [18] [19] . Farmers sold the green ear at a low price of 8.00 ETB per ear, but the market price was 15-20 ETB per ear. This was due to the farmers' lack of market information and the presence of misleading brokers. Despite farmers selling at low prices, they profit from their maize-ear sales. Accordingly, the total income received from maize green ear farming at the dough-stage harvest was 345,389.2 ETB, with an R/C ratio value of 9.95 (Table 2). This implies that every production cost of 1,000.00 ETB incurred by farmers in maize green ear farming will result in a revenue of 9,950.00 or a profit of 8,950.00 ETB. The results indicate that maize green ear farming at early or dough-stage harvest in the study area was feasible for cultivation. Dyah and Kahfi [20] and Rinaldi [5] also found that maize green ears at early or dough stage harvest were feasible and profitable.

Table 1. Maize Varieties used for green maize production at farmer's field

S/N	Varieties	Year of release	Maturity (days)	Type of variety	Grain Yield (ton/ha)	Altitude (m.a.s.l)
1	Ambo (AMH854)	2022	190	Hybrid	8-9.3	1800-2600
2	Jibat (AMH851)	2009	178	Hybrid	7-9	1800-2600

Table 2. Income and feasibility of maize green ear farming in Wolmera district

Description		Number/Quantity	Unit price (ETB)	Total (ETB)
Production facilities cost(1):				
Maize seeds		15 kg	100.00	1500.00
Inorganic fertilizer	Urea	90	37.00	3330.00
	NPS	72.6	36.00	2613.60
Herbicides		1.5	1000.00	1500.00
Insecticides		0.54 liter	3680.00	1987.20
Total (1)				**10930.80**
Labor cost (2):				
Tillage *		3 times plow	700.00	10,080.00
Planting		12 persons	200.00	2400.00
Hoeing and fertilization		20 persons	200.00	4000.00
Pest and disease control		2 persons	200.00	400.00
Guard		4 persons	200.00	4800.00
Harvest		30	200.00	6000.00
Total (2)				**27,680.00**
Total production cost (1+2=3):				**38610.80**
Revenue (4):				
Maize cob with husk (***)		240 sacks	1600/sacks	**384, 000.00**
Income:				
Farm income (4-3=5)				**345,389.20**
Revenue//cost (4/3)				**9.95**

*The revenue is without considering the maize green stalk, * 0.25 ha takes 2 days to complete the first plow. NB: The current market price of a single ear in the Wolmera district is 15 - 20 birrs, but the farmer sold a single ear for eight birrs*

3.2 Feedback from Field Visit

The field visit was organized, and the participants were researchers, government officials, urban agricultural experts, and farmers (Fig 1). Based on this, the participants expressed their surprise at the maize green farming demonstration because the crop performance in the highland area was exciting. The participants suggested that if the work was implemented on a large scale and continuously, it would benefit the farming community. This is because it creates job opportunities for youth and women in the area, provides income, and ensures food security. This work requires training farmers, providing them with seeds, and working hard to make it successful. The market price of the green ear is high in June and July; therefore, farmers should use irrigation to grow it and provide the necessary inputs. In addition, by arranging farming patterns or planting at different times, farmers can benefit from green ear sales. The participants provided this advice. Based on this advice, the research program planned to encourage farmers to cultivate green maize on a large scale. In addition, youths and women will be invited to engage in the production of green maize for fresh consumption using potential maize varieties.

3.3 Policies Implication

The early dough stage of harvested green ear farming is profitable and feasible. However, policies from the local government and farming pattern arrangements from farmers in maize farming are needed to ensure the need for staple food reserves and to archive farmer income increments [5]. Farmers' income and maize production can be increased by applying integrated crop management using high-yielding and early-maturing varieties of crops [21]. Danso-Abbeam, Ehiakpor [22] reported that policies aimed at providing extension workers with adequate training and tools to spread advanced agricultural technology may increase the revenue of maize producers. Furthermore, while the government is presently concentrating on scaling up wheat using irrigation, and the work may be intriguing, covering a field with a single crop carries a risk of loss owing to disease outbreaks and the unfavorable effects of climate change. Therefore, agricultural patterns must be set up appropriately to benefit farming communities.

Fig. 1. Field visit of maize green ear production at Wolmera District

4. CONCLUSION

Maize green ear production in Ethiopia, which involves harvesting maize ears before full maturity, is a profitable and feasible practice. Green maize cobs fetch higher prices than maize grains of the same size, making them lucrative for street traders. The demonstration and promotion of highland maize for green ear production on a 0.6 ha land area signified that maize green ear harvested at the early or dough stage is a profitable and feasible business. In particular, from this work, farmers received an income of 345,389.2 ETB, with an R/C ratio value of 9.95. In other words, every production cost of 1,000 ETB incurred by farmers in maize green ear farming will result in a revenue of 9,950 or a profit of 8,950 ETB.

In conclusion, cultivating green maize in the study area offers economic opportunities for farmers and street vendors with a higher market value and profitability. Proper management practices, including timely harvesting during the early dough stage, are crucial for maximizing the yield and ensuring marketability. Moreover, arranging farming patterns, using high-yielding and early maturing varieties, capacitating extension workers and farmers, and encouraging youth and women will boost the production size and return for green ear farming. Moreover, to maximize benefits and expand market supply, farmers should consider using varying sowing dates—ranging from one to four times—particularly in irrigated areas. This approach allows for the production of surplus green cobs and ensures a consistent supply of fresh corn at different market times.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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