AgriNat Green Journal of Debre Berhan University, 2025, 1(2), 1-10

Journal homepage: www.journals.dbu.et

Maize Production and Productivity in Ethiopia: Trends, Challenges, Opportunities, and Future Prospects, review paper

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Article information: Received 31 December 2024; Revised on 24 May; Accepted on 24 August 2025

ABSTRACT

Depending on the regions and socio-economic conditions of the population, the maize-grain is used for various purposes including food, feed, and several industrial products. The awareness created by government extension, availability of improved maize varieties, attractive maize grain prices, improved infrastructure and market access are listed under the opportunities for improving the production as well as productivity of maize in Ethiopia. Though the productivity of maize in Ethiopia is higher, still there are some limitations which hinder the production of the crop. These limitations include the population's consumption patterns, cropping system, weed control, water and nutrient management, input supply, technical expertise, and growing conditions. Given maize's enormous potential to boost the nations and state's agricultural output, research efforts may be directed toward maximizing its productivity. A number of technological and market-related issues could be viewed as the main focus of research for the crop's future production increment. Thus, the objective of this paper is to review the overall production and productivity of maize in Ethiopia.

Key Words: Challenges, Future prospects**,** Maize, Opportunities, Production status

1. Production Trends of Maize in Ethiopia

1.1. History of Maize Production in Ethiopia

Maize farming has expanded rapidly and transformed production systems in Africa as a popular and widely cultivated food crop since its introduction to the continent around 1500 A.D (Milkias, 2019). It has arrived in Ethiopia slightly later, around the late 17th century and was mainly grown as a subsistence crop in the mid-altitudes (1500-2000 meters above sea level) in Southern, South-central, and South Western parts of the country (Abate *et al.,* 2015). It is believed that maize came from Kenya to Ethiopia. In recent history, maize has emerged as a leading cereal crop in Ethiopia. Ethiopia is the second highest maize producer in Sub-Saharan Africa next to Nigeria (Santpoort, 2020).

Nowadays, maize is one of the important cereal crops grown and is critical for food security in the country. It is Ethiopia's primary means of reducing poverty, and it provides a solution for long-term development by enhancing the standard of living for disadvantaged rural areas and boosting farmers' incomes (Zeweld *et al.,* 2020). In Ethiopia, it has shown tremendous growth, in both area harvested and production per hectare. On average, the maize area harvested expanded from 1.5 million ha to more than 2 million ha between 2001 and 2006 and 2012-2015 (Yami *et al.,* 2017). Although maize is one of the most productive crops in Ethiopia, it is not playing the expected potential role in ensuring food security due to various factors like poor soil fertility (lack of nutrient), low external input use and poor agronomic management (Abdulkadir *et al.,* 2017).

1.2. Importance of Maize in Ethiopia

1.2.1. Economic importance

Food security in Ethiopia, and elsewhere in Africa, is a major socio-political issue. The economic wellbeing of the country is also dependent on the success of agriculture. Ethiopia has long suffered from food shortages and economic underdevelopment even though it is endowed with a wide range of crop and agro ecological diversity. Cereal crops are important sources of income for a majority of Ethiopia's population. Mainly, the major cereals, such as teff, wheat, maize, barely and sorghum are the core of the country's agriculture and food economy and dominate the Ethiopian smallholder agriculture (Melaku *et al*., 2020). Among those, maize is one of the major and popular cereal crops due to its high value as a stable food, as well as its stover demand for animal feed and fuel and even for construction purposes (Abebe and Feyisa, 2017). With increased production, the driving market prices down, it became more affordable relative to other staples such as teff and wheat to rural and urban consumers. It is now increasingly used both separately as well as in mixed flour with other more expensive cereals in traditional Ethiopian diets. It is Ethiopia's most important commodity, as source of food for consumers and as source of income for farmers and the country as a whole. Approximately 88% of maize produced in Ethiopia is used as food, in both green cobs and dry grains (Dula, 2019). Maize for industrial use has also supported growing demand.

1.2.2. Self-food sufficiency and nutritional importance

Maize is the most widely cultivated crop and is of great importance to food security and livelihoods of the people (Tanumihardjo *et al.,* 2020). Eleven percent (11%) of the current world population is undernourished in terms of energy intake, and 17% suffer from micronutrient deficiencies. Finding the right balance between food and nutritional security are major challenges for sustainable food systems (Willett *et al*., 2019).

Nutritionally, maize contains 60 to 68% starch and 7 to 15% protein. The embryo which forms about 12% of the whole grain is the source of protein, fats and sugars. Opaque seeded types are more nutritious and contain a high percentage of essential amino acids which are deficient in conventional maize type. Yellow maize is the richest sources of Vitamin-A. The

presence of a mixture of arytenoids (β carotene) provided maize a specific place among cereals. Maize has more riboflavin than wheat or rice and is rich in phosphorous and potash (Sanodiya *et al.,* 2024).

1.3. Trends in area, production, productivity and market prices of maize in Ethiopia

Since 1961, maize production on a global scale has increased from 205 million tons to 1,145 million tons. Maize is the primary cereal crop grown in over half of the countries in Africa including Ethiopia, and one of the top two cereals in over three-quarters of these countries (FAO, 2021).In Ethiopia, maize is the most important crop in terms of production and distribution. Among cereals, it ranks second next to teff in area coverage with 2.13 million hectares; however, it is first in productivity (3.94 t ha^{-1}) among major cereal crops and grown by more than 10.5 million smallholder households, more commonly than any other crop in the country (CSA, 2022). Maize production in Ethiopia increased from 939 thousand tons in 1970 to 8,500 thousand tons in 2019, growing at an annual rate of 7.64%. Similarly, Maize production increased from 8,350 thousand tonnes in 2018 to 8,500 thousand tons in 2019 with a growing annual rate of 1.8% (FAO, 2020). It has been reported that a lot of households now maize is grown than any other cereal in Ethiopia. Maize is an agricultural product in most of the Ethiopia regions like the Amhara, the Oromia and the South Nations and Nationalities states.

The area of land for maize production has increased by 187% and maize yields have increased almost three-fold. As a result, maize production increased in 64-70% in maize growing regions (Iizumi *et al.,* 2018). In contrast to global maize trends, the increase in maize production was highly associated with an increase in area rather than productivity, area under maize production is increased by 275%, relative to 191% increase in yield or productivity.

Table 1: Total area coverage, production and productivity of maize in Ethiopia, 2012-2022

Years	Number of holders	Area in hectares	Production in quintals	Productivity in qt ha^{-1}
2012/13	9,289,203.00	2,013,044.93	61,583,175.95	30.59
2013/14	8,809,221.00	1,994,813.80	64,915,402.92	32.54
2014/15	8,685,557.00	2,114,876.10	72,349,551.02	34.31
2015/16	9,551,764.00	2,111,518.23	71,508,354.11	33.87
2016/17	10,862,725.00	2,135,571.85	78,471,746.57	36.75
2017/18	10,573,934.00	2,128,948.91	83,958,872.44	39.44
2018/19	9,863,145.00	2,367,797.39	94,927,708.34	39.92
2019/20	10,072,246.00	2,271,442.47	96,283,366.23	42.39
2020/21	10,189,355.00	2,526,212.36	105,570,935.92	41.79
2021/22	11,168,752.00	2,563,201.21	107,513,689.44	41.95

Source; CSA survey, 2012-2022

To meet the needs of future generations, maize production must be increased by 2.2% per year (Prasanna *et al.,* 2021). Between 1981, and 2008 maize production was estimated to have increased annually by 1.7 - 1.8% worldwide (Iizumi *et al.,* 2018). However, maize yields at the country level have decreased over the last 15 years where maize is the main staple crop including Ethiopia. Maize yields are a function of a range of variables including genetics, climate, agronomy, policy, and political stability. Without an increase in maize yield levels, the area of maize cultivation in Ethiopia must increase by 184% by 2050 to meet future food security needs (Van Ittersum *et al.,* 2016). There are a wide range of proven technologies, practices, and institutional interventions which together can sustainability increase maize production (Hansen *et al.,* 2019). Improved crop genetics, and increased fertilizer use were the key components of Green Revolution and have been widely advocated to increase maize productivity (Cairns and Prasanna, 2018), however more attention is needed and has become an issue of concern and discussion for the future increment of maize production and productivity (Rutsaert and Donovan, 2020).

1.4. An Overview of Maize Research in Ethiopia

The history of maize research in Ethiopia is about 70 years old; it was initiated at Jima Junior Agricultural College in 1952 (Ayalneh Tamrat, 2020). Currently four agro-ecologies are identified for doing research in maize: mid-altitude sub-humid, mid-altitude moisture stress, highland sub-humid and lowland sub-humid, each with respective main research centres. Maize research in Ethiopia has gone through a number of changes over the last several years, which marked critical period in terms of driving the current changes in production and productivity. Some of the key events that warrant specific methods include the 1984 major drought and famine that helped to increase the profile of maize in attaining national food security.

The introduction of national developed hybrids adapted the local production condition and the introduction of an integrated system approached for research and development (Takahashi *et al.,* 2020) is interesting to observe the gradual increases in maize production and productivity in Ethiopia. Maize research work in other disciplines (agronomy, protection (both entomology and pathology), mechanization, and socio-economics) has been conducted in different maize centres situated in different suitable maize agro-ecologies. Fertilizer type, rate, time and method of application, cultural practices, cropping system and irrigation research were the focus of agronomic research, particularly in the highland areas where maize is newly expanding. The initial public sector especially the breeder ones focus was on higher grain yield and regionally important pests and diseases resistance and subsequently adding abiotic stress tolerance like drought tolerance maize varieties (Krishna *et al.,* 2021).

Research on storage structures and improving farm implements used by maize farmers has also been done by the agricultural mechanization on research centres. The continued development of improved maize germplasms is necessary

to advance yield frontiers, bolster climate change resilience, enhance nutritional quality by means of bio fortification, and respond to emerging challenges and opportunities, including transboundary diseases and insect pests (Prasanna *et al.,* 2021).

2. Major Challenges for Maize Production and Productivity in Ethiopia

2.1. Socio Economic Challenges

In the coming decades, ensuring food security for Ethiopians will face great challenges. This is because of the rapid increment of population, change of fertile farmland to construction, climate change, and decline of available natural resources, inflation of basic needs, young unemployment, political turmoil, and civil conflict (Alemu and Mengistu, 2019).

2.2. Economic problems, Market related problems

Since maize is a major food crop in Ethiopia, any price instability in the domestic maize market is expected to have an adverse effect on other tradable and non-tradable goods (Yami *et al.,* 2020). In Ethiopia the prices of maize varied for various reasons. In most markets, the prices were typically stable due to the start of the September-to-December green and dry harvest. These market-related issues include inadequate rural infrastructure including storage, roads, telecommunications, and institutional support that contribute to higher consumer producer relations. High production expenses diminish farmer profits and restrict the advantages of agricultural commercialization (Asfaw *et al.,* 2024). In addition, the prices of various cereals including maize increased exceptionally in the North Eastern parts of Amhara and Tigray region as the conflict made markets not function properly or face severe supply shortage (Araya and Lee, 2024).

2.3. Input Supply and Use Problems

Unavailability of improved seed and lack and adoption of production inputs were the two major constraints that were reducing maize productivity (Thapa, 2021). Most of the time, Ethiopian farmers have used organic fertilizers (such as farmyard manure, compost, crop residue) for maize production.

2.4. Technical Knowledge Problems

Lack of education and training, provision of input credit, land tenure, and timely availability of critical inputs are found to be important factors influencing the technical efficiency of maize farmers (Tenaye, 2020).

2.5. Agro Ecological Problems

2.5.1. Climate change

Global agriculture is facing the probable impact of global warming. Recent studies suggest that the production of major commodities has declined since 1980 due to global warming (Lobell *et al.*, 2011). It is estimated that, given current warming trends in sub-Saharan Africa, the production of major cereals could decline by as large as 20% by mid-century. Among African countries, Ethiopia is vulnerable to climate change and it posed a huge challenge to Ethiopians. It varies from season to season, and year to year in across agro-ecological regions (Dega (high land), Woina Dega (midland), and Kola (lowland)) of the country (Shekuru *et al.,*

2020). Climate change is set to further exacerbate the occurrence and impacts of biotic stresses, such as diseases and insect-pests, driving the emergence of new threats (Burdon and Zhan, 2020; Deutsch *et al.,* 2018).

2.5.2. Soil type

Soil, being the natural medium for plant growth, has a direct impact on the yield and quality of crops growing on it. Maize performs best on soils which are deep, loamy, fine-structured, well-aerated good drainage, with adequate amount of organic matter and well supplied with nutrients. Cultivation of improved maize varieties without balanced nutrient management further aggravated the problem of nutrient depletion and was reported to be yield limiting factors. Soil fertility needs to be maintained, agricultural systems need to be transformed to increase the productive capacity and stability of smallholder crop production (Nicholls *et al.,* 2017). To produce one ton of maize grains, the plant consumes 24 kg N, 3 kg P, 23 kg K, 5 kg calcium (Ca), and 4 kg magnesium (Mg) from the soil (Laekemariam *et al.,* 2016). Crop growth and development characteristics, especially for a crop such as corn are very sensitive to changes in soil fertility.

2.5.3. Shortage of rainfall (Drought)

In addition to inherently high climate variability, the looming threat of higher temperatures and more vicious droughts is a major concern that reduces the productivity of cereals including maize. It is characterized by an unequal distribution of rainfall in both time and space. It is a major abiotic constraint affecting maize production in Ethiopia. Climate instability has resulted in variation of the intra-and inter-annual rainfall and made drought a recurrent problem (Nzaro, 2020).

2.5.4. Crop pests and diseases

High incidences of diseases and insect-pests have also presented a continuous challenge to cereal productivity in Sub Saharan Africa. Since 2016, maize crops in over 40 countries in Africa including Ethiopia have been adversely impacted by the invasion of different insect pests (Kassie *et al.,* 2020). Some of the common insect pests affect maize crops are stem borer, stalk borers, spotted stem borer, aphids, cut worms, fall armyworm, African bollworm and weevil. They can be controlled by cultural practices, such as crop rotation, early planting, use of push-push technology, field sanitation treated seed with insecticides before sowing and apply insecticides like Dimethoate, Malathion, Karate, etc. (African Agricultural Handbook Series, 2017).

Maize is also vulnerable to a number of diseases that reduce yield and quality. The most common disease of maize are Maize lethal necrosis disease, Maize Cob rot, Maize Grey leaf spot, Maize Rust and Maize Leaf Blight caused by virus, bacteria and fungi. Leaf diseases reduce the photosynthetic area of the plant which in turn reduces grain fill in the ears. Ear and kernel rots decrease both yield and quality (Keno *et al.,* 2018). They can be controlled by the use of cultural practices such as crop rotation, use clean seed, treated seeds with chemicals, etc. and use of different chemicals and Integrated Disease Management (IPBO, 2017)

3. Maize Production and Productivity Opportunities in Ethiopia

In Ethiopia, the increase in maize productivity and production in the past decade is the result of various opportunities including awareness created by government extension support, availability of improved maize varieties and other technologies, relatively attractive maize grain prices in most of the years and improved infrastructure and market access. Thus, it seems that sustainable increments in maize productivity and production in Ethiopia depends on availability of improved maize technologies (improved seed and other inputs), availability of irrigation water, soil conservation and fair grain prices (Abate *et al.,* 2015).

3.1. Stress-tolerant and nutritious maize varieties

High yielding, stress tolerant and nutritious maize varieties adapted to the major agro-ecological zones are available for production and delivery to farmers. Ethiopia's National Maize Research Program released various quality protein maize varieties namely; BH542, BH545, BH548, Melkassa-1Q, Melkassa-6Q, MH138Q, AMH760Q, and AMH852Q that have been adapted to the country's mid-altitude, low moisture stress, and highland agro-ecologies. These products can provide good opportunities for sustainable intensification of production to close the yield as well as nutritional quality gap of maize (Yadesa and Diro, 2023).

3.2. Improved crop management practices

There are various agronomic practices that reduce the yield gap of maize production in Ethiopia. Those practices include; land preparation, sowing and fertilizer application, irrigation, crop protection (diseases, insect pests and weed control), cropping system and harvesting. All the above crop management practices should be on their recommended production package to boost the productivity of maize crop unless it declines the yield of the crop (Yadete, 2024).

3.3. Presence of strong public-private partnerships for product delivery

The presence of strong partnerships with the private sector and community-based seed producers as well as non-governmental organizations (NGOs) has created an excellent opportunity to deploy products adapted to Ethiopia at much higher scale for greater impact at farm level (Domínguez, 2022).

3.4. Dual-purpose maize

The decline in farms size has been seen livestock being edged out of the farm and the decline in the number of livestock units on the farm. The model of land set aside for crops and a different one for livestock feed only means more competition between food and feed. Dual-purpose maize can mitigate this as it ensures co-existence of crops and livestock on the farm (Grings *et al.,* 2013). The development and availability of such maize varieties can promote diverse utilization of maize, increase income generating opportunities for farmers and processors, reduce the labor requirement of women at household level, and contribute to reduction of waste.

3.5. Experiences in Maize Technology Transfer

To increase production and productivity, improved maize technologies have been popularised and disseminated. Demonstrations on farmers' field and training of farmers were some of the mechanisms to increase farmers' awareness and facilitate technology transfer. Thus, there is not only the need to better understand about agri-food systems, food self-sufficiency and food security but also to monitor the transformation of important maize technologies (Fanzo *et al.,* 2021) with important feedback and learning implications.

4. Future Prospects for the Production and Productivity of Maize in Ethiopia

As the crop has huge potential in the agricultural output of not only in Ethiopia but also the entire state as a whole the research directions may be focused for maximization of maize production and productivity. Keeping these in view, maize productivity technology and market related issues may be considered as the thrust area of investigation for the future.

4.1. Technological Issues

Trials may be conducted on selection and recommendation of the best hybrids considering the micro-situations prevailing in maize growing districts of Ethiopia. As maize is cultivated with a wide range of plant stand and planting geometry, research may be carried out for the best option in the region. Nutrient management in maize cultivation in the region is non-judicious and it implies scope for experiment on Integrated Nutrient Management (INM) and more precisely Site Specific Nutrient Management (SSNM) (Chaudhari *et al.,* 2024). Moreover, adoption of precision farming in maize cultivation may be another option for agricultural sustainability in the country. Weed management is also a problem in maize cultivation; hence, research may be carried out on integrated weed management. In addition, maize is cultivated with wide row spacing and crop growth during early period is slow, this creates enough potential to adopt intercropping system. Research may be also conducted for standardization of suitable maize-based intercropping system (Sagar *et al.,* 2019).

4.2. Market Related Issues

There is an opportunity of improving the efficiency of maize value chain in transfer of the modern technologies and other market services. Moreover, investigating trade competitiveness of Ethiopian maize with other producing countries under the changing trade scenario and thus there may be scope for exploring options (Sagar *et al.,* 2019).

5. General Conclusion

Maize (*Zea mays* L.) is one of the most important cereal crops in the world, ranks third position among other cereals after wheat and rice. It is also the second most widely cultivated crop in Ethiopia. It has been considered as an imperative crop by the Ethiopian government aiming at improving food security and essential source of income for farmers and economic benefit to the country as a whole. The opportunities for maize productivity and production in Ethiopia includes; awareness created by government extension support, availability

of improved maize varieties and other technologies, access to irrigation, improved infrastructure and market access. In spite of, all the endeavors and advance made so far in improvement and dissemination of maize technologies for various agro-ecologies, the biotic and abiotic constraints shall remain the major limiting factors for increasing maize productivity and production. Thus, development of improved maize technologies should be a continuous process for tackling the previous challenges to meet the changing farming system needs. In addition, maize research in Ethiopia should be enhanced by maize improving techniques for better progress in the future.

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