ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 22 No. 10 December 2022 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2022; 22(10):21863-21889 https://doi.org/10.18697/ajfand.115.22420

SOCIOECONOMIC DETERMINANTS OF MAIZE PRODUCTION AMONG NORTH WESTERN ETHIOPIA'S SMALL-SCALE FARMERS: EVIDENCE FROM THREE AGRO-ECOLOGY ZONES

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ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 10
December 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Knowing the primary maize production constraints that could lead to poor productivity which in turn lower farm income is essential to close the gap between desire and actual yield. As a result, this survey was conducted to assess the constraints on maize production across West Gojjam Zone in three districts: Jabi Tehnan, Bahir Dar Zuriya, and Mecha. Based on maize production potential, coverage, and the importance of maize in the livelihood of farmers in the study area, 10 km by 10 km X and Y geographical coordinate points as the main grid, and a quadrangle 1 km by 1km square grid was generated. Data were gathered from primary and secondary sources. We used both qualitative and quantitative data collection techniques to gather primary data. A structured questionnaire was administered to 252 randomly selected sample farmers and their farms as part of the qualitative data collection. According to the findings, farmers in all three districts were dominantly married, of working age and with extensive farming experience. The smallest and most fragmented production land was located away from the house. The most common fertilizers were urea, DAP and NPS, from which a large proportion of the farmers used urea more than others and there was difficulty in getting fertilizers from regular sources and at the right time at all of the research sites. The majority of farmers in the research area utilized local seeds than improved seeds. Weed and insect pest attack in the maize field were very low. Furthermore, the largest portion of farmers had a very small production area which they plowed repeatedly. As a result of this study, it is possible to conclude that socioeconomic, fertilizer, seed and land preparation factors impact farmers in all three maize production systems. In this regard, it is suggested that more attention should be paid to these yield-limiting factors.

Key words: Maize production, input, farming experience, *Zea mays*, land distributions, productivity, Ethiopia

INTRODUCTION

In Ethiopia, 25.5% of the population is food insecure, and around 18 million people live through emergency food assistance and productive safety net program [1]. Agriculture is the backbone of the Ethiopian economy, where it contributes about 43% of the gross domestic product (GDP), employs 80% of the total labor force, which is more than two-thirds of Ethiopia's population and contributes to 70% of foreign exchange earnings [2]. The poverty reduction efforts in Ethiopia have to put significant emphasis on improving agricultural productivity. Despite diverse crop and agro ecological diversity, people have long faced food shortages and economic underdevelopment due to the fact that production and productivity are remaining low for most of the country but there have been clear signs of improvement over the past decade [3].

In Ethiopia, smallholder farmers produce maize on 2,274,306 hectares (21.70%) of the total area used for grain crops and 30.88% of the cereals produced [4]. In terms of yield, sorghum *(Sorghum bicolor),* wheat, teff *(Eragrostis tef Zucc. Trotter)* and maize *(Zea mays L.)* contribute 30.88% (105,570,935.92 quintals), 16.12% (55,099,615.14 quintals), 16.91% (57,801,305.96 quintals) and 13.22% (45,173,502.18 quintals) to the production of grains, respectively [5]. Considering its importance in terms of wide adaptation, total production and productivity, maize has been selected as one of the high-priority crops to feed the increasing population of Ethiopia [6].

Approximately, 88% of maize produced in Ethiopia is consumed as food, both as a green and dry grain. Unlike its neighbor, Kenya, which imports a large portion of its food, Ethiopia has gradually increased its maize output self-sufficiency since the early 2000s [7]. It has even exported some surplus to neighboring countries (such as Sudan and Djibouti) during years of surplus production [8].

According to research findings, fertilizer may be responsible for 50% of the output difference in sub-Saharan Africa, which is one of the most important factors identified as impacting grain yield globally, along with irrigation and climate [9]. However, these global factors may not always be the leading factors at the local level especially when agronomic management practices are not optimized.

Although the potential of maize production and productivity in Ethiopia is satisfactory, the national average yield, 3,430 kg ha-1, is still far below the world average of 5,500 kg ha-1 [10]. The yield of maize is less in Ethiopia (3,430 kg ha-1) compared to other countries like Germany (8,828 kg ha-1), Italy (8,899 kg ha-1),

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Volume 22 No. 10
December 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Canada (9,988 kg ha-1), Argentina (6,603 kg ha-1) and China (6,016 kg ha-1) [11]. Due to the significant yield gap in Africa, particularly in Ethiopia, compared to global yield, there is the potential for production improvements [12].

To develop intervention plans and focusing on tangible investments and policy assistance on improving smallholder agricultural output, the government must first recognize basic production constraints and yield enhancing variables at the farmer level. Because distinct constraints influence various regions' productivity and yield potential, region-specific management adjustments and interventions are necessary to reduce the observed yield gap [12].

North-western Ethiopia is one of the most important regions with great potential for maize production in the country [13]. These areas are categorized among the maize crop belt areas of the country. However, maize productivity has remained low, with an estimated local average yield of 2500 kg ha-1 which is lower than the national (3430 kg ha-1) and also the world (5500 kg ha-1) due to several constraints: biotic (inadequate improved varieties, pests, and diseases), abiotic (low soil fertility, land and water degradation, and drought), and socioeconomic (input unavailability, lack of storage facilities, poor access to markets) [9]. In addition, the low yield of maize is associated with low adoption, ignorance and accessibility problem of productivity-improving technologies such as improved seeds and some agronomic activities [personal observation]. Farmers' low adoption of technologies developed by research institutions shows the need for client orientation in research. As a result, a wise understanding of the context is essential, such as agronomic activities, farmers' preference for improved varieties and the adoption of technologies and farm inputs to identify the root problem and thus find ways to boost productivity and stabilize the situation. Furthermore, farming systems must be understood to identify and implement necessary interventions for increased maize productivity. A more detailed region-specific analysis of the maize system and its potential opportunities and possible constraints is required for effective targeting of research and development efforts. As the aforementioned probable production controlling factor for the observed yield gap, however, low-cost approaches for identifying and understanding contributing factors, as well as identifying the implications of agronomic management practices, to measure an important entry point towards increasing food production and reducing within-site yield gaps, have not been well documented. The current study is, thus, intended to draw together and document maize production systems through meticulous regard on agronomic management systems existing in the study area, household and farm characteristics, cultural practices, diseases and pests and their control, yield and key general productivity constraints of maize.

ajfand SCHOLARLY, PEER REVIEWED
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ISSN 1684 5374

MATERIALS AND METHODS

Site description

This study was conducted on three representatives, potentially maize producing districts in the north part of western Ethiopia: Jabi Tehnan, Mecha and Bahirdar Zuriya Districts (Figure 1) between 15th July and 24th October 2018.

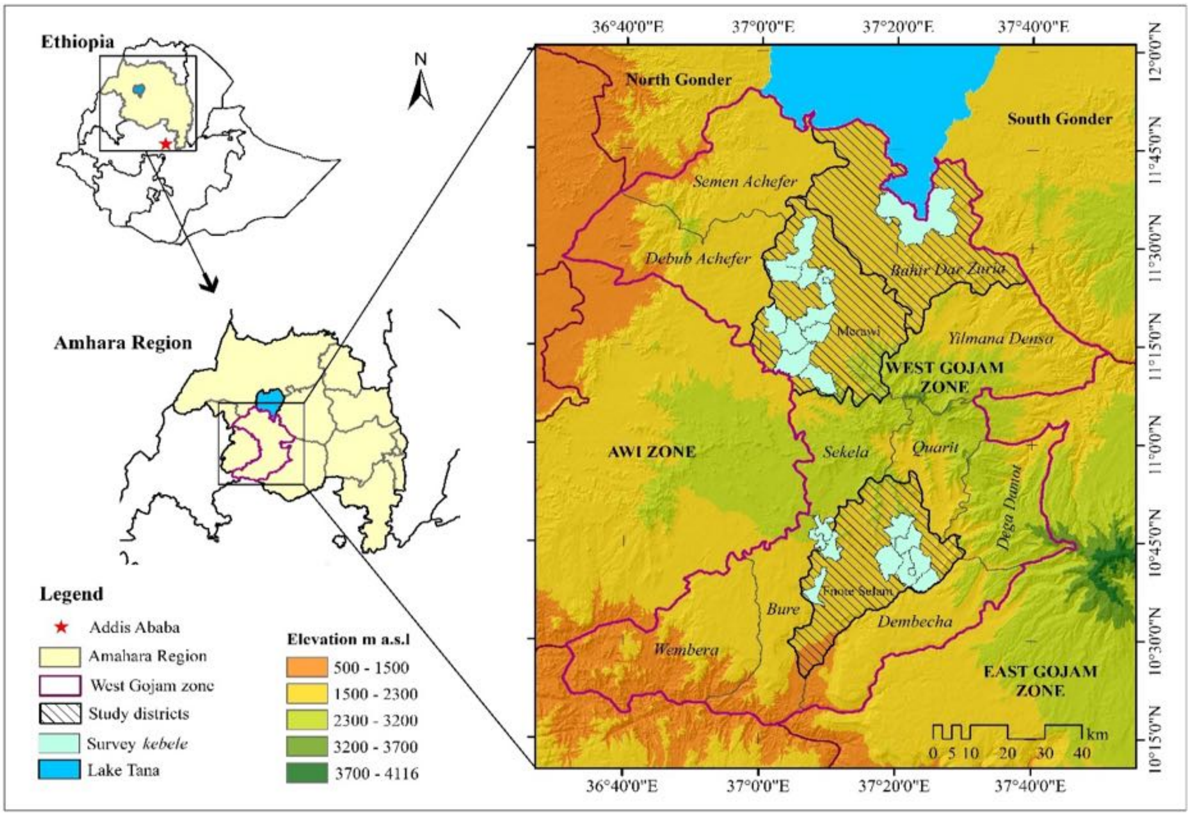

Figure 1: Location of the studied districts

Jabi Tehnan: The total area of the district is estimated to be 1,170 km2 (116,954 ha). The district receives a mean annual rainfall of 1,300 mm. The minimum and maximum daily temperatures of the area are 14°0 C to 32°C. The maximum temperature ranges from 14°C to 32°C, respectively. The altitude of the district ranges from 1,500-2,300 m above sea level. The majority of the area lies in the higher altitude range, closer to 2,300 m, Agro-ecologically, 88% of the district is classified as Woyina Dega (highland) and the remaining 12% as kola (hot lowland) [14].

Mecha: The total area of the district is about 156,027 hectares. The mean annual rainfall ranges from 1,000 mm to 2,000 mm. The minimum and maximum temperatures daily temperatures of the area are 11°C and 29°C, respectively. The altitude of the district ranges from 1,800 to 2,500 m above sea level. Eighty percent of the district lies in the mid-altitude area and the remaining 20% is in the Dega (cool high-altitude) climatic zone. Soil types in the district are Nitoisols and Vertisols with dominating soil colors are 93% red, 3% black and 4% gray [14].

Bahir Dar Zuriya: The land has an area coverage of 151,119 ha [15]. The area receives an average annual rainfall ranging from about 820 to 1,250 mm. The minimum and maximum daily temperatures of the area are 10 and 32°C, respectively. It is situated at an altitude ranging from 1,700-2,300m above sea level. The district has predominantly Woina- Dega climatic zones. Soil types in the district have dominating colors of black (3%), red (93%) and brown (4%) with heavy clay, medium clay and loam texture [16].

Sampling procedure

The study was conducted in three districts from the West Gojam administrative zone, namely Jabi Tehnan, Mecha and Bahirdar Zuriya, Using a two-stage sampling technique, representative farm households and farm plots in the study areas were selected. The districts are well known for their potential for maize production and the value of maize to farmers' livelihoods both regionally and nationally. In the first stage, based on production coverage, agro-ecological uniformity and clustering of maize production, three, two and one 10-km by 10-km X and Y geographical coordinate points were taken from Mecha, Jabi Tehnan and Bahir Dar Zuriya districts, respectively, to develop the main grid frame by using the Global Positioning System (GPS) (Table 1). Finally, using ArcGIS software (10.5), a 1-km by 1-km sub-grid cell within the main grid frame was generated and numbered sequentially (1 through 100, starting from the top left corner and proceeding left-to-right, row-by-row), and then seven systematic unaligned samplings (sub-grid cells) from each main grid. Six respondents from each sampled sub-grid were selected using simple random sampling method. Accordingly, 126,84 and 42 respondents were selected from 21,14 and 7 sub-grids, in Mecha, Jabi Tehnan, and Bahir Dar Zuriya, respectively. Finally, a total of 252 sample respondents of maize producers were interviewed (Table 1).

Selection of farmers was done in a group effort with village leaders and agricultural extension experts considering maize production and farmers' interests.

Data collection

Both quantitative and qualitative data collection techniques were employed to collect primary data Personnel observation and key informant interviews, such as discussions with woreda and kebele level leaders and agricultural experts, were employed in the qualitative data collection techniques. Different ranking and scoring systems were also employed in focus group discussions [17]. Focus group discussion was used to identify common problems facing the rain-fed maize small-scale farmers in the study areas. The discussion was guided by a checklist that covered issues related to maize production constraints, solutions for managing maize production constraints, characteristics preferred by farmers in summer rain-fed maize production and agronomy activities that they would like to grow maize and extra general information. During the discussions, farmers also scored and ranked major maize production constraints in their areas. Preliminary Roost Assessments (PRA) scoring and ranking aid was followed in identifying the group's priorities [18].

Each enumerator (person who assisted respondents in answering the questions and in completing the questionnaire) engaged in this survey monitored the focal persons and supervisors to ensure the correctness of collected data at the end of each day. The questionnaires loaded into the Open Data Kit (ODK) mobile application, included household demographic characteristics (household head educational level, marital status, sex, age, family size, land resource data (land size, distance from home and year of production in the last ten years), agronomic practices and inputs (seed and its sources, field management). Before launching the survey, a questionnaire was pretested and was improved accordingly. Focal persons, supervisors and enumerators had been trained and pre-tested with the tool by a group of experts before the actual data collection. The focal persons and supervisors made the survey work easier by establishing good relationships with district agricultural professionals, local agricultural extension agents, and village administrators. They also provided hard copy lists of farmers to be sampled for cross-checking, assisted the ODK on tablet phones whenever technical problems arose, and organized transportation for enumerators.

Data analysis

The data, which were collected from survey and field assessment, were subjected to descriptive statistical analysis such as percentages and frequency.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 22 No. 10 December 2022 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

RESULTS AND DISCUSSION

Household characteristics

Gender

The farmers' gender (Table 2) was a stand-in for their managerial skills, which they used to make farming decisions including what to plant, when and how much to sow and how much to sell. Out of the total respondents, smallholder farmers involved in maize production in the three districts headed household (95.23% at Jabi Tehnan, 95.24% at Bahir Dar Zuriya, and 97.6% at Mecha) were higher than female headed households. The share of female respondents at Jabi Tehnan, Bahir Dar Zuriya and Mecha was 4.76%, 4.76% and 2.38%, respectively (Table 2). This indicates that the participation of females in the area is minimal. The outcome proves that male-headed households mainly dominate the area. Being dominated by male-headed households may not negate the adoption of technologies. Some research findings indicate that male-headed households have a higher adaption rate to technologies than females headed households [19]. Other researchers' findings indicate that female-headed households use more technological inputs and are better at adoption than male-headed households [20]. These contrasting issues could be solved by involving both males and females. However, in a country like Ethiopia, unless a cultural shift occurs that considers males as primary farm activators and women to be housewives, the situation will remain as it is. This will hamper maize production's technological adoption, efficiency, access and technological use in the farming community [21].

Marital status and household size

The farm family is the primary source of labor for agricultural activities in subsistence agriculture. In all of the three districts the proportion of married farmers was higher than divorced farmers, polygamous farmers and single farmers. The higher married households (97.62%) was recorded at Bahir Dar Zuriya followed by Jabi Tehnan (95%) and Mecha (94.4%) (Table 2). A research report indicated that the dedication level of married farmers is higher than unmarried farmers, which can create an imperative impact on the production and productivity of maize [22]. The research areas have a fairly high number of married farmers, which could be advantageous for crop production in general and maize production in particular in the future. Oxen-drawn plowing is used by farmers, which was impossible for women to do due to widespread cultural norms. As a result, married women typically lost access to land when their husbands died or when they were divorced or widowed. Female heads of households were generally engaged in lending out their lands to sharecropping [23]. They were in a collaborative relationship with their husbands. As a result, women face gender-specific constraints related to

https://doi.org/10.18697/ajfand.115.22420

socio-cultural forces that reduce their agricultural productivity and limit their ability to ensure production [24]. The average household size for the three districts was between 4 and 6. This range accounted for 45.24%, 61.9% and 57.1% in Jabi Tehnan, Bahir Dar Zuriya, and Mecha districts, respectively. The second-highest household size was 7-9 in all three districts. Mecha had the largest (> 12) household size of the three; 1.58% of the households registered a family size of more than 12, but none of the other districts did. (Table 2). According to Oluwasola and Alimi [25], having a larger family size can create better labour which can be put on the management of crops. Household size was positively associated with net farm revenue, implying that the larger the family, the more labour donated to the farm business. Thus, the larger the farm, the higher the farm income [26]. According to Noack and Larsen [27], while farm output per unit of land decreases with increasing farm size, farmer income and consumption increase. Agricultural production decreases with farm size, which has a negative impact on consumers, whereas agricultural income increases with farm size, which has a positive impact on producers. A one percentage increase in farm size reduces output per unit of land by 0.18% while increasing output per unit of labor by 0.22%, according to the results of this specification. In the study area, as the average household size was 4-6 and most of them were adults, it can create good working power, creating an atmosphere for further enhancement in maize production.

Age and educational level

The age of the household is considered a decisive factor because it determines whether the household benefits from experience or has a foundation for its decisions on risk-taking behaviour. This study revealed that the average age of the respondents in the majority of households in Jabi Tehnan was 35-44 (highly productive), followed by 25-34 (more productive), and 45-54 (productive), (Table 3). According to Tauer [28], farmers' productivity increased with age for the age groups of 25-34, 35-44 and 45-54, respectively, as did their output per dollar (15,593,301), 44,573,767 and 98,724,744). According to the survey results, the majority of households in Bahir Dar Zuriya and Mecha had an average age of 45-54 (productive), followed by 35-44 (highly productive), and > 55 (less productive).

Farmers producing maize in all three districts were in their active productive age. Farmers who are at a productive age are more likely to succeed in investing an effort in improving productivity [29]. A farmer’s age also has a distinctive impact on adopting and using technologies. It is associated with farming experience and planning for the horizon. In such cases, young farmers have better adoption of technologies and are receptive to change. Whereas, older farmers have a characteristic of less disposition for change and adoption of new technologies [30].

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Because the age groups in the research areas are mostly young and productive, if the rate of technology adoption becomes high due to the impact of their age, it may be regarded as a benefit.

Education can encourage farming households to try out and adopt modern technologies that improve farm production. Most of the population in the surveyed districts had attended or completed high school (44, 47.6 and 45.24%) and followed by elementary (30.9, 33.3 and 34.13) in the Jabi Tehnan, Bahirdar Zuriya, and Mecha areas, respectively). Farmers who had not received any education were 14.28, 4.8 and 7.94% in Jabi Tehran, Bahir Dar Zuriya, and Mecha, respectively (Table 3). In all study districts, a non-significant number had attended above high school and university at a magnitude of 1.2, 2.4 and 3.2, in Jabi Tehran, Bahirdar Zuriya, and Mecha, respectively (Table 3). Hence, even though the other factors are on the positive side of increasing production, having less education will negate technology's use of efficiency, production and the adoption rate of new technologies. In agreement with this, the researchers reported that there is a direct relationship between the educational levels of the household and improved maize technology adoption [31].

Framing experience

The farming experience of any crop is one of the measurements that can determine the success and productivity of the crop. The survey results indicated that at Jabi Tehnan most of the farmers (52.38%) had farming experience of 16-30 years. Respondents with 31- 45 years of maize farming experience accounted for 7.14%. In Bahirdar Zuriya, 38.1% of the respondents exhibited a farming experience of 31-45 years. The next percentage, 28.6%, was accounted for by farming experience of 16-30 years. As compared to the two zones, the lowest maize farming experience in years was recorded in Mecha (Table 3). The highest proportion was recorded at 16-30, which was 49.2%, followed by 1-15 years, which was 33.3%. Some farmers have more than 45 years of farming experience, despite the fact that the ratio is lower in all three study districts (2.3, 7.1, and 2.4% in Jabi Tehran, Bahirdar Zuriya, and Mecha, respectively) (Table 3). Across three districts, the farming experience can be counted as high and could give improved maize production According to the Läpple [32], based on their research work on the adoption of precision farming, they concluded that farmers with higher farming experience have a lower adoption rate of improved technologies than new farmers. This could be a negative indication of the adoption of new technologies in the future in research areas. However, the verification of many research reports has indicated that having a higher farming experience enhances farmers' product knowledge and technical efficiency [33].

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ISSN 1684 5374

Production land distance from home

When a farmer's' home and a production site are far apart, on-time plot preparation, weeding, harvest and input utilization and farm revenue are less likely [34]. Out of the respondents at Jabi Tehnan, 97.6% indicated that maize production land distance from home was a 0-30 min walk. The time required for one round trip was about a maximum of 1hr (Table 4). Similarly, 92.9% of respondents in the Bahirdar Zuriya and 96.03% of respondents in Mecha reported that their home was within 0-30 minutes walking distance from a maize farm. The influence of production land distance from home is supported by research reports on the impact of farm distance on labor utilization and organic fertilizer use. According to Feng *et al.* [35], there is a significant impact of land distance on labor use and green manure application. This indicates that there has been a reduction in the amount of working power. According to McCall [36], farm distance from home is not a significant factor in farming systems but its effect is mainly on cropping choices, livestock integration and input use. As a result, it is expected that the distance from home affects the determinant factors listed above in the study areas.

Production land size

Due to the productive potential of huge farm sizes, larger farm holdings are engaged less frequently. This may limit off-farm involvement but diversify agricultural activities [37, 38].

A land plot size of 0.125-0.25ha was reported by 60.07% of respondents in Jabi Tehnan, 64.3% in Bahirdar Zuriya and 52.3% in Mecha. Following this, 28.6% of farmers in Jabi Tehnan, 33.3% in Bahir Dar Zuriya and 33.3% in Mecha possessed lands with 0.25 to 0.50 hectares in size. Only 0.79% of respondents from Mecha reported owning land larger than 2 hectares (Table 4).

The results showed that the farmers across the study areas owned very small land.

Having such a small share could lead to a strong decision to select the crop with the most economic impact and a mainstay. This could affect maize production in the study areas. Due to the small size of the production land and its low production cost requirement, farmers may be motivated to exert maximum effort to maximize yield through intensive use of renewable (human resources and seed) and non-renewable resources (human resources, chemical fertilizers, chemical pesticides, and electricity). A similar finding was reported by Fallahinejad *et al*. [39], the share of purchased renewable and non-renewable resources were 50.61, 42.70 and

45.50% in small, medium and large-scale farms, respectively. Contrasting research reports on the relationship between farm size and agriculture productivity are available. Liu [40] reported that farm size and agriculture productivity have an inverse relationship. It was also indicated that after improved agricultural technologies, it looks like an increase in farm size enhances agriculture productivity to the maximum [41]. According to Paustian and Theuvsen [42], labor productivity increases with an increase in farm size. Based on this evidence, the production of maize could be highly influenced by the land size of the respondents.

Land preparation

In Ethiopia, plowing by oxen has been a common farming system from time immemorial. Tractors are now used by small-scale farmers in some areas of the country [43].]. But, the farmers at Jabi Tehnan, Bahir Dar Zuriya and Mecha districts seem like they have not yet started to use tractors in their farming. All of the respondents across the three districts responded that they plowed by oxen as a means of land preparation for maize production (Table 4). The system of oxen plowing has its disadvantages in terms of natural resource degradation, soil erosion and uneven tillage depth [43]. But due to minimal availability and the high cost of plowing by tractors, farmers across different parts of Ethiopia prefer traditional plowing [44]. The highest number of respondent farmers (70.24%, 54.76% and 68.25%) at Jabi Tehnan, Bahir Dar Zuriya, and Mecha, respectively, tilled their land one to three times before sowing the maize crop (Table 4), followed by four to six times and seven to nine times, respectively in all three districts (Table 4).

Tillage frequency increases land degradation to a great extent and could be the main cause of land degradation in Ethiopia [43]. There was no soil testing of the farmers' fields in all three districts for the past three years. Maize land soil testing was not common among 97.6% of farmers in Jabi Tehnan, 100.0% of farmers in Bahir Dar Zuriya and 91.25% of farmers in the Mecha field. Except for 31.75% of the farmers' fields in Mecha, the remaining two districts had no irrigable plots of land [45].

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Input use

Seed type and rate

Farmers in the study area grow hybrids, landraces and improved open-pollinated types of maize on the same or different fields. Landrace types were grown by a larger percentage of farmers, 77.38, 59.6 and 61.9 %, in Jabi Tehnan, Bahirdar Zuriya and Mecha, respectively. Whereas farmers who grew improved varieties were 22.62, 40.4 and 38.1% in Jabi Tehnan, Bahirdar Zuriya and Mecha, respectively (Table 5). These are either local varieties or seeds from improved varieties that have been recycled. The maize production system, by improved seeds, enhances the technical efficiency of production [46].

Out of the total respondent farmers, 71.43% of Jabi Tehnan, 90.48% of Bahir Dar Zuriya and 79.4% of Mecha used a seed rate of 0.5-10 kg per ¼ ha of land. In the districts of Jabi Tehnan, Bahir Dar Zuriya and Mecha, 15.4%, 4.76% and 13.5% of farmers respectively used a seed rate of 10.1–20 kg per 0.5 ha (Table 5). In Jabi Tehran, Bahirdar Zuriya and Mecha, the proportion of farmers who used a seed rate of 20.1–30 kg per 0.5 ha was 9.5, 2.4, and 5.5%, respectively. However, some farmers in those three districts utilized more than 30 kg/ha of maize seed (3.6, 2.38, and 1.6% in the Jabi Tehnan, Bahirdar Zuriya, and Mecha areas, respectively. This indicates that a higher percentage of farmers across the study areas use seed rates lower than the national recommended rate of maize seeds, which is 25-30 kg ha-1. This could cause yield reductions in the study areas. Most farmers used the local variety rather than the improved ones in the study areas. It could be attributed to the lack of availability of improved seeds, a poor research extension system and farmers' preference for local varieties. In agreement with this, Tura *et al*. [47], reported that the adoption rate of improved maize varieties seed by farmers varied across the nation from 0 to 58%. In contrast, Yu *et al*. [48], reported that the adoption rate of improved seeds in East Gojam was 58%, which is an indication that above half the maize-producing farmers are willing to take the improved maize seeds. The statistical reports summarized by Gecho and Punjabi [49], indicated that the adoption of fertilizer combined with local seeds is the main mode of modern technology adoption.

Fertilizer accessibility and measures to mitigate its scarcity

Fertilizer access has been one of the limiting factors in cereal production all over Ethiopia. It is also one of the determining factors in maize production in the research areas. According to the respondents, 57.1% of Jabi Tehnan, 57.1% of Bahir Dar Zuriya and 69.05% of Mecha districts were not able to get sufficient fertilizers from the usual source. The lack of fertilizer supply is mainly due to delayed supply and national and stock shortages (Table 6). This could significantly reduce the production and productivity of maize across the study areas.

The non-availability of fertilizers on time significantly affects the yield of crops and the adoption of improved seeds [50]. The delayed application also reduces the fertilizer use efficiency and productivity of the maize crop. At Jabi Tehnan, the larger proportion of the respondents suffered from a delay in supply (48.8%) and a national shortage (27.4%). A higher proportion of maize-growing farmers in the Bahir Dar Zuriya faced fertilizer shortages due to a national shortage (38.1%) and a delay in supply (33.3%) (Table 6). The case in Mecha indicated that 100% suffered from a delay in supply and 11.1% of them from the national shortage. Farmers' reactions varied across districts when fertilizer was in short supply. As the shortage of fertilizers piles pressure on the farmers’ maize production, their response is summarized as either they did nothing or they traveled to another location to find fertilizer. Some farmers bought and borrowed from other farmers. At Jabi Tehnan, 50% of the farmers traveled to other locations and 28.6% did nothing. Similar to Jabi Tehnan, the larger portion of farmers either traveled to other locations to find fertilizer or did nothing. The unique case in Mecha and Bahir Dar Zuriya is that the farmers borrowed fertilizer from each other, unlike in Jabi Tehnan (Table 6). One of the primary factors affecting fertilizer use in Ethiopia is the availability and cost of fertilizer. Similarly, respondents throughout the study area experienced a lack of fertilizer supply on time and in the required amount [51].

Fertilizer types and their application

Low soil fertility, lack of balanced fertilization and ineffective soil management techniques have all contributed to the historical agriculture sector's low productivity. One major impediment to increasing fertilizer use efficiency in the country has been lack of information about the fertility status of the cultural land [52]. Assessing the soil fertility status is important so that fertilization recommendations can be based on soil test results. In Ethiopia's farming communities including the study area, the application of both organic and inorganic fertilizers is a common practice. Urea, DAP and the recently introduced NPS fertilizers are the most commonly used inorganic fertilizers [53]. The organic fertilizers are mainly farmyard manure, compost and in some areas, chicken manure.

Among farmers from the Jabi Tehnan district, 71.43% applied urea, 46.43% applied NPS, 11.9% applied manure and 4.8% applied compost (Table 6). The use of these fertilizer categories could enhance the production and productivity of maize in the research areas [54]. According to the findings of this study, the majority of respondents at Jabi Tehnan used inorganic fertilizers than organic ones. In the case of Bahir Dar Zuriya, 78.57% of the farmers applied urea, 61.9% applied NPS, 33.3% of respondents applied manure and 21.43% of them applied compost. This indicates that, even if the application of inorganic fertilizers at Bahir Dar Zuriya is higher, a large portion of farmers still apply organic fertilizers for maize production. According to the respondents at Mecha, 80.9% of applied urea, 51.6% applied NPS, 28.57% applied manure, and 17.46% of respondents used compost (Table 6).

The dominance of inorganic fertilizers over organic fertilizers is also a common trend in Mecha. This research result agrees with the report by Tollenaar *et al*. [55], which indicated an increase in fertilizer use by maize farmers across the country. The newly introduced fertilizer NPS method is variable from area to area across the research districts. Most of the respondents at Jabi Tehnan (57.2%) and Mecha (52.3%) applied NPS fertilizer all at once. In the case of Bahir Dar Zuriya, half of the farmers (45.24%) applied NPS fertilizer all at once, and the other half (45.24%) of them applied it two times. This indicated that the farmers either did not know the recommended application method or did not follow it. Farmers who followed and applied the recommended rate were 44.1%, 47.62% and 38.9% in Jabi Tehnan, Bahir Dar Zuriya and Mecha, respectively.

Weeds, Diseases and Pests

In the study area, weeds are the limiting factors in the production and productivity of maize than the disease. Witch weed was not a problem in their maize farming, according to most respondents in Jabi Tehnan (97.61%), Mecha (94.4%) and the entire Bahir Dar Zuriya (100%). The farmers also indicated that they did not use herbicides to control weeds on their maize farms. The percentage of farmers who did not use herbicides accounts for 70.24%, 83.3% and 72.2% of respondents in the Jabi Tehnan, Bahir Dar Zuriya and Mecha districts, respectively. The respondents indicated that 59.59% of farmers from Jabi Tehnan, 61.9 % of farmers from Bahir Dar Zuriya and 68.25% of farmers from Mecha used hand weeding two times per growing season. Some farmers weeded once or three times across their districts. The percentage of farmers who weeded once and three times at Jabi Tehnan was 28.9% and 11.08%, respectively. Bahir Dar Zuriya farmers who weeded once were 21.44% and 16.6% weeded three times. Mecha maize weeding was done once a season and three times a year, by 17.5% and 11.1%, respectively (Table 7). This could indicate that the land is free of weeds in which case farmers should weed less frequently. Hand weeding and cropping systems could be the possible reasons for the limited availability of weeds, diseases, and insect pest attacks [56]. The farmers from the Jabi Tehnan district (96.43%)

reported that diseases are not maize production problems. Similar reports were also obtained from the Bahir Dar Zuriya in which 97.6% of the respondents indicated diseases as not the limiting factor in the production year. The percentage of farmers (10.32%) who indicated diseases as problems in maize production in the Mecha district was higher than in the other districts. It was expected that, with no disease problems, the application of pesticides would be very limited. Based on this, 88.1% of the farmers from Jabi Tehnan, 95.23% of the farmers from Bahir Dar Zuriya and 89.68% of farmers from Mecha reported no use of pesticides for maize production (Table 7).

CONCLUSION

This study aimed to assess the constraints on maize production in Jabi Tehnan, Bahir Dar Zuriya, and Mecha districts of West Gojam Zone. The findings of this study provided proof of evidence that demographic characteristics including age, gender, household size, marital status and farmers' age have an impact on maize production. The low level of female engagement in the region could be one of the production limiting factors as the involvement of females can play a significant role in production and productivity. Household size (4-6) with active working age, young and productive age (45-54) in the study area might contribute significant benefits to maize production in the future as they increase their production via physical activity. The land holding size of farmers in the study areas is very small and fragmented. Because of the long-distance walking from home to production land, the efficiency of working power has been reduced. Even though the farmers are very experienced in maize farming, they still use the old production systems, which are oxen plowing, continue to use of local varieties and using common types of fertilizers repeatedly (Urea, DAP, and NPS) which are primarily constrained by the time and quantity desired. Insect pest attacks are limited across the study areas. Therefore, based on this research, it can be concluded that for farmers across the three districts, the maize production system is affected by socioeconomic, fertilizer, seed and land preparation factors.

ACKNOWLEDGEMENTS
Ethiopian Ministry of Education, Debre Berhan University, and Bahir Dar University are acknowledged for their support.

CONFLICT OF INTEREST
The authors declare no conflict of interest, financial or otherwise

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 10
December 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: The number of main and sub-grids, the number of sampled households, and the altitude range by district

Name of districts	No of sampled main- grid (10-km by 10-km)	No of sampled sub-grid (1-Km by 1-km)	Sample household		Altitude (m.a.s.l)
			Per sub- grid	Total	
Jabi Tehnan	2	7	6	84	1837.36 - 2171.90
Mecha	3	7	6	126	1908.30 - 2115.60
Bahirdar Zuriya	1	7	6	42	1916.30 - 2243.70

Source: Own survey data Source: Own survey result (2017/18)

Table 2: Gender, marital status and household size of respondents by districts

Household characteristics		Jabi Tehnan (n=84)		Bahir Dar Zuriya (n=42)		Mecha (n=126)	
		Freq.	%	Freq.	%	Freq.	%
Gender	Male	80	95.23	40	95.24	123	97.61
	Female	4	4.76	2	4.76	3	2.38
Marital status	Single	3	3.57	0	0.0	4	3.18
	Married	80	95.0	41	97.62	119	94.44
	Married (polygamous)	0	0.0	0	0.0	0	0
	Divorced	1	1.0	1	2.68	3	2.381
Household size	1-3	23	27.38	7	8.33	9	7.143
	4-6	38	45.24	52	61.91	72	57.143
	7-9	22	26.19	23	27.38	42	33.33
	10-12	1	1.19	2	2.38	1	0.794
	>12	23	27.38	0	0	2	1.587

Source: Own survey result (2017/18); Where; % percent, Freq; frequency

https://doi.org/10.18697/ajfand.115.22420

ajfand SCHOLARLY, PEER REVIEWED
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ISSN 1684 5374

Table 3: Age and educational status; farming experience of maize by districts

Parameters		**Jabi Tehnan (n=84)**		**Bahir Dar Zuriya (n=42)**		**Mecha (n=126)**	
		Freq	**%**	**Freq.**	**%**	**Freq.**	**%**
Age	<25 (less productive)	2	2.38	0	0	5	3.9
	25-34 (more productive)	21	25	6	14.29	16	12.8
	35-44 (highly productive)	23	27.38	10	23.81	32	25.4
	45-54 (productive)	20	23.81	12	28.57	44	34.9
	>55 (less productive)	18	21.43	14	33.33	29	23.016
Educational level	No educated	12	14.28	2	4.8	10	7.94
	Elementary level or graduate (up to 6th)	26	30.95	14	33.3	43	34.13
	High school level or graduate(6-8thn)	37	44.047	20	47.6	57	45.24
	Secondary high school	8	9.524	5	11.9	12	9.5
	Above high school	1	1.2	1	2.4	4	3.2
For how many years have you been growing maize?	1-15	32	38.095	11	26.2	42	33.3
	16-30	44	52.381	12	28.6	62	49.2
	31-45	6	7.143	16	38.1	19	15.1
	>45	2	2.381	3	7.1	3	2.4

Source: Own survey result (2017/18); Where; %-percent, Freq-frequency

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Table 4: Land size, maize producing land distance from home, and land preparation (soil test and tillage) by districts

Parameters		Jabi Tehnan (n=84)		Bahir Dar Zuriya (n=42)		Mecha (n=126)	
		Freq.	%	Freq.	%	Freq.	%
Areal of cropland- (ha)	0.125-0.25	51	60.7	27	64.3	66	52.38
	0.251-0.50	24	28.6	14	33.33	42	33.33
	0.51-2.00	8	9.5	1	2.38	17	13.5
	>2.00	1	1.2	0	0	1	0.79
Maize-producing land Distance from home (min)	0-30	82	97.62	39	92.9	121	96.03
	31-45	1	1.19	0	0	4	3.2
	46-60	1	1.19	2	4.76	1	0.79
	>60	0	0	1	2.38	0	0
Has soil testing been done on this field in the past 3 years?	No	82	97.62	42	100	115	91.27
	Yes	2	2.38	0	0	11	8.73
Mainland preparation type	Manual	0	0	0	0	0	0
	Oxen	84	100	42	100	126	100
	Tractor	0	0	0	0	0	0
Tillage frequency	One to three	59	70.24	23	54.76	86	68.25
	Four to six times	13	15.47	11	26.2	21	16.67
	Seven to nine times	12	14.3	8	19.05	19	15.08
Does this plot have any form of irrigation?	No	84	100	42	100	86	68.25
	Yes	0	0	0	0	40	31.75

Source: Own survey result (2017/18); Where; %-percent, Freq-frequency

Table 5: Seed type and rate of maize by districts

		Jabi Tehnan (n=84)		Bahir Dar Zuriya (n=42)		Mecha (n= 126)	
		Freq.	%	Freq.	%	Freq.	%
Seed type	Improved	19	22.62	17	40.4	48	38.1
	Local	65	77.38	25	59.6	78	61.9
Seed sown kg per 0.5 ha	0.5-10	60	71.43	38	90.48	100	79.4
	10.1-20	13	15.47	2	4.76	17	13.5
	20.1-30	8	9.5	1	2.4	7	5.5
	>30	3	3.6	1	2.38	2	1.6

Source: Own survey result (2017/18); Where; %-percent, Freq-frequency

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ISSN 1684 5374

Table 6: Status of inorganic and organic fertilizer by the district

Parameters		Jabi Tehnan (n=84)		Bahir Dar Zuriya (n=42)		Mecha (n=126)	
		Freq.	%	Freq.	%	Freq.	%
Mostly get inorganic fertilizer at the usual source? (Cooperative, Unions, fertilizer distribute agent)	No	48	57.1	24	57.1	87	69.05
	Yes	36	42.9	18	42.9	39	30.95
The main reason for not getting fertilizer	Delay in supply	41	48.8	14	33.33	126	100
	Stocks out	20	23.8	12	28.57	72	57.14
	National shortage	23	27.4	16	38.1	14	11.11
	Other	0	0	0	0	40	31.75
Response to fertilizer shortage?	Did nothing	24	28.6	12	28.57	32	25.4
	Traveled to another location	42	50	15	35.7	52	41.3
	Purchased from other farmers	17	20.23	5	11.9	24	19
	Borrowed from other farmers	0	0	7	16.7	12	9.5
	Other location	1	1.19	3	7.143	6	4.8
Did you apply to Urea?	No	24	28.57	9	21.43	24	19.1
	Yes	60	71.43	33	78.57	102	80.9
Did you apply to NPS?	No	45	53.57	16	38.1	61	48.4
	Yes	39	46.43	26	61.9	65	51.6
Number of applications of NPS	At one time all	48	57.2	19	45.24	66	52.3
	Two times	36	42.8	19	45.24	48	38.2
	Three times	0	0	4	9.52	12	9.5
Do you apply cattle manure?	No	74	88.1	28	66.67	90	71.43
	Yes	10	11.9	14	33.33	36	28.57
Do you apply compost?	No	80	95.21	33	78.57	104	82.54
	Yes	4	4.8	9	21.43	22	17.46
Do you follow fertilizer recommendations?	No	47	55.95	22	52.38	77	61.1
	Yes	37	44.1	20	47.62	49	38.9

Source: Own survey result (2017/18); Where; %-percent, Freq-frequency
Where; NPS: Nitrogen, Phosphors, and sulfur

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Table 7: Disease and weed control of maize fields by districts

		Jabi Tehnan (n=84)		Bahir Dar Zuriya (n=42)		Mecha (n=126)	
		Freq.	%	Freq.	%	Freq.	%
Did this field suffer from plant disease during the last cropping season?	No	81	96.43	41	97.6	113	89.68
	Yes	3	3.57	1	2.4	13	10.32
Did you apply pesticide?	No	74	88.1	40	95.23	113	89.68
	Yes	10	11.9	2	4.77	13	10.32
Did this field suffer from witchweed (Striga)?	No	82	97.61	0	0	119	94.4
	Yes	2	2.39	0	0	7	5.6
Did you Apply herbicide?	No	59	70.24	0	83.3	91	72.2
	Yes	25	29.76	0	16.7	35	27.8
The number of weeding in the current season?	Not weeding at all	0	0	0	0	3	2.4
	One time	24	28.98	9	21.44	22	17.5
	Two times	50	59.59	26	61.9	86	68.25
	Three times	10	11.089	0	16.66	14	11.1
	Four times	0	0	0	0	1	0.79

Source: Own survey result (2017/18); Where; %-percent, Freq-frequency

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