

Research Article

# Demonstration of Pre-Determined ECONAT Organic Liquid Fertilizers on Tef Production in Bora District of East Shewa Zone of Oromia Region, Ethiopia

Tilahun Chibsa Birru<sup>1,\*</sup> , Abdurahman Husien<sup>2</sup>, Getachew Haile<sup>1</sup> 

<sup>1</sup>Oromia Agricultural Research Institute, Addis Ababa, Ethiopia

<sup>2</sup>Batu Soil Research Center, Batu Oromia, Ethiopia

## Abstract

The use of organic fertilizers aligns with sustainable agricultural practices, promoting soil health and reducing dependency on chemical inputs, which can have adverse effects on the environment and human health. The study conducted a pre-extension demonstration and evaluation of pre-determined ECONAT organic liquid fertilizers compared to combination of recommendation NP and econat 3.2 lit/ha over sole recommended in various locations. The trial was implemented in Bora district. On-farmers field, the overall mean yield 1129 kg ha<sup>-1</sup> and 1124 kg ha<sup>-1</sup> were obtained from recommended NP and combination of recommendation NP and econat 3.2 lit/ha; respectively. Moreover, sole recommended econat and controls gave the lowest yield. The mean yields of the four applied treatments were summarized as follows. Which showed that, combination of recommendation NP and econat 3.2 lit/ha is stable and showed good performance across locations in the study area. Mini farmers' field days further engaged stakeholders, with participants expressing appreciation for the demonstrated recommendations' positive impact on multiple yield-related traits. Based on the comprehensive evaluation and positive feedback from farmers and stakeholders, it is recommended to promote and adopt combination of recommendation NP and econat 3.2 lit/ha over sole recommended econat. The demonstrated and evaluation consistently delivered with the observation of higher yields and exhibited desirable traits crucial for successful crop cultivation. Further extension programs and awareness campaigns could enhance the adoption of this technology among farmers, contributing to increased agricultural productivity and overall farm sustainability. In conclusion, combination of recommendation NP and econat 3.2 lit/ha demonstrated superior performance in terms of yield. To capitalize on this success, incorporating targeted awareness programs, training sessions, and collaboration with agricultural experts. This approach aims to facilitate a widespread shift towards adopting combination of recommendation NP and econat at 3.2 lit/ha among farmers, thereby optimizing crop outcomes and promoting sustainable agricultural practices in the study area.

## Keywords

Tef, ECONAT, Technology, Farmers' Preferences, FRG/FREG Approach

\*Corresponding author: [tcbirru2008@gmail.com](mailto:tcbirru2008@gmail.com) (Tilahun Chibsa Birru)

**Received:** 20 November 2024; **Accepted:** 2 December 2024; **Published:** 22 January 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

## 1. Background and Justification

Agriculture forms the backbone of the Ethiopian economy, with smallholder farmers contributing significantly to national food security and livelihoods [1]. However, its production faces numerous challenges, including soil degradation, nutrient depletion, and limited access to modern agricultural inputs. In recent years, organic liquid fertilizers have gained attention as a potential solution to enhance soil fertility and crop productivity sustainably. One such fertilizer, known as ECONAT (Organic Natural Fertilizer), has shown promise in improving crop yields while minimizing environmental impact. Among the staple crops grown in the region, Tef (*Eragrostis tef*) holds a prominent position due to its nutritional value and adaptability to diverse agro-ecological zones [2]. However, sustaining high yields of Tef presents a formidable challenge, particularly in regions like the Bora District, where soil fertility and resource constraints hinder optimal crop production [3]. Improved high yielding, disease resistant well adapted and preferred tef variety for the agroecology by the end users (farmers, Researchers, etc) might improve the yield of tef with the managements intervention [11]. Also growing tef has been increased income earnings better than growing other cereal crops [16].

In response to these challenges, there has been a growing interest in exploring sustainable and environmentally friendly approaches to enhance crop productivity. Although the extents of field crops grown with organic fertilizer showed decreasing trend last decades [13] organic fertilizers have emerged as promising alternatives to conventional chemical inputs, offering multiple benefits such as improved soil health, reduced environmental degradation, and enhanced crop resilience to biotic and abiotic stresses [4]. Within this context, the utilization of pre-determined ECONAT organic liquid fertilizers presents an innovative avenue for optimizing tef production while promoting ecological balance and farmer welfare.

Demonstration of Pre-Determined ECONAT Organic Liquid Fertilizers on Tef production in the Bora District, holds significant importance for several reasons. Firstly, given the importance of Tef as a staple crop in Ethiopia, any intervention aimed at improving its productivity can have substantial socio-economic implications, particularly in rural areas where livelihoods heavily depend on agriculture. Secondly, the use of organic fertilizers aligns with sustainable agricultural practices, promoting soil health and reducing dependency on chemical inputs, which can have adverse effects on the environment and human health. Thirdly, conducting such verification studies contributes to the growing body of knowledge on organic farming practices, particularly in the context of smallholder farming systems prevalent in many developing countries. Recent literature supports the importance of organic fertilizers in sustainable agriculture and their potential to enhance crop productivity. For instance, [5] investigated the effects of organic liquid fertilizers on maize production in

Ethiopia and found significant improvements in yield and soil fertility parameters compared to conventional fertilizers. Similarly, [6] evaluated the impact of organic liquid fertilizers on teff production in the Amhara region of Ethiopia, demonstrating increased yields and improved soil health indicators.

Moreover, [7] conducted a study comparing the effects of liquid organic and inorganic fertilizers on tef growth and yield in Northwestern Ethiopia, showing that organic fertilizers significantly improved yield and soil fertility parameters compared to inorganic fertilizers. Additionally, [8] investigated the effect of different organic and inorganic fertilizer sources on tef yield and yield components in Lay Gayint District, Northern Ethiopia, revealing that organic fertilizers demonstrated superior performance in improving yield and yield components compared to inorganic fertilizers.

In light of these findings and the need for context-specific research, conducting a verification study on the effectiveness of ECONAT in the Bora District of East Shewa Zone becomes imperative. Such research can provide valuable insights into the practical applicability of organic liquid fertilizers in improving Tef production in specific agro-ecological zones within Ethiopia, contributing to sustainable agricultural development strategies tailored to the needs of smallholder farmers. Moreover, the findings from this study can inform policymakers, agricultural extension services, and farmers alike, facilitating the adoption of appropriate soil fertility management practices conducive to enhancing food security and rural livelihoods in the region.

## 2. Material and Methods

### 2.1. Description of the Experimental Site

Bora is one of the Aanaa in the Oromia Regiona State of Ethiopia. Bora district is one of the 12 districts. It was formerly part of Dugda Bora district, which was split into Bora and Dugda Districts in 2005. Bora district has a population of 58,748 as of 2007, of which 19.41% are urban dwellers. The district covers an area of 1,050.54 square kilometers and has an average elevation of 1,600 meters above sea level. The main town of Bora district is Bote (Alem Tena), which is located about 80 kilometers south of Adama, the capital of East Shewa Zone. Bora district is known for its agricultural production, especially of maize, teff, wheat, and coffee. The district also has some natural attractions, such as hot springs, waterfalls, and caves. Bora district is home to various ethnic and religious groups, such as Oromo, Amhara, Gurage, Orthodox Christian, Muslim, and traditional believers. Bora district is one of the areas where tef is cultivated in East Shewa Zone, Oromia. According to the web search results, Bora district has been involved in some research and extension activities to improve tef production and adoption of new varieties. According the Bora District study area is located at

9° 12' 21.852" N and 117° 10' 23.912" W.

The major soil types in Bora district are Vertisols and Fluvisols. Vertisols are clay-rich soils that swell and shrink with changes in moisture content. They are fertile but prone to water logging and cracking. Fluvisols are alluvial soils that are formed by the deposition of sediments from rivers or floods. They are generally fertile and well-drained, but may

have problems of salinity and sodicity. The climatic conditions in Bora district are characterized by a subtropical high-land climate. The average annual temperature is about 18 °C, with a range of 10 °C to 26 °C. The average annual rainfall is about 900 mm, with a bimodal distribution. The main rainy season is from June to September, and the short rainy season is from February to May.

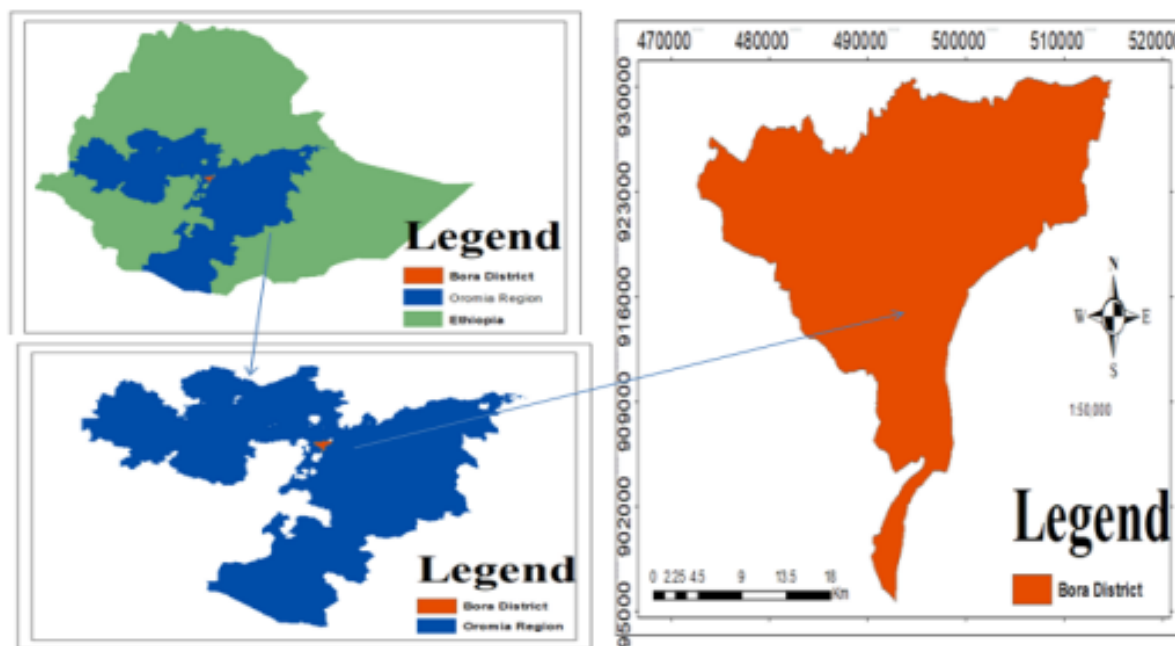


Figure 1. Location map of study area.

## 2.2. Site and Farmers' Selection

The trial was implemented on dominant soil type Vertisols where Tef, barely, wheat and faba bean were the major crops grown [10, 14, 15] in Bora from East shewa zone were selected due to their potential for tef production and the high demand for the crop. Likewise, from the district, three representatives kebele were also selected purposefully as demonstration sites of the soil fertility technology based on their accessibility and potentiality. Moreover, now days, group approach is more efficient than dealing with individuals especially in our context where the majority of farmers are smallholders and clear socio-economic differences are existing. It enhances the development, popularization, dissemination of technology.

## 3. Material Used and Field Design

The experimental field will be arranged with four (4) treatments. The trial will be carried out in RCBD with over five (5) farmers as replicate. The treatment will include control (without fertilizer), Blanket/research recommendation

(100 kg DAP & 100 kg urea)/ soil test based fertilizer recommendation with recommended Nitrogen and recommended econat 3.2 lit/ha. The gross plot area was 10 \* 10m and the space between plots will be 1m. Improved high yielding, disease resistant well adapted and preferred tef variety were selected as test crop for the study agroecology by the end users (farmers, Researchers, etc) [11]. Bora recently released tef variety with the higher yield advantage over the existing boset variety was used as test crop [12].

The required amount of seeds will be weighed per plot by considering the recommended rate (30 kg/ha for tef) seed rate per hectare. Urea and TSP were used as source of nitrogen and phosphorus containing fertilizers. Improved tef varieties of the area were used as a seed source. Uniform field management practices for all plots were conducted.

Treatments were those of blanket or recommended optimum N/P fertilizer rate with sole and combination of 3.2 lit/ha ECONAT peat based organic plant growth regulator per respective allocated center's cereal crop of the study sites. The initial N/P content of the soil from soil test and the others from PC and Pf will be used for N/P recommendations or where no calibrated N/P recommendation is available blanket recommendation of N/P will be used. All the Recommended P obtained by soil test based crop response P calibration for cereals

will be applied at planting. One-half of N will be applied at sowing. The remaining one-half of N will be top dressed at knee height of maize or at a time of tillering for wheat and tef crop growth stages. The source of N/P fertilizers will be from Urea, NPS; DAP and/or TSP. All other recommended agronomic management practices such as weeding frequency, disease and insect pest control will be done during the experimental period.

### 3.1. Focused Group Discussion (FDG)

Having suitable and sufficient land to accommodate the demonstration activity, willingness to contribute the land, vicinity to roads so as to facilitate the chance of being visited by many farmers, initiatives to implement this activity in high-quality, good in field management and willingness to explain the technologies to others were criteria used to select the hosting farmers. In each PA's, three FRG unit comprising of 10-15 farmers were established. Then, three to four representative hosting farmers from each FRG were proceeding of pre-extension demonstration of agricultural technologies of the selected at each kebele with the help of group members and DAs.

Before leading the participant farmers and experts to focus group discussion, brief orientation was given to the evaluators on why the technology evaluation and selection is necessary in the soil fertility improvement research process. Then evaluators were grouped in to small manageable group and encourage setting their own criteria to select the demonstrated technology in order of their preference. These were mechanisms used to enhance farmer-to-farmer learning and information exchange such as trainings, field visits/tours, experience sharing, field days, etc.

### 3.2. Monitoring and Evaluation, Field Visit and Field Day

Initially, agreement was made with farmers, DAs, supervisors and experts on responsibility sharing since the activity needs collaborative work and partnership. Regular joint monitoring and evaluation (follow up actions) and provision of technical advice were undertaken at different crop stages based on necessary emerging knowledge/skill and technical advice needs. Field visit was arranged to create awareness and farmers shared experience and knowledge. Field day is a method of motivating people to adopt new practices by showing what has already achieved under field conditions. In other words, it is to show the performance and profitability of new technologies and to convince about the applicability. Besides, it is a way of facilitating people to visit new innovation for the purpose of bringing mass mobilization. Thus, mini field days were organized at each demonstration site in order to involve key stakeholders and enhance better linkage among relevant actors. Discussion session and result communication forum were also organized.

### 3.3. Farmers' Preferences and Selection Criteria

The technology were demonstrated, evaluated at crop maturity stage and validated by farmers, agricultural experts, development agents, researchers and other stakeholders based on the following selection criteria. The criteria were tillering capacity (fertile tillers), disease tolerance (for rusts), plant height, lodging resistant, crop stand, seed color and size and overall yield.

### 3.4. Data Collected

Both qualitative and quantitative data were collected using appropriate data collection methods such as FGD, direct field observation and measurements. Agronomic data and grain yield per plot were recorded. Total number of farmers participated on extension/promotional events such as training, field visits and mini field days were recorded by gender composition. Feedback assessment on farmers' preference to the demonstrated varieties (likes and dislikes, which is the base for plant breeding process) and farmers' perception towards the performance of the technologies were also identified.

### 3.5. Data Analysis

The collected data was analyzed using SPSS and descriptive statistics such as mean, frequencies distribution and percentages. Besides, pair wise ranking matrix was used to evaluate and select best performing varieties and rank the varieties in order of their importance.

## 4. Results and Discussions

The pre-soil analysis revealed a range of phosphorus levels on the major soil types in Bora district are vertisols and fluvisols across the Bora district, indicating significant variability. Soil samples exhibited diverse nutrient profiles, suggesting that the phosphorus content may play a pivotal role in the observed differences on tef yields. The discussion explores these findings in the context of local soil characteristics, climate conditions, and agricultural practices, providing a foundation for subsequent investigations into tailored phosphorus management strategies. Generally, the soil of the study area was characterized as moderately alkaline soil (pH=7.73) according to [17]. Likewise, according to [18] the available phosphorus was in the very low range (4.92 ppm).

**Table 1.** Pre-soil analysis results of Bora district.

Parameters	Results
pH (H <sub>2</sub> O 1:2.5)	7.73
EC (dS/cm)	0.11

Parameters	Results
Ava. P (ppm)	4.92
OC (%)	1.11
TN (%)	0.10
CEC (meq/100 gm soil)	13.34
Exch. Ca (meq/100 g soil)	17.43
Exch. Mg (meq/100 g soil)	3.99
Exch. Na (meq/100 g soil)	1.17
Exch. K (meq/100 g soil)	1.67
Sand (%)	54.60
Clay (%)	12.40
Silt (%)	33.00

#### 4.1. Yield Performance of the Demonstrated Technology

On-farmers field, the overall mean yield 1129 kg ha<sup>-1</sup> and 1124 kg ha<sup>-1</sup> were obtained from recommended NP and combination of recommendation NP and econat 3.2lit/ha respectively. Moreover, sole recommended econat and controls gave lowest yield. The mean yield of demonstrated at all locations from recommended NP and combination of recommendation NP and econat 3.2lit/ha, sole recommended econat and controls were summarized in the following table. Which showed that, combination of recommendation NP and econat 3.2 lit/ha is stable and has good performance across locations in the study area. In their comprehensive review of agricultural technologies demonstrated in Ethiopia, including various soil management practices and fertilizer applications, [9] highlighted the effectiveness of liquid fertilizers, such as eco-friendly liquid formulations, in improving crop yield performance, particularly when combined with recommended nutrient management practices.

**Table 2.** Mean yield obtained from demonstrated sites.

Treatments	Plant Height (cm)	Biomass (ton ha <sup>-1</sup> )	Grain Yield (Kg ha <sup>-1</sup> )	HI (%)
Control	77.16 <sup>a</sup>	3.70 <sup>a</sup>	572.50 <sup>a</sup>	15.39
RNP	95.08 <sup>c</sup>	6.70 <sup>c</sup>	1124.50 <sup>b</sup>	16.67
Sole Econat	86.48 <sup>b</sup>	5.00 <sup>ab</sup>	918.50 <sup>b</sup>	19.12
Sole Econat +RNP	92.68 <sup>bc</sup>	6.40 <sup>bc</sup>	1129.00 <sup>b</sup>	18.11
Lsd (0.05)	7.25	1.55	311.20	NS
CV(%)	6.00	20.70	24.10	24.5

Means followed by the same letter with in the same column of the respective treatment are not significantly different ( $P \leq 0.05$ ) according to Duncan Test, HI= Harvested Index, RNP = recommended nitrogen and phosphorus, CV = Coefficient of variation, LSD = Least Significant differences, NS = not significant

#### 4.2. Field Day and Focus Group Discussion (FGD)

Mini field day was arranged to create awareness, collect feedback and facilitate knowledge & experience sharing among farmers. Regular joint monitoring and evaluation (follow up actions) and provision of technical advice were undertaken at different crop stages based on necessary emerging knowledge and skill needs. Mini farmers' field days were organized at each demonstration site in order to involve key stakeholders and enhance better linkage among relevant actors. Accordingly, participant farmers appreciated combination of recommendation NP and econat 3.2 lit/ha for its high yield, and good uniformity, high tillering capacity, good crop stand.

**Table 3.** Participants in Bora and Dugda district.

District	FRG	Farmers		DA's		Total		Total
		M	F	M	F	M	F	
Bora	1	10	2	1	0	11	2	13
	2	12	3	2	1	14	4	18
	3	13	3	3	1	16	4	20
		35	8	6	2	41	10	51

Where M= Male; F = female DA = developmental agent



### 4.3. Farmers' Preferences and Selection Criteria

Pre-Determined ECONAT Organic Liquid Fertilizers were demonstrated and evaluated under farmer's condition and rank of technology demonstrated based on farmers preferences. Accordingly, the demonstrated pre-Determined ECONAT Organic Liquid Fertilizers had been beaten by recommended NP fertilizers by well in all demonstration

sites. Moreover, the participant farmers liked the combination of recommended NP fertilizers and ECONAT for its high yield. The technology were demonstrated, evaluated at crop maturity stage and validated by farmers, agricultural experts, development agents, researchers and other stakeholders based on the following selection criteria. The criteria plant height, crop stand, biomass yield and size and overall grain yield.

**Table 4.** Pair wise ranking results to rank technology traits in order of importance.

No	Technology traits	A	B	C	D	E	F	Frequency	Rank
1	A		0	0	0	0	0	0	4 <sup>th</sup>
2	B	1		0	0	0	0	1	3 <sup>rd</sup>
3	C	1	1		0	0	0	2	2 <sup>nd</sup>
4	D	1	1	1		0	0	3	1 <sup>st</sup>

A= plant height, B= crop stand, C= biomass yield and D= overall grain yield

**Table 5.** Ranking technology demonstrated based on farmers preferences.

Technology	Rank	Reasons /Criteria
Combination of RNP and Econat, 3.2 lit	1st	Very good biomass yield, Good plant height (78-105 cm), expected very good grain yield of tef
Sole RNP	2nd	Very Good biomass yield, very good plant height (75-96 cm), expected good grain yield of tef
Sole recommended econat	3rd	Good biomass yield, Good plant height (68-90 cm), expected good grain yield of tef
Control	4th	Low biomass yield, short plant height (58-88 cm), expected low grain yield of tef

## 5. Conclusion and Recommendations

The study conducted a pre-extension demonstration and evaluation of recommended NP fertilizers compared to ECONAT organic liquid fertilizers in various locations. On-farmers field, the overall mean yield 1129 kg ha<sup>-1</sup> and 1124 kg ha<sup>-1</sup> were obtained from recommended NP and combination of recommendation NP and econat 3.2 lit/ha respectively. Moreover, sole recommended econat and controls gave lowest yield. This showed that, combination of recommendation NP and econat 3.2lit/ha is stable and has good performance across locations in the study area. Mini farmers' field days further engaged stakeholders, with participants expressing appreciation for the demonstrated recommendations' positive impact on multiple yield-related traits. Based on the comprehensive evaluation and positive feedback from farmers and stakeholders, it is recommended

to promote and adopt combination of recommendation NP and econat 3.2lit/ha over sole recommended econat. The demonstrated recommendations consistently delivered higher yields and exhibited desirable traits crucial for successful crop cultivation. Further extension programs and awareness campaigns could enhance the adoption of this technology among farmers, contributing to increased agricultural productivity and overall farm sustainability.

In conclusion, combination of recommendation NP and econat 3.2 lit/ha demonstrated superior performance in terms of yield and various key traits compared to sole recommended econat and controls. To capitalize on this success, an adoption strategy should be implemented, incorporating targeted awareness programs, training sessions, and collaboration with agricultural experts. This approach aims to facilitate a widespread shift towards adopting combination of recommendation NP and econat 3.2 lit/ha among farmers, thereby optimizing crop production and promoting

sustainable agricultural practices in the study area.

## Abbreviations

FRG/FREG	Farmer Research Group or Farmer Research and Extension Group
PA	Peasant Association
lit/ha	Liter Per Hectare
kg/ha	Kilogram Per Hectare

## Acknowledgments

The authors would like to thank KAB PHARMA PLC through Oromia Agricultural Research Institute for funding the research and Batu Soil Research Center for providing all the necessary facilities required for the research. Lastly but not least, our special thank also forwarded to all staff members.

## Author Contributions

**Tilahun Chibsa Birru:** Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing—original draft, Writing—review & editing

**Abdurahman Husien:** Formal Analysis, Project administration, Software, Supervision, Validation, Writing—original draft, Writing—review & editing

**Getachew Haile:** Data curation, Formal Analysis, Methodology, Project administration, Supervision, Writing—review & editing

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] Abate, T., Berhanu, K., Yirga, C., & Mamo, G. (2018). Agriculture in Ethiopia: An Overview. *Journal of Agricultural Sciences*, 13(2), 67-78.
- [2] Girma, H., Fikre, T., Assefa, K., & Tadesse, W. (2019). Tef (*Eragrostis tef*): A Review on its Nutritional Composition and Health Benefits. *Food Science and Quality Management*, 84, 12-19.
- [3] Alemayehu, T., Asfaw, S., Tadesse, W., & Zeleke, T. (2020). Challenges and Opportunities of Tef (*Eragrostis tef*) Production in Ethiopia. *Ethiopian Journal of Agricultural Sciences*, 27(2), 19-34.
- [4] Mengistu, D., Hailemariam, T., Asfaw, S., & Tadesse, W. (2021). Organic Fertilizer Application in Ethiopian Agriculture: Current Status and Future Prospects. *Journal of Sustainable Agriculture*, 45(3), 234-245.
- [5] Gebre, H., Tadesse, T., & Nigussie, Z. (2020). Effects of organic liquid fertilizers on maize (*Zea mays* L.) productivity and soil fertility in Ethiopia. *African Journal of Agricultural Research*, 15(8), 1521-1531.
- [6] Tesfaye, T., & Endalkachew, W. (2021). Effects of organic liquid fertilizer on growth and yield of teff [*Eragrostis tef* (Zucc.) Trotter] in Amhara region, Ethiopia. *African Journal of Agricultural Research*, 16(5), 766-775.
- [7] Abera, B., & Girma, G. (2020). Comparative Effect of Liquid Organic and Inorganic Fertilizers on Growth and Yield of Tef (*Eragrostis tef* (Zucc.) Trotter) in Northwestern Ethiopia. *International Journal of Agronomy*, 2020, 1-9.
- [8] Demissie, B. G., Mohammed, A., & Zinash, A. (2021). Effect of Different Organic and Inorganic Fertilizer Sources on Tef (*Eragrostis tef* (Zucc.) Trotter) Yield and Yield Components in Lay Gayint District, Northern Ethiopia. *International Journal of Agronomy*, 2021, 1-7.
- [9] Tekalign Mamo, Yoseph G. Negisho, & Tsegaye Belay. (2017). "Yield performance of demonstrated agricultural technologies in Ethiopia: A review." *Journal of Agricultural Science and Development*, 9(6), 145-159.
- [10] Temesgen Jembere, Tadele Mamo, Musa Jarso, Ulfina Galmessa, Kebede Dinkecha, Gezahegn Mengistu, Takele Mebratu and Fekede Feyissa, 2024. Investigating Soil Types, Crops and Use of inorganic and Organic Fertilizer in Mixed Farming System of Ethiopia: A Baseline Survey. *Ethiop. J. Agric. Sci.* 34(1) 60-79.
- [11] Endale Mekonnen, Hana Amare. (2023). Pre-extension Demonstration of Improved Tef Varieties in the Potential Growing Areas of West Shewa Zones of Oromia, Ethiopia. *Research & Development*, 4(2), 53-57.
- [12] Chiche W. and Ahmed M. (2024). On-farm Demonstration and Evaluation of Tef (*Eragrostis Tefabyssinica*) Bora Variety for Selected Moisture Stress Area of Amhara and Oromia Region, Ethiopia, *Global Journal of Agricultural Research*, 12, (2), 53-61.
- [13] Desta, T. B., Gezahegn, A. M., Zemedu, A., & Tesma, S. E. 2023. Fertilizer Use Trends for Major Ethiopian Crops by Smallholder Farmers. In *Ethiop. J. Crop Sci* (Vol. 11, Issue 1)
- [14] Elias, E., Biratu, G. K., Smaling, E. M. A. 2022. Vertisols in the Ethiopian Highlands: Interaction between Land Use Systems, Soil Properties, and Different Types of Fertilizer Applied to Teff and Wheat. *Sustainability*, 14, 7370. <https://doi.org/10.3390/su14127370>
- [15] Habte, A., Worku, W., Mamo, G., Ayalew, D., & Gayler, S. 2023. Rainfall variability and its seasonal events with associated risks for rainfed crop production in Southwest.
- [16] Fikire, Abebaw Hailu, Emeru, Girma Mulugeta. 2022. Determinants of Modern Agricultural Technology Adoption for Teff Production: The Case of Minjar Shenkora Woreda, North Shewa Zone, Amhara Region, Ethiopia, *Advances in Agriculture*, 2022, 2384345, 12 pages, 2022. <https://doi.org/10.1155/2022/2384345>

- [17] Tekalign Tadese. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.
- [18] Cottenie, A., 1980. Soil and plant testing as a basis of fertilizer recommendations FAO soil bulletin 38/2. Food and Agriculture Organization of the United Nations, Rome.