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# Enset Production, Its Challenges and Controlling Methods in South Omo Zone, Southern Ethiopia

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**Abstract**

Enset (*Ensete ventricosum (Welw.) Cheesman*)is economically a useful crop that provides forage for animals, construction materials, fuel and traditionally it is used as a medicine. The production and productivity of enset is mainly affected by many diseases and pests which causes serious devastating cultivar diversity and finally a yield lose of the crop. Moreover, its production sustainability is also threatened by many factors like wild animal pests, enset root pests, high population pressure and the shift of the producers to cash-oriented crop production. The assessment on enset production, its challenges and controlling methods was carried out in Debub Ari district of South Omo Zone, in southern Ethiopia from November 2021 to January 2021in four randomly selected representative Kebeles. Simple random sampling method were employed to select a representative sample of the study (n = 138). Qualitative and quantitative data were collected through structured questionnaire, focus group discussions, individual interview and personal observations. The collected data were analyzed by using appropriate simple descriptive statistics. The land under enset production is declining from time to time, as well as its production also declines due to social,bio-physical and environmental factors such as land fragmentation, enset bacterial welt, insects and pests and environmental variability factors. To overcome these factors farmers practicing many controlling methods such as by burying the infected plants, restricting the movement of infected plant materials, sterilizing production tools and raising awareness about how to protect disease like enset bacterial welt and use of aluminum phosphate for pests like mole rate.

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## Introduction

Enset (*Ensete ventricosum (Welw.) Cheesman*) is one of the perennial crops, which is mainly produced in southern and southwestern parts of Ethiopia.Itis used as a main staple food crop for a high number of populations which is more than 15 million people who are practicing a mixed subsistence farming systems type in the country. Enset is economically the main useful crop that provides forage for animals, house construction materials, fuel and traditionally used as medicine amongst others.[1] It is mainly grown at an altitude that ranges between 1600 to 3000 m above sea level with an annual average rainfall of 1100-1500 mm and it is mainly propagated vegetative. Enset production system in the area is an indigenous based and it is also used as a sustainable agricultural production system that covers large hectares of land.[2] Enset is affected by several factors such as management, drought, insect pests, diseases, populationpressure, biotic and abiotic factors that affect the production and productivity of the crop.[3] Exhaustive use of producers' local knowledge and skills in association with the origin of the crop has a value to handle the crop and traditional ways of disease management strategy of the crop.

The production and productivity of the crop is mainly affected by many diseases and pests that results in a serious devastation of the cultivar diversity and a total yield loses of the crop. This total yield lose is the evolutionary consequence of growing a single variety crops (mono-culture cropping system) and it leads to the continuing emerge of a new pests and pathogens races that have the ability to affect the resistance genes technologically introduced by modern breeding system.[4, 5] Moreover, the production sustainability of the crop is also threatened by factors such as high population pressure, wild animal pests, enset root pests and the shift of production to cash-oriented crops. Also, different types of enset production diseases such as fungal, bacterial and viral caused are the major challenging the production area. Some of the fungal diseases are enset corm rot, enset sheath rot, dead heartleaf rotof ensetand enset bacterial wilt, and among the viral diseases of the crop, mosaic and chlorotic enset leaf streak diseases, nematode diseases of root knot, enset root lesion and black leaf streak, insects such as Jassid, fly spider, mites, enset mealy bugs and some vertebrate pests' also damage widely enset plant and reduce the yield potential of the crop.[4]

However, the distribution and severity of the major diseases and pests that affect the production and productivity enset, the main one isenset bacterial wilt caused by Xanthomonas campestris PV. Musacearum is the well-known threatening and serious problem to enset production system in the study area in particular and the country as a whole.[6, 7] Increasing the production of enset has played a great role to enhance the food security of the people and environmental welfare improvement. Therefore, this study was carried out to assess the enset production, its challenges and controlling methods in South Omo Zone of Southern Nations Nationalities and peoples regional state in Ethiopia, addressing the objectives of assessing the area coverage of enset and production status in the study area, to identify enset production challenges and to identify enset production challenges controlling methods, and to recommend solution to the main enset identified problems.

## Materials and Methodology

### Study Area

South Omo Zone isfound in Southern Nations, Nationalities, and People's Regional State in Southern Ethiopia. It is located at 4° 27'- 6° 26' longitude and 34º 57'–37º 49' latitudeand mainly bordering with Gamo, Gofa, Keffa Zones and the two especial districts such as Konta and Besketo to the north; Konso Zone, Alle and Derashe special districts to the eastern part; Borana Zone to the southeastern part; Kenya to the southern part; Sudan to the southwestern part, and Mirab Omo Zone to the western part. Totallythe Zone covers an area of about 22,360.76 $Km^2$ and has an altitude which ranges from 380 to 3,300 m.a.s.l.[8]

The study was carried out in Debub Ari districts of South Omo Zone in SNNPR. The district is bordering with Semen Ari district in the northern part, Mago national park in the southern part, Salamago district in the western part, Malle district in eastern part and Bena Tsemay district in the southeastern part. Gather is the administrative center or city of the district and is located at 798 Km from Addis Ababa the capital city of Ethiopia.

### Methods

Based on the plan study was carried out from November 2021 to January 2021. Within the planned study sessions, the enset production, its

challenges and controlling methods were assessed in the selected representative Kebeles of the district. The selection criteria of representative Kebeles and households or interviewed respondents from each Kebele were based on a simple random sampling technique. The study district was selected purposively, and thenKebeles and the representative respondents were selected randomly.

**Preliminary Survey**

A preliminary survey was conducted before starting the main survey at the first month of the study to identify the main enset producing district as well as Kebeles. During the preliminary survey, all relevant information about theenset production and study area was gathered. FGD, KII and transact walk was carried out to gather background and history of enset production as well as area coverage and production trend data were collected from the documents of agriculture and natural resource office.

**Sampling Design**

A simple random sampling technique was conducted to draw sample households. In the first stage, potential enset producing district were selected purposively from the zone. In the second stage, from the selected district, potential Kebeles were also selected purposively based on enset producing potential. Finally, the number of sample households from each sample Kebeles was determined from the recent lists of households using proportional to size. Therefore, a total of 138 sample respondents were selected using simple random sampling method.

Following to this, sample size determination formula of which described below was used to determine the sample size.[9]

$$n = z^2pq/d^2 \quad ...(1)$$

Where n = required sample size, z = 95% confidence interval (1.96), p = proportion of the population to be included in the sample determined (0.1) of the population, q = 1 − p = 1 − 0.1 (0.9), d = margin of the error occurred during sampling (0.05).

Accordingly, the sample size was determined by using the equation as follows:

$$n = \frac{(1.96)^2 \times (0.1 \times 0.9)}{(0.05)^2} = \frac{3.842 \times 0.1 \times 0.9}{0.0025} = 138$$

**Data Collection**

Both formal and informal survey techniques were used to implement this study. Regarding the formal survey, a structured questionnaire was developed and employed over the sampled households to collect quantitative data. On the other hand, some informal survey tools like FGD, KII were used to generate qualitative data from the elders who know deeply the area in which he/she lives in it. In each Kebele, a total of about 8-12 elder members participated in FGD during the survey time.

**Data Analysis**

The data collected from sample respondents were analyzed, tabulated and organized in graphs, charts and tables. The analysis was undertaken by using simple descriptive statistics with the help of SPSS version 23.0 and STATA version 14.0 Statistical Software. The appropriate simple statistical methods such as frequency, mean, percentage, and standard deviation were used.

**Results**

**Area under Enset Production/ha (2013-2019)**

Cultivation of enset is mainly concentrated in the south and southwesternmidland and highland parts of Ethiopia. In southern region it is a dominant staple food crop which covers approximately about 168,000 ha and is the main source of food for about 7-10 million people in the region.[10] The main enset-growing zones in southern region are Gurage, Hadiya,Kembata, Wolaita, Gamo, Keffa, Gedio, South Omo and the related ethnic groups whose culture mainly based on enset. The area coverage of enset production has increased approximately to 46% over the past twenty years.[11] But in the study area, the area under enset production in the last seven consecutive years (Fig 1) were 2890hectare in the year 2013, 3052.3 hectare in the year 2013, 3140hectare in the year 2015, 4263.7 hectare in the year 2016, 3970.4 hectare in the year 2017, 3245 hectare in the year 2018 and 2738.8 hectare in the year (P = 0.088).

**Enset Production/tons (2013-2019)**

According to the Central Statistics Agency, enset area coverage and production have direct relationship this means as the area of land under enset production has increased the production also increases.[11] The production of enset between the production years (Fig 2) were 101901.4 tons in the year 2013,

109304.3 tons in the year 2014, 113400 tons in the year 2015, 149208.6 tons in the year 2016, 137375.8 tons in the year 2017, 113620.6 tons in the year 2018 and 93420.8 tons in the year 2019 (P = 0.09).

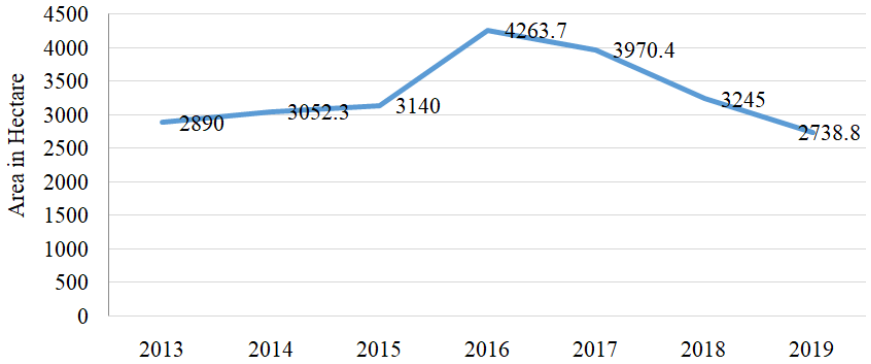


**Fig. 1: Area Under Enset Production/Ha (2013-2019)**

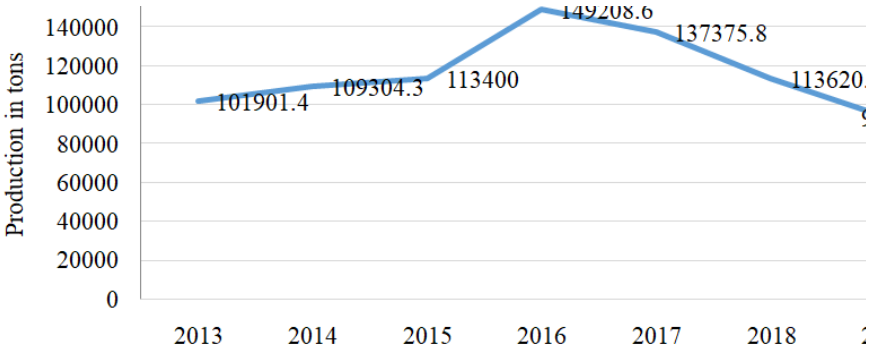


**Fig. 2: enset production (2013-2019)**

**Enset land Landraces (Clones)**

Enset production in Ethiopiahas high landrace (clone) diversity. A total of 278 clones were identified with their distinct names from seven main enset growing zones.12From the identified zones Hadiya Zone is the richest having a total of 59 enset landraces (clones) followed by Kembata Tembaro zone (43), Dawro zone (42), Wolaita zone (39), both Gamo and Gofa zones (34) and Gurage zone (31). There are about 146 deferent enset clones in Sidama, Wolaita, and Hadiya zones.13 Similarly, about 146 deferent enset clones were recorded from four zones such as (65from Kefa and Sheka zones, 30 from Sidama, 45 from Hadiya, and the rest 6 from Wolaita). 14 Moreover, about 111 enset clones were identified from nine enset growing areas of Ethiopia.15 The reports shows that the number of enset clones identifiedhave a high inconsistency which could be due to the fact that farmers distinguish enset clones or land races on the basis of enset phenotypic characteristics such as petiole, midrib and leaf sheath color, height of the plant, angle of leaf orientation, size and color of the leaves, circumference of the plant and length of the pseudo stem.16 In the study area the researcher identified about 24 clones during the survey time, this are Jolack, Qarita, Gena, Haqisa, Salita, Maqa, Dakay, Suferaki, Baysamatoch, Dayaga, Babisul, Soda, Kayaka, Barika, Batira, Alifakumisa, Ela, Tsela, Osad, Qaket, Shoka, Bubin, Maka and Kufera are among the clones found in south Omo Zone.

**Selection Criteria of Enset Clones**

Reports show that there isa wide diversity of enset clones exist in Ethiopia. The farmer criteria to selection clone is based on the quality and quantity of food products obtained from enset, the maturation period of the plant, its tolerance to disease and pest and its adaptation to climatic variability conditions mainly drought, its uses for forage, traditional medicinal value, ease of scraping for the extraction of starch, the enset corm quality and productivity.[13]

A single enset clone doesn't fully address all the farmers' selection criteria, so they tend to maintain adverse range of enset clones on their farm sites.[13] Based on the identified characteristics farmers characterize and select enset clones based on physiological, morphological and the agronomic traits of the plant and the use value. Through traditional knowledge and skill based selection, farmers' are thus influencing enset genetic diversity.[13]

**Propagation and Cultivation Methods**

The well-known and common method of propagation is by means of suckers originating from animmature enset corm. Although it is not known and common in the study area but, seeds may also be used to produce seedlings in some parts of the enset producing areas of southern Ethiopia. In the traditional way of cropping system in the country, it is a known and common practice to transplant suckers several times. This means they transplant suckers from mother plant in to a nursery beds before taking them into the main or permanent field. The suckers transplanted to the nursery site stay at the site for a period of one year. Under the traditional way of enset production system, depending upon the altitude range and the management practices undertaken, the maturation of enset takes a range of 5-10 years.

**Enset Crop Livestock Interaction**

The leaf of enset is a good source of fodder for animal, which containing 13% protein, 20% crude fiber and 10% sugar.[17] The leaf is also important material for starting the silage production. There is no as such much enough fiber in the pseudo stem of the enset to make a suitable fodder for ruminants consumption, but the problem is solved if the remaining part of the pseudo stem, after the kocho preparation, are mixed up with the other plant materials. The pseudo stem part of enset, like the leaf blades, mainly contains elements such as potassium, magnesium, zinc and manganese in suitable amounts to be used as forage for ruminants, while the calcium levels found in the pseudo stem are not high enough to support the animal mainly the lactating caws. The pseudo stem of enset provides a similar amount of energy to that of oats and performs similarly to barley in provision of net energy mainly suitable for lactation caws. Furthermore, livestock holding and enset production are interconnected, in whichlivestock holding is crucial for enset cultivation due to manure production, and the low livestock holding in turn negatively affected the yield of enset. In the study area, enset production and livestock have a positive relationship in which livestock's are kept within farm compounds grazing in front yards, and fed the enset leaves and other crop residues and produce manure. The produced manure is mainly collected by women's and applied around enset plants in enset farm. So, enset production of and livestock are interdependent components. Mainly in the study area when enset yield is not enough to feed the family members and when farmers do not expect enset to be harvested in the immediate future, enset producers more of time bring their field covered by ensetinto the cultivation of other annual food and cash crops, especially the well-known crops in the area such as maize, common bean, sorghum and sweet potato.[18] Land fragmentation is the main problem in the study area, so this leads to the increasing of annual crops land share.

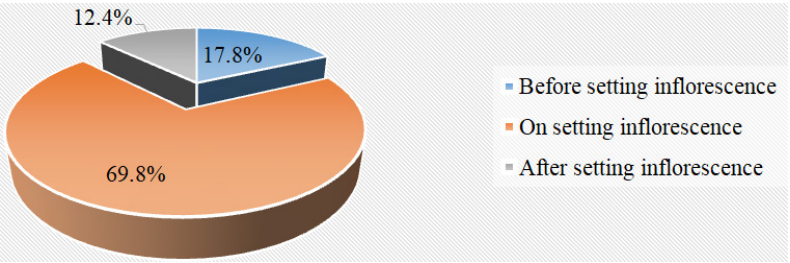


**Fig. 3: enset harvesting time**

**Enset Harvesting Time**

Mainly enset producers harvest it just after the appearance of the inflorescence (Fig. 3). About 69.8% of respondents responded that, they harvest enset on setting of inflorescence, 17.8% were before setting inflorescence, and this is happen during the periods when drought occurs. The rest 12.4% were harvest after setting inflorescence

this is for those who uses enset as an ornamental plant in and around their compounds. Harvesting and processing mainly includes cutting the leaf sheaths of enset pseudo stem into pieces, enset pulp scraping (parenchymatous tissue) from the cut pieces, pulverizing the corm and mixing it with the scraped leaf sheaths pulp and fermenting the mixture of them for a certain period of time.

**Enset Products and Storage**

Three main food types were obtained from enset, this are the food product obtained by fermenting the mixture which is locally known as 'kocho'. The starchy liquid part that is obtained by squeezing the mixture is locally called 'bulla'. Bulla was consumed after it will be allowed to settle for some days. Producers in the study area do not have the skill and knowledge of how to produce 'bulla,' they only produce 'kocho and amicho' only. The freshly cooked and consumed corm that is similar to Irish potato is locally called 'amicho'. Enset can be harvested for consumption at any developmental stage if there is occurrence shortage of food in the area. Thus, the plant is mainly considered as a field bank for food and called a crop against hunger.

**Enset Production Challenges**

Enset is affected by many factors such as pests and pathogens of varying severity. Among this factors the most important biotic ones include Mole rate, Enset bacterial wilt (EXW, bacterial rots (Erwinia sp.) and the enset root mealy bugs.[19, 20] For this reasons farmers in the study area shifts from enset cultivation to other crops production and the expansion of eucalyptus tree for the purpose of income generation. Enset production cannot be commercially marketed and known but the crop has multipurpose use for subsistence farmers in the production areas.

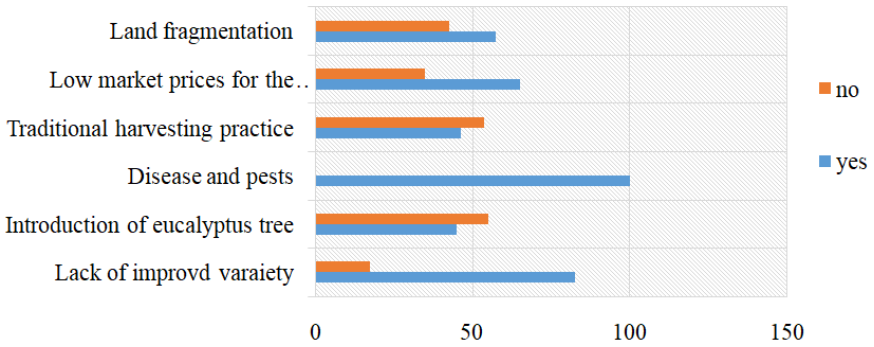


**Fig. 4: enset production challenges**

The enset production based farming systems in the country is poorly known. Particularly details about enset's production and management systems, cultivation methods, and the genetic diversity. The average farm sizes of producers have decreased due to increasing population number that leads to land fragmentation, and enset cultivation under traditional ways of production and management practices has failed to produce enough to feed the increasing population. About 57.5%, 62.2%, 46.4%, 100%, 45.0% and 82.5% of respondents respectively responds that, land fragmentation, low market price for enset products, traditional harvesting practice, disease and pests, introduction of eucalyptus tree and lack of improved variety are the major problems of enset production in the study area (Fig 4).In the traditional ways of production and management systems enset has a long-growing cycle, and gives very low yield. As enset is cultivated indifferent agro-ecological zones and ethnic groups, the production and management systems as well asthe processing procedures used were also vary greatly. In order to improve this traditional production and management systems, the indigenous knowledge of different enset-growing regions as well as the ethnic group's ways of production also needs to be analyzed and well understood. Though, the characterization of the enset genetic diversity and to identify the plant material which are resistance to diseases infestation and pests, or the enset genetic ability to excel in specific environments, has not yet begun in the country.

**Controlling Methods**

The economic impact of EB Wand Mole rats in the study area were potentially very disastrous because it destroys the whole plant parts and finally leads to a complete yield loss. Eenset Bacterial Wilt the enset common disease spreads within and across fields by means agents such as contaminated production and processing tools, infected enset plant materials, infested soil, wind driven, rain and insects. EBW can be managed and controlled by the following phyto-sanitary practices undertaken by the farmers such as burying of infected plants, restricting the movement of infected plant materials, sterilizing production and processing tools and raising awareness about how to manage and control the disease and the implementation of the above listed practices. But the practices have been inconsistent because they are labor-intensive and farmers are reluctant to implement them properly. Moreover, currently there are no commercial known fungicides, bactericides and bio-control agents to control EBW and other related diseases and pests. Therefore, further researches will be conducted on the controlling methods and attention is given to search for the effective controlling methods enset pests and diseases as well as environmentally friendly ones. Strategies for bacterial disease control in crop production like enset are to improve the plant defense mechanisms.

Aluminum Phosphate (ALPO4)is an effective controlling method for mole rates that are the serious problem of enset production in the study area. It is a tablet and needs care during its application. Because this chemical will decompose after use into a small pile of grayish powder and is the most effective ways to control moles. The chemical has no residual effect on soils where it is applied and will also not harm the plant life in the treated area.

**Discussion**

A total farm size a farmer have and area under enset production is very important factor that could positively or negatively affect enset production and also the home gardens allocatedfor ensetcoffee agro forestry system. The high increase in population number during the last few decades has mainly reduced the availability of land for main crops cultivation and land left for grazing in which, smallholder farmers account more than 96% of the total cultivated land in Ethiopia.[21] Enset production and management system at traditional technical level has been failed to feed the increasing population number that has been growing at a higher rate. The traditional methods of enset cultivation are diverse among agro-ecologies and ethnic groups as well as the crop has a long maturity period and the yield potential of the crop has not been properly utilized due to this farmers assess their comparative economic advantage and shift their production to increasing market opportunities, as they manifested their production potential in to the expansion of annual crops.[18]

The production and productivity potential of a crop is determined by a combination of factors. The interaction effect of factors like climatic conditions or agro-ecology of a region with its soil and the crop characteristics are the major ones. Climatic change and variability impact under a wide range of the future scenarios is yet to be quantified for enset production and will form an important part for the future development strategy to enhance the crop production and productivity, as undertaken for the coffee production in Ethiopia.[22, 23] So farmers whose livelihood mainly depends on enset production claims to maintain the diverse enset clones or varieties for several reasons, among the main reasons why they maintain diverse varieties including: the enset qualities to have alternative uses such as fiber production, fodder for animals or serve as medicine, and that adapt to different climatic conditions and a varieties that have the ability to tolerate the main diseases and pests.[6, 12]

The diseases caused by virus and bacteria were identified as the main yield reducing factors ofenset production. There are a various symptoms characterize the occurrence of the disease: such as leaf yellowing, distortion of the plant, wilting/collapse of enset, and the pockets of the crop became yellow or cream colored slimy ooze are visible in cut vascular tissues of the plant as well as in the leaf sheaths, leaf midribs and the real stem.[19] The vascular bundles of enset often become discolored and totally it leads to a yield loss once the disease takes hold, in tolerant landraces or varieties plant recovery has been sometimes observed.[5] The morphological and agronomical practices of ensetwere varietybased the type of landrace.[24] Specifically enset processing is traditionally imaged as a role of women, who mainly act as a reservoir of processing knowledge

and skillsas well astechniques involved. The tasks involved in the processing steps of enset are labor-intensive and very tedious.[25, 26]

Previous studies indicate that among the control measures that could prevent, reduce or eliminate the spread of enset bacterial wilt include the disinfection of production and processing tools after use it, preventing home animals from browsing the infected enset plants, fencing infected enset sites and the rigorous and proper removal of infected enset plants.[27] Intensive genomic research was done to identify the candidate virulence factors that may facilitate host infection and suggesting the right solution to control the disease.[28]

In general enset is a multipurpose crop, which has social, cultural, medicinal and environmental stability uses. It is named as a tree against hunger due to it's withstand of climatic variability impacts and enhances the food security of the producers. In areas where there is enset production there is no food security problem. But still now the crop do not given attention by the society as well as the government of Ethiopia, so serious attention will be given to the crop to overcome climatic variability impacts and to enhance the food security problems of increasing population growth.

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**Conflict of interest**

Regarding the publication of this manuscript, there is no any conflict of interest.

## References

1. Belachew Garedew and Aklilu Ayiza, "Major constraints of enset (Ensete ventricosum) production and management in masha district, southwest Ethiopia," *Int. J. Agric. Res.,* 13: 87-94, 2018.
2. Ayele, A. and O. Sahu, 2014. Extension of Enset plant product for rural development in Ethiopia.
3. Birmeta, G. and M. Welander, 2004. Efficient micro propagation of Ensete ventricosum applying meristem wounding: A three-step protocol. *Plant Cell Rep.*, 23: 277-283.
4. Addis T., F. Azerefegne and G. Blomme, 2008. Density and distribution on enset root mealybugs on enset. *Afr. Crop Sci. J.,* 16: 67-74.
5. Hunduma, T., K. Sadessa, E. Hilu and M. Oli, 2015. Evaluation of Enset clones resistance against Enset bacterial wilt disease (Xanthomonas campestris pv. musacearum). *J. Vet. Sci. Technol.*, Vol. 6. 10.4172/2157-7579.1000232.
6. Olango, T.M., B. Tesfaye, M. Catellani and M.E. Pe, 2014. Indigenous knowledge, use and onfarm management of enset (Ensete ventricosum (Welw.) Cheesman) diversity in Wolaita, Southern Ethiopia. *J. Ethnobiol. Ethnomed*. Vol. 10. 10.1186/1746-4269-10-41.
7. Yemataw, Z., A. Mekonen, A. Chala, K. Tesfaye and K. Mekonen *et al*., 2017. Farmer's knowledge and perception of enset Xanthomonas wilt in Southern Ethiopia. *Agric. Food Sec.,* Vol. 6. 10.1186/s40066-017-0146-0.
8. Districts Agricultural office (DAO), 2003. Anuual report, South Omo Zone, Jinka, Ethiopia.
9. Schwarzer G (2007) M eta: an R package for meta-analysis. R News 7(3):40–45
10. CSA - Central Statistical Authority, 1997a. Enset sample survey results. Addis Ababa, Ethiopia. 106 pp.
11. Central Statistics Agency. (1995–2017). Central Statistics Agency-Agricultural Sample Survey (Belg and Meher seasons). Retrieved from http://www.csa.gov.et/survey-repor t/

category/58-mehermain-season-agricultural-sample-survey

12. Yemataw, Z., Mohamed, H., Diro, M., Addis, T., & Blomme, G. (2014). Enset (Ensete ventricosum) clone selection by farmers and their cultural practices in southern Ethiopia. Genetic Resources and Crop Evolution, 61(6), 1091–1104. Https: //doi.org/10.1007/ s10722-014-0093-6
13. Tsegaye A (2002) on indigenous production, genetic diversity and crop ecology of enset (Ensete ventricosum (Welw.) Cheesman). Dissertation, Wageningen University
14. Negash, A. (2001). Diversity and conservation of enset (Ensete ventricosum Welw. Cheesman) and its relation to household food and livelihood security in South-western Ethiopia. Wageningen: Wageningen University.
15. Birmeta, G. "Genetic variability and biotechnological studies for the conservation and improvement of Ensete ventricosum," p. 38, Doctoral thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden, 2004.
16. Shambulo, A., Y. Gecho, and M. Tora, "Diversity, challenges and potentials of enset (Ensete ventricosum) production: in case of offa woreda, Wolaita zone, southern Ethiopia," *Food Science and Quality Management*, vol. 7, pp. 24–31, 2012.
17. Mohammed, B., Martin, G., & Laila, M. K. (2013). Nutritive values of the drought tolerant food and fodder crop enset. *African Journal of Agricultural Research*, 8(20), 2326–2333. https://doi.org/10.5897/ AJAR12.1296
18. Tesfaye Abebe, Wiersum, K. F. & Bongers, F. (2010). Spatial and temporal variation in crop diversity in agroforestry home gardens of Southern Ethiopia. *Agroforestry Systems,* 78,309–322.
19. Blomme, G., Dita, M., Jacobsen, K. S., Pérez Vicente, L., Molina, A., Ocimati, W., *et al*. 2017. Bacterial Diseases of Bananas and Enset: Current State of Knowledge and Integrated Approaches toward Sustainable Management. *Front. Plant Sci.* 8:1–25 Available at: http://journal.frontiersin.org/ article/10.3389/fpls.2017.01290/full
20. Tewodros, M., and Tesfaye, W. 2014. Farmers' indigenous knowledge and assessment of enset (Ensete ventricosum Welw. Cheesman) cultivars for major insect pests in Ojojia water shade Kembata- tembaro zone, South Ethiopia. *Sky J. Agric.* Res. 3:112–119.
21. Taffesse, A. S., Dorosh, P. A., & Gemessa, S. A. (2013). Crop production in Ethiopia: Regional patterns and trends. Food and Agriculture in Ethiopia: Progress and Policy Challenges, (Essp Ii), 53–83. Retrieved from http:// ebrary.ifpri.org/cdm/ref/colle ction/ p1573 8coll 2/id/127350
22. Moat J, Williams J, Baena S, *et al*. 2017. Resilience potential of the Ethiopian coffee sector under climate change. *Nature Plants* 3: 17081.
23. Davis AP, Wilkinson T, Challa ZK, Williams J, Baena S, Gole TW, Moat J. 2018. Coffee atlas of Ethiopia. Richmond: Kew Publishing.
24. Yemataw, Z., Tesfaye, K., Grant, M., Studholme, D. J., & Chala, A. (2019). Multivariate analysis of morphological variation in Enset (Ensete ventricosum (Welw.) Cheesman) reveals regional and clinal variation in germplasm from south and south western Ethiopia. *Australian Journal of Crop Science,* 12(12), 1849–1858. Https: // doi.org/10.21475/ ajcs.18.12.12.p1135
25. Hunduma, T., & Ashenafi, M. (2011). Traditional Enset (Ensete ventricosum) processing techniques in some parts of West Shewa Zone, Ethiopia. *Journal of Agriculture and Development,* 2(1), 37–57. Retrieved from http://opend ocs.ids.ac.uk/opend ocs/ handl e/12345 6789/8730
26. Garedew, B., Ayiza, A., Haile, B., & Kasaye, H. (2017). Indigenous knowledge of Enset (Ensete ventricosum (Welw.) Cheesman) cultivation and management practice by Shekicho people, southwest Ethiopia. *Journal of Plant Sciences,* 5(1), 6–18. Https: //doi. org/10.11648/ j.jps.20170 501.12
27. Quimio AJ, Tessera M. 1996. Diseases of enset. In: Tsedeke A, Clifton H, Steven BA, GebreMariam S (eds) Enset-based sustainable agriculture in Ethiopia. Proceedings of the International Workshop on enset. Addis Ababa: *Ethiopian Institute of Agricultural Research,* 188–203.
28. Nakato V, Mahuku G, Coutinho T. 2018.

Pathogen profile Xanthomonas campestris pv. musacearum: a major constraint to banana, plantain and enset production in central and east Africa over the past decade. *Molecular Plant Pathology* 19: 525–536.