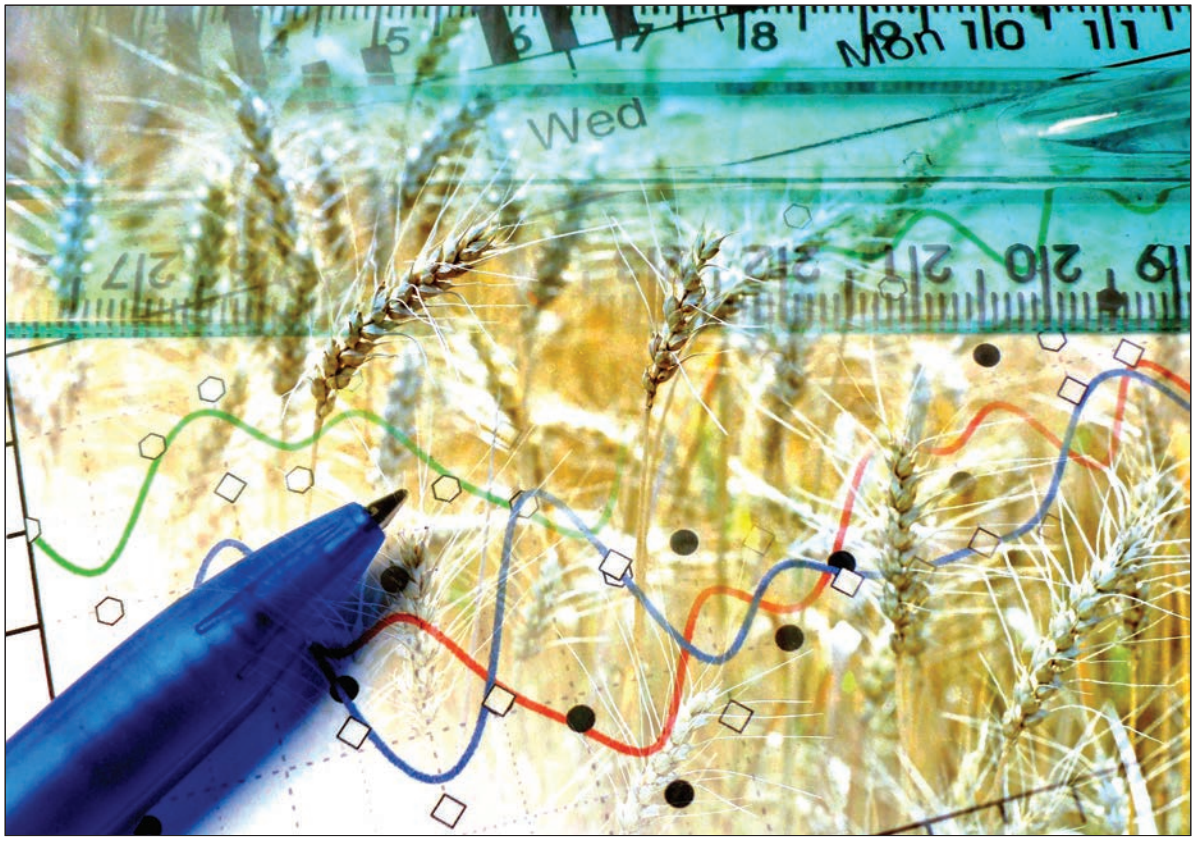

Trends in Agricultural Economics

ISSN 1994-7933

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Trends in Agricultural Economics

ISSN 1994-7933
DOI: 10.3923/tae.2024.1.7

Research Article
Economic Analysis of Loss Associated with Wilting Disease of *Ensete ventricosum* in Sidama Region, Ethiopia

Tsadiku Alemu

Sidama Region Agricultural Research Institute, Hawassa Agricultural Research Center, P.O. Box 2026, Hawassa, Ethiopia

Abstract

Background and Objective: Enset based mixed agricultural system is the main agricultural production in Sidama Region, Ethiopia. However, despite the potential, *Ensete* cultivation has been endangered by a devastating bacterial disease (wilting disease) caused by *Xanthomonas campestris* pv. *musacearum* (Xcm) and a large volume of post-harvest loss due to the unavailability of modern *Ensete* processing technology at farm households in Sidama Region, Ethiopia. This study was therefore initiated to analyze economic loss associated with wilting disease and post-harvest handling of *Ensete* in Sidama Region, Ethiopia. **Materials and Methods:** In total, 67 sample households were selected from Hula (Wirama and Chalbesa kebeles) and Dale (Shoye and Moto kebeles) areas of Sidama Region in a systematic random sampling technique. The measured variables were the number of *Ensete* plants affected by the wilting disease and the estimated loss quantified in Ethiopian Birr. Descriptive statistics was used to analyze the data. **Results:** On average, the economic loss associated with wilting disease and post-harvest handling in the study area was 79,749.47 Ethiopian Birr. The prevalence of wilting disease was higher in Sidama areas under the study (Hula and Dale). Approximately, 30% of *Ensete* in the study area was affected by wilting disease (*Ensete* bacterial wilt). Most growers harvest their *Ensete* using traditional methods and depending on the season and length of storage, they either store it above ground in a prepared storage area made of wrapped leaves and leaf sheaths or in a pit. Sacks and pits cause the kocho to turn black, emit unpleasant smells and harbor worms, worsening the quality loss. **Conclusion:** Therefore, training and addressing farmers about the severity of *Ensete* bacterial wilt, introducing diseases resistant clones, modifying traditional storage and processing methods and working on innovation and introduction of fermentation starter are recommended.

Key words: *Ensete ventricosum*, economic analysis, loss assessment, wilting disease, post-harvest handling

Citation: Alemu, T., 2024. Economic analysis of loss associated with wilting disease of *Ensete ventricosum* in Sidama Region, Ethiopia. Trends Agric. Econ., 17: 1-7.

Corresponding Author: Tsadiku Alemu, Sidama Region Agricultural Research Institute, Hawassa Agricultural Research Center, P.O. Box 2026, Hawassa, Ethiopia Tel: +251926525843

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ethiopia's economy is dependent on agriculture, which boosts GDP, employment opportunities and food security. With 85% of the working force employed in agriculture, it forms the foundation of the rural economy, generates roughly 46.3% of the nation's GDP and the sector is the backbone of the country's economy with 90% of export revenues[1-4]. Thus, it is not surprising that policy action in Ethiopia is largely based on influencing the dynamism of the agricultural sector.

There are four main agricultural systems in Ethiopia: Enset-based cultivation, pastoralism, shifting cultivation and grain-based cultivation. The primary agricultural production in Southern Ethiopia is *Ensete* based mixed agricultural system. *Ensete* is the main crop of a sustainable indigenous African system that guarantees food security in the food-deficient nation since its products are year-round and can be kept in pits for extended periods without damage allowing for year-round consumption. One notable advantage of enset is its role in promoting sustainable agriculture. Traditionally, homesteads are surrounded by tiny plantations where *Ensete* is grown. In many areas of Ethiopia's densely populated south and southwest highlands, this native root crop is grown as a traditional staple food crop. Its cultivation accounts for over 65% of all agricultural production and has a relatively high yield when compared to other crops; yet, altitude variations, ecological factors and cultural practices all affect this crop differently. The recent spate of droughts has caused the *Ensete* crop to spread throughout the nation[5]. Farmers in the central and northern regions, however, mostly cultivate the crop for ornamental purposes, using its leaves for a variety of uses[6]. It is a never-ending battle for Ethiopian farmers to provide for their families because farming is frequently risky and done so at the mercy of the environment.

Likewise, *Ensete* cultivation has been endangered by a devastating bacterial disease (wilting disease) caused by *Xanthomonas campestris* pv. *musacearum* (Xcm) and large volume of post-harvest loss due to unavailability of modern *Ensete* processing technology at farm households in enset cultivating areas of the country. In view of these situations in enset cultivation, considering loss from *Ensete* cultivation due to wilting disease and unavailability of processing technology is important to maximize the crop's harvest. Therefore, this study aimed to assess economic loss from *Ensete* cultivation due to wilting disease and post-harvest handling. Since *Ensete* is a multipurpose crop whose production has become endangered by a devastating bacterial wilt and post-harvest handling problem, assessing loss associated with *Ensete* bacterial wilt and post-harvest handling was expected to provide quantitative information for policymakers to focus on solution, help to examine livelihood change due to the occurrence of the disease and will help development organizations to respond to the disease and post-harvest handling problems in enset cultivation. Hence, it was undertaken to estimate yield loss in *Ensete* cultivation due to *Ensete* bacterial wilt and post-harvest handling the problem in the major *Ensete* growing areas of Sidama Region and assess economic loss from *Ensete* cultivation due to enset bacterial wilt and post-harvest handling at smallholders' livelihood.

MATERIALS AND METHODS

Site description: This study was conducted from January, 2022 to December, 2022 in the two major *Ensete* growing areas of Sidama Region, Hula and Dale Woredas, Ethiopia.

Data type, source and method of data collection: Both primary and secondary data were used for this study. The primary data was collected from producers using an interview schedule through trained enumerators and pre-tested structured questionnaire. In addition, *Ensete* farms were observed and the number of diseased *Ensete* removed from *Ensete* fields and existing during the time of interview were counted to estimate the yield and economic loss based on the average yield per plant history. Post-harvest loss was measured qualitatively as it was difficult to account for the exact amount of post-harvest loss. The quantitative post-harvest loss refers to the volume of *Ensete* products lost due to post-harvest handling problems. The qualitative post-harvest loss refers to the loss of quality (color, taste and/or odor) of *Ensete* products due to enset post-harvest handling problems. Accordingly, processing methods; the effectiveness of each method and strengths and weaknesses of the methods were collected from growers. Processing techniques (harvesting, decorticating, grating, fermenting and storage, etc.) were interviewed and observed to assess the losses. Focus Group Discussion (FGD) were held to collect data that might not have been collected during individual interviews and farm observation using checklists.

Secondary data were collected from different sources such as government and non-government institutions, reports, articles and websites. Published and unpublished documents were also reviewed to get relevant information regarding enset post-harvest handling and *Ensete* bacterial wilt.

Sampling procedure and sample size: To conduct the household survey with farmers, a two-stage sampling technique was employed to draw representative sample households for the population under consideration. First, two Woreda from Sidama Region were selected based on maximum *Ensete* production. In the second stage, two kebeles from each woredas, from Hula (Wirama and Chalbesa kebeles) and Dale (Shoye and Moto kebeles) were selected purposively based on disease severity and post-harvest problem level. Finally, the household list of the sampled kebeles was updated and the sample size was determined based on population proportional to the size of households in the kebeles. In Total, 67 households were used as a sample in the study.

Method of data analysis: Descriptive statistics was used for analyzing the data collected from producers. It included statistics like percentages, frequencies, means and standard deviations to describe demographic and socioeconomic characteristics of farm households in the study area by employing 95% confidence interval for data. These descriptive statistics were also used to assess yield and economic losses that occurred in *Ensete* cultivation due to wilting disease and post-harvest handling problems.

Statement of the informed consent: Study participants were informed that their personal identity will not be disclosed in any form in this study and the information they provided was used solely for the purpose of the study. Ahead of the study, their willingness to participate was asked and the objectives of the study were clearly indicated.

RESULTS AND DISCUSSION

Demographic and socio-economic characteristics

Continuous variables: Summary statistics for continuous variables was presented in Table 1. The average age of the sampled households was about 48 years. This implies that the household heads were old enough and experienced in enset production in the study area. The average educational level of sampled households in formal years of schooling was about 5 years. This result implies that *Ensete* grower farmers were able to read and write if they were to be given training on agronomic management. The average family size for the sampled households was 5 persons. The average year of experience in production of enset was about 27 years. The average land allotted to the enset cultivation in the study area was 0.275 ha. The land areas allotted to perennial crops, trees and grazing land were 0.16, 0.08 and 0.16 ha, respectively. The average total land holding of the sampled households was 1.325 ha. These socioeconomic variables are important and in line with findings of previous studies which indicated age, sex of household head, education level, livestock owned, distance from nearest market center, enset plantation size, transport access, access to market information, availability of labor, perception on prices and a quantity of enset product as significant factors in affecting the probability of market participation decision[7-9].

Prevalence status of EBW in the study area: The prevalence of EBW was almost on the entirety of sampled households' farm in Hula woreda whereas 35.71% of households reported that EBW was prevalent in their farm in Hula woreda (Table 2). A report data of The McKnight Foundation Collaborative Crop Research Program Project in Ethiopia (McKnight-CCRP 11-283: Enset bacterial wilt, Annual report (November, 2012 to October, 2013) by Aytenfsu and Haile[10] indicated that wilting disease, *Ensete* root mealy bug, mole rat and porcupine constituted major challenges in the cultivation of enset in Sidama Region.

Yield and economic loss estimation of EBW: The average number of enset that were affected by EBW in the study area in the age category of 1, 1-2, 2-3 and 3-4 were about 24, 48, 26 and 129, respectively. The probable implication for this result might have been that as the age increases, the vulnerability of enset to EBW increases. If the bacterial wilt disease affects mature enset plants after years of field management, the damage could range from 70 to 100% yield loss with significant economic consequences[11]. Bacterial wilt incidence for matured enset in some studies was up to 30%[12]. The average number of total enset affected by EBW within all age categories was about 293. Apart from that *Ensete* which showed symptoms of EBW, the number of *Ensete* which have already died because of EBW was about 51. Those with early symptoms were expected to die eventually as a result of the effect of EBW. When converted into monetary value, the economic yield loss of enset as the result of EBW was 79,749.47 Ethiopian Birr (ETB) (Table 3).

EBW management practices: Farmers were able to prevent the spread of the EBW by cutting the enset and burning and burying the dried parts of *Ensete* as a result of the disease. However, some farmers were observed

to have put the cut part in the middle of the farmlands beneath bamboo trees not far from the farmland or on the margins of farmland border. For farmers, there are no efficient pesticides or biocontrol agents to prevent bacterial wilt. Farmers are only able to prevent disease by using phytosanitary measures, such as removing and burying affected plants, restricting the movement of contaminated plant materials and using clean farm equipment[13].

Farmers' perception of the means of EBW transmission: The top means of transmission of EBW from one farmland to another as per the way farmers perceived were the use of contaminated materials like sacks in common by exchanging (49.25%), exchanging farm tools (44.78%) and the role of air in transmitting the carrier (5.97%). In the same farmland, according to the response of farmers, the major means of transmission were farm tools (46.27%), contaminated material (29.85%) and animals (14.93%) as per the result (Table 4).

Table 1: Summary of socioeconomic factors affecting enset production and marketing

Variable (n = 67)	Unit	Mean	Standard deviation	Minimum	Maximum
Age	Years	48.52	7.99	35	62
Education level	Years	5.52	2.68	1	10
Family size	Number	5 .00	1.25	3	7
Experience in production of enset	Years	27.51	10.31	10	45
Annual crop land	Hectares	0.65	0.26	0.2	1.1
Enset land	Hectares	0.275	0.13	0.05	0.5
Perennial land	Hectares	0.16	0.08	0.02	0.3
Tree land	Hectares	0.08	0.04	0.01	0.15
Grazing land	Hectares	0.16	0.08	0.02	0.3
Total land	Hectares	1.325	0.60	0.3	2.35

Source: Survey result, 2022

Table 2: Prevalence status of EBW in two woredas of Sidama Region

Woreda	Frequency	Percentage
Hula (n = 25)	25	100
Dale (42)	15	35.71
Total (n = 67)	40	59.70

Source: Survey result, 2022

Table 3: Summary statistics of yield and economic loss estimation of EBW

Variable	Mean	Standard deviation	Minimum	Maximum
Affected enset aged below 1	24.15	7.26	15	40
Affected enset aged below 1-2	48.31	14.51	30	80
Affected enset aged below 2-3	26.11	17.83003	50	147
Affected enset aged below 3-4	129.63	55.10	60	250
Total affected enset in number	293.20	95.80	155	500
Enset died because of EBW	51.98	17.41	30	90
Number of available enset	584.5	170.9369	295	874
Economic yield loss estimation in ETB	79,749.47	26,058.3	42,160	136,000
Ratio of infected to total enset		11,727/39,161= 0.2995~30%		

Source: Survey result, 2022

Table 4: Farmers' perception of means of transmission

From one field to another			From one plant to another		
Responses	Frequency	Percentage	Responses	Frequency	Percentage
Contaminated material	33	49.25	Contact between infected and healthy plant	0	0.00
Drought	0	0	Contaminated material	20	29.85
Farm tools	30	44.78	Farm tools	31	46.27
Air	4	5.97	Air	0	0.00
Insect	0	0	Animals	10	14.93
Animal dung	0	0	Human	6	8.95
No idea	0	0			
Animals	0	0			

Source: Survey result, 2022

Table 5: Techniques of identifying matured *Ensete*

Methods of identifying mature enset	Frequency	Percentage
Inspecting change in size and leaf color	38	56.72
Year count	59	88.06
Flowering and upcoming of corm	47	70.15

Source: Survey result, 2022

Table 6: Storage techniques of processed kocho in the study area

Time	Frequency	Percentage
In hole lined with leaf and leaf sheath	37	55.22
A place above the ground prepared from wrapped leaf and leaf sheath	33	49.25
Sacks	21	31.34

Source: Survey result, 2022

Table 7: Amount of production and sale at household level

	Production (kg)		Sale (kg)	
Product	Mean	Standard deviation	Mean	Standard deviation
Kocho	1169	341.87	315.63	92.31
Bula	292.25	85.47	204.57	59.83
Fiber	248.41	72.65	198.73	58.12

Source: Survey result, 2022

Post harvest handling techniques

Farmers' method of identifying mature enset for harvesting: As indicated in Table 5, majority of enset growing farmers indicated years counting technique (88.06%) as a method of identifying matured enset for harvesting. This helps farmers in two ways. In the first case, farmers are obliged to harvest *Ensete* and process it into kocho before the enset has become mature enough due to stress in living conditions. In second case, farmers know the age of *Ensete* so that they can estimate the price as per the age in case they decide to sell the enset on-farm. Other ways of identifying maturity include observing flowering enset with emerging bulb/corm (70.15%) and having a clue of maturity from changes in leaf color and size of the enset (56.72%). The traditional harvest process includes identifying mature enset, digging and preparing the pit and lining the pit's surface, removing external leaf sheath and decorticating and pulverizing the inner leaf sheath using traditional processing (harvesting) tools.

Kocho storage places: As indicated in Table 6, the major techniques being employed by farmers to store kocho are putting in a hole or pit (55.22%) and putting it above the ground in the backyard (49.25%).

According to respondents, this method was preferred for long-period storage. It is convenient during dry season. The first technique of putting kocho in the pit is problematic because of lack of free air movement. It also risks intrusion of flood water into the pit if the cover of enset canopy is scant. The second technique (preparing a confined area above the ground) exposes the food item to be stolen by thieves in the cover of darkness. This method was preferred during the rainy season which can overcome moderate flood damage but is easily destroyed by other external environment like animals and is not appropriate for long storage periods. Aeration causes the blackening of kocho, the development of a repugnant smell and worm development, thus consequently losing quality. Some farmers were reported to have used sacks. As per the agreed-upon arrangement, farmers stay alert by putting the kocho in sacks. This is a case when traders want kocho to take and sell at town markets. Some households in town areas put the purchased amount in sacks as there is no way to dig pits. This condition minimizes the quality and consequently rejection by customers and loss. The fermentation period of processed kocho varied based on the area's altitude (temperature), accession used and the economic situation of farmers. As a result, for 15 to 30 days, 74.62% of respondents kept their kocho in the pit. Less than 15 days and more than a month are acceptable fermentation periods, according to the remaining 14.93 and 10.45% of farmers questioned, respectively.

Production and sale: As indicated in Table 7, kocho, bula and fiber are sold after storing the amount required for household consumption. On average, 27% of kocho, 80% of fiber and 70% of bula are supplied to the market. Majorly, kocho is used for household consumption. On the other hand, bula and fiber are sold at the marketplace to get cash and they are not used at home that much. Fibers are used at home as a mattress beneath spread carpets and to make a rope, which is used to tie cattle. The average price of kocho, fiber and bula were 30, 15 and 60 Birr, respectively.

Table 8: Estimated amounts of losses at different chain actors

Chain	Kocho loss (%)	Bula loss (%)
Producers	5	1
Retailers	20	5
Consumers	3	0.5
Total loss	28	6.5

Source: Survey result, 2022

Losses at different chains: At producers' level, the amount of kocho lost was small in cases of both bula and kocho. At retailers' level, the loss became higher as there is a loss in quantity due to the effect of temperature and suffocation in the storage materials like sucks during transportation and storage (kocho, 20% and bula, 5%). At consumer level, the loss was small in cases of kocho and bula. This is because consumers do not store kocho for too much time after purchasing it; they prepare food and use it immediately. In the case of fiber, it is unusual to observe losses as it is used either for domestic uses or for sale (Table 8).

CONCLUSION

The prevalence of EBW was higher in Sidama areas under the study (Hula and Dale). On average, the economic loss associated with wilting disease and post-harvest handling in the study area was 79,749.47 Ethiopian Birr. Approximately, 30% of enset in the study area was affected by EBW. Depending on the season and length of storage, most farmers harvest and process their enset using traditional ways and store it either in a pit or above ground in a prepared place of storage made of wrapped leaves and leaf sheaths. Sacks and pits make kocho more susceptible to worm development, horrid smells and quality degradation.

RECOMMENDATIONS

Generally, the prevalence of EBW and negligence in implementing what is known need attention through training and addressing farmers about the severity of the spreading pace. The diseases resistant clones' introduction is required here. In addition, there were no scientifically modified harvesting and storage methods of enset in the study area. The intervention of government and non-governmental organizations is paramount in modifying traditional processing through mechanization. Additionally, the role of addition of a fermentation starter or fermentation enhancer in shortening of fermentation period and increasing kocho quality requires scientific investigation.

SIGNIFICANCE STATEMENT

The study estimated the economic loss of *Ensete ventricosum* by the effect of wilting disease in Ethiopian Birr to make required policy interventions and minimize the effect of the wilting disease severity. The expected interventions/results after this study are working to minimize the effect of wilting disease by governmental and nongovernmental organizations so that *Ensete* continues to serve as a source of food security, accumulation of assets, nutrition, cultural value and income from the sale of kocho and fiber. Interventions might include training farmers on the prevention mechanism of *Ensete* bacterial wilt, introduction of environmentally adaptable and diseases resistant clones of *Ensete*, modification of traditional storage and processing methods and innovation and introduction of fermentation starters. This study will also act as input for the coming researchers who want to make further investigations concerning *Ensete ventricosum* in the study area in the future.

ACKNOWLEDGMENTS

This study was financially supported by the Hawassa Agricultural Research Centre, Sidama Region Agricultural Research Institute with the budget code 213-02-09-00-003. The authors thank the respondent farmers, agriculture experts, development agents, group participants and key informants for sharing their indigenous knowledge and invaluable time for the study.

REFERENCES

1. Abebe, T., K. Shitu, H. Mekonnon and F. Godade, 2022. To review studies conducted on soil fertility management measures and their role in improving soil fertility. Ann. Earth Sci. Geophys., 1: 1-7.
2. Hailu, H. and S. Feyissa, 2023. Role of integrated nutrient management on soil fertility improvement and selected crop production in Ethiopia: Review study. Int. J. Appl. Agric. Sci., 9: 149-158.

3. Hailu, D., 2024. Development of the agricultural sector and its contribution to the growth of the Ethiopian economy. Int. J. Agric. Econ., 9: 36-40.
4. Wato, T., 2019. Improvements of crop production through integrated soil fertility management in Ethiopia. Asian J. Environ. Ecol., Vol. 1. 10.9734/AJEE/2019/v11i130130.
5. Peveri, V., 2015. The exquisite political fragrance of enset. Silent protest in Southern Ethiopia through culinary themes and variations. Partecipazione Conflitto, 8: 555-584.
6. Shumbulo, A., Y. Gecho and M. Tora, 2012. Diversity, challenges and potentials of Enset (*Ensete ventricosum*) production: In case of Offa Woreda, Wolaita Zone, Southern Ethiopia. Food Sci. Qual. Manage., 7: 24-31.
7. Mulatu, E., 2021. What determines Enset (*Ensete ventricosum*) production and its contribution to household income? Empirical evidence from Ethiopia. Int. J. Agric. Res. Innovation Technol., 11: 17-25.
8. Erchafo, T., 2017. Determinants of market participation of enset (*Ensete ventricosum*) farmers: The case of Doyogena District, SNNPR, Ethiopia. J. Econ. Sustainable Dev., 8: 85-94.
9. Lefebo, N., J. Haji, E. Geta and L. Zemedu, 2016. Determinants of status and extent of market participation among bulla producers in Hadiya Zone, Southern Ethiopia. J. Biol. Agric. Healthcare, 6: 84-92.
10. Aytenfsu, M. and B. Haile, 2020. Distribution and management of bacterial wilt (*Xanthomonas campestris* pv. *musacearum*) of enset (*Ensete ventricosum*) in Ethiopia: A review. Int. J. Res. Agric. For., 7: 40-53.
11. 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.
12. Wolde, M., A. Ayalew and A. Chala, 2016. Assessment of bacterial wilt (*Xanthomonas campestris* pv. *musacearum*) of enset in Southern Ethiopia. Afr. J. Agric. Res., 11: 1724-1733.
13. Blomme, G., K. Jacobsen, W. Ocimati, F. Beed and J. Ntamwira *et al*., 2014. Fine-tuning banana Xanthomonas wilt control options over the past decade in East and Central Africa. Eur. J. Plant Pathol., 139: 271-287.