Table 3.5. Laboratory result for the various land use types across the various farm level

Farm levels	PH (H2O)	EC (ms)	TN %	% OC	CEC (cmol $_c$ $^{kg-1}$) soil	Available P (ppm) mg/kg soil	Soil texture
Enset near the homestead	**6.5**	**0.1**	**0.406**	**21.2**	**36.2**	**12.54**	**Sandy loam**
Enset in the middle farm plot	6.4	0.4	0.476	1.794	35.4	4.78	Sandy loam
Enset in the lower farm plot	5.7	0.4	0.434	5.304	28.4	1.56	Sandy loam
Cereal in the top level	5	0.1	0.35	3.237	28.4	1.54	Sandy loam
Cereal in the middle level	4.9	0.1	0.35	3.925	26.4	1.32	Sandy loam
Cereal in the lower level	5.2	0.1	0.308	4.524	31.2	0.7	Sandy loam
Grazing land in the top	5.1	0.3	0.322	2.886	20.4	0.66	Sandy loam
Grazing land in the middle level	5	0.1	0.392	3.861	31	0.78	Loam Sand
Grazing lower	5.2	0.1	0.35	3.939	27.4	0.5	Loam Sand
Cereal mixed in all level	4.9	0.1	0.294	3.744	25.8	1.38	Loam Sand
Enset farm mixed in all level	6.5	0.2	0.462	4.797	31.8	6.42	Sandy loam

3.4.1Soil total nitrogen status

As shown Table 3.6, the distribution of total Nitrogen is greatly varying across the various land use types. The change was significant ($p<0.05$) levels of degree of significance towards the cereal and grazing land use types (Table 3.6) while no significant change was observed between the cereal and grazing land use types. This change resulted from the management aspects they apply for the respective land use types and the sustainability of the farming system in general. Farmers regularly use manure and house waste as a basic source of fertilizer for the enset farm plot and inorganic fertilizers for the cereal farm plot (See also table 3.5)

Table 3.6. Mean comparison in the amount of total nitrogen statues among enset, cereal and grazing land use types.

Treatment	Mean TTN	Mean pH
Enset	0.44 a	6.20 a
Cereal	0.34 b	5.03 b
Grazing	0.35 b	5.10 b

Means followed by the same letter in a column are not significantly differ at ($P<0.05$)

However, the N concentration near to the homestead was found to be lower in the case of enset farm plot when compared with the middle and lower farm (far from the homesteads) plots .This is may be because of the area near the homestead commonly allocated for sucker production by which the area is vulnerable for erosive rainfall and exposed to direct sunrays at least 3to5 months, owing to less canopy coverage of the farm in at the beginning of the rainy season and from the time of land preparation for propagation to until the emergence of suckers, makes the soil more vulnerable to leaching and out ward loss of N compared to the high canopy coverage of the middle and the out ward lower farm zone of the enset. Moreover as the researcher personal observation, the general configuration of the farm land of the area is declines in slope level from the homesteads to the out ward lower farm zone. Hence, N was more susceptible to leaching and down ward erosion of the nutrients as compared to the middle and lower farm plots. A minimal change in the amount of N concentration was explained by change in slope level from the homestead to down to the out ward lower farm plot, resulted in a small shift in the amount of N concentration in the various farm levels. The result agreed with the explanation of (Funte et.al., 2010) who noted that leaching losses of plant nutrients, particularly nitrogen, may be reduced by enset as compared to annual crops. This should be possible because of the continuous soil occupation by the roots. At the beginning of the rainy season and after maturation, annual crops have little root proliferation and little effect on nutrient leaching. For established enset, roots already proliferate the soil profile at the beginning of the rainy season. The large mass of the plant should serve as a storage reserve, reducing the availability of the nutrients in the soil by leaching.

3.4.2. Soil Available phosphorus content (ppm*)*

The result indicated that the mean amount of phosphors in enset farm plot was higher than the cereal and grazing land use types. The result showed that the amount of phosphors in cereal and grazing land use types were only 37.1 and 9.7% of the enset farm plot respectively (Table 3.7). Moreover, Soil phosphorus content was higher in the homesteads and successively decline to the lower farm level. The P content of the cereal farm in the top level (farm land situated in similar contour line west to east from the homestead) and enset in the lower farm level (the most lower out ward farm from the homestead) level was only 12% of the P content of the homestead in the enset farm.(see also table 3.5). Further the result indicated that the N concentration of the outfield was adequate, but P was the major nutrient in deficit in the outfield followed by potassium.

Table 3.7. Amount of mean OC, CEC and available phosphors among enset cereal and grazing land use types

Land use types	Mean %OC	Mean CEC cmol $_{c}$ ^{kg} soils	Mean Available Phosphors (ppm) /mg/kg soil
Enset	9.4	33.3	6.2
Cereal	3.9	28.7	2.3
Grazing	3.7	26.3	0.6

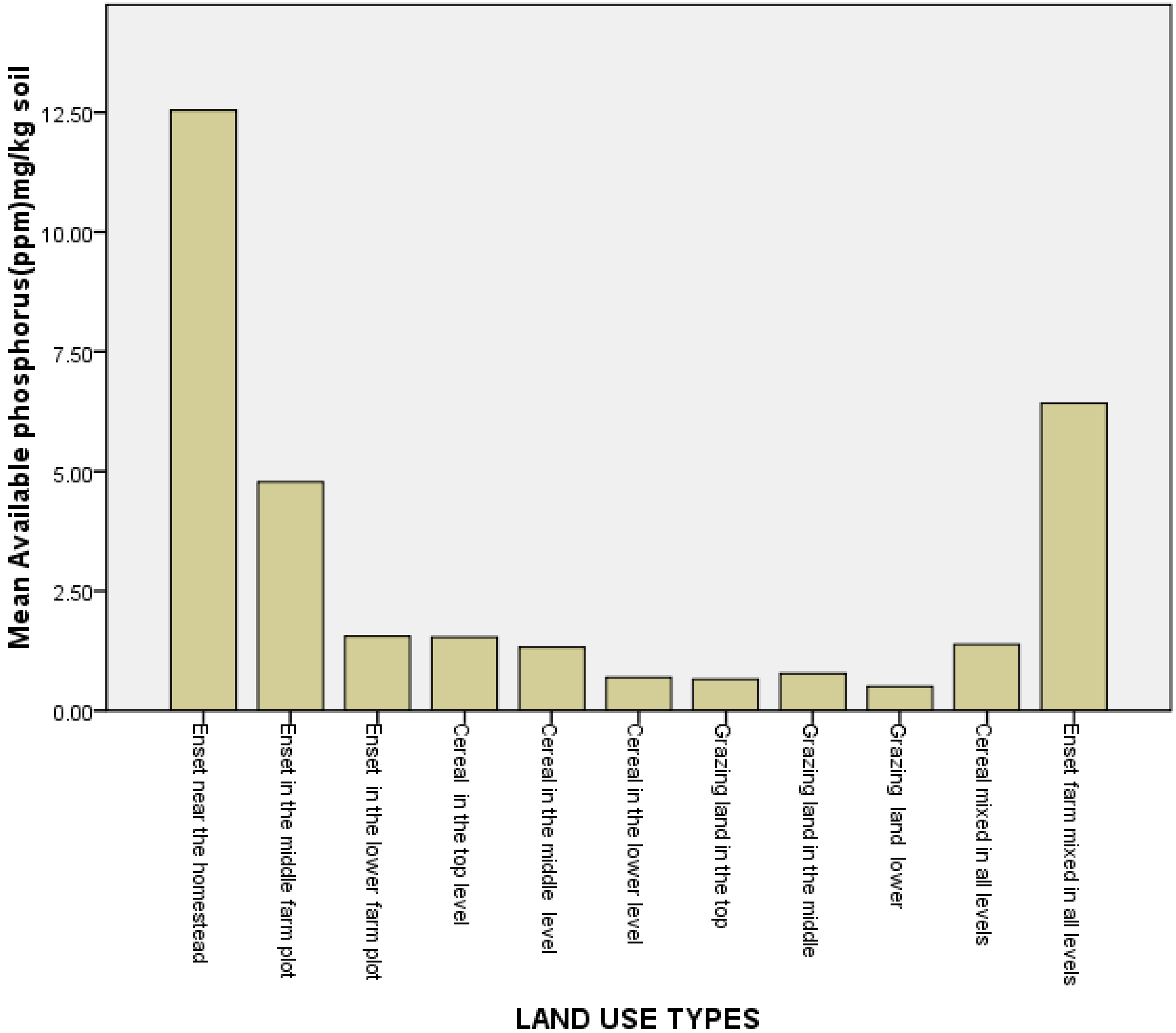

Figure 3.1 Available phosphorus across the various land use and farm levels

3.4.4. Soil organic matter content (%)

Similarly, the mean amount of OC in enset was higher than the cereal and grazing land use types. The result showed that the amount of OC in cereal and grazing land use types were only 41.5 and 39.4 % of the enset farm plot respectively (Table 3.5 and fig 3.2). Moreover, there was a decrease in organic matter with distance from the homestead in the enset farm plot. The amount of OC in the lower portion of the enset and cereal farm is about 20% and 15% of the homestead in the enset farm, respectively (Table 3.5). But, the amount of organic matter concentration in the middle farm plot was lower than with that of the lower portions. This may be due to change in the declining of slope levels from the homestead to the far out lower zone of enset farm resulted in continual removal and accumulation of soil organic carbon from the high sloppy area of the middle zone to the lower out field of enset farm.

However, the organic matter concentration of the cereal farm plot and the grazing land use type increased down to the lower zone (farm lands the far out filed from the homestead), as one move from the top farm (farm near the homestead). From the ongoing explanation, the gradual decline of OC in the middle of enset farm and in the other land use types resulted from change in slope towards the down cultivation (from the homestead ,down to the outfield of lower zone), since there is a small relocation of the above nutrients towards the lower zone because of surface erosion. Though, there is change in the amount OC observed in all land use types, the change is interrupted in the case of enset and the process is continuing increased for the other land use types. This implies that erosion is minimal in the case of enset farm and relatively higher in the other land use types. Moreover, farmers frequently apply manure to the enset farm than cereal land use types in the system. The above results were agreed with the finding of (Diro and Amede. , 2005), who noted that the major plant nutrient in the enset farm shown a declining trend from the homestead to the out fields. They reported that organic matter in the outfield was only about 40% of the homestead. They farther noted that the NPK content of the plant tissues grown in the outfield was significantly higher, in some case up to 150% than those planted in homestead and they concluded that growth reduction in the outfield was not directly related to NPK deficiency, but it could have been caused by off-season moisture stress in the outfields, manifested by low soil organic matter content.

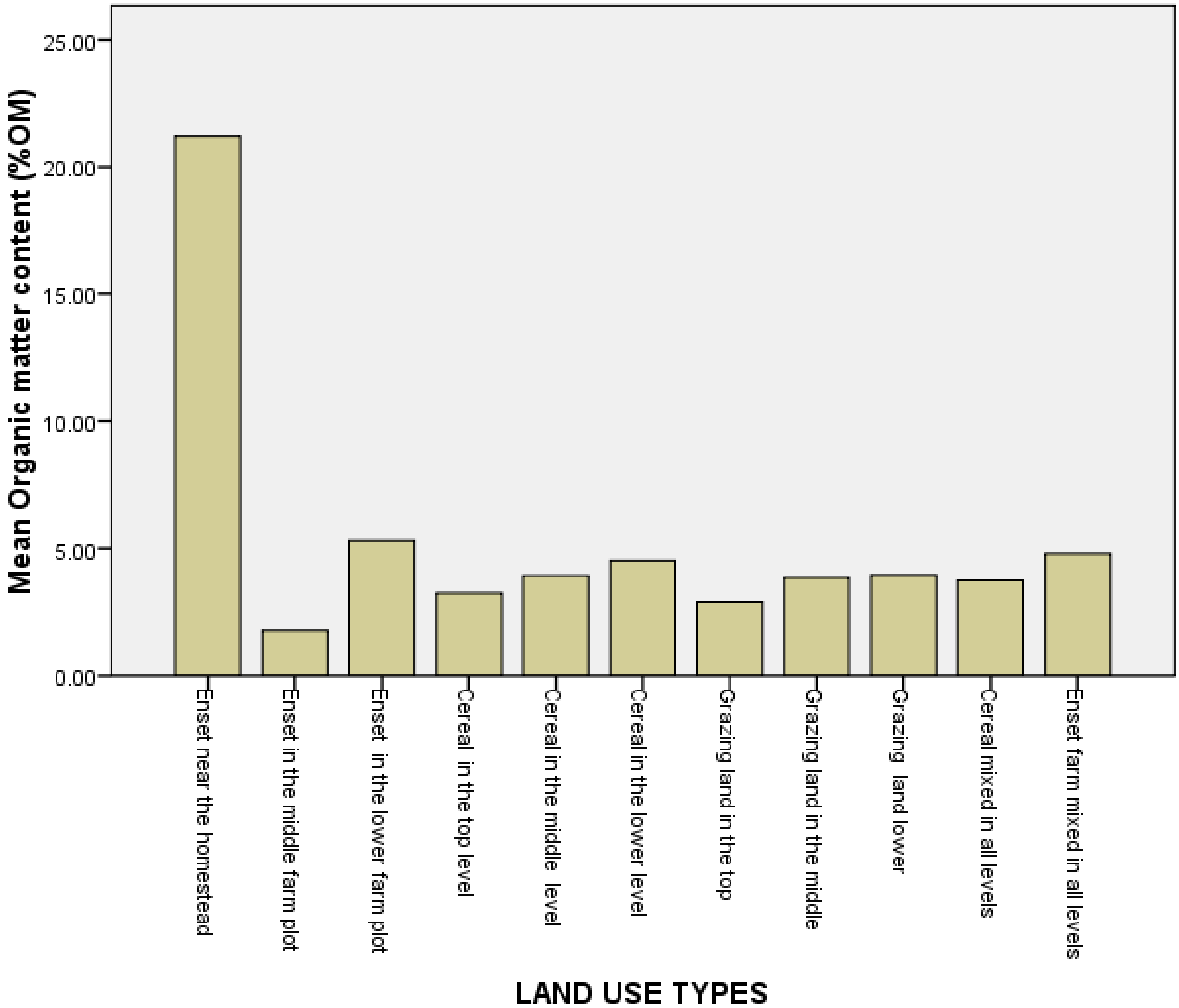

Figure 3.2. Mean organic matters across the various land use types

3.4.5 Cataion exchange capacity

As shown in figure 3.3 the mean Cation exchange capacity was differing among enset farm cereal and grazing land use types by which the former one expected to be received special treatment in the system. On the other hand, there was a general decline of cataion exchange capacity towards the cereal and grazing and use types as compared with the enset farm system, although no significant variations were observed among land use types.

The overall assessment showed that, the higher CEC was recorded under enset farm while the lower under the grazing land (Table 3.5). Accordingly, the highest and the lowest mean values were 33.3 and 26.2 cmol $_c$ ^{kg} soils in the enset and grazing land respectively. But across the various farm levels the higher value was 36.2 for enset farm plot in the homestead and the lowest

20.4 in the top farm of the grazing land. Once again, the amount found to be higher near to the homesteads than the middle and the lower out field of the enset farm plot. On the other hand, the values are higher in the lower outfield than close to the homestead (the top farm) for the rest of land use types following the down slope (Table 3.5)

The above conditions are partially explained by two possible situations. In the first case the various ingredients or nutrients that affect the CEC of the soil relocated towards the down zone due to surface erosion a raised from the farming system itself. This indicated that in the case of cereal and grazing land use types, the farmer's management level and the sustainability of the farming system to minimize surface erosion and improving the overall fertility status of the soil is low. While in the case of enset farm land use types, the effect of surface erosion was minimal and it is not exceeding the second farm level in which the enset plants effectively checks surface erosion. Moreover, the frequent use of organic fertilizer contributes a lot for the occurrence of such soil fertility variations under comparison, observed between the various land use types. Hence, farmers use manure frequently for the enset farm and apply periodic management cares timely, as it was close to the homestead and the homestead fields being rich in major plants nutrients. Farmers report showed that, due to shortage of manure they were forced to restrict manure application close to the homesteads than the far out farm plots. This agreed with the idea of (Diro and Amede. , 2005) who reported that the limited transfer of manure to the outfield in the Enset systems of Areka was as because of the limited manure available. Households, with no/few animals, lack access to manure as it become an increasingly valuable resource, and not even keen ship or local market can guarantee a supply of it (Eyasu, 2000).

On the one hand the intercropping system of the enset farm also contributes positively for the better fertility status of the enset farm as compared with the mono cropping system of the cereal and the untreated of grazing land use types.

The above all conditions showed that, although, enset cultivated for a long period of time in the same plot of lands , still the fertility status of the soil and the sustainability of the farming system found to be stands in a better condition than the other land use types in comparison

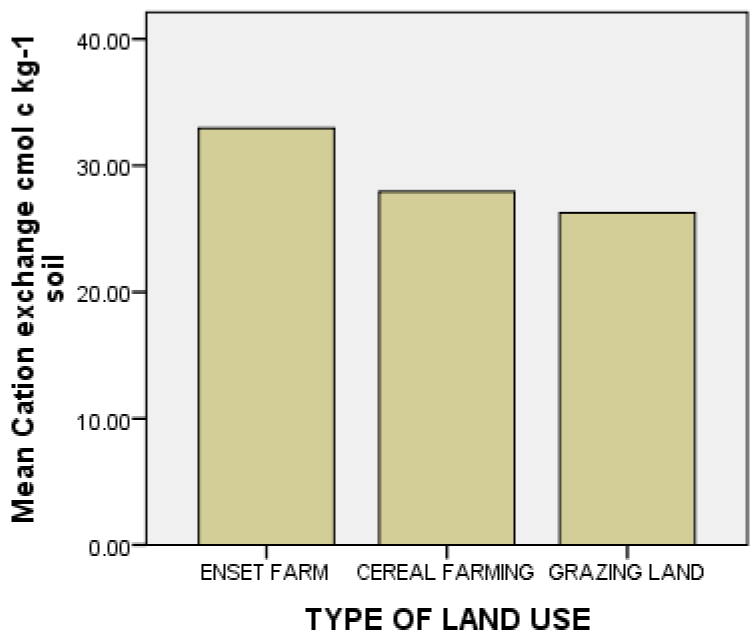

Figure 3.3.Mean cataion exchange capacity

Differences in the amount of organic matter concentration and other soil nutrient status under comparison in the different land use types resulted in effects in soil pH status between the various land use types and across the various farm levels within the specific land use type. Regarding to the general rating, according to (Metson, 1961) the soil pH ranges from strongly acidic in the crop land to slightly acidic in the enset farm plot; accordingly the value is reducing from 6.50 to 4.9 from the homestead in the enset farm to the middle zone of the crop farm (Table 3.5). Similarly soil pH found to be declining away from the homestead in the enset farm plot and for the other land use types progressively. In the enset farm the highest value is 6.5 and the lowest is 5.7 near to the homestead and distant farm from home respectively. There is no major soil pH change within the various farm levels of enset. However when it is compared to the three land use types there is a significant mean variation ($p<0.05$) observed in the amount of soil pH changes towards the cereal and grazing land use types from the enset farm plot (Table 3.6) But the change is not significant in the case of cereal and grazing land use types in comparison During group discussion farmers reported that for cereal production they were used inorganic fertilizer and manure for enset production. Therefore in cereal farming system doe to shortage of manure and periodic loose occupation of the soil with crop/plant root made the system vulnerable for erosive erosion and leaching process. Moreover, the researcher believed that the mono use of inorganic fertilizer and the method and application they were used resulted in a low pH status. The highest pH value (6.5) was recorded in the homesteads of enset farm and the lowest soil pH (4.9) in the middle of cereal farm. This variation is mainly resulted from change in the management system they were adopted, like in terms of fertilizer use and amendment, the cropping pattern in the system resulted in change in soil pH in the respective land use types (Figure 3.4). The soil pH is mainly affected by organic matter content of the soil and other nutrients concentration in the system. Because of the frequent use of animal manure and management variations, the result indicates the enset farm found to be in a better pH status which is close to neutral. As a result acidity found to be lower in the enset farm than the other land use types.

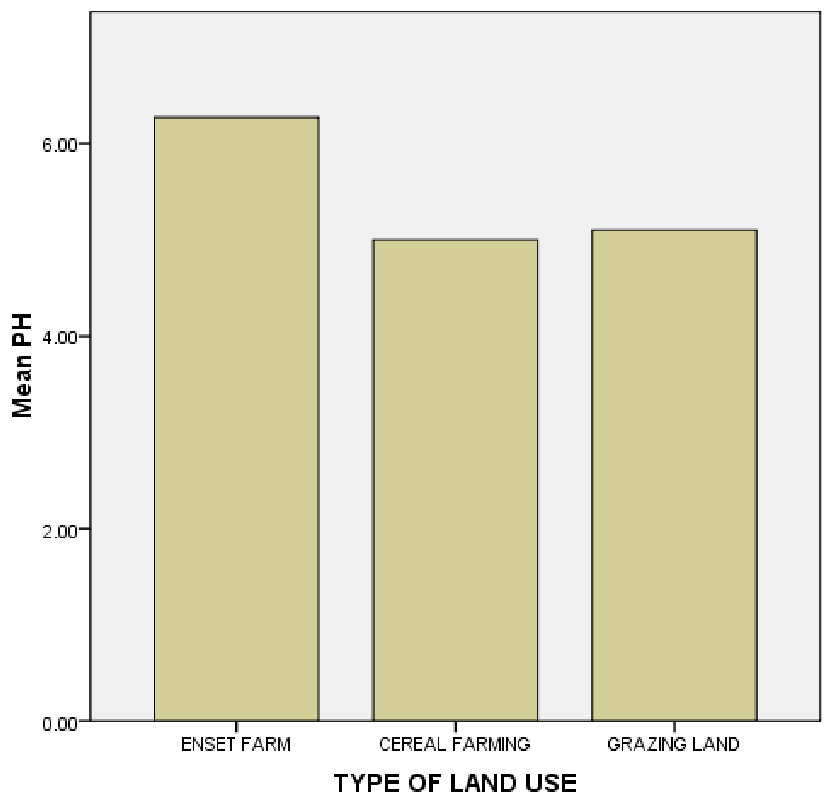

Figure 3.4.Mean pH across the various land use types

Conclusion

The survey result interestingly pointed out that the fertility status of the enset farm was found to be in the better stands, because of the management practices tied with the inherent sustainable system of enset farming, as compared with the cereal and grazing land use types.

Recommendations

From the study result the following recommendations can be suggested to keep the sustainability of farmig system Attention should be given to improve animal health status and mounting veterinary services at the farmers' level, improve pastures and increase the quality and types of forage resources available in the area.Adopting and implementing effective family planning programs to maintain optimum house hold family size in order to minimize the effect of population pressure on the long term sustainability of enset farming system is required. Introducing and expanding other food crops which are friendly growing with enset crops taking in to account the nutrient status of the enset farm in order to supply additional food values for the local community and minimizing immature enset consumption in households is essential.Adopt and implement different conservation measures increasing the soil organic matter content of the middle and far out lower fields of the enset farm plot and reduce the loss of moisture through mulching, low quality crop residues, tree litters, diversifying enset clones and the like.

Referances

Admasu. 2002. On Indigenous Production .Genetic Diversity and Crop Ecology (*Enset-ventricosum*), PhD thesis Wogagin University.2002.

Agricultural Bureau of Guraghe zone. 2015. The Basic Information of Agricultural Development of the zone. Department of Agricultural Extension. Guraghe zone. Wolkite, Ethiopia. pp.58. 2015.

Alemu K., and Zippel, K. 1995. A Field Guide to Enset Landraces of North Omo, Ethiopia. FRP Technical Pamphlet No 9. Addis Ababa: FARM Africa(http://www.africa ufa.edu/sq/vs./v6i/as.htm).1995

Amede T. and Diro M. 2005. Optimizing soil fertility gradients in the Enset (*Ensete ventricosum*) systems of the Ethiopian highlands: Trade-offs and local innovations. In Bationo et al. (eds) Improving Human Welfare and Environmental Conservation by Empowering Farmers to Combat Soil Fertility Degradation. African Highlands Initiative (AHI), Working Papers No. 15, 1-10 p.2005

Asnakech Weldetensay .1997.The Ecological and Production of (*Enset-ventricosum*) in Ethiopia. Doctorial thesis Department of Soil Science Swedish University of Agriculture Science Uppsala. 1997

Benin et al. 2003. Benin S., Ehui S. and Pender J. 2003. Policies for Llivestock Development in the Ethiopian Highlands. Environment, Development and Sustainability. 5: 491-510. 2003.

Dougherty M.,.2OO2. Gendered Scripts and Declining Soil Fertility in Southern Ethiopia African Studies Quarterly 6, no.1: http://web.africa.ufl.edu/asq/v6/v6i1a5.htm

Elias, Eyasu .2000.Soil enrichment and deletion in Southern Ethiopia. Pp 65-82. In: Hillhorst, T. and Muchena, F. (editors). Nutrients on the move: Soil fertility dynamics in African farming systems. 146p.2000

FAO (Food and Agriculture Organization). 1995. Energy and Protein Requirements. Report of Joint Expert Committee. Rome: FAO 1995.

Funte, S.; Negesse, T.; Legesse . 2010. Feed Resources and Their Management Systems in Ethiopian Highlands: The case of Umbulo Wacho Watershed in Southern Ethiopia Tropical and Subtropical Agro ecosystems, Vol. 12, Núm. 1, enero-abril, 2010, pp. 47-56 Universidad Autónoma de Yucatán México 2010

Garedew, B., and Ayiza, A. .2018. Major Constraints of Enset (*Ensete ventricosum*) Production and Management in Masha District, Southwest Ethiopia. International Journal of Agricultural Research, 13, 87-94. http://doi.org/10.3923/ijar.2018.87.94, 2018.

Jemimah N., Jane P., Nancy J., Isabelle B., Pamela P., Zaibet L. and Samuel M. 2011.Genders, Livestock and Livelihood Indicators. International Livestock Research. Institutes ILRI October, 2011 pp"10-13.2011

Legesse G. 2008. Productive and Economic Performance of Small Ruminants in Two Production Systems of the Highlands of Ethiopia. PhD Dissertation, University of Hohenheim, Stuttgart, German. 2008.

Merga, I. F., Tripathi, L., Hvoslef-Eide, A. K., and Gebre, E.2019: Application of genetic engineering for control of bacterial wilt disease of enset, Ethiopia's sustainability crop. Frontiers in Plant 560 Science, 10, 1-8, https://doi.org/10.3389/fpls.2019.00133, 2019.2019.

Metson reven.E.W.1961. Standardization of soil nutrient rating. Soil Sci. Soc. Am. J. 51:599-604. 1961.

Muluneh Weldetsadik .2003.Impact of Poppulation Pressure on Landuse /Land Cover Change, AgriculturalSsystem and Income Diversification in West Gurageland, Ethioppia Department of Geography, Faculty of Social science and Technology Management, Norwegian University of Science and Technology, NTNU,Trondohein.pp . 359 .2003

Nurfeta, A., Tolera, A., Eik, L. O., and Sundstøl, F.2008: Yield and mineral content of ten enset (Ensete ventricosum) varieties. Tropical Animal Health and Production, 40, 299-309. https://doi.org/10.1007/s11250-007-9095-0, 2008.

Olsen SR, Sommers LE. 1982. Phosphorus. In A.L. Page, R.H. Miller, & D.R. Keeny (Eds.), Method of Soil Analysis. II. Chemical and Microbiological Properties, Agronomic Monograph P. 9 (2nd edn). SSSA, Madison, Wisconsin.PMid:6919581 1982.

Van Riemsdijk, van der W.H. .1992. Protocol phosphate saturated soils. Department of soil science and plant nutrition, Agricultural University, Wageningen, The Netherlands.1992

Van Riemsdijk, van der W.H.. 2002. Role of Eh and pH on phosphorus geochemistry in sediments of Lake Okeechobee. Soil Sci. Soc. Am. J. 48:541-544.2002.

Watson, Jeff .2001. How to Determine a Sample Size: Tipsheet #60, University Park, PA: Penn State Cooperative Extension.2001

SNNPR. 1997. Agricultural Office of SNNPR.1997.Cultivation of Enset Plant, (Amharic version), extension manual Awasa. 1997.

Steven. 1997. Steven A. Brandt, Anita Spring, Clifton Hiebsch, J. Terrence McCabe, Endale Tabogie, Mulugeta Diro, Gizachew Wolde-Michael, Gebre Yntiso, Masayoshi Shigeta, and Shiferaw Tesfaye.1997. “Tree Against Hunger” Enset-Based Agricultural Systems in Ethiopia American Association for the Advancement of Science With Awassa Agricultural Research Center Kyoto University Center for African Area Studies And University of Florida1997.

Sahlemedhin Serstu and Taye Bekele. 2000. Procedures for soil and plant analysis: Technical P. 74. National Soil Research Center and Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.2000.

Watson, Jeff .2001. How to Determine a Sample Size: Tipsheet #60, University Park, PA: Penn State Cooperative Extension2001.

Westphal. 1975. Westphal, E. 1975. Agricultural Systems in Ethiopia. Wageningen: Centre for Agricultural Publishing and Documentation. 1975.

Yemataw et al. 2014. Yemataw, Z., Mekonen, A., Chala, A., Tesfaye, K., Mekonen, K., Studholme, D. J., and Sharma, K.: Farmers’ knowledge and perception of enset Xanthomonas wilt in southern Ethiopia. Agriculture and food security, 6, 1-12. https://doi.org/10.1186/s40066-017-0146-0, 2017. 2014.