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Mechanization status in the Lake Victoria Basin of East Africa

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Abstract

The study evaluated the mechanization status in the Lake Victoria Basin (LVB) of East African countries namely; Kenya, Tanzania and Uganda. Baseline survey was conducted using semi-structured questionnaires. Initial soil physical and fertility analysis were conducted. It was established that tractor mechanization is not highly practiced while draft animal use is widely practiced in the study areas. Soil physical characterization showed that, the soil largely lay between loamy sand and sandy loam. The changes in soil texture with depth were significant (at 5% level) whereby the clay contents increased with depth indicating clay alleviation. Water content also increased with depth. The differences were not significant but this shows that, under proper rooting environment, more water could be harvested from the lower B-horizons. Soil strengths were high, ranging between 1.1 and 2.0 Mg/m^3 and increased with depth. Although the differences in soil strengths with depth were not significant (at 5% level) the means at the 15-30 cm depth were high at 1.5677 Mg/m^3. This indicates the need for sub-soiling and ripping to initially break and shatter the hardpan. In all sites; % C was very low (mean of 0.5790%), % N ranged from poor to medium with a mean of 0.1193%, P (ppm) was medium to high with a mean of 6.02 and the pH was medium (mean of 7.2). Hence, there is need to further evaluate conservation tillage practices and other appropriate technologies in mechanization and possibilities of their introduction in the LVB.

Keywords: Conservation; Hardpan; Sedimentation; Soil Strength; Survey; Tillage

Introduction

The water quality in the Lake Victoria continues to decline day after day. Research findings attribute this to the increase in population pressure in the region, un-environmentally friendly land use and management (Tenywa and Majaliwa, 1998). The major socio-economic activities of about 30 million inhabitants in the Lake Victoria Basin (LVB) with an approximate total land area of 193,000 sq. km are agriculture and fishing. As the population growth in the great lake region increase at a rate of about 3% annually, the demand for natural resources also increases and land-use changes continue to occur, pollution loading is intensified making the Lake Victoria and its catchments an alarming ecological risk (World Bank, 1996). Expansion of the agricultural land, the method of land tillage has severely degraded the land due to erosion depleting the fertile land, which in turn causes sedimentation into the Lake. The way soils are cultivated today needs to be drastically changed (Lagat *et al*., 2007; Saxton and Baker, 1990). The common practice of using an ox-plough and hand-hoe leaves the soil surface loose and unprotected, which makes it vulnerable to erosion while also accelerating the oxidation of organic matter (Dumanski *et. al*., 2006). In general, soils in tropical countries do not need to be tilled. Interventions using machinery should be reduced to the minimum possible levels. The most desirable form of tillage is conservation tillage, which leaves a protective blanket of leaves, stems and stalks from the previous crop on the surface. This cover shields the soil surface from heat, wind and rain, keeps the soils cooler and reduces moisture losses by evaporation. Less tillage also means lower fuel and labour costs (Baker, 1994; Hunt, 1981). Literature shows that farmers have applied minimum tillage for a long time. But according to FAO, with the advent of tractors, the tendency was to increase tillage and farmers started to believe that the more you till the soil, the more yield you get. Unfortunately, more tillage causes more erosion and soil degradation, especially in warmer areas where the topsoil layer is thin. Today, the concept of conservation tillage is mainly applied in America where more than 14 million hectares are cultivated by this method; in contrast, only relatively small patches under conservation tillage are to be found in the rest of the world (CTIC, 2005). The Lake Victoria basin (LVB) is among the high potential areas for production of cash and food crops, fishing, mining, commercial and industrial development. However, due to fast changes in land uses, Lake Victoria shoreline and the surroundings suffer from high environmental degradation and sedimentation of the lake and rivers. A high population growth rate in an already densely populated area has led to intensification of agriculture, expanding settlements and industrial development. The increased pressure on land resources coupled with inappropriate land use practices have contributed to environmental degradation as manifested in siltation and eutrophication of the lake leading to adverse effects on the natural habitats, loss of biodiversity and reduced fish catches, thus threatening people's livelihoods. Minimizing environmental degradation around Lake Victoria and sedimentation of the lake due to tillage erosion will require identification of appropriate cover crops and gender friendly conservation agricultural equipment and implements. However, such information that would contribute to the preparation and development of sound land use plans and environmental policies for sustainable crop production for Districts around the LVB is lacking. It is upon these considerations that introduction and evaluation of conservation agriculture technologies for sustainable crop production in the Lake basin has been given high priority. Specifically the work aimed at; collecting detailed data with regard to soil status and mechanization systems under existing tillage practices to inform policy.

Materials and methods

Study Sites

The study was conducted in three sites along lake Victoria shore line namely Jinja District, Uganda; Magu District (near Mwanza), Tanzania and Rachuonyo District (near Kisumu), Kenya. Figure 1 shows the LVB and the location of study sites.

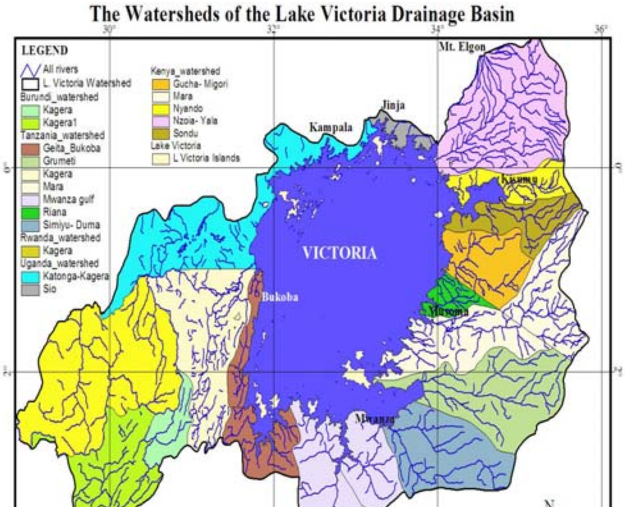

Fig 1 . Lake Victoria Basin and the Study Sites

Baseline Mechanization Surveys

Baseline surveys were undertaken and used to select contact farmers in each country. Participatory Rural Appraisal (PRA) and semi-structured questionnaires were conducted to assess farmers' opinions and determine the existing mechanization systems and farming practices. The conducted survey focused on; households' sizes and sex, farm holdings and land preparation equipment and availability. Informal interviews with key informants (elders, leaders and other prominent members of the community) were carried out. Relevant data and information were gathered on: general understanding of the communities; information pertaining to crop and livestock production practices, tools and equipment in use, soil erosion, crop yields and other economic activities in the study areas which influences the ecology of Lake Victoria. A total of 60 households (each from the three countries) were sampled for survey using the structured questionnaire. Since the average population density was 400 persons per km^2 the 15% representative sample (60 households) was found to be adequate and appropriate.

Soil Characterization

For determination of soil fertility and physical properties in the study area, three depths were taken for sampling (0-15 cm, 15-30 cm and 30+ cm depths) as outlined by Okalebo *et al.* (2002). The transverse method was used for sampling and laboratory soil analysis conducted. Soil sampling was done at every household that was involved in the survey over the three depths. Thus a total of 180 samples were sampled for fertility and physical analysis from each country. Initial soil physical (bulk density and water content) and fertility analysis (%C, %N, pH and P (ppm)) were computed over the three sites in each country. After soil characterization and consideration of; climatic condition, altitude and farming practice, appropriate cover crops were established.

Result and discussion

Mechanization Status

The results from the survey showed that, more households are male headed (over 75%) hence they influence about all the farming decisions. The dominant land preparation equipment is the ox-plough (over 40%). It was established that, draft animal use (in tillage and transport) is widely practiced (80-90%) in Tanzania, (70 - 80%) in Kenya while in Uganda it is not widely practiced (0.02%). There is an increasing shift towards hiring of land preparation equipment as only about 7% of households owned an ox-plough in the areas. Again, the combination of oxen and hand-hoe at about 37% is a good indicator towards introduction of Conservation Agriculture (CA). Labour shortage, transport services and storage were ranked in that order as the major mechanization related problems facing farmers. Lagat *et al.* (2007) reported similar findings. Thus there is need to introduce CA since labour intensive operations such as ploughing and weeding can be eliminated. At the same time, it maximizes the vegetative soil cover that protects the soil surface. Table 1 gives a summary of the sites history over the LVB. It is imperative to appreciate that, the characteristics of the sites were relatively similar.

Soil Characterization

Soil physical characterization showed that, the soil largely lay between loamy sand and sandy loam. The change in soil texture with depth were significant (at 5% level) whereby the clay contents increased with depth indicating clay alleviation (movement of clay to the lower B-horizon) and potential occurrence of a hard pan. Water content also increased with depth. The differences were not significant but this shows that, under proper rooting environment, more water could be harvested from the lower B-horizons. Soil strengths were high

Table 1. Summary of Sites Characterization

No.	Site - Parameter	JINJA (UGANDA)	MAGU (TANZANIA)	RACHUONYO (KENYA)
1	Location			
	- Latitude	- 0°5' and 0°12'N	- 2°25' and 2°35'S	- 0°45'S
	- Longitude	- 33°12' and 33'E	- 33°25' and 33°30'E	- 34°12' and 35°01'E
2	Altitude (m asl)	1,200	1, 100	1,180
3	Area (Km^2)	768	1,500	1,173
4	Rainfall (mm)	1, 200 – 1, 550	800 – 1,200	700 – 1,800
5	Temperature (°c)	19 -27	16 - 28	15 - 29
6	Population	500,000	560, 000	420, 000
7	Soil type (0 – 40 cm)	Sandy clay loam to clay loam	Loamy sand to sandy loam	Loamy sand to sandy loam
8	Male headed (%)	81	83	77
9	Household Size	5.63 (3.05)	6.24 (2.59)	6.53 (2.77)
10	Dominant Equipment	Hand-hoe	Ox-plough	Ox-plough
11	Farm Size (Ha)	2.58 (1.31)	3.8 (2.1)	3.22 (1.78)
12	ADP (%)	0.02	80 - 90	70 - 80
13	Dominant Crops	Maize and Cassava	Maize and Cassava	Maize and Groundnuts
14	Main Activity	Farming	Farming	Farming
15	Soil Strength (Mg/m^3)	1.19 – 1.64	1.14 – 1.88	1.12 – 1.93
16	Soil Fertility			
	- pH	Slightly acidic	Medium	Medium
	- % C	Moderate	Low	Low
	- % N	Moderate	Low	Medium
	- P (ppm)	Medium	Medium	Medium to High
17	Viable Cover Crops	*Dolichos lablab*	*Dolichos lablab* and *Canavalia ensiforis*	*Dolichos lablab*

Note: - ADP_Animal Draft Power; - asl_above sea level; - Figures in parenthesis represent those committed to Farming activities

ranging between 1.1 and 2.0 Mg/m^3 and increased with depth. Although the differences in soil strengths with depth were not significant (at 5% level) the means at the 15-30 cm depth were 1.5677 Mg/m^3. This indicates the need for sub-soiling and ripping to initially break and shatter the hardpan. In all sites; % C was very low (mean of 0.5790%), % N ranged from poor to medium with a mean of 0.1193% and P (ppm) was medium to high with a mean of 6.02 and the pH was medium (mean of 7.2). Hence, in all the sites; sandy clay loam and sandy loams with optimum levels of pH, total nitrogen, available phosphorus and cation exchange capacity dominate soils. Thus, soil fertility in these places could support crop growth. However, soil organic matter was found to be very low in all the sites. It is desirable to have high levels of organic matter since it's the basis for sustainable crop production. Organic matter increase water holding capacity, it is also a reservoir of nutrients and improves the structure and texture of the soil. Integration of cover crop in the present farming system to improve soil organic matter content that will lead to loosening of the sub-soil and hard pans for proper root growth is essential. Gitau *et al.* (2008) while working on mechanical behaviour of similar soils reported on the importance of shattering the hardpan to ease water infiltration and allow crop roots to access water and nutrients in the B-horizon. Figure 2 shows a scatter plot from the numerous pertinent parameters evaluated. It shows that there is some correlation between % C and % N and bulk density and water content (i.e. more water in the B-Horizon) in all sites. Again the water can be utilized by the crop if the roots can access it. Cover crops once established will accelerate mineralization and release carbon and subsequently the Nitrogen needed by the crops since they are related as per the scatter. CA technologies will use gender and environmentally friendly equipment. This will improve surface mulch that improves soil fertility and again reduce the compact nature of the soils.

Attitude towards the future and ecological concerns

Most of the farmers are careful about how they farm (83%) and all are concerned about the status of their soils. Concerns varied from productivity of the soils i.e. low and declining soil fertility to soil erosion. Future food, fuel and timber supply is a major concern in the study areas. The majority wondered whether their farm families would be self sufficient in terms of food (90%) and firewood and timber (98%). Farmers are proud of Lake Victoria and attach high value to it, at 81%. Accruing benefits reflect the important ecological function this resource offers to the local community in its neighbourhood. Benefits in order of decreasing importance include: water and fish (91%), income, and transport (5%), fresh air (wind breeze) and irrigation (2%) each. However, only a few (10%) of farmers say the Lake has no problems. In contrast they indicated that the water level is decreasing due to siltation (35%) and that deforestation (33%) is a major problem. Furthermore, drought (29%) and threat to some fish species (23%) raised a lot of concern to most respondents. In addition, water weeds (8%) e.g. water hyacinth and papyrus were also mentioned among the most noxious plants around the lake.

Poor agricultural practices in the steeplands such as cultivation close to the lake shore were identified by some farmers (about 12%) as a cause of lake pollution through siltation.

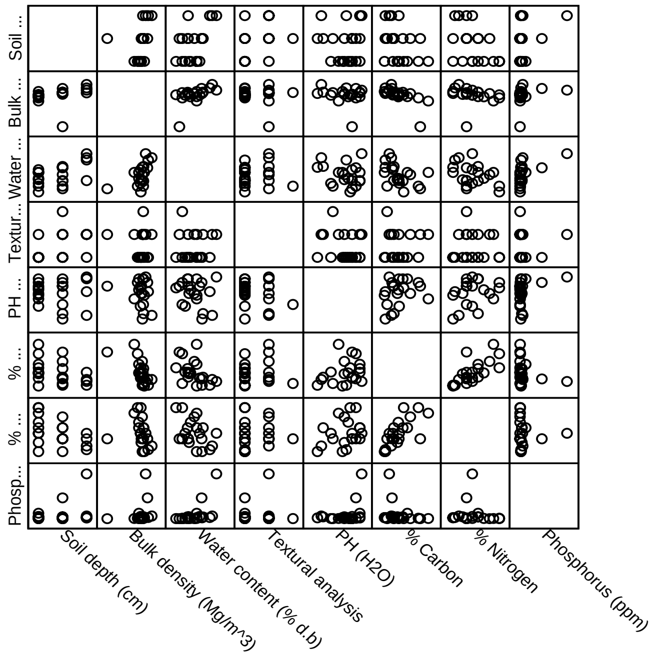

Fig 2. Scatter plot for the pertinent variables showing the levels of correlation

CA technologies awareness creation and introduction of CA equipment

Sensitization will continue to be done at different levels to create more and more awareness on the Conservation Agriculture (CA) technologies. Workshop and seminars will be conducted to include various stakeholders, farmers, extension staff and District officials and policy makers. Agricultural tools and equipments, suitable for CA practices and for use with human labor and draft animals have been introduced. The equipments are placed under the care of the farmers groups, who will use them for training and demonstration purposes of no-till/CA practices. Farmer Field School (FFS) methodology will be followed. A series of on-farm management training plot for demonstration purpose will be organized to promote awareness of the equipment and no-till techniques through farmer-to-farmer exchanges. The immediate community will also be encouraged to participate and adopt similar techniques to speed the spread of the technology during field days. It is planned that all farmers' groups will be trained on how to use the hand jab planter. Each group will also be trained on how to use the animal drawn implements such as; rippers, subsoilers, knife roller and no-till planters.

Conclusion

Conservation Agriculture (CA) technologies are not widely practiced (although had been introduced in some areas). Farmers were willing to take up the CA technologies. Their feelings were that, these technologies needed follow-up to conclusion and beyond the project period (cycle) which was lacking in earlier inceptions; Other stakeholders felt that full farmers participation (through out the cycle) was highly essential if up-take was to be promoted. Issues of value addition through post harvest handling, processing and the value chain were raised albeit indirectly. The farmers felt that if the technologies were as such useful, then they should 'add more money into their pockets'. The researchers believe that with increased production from the CA technologies then the farmers could get more returns and value for their inputs. The initial laboratory analysis results showed that, the soil for the selected sites have low fertility hence contributing to the low crop yield. Tillage techniques practiced causes hardpan formation (as evidenced by high bulk densities with increase in depth) and soil erosion resulting in soil sedimentation in the Lake Victoria. Based on the soil physical properties (texture, soil moisture and bulk densities) at the selected sites, appropriate cover crops (*Dolichos lab lab* and *Canavalia ensiforis*) were identified and introduced. Combination of hand hoe and animal drawn plough are the major tillage implements used in the selected sites (at 37%). The economic activities in the selected sites are fishing, farming and livestock keeping. The farmers are aware of lake pollution due to mechanized tillage and livestock free range grazing. Elderly farmers are aware of indigenous practices of soil conservation even though they don't practice them. Many households respond to labour shortage by scaling down their activities, reducing the area under cultivation and growing a limited range of less labour-intensive crops. Ultimately, there is high potential in these levels of mechanization (human and animal power) which should be promoted with incorporation of CA technologies.

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