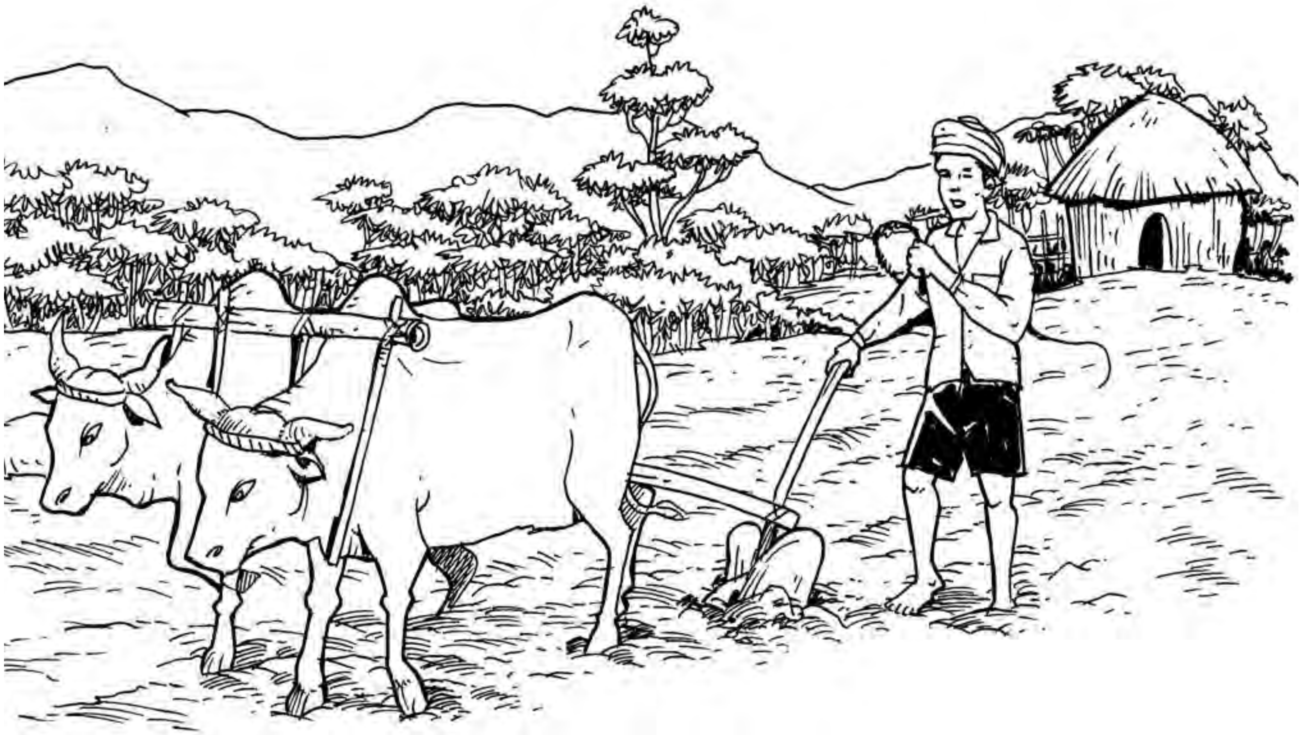
Arashogel: A Simple Oxen-drawn Tillage Implement for Soil and Water Conservation



Conservation agriculture (CA) is introduced to tackle the problem of land degradation as a result of intensive tillage. Conservation tillage is a tillage practice that involves minimum soil disturbance aimed at conserving soil, water, and labor and traction requirements (Rockstrom *et al.,* 2009).

In tractor-drawn commercial farms, the main cause of land degradation is soil inversion with tractor-drawn moldboard and disc plows. In addition to soil inversion, movement of soil at higher speeds with tractors causes significant soil pulverization. Such tillage practices speed up soil organic carbon losses. Loss of soil organic carbon causes land degradation (Reicosky, 2001). In addition, the use of tractors for tillage makes weed control more expensive than zero tillage combined with the application of nonselective herbicides. These factors and the fact that higher soil temperatures caused by intensive tillage jeopardize seed viability (Diaz-Zorita *et al.* 2002) led to the introduction of zero tillage.

When it comes to Ethiopia, oxen-plowing is the dominant method used by most farmers. It is also, however, the main cause of soil erosion and land degradation because of repeated cross-plowing. Cross-plowing is the practice of orienting the directions of two consecutive tillage operations perpendicular to each other. Farmers in Ethiopia are forced to undertake cross-plowing because of the geometry of the traditional tillage implement, *maresha* (Fig. 1a). Maresha creates V-shaped furrows (Temesgen *et al.,* 2008), while leaving strips of unplowed land between consecutive passes (Fig. 1b). During the next tillage, farmers cannot easily access the unplowed strips without resorting to cross-plowing. The situation calls for a locally adapted conservation tillage system that can achieve the main objectives of CA (Giller *et al.,* 2009).

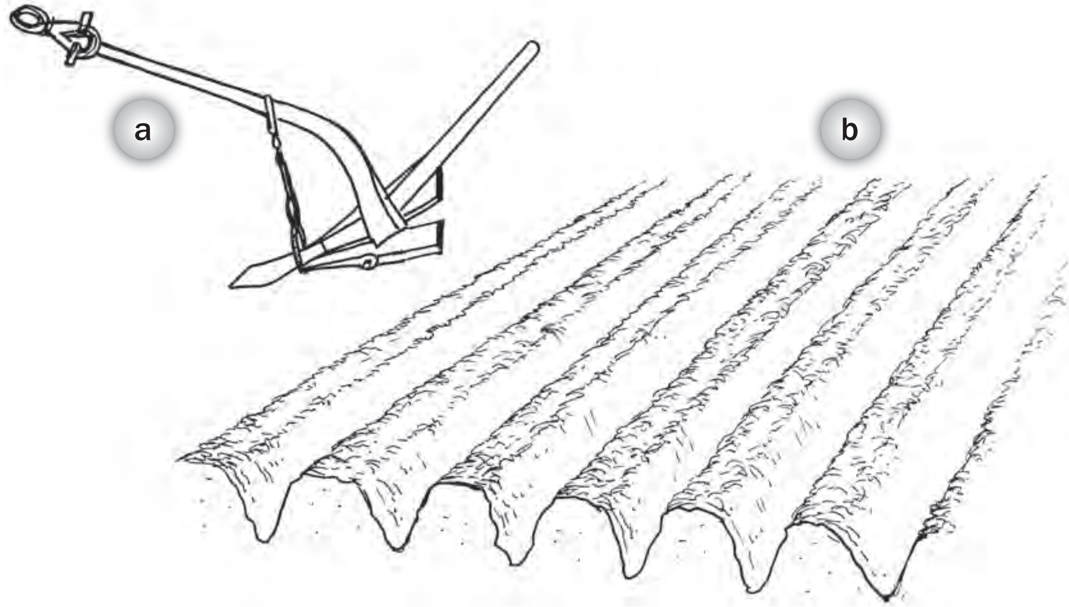


Fig. 1. (a) Maresha, the traditional tillage implement of Ethiopia; (b) V-shaped furrows left after plowing by maresha. The land between passes can only be disturbed through repeated cross-plowing, the main cause of soil erosion and high tillage frequency in the country.

The problem

Most Ethiopian farmers use oxen-drawn plows and practice cross-plowing. However, there are many disadvantages of cross-plowing:

- Cross-plowing wastes time and energy. During the second plowing, the plow is run across the already plowed furrows in order to access the unplowed strips of land. This wastes close to 50% of the time and energy of both the oxen and the farmer. Even after the second tillage, spots of unplowed land are left between pairs of crossing furrows. These spots of land carry weeds that have to be controlled. Additional tillage operations are required to fully disturb these spots during which the farmer has to spend most of the time running over the already plowed land. This is the main reason farmers in Ethiopia have to plow so many times. Moreover, where there are slopes, walking up and down these slopes puts an extra burden on both the farmer and the oxen due to gravity effects, while the variation in the inclination of the plow makes it difficult to maintain the depth of tillage while alternating between up-slope and down-slope plowing.
- Cross-plowing leads to high surface runoff and soil erosion. It rules out contour tillage, which is highly recommended in moderate to steep slopes. With cross-plowing, one of any two consecutive tillage operations falls along or nearly along the slope. Orientation of tillage directions along the slope provides channels for rapid flow of water, which causes higher surface runoff. Consequently, in addition to loss of soil moisture in dry areas, higher surface runoff is generally associated with higher soil erosion. Soil erosion is the main cause of land degradation in Ethiopia.
- Cross-plowing is inconvenient in fields treated with soil conservation structures. On moderate to steep slopes, much of the land is treated with soil conservation structures. However, farmers usually destroy the soil conservation structures due to the difficulty of undertaking cross-plowing between the structures, which are usually constructed in short intervals. Some farmers plow the field parallel to the structures but they have to employ more labor to manually dig the strips of land left between two consecutive passes.

An appropriate conservation tillage system

To help farmers avoid cross-plowing, a different type of plow called *Arashogel* has been developed (Fig. 2). Arashogel is attached to the traditional tillage implement, maresha, by replacing the connecting ring of the traditional maresha, which is called *wogel*. The arashogel functions as the connecting ring for different parts of the maresha and it is redesigned with parts that cut the soil. Thus, these parts cut the strips of the land left undisturbed during the first pass, thereby enabling the farmer to finish plowing in two passes as opposed to three to five passes and to undertake tillage in the same direction (e.g., along the contour). The cutting parts are designed to operate with minimal pulling force requirement.

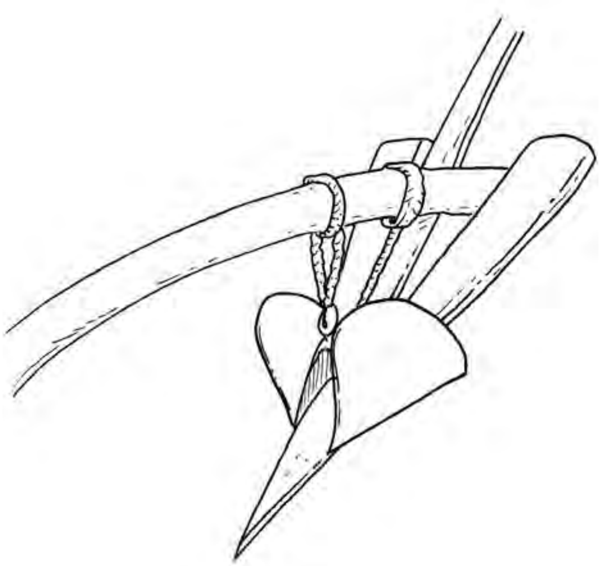


Fig. 2. *The* arashogel *is designed to avoid cross-plowing during consecutive tillage operations because of its wings, which cut the unplowed strips of land left by the* maresha*.*

Field test results

Field experiments were carried out to assess the effects of the new tillage system at a site known as Enerata in the upper Blue Nile Basin (Temesgen *et al.,* 2012). The experiment compared traditional tillage (TT) with conservation tillage (CT), which avoided cross-plowing, on fields treated with soil conservation structures. Both biomass and grain yield were consistently higher in CT than in TT in both crops, wheat and teff, with 35% and 28% increment in grain yield of wheat and teff, respectively, although the differences were not statistically significant ($\alpha = 0.05$) (Temesgen *et al.,* 2012). This is due to high variation in soil fertility as replications were made in different farmers' fields.

Participating farmers noted the differences in biomass and grain yield. Farmer-interviewees, believe the reasons could be (1) reduced soil erosion, (2) better weed control, (3) extended period of soil wetness, and (4) reduced waterlogging. They believe that reduced soil erosion in CT led to reduced loss of soil nutrients, whereas retention of soil moisture in deeper layers extended the growing period. Consequently, farmers harvested the CT plots, on average, 1 week after harvesting the TT plots. They believe this resulted in more biomass and grain yield. Reduced waterlogging and, hence, better aeration in CT made the crop greener compared with waterlogged strips behind soil conservation structures under TT.

Arashogel has been demonstrated on farmers' fields in Semen Achefer and Gonder Zuria *woredas* of the Amhara Regional Administration during the main season of 2014. Nature Conservation Alliance (NABU) conducted the demonstration. During field days organized by NABU in collaboration with the woreda agricultural bureaus, farmers who used arashogel mentioned several advantages of the implement. They stated that their oxen pulled the implement easily; they were able to save time on tillage; the runoff in fields plowed using arashogel was significantly smaller and, hence, there was less soil loss compared with fields plowed with the traditional method. Farmers and experts also commented that, based on crop growth and other visual assessments, they expect higher crop yields (sorghum and teff) from fields plowed with arashogel. Data are yet to be analyzed and reported after the crop is harvested.

Reduced tillage reduces loss of soil organic carbon, and reducing the loss of soil organic carbon is one of the main objectives of CA (Reicosky, 2001). Tillage with arashogel creates invisible barriers along the contour that retard the movement of water along the slope, thereby significantly reducing soil erosion and conserving water through increased infiltration. Moreover, arashogel makes it more convenient to plow between soil conservation structures. The invisible barriers left between passes allow more infiltration by reducing surface runoff toward the soil conservation structures. It also prevents waterlogging behind the soil conservation structures and possible damage to the structures that would have had detrimental effects downstream. The results of the field experiments have shown that crop yield and the life span of the soil conservation structures can be increased by the application of such a tillage system (Temesgen *et al.,* 2012).

Currently, arashogel is sold at US$ 15. Further reduction in price is expected with increased sale volume. Added together, the reduction in tillage time plus the increased crop yield as a result of using arashogel are equivalent to several times the current price of the implement. Soil conservation as a result of using arashogel is an added advantage. The implement can be used for more than a year, though the exact working life of the tool has not been determined yet.

Conclusion

Conservation tillage, based on the use of arashogel to avoid cross-plowing, has been found to be an effective and appropriate system to achieve the objectives of CA. It reduces soil and water losses, while reducing labor and traction requirements for tillage, which is the immediate benefit that attracts smallholder farmers. In moisture-stressed areas, the tillage system also conserves soil water, thereby increasing crop yield, which is another factor to motivate farmers. Unlike other types of CA that focus on long-term benefits, the arashogel-based conservation tillage achieves both short-term and long-term benefits, while being simple and cheap

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References

Diaz-Zorita, M., Duarte, G. A., Grove, J. H. 2002. A review of no-till systems and soil management for sustainable crop production in the subhumid and semiarid pampas of Argentina. Soil Till. Res. 65: 1-18.

FAO (Food and Agriculture Organization). 2008. Conservation agriculture.<http://www.fao.org/ag/ca/index.html> Accessed on 2014-03-10.

Giller, K.E., Witter, E., Corbeels, M., Tittonell, P. 2009. Conservation agriculture and smallholder farming in Africa: the heretics' view. A review. Field Crops Res. 114: 23–34.

Reicosky, D. C. 2001. Tillage-induced CO_2 emissions and carbon sequestration: effect of secondary tillage and compaction. In: Proceedings of the World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. p 265-274.

Temesgen, M., Rockström, J., Savenije, H.H. G., Hoogmoed, W.B., Alemu, D. 2008. Determinants of tillage frequency among smallholder farmers in two semi-arid areas in Ethiopia. Phys. Chem. Earth 33: 183–191.

Temesgen, M., Uhlenbrook, S., Simane, B., van der Zaag, P., Mohamed, Y., Wenninger, J., Savenije, H.H.G. 2012. Impacts of conservation tillage on the hydrological and agronomic performance of Fanya juus in the upper Blue Nile (Abbay) river basin, Hydrol. Earth Syst. Sci. 16, 4725–4735 (www.hydrol-earth-syst-sci.net/16/4725/2012/ doi:10.5194/hess-16-4725-2012).