Reversing the Negative Impact of Excess Water on Smallholder Farming

In the Ethiopian highlands, where there is moderate to high rainfall, waterlogging is a major constraint to crop production. The problem prevails in about 7.6 million ha of land covered with vertisols. Vertisols are fine-textured soils characterized by poor infiltration. Due to this waterlogging problem, less than 2 million ha of the highlands are cultivated in any one season (Debele, 1985). In addition, the problem renders smallholder farming not climate-friendly. In most cases, the fields remain waterlogged in July and August. As a result, farmers either resort to late planting or they simply abandon the fields. Late planting entails repeated tillage as farmers try to control weeds. Repeated tillage causes higher losses of soil organic carbon and soil erosion. In addition, waterlogged fields create anaerobic conditions, which enhance the production of methane gas. Once the rains stop and the soils dry out, this gas is emitted. This is considered to be a more potent greenhouse gas (GHG) than carbon dioxide.

One solution to waterlogging is the construction of broad beds and furrows to drain excess water from the fields. The operation requires a special equipment called broadbed and furrow maker (BBM). The development of animal-drawn BBMs began in 1984 (Jutzi and Abebe, 1986). However, farmers' adoption of the BBM prototype was low because of its high draft power requirement and heavy weight; also there are other issues related to the assembly and field operation of the implement.

The Aybar BBM

To address the problem of adoption of the BBM prototype introduced earlier, a new type of prototype was developed following a different approach to design the soil-engaging components. The new prototype is called Aybar BBM (Fig. 1).

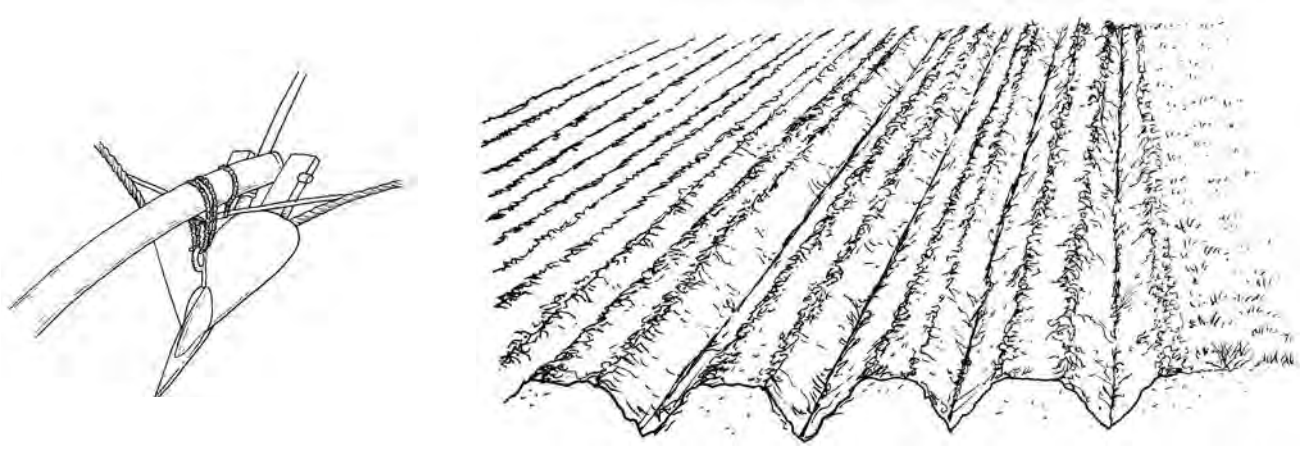

Fig. 1. *Aybar BBM as assembled (left) and the broad beds that it constructed (right).*

The Aybar BBM was demonstrated in 60 farmers' fields in 2012 at selected sites of the Oromia administrative region in Ethiopia. Field days were organized and farmers were asked to compare the two prototypes. Farmers compared the two prototypes based on 10 criteria and stated that Aybar BBM is superior in all aspects. The following are the most important comparisons.

- The old BBM weighs 7 kg, while Aybar BBM weighs 3.5 kg. In addition, the old BBM carries on it a lot of mud, which makes it difficult for the operator to lift it at the end of the plot. The old BBM therefore required a higher draft force than what a pair of oxen can sustainably exert. Field tests have shown that the former requires 50% more draft power than the latter.
- The old BBM makes kinky beds because the oxen react to the high draft force requirement by moving in a zigzag direction. Kinky beds are less efficient in draining excess water. On the other hand, the Aybar BBM produces straight furrows, which gave higher grain yield.
- The old BBM becomes loose and thus unstable during operations, whereas Aybar BBM remains stable.
- The old BBM requires very friable soil, whereas Aybar BBM can be operated in relatively wet soils, thus extending planting time by up to 1 week.
- The old BBM bends and breaks, whereas Aybar BBM does not.
- The Aybar BBM can also be used as a tie ridger to conserve soil moisture in dry areas.

The advantage of the old BBM is that its features are a lot simpler than those of Aybar BBM. However, because less material is used for fabrication, the total cost of manufacturing of Aybar BBM is lower than that of the old BBM.

In early 2012, the Ethiopian Institute of Agricultural Research and the Federal Ministry of Agriculture (MoA) conducted a joint assessment of the Aybar BBM by interviewing farmers who used the implement. In June 2012, based on the findings, the MoA circulated a letter to the four major administrative regions urging the respective agricultural bureaus to disseminate Aybar BBM among farmers, citing the technology as a success after many years of failure. Mass production of the Aybar BBM began in 2012.

In 2013, the MoA conducted a survey to assess the performance of Aybar BBM. Farmers in Oromia region confirmed that the drainage of excess water by the Aybar BBM made it possible to increase crop yield threefold. Farmers reported that, before the introduction of the BBM, they used to get a maximum of 1,500 kg/ha. When conditions were suitable for field operation, the old BBM could give a maximum of 2,800 kg/ha, whereas Aybar BBM gave a minimum of 3,800 and a maximum of 5,700 kg/ha. (See www.aybareng.com for the interviews.)

Recent reports also show that some farmers produced as much as 8,200 kg of wheat/ha using Aybar BBM (A.G. Keneni, Oromia Agricultural Bureau, pers. commun.). Farmers also reported growing a second crop, usually chickpea, using the residual moisture. So far, a total of 45,000 units of Aybar BBM have been distributed in different regions and have been used not only to drain excess water from

vertisols but also to construct tied ridges in dry areas to prevent runoff (and thereby increase moisture availability), to prepare fields for small-scale furrow irrigation, and even to harvest potato.

The Aybar BBM costs about 239 birr (US$12). The cost is lower than prices farmers pay for other agricultural inputs. For example, farmers pay up to US$ 80 for a 100 kg sack of fertilizer, which can only be used on 1 ha and only for one season, whereas Aybar BBM can be used on several hectares and for many years. The tool is also durable. For example, farmers who started using Aybar BBM for testing 5 years ago are still using the same tool and it does not show any sign of wear and tear other than removal of the paint.[1]

Case study

Farmer Berhanu Angassa, from Awash Bule kebele, southwest Shoa, Oromia region, reported that he used to produce 800 kg of wheat/ha from his field. The use of Aybar BBM enabled him to harvest 4,400 kg of wheat/ha. He planted chickpea using the residual moisture and harvested 800 kg. He also stored the drained excess water in a pond and later used it to grow vegetables.

The BBM technology reversed the negative impact of water on both crop production and the environment. It did so by moving away excess water that would have reduced yields, increased soil erosion and GHG emission and by making it possible to use that same water to grow another crop. Therefore, the technology not only helps increase crop production but also protects the environment. Early planting with the help of BBM allowed early soil cover with live crops, which means reduced soil erosion as the soil is protected by the crops instead of being cultivated during the rainy season that would cause higher soil loss. On the other hand, tillage increases carbon dioxide emission, while live crops absorb carbon through photosynthesis. Moreover, growing three crops per year results in an extended period of soil cover with live crops, which is in line with one of the main principles of conservation agriculture. In addition to reducing soil erosion, retention of rainwater in the field makes more water available for the crops, thereby increasing crop production by up to 60–73% (McHugh *et al.*, 2007).

Conclusion

Drainage of vertisols using Aybar BBM makes it possible to reverse the negative impact of water on smallholder farming by removing excess water. Consequently, the negative impact due to water-logging is avoided, while storage of excess water in a pond allows farmers to use that same water to grow more crops later through irrigation. These practices help farmers use water for agriculture in a smarter way and can triple their income, while reducing soil erosion and carbon dioxide and methane emissions. They also increase carbon absorption through an extended period of soil cover with live crops. Aybar BBM can also be used in dry areas to construct tied ridges that minimize runoff, which would have caused soil erosion, while allowing more water to infiltrate into the soil horizon for increased crop production. Farmers can also use Aybar BBM for small-scale furrow irrigation and other agricultural operations such as potato planting and harvesting.

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[1] The address of the company that manufactures Aybar BBM is Hn 538 Woreda 09, Gulele, Addis Ababa, Ethiopia. Email: admin@aybareng.com Website: www.aybareng.com.