

Biochar-based fertilizer can decouple smallholder farm economy from global market disturbances



Burkhard Wilske¹, Abebe Nigussie², Tilahun Abera³, Konrad Siegfried¹, Milkyas Ahmed², Reta Worku³, Bayu Dume², Gebeyanesh Worku², Amante Lema³



Development project ETH-Soil

ETH-Soil supports Ethiopia in establishing the use of biochar-based fertilizer (BBF) to avert degradation of acidic soils and achieve sustainable and resilient agriculture. ETH-Soil promotes resource use efficiency and soil amelioration through the combined energetic and material use of biomass residues. Capacity building, infrastructure upgrade, biochar certification, and linking up a carbon credit scheme is flanked by **soil monitoring** to collect evidence that can justify recommending BBF to resource-poor smallholder farmers. BBF rates reflect the resource limitations, even though this lowers expectations in quick improvements of soils and crop yield. Key to BBF acceptance is to return sovereignty to farmers by amplifying their range of options for sustainable soil fertility management.

Soil Monitoring of BBF effects

BBF was tested vs. business-as-usual (BAU=farmers' usual rate of imported mineral fertilizer) in 28 fields (total) across five landscape positions (elevation gradient 1160 m). Corn cob biochar (bc; from *Kontiki kiln*) was co-composted (ratio 30:70) with manure at Dedo (1900–2900 m a.s.l.) west of the Rift Valley, and with vermicompost at Kombolcha in the Rift (~1660 m) and Kofele (~2591 m) east of the Rift. BBF was applied on the basis of 10 t bc/ha in duplicate 4x4-m plots (similar for BAU). BAU was NPSB 60 + Urea 90 at Dedo-Ilala, -Sito and -Ofole, and 100 NPS + 100 Urea at Kofele and Kombolcha. Three triple mixed soil samples for BBF and BAU were collected as per Maresha plough depth (0–20 cm) in - and biomass past - growing seasons. Analytics were conducted as described in Mekonnen et al., 2025, <https://doi.org/10.1002/bbb.2777>.

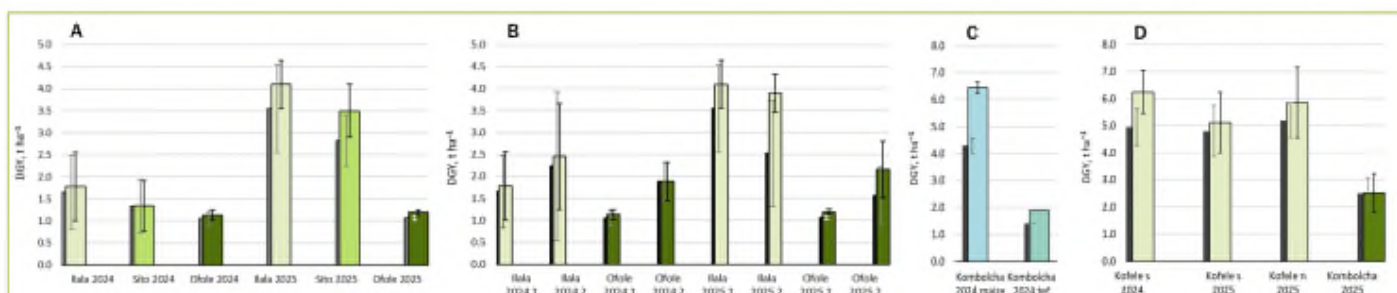


Fig. 1: Dry Grain Yield (DGY) from business as usual (BAU) and biochar-based fertilizer (BBF) at different landscape positions in Oromia, Ethiopia in 2024 and 2025
Colored bars represent BBF, error bars are standard deviation; BAU bars shown as left shadow. Landscape positions (A, B) West of Rift Valley at Jimma - Dedo - Ilala (2819 m a.s.l.), -Sito (2326 m) and -Ofole (1909 m), (C) in the Rift at Kombolcha (1660 m), and (D) east of the Rift at Kofele (2591 m). Figure part B shows applications of 1 kg and 2 kg biochar. Crop was wheat except of figure part C.

Imported mineral fertilizer	Minimum	Maximum
blanket fertilizer recommendation: 100 kg Urea/ha + 150 kg NPSB/ha	86*	143
Biochar based fertilizer BBF		
Compost → Vermicompost, 1 ton	16	109
Compost → Vermicompost, 23.3 t	380	2533
Corn cob feedstock + transport, 1 t	0	16
22% wt/wt biochar yield + 10 t	0	741
BBF from SME (corn cob biochar with compost/vermicompost for 1		3274
BBF from on-farm/community production with corn cob available	380	2533
BBF from on-farm/community with vermicompost/manure available		741
BBF from on-farm/community with all components available	0	
Annual small farm HH income	978	2500

Fig. 2: BBF preliminary economic analysis

Many small farms have <1 ha available. Imported mineral fertilizer does at times not cover demand or become unaffordable. Biomass for BBF production is depending on region/often freely available or can be gathered, when produced by farm community. *BAU is often 60% of blanket rate. [184 ETB = 1 €]

Abstract ID 312

¹ DBFZ, Bioenergy Systems Department, Work Group Mobilisation, Leipzig, Saxony, DE
² Jimma University, College of Agriculture and Veterinary Medicine, Jimma, Oromia, ET
³ IQQO – Batu Soil Research Center, Batu-Ziway, Oromia, ET

Contextual Abstract ID 253: Amsalu Nebiyu et al.: Integrated farmers' perception ...

2024	K*	pH	SOC	PAV	CEC	DGY	AGB	BGB
Ilala	—	+0.02	—	—	—	—	—	—
Sito	*	+0.16	—	—	—	—	—	—
Ofole	—	+0.12	—	—	—	—	—	—
Kofele	/	+0.03	—	—	—	—	—	—
2025	K*	pH	SOC	PAV	CEC	DGY	AGB	BGB
Ilala	**	—	—	—	—	—	—	—
Sito	***	*	—	—	—	—	—	—
Ofole	***	**	—	—	—	—	—	—
Kofele	/	—	—	—	—	—	—	—
Significance		+0.1	+0.05	+0.01	+0.001	—	+0.1	—

Fig. 3: Positive effects of BBF

Changes in soil parameters and biomass yields relative to BAU. Different significance levels (p-values) color-coded. Parameters: K (* biochar tracer)(mg/kg), SOC %, PAV plant available P [mg/kg, ppm], CEC [meq/100g]; Biomass [t/ha]; dry grain yield DGY, oven dry above (AGB) and below ground biomass (BGB).

Results and Outlook

- Crop yield with BBF was generally similar or better than with BAU (Fig. 1). Mean wheat yields increased by 7–26% (0.3–1.3 t/ha) at Kofele, and by 6–23% at Dedo across 2024 and 2025.
- Comparing the costs for BAU and BBF fertilization justifies recommending BBF to smallholder farmers (Fig. 2).
- BBF effects on measured soil quality parameters become more apparent in year two of BBF application (Fig. 3).
- Farmers are positive as BBF provides various options, e.g., to
 - combine BBF with lower amounts of mineral fertilizer,
 - apply BBF to different parts of your field year after year,
 - collect biomass to produce your own BBF, etc. to finally produce healthier crop at reasonable costs with local/regional resources.
- Local BBF production can protect farmers from economy shockwaves that often render imported fertilizer unaffordable.
- Recovery of healthy and fertile soils comes as a co-benefit.

The ETH-Soil Project is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and is implemented by DBFZ in cooperation with GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit.

