



Increasing Rainwater Productivity with Conservation Tillage

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Drought and Famine in Sub-Saharan Africa: Just Fate or inefficient Use of Precious Rainwater?

Food security in the semi-arid tropics (<800 mm rainfall annually coming often in storms, >6 months dry season) is threatened by frequent droughts and dry spells. While droughts and dry spells are not new to these regions, the effects become more pronounced due to progressing soil degradation and dwindling farm sizes (farm size/capita). Even in years with just below average rainfall yield losses and consequently food shortage and famine are common. This gives the false impression that droughts are more frequent. Crop failure is less the consequence of lacking rainfall than the effect of soil degradation caused by inappropriate management practices. Even in "dry years" a high percentage (>50%) of precious and free rainwater is lost by surface run-off and evaporation from the soil surface.

Major causing factor: Inappropriate management practices

Inappropriate management practices in dry-land farming are, e.g., ploughing and intensive hoeing. These result in surface crusting or sealing, soil compaction, decrease of organic matter and hard-pan formation which are major factors contributing to inefficient use of precious rainwater.

The main effects of ploughing are:

- the formation of an impermeable hardpan at a depth of 10-20 cm which impedes both rainwater and crop roots in entering the deeper layers of the soil profile
- the upper soil will rapidly be saturated during heavy or prolonged rains, resulting in water logging and run-off and erosion problems

- with the first rains the soil surface is crusted and sealed, impeding the infiltration of rainwater and enhancing run-off
- the soil will have a low water holding capacity with rapid depletion of moisture for crop growth during dry spells

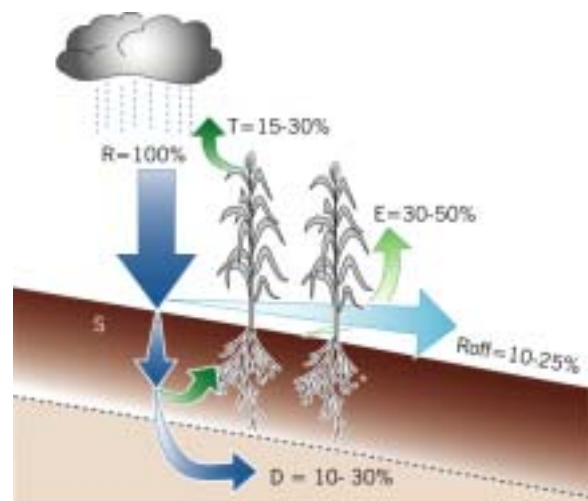
These effects are known since long, and at large-scale commercial farmers' level in South-Eastern Africa, ploughing was successfully replaced by subsoiling/ripping using heavy tractors. However, applications at small to medium-scale farmers' level are still low and limited to some project areas.

Main objective of dryland farming is optimum utilisation of precious rainwater

Objective of conservation tillage (CT) in SAT (including the Sahelian countries):

- Increase rainwater use efficiency
- Reduce risk of yield losses due to drought
- Increase food security

General overview of rainfall partitioning in farming systems in the semi-arid tropics of sub-Saharan Africa (Rockström, 2001a)





Avenues towards increased rainwater productivity

CT practices have proved to significantly improve the situation.

Water losses through surface run-off are reduced by:

- a ground cover (crop residues, cover crops) which slows down the water flow, and prevents surface crusting
- ripping, "open plough furrow" (planting furrows), planting pits, tied ridges which collect and store access water



Ghanaian farmer in his field covered with Mucuna (Photo: Steiner)



Fields with tied ridges and pits, filled with water (Photo: Kriegl)

Water infiltration is improved by:

- a ground cover which prevents crust formation on the soil surface
- formation of macro pores by soil biota (e.g. earthworms) which increase in number under the protective soil cover

- breaking of hardpans (e.g. plough pans) with an animal or tractor drawn subsoiler or pitting in case of manual labour. These operations enhance infiltration into deeper soil layers

Evaporation is reduced by:

- A permanent soil cover protecting the soil from impact of wind and solar radiation
- Infiltration into deeper soil layers

Support for water uptake through careful application of fertilizer:

Growing of green manures/cover crops to improved soil fertility and application of manure and mineral fertiliser, especially P fertiliser, enhance plants growth and the formation off a dense and deep root system. This favours uptake of water, also from deeper layers.

Effective Weed Control reduces water competition:

Weeds compete for water with food crops. Often the root system of weeds is even more efficient and reaches deeper soil layers. Controlling weeds by using cover crops, early weeding, slashing or even use of herbicides is pertinent in order to avoid soil water losses. Weeds must be controlled even in the dry season, as species like "Mexican poppy" have a deep reaching root system which, taps water from deep soil layers.

Improved rainwater use efficiency

- Timely planting
- Reduced run-off
- Increased water infiltration
- Root penetration
- Fertilisation
- Weed control

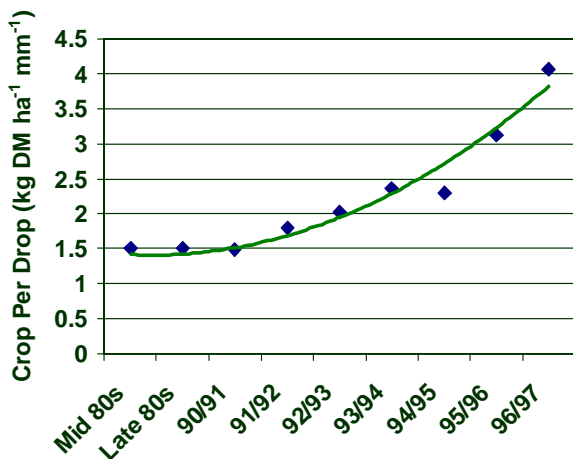
Dryland farming in Tanzania

Promotion of animal and tractor drawn CT using rippers and subsoilers among smallholder farmers in Babati District, Tanzania, has over the last decades resulted in significant water productivity increase. As seen from the figure below rainwater productivity was estimated at approximately 1.5 kg/mm/ha in the mid-eighties under

conventional disc plough agriculture, compared to progressively increasing trend from 2 to 4 kg/mm/ha, during 1990s after introduction of mechanised subsoiling. Similar improvements in water productivity have been observed in other districts of Tanzania and in Zambia.

The effects of CT, especially that of a ground cover, are striking and can be easily observed. Even some weeks after the last rains the soil under the cover is still moist and soft while on neighbouring, ploughed fields the soil has turned dry and hard. Even after a prolonged dry spell crops are still vigorous and do not show signs of water stress as in conventional fields.

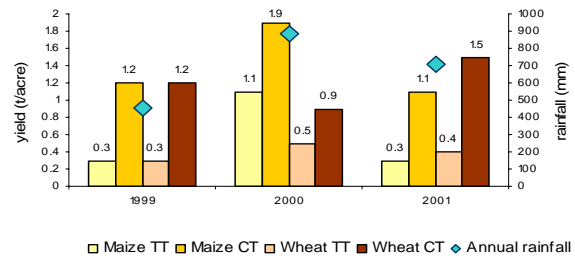
Development of rainwater productivity (Kg DM grain/mm/ha) of maize in Babati district, Tanzania. (Rockström, 2001b)



Effects on crop yields

A more continuous water supply and a deeper rooting system following subsoiling lead to higher and more stable crop yields. This is more pronounced in “dry” years where crop yields of fields under CT are significantly higher compared to conventionally tilled fields. Complete crop failure is rare and limited to real “disaster” years where crops fail whatever the farming practice. Higher yields are a result of better water supply during critical growing stages, especially flowering and corn filling.

Impact of subsoiling on maize and wheat yields, Hanang District, Tanzania, 1999-2002 (TT=Traditional Tillage) (SARI/TFSC, 2000-2002)



Constraints to a fast adoption of CT by smallholders

While all facts prove the superiority of CT compared to conventional tillage adoption by smallholder farmers are still low and increase only slowly. A number of reasons, mainly economic and social ones, prevent farmers to change their farming systems.

Groundcover:

A complete groundcover is difficult to achieve in dry regions due to low biomass production, stubble grazing and/or uncontrolled bush fires. In regions with below 600 mm of rainfall, covercrops compete with food crops for soil moisture. Residual moisture after crop harvest is not sufficient for growing cover crops. Access to covercrop seeds is difficult, as long as only a few farmers practice this technique. It is, however, assumed that biomass production under CT is significantly increased leaving enough crops residues both for livestock feeding and for groundcover.



Maize on subsoiled fields compared to traditional fields in a dry year, Hanang District, Tanzania (Photo: Mariki)



Subsoiling:

Subsoiling, even though effective and profitable, is costly and difficult to achieve without a tractor because of the high draft power requirement. Draught animals are often too weak for efficient subsoiling and farmers not willing to make several passes in order to break deeper layers. While pitting as an old and effective practice, it is very labour intensive, and therefore applied only on a limited scale. In addition, access to implements for ripping and subsoiling and to hire services is limited.

Prospects:

Reducing risks of dryland farming

Dryland farming is a risky enterprise. Therefore farmers apply risk aversion strategies. Investments remain low and are mainly done, when rainfall seems to be sufficient. CT can be considered as a strategy of reducing risk of crops failure and one option of improving food security. Once exposed to this option in a dry year, farmers take up the message. They regard e.g. subsoiling and ripping as a kind of risk insurance. This risk insurance may create the incentive to invest in other critical inputs such as soil fertility and weed management.

The Win-Win opportunity

Women groups in Machakos District/Kenya Subsoiling as risk insurance

Despite insufficient draft power, women farmers in Machakos District of Kenya try to subsoil every year as a kind of risk insurance. And even in "normal" years costs are usually recovered by yield increases. Because subsoiling not only enhances water penetration into deeper soil layers, but allows also deeper rooting of crops and thus exploitation of greater soil volume.

Managing soil fertility and water simultaneously:

Better soil fertility results in improved plant growth; a denser root system, especially when P applied; plants roots exploit a greater soil volume thus making better use of soil water. Farmer driven trials on CT in drought prone areas of Arusha in Tanzania show that



Zambian women with ripper-planter (Photo: J.Kienzle)

it is only when soil fertility management is combined with the positive water harvesting effect of conservation tillage that maximum yield effects are achieved.

Over four years (1998–2002) farmers experienced on average more than a doubling of yield levels of maize when ripping was combined with nitrogen and phosphorus fertilisation (combined effect of soil nutrients and water). Ripping alone (addressing only water harvesting) resulted in a yield increase, but "only" a 60% increase compared to conventional ploughing, indicating the water effect alone of adopting conservation tillage. There is thus a clear win-win opportunity of combining soil nutrient and water management. Conservation tillage moreover enables farmers to easily adopt spot application of manure and fertilisation, making it a form of precision agriculture, which concentrates expensive inputs to the crop.

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