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Research Paper

Improving on-site water availability by combining in-situ water harvesting techniques in semi-arid Northern Ethiopia

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ABSTRACT

Crop production in arid and semi-arid environments is strongly affected by temporal variation of water availability during the growth period. In-situ water harvesting techniques such as tied ridges and mulching improve water availability over time and may improve crop yield. A field experiment was conducted in 2013 and 2014 in the Gule sub-watershed, Northern Ethiopia to study the effect of combining in-situ water harvesting techniques on on-site water regime, i.e., runoff and soil-moisture content. Five treatments with tied ridges, straw mulch, tied ridges and straw mulch together, straw mulch plus effective microorganisms and a combination of tied ridges, straw mulch and effective microorganisms and an untreated control were tested. Combined tied ridges and straw mulch with and without effective microorganisms significantly reduced average runoff per event by 78 and 88%, respectively, compared to the control. Tied ridges alone reduced runoff by 56% and straw mulch with and without effective microorganisms reduced runoff by 49 and 53%, respectively. Average soil-moisture content over the two years was significantly higher (22.4%) in combined tied ridges and straw mulch than the control (19.9%). Tied ridges or straw mulch alone significantly reduced runoff and improved soil-moisture content, but the two combined were more efficient. The findings suggest that combining straw mulch and tied ridges enhance water infiltration into the soil and improve water availability during the growing season, thereby protecting crops from dry periods.

1. Introduction

The efficient use of water in agricultural systems is needed to improve crop production and resilience to environmental adversities that may be caused by climate change and extended droughts, especially in arid and semi-arid areas. Marginal and erratic rainfall aggravated by the loss of water by runoff and evaporation are the main causes of low crop production in these areas (Yosef and Asmamaw, 2015). Ethiopia has been dependent on subsidence rain-fed agriculture for centuries, and crop production has thus been heavily reliant on the availability of rainwater (Araya and Stroosnijder, 2010; Yosef and Asmamaw, 2015). Most of the cultivation in Ethiopia is in the highlands, which have fragile natural resources and often coarse-textured soils low in organic-matter and water-holding capacity that are prone to wind and water erosion (Boelee et al., 2013). Water harvesting techniques (WHTs) have played a key role in improving the efficient use of rainwater and have increased the sustainability and reliability of rain-fed agriculture (Biazin et al., 2012).

In-situ WHTs such as tied ridges, mulching, conservation tillage, and the application of compost and manure (Mati, 2005) improve the availability of water in the soil profile to decrease the effects of dry periods caused by the seasonal variation of rainfall. Soils can temporarily hold water, so in-situ water harvesting prolongs the availability of water in the root zone by reducing runoff and evaporation losses (Vohland and Barry, 2009). Some techniques (e.g. ridges and furrows) can conserve water in the soil profile mainly by reducing net runoff, and others (e.g. mulching) can conserve water by reducing evaporation.

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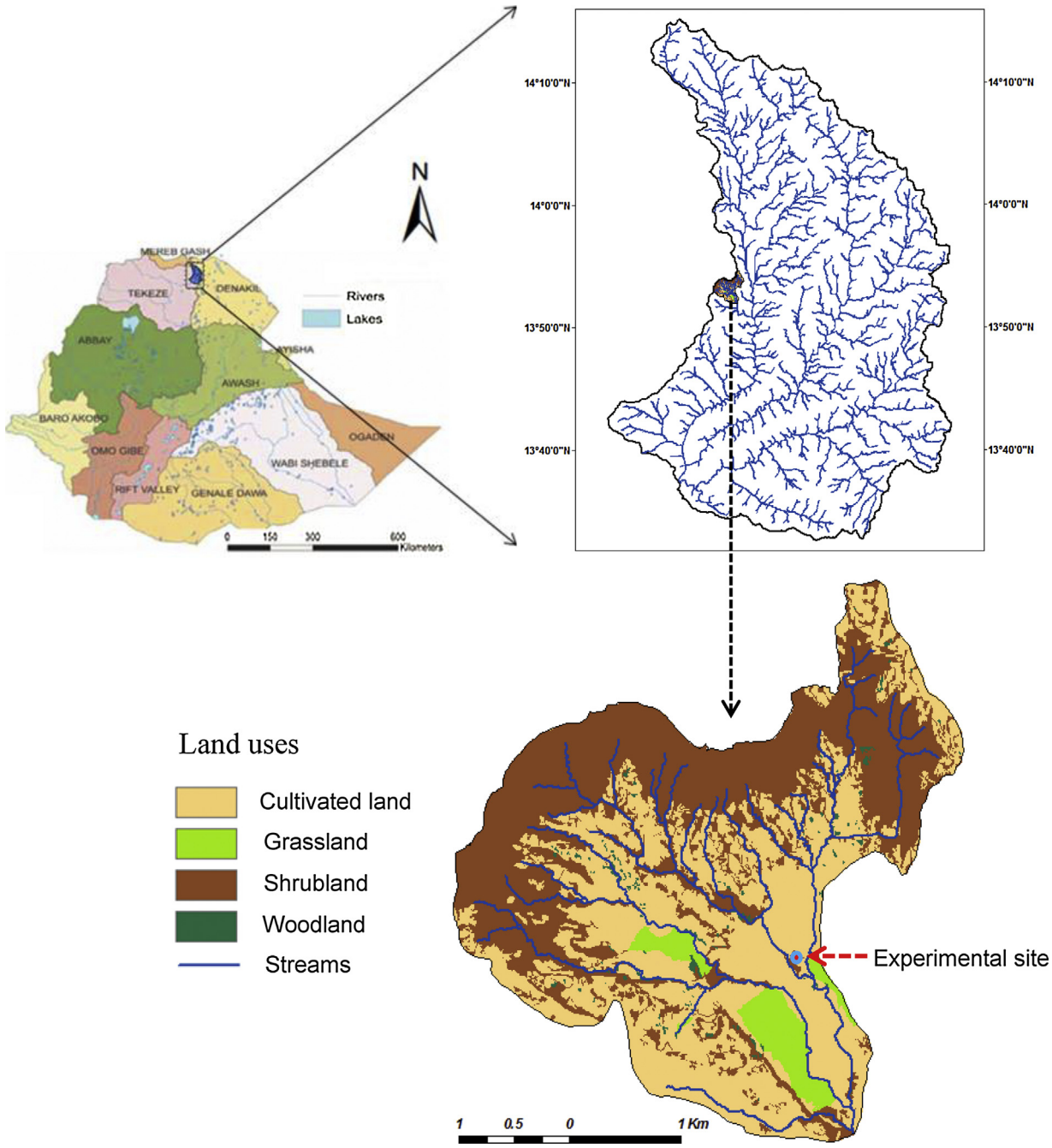

Fig. 1. Location of the Gule sub-watershed and the experimental site.

The effect of mulch on soil properties, soil-water storage, and crop yield is well documented (Chakraborty et al., 2008; Cook et al., 2006; Li et al., 2007; Ramakrishna et al., 2006). Several other studies have focused on the effect of conservation agriculture (e.g. contour furrows and soil tillage) on soil and water conservation (Abrisqueta et al., 2007; Araya et al., 2011; Gebreegziabher et al., 2009; McHugh et al., 2007; Mesfine et al., 2005; Temesgen et al., 2009). The effects of individual tied ridges and mulching on water availability and crop production have also been evaluated in different parts of the world (Araya and Stroosnijder, 2010; Mudatenguha et al., 2014; Wang et al., 2009).

Combining WHTs (e.g. mulching and tied ridges) ensures high-level and reliable crop production, benefiting from enhanced soil-water storage and decreased net runoff (Li et al., 2000). Integrating in-situ WHTs and soil fertility improvement measures is needed not only to improve yield but also to increase the efficiency of water harvesting (Miriti et al., 2007; Nyamadzawo et al., 2013). The application of effective microorganisms (EMs) to the soil can enhance soil properties such as infiltration rate and water-holding capacity hence increase soil-moisture (Ismail, 2013; Lee et al., 2008).

Combinations of in-situ WHTs such as wood-chip mulch and ridges substantially improved the growth and straw yield of sorghum (Chiroma et al., 2006a). Moreover, combined application of wood-shavings mulch with ridge tillage improved soil fertility and slowed down the acidification of a coarse-textured soil (Chiroma et al., 2006b). Similarly, combined use of ridges and furrows with gravel/plastic mulch improved runoff and water use efficiency, and significantly increased corn yield (Li et al., 2000; Li et al., 2001). Positive effects of ridges and mulch on cowpea