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Tinkering on the periphery: Labour burden not crop productivity increased under no-till planting basins on smallholder farms in Murehwa district, Zimbabwe

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ABSTRACT

No-till planting basins are promoted using seed and fertiliser inputs as incentives for their widespread uptake in Zimbabwe. The short term effects of planting basins on crop yields and labour requirements were evaluated in an on-farm experiment over two seasons (2009/2010 and 2010/2011) in Murehwa district, Zimbabwe. The experiment was established on clay (Luvisols) and sandy soils (Lixisols), in two field types; outfields (degraded) and homefields (better managed fields). Fields closest to homesteads (homefields) typically receive most nutrients and preferential management, and are more fertile than outlying fields (outfields), with implications for crop production and nutrient use efficiencies. The fertiliser sub-treatments consisted of (a) no fertiliser (control), (b) 60 kg N + 3 t manure ha^{-1}, (c) 60 kg N ha^{-1} + 10 kg P ha^{-1} (SSP) and (d) 60 kg N ha^{-1} + 20 kg P ha^{-1} (SSP). In addition, a socio-economic survey was carried out to understand the diversity in resource ownership among farmers and to explore whether there was a relationship with uptake of planting basins. Results showed that field type, nutrient application and season had a significant effect on crop yields ($p < 0.001$); there was no significant effect of tillage practice. The largest maize grain yield of 5.6 t ha^{-1} was obtained with a combination of manure (3 t ha^{-1}) and 60 kg N ha^{-1} under conventional tillage; the equivalent treatment under planting basins yielded 4.6 t ha^{-1} in the 2009–2010 season. Rainfall was poorly distributed in 2010–2011 season and the same treatment gave the largest grain yield of 1.6 t ha^{-1} under conventional tillage and 1.2 t ha^{-1} under no-till planting basins. Land preparation under conventional tillage required 6 man days ha^{-1} while planting basins construction required 76.5 man days' ha^{-1} for the clay soils and 51.5 man days ha^{-1} for the sandy soils. Weeding in planting basins required 40% more labour compared with conventional tillage (12 man days ha^{-1}) due to greater weed densities associated with early years of no-tillage. Planting basins did not enhance moisture conservation in a the 2010–2011 season when rainfall was poorly distributed as shown by the smaller yields. The increased labour requirements suggested a major impediment to the uptake of planting basins even for farmers without livestock. Farmers differed greatly in resource ownership; four resource groups were identified based on land size, cattle ownership, labour availability and land utilisation. However, the practice of planting basins did not relate to resource ownership due to the incentives provided by the NGOs. Given that planting basins increased the labour burden but not crop yield, and that incentives cannot go on forever, widespread adoption by smallholder farmers seems unlikely.

1. Introduction

The barriers to improved crop productivity and food security in Zimbabwe centre on poor soil fertility status and climatic volatility (e.g. Rurinda et al., 2013; Rusinamhodzi et al., 2013), and these conditions are also true for much of southern Africa (Challinor et al., 2007). The situation is further compounded by the limited resources (land and capital) that smallholder farmers possess (Giller et al., 2006, 2011b). Cropping systems that improve

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soil moisture and nutrient cycling while being locally adapted to the socio-economic as well as biophysical circumstances of farmers are therefore desired (Rusinamhodzi, 2013). No-till planting basins have been promoted since the turn of the millennium to improve crop productivity, soil fertility and reduce hunger on smallholder farms in Zimbabwe (Mazvimavi and Twomlow, 2009; Ngwira et al., 2013). Planting basins are shallow structures roughly 30 cm long, 15 cm wide and 15–20 cm deep that are maintained each season in the same place (Twomlow et al., 2008). Seeds and other inputs such as lime, fertiliser, manure or compost are precisely placed in the basins. Inputs are placed close to the plant where they are most required leading to efficient uptake and use. The purpose of the practice is to disturb the soil only where the crop is established, leaving the surrounding soil untouched. Planting basins allow water to accumulate thus improving water infiltration and are often described as a water-harvesting technique similar to the *Zai* soil restoration system, a complex cropping system concentrating runoff water and manure in microwatersheds used in West Africa (Roose et al., 1999).

Theoretically, planting basins have potential to improve crop productivity due to water conservation and targeted nutrient application (Van Niekerk, 1974). However, moving from mouldboard plough to planting basins may entail substantial initial labour inputs for resource constrained farmers. Under low-input systems, labour is often the major input and is critical for timing operations; insufficient labour often leads to reduced land utilisation and late planting, leading to small yields (Giller et al., 2006; Muoni et al., 2013). For example, Nyamangara et al. (2013) reported that weeding in planting basins required double the labour in conventional tillage, and that weed growth and labour demand remained higher under planting basins tillage even after several years. Moreover, increased crop productivity under planting basins was only observed when adequate fertiliser application was achieved (Nyamangara et al., 2014). However, Mazvimavi and Twomlow (2009) observed that household labour availability did not influence adoption intensity of planting basins and might not be a major consideration for the practice.

Although planting basins are considered a form of conservation agriculture for the semi-arid regions and specifically for farmers without draught power in Zimbabwe (Mazvimavi and Twomlow, 2009), they have been promoted indiscriminately by NGOs and development practitioners using incentives to improve their uptake by smallholder farmers (Nyamangara et al., 2013). Such an approach has been considered necessary to stop the rampant land degradation and to address the persistent food insecurity status of smallholder farmers. However, this approach does not necessarily work for all farmers due to differences in resource endowment and locally prevailing biophysical barriers (Giller et al., 2011b). The combination of biophysical factors such as soil type and climate, socio-economic factors such resource ownership and access to markets determines farmers' production orientation within each locality (Rusinamhodzi, 2013). At farm level, limited labour and inadequate resources such as cattle manure or chemical fertilisers often force farmers to apply only on limited portions of the farm each year leading to heterogeneous soil fertility status across the fields (Mtambanengwe and Mapfumo, 2005; Tittonell et al., 2007). Therefore, efforts to bring improved management options need to recognise the wide diversity of farmers in terms of resource endowments, priorities and constraints as well as the broader institutional and policy environment in which they operate (Giller et al., 2011a)

The occurrence of the soil fertility gradients within smallholder farms i.e. the so-called homefields and outfields (Mtambanengwe and Mapfumo, 2005; Zingore et al., 2007a) is a local biophysical condition which may determine the performance and the fate of new technologies. Homefields are often closer to the homestead and have historically received more nutrient inputs (fertiliser and manure) than outfields and are characterised by high concentrations of available P and soil organic matter, and a pH conducive for crop growth (Zingore et al., 2007a). The soil fertility gradients caused by differences in previous resource allocation require adapted nutrient management strategies to improve nutrient use efficiency and crop productivity (Zingore et al., 2007b; Rusinamhodzi et al., 2013). New technologies aimed at improving crop productivity often performs differently in these field types thus field type should be an integral component of the experimental design aimed at assessing such technological performance on smallholder farms (Zingore et al., 2007a,b).

According to available literature, there is no sufficient and congruent scientific evidence on the suitability of planting basins to alleviate the short term constraints to increased crop productivity to warrant their widespread promotion under the smallholder farming systems of Zimbabwe. Therefore, an on-farm experiment testing two tillage practices i.e. conventional tillage and planting basins was established over two seasons (2009/2010 and 2010/2011) in Murehwa, Zimbabwe to measure crop productivity and labour input requirements of the two tillage systems. In this farming system, crop residues are strongly needed for animal feed in the dry season (Valbuena et al., 2012; Rusinamhodzi, 2013), which competes directly with the need to provide soil cover (Nyamangara et al., 2013).

2. Materials and methods

2.1. Site description

The experiment was established over two seasons (2009/2010 and 2010/2011) in Chikore (17°50′S, 31°35′E, 1301 m above sea level—masl) and Ruzvidzo (17°51′S; 31°34′E, 1300 m masl) villages located in Murehwa smallholder farming area, 80 km north east of Harare, Zimbabwe. Murehwa is located in agro-ecological region II (Vincent and Thomas, 1960) which receives annual rainfall of between 750 and 1000 mm in a unimodal pattern between November and April. Prolonged mid-season dry spells are common. The soils in the area are predominantly granitic sandy soils (Lixisols: FAO, 1998) of low inherent fertility with intrusions of dolerite derived clay soils (Luvisols; FAO, 1998) that are relatively more fertile (Nyamapfene, 1991). Previous preferential application of fertiliser and manure has created soil fertility gradients within farms, the so-called homefields and outfields (Mtambanengwe and Mapfumo, 2005; Zingore et al., 2007a). Cattle ownership varies widely among households (Zingore et al., 2007a). Other small livestock such as goats and local chickens are also important. Farmers who own cattle use manure together with small amounts of mineral fertiliser they can afford on small areas of the farm resulting in improved crop productivity. Maize (*Zea mays* L.) is the dominant staple crop while groundnut (*Arachis hypogaea* L.), sweet potato (*Ipomoea batatas* (L.) Lam.) and sunflower (*Helianthus annuus* L.) are important crops.

The communal grazing area is characterised by the Miombo woodland dominated by *Julbernardia globiflora* (Benth.) Troupin, *Brachystegia boehmii* (Taub.) and *Brachystegia spiciformis* (Benth.) (Mapaure, 2001). Grass species of the genus *Hyparrhenia* are predominant, and *Andropogon*, *Digitaria*, and *Heteropogon* spp. are also common species. *Sporobolus pyramidalis* (P.) Beauv., a grass of poor grazing quality often dominates in overgrazed areas and perennially wet 'vlei' areas of the veld. In the dry season, the grazing is often of poor quality both in amount and nutrient composition.