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Research Application Summary

Evaluating the effects of conservation agriculture and related technologies on soil biodiversity, crop and labour productivity in semi-arid Zimbabwe

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Abstract

This on-going study is examining the linkage between termite prevalence and residue amount under conservation agriculture in Zimbabwe. Preliminary results show that convectional ploughing had lowest termite abundance while tied ridging increased yield of test crops by up to 29.8% and conservation agriculture by 15.2% compared to the control.

Key words: Convervation agriculture, termite prevalence, tied ridging, Zimbabwe

Résumé

Cette étude en cours examine le lien entre la prévalence de termites et la quantité de résidus en vertu de l'agriculture de conservation au Zimbabwe. Les résultats préliminaires montrent que le labourage conventionnel a la plus faible abondance des termites tandis que le point lié de buttage augmente le rendement des cultures d'essai d'un maximum de 29,8% et l'agriculture de conservation de 15,2% par rapport au témoin.

Mots clés: Agriculture conventionnelle, la prévalence du termite, buttage liée, Zimbabwe

Background

Africa is the only continent whose cereal productivity has remained static in the last 3 decades, yet its population continues to grow at rates far exceeding food production. Unless concerted measures are undertaken to address soil degradation which has led to loss of soil biodiversity and desertification, food insecurity and poverty will remain a serious challenge for Africa by 2015.

Poor soils, erratic rainfall, frequent dry spells and lack of irrigation infrastructure, among others, have been cited as the major threat to the development of a sustainable agricultural system in Southern Africa (Kahinda, 2007). Most cropping seasons in this region are characterized by mid-season dry spells which seriously reduce yield potential, making water the greatest limitation to crop productivity. The static growth of crop productivity despite efforts to conserve soil water, necessitated further tillage research

and concepts of better land husbandry such as no-till which emerged to tackle problems of soil water deficits and soil degradation (Nyagumbo, 2008). In addition to low rainfall, soil nutrient deficiencies contribute significantly to the continued declining in smallholder maize production (Woomer and Swift, 1994) and correction of this using inorganic fertilizers is severely limited by prohibitive purchasing costs and general lack of availability (Scoones *et al.*, 1996). The scarcity of mineral fertilisers, poor quality and low quantity of organic fertilisers (Mugwira, 1995**)**, leave smallholder farmers with limited options for sustaining agricultural productivity (Mapfumo and Giller, 2001). Smallholder crop production thus remains low despite several breakthroughs in research work on water and nutrient conservation technologies and gaps still exist in exploring the benefits derived from the synergy of integrating these technologies to ensure sustainability in the smallholder agricultural sector.

Conservation Agriculture (CA) seeks to achieve sustainable and profitable agriculture and to improve the livelihoods of farmers through the application of three principles: minimal soil disturbance, permanent soil cover and crop rotations (PFA, 2007). Provision of soil cover through crop residues ultimately results in a more favourable environment beneficial to soil fauna, which in turn enhances soil fertility. In spite of their known benefits, many farmers believe retention of crop residues contributes to increased termite prevalence in semi-arid regions. This is more apparent towards the end of the rainy season where resultant lodging contributes to yield losses. On the other hand, some scientists suggest that the presence of dry crop residues may actually reduce termite attack on growing crops as they are thought to prefer dry stover as compared to fresh biomass (Nhamo, 2007). Unfortunately, no conclusive studies have been carried out to prove or disprove these two schools of thought. Furthermore, there is also need to assess changes in termite populations that take place in the soil in CA systems in general and in particular at different soil cover levels. This study therefore also seeks to address this bottleneck to CA systems by establishing the linkage between termite prevalence and residue amounts.

Literature Summary

Climate change associated with global warming is predicted to bring droughts to sub Saharan Africa and is likely to cause even more serious water deficits in the near future. Very few such studies have attempted to fully capitalize on the benefits of

integrating promising nutrient management techniques with water management technologies which provides a platform for mitigating effects of global warming. For example, benefits to crop yields and water use efficiency were obtained when the tied furrow water harvesting system was integrated with increased fertilizer use at Makoholi, a semi-arid region in Zimbabwe (Nyamudeza and Nyakatawa, 1995). In order to mitigate the impact of climate change, manifesting themselves in the form of droughts and increased temperatures, technologies including diversification to drought tolerant crops, *conservation agriculture* and rain water harvesting technologies are needed to enhance crop productivity.

However the retention of crop residues as soil cover remains a major bottleneck to CA adoption by farmers in Zimbabwe (Mazvimavi and Twomlow, 2008; Giller *et al.*, 2009). Provision of soil cover through crop residues ultimately results in a more favourable environment beneficial to soil fauna, which in turn enhances soil fertility. In spite of their known benefits, many farmers believe retention of crop residues contributes to increased termite prevalence in semi-arid regions. This is more apparent towards the end of the rainy season where resultant lodging contributes to yield losses.

Study Description

Studies are being conducted under rainfed agriculture for two seasons on two sites which have different ecological rainfall patterns. Eight experimental plots were established in Kadoma (NR-III) and one similar trial was established at Domboshawa Training Centre (NR-II) which receives between 500-650mm and 750-1000mm annual rainfall, respectively. Soils in Kadoma are dominated by kaolinitic fersiallitic soils, red clay soils derived from mafic rocks (Nyamapfene, 1991). The trial plot at Domboshawa was established in order to assess the effects of the treatments under different climatic conditions and for close monitoring of some parameters since Domboshawa is closer to University of Zimbabwe facilities. These trial plots were set to investigate how soil moisture storage, grain yield, and total biomass are affected by tied ridging, conservation farming basins, rip and pot holing and conventional (control) where fertility amendments, i.e., 200 kg ha^{-1} compound D, 200 kg ha^{-1} compound D + 5 tonnes ha^{-1} manure, 5t ha^{-1} manure and 0kg ha^{-1} (control) were superimposed as sub-treatments.

For termite prevalence experimental plots will be set in Kadoma and a parallel experiment will be established in Chikombedzi which is in NRV, receiving less than 450 mm annual rainfall and

is mainly dominated by semi-intensive livestock farming (Nyamapfene, 1991). Chikombedzi is characterised by calcimorphic vertisols. Sorghum is the major cereal grown, hence sorghum residue was used there in contrast to maize residues in Kadoma. A Complete Randomised Block Design (CRBD) experiment with 4 replicates per treatment was laid out. Five treatments of surface residue cover amounts of (0, 2, 4 and 6 t ha^{-1}) and a control (conventional mouldboard ploughing treatment), were randomly allocated to plots in each of the four blocks giving 4 replicates per treatment. Conservation agriculture plots with applied residues were planted using basins prepared by hand hoes and manually weeded twice or more per season . Plot sizes of 5 x 6 m were laid out in the experiment with an inter-block spacing of 1m. At least 3 farmer fields were used for analysis in each site per season. A *combined analysis of variance across sites* derived from split plot arrangements on each farmer/site was used to analyse effects of integrating nutrient management with moisture conservation technologies on the various parameters using GENSTAT. GENSTAT was also used to assess the role of termite prevalence in CA, termite control techniques and soil physical and chemical parameters.

Research Application

In terms of termite abundance/prevalence, generally conventional ploughing had the lowest termite abundance but differences were only significant between conventional ploughing and CA-4t/ha and / 6t/ha in both sites for both seasons. The preliminary results showed that an increase in soil moisture content from about 20 to 34 % resulted in increased termite abundance.

The addition of residues under CA across the sites had no significant impact on crop lodging. Generally lodging was lower under CMP than CA while % lodging on sorghum crops (Chikombedzi) was lower than on maize crops (Kadoma). Tied ridging showed an increase of yield by 29.8% from the control, while conservational farming basins and rip and pot holing had 15.21%, 10.86% increases in yields from the control. In tied ridging the fertilizer and manure sub-treatment further increased the grain yield by 2.75%. Generally CA had significantly higher maize grain yield compared to CMP but there was no significant difference across the different residue amount treatments under CA. In 2008/9 in Chikombedzi, a significant farmer x treatment interaction ($p<0.001$) was observed, an effect attributed to management factors (especially weeding) and rainfall regimes.

This study has provided only preliminary results. Termite control measures are needed under CA if termites reach pest damaging

level. Water harvesting techniques like tied ridging and basins should be incorporated into the farming systems as a way of averting the effects of climate change. Combining inorganic and organic fertiliser should be used under resources constraining conditions in order to further boost yield benefits derived from water harvesting techniques.

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