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Termite prevalence and crop lodging under conservation agriculture in sub-humid Zimbabwe

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A B S T R A C T

Provision of permanent soil cover using crop residues in conservation agriculture (CA) is constrained by livestock grazing and termite consumption in smallholder farming systems of sub Saharan Africa. This study evaluated the effects of surface applied maize (*Zea mays* L.) crop residues on termite prevalence, crop damage due to termite attack and maize yield over two seasons, 2008/9 and 2009/10. Treatments with residue application rates of 0, 2, 4 and 6 t ha^{-1} under CA and a conventional mouldboard ploughing (CMP) control were laid out in a randomized complete block design with four replicates on three farm sites in Kadoma, Zimbabwe. Maize residues increased ($P < 0.05$) termite numbers compared to CMP treatment. Crop lodging at harvest increased ($P < 0.05$) from 30 to 34% in CMP to 42–48% in CA systems. However, no significant difference was found in crop lodging with increasing residue rates within CA treatments. Significantly higher crop yields were observed under CA ($P < 0.05$) ranging from 2900 - 3348 kg ha^{-1} in 2008/9 season compared to CMP with 2117 kg ha^{-1}. Nevertheless, increasing residue cover in CA did not necessarily increase maize crop yield. Thus, increasing crop residue application rates under CA increased termite prevalence while crop lodging was influenced more by soil tillage system than by crop residue application rates.

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1. Introduction

Conservation agriculture (CA) is based on minimal soil disturbance, crop rotations and permanent soil cover (FAO, 2009). The provision of permanent soil cover using crop residues under CA is believed to result in a more favourable environment for soil fauna (Sileshi and Mafongoya, 2006). Termites are usually the dominating macrofauna group in croplands of Zimbabwe (Mutema et al., 2013) and have been reported to prevail under diverse environmental conditions (Uys, 2002). In cultivated fields, termite abundance is highly influenced by biophysical site characteristics and management factors. According to farmers, major factors affecting termite prevalence and activities are temperature (Papendick et al., 1978), humidity, soil moisture and soil type (Doran and Parkin, 1994; Mando, 1997; Nhamo, 2007).

Termites can cause significant damage to maize (*Zea mays* L.) crops, with the most damaging termite species being in the Macrotermitinae subfamily. Termites attack the base of the stem or root system which directly kills the plant or indirectly lowers yield through decreased translocation of water and nutrients. When mature plants lodge, they fall on the ground and the whole plant including cobs is attacked by termites. A delay in harvesting the lodged plants results in increased yield losses (Semakatte et al., 2003). Termite damage on maize in African cropping systems can reach more than 60% (Maniania et al., 2001) resulting in yield losses of 15–25% (Verma et al., 2009). However, benefits of termites to farmers include use as food (Nyeko and Olubayo, 2005), use of soils from termite mounds (anthill soil) for planting basins (Nyamapfene, 1986; Siame, 2005) and for soil fertility replenishment (Nyamangara and Nyagumbo, 2008). Addition of termitarium soil to arable lands has been reported to increase the calcium, magnesium and top-soil clay contents (Nhamo, 2007). Termites are also the main agents for primary breakdown of surface mulches under CA and they also perforate soil surfaces resulting in increased soil water infiltration (Mando and Miedema, 1997).

Despite the stated benefits of termites, the majority of smallholder farmers in termite infested areas hesitate to adopt the principle of maintaining permanent soil cover as they believe that

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crop residues attract termites which leads to increased crop damage. These farmers believe that the detrimental effects of termites far outweigh their beneficial effects and are thus classified as pests (Logan et al., 1990). This is more apparent towards the end of the rainy season at crop maturity (Wood et al., 1980). As such, farmers resort to burning crop residues to reduce termite infestations. On the other hand, Nhamo (2007) suggested that the presence of dry crop residues reduces termite attack on growing crops as termites prefer dry stover compared to fresh biomass.

The effect of increasing surface crop residues on prevalence of termites and the resultant crop lodging in termite infested fields thus remains controversial. The question at hand therefore is ‘Does application of crop residues under CA increase termite attack on maize plants and at what residue application rate can termites cease to be pests if the crop residues are applied at the beginning of the season?’ This study thus sought to establish the effect of increasing maize residue application rates on termite prevalence, crop lodging and grain yield in termite infested fields under subhumid conditions of Zimbabwe.

2. Materials and methods

2.1. Site description

The study was conducted in Kadoma, Sanyati district in Mashonaland West Province of Zimbabwe (18°21′S; 29°55′E) during 2008/9 and 2009/10 seasons. Kadoma is in Natural Region III at an elevation of about 1156 m above sea level (masl), receiving a unimodal annual rainfall of 650–800 mm. The wet months stretch from November to March and the dry months are April to October. Semi-intensive mixed farming is generally practiced (Vincent and Thomas, 1960) where farmers grow crops and rear livestock such as goats (*Capra hircus* L.) and cattle (*Bos indicus* L.). Maize is the major cereal crop grown in rotation with cotton (*Gossypium hirsutum* L.).

The site is a smallholder communal area with resettled farmers as it was under commercial farming before the agrarian reform in 2000. From 2000 to 2008, these fields were conventionally tilled using ox-drawn mouldboard ploughs. The soils are dominated by Chromic Luvisols (FAO, 1998) derived from mafic rocks (Nyamapfene, 1991). Before setting up the experiment in August 2008, key soil characteristics determined from initial soil samples indicated mean soil organic carbon of 1.3%; clay content of 24.6%; silt content of 51.3%; sand content of 24.2% and pH ($CaCl_2$) of 4.3. Organic carbon was thus relatively high on these soils compared to other soils of a similar texture but the pH suggests the soils were acidic.

2.2. Selection of host farmers

A community workshop was conducted in August 2008 to select sites where trials were to be established. A group of 20 farmers in the host community were asked to select fields which were known to have the most intensive termite infestation problems in the area. The termite infested fields were ranked from the most to the least infested. After ranking, participants visited each of the highly ranked infested fields for physical verification taking into consideration uniformity, slope and visible signs of termite activity such as termite galleries. The visit resulted in three fields being selected to host the trials. All the selected fields had a maize crop prior to trial establishment.

2.3. Treatments

A randomised complete block design experiment with four replicates per treatment was laid out on each of the three farmer fields. Plot sizes of 5 m × 6 m were laid out in the experiment with an inter-block spacing of 1 m and the blocks were oriented across the main slope on each farm. Four levels of surface maize crop residues of 0, 2, 4 and 6 t ha^{-1} under CA and a control (conventional mouldboard ploughing treatment) were randomly allocated to plots in each block. On each farmer's field, there were five treatments for a total of 20 plots per farm. A total of 12 blocks and 60 plots comprised the whole experiment across the three farmer fields. Conventional mouldboard ploughing (CMP) mimicked the current farming practice by the smallholder farmers where residues are grazed by livestock during the dry season, followed by ploughing to a depth of about 20 cm incorporating any ungrazed residues into the soil at the start of the cropping season. The maximum crop residue cover of 6 t ha^{-1} represents a typical high yielding farmer, so the 0–6 t ha^{-1} range included the residue amounts most likely to be obtained in smallholder farming systems.

2.3.1. Land preparation and management

Land preparation under CA was done by digging planting basins using hoes and applying crop residues in the field before the onset of the season. Planting basins were prepared between September and October and application of crop residue cover was done from late October to early November. Feeding on the mulch by grazing livestock was prevented from October to May since the livestock were allowed to graze in designated grazing areas only. The common practice in communal areas in Zimbabwe is that livestock are kept out of cropped fields in summer but communally graze freely on crop residues after harvesting in April or May until the time the next cropping season starts, usually in October or November. Planting basins were spaced at 0.90 m inter-row x 0.60 m in-row. Each basin covered an area of 15 cm × 15 cm and was 15 cm deep. In the CMP treatment, the field was ploughed to a flat seed bed in November after which planting furrows were opened on the seeding day after receiving some rain.

Basal fertilizer, Compound D (7% N: 14% P_2O_5: 7% K) was applied at a rate of 300 kg ha^{-1} at planting in furrows and in basins under CMP and CA treatments respectively. Top dressing was applied at 200 kg ha^{-1} using Ammonium Nitrate (34.5% N) at four weeks after crop emergence. Weeding in CA treatments was done manually using hand hoes and the first weeding was done soon after crop emergence. Since no herbicides were used in the CA treatments, the first weeding had higher labour demand compared to CMP due to greater weed densities. In the CMP treatment, weeding was partially mechanized with the aid of the ox-drawn plough in between crop rows followed by the use of hand hoes to remove any weeds remaining along crop rows. Two to three weeding runs cutting across all treatments were conducted until harvest time.

2.4. Data collection

Sampling for termites was carried out in February 2009 and March 2010. A soil monolith measuring 20 cm × 20 cm x 30 cm deep was used for sampling in each plot (Anderson and Ingram, 1993). From the excavated soil samples, termites were handpicked and stored in 70% alcohol for counting and classification in the laboratory (Anderson and Ingram, 1993). In this study, the term ‘*termite abundance*’ refers to the number of termites per square meter of soil. From the collected termites, a sample was taken and dominant species were identified using a microscope according to the presence of teeth, shape and presence of mandibles, and size/colour of the head.

The number of crops lodged by termites was physically counted in each plot at harvest. The number of lodged plants was expressed

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