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Weed community responses to rotations with cover crops in maize-based conservation agriculture systems of Zimbabwe

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A B S T R A C T

Weed management is a challenge to resource constrained smallholder agricultural production in sub Saharan Africa due to insufficient and inadequate management strategies. When weeds are controlled with herbicides or through rotations under conservation agriculture, shifts in weed spectra are expected, increasing the need to adapt to this new situation. Experiments were conducted at four experimental sites namely the University of Zimbabwe farm (UZ) (clay soil), Domboshava Training Centre (DTC) (sand soil) and two contrasting soil types at Henderson Research Station (HRS sand (s), HRS clay (c)) to investigate the responses of weed communities to crop rotations. The trial was carried out from the 2008–09 to the 2013–14 cropping season. Rotations consisted of maize (*Zea mays* L.) rotating with a range of green manures, and the control treatment was maize monocropping. Herbicides were only applied in the maize phase at seeding, supplemented by hand weeding whenever weeds were 10 cm tall or 10 cm in diameter for weeds with a stoloniferous growth habit. Weed count data was collected between 2011 and 2014. Weed density, the Shannon–Weiner index and its components were used to explain weed community responses to rotations. There was a decrease in weed densities over time at all sites with a percentage decrease as high as 92% (i.e. from 357 to 30 weeds m^{-2}) observed in maize-velvet bean (*Mucuna pruriens* (L.) DC) rotation. At all sites, some maize–green manure rotations were associated with high weed densities and these included maize-black sunnhemp (*Crotalaria juncea* L.) and maize-cowpea (*Vigna unguiculata* Walp) rotations. The two weeds *Galinsoga parviflora* Cav. and *Ricardia scabra* L. remained abundant throughout the study at all sites with densities reaching above 1000 plants m^{-2} per season in some plots. Shannon's E′ index was highest at HRSs and HRSc sites in the maize-velvet bean rotation and maize-common rattle pod (*Crotalaria grahamiana* Wight & Arn.) rotations respectively suggesting that in these treatments dominant weeds were reduced in numbers. This suggests that rotations with cover crops such as velvet bean may reduce weed numbers and dominance of problematic weeds over time. This can potentially lead to a less intense weeding schedule, which is more cost effective and affordable for smallholder farmers.

1. Introduction

The influence of weeds on smallholder farm productivity has become an important aspect in the farming systems of sub-Saharan Africa (SSA) as poor weed management combined with poor soils and low nutrient application rates have led to yields well below 1 t ha^{-1} (Gianessi, 2009). Conservation agriculture (CA) has been proposed by many researchers as a possible way to tackle these production constraints (Thierfelder et al., 2014) by reducing the rate of soil disturbance, maintaining a permanent soil surface cover using crop residues, and by increasing the diversity of farming systems through rotations and/or associations (FAO, 2002). However, shifts in weed communities have been reported during the early years of adopting CA and, due to low income and nominal weed management strategies, smallholder farmers have found it difficult to achieve timely weed control due to shortage of labour,

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hence leading to poor yields (Nyamangara et al., 2014). Farmers may use herbicides to timely control weeds but these herbicides are often unaffordable and inaccessible to smallholder farmers (Muoni et al., 2013).

For smallholder farmers who cannot afford herbicides, weed control through crop rotations with cover crops can be an alternative (Khanh et al., 2005). Cover crops suppress weed growth and development either as competing live crops or as surface mulch through the production of toxins (allelochemicals) which adversely affect certain weed species (Narwal and Haouala, 2013). Cover crops modify the micro-environments around weed seeds such as soil temperature and moisture that either promote or inhibit weed germination depending on the requirements of different weed species (Teasdale et al., 2007). Furthermore, light transmitted to the soil is reduced in the presence of cover crops and this affects a phytochrome-mediated germination process that takes place in some weed seeds prior to emergence leading to reduced populations (Teasdale and Mohler, 1993).

Thus, the responses of weed flora to a cropping system cannot be attributed to one single factor since response is affected by many biotic and abiotic factors. Weed responses can be investigated using different tools such as the Shannon–Weiner diversity index and the Simpson's index. The Shannon–Weiner diversity index H′ has been more commonly used by researchers in weed research. Although changes in weed flora in CA systems with cover crops have been previously investigated, there has been little data generated from southern Africa, including Zimbabwe.

The aim of this study was to investigate the effects of rotating leguminous and non-leguminous cover crops on weed densities and weed species composition in maize-based systems under CA in Zimbabwe.

2. Materials and methods

2.1. Site description

The experiments were conducted at the University of Zimbabwe farm (UZ) (17.73° S; 31.02° E), Domboshava Training Centre (DTC) (17.62° S; 31.17° E) and Henderson Research Station (HRS) (on a clayey and a sandy soil site). University of Zimbabwe farm has an altitude of 1503 m above sea level (masl) and is characterised by soils classified as *Chromic Luvisols* (Nyamapfene, 1991). Domboshava Training Centre has an altitude of 1560 masl and it is characterised by soils classified as moderately deep *Arenosols* formed from granitic rocks according to FAO classification (Vogel, 1994) with a clay content of less than 5% (Nyagumbo, 1999). The sandy site of HRS (HRS sand) (17.57° S; 30.90° E and 1136 m.a.s.l) has soils classified as *Arenosols* according to FAO classification and these soils originate from granitic rocks (Nyamapfene, 1991). The soils are generally high in sand (above 83%) and low in soil organic matter content (Thierfelder and Wall, 2012). The clay site of HRS (HRS clay) (17.59° S; 30.96° E and 1282 m.a.s.l) has soils classified as *Chromic Luvisols* (Jones et al., 2013). All sites experience average daily maximum temperatures reaching 31 °C and they all lie in Zimbabwe agro-ecological region II. All sites have agricultural seasons that begin around October and end around April. All the sites receive rainfall in a unimodal pattern which onsets from the first week of October (Fig. 1).

2.2. Description of experiment

Crop rotation cycles of maize (control) and different green manure cover crops (GMCCs) were initiated in the summer growing

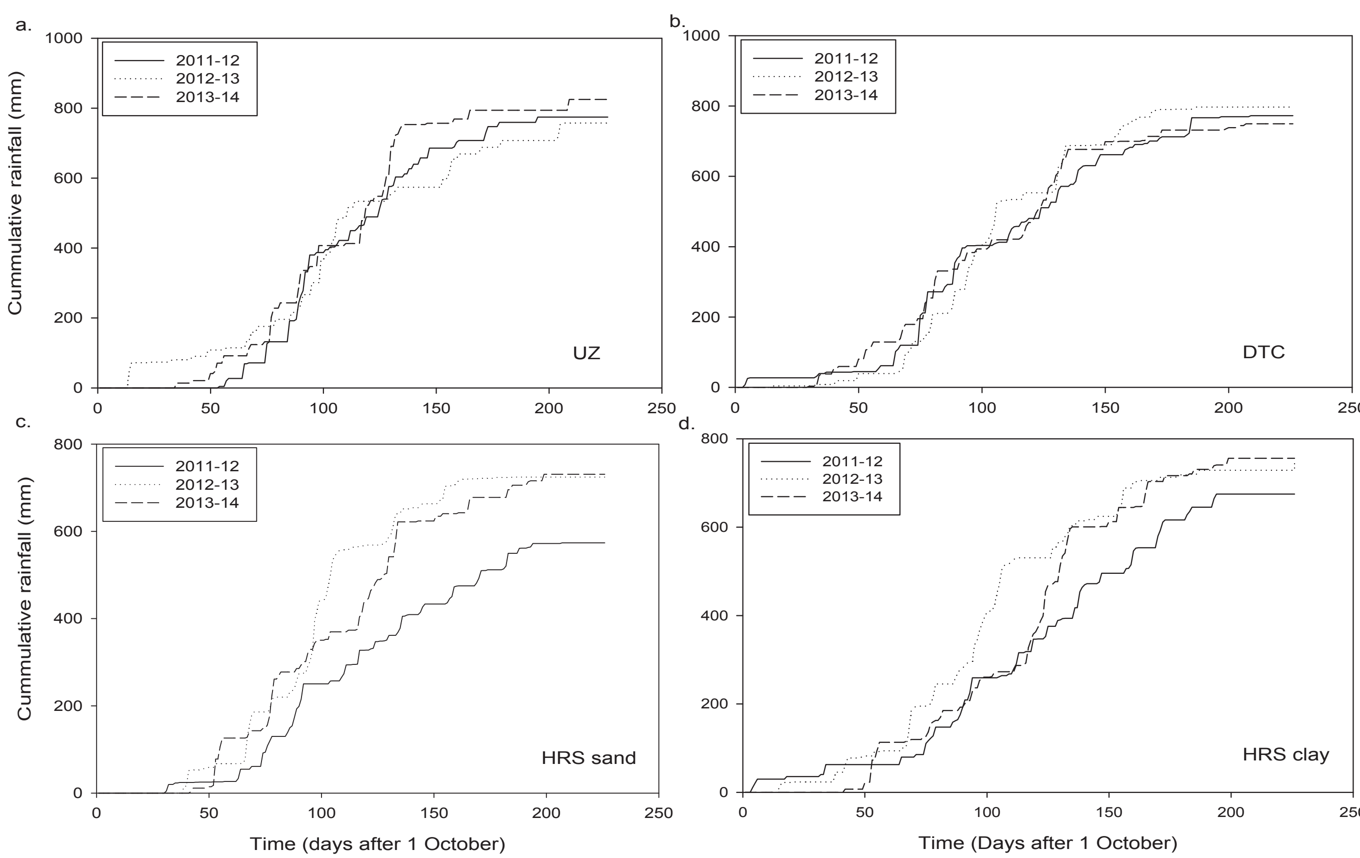

Fig. 1. (a–d). Rainfall distribution at UZ (a), DTC (b), HRS sand (c) and HRS clay (d) in the 2011–12, 2012–13 and 2013–14 seasons.