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Weed dynamics in low-input dryland smallholder conservation agriculture systems in semi-arid zimbabwe

by

Nester Mashingaidze

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Supervisor: Dr. I.C. Madakadze
Co-Supervisor: Dr. S. Twomlow

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DECLARATION

I , Nester Mashingaidze declare that the thesis, which I herby submit for the degree PhD Agronomy at the University of Pretoria, is my own work and has not previously been submitted by me at this or any other tertiary institution.

SIGNATURE: ……………………………………….

DATE: ………………………………………

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AGRITEX	Zimbabwe Department of Agricultural, Technical and Extension Services
ANOVA	Analysis of variance
CA	Conservation agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CONV	Conventional mouldboard plough tillage
FAO	United Nations Food and Agricultural Organization
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
GART	Golden Valley Research Trust
LSD	Least significant difference
MT	Minimum tillage
NGO	Non-Governmental Organisation
NR	Natural Region
OC	Organic carbon
PB	Planting basin
PRA	Participatory Rural Appraisal
REML	Restricted maximum likelihood model
RIV	Relative Importance Value
RT	Ripper tine
SED	Standard error of difference of means
WAP	Weeks after planting
ZCATF	Zimbabwe Conservation Agriculture Taskforce
ZFU	Zimbabwe Farmers' Union

ABSTRACT

The reported requirement for a higher weeding effort due to increased weed infestations under conservation agriculture (CA) relative to conventional mouldboard plough tillage is perceived by both smallholder farmers and extension workers as the main limiting factor to the widespread adoption of CA by smallholder farmers in southern Africa. However, proponents of CA argue that weeds are only a problem under CA in the initial two years and decline afterwards resulting in reduced labour requirements for weeding under CA. They further posit that weeds are only major problem where minimum tillage (MT) is adopted without crop residue mulching and diverse crop rotations. This thesis explores the effect of time under CA on weed population dynamics and crop growth under the recommended CA practices and actual smallholder farmer practice in semi-arid Zimbabwe.

Assessment of weed and crop growth on a long-term CA experiment at Matopos Research Station revealed that the MT systems of planting basins and ripper tine were associated with higher early season weed density and biomass than conventional early summer mouldboard tillage (CONV) in both the fifth (cowpea phase) and sixth (sorghum phase) years of CA. This increased weed infestation within the first four weeks after planting in CA necessitated early weeding to provide a clean seedbed and avert significant crop yield loss. Maize mulching only suppressed early season weed growth in sorghum mostly at a mulch rate of 8 t ha^{-1} which is not a mulching rate that is attainable on most smallholder farms. However, the lower maize residue mulch rate of 4 t ha^{-1} was consistently associated with increased weed emergence and growth as from the middle of the cropping season in both crop species. The increased weed infestations under the mulch were probably due to the creation of 'safe sites' with moist conditions and moderate temperatures. The high weed growth under the mulch contributed to the low sorghum grain yield obtained under mulched plots. In addition, maize mulching was also associated with a less diverse weed community that was dominated by the competitive *Setaria* spp. and difficult to hoe weed *Eleusine indica* (L.) Gaertn. However, the weed community under CA was similar to that under CONV tillage with no evidence of a shift to the more difficult to control weed species. The increased early season weed growth and high weed pressure under CA meant that it was still necessary to hoe weed four times within the cropping season to reduce weed infestations and improve crop growth even after four years of recommended CA practices. Early and frequent weeding was effective in reducing weed growth of most species including *Setaria* spp. and *E. indica* demonstrating that on smallholder farms where labour is available hoe weeding can provide adequate weed control. The wider spacings recommended for use in CA contributed to the low cowpea and sorghum grain yields obtained under CA compared to CONV tillage.

On smallholder farms in Masvingo District, the MT system of planting basin (PB) was the only conservation farming (CF) component adopted by farmers. There was no difference in the total seedling density of the soil weed seed bank and density of emerged weeds in the field in PB and conventional mouldboard ploughing done at first effective rains (CONV tillage). However, the first weeding in PB was done at least 15 days earlier ($P < 0.05$) than in CONV tillage suggesting high early season weed growth in PB relative to CONV tillage. As weed density did not decline with time in PB, weed management did not differ with increase in years under PB. Shortage of inputs such as seed and fertiliser was identified by smallholder farmers as the most limiting factor in PB crop production with the area under PB was equivalent to the seed and fertiliser provided by CARE International for most farmers. On this small area, weeds could be managed by available family labour. Double the maize grain yield was obtained in PB (mean: 2856 kg ha^{-1}) due to improved weed management and soil fertility. However, the use of poorly stored composts was found to introduce weeds into some PB fields. The findings of this study demonstrated that weed pressure was still high and weed management were still a challenge under the practice recommended to smallholder farmers in Zimbabwe even in the sixth year of practice. There is, therefore, a need for research on the economic feasibility of using herbicides, intercropping and optimal crop density to ameliorate the high weed pressure under CA.

Key words: Conservation agriculture, minimum tillage, maize residue mulching, hoe weeding intensity, weed density and biomass, weed species composition, cowpea (*Vigna unguiculata* (L.) Walp), sorghum (*Sorghum bicolor* (L.) Moench), maize (*Zea mays* L.)