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Adoption and impact of conservation farming on crop productivity among smallholder farmers in Kapiri Mposhi District of Zambia

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Conservation farming, adoption, impact, farmers, crop productivity, new technology

1 SUMMARY

Crop productivity among small-scale farmers in Zambia is constantly low mainly due to poor and unsustainable farming systems. As a solution, conservation farming (CF) is being advocated to scale up crop productivity. This study was undertaken to assess the rate of adoption and ascertain the impact of this practice on crop productivity among small-scale farmers in Kapiri Mposhi District. A structured questionnaire was administered to 252 farm householders randomly selected and data collected were analyzed using SPSS. About 91% of farmers are practicing the technology at different levels depending on the component adopted out of the six, namely minimum land tillage; laying out fixed planting basins; no burning of crop residues; planting and input application in basins; and rotation with nitrogen-fixing crops for soil fertility restitution, outlined by the Conservation Farming Unit (CFU). Some respondents (10.3%) have adopted five to six components of the technology, 39.7% four and 40.5% practicing only the reduced tillage. Overall, the adoption rate between 2000 and 2008 stands at 98.9%. Increased maize yield after CF adoption was recorded among 65.7% of the respondents with a gain in yield amounting to 2 tons/ha on average, which is three times more than the yield from conventional farming. It is, therefore, concluded that CF constitutes currently one of the major keys to increasing crop yield and productivity in Zambia. The extension service should focus on achieving the adoption of the technology on a larger scale to ensure food security in the country. To diffuse the adoption, the Ministry of Agriculture in partnership with other stakeholders should take a proactive role to strengthen and support extension services for the provision of farmers hands-on training, production and dissemination of training materials, increase in number of demonstration plots, backstopping in fields and for monitoring and evaluation of adoption and impact. It should also embark on full scale distribution of CF implements such as Chaka hoe, Magoye ripper and Teren rope within the current Fertilizer Support Programme Pack as incentive. A policy framework should be in place to link up farmers to markets to increase their confidence and scale up the adoption rate.

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2 INTRODUCTION

The majority of small-scale farmers in Zambia is poor and experiences numerous hardships due to decreasing land productivity (Mwale, 2002). The decrease in land productivity has been attributed to several factors including soil degradation due to long term practice of low input agriculture and poor farming systems associated with government policy of subsidizing chemical fertilizers for maize production. This has resulted in low fertile and fragile soils due to organic matter and carbon depletion leading to increased land desertification, declining or stagnant crop yields, poverty, and food insecurity and malnutrition. As a result of continuous heavy application of chemical fertilizers and unsustainable extensive land plowing systems, agriculture in Zambia entered the 1990s with significantly declining land quality and productivity (Haggblade & Tembo, 2003). Soils were acidified due to depletion of organic matter and the effect of residual chemical fertilizers, and compacted and hampered by impermeable plow pans in fields, following excessive plowing, that stymies both plant roots and soil water penetration.

In response to this land degradation, several actors in the development of improved agricultural technologies emerged during the 1980 - 1990s to mitigate loss in soil fertility and reduced crop productivity problems. The effort culminated in the development of conservation farming (CF) practices (Haggblade & Tembo, 2003). CF implies cropping using minimum tillage or conservation tillage (CT), incorporating legumes in rotation and diversifying crops often resulting in reduced soil erosion and better rain water infiltration (Aagaard, 2007). It involves dry-season minimum land tillage using either ox-drawn rip lines or hand-hoe basins laid out in a precise grid of 15,850 basins per hectare (Figure 1); no burning but rather retention of crop residues from the previous harvest; planting and input application in fixed planting stations and rotating with nitrogen-fixing crops for fertility restitution to soils. CT practices under CF have been developed for various categories of farmers.

Figure 1: Land cultivation practices in Kapiri Mposhi District, Central Province of Zambia. (A) Ripping furrows with Ox-drawn plough in a conservation farming field; (B) Basins made in a conservation farming demonstration plot at GART, and (C) Conventional field cultivated by tilling all areas of the land showing creeping desertification because of repeated cultivation (Source of photos: GART, 2003).

At the lowest level of farming consisting mainly of hand-hoe farmers, the Golden Valley Agricultural Research Trust (GART), in Chisamba, Chibombo District, validated and recommended the use of permanent planting basins or potholes of the size of a hoe dug at about 90 cm x 70 cm spacing during the dry season. For farmers with animal draught power, ox-ripping of furrows (Figure 1) and spot application of nutrients in opened furrows are recommended. To overcome the challenge of intense weed infestation in CF fields, GART (2006) developed various practices such as the use of cover crops and application of herbicides using the weed wipe.

CFU, in collaboration with GART and the Ministry of Agriculture and Cooperatives (MACO), has been advocating for CF adoption among small-scale farmers as a strategy to increase soil organic carbon and organic matter levels (GART, 2006). Efforts to extend the CF technology for general use among smallholder farmers have attracted strong support and interest from various institutions, e.g. private companies, NGOs and MACO extension service (Haggblade & Tembo, 2003). As a result, MACO embraced CF as one of the official agricultural policies of the Zambian government (Baudron *et al.* 2007) leading to more efforts towards expanding its adoption. This is achieved through several demonstration field trials and farmers' field days, specialized training of farmers' trainers, radio broadcasting, and production of field manuals and pamphlets in different local languages. A goal was set to broaden CF adoption to about 250,000 small-scale farmers by the year 2011 on basis of the assumption that wider CF adoption would increase yields and generate profits for small-scale farmers, and enhance their ability to withstand recurrent drought impact (GART, 2003).

However, it remains unclear whether there have been noticeable changes among small-scale farmers in crop productivity, diversification and food security as a result of CF adoption in Kapiri Mposhi District. This study was therefore carried out to ascertain the levels of adoption of CF, the perceptions and attitudes of farmers towards the technology and its benefits on crop productivity and household income and food security.

3 MATERIALS AND METHODS

3.1 Study area: The study was conducted in Kapiri Mposhi District (13°97´S; 28°66´E, 1286m above sea level) in Central Province, covering 15,000 Km² and with a population of about 194,752 inhabitants (CSO, 2003). The district is situated in agroecological region II with average annual rainfall of 1000 mm, daily temperatures ranging from 23 to 25 ºC during the growing season, but can reach 32 ºC during the hot season, and minimum temperature below 10 ºC during the cold season in June to August with intermittent frost occurrence. Soils are acidic sandy loamy and the main vegetation type is Miombo woodland. The major economic activity in the district is agriculture with maize, groundnuts, sweetpotato, cotton, water melons, tomato and several other vegetables as important crops produced by a total of 2,108 small-scale farm households; 1,517 medium-scale farmers and 76 commercial farmers. Kapiri Mposhi is divided into six agricultural blocks (Figure 2) namely; Changondo, Chipepo, Lukanga, Lunchu, Mulungushi and Nkole which are further sub-divided into 32 agricultural camps.

3.2 Study approach and methodology: This study is a descriptive extension activity specifically focusing on the adoption rate of an improved agricultural practice and its impact on crop productivity among small-scale farmers. For adoption rate, variables assessed included levels and progression of CF adoption, number of CF components used by farmers out of the six outlined above by CFU (CFU, 2003), crops grown and number of crop husbandry practices in CF out of the 10 defined by Baudron *et al.* (2007). These are using ropes to mark out planting basins, applying and incorporating precise amounts of manure or basal fertilizers in planting holes in accordance with agronomic recommendations, planting seeds accurately and rapidly at the onset of the rains to achieve even emergence and optimal population, completing planting on time, digging interrow potholes to capture moisture in seasons with poor rainfall, and weeding early and continuously to avoid competition from weeds. The year 2000 was the baseline year and the rate of CF adoption was estimated for farmers using the technology on the basis of the number of farmers who had been practicing it prior to 2000 using the following formula:

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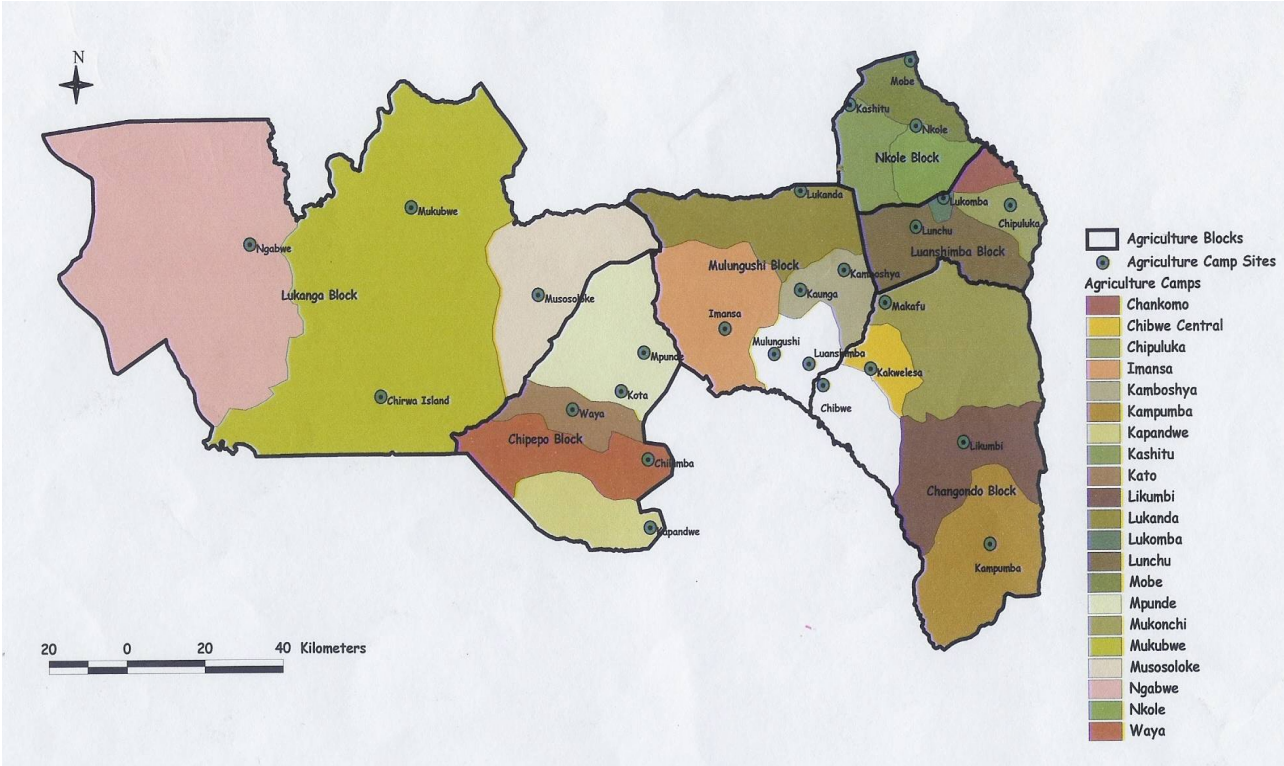

Figure 2: Map of the different agricultural blocks in Kapiri Mposhi District, Central Province of Zambia (Source: CSO GIS Unit, Lusaka).

$$\text{Adoption Rate} = \frac{\text{Difference between numbers of farmers practicing CF after and before 2000}}{\text{Number of farmers practicing CF after the year 2000}} \times 100$$

For impact of CF, variables assessed were the perception of the technology by farmers, crop productivity before and after CF adoption, and assessment of crop yield data from MACO for the entire district starting 2003 to 2008. The impact on crop productivity was estimated by subtracting the level of productivity before the adoption from the level after the adoption using maize yields (t/ha) as standard crop:

$$\text{Conservation Farming Impact} = (Y) - (X)$$

Where Y is the level of productivity after the adoption and X the level of productivity before adoption (FAO, 2003).

Farm households visited for interview were randomly selected from the list kept by the contact farmer using the lottery method (Kothari, 2005). The procedure involved writing individual names of households on paper slips, the slips were thoroughly mixed in a box and drawn without looking up to a representative sample size which was 10% of the total population of small-scale farmers in the district. Informal interviews were then conducted with individual farmers using a structured questionnaire (Kothari, 2005) administered using the same wording and in the same order to all respondents to assess respondents' perception about the technology and obtain primary data. Secondary data were collected through literature survey on the internet, available records from MACO and CFU, and other publications. Additional information about the farming community of interest was also obtained by attending various Camp Committee's meetings.

3.3 Data analysis: Data collected were entered into an MS Excel template specifically designed for the study and analyzed using Statistical Package for Social Sciences (SPSS) 11.5 for Windows 2004 Version (SPSS Inc., USA). Frequency distribution of

responses and tables were constructed, and confidence interval limits of the proportion of respondents were determined for interpretation of the results.

4 RESULTS AND DISCUSSION

From a total of 252 small-scale farmers who were interviewed, 91% indicated that they are practicing some form of CF while 9% were not. CF is a new package of agricultural practices for hand-hoe and/or ox-smallholder farmers using minimum tillage for land preparation. Malcoln (1989) and Oldrieve (1993) reported that CF is similar to tractor-drawn minimum tillage technology practiced during the 1980s by commercial farmers in countries like Zimbabwe and South Africa. CF for commercial farmers in Zambia involves mechanized minimum tillage methods with leguminous crop rotations such as soybeans, green gram and sun hemp (Haggblade and Tembo, 2003). Smallholder farmers grow legumes in rotation with other crops and diversify crop production, thereby reducing the risks of crop failure and hunger.

Table 1: Levels of adoption of conservation farming technology during 2007/08 cropping season by small-scale farmers in Kapiri Mposhi District, Central Province of Zambia.

Nature of Conservation Farming[a]	Farmers Frequency Distribution	Level of Adoption (%)
Improved Reduced Tillage	102.0	40.5
Conservation Tillage	100.0	39.7
Whole Package of CF	26.0	10.3
No adoption	24.0	9.5
Total	252.0	100.0
Maximum CI[b] 95%	…	52.8
Minimum CI 95%	…	2.8
CV (%)	…	69.8
Std Deviation	…	8.7

[a] Adopting the 1st to the 3rd husbandry practices (Baudron *et al.*, 2006) means practicing reduced tillage (RT), practicing conservation tillage (CT) is by adopting four practices from the 1st and practicing conservation farming (CF) is when the 1st five or all the 10 practices of CF are adopted. [b]CI represents mean confidence intervals at 95%.

Out of 91% of farmers who practiced CF, 68.7% were male while only 22.6% were female. Three age groups were also identified with the youths (20 - 35 years) accounting for 15% of the population applying CF, middle aged (36 - 55 years) being the majority accounting for 48% of the population utilizing the technology and old people (56 - 100 years) representing only 29% of farmers using CF. The low rate of youth involved in agriculture clearly shows that rural-urban drift is still a problem in Zambia. Many youths have relocated to urban areas to seek for odd jobs leaving farm work mostly to aging parents. This constitutes one of major constraints to the widespread adoption and application of this new agricultural technology requiring energetic individuals, beside others such as lack of CF implements and tools; pressure of weed control under no-tillage systems; and lack of credit and necessary technical information (Twomlow *et al.*, 2006), to increase agricultural productivity for food security in the country.

Table 2: Perception by small-scale farmers of the impact of conservation farming technology on maize yields (t/ha) during 2007/08 cropping season in Kapiri Mposhi District, Central Province of Zambia.

Type of Impact Recorded	Farmers Frequency Distribution	Farmers (%)
Positive	164.0	65.1
Negative	58.0	23.0
None	30.0	11.9
Total	252.0	100.0
Maximum CI[a] 95%	…	102.9
Minimum CI 95%	…	36.3
CV (%)	…	84.1
Std Deviation	…	16.2

[a]CI represents mean confidence intervals at 95%.

Prior to the year 2000, only 0.8% of farmers practiced CF and about 2.4% during the year 2000. Between 2001 and 2004 the proportion of farmers using CF practices went up to 4% and by 2005/06 cropping season, the number of farmers engaged in CF increased only slightly to 4.8%. During the 2007/08 cropping season, however, the number of small-scale farmers who had adopted the technology had increased to 79% (Figure 3). Similar trend of progression in the adoption of CF has been reported in Australia (Pratley, 2008). The number of CF components (CFU, 2003) and crop husbandry practices in CF technology (Baudron *et al.*, 2007) applied by farmers determines the level of adoption achieved (Dutch G. at CFU, *pers. comm*). Adopting the 1st to 3rd husbandry practices suggests the farmer is practicing only reduced tillage. The full practice of conservation tillage is attained when the farmer has adopted the four initial husbandry practices and the farmer only starts using CF when the 1st five or more of CF crop husbandry practices have been adopted. Out of the ten CF practices, 46% of respondents have been applying between four and six during the 2007/08 cropping season, 38.9% between seven and eight, 11.1% between one and three practices and only 4% using the full CF package (Figure 4). Overall levels of adoption of CF practices among small-scale farmers during 2007/08 cropping in Kapiri Mposhi District are shown in Table 1. Only about 9.5% of small-scale farmers in the district had not adopted the technology during the period covered in this survey.

Despite the higher adoption of some of the CF practices as of 2007/8 cropping season, the number of farmers practicing the full package of this technology was only 10.3%. This low rate could be explained by the grading system used which is based on the number of CF practices a farmer has adopted. The progress for an individual farmer towards adopting a crop husbandry practice and passing from one stage to the next is mostly hampered by a *disadoption* phenomenon of improved technology which may take place after the farmer gives up and opts to return to traditional cultivation practices. Factors which lead to disadoption were reported by respondents as failure to manage CF fields particularly as a result of a high labour requiremnt for control of weeds in CF systems and frustrations due to unachieved expectation.

In this study, 65.1% of respondents recorded positive impact of practicing CF on maize yields (Table 2). The average increase in maize yields was 2.0 tons/ha, representing an average ratio of 3:1 between yield from CF fields and that from conventional fields. Haggblade and Tembo (2003) have attributed the positive effects of CF on maize yields mainly to easy access to various types of support from the extension services. They cited Kapiri Mposhi as an area with higher rates of CF adoption than elsewhere in Zambia due to a continuous support to farmers by several organizations such as the CFU, Cooperative Leagues of USA (CLUSA), the Land Management and Conservation Farming Project (LMCF) Dunavant Cotton Company support for CF and the extension service of MACO. Contrary to the perception that CF adoption has been successful, 23% of farmers indicated that they have experienced negative effects while 11.9% had observed no change in maize yields regardless of using CF practices (Table 2). Those claiming negative impacts acknowledged that they were overwhelmed by the high labour requirement especially for weed control. Their decrease in maize yields was 0.7 ton/ha which is an average ratio of

about 1:2 between yield obtained from CF fields and their conventional fields. These findings also concur with the report by Haggblade and Tembo (2003) that, on average, hand-hoe CF farmers in Zambia produce about 1.5 tons more maize than farmers using conventional cultivation practices.

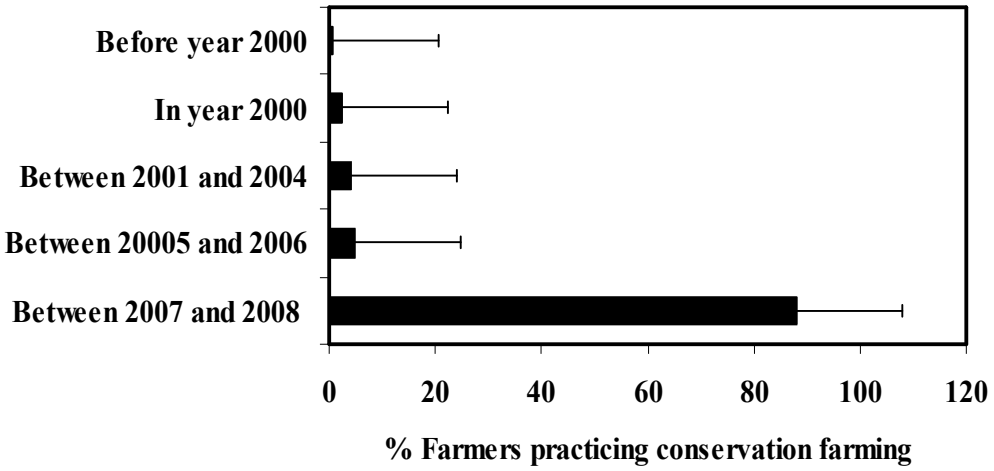

Figure 3: Progression in the adoption of conservation farming from 2000 to 2008 cropping seasons in Kapiri Mposhi District, Central Province of Zambia. Horizontal bars are standard errors of number of small-scale farmers in each category.

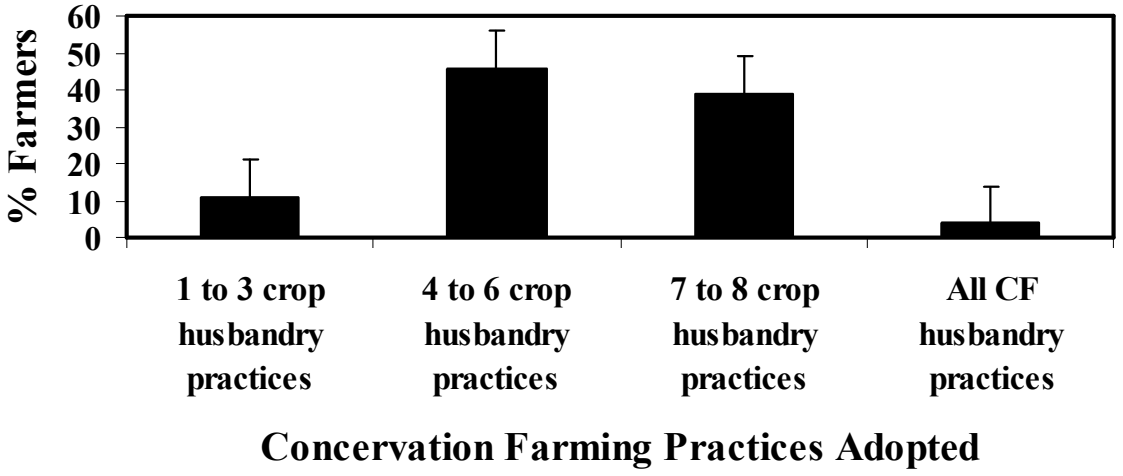

Figure 4: Variation in the adoption of conservation farming crop husbandry practices among small-scale farmers during 2007/08 cropping season in Kapiri Mposhi District, Central Province of Zambia. Vertical lines are standard errors of number of farmers in each category.

Records of crop yields obtained from MACO in Kapiri Mposhi District for the four previous successive growing seasons, namely 2002/03, 2005/06, 2006/07 and 2007/08, with data for 2004/05 season missing from MACO office due to a prolonged drought in the district and some parts of Zambia, were assessed to establish a trend in the change of yields of maize, cotton, groundnuts and cowpea as more farmers adopt CF. Overall, the results showed an increase in crop yields/ha during the respective seasons. For instance, the average yield of maize was 1.5 and 1.8 tons/ha during the 2002/03 and 2005/06 cropping seasons, respectively, and dropped to 1.3 ton/ha in 2006/07 due to a severe flood that submerged many fields causing huge losses to the farming community. As a

result of a good cropping season in 2007/08, Kapiri Mposhi District recorded again a good harvest with an average yield of 1.9 ton/ha for maize from small-scale farmers. This increasing trend in maize production has been associated with the increase in the adoption of CF technology (Haggblade & Tembo, 2003). Hence, despite the hard work associated with CF as reported by other respondents, especially when a farmer adopts the technology for the first time, CF still remains one of the key practices to increasing crop yields and ensuring food security. Moreover, during the 2004/5 cropping season when some areas of Zambia experienced prolonged drought, FAO (2006) reported that farmers practicing CF in some locations like Chibombo and Serenje Districts planted maize early, ensured more precise input management and the crop matured before the rain had stopped providing some harvest that allowed them to escape the prevailing hunger that followed.

After analyzing the possible causes of yield increase, Langmead (2002) found that about 1.1 tons of the increase resulted from adoption of CF technology, 400 kg from early crop planting, 700 kg from use of water harvesting technologies and greater precision in input use in the basins, another 400 kg from high application doses of fertilizer and lime, and planting high yielding varieties of seeds. Baudron *et al.* (2007) argued, however, that part of the differences observed in yield stemmed undoubtedly from higher input use under CF and were not real since most CF farmers received hybrid seeds and fertilizers from sponsoring agencies like CFU and CLUSA while most ox-plow farmers did not. In our study, the majority of respondents appreciated the positive impacts of CF and indicated that the technology is now fully utilized without assistance from the extension services. CFU (2003) compared the value of increased outputs with that of increased inputs and labour costs from the income to farmers resulting from CF adoption. The outcome showed that hand-hoe CF farmers had generated higher returns and outperformed conventional tillage farmers. Furthermore, Pratley (2008) reported that greater harvesting of water from CF fields, which provides reservoirs for use on other crops and pastures, led to less surface soil erosion and constituted an additional benefit of CF to farmers. Beside the adoption of CF technology, there is also crop diversification, which has become more prominent. About 58% of farmers were growing a minimum of two and a maximum of four crops under CF. The crops that farmers grow under CF include cereals, tubers and legumes which enable farmers to practice either intercropping or crop rotation to restore soil fertility and to enhance household income and nutrition. The presence of legumes in the mixture always benefits the soil by nitrogen fixation whereas intercropping increases total yields per unit area and protects the soil from erosion (Ngugi *et al.*, 1990). It was found that maize dominated more in the system as more farmers, about 41.3% of the respondents, cultivate this crop in their CF fields followed by 35.7% of farmers growing a combination of maize and groundnuts and 0.8% growing none of the crops under CF (Figure 5).

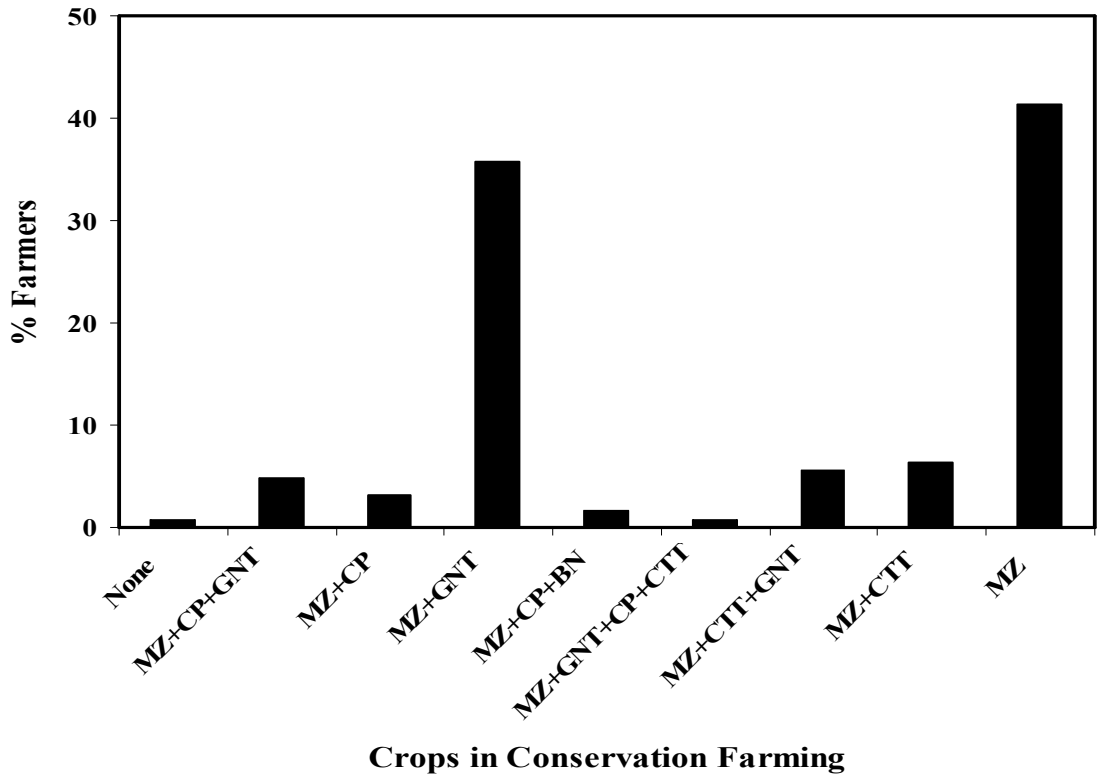

Figure 5: Major crops grown by small-scale farmers in fields using conservation farming practices during 2007/08 cropping season in Kapiri Mposhi District, Central Province of Zambia (MZ= Maize, CP= Cowpea, GNT= Groundnuts, BN= Beans, CTT= Cotton).

CONCLUSION

Our study has shown that CF adoption rate averaged 98.9%, indicating that from 2000 to 2008, about 2085 out of 2108 small-scale farmers in the district have adopted CF technology. During this same period, the average gain in maize yields of small-scale farmers in Kapiri Mposhi after CF adoption was 2.0 tons/ha, which is a substantial increase representing a ratio of 3:1 between yield from CF fields and that from conventional fields. Furthermore, an analysis of crop yields for the district for the last four consecutive cropping seasons also clearly showed a steady increase in yield of the major crops with an increase in the adoption of CF suggesting a positive impact on crop productivity compared to conventional tillage. We, therefore, conclude that CF constitutes currently the key to increasing crop yield in Zambia and that the extension service should focus on expanding its adoption and utilization on a larger scale to ensure household income and food security among small-scale farmers in the country. In an attempt to diffuse the adoption, MACO in partnership with other stakeholders should take a proactive role to strengthen and support extension services for the provision of more farmers' hands-on training, mass production and widespread dissemination of training materials, increase in demonstration plots, backstopping in fields and for monitoring and evaluation of adoption and impact. It should also embark on full scale distribution of CF implements such as Chaka hoe, Magoye ripper and Teren rope within the current Fertilizer Support Programme Pack as incentive. A coherent policy framework should be in place to link up farmers to markets to increase their confidence and scale up the adoption rate

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