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Urban farmer practices in soil fertility and water management and the influence of gender in Harare and Chitungwiza, Zimbabwe

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Poor soil fertility and increased frequency of mid-season droughts have made it difficult for urban farmers to get sustainable crop yields against a background of unemployment and reliance on urban agriculture for livelihoods in Harare and Chitungwiza. It is important to know soil fertility and water management practices used by urban farmers so that their performance can be evaluated and gender influence on their use assessed. The objectives of this study were (i) to identify soil fertility and water management practices used by urban farmers and their effect on maize yields and (ii) to determine the influence of gender on their use. Results showed a dominance of women (62.4%) over men (37.6%) in carrying out farming activities. Farmers used a combination of either poultry manure, sewage sludge or cattle manure with mineral fertilizers and attained an average maize grain yield of 1.5 t/ha. More women used organic fertilizers than men, but they applied lower rates leading to lower yields. Quantity of mineral fertilizer and sewage sludge used was significantly correlated with gender. More women than men used ridges and furrows, raised beds and mulching as water management practices. Development programs targeted for these farmers should consider gender in their design to ensure sustainability.

Key words: Gender, manure, soil fertility, urban agriculture, water management.

INTRODUCTION

In most developing countries, poverty, food insecurity and malnutrition have become critical urban problems as more people move to urban areas (WOGAN, 2009). To solve this problem, food production in and around cities is an important strategy to meet household food self sufficiency particularly in major cities in sub-Saharan Africa. Drescher (1994) reported that close to 40% of households in Lusaka, Zambia and 29% in Nairobi, Kenya relied on the urban environment to grow food for consumption and sale. High rural-urban migration after independence coupled with decline in income since 1990 has contributed to the increase in urban agriculture (UA) in Zimbabwe (Mbiba 1995). Bowyer-Boyer and Drakakis-Smith (1996) reported that 60% of the food consumed by

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low-income groups in Harare was self produced through urban agriculture. About 40% of the farmers produced enough food to cover half a year's consumption (Toriro, 2007). By the year 2000, the land under cultivation in Harare was 36% of open space (10,000 ha) (Mbiba, 2000) on which crop production was practiced with maize grown during the rainy season (November-April) and vegetables grown during the dry season (May-September). When practiced effectively, UA can contribute significantly to socio-economic development by providing income and improved food and nutrition security.

Farmers in most urban communities in Zimbabwe have experienced low yields due to several reasons. One of the reasons is poor soil fertility as a result of inappropriate practices such as burning crop stover and other trash before tillage. Burning crop residues results in reduction in soil organic carbon thereby contributing to increased nutrient loss through erosion. As in most parts of Zimbabwe, the majority of the soils are derived from granitic rocks with inherent deficiency in key essential nutrients (Nyamangara et al., 2000). This implies that nutrients should be added in the form of organic and/or mineral fertilizers in order to maintain soil nutrient supply potential. However, most of the urban farmers are economically marginalised hence cannot afford to buy the needed nutrient resources to improve crop yields. An increase in rainfall unreliability and mid-season droughts has also contributed to low crop yields especially on sandy soils. Limited access to irrigation (except for plots along streams where wastewater is used for vegetable production) (Mapanda et al., 2005) has also negatively affected crop growth. It is therefore necessary to find out how urban farmers are trying to manage the environmental conditions of limiting water and nutrients for crop production in order to optimize productivity.

Gender roles in soil fertility and water management have also become important in UA as women and men have different but specific contributions in soil fertility and soil water management (Mbiba, 1995; Mudimu, 1996). Gender as an analytical category is meant to capture a complex set of social processes; involves the examination of men's and women's roles, responsibilities, and social status in relation to cultural perceptions of masculinity and femininity (Overholt, 1991; FAO, 2002). Gender analysis therefore allows for the disintergration of data on UA and to explore why certain processes and structures generate different opportunities and constraints for different people (Hovorka, 2005). It is therefore important to analyse how gendered the responsibilities in soil fertility and water management in UA are so as to enable a more focussed provision of extension services, training and financial support to allow for efficient and sustainable crop production. The objectives of this study were to identify farmer soil fertility and water management practices used to grow crops in Harare and Chitungwiza and to determine the influence of gender on the implementation of such practices.

Study area

The study was conducted in Harare (17°46'S and 30°54'E) and Chitungwiza (18°00'S and 31°00'E) (Figure 1) in Zimbabwe. Harare and Chitungwiza are the major cities in Zimbabwe (en.wikipedia.org/ 2010) and are situated on a watershed plateau. These cities have been experiencing exponential population growth of 5 to 7% per year due to internal displacement caused by drought and political and economic instability (Kisner, 2008). The majority of soils in the northern part of Harare are red clays classified as chromic luvisols (FAO/UNESCO, 1998) derived from dolerite and are relatively fertile. Chitungwiza is covered by coarse grained sandy loam soils derived from granitic parent material, which are relatively less fertile and are classified as ferrallitic cambisols (FAO/UNESCO, 1998). These two represent the dominant soil types used for agriculture in the two cities. The main crops grown include maize (*Zea mays* L), beans (*Phaseolus vulgaris*) (Toriro, 2009), sweet potatoes (*Ipomea batatas*), groundnut (*Arachis hypogaea* L), and vegetables such as mustard rape (*Brassica juncea*), tomato (*Lycopersicon esculentum*) and giant rape (*Brassica napus*). The majority of the crops are rain-fed and therefore grown between November and March (rain season) except for vegetables which are also grown during the dry season using wastewater for irrigation (Tandi et al., 2004; Mapanda et al., 2005).

MATERIALS AND METHODS

A survey was conducted over a period of four weeks (July to August, 2010) where structured questionnaires were administered to 205 farmers (137 in Chitungwiza and 68 in Harare to account for differences in soil type).The farmers who were interviewed constituted 30% of farmers in the extension workers' records and were selected using the random number method. Key questions covered aspects on crop production systems (soil fertility management practices such as types and rates of fertilizers used and water management technologies) and gender responsibilities in soil fertility and water management activities. Key informant interviews using semi-structured questionnaires were conducted with 4 local extension workers and local authorities (District administrator and 4 ward councillors) and farmer group chairpersons. A participatory workshop was also held with local authorities, extension workers and farmer representatives. The aim of both the key informant interviews and workshop was to obtain general information on issues that affected urban agriculture such as availability and access to land, soil fertility management practices, water management technologies, number of households engaged in cropping, crop management and land degradation challenges.

Characterization of organic manures used was done to determine total nitrogen (N) (so as to calculate N application rates related to recommended rates), total phosphorus (P) and pH. Poultry manure and cattle manure samples were obtained locally from Dutch Poultry Farm and Nyarungu dairy farm respectively and sewage sludge from Zengeza sewage treatment works, which lie about 20 km south of Harare. These are the most common sources of organic amendments used by the urban farmers. The fertilizers were air-dried and ground to pass through a 2 mm sieve prior to analysis. Total N in manure was determined by the semi-micro-

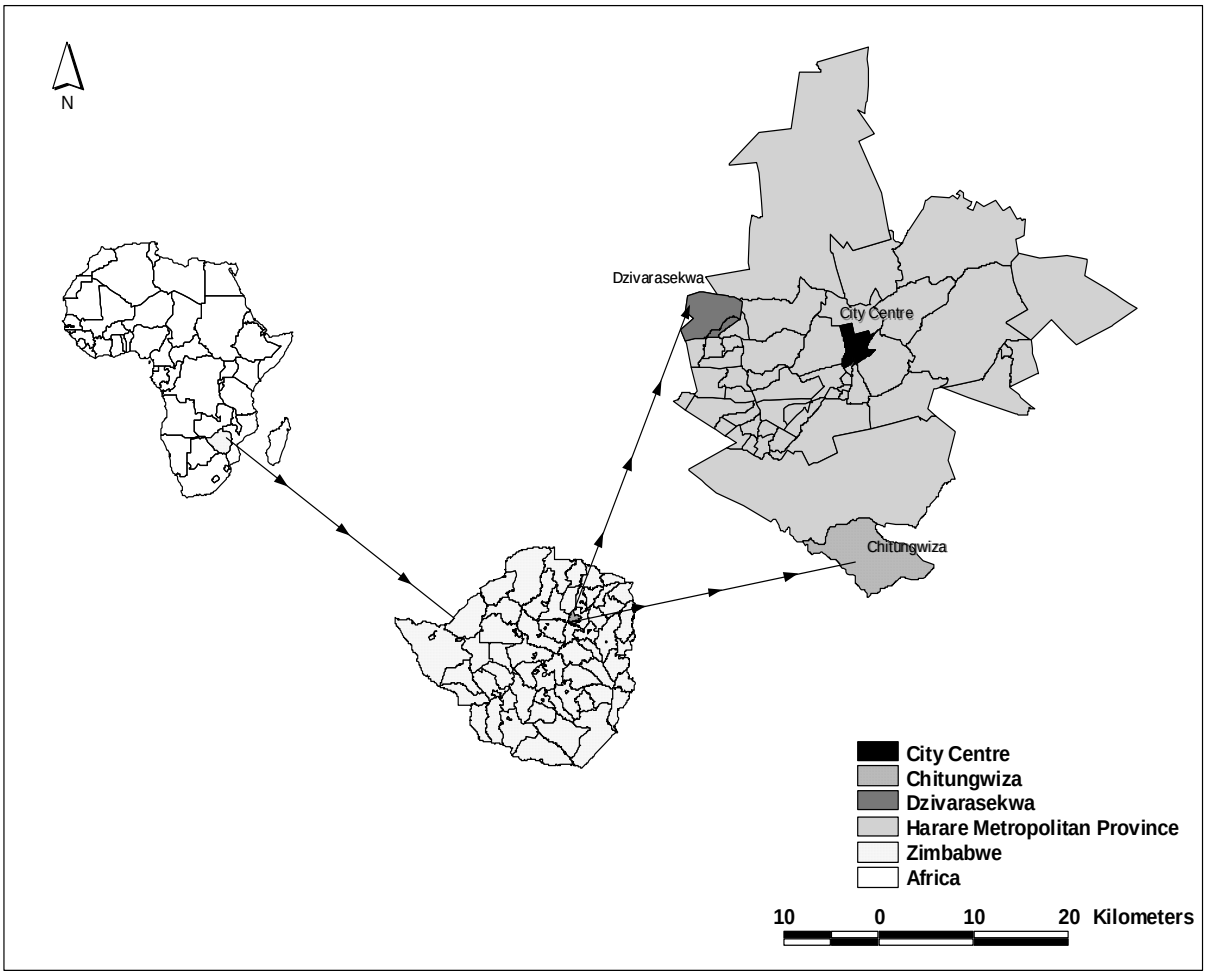

Figure 1. The study sites; Harare and Chitungwiza in Zimbabwe.

Kjeldhal method (Okalebo et al., 2002). Total C was estimated from organic matter loss by weight after overnight slow ignition in a muffle furnace at 550°C. Manure pH was determined in 1 to 5 manure to distilled water suspension as described by Okalebo et al. (2002).

Data analyses

The responses from the questionnaires were post coded and analysed using the Statistical Package for Social Sciences (SPSS version 16). A double-entry system was used to minimize errors, data cleaning was done and inconsistencies rectified by referring back to the respective questionnaires. Descriptive statistics such as means, frequencies and cross-tabulation analysis (to compare variables across gender groups) were done. Independent t-tests were done so as to compare means between males and females.

RESULTS

Manure characterization

Initial composition of domestic sewage sludge, poultry and cattle manure showed that sewage sludge had the highest total N content followed by poultry manure then cattle manure. Carbon to nitrogen ratio (C-to-N) was in the order cattle manure > sewage sludge > poultry manure (Table 1) implying that cattle manure had the poorest quality. Sewage sludge was acidic and this may negatively affect microbial activity and nutrient availability.

General characterization of gender roles

Most farming activities such as land preparation, planting and fertilizer application were done mostly by women (Table 2) who dominated urban agriculture in Harare and Chitungwiza (62.4%) over men (37.6%). Over 90% of female farmers were not formally employed as compared to 25% of their male counterparts and hence women carried out most of the farming activities while male farmers were at work. However the guarding of fields, which was risky and also occurred at night, was done mostly by men (23% male compared to 4% female) as

Table 1. Selected properties of organic manures used.

Organic manure	pH	Total N %	Organic C %	C-to-N
Poultry manure	7.2	2.26	41.22	8.56
Cattle manure	7.7	1.26	15.27	12.12
Sewage sludge	4.8	3.26	27.99	8.59

Table 2. Gendered labour responsibilities in Harare and Chitungwiza urban agriculture.

	Activity							
% responsible	Land preparation	Planting	Fertiliser application	Weeding	Irrigating	Pest control	Guarding	Harvesting
Men	33.7	16.1	12.7	11.8	6.8	16.6	22.9	10
Women	43.4	46.3	47.8	45.6	6.3	5.9	3.9	40
Both	22	37.1	39	39.7	3.9	4.4	5.4	46
Neither	1	0.5	0.5	2.9	82.9	73.2	67.8	2.9

well as use of plant protection chemicals to control pests and diseases (17% male compared to 6% female).

Tillage and land preparation practices

The majority of farmers in Harare and Chitungwiza (77%) practiced minimum tillage using hand hoes. This method tills the soil to about 10 cm after removal of all the crop residues. Of the 24% farmers that used conventional tillage (using tractors or ox-drawn ploughs), 77% were men.

The tillage services were hired and therefore could only be afforded by resource-endowed farmers who were mainly male farmers in formal employment.

Soil fertility practices

At the two study sites, farmers used a combination of poultry manure, domestic sewage sludge, cattle manure and mineral fertilizers at rates below the recommended despite most of them cultivating small pieces of land (average 0.84 ha). In Chitungwiza (sandy soils), men generally applied on average 19.5 kg N/ha and women applied 15.5 kg N/ha from a combination of organic manure (basal) and mineral fertilizers (top dressing). The N rate was only 52.2% of recommended rate (67 kg N/ha) for low agriculture potential maize (FAO, 2006). In Harare (clay soils), the farmers used mineral fertilizers only. Farmers applied these amendments by broadcasting or placing in planting statitons. Low application rates of fertilizer resources resulted in low maize grain yields of 1.5 t/ha even when mineral and organic sources of fertilizers were applied in combination. Maize grain yield averaged 1.1 t/ha when mineral fertilizer only was applied (Figure 2).

This study found that female farmers applied significantly higher amount of sewage sludge ($t(203)=2.00$ $p=0.047$). Men on the other hand, applied significantly higher amount of mineral fertilizers (Basal N, P, K $t(203) = 2.034$, $p=0.043$; Top dressing $t(203)=1.997$, $p=0.05$). Across sites, men applied an average of 110 kg/ha of basal mineral fertilizer (N:P:K, 7:6:7) per season to maize compared to women who applied 86 kg/ha. However, both rates were lower than recommended rates (200 kg/ha) for low agricultural production potential areas (FAO, 2006).

Although more women than men used animal manure as organic amendments in Chitungwiza (sandy soils), women were associated with lower application rates except for domestic sewage sludge (Figure 3). However, the application rates of animal manures were very low in all cases (< 1 t/ha) compared to the recommended 10 t/ha if cattle manure is applied as the sole basal fertilizer for maize (Nhamo et al., 2004). Despite higher domestic sewage sludge application rate by women, their mean maize yield was lower than that obtained by men (Figure 3).

Water management practices

Farmers in the two study sites used at least one practice for managing soil water (Table 3). The most common practices were pre-plant ridges and furrows which were constructed in such a manner that maize was planted on the ridge. After harvesting the stover is placed in the furrows and covered with soil from the old ridge thereby creating a new ridge for the next season. Decomposition of the stover improves soil fertility but can result in intense soil N immobilisation with negative effects on yield if inadequate mineral N is applied at planting. Construction of raised beds (1 - 3 m wide) to drain excess

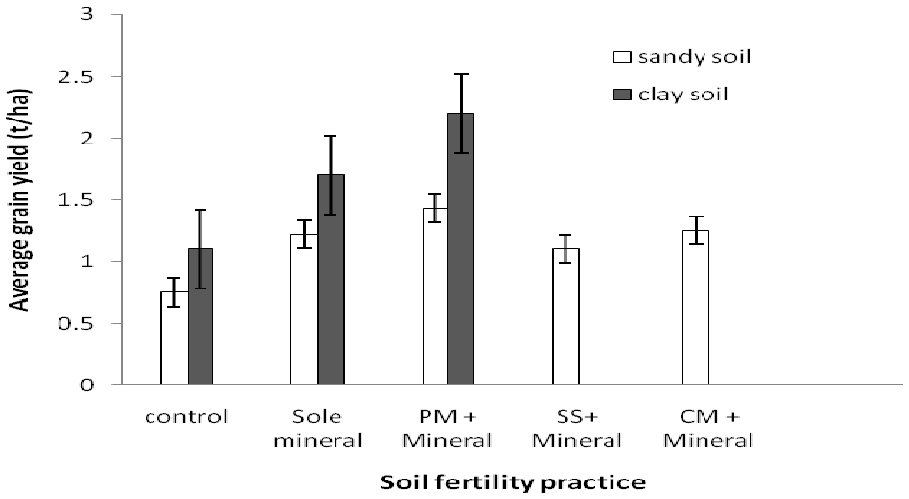

Figure 2. Maize grain yield attained from different fertilizer amendments on sandy (Harare) and clay soils (Chitungwiza) (Error bars represent standard error of means).

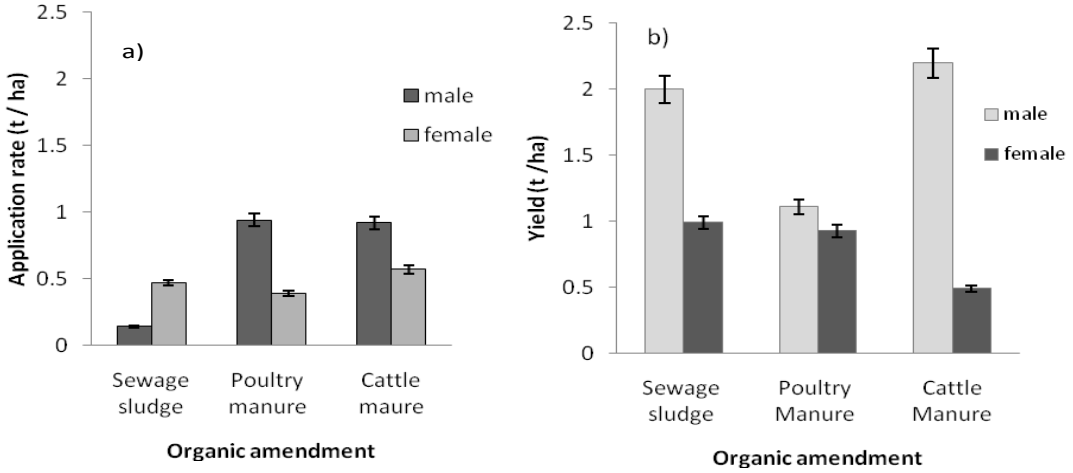

Figure 3. Manure application rates (a) by gender and (b) and maize grain yield attained in Harare and Chitungwiza (Error bars represent standard error of means).

water, was also done in fields located in wetlands. Mulching with grass, maize stover, banana leaves and sugarcane residues to conserve moisture was one of the water management practices used for both vegetable and maize production. The least used moisture conservation technologies were pot holing and winter ploughing.

In Chitungwiza (sandy soils), use of water management practices significantly improved maize yield and the latter was higher for men than women farmers. In Harare (clay soils), however, use of water management practices depressed maize yield for both male and female farmers (Figure 4). Most of the production (80%) was rain fed except where waste water and groundwater was used for irrigation of green maize and vegetables. Of the farmers that practiced irrigation, 53% were men.

DISCUSSION

Farmers in Harare and Chitungwiza have resorted to the use of different soil organic amendments to counter the effect of poor soil fertility and improve their crop yields. The use of animal manure and domestic sewage sludge was common because these amendments were readily available to the farmers and in some cases are free. Animal manures and domestic sewage sludge are good examples of organic amendments with fertilizer value that improve plant growth directly through nutrients which are slowly released through mineralization and indirectly by improving the physical and biological properties of the soil, such as water retention, aeration and microbial activity and diversity. Domestic sewage sludge is

Table 3. Water management practices (by gender) used by farmers in Harare and Chitungwiza.

Water management practices	Farmers using practice	Female farmers (%)	Male farmers (%)
Ridges and furrows	93	71	29
Raised beds	52	58	42
Mulching	61	51	49
winter ploughing	19	74	26
Pot holing	8	63	37

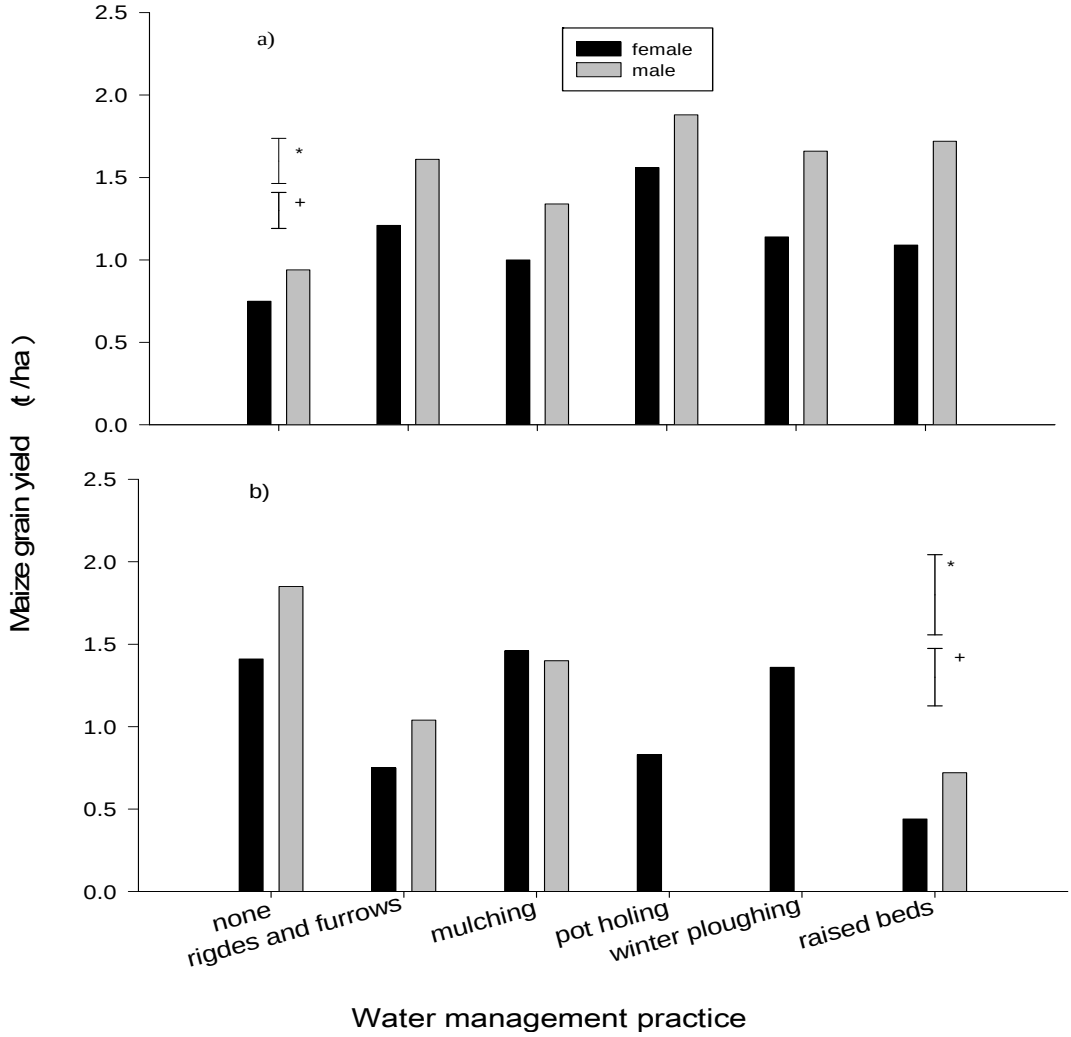

Figure 4. Maize grain yield and water management practices by gender for (a) Chitungwiza (sandy soils) and (b) Harare (clay soils) (Error bars represent standard error of means).

inherently deficient in potassium (Nyamangara and Mzezewa, 1996). However the application rates for the organic resources was too low (Figure 3) to significantly increase crop productivity. Only a fraction of the nutrients contained in organic matter are mineralised in the first year, the balance is released in the second and third years. Therefore combined application of organic and inorganic nutrient sources, in adequate amounts, is a viable strategy to enable high productivity on the small pieces of land cultivated by the majority of the farmers. Organic amendments can ensure increase in soil microbial biomass C and N due to labile organic compounds in them which provide energy sources for soil microbes while the mineral fertilizer ensures that the

nutrients are supplied in forms that are soluble and readily available for plant uptake (Chen, 2008). The acidifying effects of the inorganic fertilizer are mitigated by the organic fertilizers which release bases into the soil resulting in better soil health. Organic fertilizers are important in sandy soils which are inherently infertile and weakly buffered against development of acidic conditions and degrade easily when continuously cultivated without organic inputs.

However, the use of domestic sewage sludge is of concern because of potential hazards such as the presence of pathogenic organisms (e.g. bacteria, protozoa and viruses), excess salts and the presence of heavy metals (e.g. copper, lead, and cadmium) (Mapanda et al., 2005). Salts destroy soil structure and can impede root growth (Nyamangara et al., 2007). Although some heavy metals are essential for plant growth (e.g. Zn and Cu), they are toxic to plants above certain thresholds and can remain in the soil indefinitely. The health risks associated with domestic sewage sludge were higher in women as they constituted the largest proportion that used this organic resource to fertilize their crops.

The use of ridges and furrows is common with farmers and can result in increased yields by not only conserving soil moisture but also by reducing nutrient loss due to erosion and increasing plant rooting depth (Critchely, 1991). In wetland areas, farmers used wide raised beds that resulted in reduced water logging and soil loss. Mulching with grass and maize stover conserves soil moisture by reducing evaporation from the soil (Critchely, 2010). In Chitungwiza (sandy soils), maize yield was significantly higher where water management practices were used because rainwater collects in the furrows and can be available in times of low rainfall (Ibraimo and Munguambe, 2007). In Harare (clay soils), however, use of water management practices depressed maize yield. Clay soils do not drain freely and are prone to water logging which impedes root respiration and nutrient uptake. Therefore water management practices need to be targeted according to soil type and training in such management practices should target women farmers as most of them applied these practices.

Contrary to studies carried out in greater Garborone, Botswana where UA was gender balanced (Hovorka 2005), UA in Harare and Chitungwiza was not. Women constituted the majority of farmers in Harare and Chitungwiza as in many developing countries for example Windhoek in Namibia, 54% (Hovorka, 2004) and Oshakati 58% (Dima et al., 2002). This is because in most developing cities in sub- Saharan Africa, men feature prominently in middle- and high-income categories, while women are concentrated in lower-income brackets hence for most of them farming is their main source of livelihood (Wilbers, 2004; Mawoneke and King, 2005). In this study male farmers were more able to hire tillage services, and application of more cattle manure and mineral fertilizer. According to Kasanga (2001), women are more likely to use organic amendments to grow food crops and are constrained by a cycle of low productivity from investing in further farm development. Men on the other hand are likely to use technologies that may include use of inorganic fertilizers because most have alternative sources of income to buy fertilizers and also get extra income from the sale of excess crops whilst most women have no extra income because they mainly practice subsistence farming (Wilbers, 2004; WOGAN, 2009). In Senegal, women are deeply involved in the management of manure and other household waste for disposal in the family manure pile (*sëntaare*) (McClintock, 2004).

Overall farmers in Chitungwiza and Harare applied sub-optimal fertilizer rates and consequently their maize grain yields were low. Both towns are located in a high rainfall zone and farmers can substantially increase yields by increasing fertilizer use. The fertilizer rates were much lower for women farmers, as most of them lacked resources to purchase animal manure and mineral fertilizer. Water management practices and use of domestic sewage sludge, which were practiced by more women farmers, did not seem to give yield advantages to the women farmers.

CONCLUSION AND RECOMENDATIONS

Farmers in Harare and Chitungwiza used sub-optimal fertilizer application rates and this resulted in low yields. The use of fertility inputs was gendered with more women than men using the organic manures and men using the relatively more expensive but more effective mineral fertilizer. The use of water management practices was also gendered and was practiced by more women than men, but positive yield responses were only recorded on sandy soils. There is need to train the urban farmers to apply adequate amounts of nutrient inputs (organic and inorganic) and use appropriate water management technologies, with a special focus on female farmers.

Conflict of Interest

The authors have not declared any conflict of interest.

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