

Research Application Summary

Effects of optimised innovative soil fertility and water management technologies on maize production in two contrasting soils in Harare, Zimbabwe

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Abstract

Poor soil fertility and fertiliser management coupled with increased frequency of mid-season droughts induced by climate change have made it difficult for urban farmers to get sustainable crop yields especially on sandy soils. Urban farmers can obtain higher crop yields if they apply the right types of fertilizer at the right rates. The use of animal manures and organic municipal wastes as fertilizers is on the increase in urban agriculture (UA). However, farmers need to know the nutrient dynamics of these organic materials to optimise nutrient uptake and ultimately crop productivity. This study will investigate maize productivity on sand and red clay soils fertilized with organic and inorganic fertilizers under conventional (CT) and zero tillage (ZT) systems with and without mulching. The study will also investigate nitrogen (N) and (P) mineralization from sewage sludge and animal (cattle, poultry and pig) manures. A green house experiment will be conducted to determine maize dry matter production at 4 weeks after germination. The goal of the project is to enhance food security to urban farmers and better prepare them to face the impacts of climate change. Preliminary results for field agronomic trials showed that zero tillage + mulch + manure treatment yielded significantly higher grain yield than other treatments for both soils ($p < 0.05$). Poultry and pig manure treated soils produced the highest dry matter for both soils from the green house experiment ($p < 0.05$). Poultry manure released significantly high CO_2 than other manures with sewage sludge releasing the lowest. Generally, there was net N and P mineralisation throughout the incubation period. Carbon dioxide was released linearly from the start of the experiment which corresponded to immobilisation of N. Zero tillage with mulch using a combination of organic and inorganic fertilisers has a potential to raise maize grain yield.

Key words: Conventional tillage, mulch, urban agriculture, zero tillage, Zimbabwe

Résumé

La pauvre fertilité des sols et la pauvre gestion des engrais, conjuguées avec une fréquence accrue des sécheresses de la mi-saison provoquées par les changements climatiques, l'ont rendue difficile pour les agriculteurs urbains afin d'obtenir des rendements durables des cultures en particulier sur les sols sableux. Les agriculteurs urbains peuvent obtenir des rendements plus élevés s'ils appliquent de bons types d'engrais à de bons taux. L'utilisation de fumiers et de déchets organiques ménagers comme engrais est en hausse dans l'agriculture urbaine (AU). Toutefois, les agriculteurs ont besoin de connaître la dynamique des nutriments de ces substances organiques afin d'optimiser l'absorption des nutriments et la productivité des cultures en fin de compte. Cette étude portera sur la productivité du maïs dans les sols sablonneux et les sols d'argile rouge fertilisés par des engrais organiques et inorganiques dans les systèmes de labourage classique (CT) et de culture sans labour (ZT) avec et sans paillage. L'étude examinera également la minéralisation de l'azote (N) et du phosphore (P) à partir des vidanges et des fumiers d'animaux (bétail, volailles et porcs). Une expérience dans la serre sera menée pour déterminer la production de matière sèche de maïs, 4 semaines après la germination. L'objectif du projet est d'améliorer la sécurité alimentaire des agriculteurs urbains et mieux les préparer à faire face aux impacts du changement climatique. Les résultats préliminaires pour les essais agronomiques sur terrain ont montré que la culture sans labour + paillage + traitement des engrais a donné le rendement en grain nettement plus élevé que d'autres traitements pour les deux sols ($p < 0,05$). Les sols traités avec des fumiers des volailles et du porc ont généré plus de matière sèche pour les sols de l'expérience de serre ($p < 0,05$). Le fumier de volaille a donné significativement plus de CO_2 que les autres engrais avec vidanges libérant la plus basse quantité. En général, il y a eu une nette minéralisation de N et P pendant toute la période d'incubation. Le dioxyde de carbone a été libéré de façon linéaire depuis le début de l'expérience qui correspondait à une immobilisation de N. La culture sans labour avec paillage en utilisant une combinaison d'engrais organiques et inorganiques a un potentiel d'augmenter le rendement en grains du maïs.

Mots clés: Labourage classique, paillage, agriculture urbaine, culture sans labour, Zimbabwe

Background

Urban agriculture (UA) is on the increase and has gained significance in Harare, the main city of Zimbabwe, and it is being practiced on a grand scale involving the middle and high

income groups (Tsuru, 2006) for food security and to augment family incomes. In Harare, 60% of the food consumed by low-income groups is self-produced through UA and 40% of the farmers produce enough food to cover half a year's consumption (Toriro, 2007). Crop production is largely rain-fed and it suffers from unpredictable rainfall regimes which are intensifying as climate change impacts become more severe. Harare experienced more severe midseason droughts in the past two seasons (2007/2008 and 2008/2009) resulting in crop failure and low yields especially on sandy soils. Furthermore, inputs like inorganic fertilizers are beyond farmers' reach (Hungwe, 2007). These harsh conditions have prompted urban farmers in Harare to use organic and inorganic amendments such as farmyard manure, woodland litter, sewage sludge and termitaria to fertilize their crops. However, nutrient dynamics of these organic materials used as fertilizers is not well understood. An understanding of it will help farmers to manage them in a manner that optimizes nutrient uptake and ultimately crop productivity (Nyamangara *et al.*, 2009). Water management technologies have also been used to increase soil moisture available for crop growth. Conventional tillage predominates most parts of Harare with zero tillage (ZT) and/ or minimum tillage being practiced by very few farmers. Most researches on soil fertility and water management have been more inclined to communal (smallholder) farming areas but UA has gained significance of late. Thus, there is need for similar researches to be done in UA to take into consideration the unique environment of the urban farmer so as to maximize crop production without causing environmental damage.

Literature Summary

Urban agriculture has been propelled by population pressure due to rural-urban migration. This has impacted negatively on food security within urban families (Chiyoka, 2006) and raised levels of unemployment, aggravated by the economic meltdown in the last 15 years (Toriro, 2009), prompting urban dwellers to turn to UA for food security and to augment family incomes. However, almost 33.3% of crop production fields are on environmentally sensitive areas like sloping land which is prone to soil erosion and along stream banks where agro-chemicals are easily washed into water bodies causing eutrophication (ENDA-Zimbabwe, 1996). In sub-Saharan Africa, research on organic manures has mainly focused on their role in supplying N required by crops (Nyamangara *et al.*, 2000) with little attention given to P. Nitrogen is the single most limiting nutrient to both crops and microbes in Zimbabwean soils and P is ranked second.

Study Description

The study sites are located in North-Western Harare [Dzivarasekwa (17°S and 30°E) and National Sports Stadium (17°S and 30°E)], and Chitungwiza (18°S and 31°E). The soils in Chitungwiza are granitic sands classified as ferrallitic cambisol (FAO) while those from Dzivarasekwa and National Sports Stadium are clay soils derived from dolerite and classified as chromic luvisols (FAO).

Firstly, field trials were conducted in the 2009/2010 summer season and a greenhouse experiment carried out after harvesting. Maize was used as the test crop. Nitrogen was applied at 120 kgN ha⁻¹ (40 kgN ha⁻¹ applied as basal fertiliser + 80 kgN ha⁻¹ as top dressing fertiliser) for all treatments except for controls. Maize stover mulch (M) was applied at 5 t ha⁻¹. Two tillage systems were used, namely conventional (CT) and zero (ZT) tillage systems. An incubation experiment was carried out parallel to the greenhouse experiment. A completely randomised block design was used for field agronomic trials and greenhouse experiments, and a completely randomised design was used for incubation experiments. Field agronomic trials will be repeated in the 2010/2011 summer cropping season.

Research Application

Urban farmers have innovative soil fertility and water management practices that they are implementing. This study is expected to optimise some of the practices to contribute towards enhancing food security of urban farmers using sustainable and affordable means of crop production that promote high crop yields. In this study, preliminary results suggest that zero tillage with mulch using a combination of organic and inorganic fertilisers raises crop yields as shown in Figure 1.

In all soils, zero tillage + mulch + manure treatment produced significantly the highest grain yield than any other treatment ($p < 0.05$) except for pig manure where it was insignificantly higher than zero tillage + manure treatment in a red clay soil (Fig 1a). Controls for the clay soil were insignificantly different. Mulched controls yielded significantly lower grain yield than controls without mulch ($p < 0.05$).

In a green house experiment, poultry and pig manures produced the highest dry matter while cattle manure yielded the lowest. Poultry manure released significantly higher CO₂ than other manures (Fig. 3).

Poultry manure released significantly higher CO₂ and sewage sludge the lowest ($p < 0.05$) measured as cumulative CO₂ per

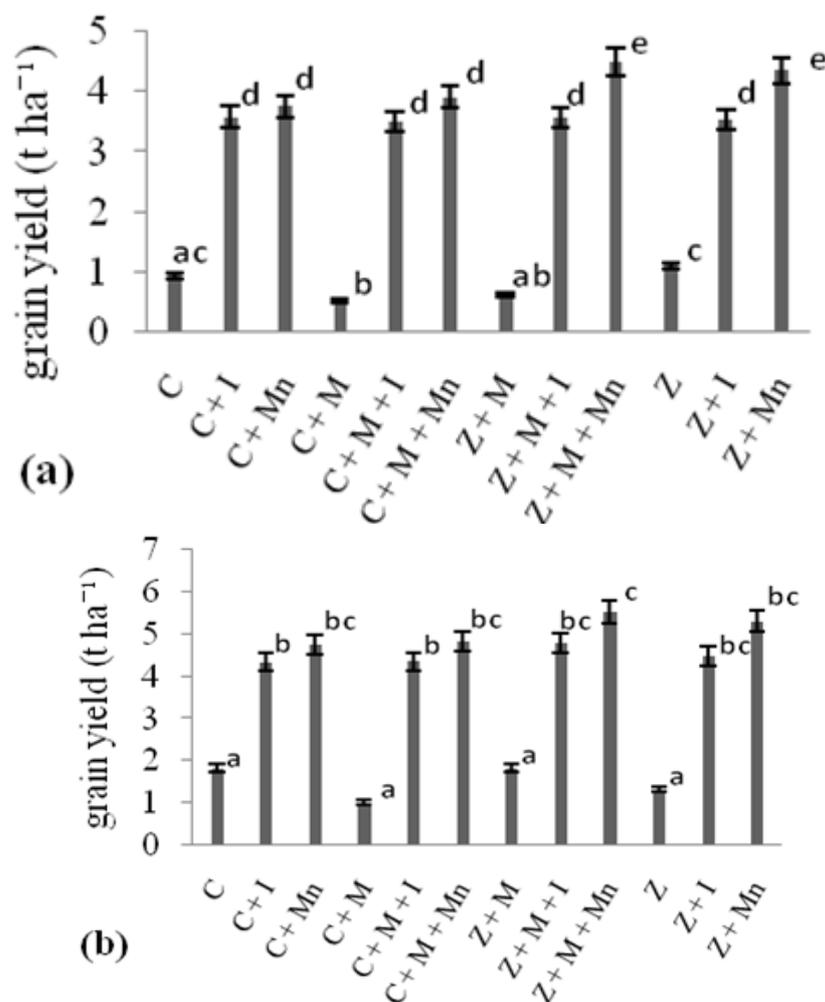


Figure 1. Maize grain yields on (a) red clay soils and (b) sandy soils subjected to application of pig and cattle manure and inorganic fertilizer. Bars show standard errors of the means. Values denoted by the same letter are insignificantly different ($p < 0.05$). (C – conventional tillage, I – inorganic fertiliser, Mn – manure, M – mulch, Z – zero tillage).

sampling day. All manures followed the same trend in CO₂ release. They released CO₂ linearly from the start of the incubation period upto day 21.

Acknowledgement

The authors are grateful to RUFORUM for fully funding the project, the University of Zimbabwe for hosting the project and AGRITEX extension workers for their collaboration.

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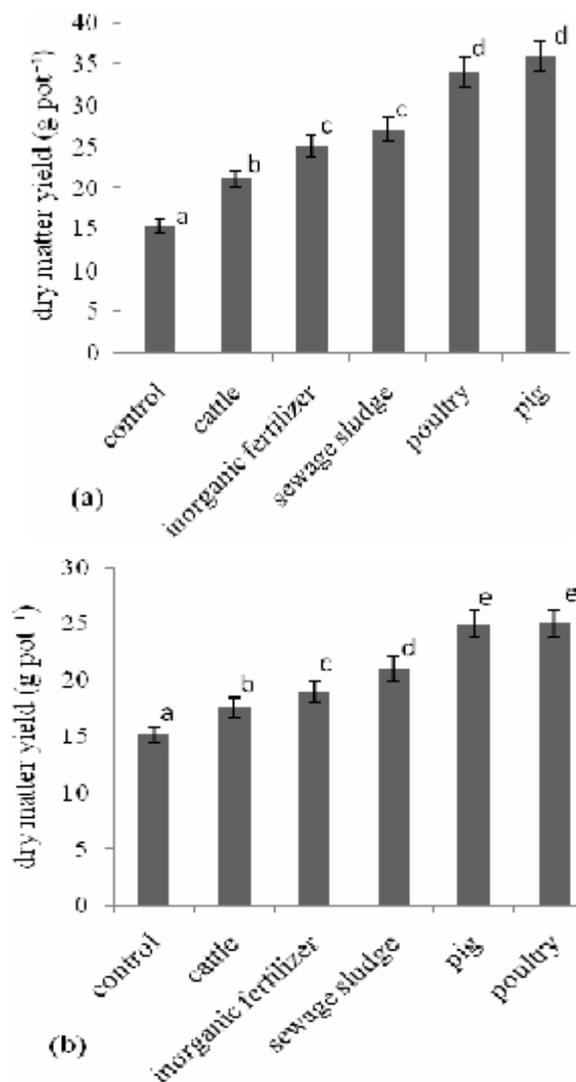


Figure 2. Maize dry matter yields at 4 weeks after germination in red clay (a) and sandy (b) soils. Bars show standard errors of means. Values denoted by the same letter are insignificantly different ($p < 0.05$).

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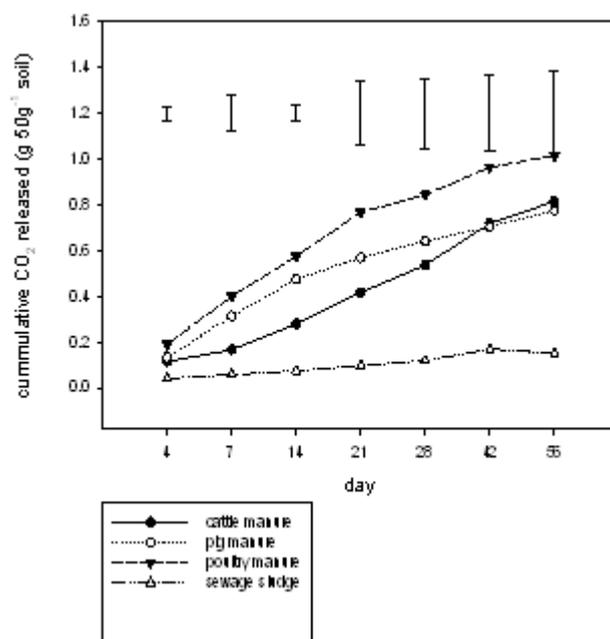


Figure 3. Cumulative CO₂ released from different manures.

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