Evaluating Cured Manure (Bokashi) as an Agro ecological Climate Resilience Strategy in Crop Production in Gutu District of Zimbabwe

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Abstract

The study explored the use of cured manure (Bokashi) and its awareness among smallholder farmers in Gutu District, Zimbabwe. Three treatments (cured manure, non-cured manure and ordinary soil) were experimented in four nutritional gardens which are Tapudzai, Mukuro, Mazare and Mutendeure under peas and rape crops. From these gardens, fifteen participants (n = 60) were selected using purposive sampling while data was generated using face to face interviews and the data was analysed using MiniTab 15. Results indicated that the yield of rape and peas across the four gardens was high ($p < 0.03$) where Bokashi manure was administered. The findings were supported by the soil sample test results which showed that Bokashi cured soil had higher quantities of macro (N, P, K & Mg) and micro (Zn, Cu, Mn & Fe) nutrients than uncured manure and ordinary soil. Recommendations for Bokashi cured manure use are suggested.

Keywords: Organic manure, Green House Gas emissions, climate-resilient, innovations

Introduction

According to the World Bank (2008), agriculture causes approximately one-third of global Green House Gas emissions from livestock, fertilizers, pesticides, machinery, and equipment as well as soil degradation and land-use change. In particular, fertilizer production and consumption add millions of tons of carbon dioxide equivalent gases, kill beneficial microorganisms as some of them are responsible for nitrogen fixation, burn plant roots if

over-applied, and often leach as they dissolve faster than plants can use them (Sharma and Gupta 2016). Organic manure, on the other hand, improves water retention thereby enhancing soil fertility, improving soil structure, and allowing the microbial breakdown of soil and water components that reduce the environmental hazard. Given this, the global community at large is in search of efficient practices that reduce greenhouse gas emissions (mitigation) as well as build resilient systems that adapt to impacts of climate change (adaptation).

One such method that promotes climate-resilient farming is the use of organic manure. Niggli and Kasterine (2007) assert that organically managed soils absorb more carbon dioxide than conventionally managed soils. Adapting to climate change seems easier using organic farming because induced diversification spreads and more varieties are grown. This project aims to build climate- smart practices, resilience and sustainability for the area under study as Zimbabwe has not been spared from climate change-related threats that includes increased temperatures, prolonged and frequent droughts, and floods. The majority of smallholder farmers in Zimbabwe are located in agro ecological regions exposed to climatic hazards, with inherently low soil fertility (Mashiringwani, 1983), and where rain fed agriculture accounts for the most land use.

Land use assessments supported by the Oxfam-SIDA Climate Adaptation for Rural Livelihoods (CARL) project in the climate-resilient villages of Gutu District have shown that farmers lack sustainable soil fertility management options. The climate-resilient villages or CRVs are a group of vulnerable villages that range from 4 to 12 villages in a specific ward. The concentration of strategies to improve the communities' adaptation, absorptive, and transformation capacities through varied interventions are done to build their resilience. Inorganic fertilizers are costly and mostly inaccessible by most rural farmers. In addition, poor farming practices and deforestation cause leaching leading to poor soil fertility. Limited knowledge and capacity to test soils due to high costs and limited access to testing centres have also resulted in farmers failing to monitor the available soil nutrients for their crops. The combined effect of these challenges results in poor soil fertility. The infertile soils have not been able to sustain effective crop growth leading to low crop productivity (Khanal, 2009). This has in turn resulted in food and income insecurity among rural communities of the Gutu District.

According to Awer and Rosario (2012), women have limited access to information and resources such as land and credit. This further prevents them from developing their capacities in agriculture although they play a crucial role in food security. Women tend to be most affected by climate change impact and in Gutu this has also been confirmed by a gender analysis study done by the CARL project. Most women are the ones involved in gardening activities in the district. The change project is part of the building adaptive community capacity component of the SIDA funded CARL project (September 2018- August 2021) whose development objective is to improve the climate resilience of agricultural production and livelihoods of 6000 rural households in 3 districts (Bulilima, Gutu, and Buhera) of Zimbabwe.

The major objective of this study was to improve crop productivity using Bokashi manure as an agro ecological climate resilience building practice among rural farmers that were supported with micro solar-powered irrigation systems in four nutritional gardens. To help understand this, specific objectives measured crop yields of leafy vegetables under cured and non-cured manure and evaluated the nutrient status of cattle cured manure, non-cured manure, and natural soil.

Materials and Methods

Study site

The project was carried out in Gutu District which is located in the southeast region of Zimbabwe, about 260 km from the capital, Harare (Crop and Livestock Assessment Report, 2021). It is classified as a communal extensive crop-livestock production system with limited improved pastures for grazing livestock (Zembe, 2019). Soils in Gutu are generally sandy and rarely have sufficient nutrients for crops to reach potential yield.

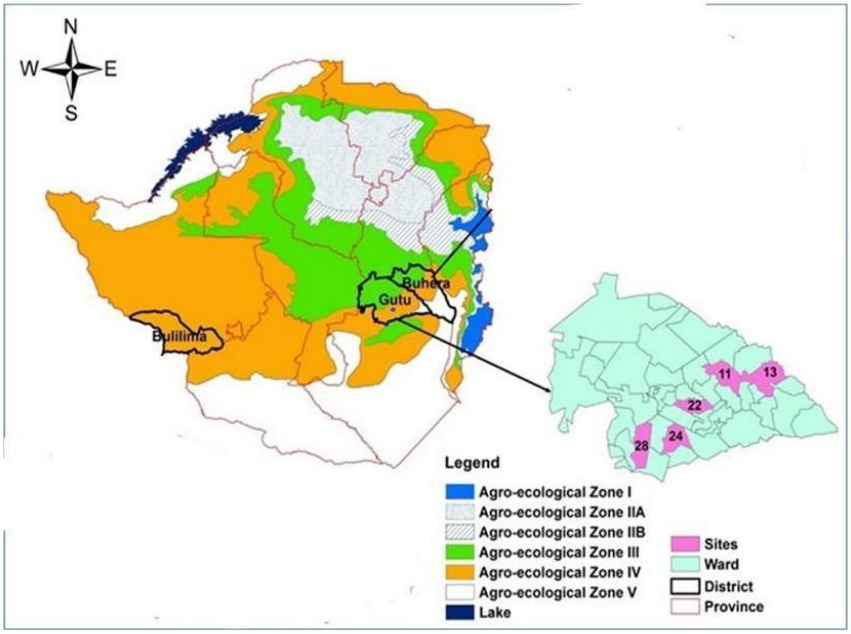

Fig 1. CARL map showing Gutu district wards.

Participants

The sample consisted of 100 farmers (44 women, 15 men and 31 youths) who participated in Bokashi manure preparation in four nutritional gardens. The farmers also participated directly in all other key crop production processes like planting, weeding, pest and disease control as well as harvesting with technical guidance from Agritex extension officers and Oxfam field assistants. The age range of participants was between eighteen and forty-six years. Purposive sampling was employed. Purposive sampling involves selecting certain units based on a specific purpose rather than randomly (Tashakkori and Teddie, 2001). It is based on the knowledge of a population and the purpose of the study.

Manure treatments

Manure curing was done for 10 days under the same conditions for the four nutrition gardens through community and stakeholder participation. Twelve samples, four cured, four non cured (4) and four natural soil (4) were collected and sent for laboratory analysis. However, planting was delayed owing to challenges that were associated with too many rains that hindered Bokashi manure preparation, Covid 19 restrictions in movement and related vaccinations as well as farmers having competing demands in their rain-fed fields.

Quasi-experimental approach

Three treatments, that is Bokashi manure, non-cured manure and ordinary soil (control) were used under peas and rape in four nutritional gardens which are Tapudzai in ward 11, Mukuro garden in ward 22, Mazare garden in ward 24, and Mutendeure garden in ward 28. Planting was done on 07 May 2021 using the same design and treatments across the 4 nutrition gardens. Bed sizes measured 4m by 1m each and each treatment had two beds for each crop hence each garden had 12 beds. 1kg of peas seed and 288 rape seedlings were planted per garden. Harvesting of the rape crop started around mid-July and farmers were encouraged to weigh and document the yields obtained. Application of cured and non-cured manure was done on a weekly interval after 2 weeks of planting. Harvesting of peas was done during the first and second weeks of August 2021.

Monitoring visits

Joint monitoring visits with government stakeholders were carried out with the project team to carry out critical operations like manure curing, land preparation, design, planting, and harvesting. Discussions were also made during the monitoring visits with project participants to review progress, provide technical guidance and capture recommendations. Covid restrictions and lockdown measures instituted by the Government of Zimbabwe on 29 June 2021 to curb the spread of the disease coupled with Covid related cases and deaths in the operational wards affected joint routine close monitoring of the project. For example, in 2 of the gardens (Mukuro and Tapudzai) farmers failed to apply manure on the other 2 treatments and this, in turn, had a bearing on the yields.

Observations

Observation checklists were utilized to collect information on specific indicators like germination, crop growth, color, and general performance of the 3 different treatments. An observation checklist was used to record these metrics.

Qualitative questionnaires

These were used to capture information on participants' demographics, perceptions, organic and soil fertility management. In addition, factors affecting crop performance and crop yields were captured in these forms. 15 respondents per garden were interviewed from the total that was part of the experiment.

Data analysis

Data was captured using questionnaires and a digital voice recorder following the thematic content analysis (TCA). Previous research shows that thematic content analysis is well suited to analyse sensitive situations Vaismorade et al. (2011) such as perceptions. Weights recorded from leaf vegetables experiments were analysed using Minitab 15 software.

Ethical considerations

Consent was obtained from the participants before data collection. The research team explained to the participants that they were free to withdraw from the study at any time if they felt so (Al-Krenawi etal. 2001). The purpose of the study was also explained to the participants before taking part in the study.

Findings and Discussions

This study experimented crop productivity and perceptions of using Bokashi manure in Gutu District. The results are presented under main themes namely; comparison of crop yields of leafy vegetables under cured and non-cured manure, nutrient status of cattle cured manure, non-cured manure, and natural soil and perceptions on the efficacy of cured manure.

Comparison of crop yields of leafy vegetables under cured and non-cured manure

A one-way ANOVA was conducted to determine if productivity in leaf vegetables was different for treatments with different manure types. Treatments were classified into three groups: Natural soil, non-cured manure and cured manure. The experiment showed that the yield of rape and peas across the four gardens was high as determined by a one-way ANOVA, $F(2,9) = 11.47$, $p = .003$ and $r^2 = 71.8\%$ where Bokashi manure was administered. This was observed in all the participating gardens. The data presented in figure 1 below shows that the addition of Bokashi manure led to an increase in the yield more than the cattle manure and natural soil.

In Mazare garden under natural conditions, the yield was 0.86 kg/m^2, 1.52kg/m^2 in uncured cattle manure and the yield rose significantly where the beds were treated with cured cattle manure with a yield of 3.13kg/m^2. These findings indicate that there was a 263.95% increase in yield from the natural conditions to the Bokashi manure condition.

There was no significant difference in Mukuro gardens, with the natural yield 1.0kg, cattle manure 1.25kg, and the Bokashi manure 1.65kg presenting a minute 65% increase in yield between treated and untreated soil. In Mutendeure natural conditions recorded 0.71kg yield, cattle manure 2.4kg, and Bokashi manure recording 3kg yield. The increase was significant from the untreated to then treated field represented by a 322.95% increase in yield Tapudzai recorded 0.63kg yield in natural conditions increasing to 1.8kg in cattle manure rising even further to 2.23kg in Bokashi manure gardens. The increase in yield represents a 253.96% increase in yield from the control field to the experimental field. The findings are consistent across all the experimental conditions this is indicative that the Bokashi manure does indeed increase significantly the yield per kg in terms of leafy vegetables(rape)

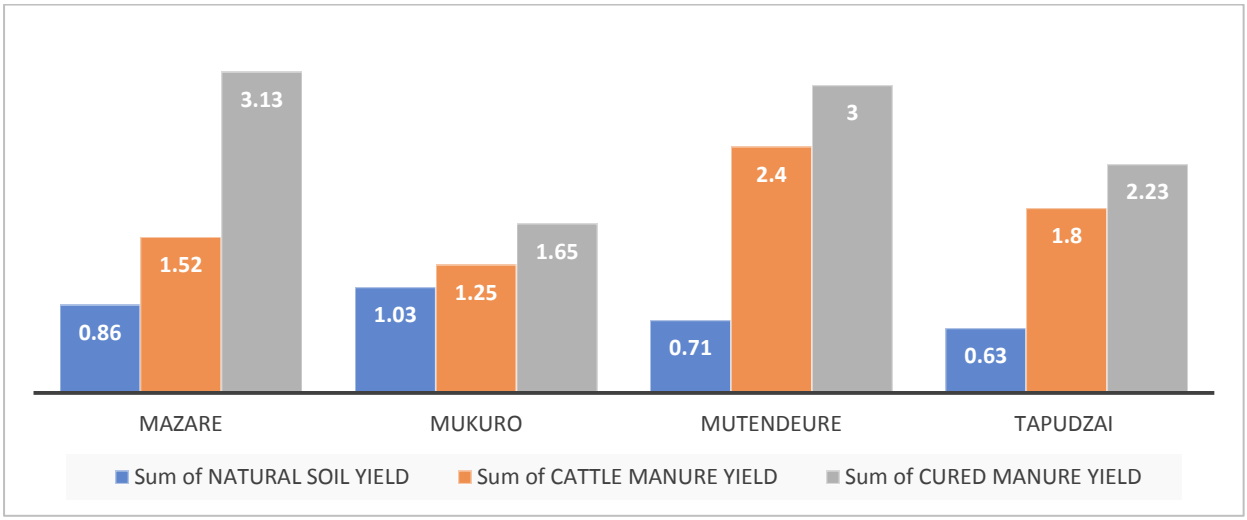

Fig 1. Yield comparisons for rape

The graphical data represented in Figure 2 shows that in terms of peas production in Mazare garden there was a significant increase from the natural conditions and the gardens with manure although the difference between the Bokashi manure is 4.35kg/2m^2 and cattle manure 4.1kg/2m^2 was not significant as shown by a one-way ANOVA, F (2, 9) = 1.28, p = 0.323 and r^2 = 22.2%. The results show that the yields were not that significant between all the three experimental conditions suggesting that there might be another factor that is mitigating

against the production of higher yields other than the soil nutrient compositions. In Mutendeure the difference between the control garden and the ones that received the treatment was significant. Natural conditions recorded a yield of 2.3 kg/2m^2 whereas the Bokashi manure treated garden recorded a high of 4.21kg/2m^2 yield. This is indicative of the fact that the treatment that was given to the garden was in the form of Bokashi manure. Just like Mukuro the results of the Tapudzai garden were clustered which shows the little significant impact of the treatment with the natural conditions recording 1.36kg/2m^2 and the treatment fields recording 1.72kg/2m^2 and 2.15kg/2m^2 respectively for cattle and Bokashi manure fields.

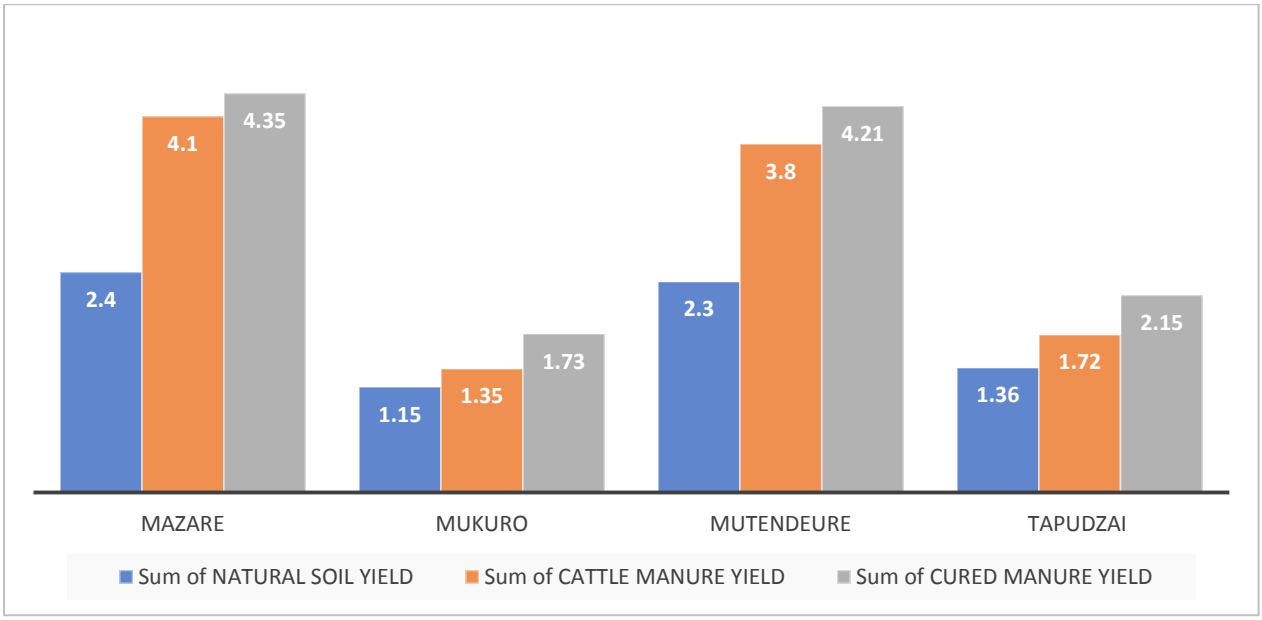

Fig 2. Yields for peas

Nutrient status of cattle cured manure, non-cured manure, and natural soil

The laboratory results indicate that Bokashi has higher quantities of macro (N, P, K, Ca, and Mg) and micro (Zn, Cu, Mn, Na, and Fe) plant nutrients than ordinary manure and ordinary soil. The pH for Bokashi or cured manure is higher than the other 2 samples. This is beneficial to the soil compared to inorganic fertilizers which reduces pH levels with use as revealed by Fageria et al (2010) in rice production. Similarly, a study reported that the soil pH declined to 4.3 after 13-years of production in Shouguang and Shandong provinces in China, which potentially can lead to reduced crop yields and quality Ju et al (2007). Preliminary field results tally with laboratory certificate results in indicating Bokashi to be more productive

than the other two treatments as shown in the results Table 1 below. Besides the supply of diverse soil nutrients, Bokashi manure also contains a diversity of microbes. Soil nutrient diversity and availability mean the production of healthy crop products. Bokashi can also be used to amend acidic soils by smallholder farmers since it has a higher pH. The use of Bokashi manure improved both crop quantity and hence the yields. Owing to the high presence of both macro and micronutrients, Bokashi manure also improves the quality of the crops produced. Quantity and quality improvements of crop production contribute to food and nutrition security at the household level among smallholder farmers.

Table 1. Extract Soil Tests Results for Mukuro nutritional garden

	pH	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe
Bokashi manure	7.7	118	179	0.95	15.4	8	3	22	460	230
Cattle manure	7.5	54	147	0.51	31.5	6.25	3	11	400	80
Natural soil	6.4	40	19	0.34	3.24	1.72	1	1	90	31

Perceptions on the efficacy of cured manure

In the investigation farmers were able to establish the advantages of cured Bokashi manure. Manure that had been cured was believed to have more nutrients and power. Ninety-five percent of the participants indicated that Bokashi manure contributed to high crop yields and improved their inherently poor fertile soils. This is contrary to the findings by (Grant, 1981; Mugwira, 1985) who reported that manure alone generally produced low crop yields and that it needed supplementation with inorganic fertilizers. One female participant had this to say ‘Bokashi manure has more strength compared to the ordinary manure and natural soil that we normally utilize for crop production in our garden. However, a lot of water is required for crops grown using Bokashi manure - 15 farmers (5 men and 10 women) in the Guvuriro garden produced Bokashi manure and are already using it for their crops while Tapudzai and Mutendeure farmers (95 farmers) indicated that they would use Bokashi manure for their summer crops which include butternuts, watermelons, and maize.

According to Darmaun et al., (2021), agroecology not only can foster climate change adaptation and increase resilience but also contribute to a low-emission pathway. A study done in the Netherlands showed that amendment with compost to agricultural soils could reduce the impact of Carbon dioxide and Methane emissions which are GHGs (Ho et al,

2000). The results of this study support the claim by most researchers that agroecology should be acknowledged as a powerful approach to transforming agricultural production systems for a more sustainable and climate-resilient future.

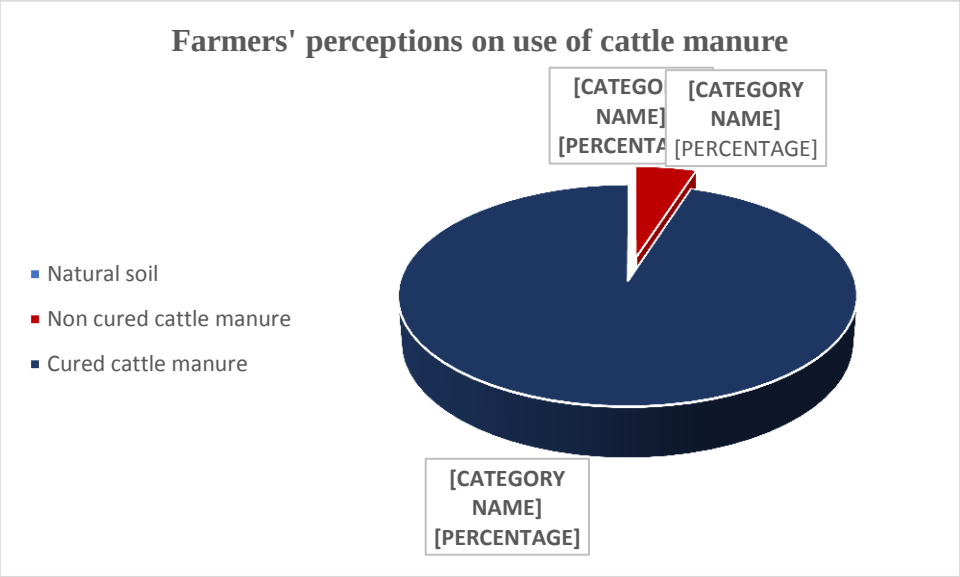

Fig 3. Farmers' perceptions on use of cattle manure

Conclusion

The findings of this study indicate that cattle manure effectiveness can be greatly enhanced by curing to improve crop yields. This technology is economic, feasible and environmentally friendly particularly with resource poor small-holder farmers who are always limited by the cost of fertilizers.

Recommendations

Based on the findings from this study, farmers are encouraged to carry out fertility soil tests as well as crop quality tests through capacitation by government technical staff from Agritex or other partners. Further tests to determine crop quality could not be done due to the limited project time frame and this can be done for further studies. Furthermore, results from this project can be used to influence existing government initiatives to improve crop production (for example integrating Bokashi/cured manure into the government's conservation agriculture or Pfumvudza/Intwasa program and in schools' gardens). In addition, the AGRITEX Department can also combine the scheduled conservation farming demonstrations with Bokashi manure demonstrations in preparation for the coming 2021/22 farming season where most farmers will be engaged in summer cropping.

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