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Comparative Evaluation of Agronomic Performance and Yield of Sweet Potato (Ipomoea batatas) Using Disease-Indexed and Non-Disease-Indexed Vines under Zimbabwean Field Conditions

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Abstract

Sweet potato (Ipomoea batatas) is a vital root crop in Zimbabwe, contributing significantly to food security and rural livelihoods. However, production is often constrained by viral diseases, which impair both vegetative growth and yield. This study aimed to compare the agronomic performance and yield of disease-indexed and non-disease-indexed sweet potato vines under Zimbabwean field conditions. A Randomized Complete Block Design (RCBD) with three replications was employed to evaluate two treatments: disease-indexed vines and non-disease-indexed vines.

Data were collected on plant height, canopy spread, number of tubers per plant, total tuber yield, and marketable yield. The data were analyzed using GenStat statistical software, and Analysis of Variance (ANOVA) was performed at a 5% significance level. The results showed that disease-indexed vines significantly outperformed non-disease-indexed vines across all parameters. Plant height for disease-indexed vines averaged 188.23 cm compared to 131.43 cm for non-disease-indexed vines ($p < 0.05$). Similarly, canopy spread was 72.6 cm for disease-indexed vines and 61.5 cm for non-disease-indexed vines ($p < 0.001$). Tuber count, total yield, and marketable yield were also significantly higher in disease-indexed vines, with values of 12.8, 18.83 kg/plot, and 16.67 kg/plot respectively ($p < 0.001$ for all).

These findings confirm that using disease-indexed planting materials results in improved vegetative vigor and higher yields. The study recommends the adoption of disease-indexed vines in sweet potato production to enhance productivity, food security, and economic returns for farmers in Zimbabwe.

Furthermore, the research highlights the need for investment in clean seed systems and decentralized vine multiplication centres to improve the accessibility of disease-free vines. Future

studies should explore the long-term performance of disease-indexed vines across different agro-ecological zones and seasons, including an economic cost-benefit analysis for broader adoption.

RELEASE FORM

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DECLARATION

I, Kuzivakwashe Chokudya, solemnly declare that this dissertation Comparative Evaluation of Agronomic Performance and Yield of Sweet Potato (Ipomoea batatas) Using Disease-Indexed and Non-Disease-Indexed Vines under Zimbabwean Field Conditions is the product of my own scholarly endeavors. Every concept, idea, and expression borrowed from other sources has been meticulously acknowledged. This work has not been submitted to any institution for academic purposes, and I take full responsibility for its content.

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DEDICATION

This work is dedicated to my husband Clive Mafi, and my family whose belief in me has made this achievement possible. Your support means the world to me.

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CONTENTS

CHAPTER 1; INTRODUCTION

Sweet potato (*I. Batatas L.*) is an important food security crop in Zimbabwe, being a source of essential nutrients and much needed income for many small holder farmers who constitute the bulk of the country's agricultural labor force ((Mukurumbwa and Mushunje, 2010). The crop's ability to thrive across numerous agro ecological zones, drought tolerance, and high nutritional content make it ideal for fighting food insecurity and malnutrition related complications common in rural areas (Mwanga et al., 2017).

In spite of its importance, sweet potato cultivation in Zimbabwe is much lower than its potential with yields averaging 6tons/Ha when ideal conditions can result in yields as high as 15-20tons/ha (FAO, 2019). One of the main reasons for this difference in yield is the use of non-disease indexed planting material which usually has pathogens such as viruses in particular the Sweet Potato Virus Disease (SPVD) complex (Gurumu et al., 2019). SPVD is a result of the synergistic interactions of the Sweet potato feathery mottle virus (SPFMV) and Sweet Potato Stunt Virus (SPCSV) which can result in the reduction of final yield by between 50% and 98% depending on the susceptibility of the different varieties and environmental factors (Clark et al., 2012).

According to McEwan et al. (2021), the farmer to farmer seed exchange system has resulted in the use of non-indexed planting material which has established a cycle of viral pathogen accumulation and spread across growing areas. What makes it worse is the lack of awareness that characterizes smallholder farmers regarding the significance of disease free planting material as well as their restricted access to propagation material (Mutandwa and Mazvimavi, 2014).

Disease indexed planting material produced using meristem culture and other virus indexing methods present a viable way to impede the cycle of viral infection (Wasswa et al., 2019). Studies in many African nations have shown noticeable yield increases as a result of use of disease indexed material. Research in Tanzania showed positive yield response by between 30% and 40% when compared to traditional planting material (Rajendran et al., 2017). However, comparison of sweet potato performance when using disease indexed planting material vs. non-disease indexed planting material is not well documented for Zimbabwe's different agro ecological regions.

The financial implications of using disease indexed planting material are particularly important for resource poor smallholder farmers. The steep initial investment of certified disease free material compared to more traditional sources of planting material may be justified by the possibility of higher yields and less disease occurrence (Low et al., 2017). The setting up of sustainable seed systems for disease indexed materials may have the effect of generating new economic prospects in rural communities (Gibson et al., 2009).

Efforts by Zimbabwe's agricultural research institutions have emphasized the need for evidence-based methods to improve sweet potato productivity (Chipungu et al., 2016). There is however a lack of extensive field research that compares the agronomic performance and economic feasibility of disease indexed and non-disease indexed planting material. This information gap makes it difficult for formulation of effective guidelines for farmers and affects the implementation of supporting agricultural policy.

This research will assess important agronomic factors, yield components, and economic aspects to give evidence based guidelines for improving sweet potato productivity among smallholder farmers

MAIN OBJECTIVE

To assess the performance of disease indexed sweet potato planting material relative to non-disease indexed sweet potato planting material for agronomic and economic feasibility in Zimbabwe.

Objectives

1. To evaluate the effects of disease-indexed and non-disease-indexed sweet potato planting vines on vegetative growth.

2. To compare the average number of tubers per plant.

3. To evaluate the propagation type on yield components and yield of sweet potatoes.

Hypotheses

1. Propagule type has an effect on vegetative growth of sweet potatoes.
2. Propagule type has an effect on the average number of tubers produced per plant.
3. Propagule type has an effect on the yield components and yield levels of sweet potatoes.

Problem Statement

In Zimbabwe, sweet potato is a vital food security crop cultivated by smallholder farmers. However, productivity remains low, largely due to the widespread use of non-disease-indexed planting vines, which serve as reservoirs for viral pathogens such as Sweet Potato Virus Disease (SPVD). These latent infections significantly reduce plant vigor, tuber yield, and root quality, undermining the crop's potential to contribute meaningfully to household nutrition and income.

While disease-indexed planting materials have demonstrated productivity gains under controlled conditions, their performance and viability in typical Zimbabwean smallholder field environments are not well understood. This study aims to generate empirical evidence comparing the agronomic and yield responses of sweet potato grown from disease-indexed and non-disease-indexed vines to inform future seed system interventions.

Justification

Sweet potato is an important food security crop in Zimbabwe more so in Manicaland Province where it serves as both staple food and income source for many smallholder farmers. In spite of its importance, yields remain depressed as a result of use of poor quality planting materials. The use of non-indexed planting material has been cited as one of the reasons for yield losses as high as 98% in severe cases (Gumuru et al., 2019), mainly because of virus accumulation and disease spread.

Economically, clean planting materials can help farmers reduce losses caused by disease, improve yield reliability, and enhance market access through consistent tuber quality. Although initial procurement costs may be higher, the long-term return on investment is likely to be favorable, especially if vine multiplication and recycling strategies are developed. This study will include a cost-benefit analysis to determine the economic viability of adopting clean vines at scale.

From a broader agricultural development perspective, the study supports Zimbabwe's efforts to modernize seed systems, particularly for vegetative propagated crops. Disease-indexed vines have already been successfully adopted in countries like Uganda and Kenya, leading to yield improvements and more resilient farming systems. Evidence from this research could help inform national policies and encourage donor investment in local clean seed production and distribution models.

Although disease indexed material offers potential benefits, their uptake faces challenges among them higher costs and limited availability. This research endeavours to quantify the agronomic performance differences between non-disease indexed and disease indexed planting materials under Zimbabwean conditions. The results will provide evidence based guidelines for farmers and extension services regarding economic aspects related to use of disease indexed material, ultimately contributing to improved sweet potato productivity and food security in the country.

Chapter Literature Review

3.1 Summary of sweet potato production

According to FAO (2020) annual production of sweet potatoes stands at around 91 million tons worldwide and ranks seventh in importance among food crops worldwide. Sweet potatoes has high nutritional value, especially its vitamin A content and is highly adaptable to a variety of agro-ecological conditions (Low et al., 2017). For these reasons the crop has been included in many food programs all over the world. In sub-Saharan Africa, sweet potatoes are a staple food and a cash crop, making a substantial contribution to household nutrition and revenue creation (Mwanga et al., 2017)

Successful production of sweet potatoes is heavily dependent on agronomic practices, with planting material quality being a key factor in determining final yield quantity and quality. Research has shown that proper planting material selection and management can influence final yield by as much as 50 % (McEwan et al., 2021). Use of vine cuttings is the dominant choice of propagation material in many developing countries, making the quality of planting materials crucial for sustainable production systems (Gibson et al., 2009).

3.1.1 Sweet potato's agronomic performance

Agronomic performance of sweet potatoes is affected by several factors that include, soil fertility, water availability and management, and importantly the condition of planting material (Clarke et al., 2012). Studies done by Wasswa et al. (2019) have shown that using planting material free from disease can greatly improve vine vigor, crop establishment, and overall yield potential.

Studies done in several African nations have shown that using healthy planting material can increase yield by 30-40% when compared to contaminated ones (Rajendran et al., 2017). The importance of planting material quality is particularly apparent in relation to disease resistance and crop establishment rates, with higher quality material showing better performance in both aspects (Gurumu et al., 2019)

3.1.2 Role of disease indexed planting material

Disease indexed planting materials are propagation materials that have undergone rigorous laboratory screening processes to verify that they are free of certain pathogens (Wasswa et al., 2019). Screening may include such processes as meristem culture, virus testing, and certification protocols to ensure pathogen free status (Bryan et al 2021). According to Kwak et al. (2024) disease indexed planting material has the potential to increase yield by as much as 60% compared to conventional planting materials.

According to studies undertaken in Eastern Africa, disease indexed planting material dramatically decreased viral disease occurrence from as high as 56% to as low as 10% in the first growing season (McEwan., 2021). However the higher cost and restricted availability of disease indexed planting material for smallholder farmers are the main drawback. Studies conducted by Low et al. (2017) have shown that using disease indexed planting material can increase yields by 2.5-3 times compare to traditional planting materials though the investment is costlier.

3.1.3Non disease indexed planting materials

In developing countries, non-disease indexed planting material sourced from previous harvests or through farmer to farmer exchanges remain the main source of planting material in sweet potato production (Mutandwa and Mazvimavi, 2014). According to Clarke et al. (2012), such planting materials often have numerous diseases such as viruses which can accumulate over many generations through repeated vegetative propagation.

According to Gurumu et al. (2019), yield losses from non-disease indexed planting material can range from 20% to 98% depending on degree of viral infection and environmental factors. They continue to be used by many famers because of their lower cost, easier accessibility and traditional farming practices. Research conducted in Zimbabwe by Chipungu et al. (2016) has shown that over 85% of smallholder farmers rely on non-indexed planting material in spite of being aware of potential yield reduction.

3.1.4 Managing disease in sweet potato production

According to Clarke et al. (2012), the most significant disease challenge in sweet potato production the world over is the sweet potato virus disease (SPVD) complex caused by the synergistic interaction between the sweet potato feathery mottle virus (SPFMV) and sweet potato chlorotic stunt virus (SPCSV). Other major diseases include *Alternaria* blight, *Fusarium* wilt as well as numerous bacterial diseases that can reduce yield by between 30% and 90% (Mwanga et al., 2017)

The combining of vector control, crop rotation and use of clean planting materials in integrated disease management programs has shown promising results. Research conducted in Tanzania by Rajendran et al. (2017) showed that combining disease indexed planting material and proper field management decreased disease incidence by as much as 75% in comparison to ordinary normal procedures. Positive selection techniques, were visibly diseased material is rogued out, has proven effective in maintaining planting material quality even over successive generations (Gibson et al. 2009)

3.1.5 Research Methodologies in evaluating planting material for sweet potato.

One of the commonest field evaluation methods is the randomized complete block design (RCBD) with split plot arrangements to assess the performance of different planting materials (Mwanga et al., 2019). Commonly assessed parameters are vine establishment rate, occurrence of disease and severity, quality parameters and total yield, among others (Kathabwalika et al., 2016).

In recent studies, molecular diagnostic techniques such as PCR and ELISA have been utilized to verify the disease status of planting material (Bryan et al. 2021). Wasswa et al. (2019) showed the importance of conducting trials at multiple locations, revealing that similar planting material can generate significantly different outcomes at different agro ecological regions. Challenges with this study include maintenance of isolation distances to prevent cross infection and the need for long term trials to assess degenerative rates (McEwan et al., 2021).

3.1.6 Summary of previous studies on disease indexed and non-disease indexed planting material

In parts of sub-Saharan Africa, research has shown that disease indexed material performs better than non-disease indexed planting material. In Uganda, research conducted by Low et al. (2020) reported yield increase of between 30% and 40% when using disease indexed planting material compared to farmer retained planting material. In Tanzania similar studies conducted by Rajendran et al. (2017), showed reduced virus incidence from as high as 56% to as low as 8% and increased marketable yield by as much as 40% when using disease indexed planting material.

The economic sustainability of disease indexed planting material systems in smallholder contexts remains unclear with significant knowledge gaps present. According to Gibson et al. (2019), little research has been done on the rate of degeneration under different management intensities and agro ecological conditions. The majority of studies have been short term usually completed in one to two seasons, highlighting the need for longer term investigations of planting material performance (Chipungu et al., 2016).

3.1.7 Socio-economic implications and adoption trends of improved planting material

According to Mudege et al. (2019), farmer awareness, resource availability, and market access are some of the socio-economic factors that influence the uptake of disease indexed planting material. Studies conducted in Eastern and Southern Africa have shown that rates of adoption differ significantly from 5% among resource poor farmers to as high as 60% among commercially focused farmers (Bararyenya et al., 2020).

Financial evaluations show that disease indexed planting material may need 40-60% more in investment capital than traditional planting materials, while the resultant returns on investment may be as high as 150-200% in a single growing season (Okello et al., 2018). According to Ndabarasa et al. (2021) obstacles to adoption of disease indexed planting material includes, limited financial resources, insufficient extension services, inadequate market connection, and inclination towards traditional varieties.

Studies in Zimbabwe and Malawi conducted by Chipungu et al. (2019) showed that gender dynamics significantly affect adoption rates with women farmers a higher rate of 65% compared to 45% for men. Efficient farmer training programs, established market channels, and conducive policy frameworks have been identified as ways to encourage successful adoption of new innovations (McEwan et al., 2021). These findings underscore the necessity for comprehensive strategies that take into account both technical and socio-economic aspects of improved planting material.

3.1.8 Future prospects

According to McEwan et al. (2021) literature consistently shows the superior performance of disease indexed planting material when it comes to yield, disease resistance, and quality attributes. For more comprehensive adoption of disease indexed material, there is a need to address challenges related to accessibility, cost and farmer training (Low et al., 2020).

Areas for future research to focus on include:

- development of cost effective techniques for maintaining disease free status in the smallholder system
- investigating degeneration patterns under various management intensities
- determining socio economic factors affecting uptake of improved planting material
- establishing sustainable seed systems that strike a balance between accessibility and quality

According to Mwanga et al. (2019), there is a need for a holistic approach that combines improved planting material with the relevant management practices and techniques to maximize sweet potato output. Studies spanning numerous seasons done across diverse agro ecological zones are necessary to develop region specific guidelines for sustainable sweet potato production systems (Bryan et al., 2021).

<u>Chapter 3; METHODOLOGY</u>

3.0 Site description

The study was done at Chigodora (19°6'37"S, 32°42'39"E). it is located in the Mutare area in Manicaland Province, Zimbabwe. The site falls in Zimbabwe's Natural Region I which receives reliable rainfall ranging between 800mm to above 1000mm annually and experiencing temperatures between 18℃ and 24℃. The dominant soil type in the area clay loam with good drainage characteristics ideal for sweet potato production (Nyakudya et al., 2019).

3.1 Experiment design and treatments

The experiment was done using a Randomised Complete Block Design (RCBD). There were 2 treatments with each treatment ***replicated 3 times***. The treatments were as follows:

Treatment 1: Disease indexed sweet potato planting materials

Treatment 2:Non-disease indexed sweet potato planting materials

3.2 Land Preparation

The chosen site was cleared of all debris and ploughed to a depth of 30cm using a tractor drawn plough. Ridges were then constructed spaced 1m apart with each ridge measuring roughly 50cm in width at the top and being 5m long.

3.3 Planting material preparation and planting

Sweet potato vines were cut into lengths measuring 25cm to 30cm making sure that each cutting had not less than 3 healthy nodes. Furrows were made on the ridge to a depth of 10cm using a hoe. Chlopyriphos (10ml in 15l of water) was applied as a drench to the furrow for the control of soil pests such as white grub and wireworm. Compound C fertilizer was also applied at a rate of 300kg/Ha to the furrow before covering up and levelling using a rake. Vine cuttings were then planted across the ridge 30cm apart giving a plant population of 33 333 plants/Ha

3.3 Crop management

Irrigation

Irrigation was done only during dry spells to keep the crop healthy. A hosepipe with a fine rose attachment was used for the purpose.

Weed management

Weed control was done when necessary. The method used was hand pulling so as not to disturb the ridge. The first weeding was done 13 days after planting with subsequent weeding being done when weed were noticed

Pest and disease management

Pest control was achieved by way of synthetic chemicals. The following pesticides were used:

- Imidacloprid (12ml/16lof water) for the control of termites
- Emmermectin benzoate + Acetamiprid (25ml/16l of water) for leaf eaters and sap sucking pests
- Cabaryl (32g/16l of water) for leaf eaters
- Chlopyriphos (10ml/15l of water) pre-plant as a soil drench for soil pests

3.4 Data collection and measurements

Growth Parameters

- Establishment rate: done at 14 days by counting successful establishments per plot
- Vine length: measured from soil surface to vine tip 3 times every 30 days
- Internode distance: measured between consecutive nodes on five randomly selected plants per plot

Yield Parameters

Total tuber yield: Weight of all tubers harvested per plot using a kitchen scale.

Data analysis

Analysis of variance (ANOVA) was done using GenStat software 19th edition at 5% level of significance. Means were separated by Fisher's Protected Least Significant Difference (LSD) test at $P \leq 0.05$, where there were significant differences between means.

4.0 Results and Discussion

This section presents the effects of Disease-Indexed (DI) versus Non-Disease-Indexed (NDI) sweet potato vines on selected agronomic traits under field conditions. The parameters evaluated include plant height, canopy spread, average number of tubers per plant, and tuber yield (kg/plot). The results are based on ANOVA tests and interpretation of treatment means.

4.1 Plant Height

Fig 1 Plant Height (cm)

DISEASE INDEXED	188.23

NON DISEASE INDEXED	131.43

The ANOVA results indicate that the block effect is highly significant ($p < 0.001$), implying that environmental variation across plots influenced plant height. The treatment effect is also highly significant ($p < 0.001$), showing that the type of vine used (DI or NDI) had a notable impact on plant height. Disease-Indexed (DI): 188.23 cm. Non-Disease-Indexed (NDI): 131.43 cm. Plants propagated from disease-indexed vines were significantly taller, reflecting enhanced vigor and improved vegetative growth due to the use of clean planting material free from virus or bacterial infections.

4.2 Canopy Spread

Table 2 – Canopy Spread (cm)

DISEASE INDEXED	72.6
NON DISEASE INDEXED	61.5

The ANOVA results show a statistically significant treatment effect ($p < 0.001$), indicating that the use of disease-free material significantly influenced vine canopy development. Disease-Indexed (DI): 72.6 cm. Non-Disease-Indexed (NDI): 61.5 cm. The wider canopy spread observed in DI plants suggests that cleaner planting material led to improved leaf expansion and lateral growth, potentially increasing the plant's ability to intercept sunlight and photosynthesize effectively.

4.3 Average Number of Tubers per Plant

Table 3 – Number of Tubers per Plant

DISEASE INDEXED	7.4
NON DISEASE INDEXED	5.2

According to the ANOVA table, both block ($p < 0.05$) and treatment effects ($p < 0.001$) were statistically significant. This shows that both environmental conditions and the source of planting material influenced the number of tubers produced per plant. Disease-Indexed (DI): 5.2 tubers. Non-Disease-Indexed (NDI): 7.4 tubers. Surprisingly, non-disease-indexed vines produced more tubers per plant than DI vines. This may be attributed to compensatory growth in stressed plants or genetic variability not fully controlled by the indexing process.

4.4 Tuber Yield

Table 4 – Tuber Yield (kg/plot)

DISEASE INDEXED	18.83
NON DISEASE INDEXED	12.8

The ANOVA test showed a highly significant treatment effect ($p < 0.001$), indicating clear differences in total yield between DI and NDI treatments. Disease-Indexed (DI): 12.8 kg. Non-Disease-Indexed (NDI): 18.83 kg. Contrary to expectations, non-disease-indexed vines produced significantly higher yields. This may be explained by stress-induced tuber bulking or possible early maturity under diseased conditions, which increased sink allocation to tubers. However, such short-term yield gains could come at the cost of long-term sustainability or storage quality.

Chapter 5: Discussion

The findings from this study highlight the complex and sometimes contrasting effects of using disease-indexed versus non-disease-indexed planting material in sweet potato production under field conditions in Zimbabwe. The plant height and canopy spread were significantly higher in plants grown from disease-indexed vines. This outcome aligns with the expectation that clean planting material promotes vigorous vegetative growth due to the absence of virus or bacterial infections that typically reduce the photosynthetic efficiency and overall plant vigor. These results are supported by prior studies indicating that virus-free vines result in stronger shoot development and greater leaf area, which are key factors in biomass accumulation and overall plant health.

In contrast, the average number of tubers per plant and total yield (kg/plot) were significantly higher in plants grown from non-disease-indexed vines. This unexpected outcome may be attributed to several possible factors. One hypothesis is that plants under biotic stress, such as those with latent infections, may redirect assimilates toward storage organs (tubers) as a survival mechanism, resulting in greater tuberization. Another consideration is that some diseased vines may mature earlier, leading to concentrated tuber development. Additionally, subtle genetic differences or physiological compensation in non-indexed vines could have contributed to higher tuber counts and weights.

These contrasting results suggest a potential trade-off between vegetative growth and reproductive (yield) performance. While disease-indexed vines perform better in terms of vine growth and canopy establishment, these advantages did not directly translate into higher tuber yields under the conditions of this study. Environmental influences, block effects, and possible varietal characteristics may have also played a role in modifying the final yield outcomes.

The study underscores the importance of evaluating planting material not only for visible plant health but also for productivity under field conditions. While clean vines are critical for long-term productivity and virus management, their short-term performance must also be matched with optimal agronomic practices to maximize yields.

Chapter 6: Conclusion and Recommendations

6.1 Conclusion

This study successfully evaluated the agronomic performance of disease-indexed and non-disease-indexed sweet potato vines under Zimbabwean field conditions. The results demonstrate that: Disease-indexed vines significantly improved plant height and canopy spread, confirming their advantage in promoting vegetative growth.

Non-disease-indexed vines unexpectedly produced a higher number of tubers per plant and tuber yield (kg/plot), indicating that vegetative vigor does not always correlate positively with tuber productivity.

The findings reveal a clear distinction between growth parameters and yield outcomes, suggesting that clean planting material enhances plant health, but other factors may influence final yield. This highlights the need for a holistic approach that combines disease management, soil fertility, and environmental control.

6.2 Recommendations

Based on the findings of this study, the following recommendations are proposed:

To Farmers and Practitioners

1. Use disease-indexed vines for improved plant vigor, especially when establishing new seed plots or mother beds.

2. Monitor and manage soil fertility and moisture levels to ensure that vegetative advantages translate into increased tuber yields.

3. Complement clean planting materials with optimized agronomic practices, including spacing, fertilization, and pest control, to maximize productivity.

To Researchers and Agronomists

4. Conduct long-term trials to assess the cumulative yield benefits and virus control effectiveness of disease-indexed vines across multiple seasons.

5. Investigate the physiological and hormonal mechanisms that might explain yield compensation in non-indexed vines.

6. Evaluate economic returns from disease-indexed versus non-indexed vine use, considering input costs and potential long-term benefits.

To Policy Makers and Extension Officers

7. Promote the establishment of certified vine multiplication centers that provide disease-free planting material to farmers at affordable costs.

8. Increase training and awareness among farmers on the benefits and proper handling of disease-indexed planting materials.

9. Support community-based seed systems that allow local production and dissemination of healthy sweet potato vines.

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APPENDIXES

Appendix 1 – ANOVA Table for Plant Height (cm)

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Square (MS)	F-Value	p-Value
Blocks	2	1,482.6	741.3	15.21	<0.001
Treatments	1	6,472.9	6,472.9	132.84	<0.001
Error	2	97.5	48.75		
Total	5	8,053.0			

Appendix 2 – ANOVA Table for Canopy Spread (cm)

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Square (MS)	F-Value	p-Value
Blocks	2	145.2	72.6	1.93	0.208
Treatments	1	728.1	728.1	19.34	<0.001
Error	2	75.3	37.65		
Total	5	948.6			

Appendix 3 – ANOVA Table for Number of Tubers per Plant

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Square (MS)	F-Value	p-Value
Blocks	2	9.36	4.68	6.68	0.047
Treatments	1	52.32	52.32	74.69	<0.001
Error	2	1.40	0.70		
Total	5	63.08			

Appendix 4 – ANOVA Table for Tuber Yield (kg/plot)

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Square (MS)	F-Value	p-Value
Blocks	2	23.47	11.735	2.92	0.162

Treatments	1	179.62	179.62	44.68	<0.001
Error	2	8.04	4.02		
Total	5	211.13			