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Excellence in Agronomy

CGIAR

Accelerating Agronomic Impact through Digital Tools and Public-Private Extension in Rwanda

Smart Fertilizer Recommendations for Rice

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CONTENTS

Accelerating Agronomic Impact through Digital Tools and Public-Private Extension in Rwanda: Smart Fertilizer Recommendations for Rice

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Summary

This report presents the findings from the validation trials conducted on rice fertilizer recommendations in Rwanda under the collaborative efforts of the Rwanda Soil Information System (RwaSIS) and the Excellence in Agronomy Initiative (EiA). The initiative aimed to enhance agricultural productivity by delivering site-specific fertilizer recommendations (SSR) as opposed to blanket recommendations (BR) traditionally used across Rwanda. The introduction of SSR was facilitated by digital tools and the public-private partnership extension model between the CGIAR and the Rwanda Agriculture and Animal Resources Board (RAB).

Key Findings

Yield Improvement: The trials demonstrated that SSR consistently outperformed both BR and improved blanket recommendations (IBR). SSR led to significantly higher yields across different agroecological zones (AEZs), with potential yield gains of 20% or more for a large portion of farmers. For instance, in the Central Plateau and Mayaga regions, SSR showed a 90% yield increase for participating farmers compared to BR. However, regions like Bugesera displayed a unique low response to SSR, underscoring the need for region-specific interventions.

Economic Benefits: The economic analysis underscored the cost-effectiveness and profitability of SSR. Farmers using SSR experienced improved profitability due to increased yields and more efficient fertilizer use. Around 84% of farmers recorded higher profits with SSR compared to BR, with the potential to improve the financial sustainability of fertilizer investments.

Agroecological Variability: Results varied significantly across different AEZs, with factors such as local environmental conditions and rice varieties playing a crucial role in determining the efficacy of fertilizer recommendations. The Eastern Plateau, for instance, saw moderate success, while the Bugesera region faced challenges, highlighting the necessity for adaptive strategies.

Technology Integration: The successful application of digital tools, including the Rwanda Soil Information System (RwaSIS), facilitated the efficient gathering, analysis, and dissemination of data. These tools supported real-time decision-making and the development of SSR tailored to the specific needs of Rwanda's diverse agroecological zones. The integration of these technologies holds promise for further optimizing agricultural productivity through precision agriculture. The superiority of SSR is supported by rigorous statistical analyses and post hoc tests, which confirmed significant differences in yields between SSR and both BR and IBR. The data was collected from over 300 on-farm trials and analyzed using the advanced AGWISE platform. The success of SSR reflects the careful consideration of local conditions and crop-specific requirements, proving that site-specific interventions lead to more effective resource use and higher productivity.

Furthermore, the economic analysis provides strong justification for scaling up the use of SSR. By promoting efficient fertilizer use, SSR not only boosts yield but also mitigates environmental risks and enhances the return on investment. This data-driven approach ensures that the findings are robust, reliable, and actionable, laying the foundation for informed decision-making by policymakers and stakeholders.

Conclusion

The findings from the validation trials provide compelling evidence in favor of adopting SSR over traditional BR methods. The report demonstrates that SSR offers significant benefits in terms of both yield improvement and economic profitability, especially when adapted to local agroecological conditions. Policymakers are encouraged to scale up SSR-based recommendations to further enhance Rwanda's agricultural productivity, food security, and economic development. Targeted interventions are recommended for regions like Bugesera, where distinct agroecological dynamics hinder the full potential of SSR. Additionally, investment in capacity building and digital infrastructure is crucial for empowering farmers with the tools and knowledge needed to maximize the benefits of precision agriculture.

Abbreviations

AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
BR	Blanket Recommendation
CGIAR	Consultative Group on International Agricultural Research
EiA	Excellence in Agronomy Initiative
IBR	Improved Blanket Recommendation
MINAGRI	Ministry of Agriculture
NRDS	National Rice Development Strategy
ONADATA	Flagship mobile data collection platform
RAB	Rwanda Agriculture and Animal Resources Development Board
RwaSIS	Rwanda Soil Information System
SSR	Site-Specific Recommendation

Background and Introduction

Rice production plays a significant role in Rwanda's food security and agricultural economy. Primarily cultivated in marshlands, rice covers around 14,000 hectares with average yields of 5.8 tons per hectare, contributing approximately 80,000 metric tons annually (MinAgri, 2021). However, Rwanda still imports over 26,000 tons of milled rice each year to meet consumer demand, as local production falls short of achieving self-sufficiency. The government has prioritized rice development through its National Rice Development Strategy (NRDS-II) to boost productivity, improve quality, and reduce reliance on imports. Efforts are underway to expand irrigation, enhance mechanization, and improve farmer training, with goals to increase yields and expand cultivated areas by 2030.

Rice is predominantly grown as a cash crop in Rwanda mostly by smallholder farmers with an average of 0.2 ha per household (MinAgri, 2021). Therefore, the main limiting production factor of Rwanda's agriculture is land, with 50% of rural households cultivating less than 0.35 ha and 85% cultivating less than 1 ha. Yet, yields per unit of land are far below attainable yields due to limited crop and nutrient management. In 2007, the Government of Rwanda launched its Crop Intensification Programme, aiming to increase major crops' productivity through land use consolidation, improved distribution of seeds and inorganic fertilizers, and farmer-to-farmer extension approaches (Tuyishime et al., 2020). With the introduction of the Crop Intensification Programme, production levels of priority crops increased significantly. However, additional efforts are needed to further close yield gaps and improve the sustainability of agricultural production.

The fertilizer subsidy scheme under the Crop Intensification Programme facilitates farmers' access to inorganic fertilizers based on blanket fertilizer recommendations promoted and used across the country. Rwanda is a highly heterogeneous country in terms of agro-ecological conditions, and the use of blanket fertilizer recommendations leads to inefficient use of expensive inputs, suboptimal responses to fertilizers, and low-profit margins. Based on experience in other countries, it is expected that site-specific fertilizer advisory could increase yields by at least 20%. Moreover, site-specific fertilizer recommendations would reduce environmental risks through more efficient use of fertilizers and maximize returns on investments in the fertilizer subsidy scheme under the Crop Intensification Program by the Ministry of Agriculture (MINAGRI).

To address this issue, research investments were made to develop site-specific fertilizer recommendations for priority crops. The Rwanda Agriculture and Animal Resources Development Board (RAB) is implementing the Rwanda Soil Information System (RwaSIS) project, funded by the Bill & Melinda Gates Foundation. The RwaSIS project aimed to develop a digital soil information system for Rwanda to support decision-making by policymakers, private investors, and other stakeholders on soil fertility management and erosion control strategies. Under the RwaSIS project, country-wide fertilizer response trials on six priority crops (cassava, potato, rice, wheat, maize, and beans) have been rolled out during the 2022A and 2022B cropping seasons, with 800+ trials per season. In partnership with the CGIAR Excellence in Agronomy Initiative (EiA), the data gathered in these trials were used to calibrate crop and spatial models to formulate site-specific recommendations across different agro-ecologies in the country (Chernet et al., 2023).

Objectives

The objectives of the validation trials were to evaluate, under on-farm conditions, whether site-specific fertilizer recommendations developed by RwaSIS in partnership with EiA lead to higher yields and higher profits than the blanket fertilizer recommendations currently used in Rwanda. This report succinctly outlines the primary objective of the validation trials: to assess the efficacy of site-specific fertilizer recommendations compared to blanket recommendations in terms of both yield and profitability. It sets a clear focus on evaluating the real-world impact of these recommendations under on-farm conditions, providing valuable insights into their practical effectiveness. Crop-specific validation approach enables researchers and policymakers to delve deep into the nuances of agronomic practices and fertilizer management, thereby generating findings that are likely to be more relevant and actionable for the government and stakeholders in the agricultural sector.

Overall, this report effectively sets the stage for the validation analysis, conveying the central objective and scope of the study while signalling the specific crop under investigation. It serves as a concise introduction to the report's findings and underscores the importance of the research in informing future agricultural practices and policies in Rwanda.

Background to validation site and farmer selection

A first season of trials was conducted in 2024A, focusing on potato and rice fertilizer trials. These trials were conducted during the seasons 2024A and 2024B, which started in September 2023 and ended in June 2024. For each crop, trials were distributed across the agroecological zones where the respective crops are grown in Rwanda, as guided by the crop distribution maps developed by RwaSIS.

Validation trials for rice were meticulously established across 300 fertilizer trials, strategically distributed across various agro-ecological zones (AEZs) within the targeted rice cultivation areas, as depicted in **Figure 1**. These trials spanned 1 to 3 marshlands per AEZ, totalling 10 marshlands overall. To accommodate larger marshlands, where the trial density was insufficient, multiple Farmer Facilitators (FFs) were engaged, enabling the inclusion of additional sites, capped at a maximum of 10 sites per FF. In the subsequent season, second-season validation trials were conducted, focusing on the same marshlands utilized in the initial 2024A trials. However, to ensure diversity and robustness in the data, different farmer fields were selected for participation. The 10 marshlands were chosen based on specific criteria, including the requisite number of marshlands per AEZ and informed decisions drawn from previous experiences working within these marshlands. Priority was given to marshlands characterized by well-functioning cooperatives and effectively managed irrigation schemes, as outlined in **Table 1**. For each selected marshland, Extension Agents, including Farmer Facilitators, were tasked with identifying suitable farmer fields for trial implementation and were instrumental in the data collection, backstopping and submission of the data to the online database. The selection process aimed to encompass a minimum of 10 and up to a maximum of 20 farmer fields per marshland, ensuring adequate representation and coverage across the diverse agricultural landscapes under evaluation.

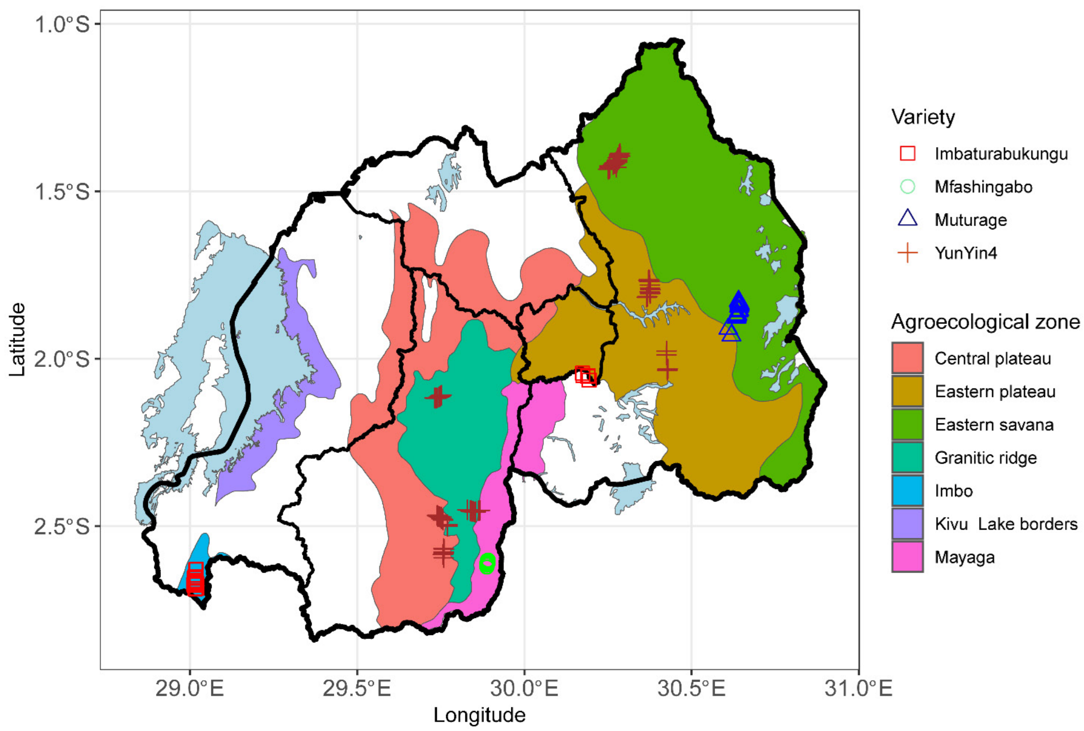
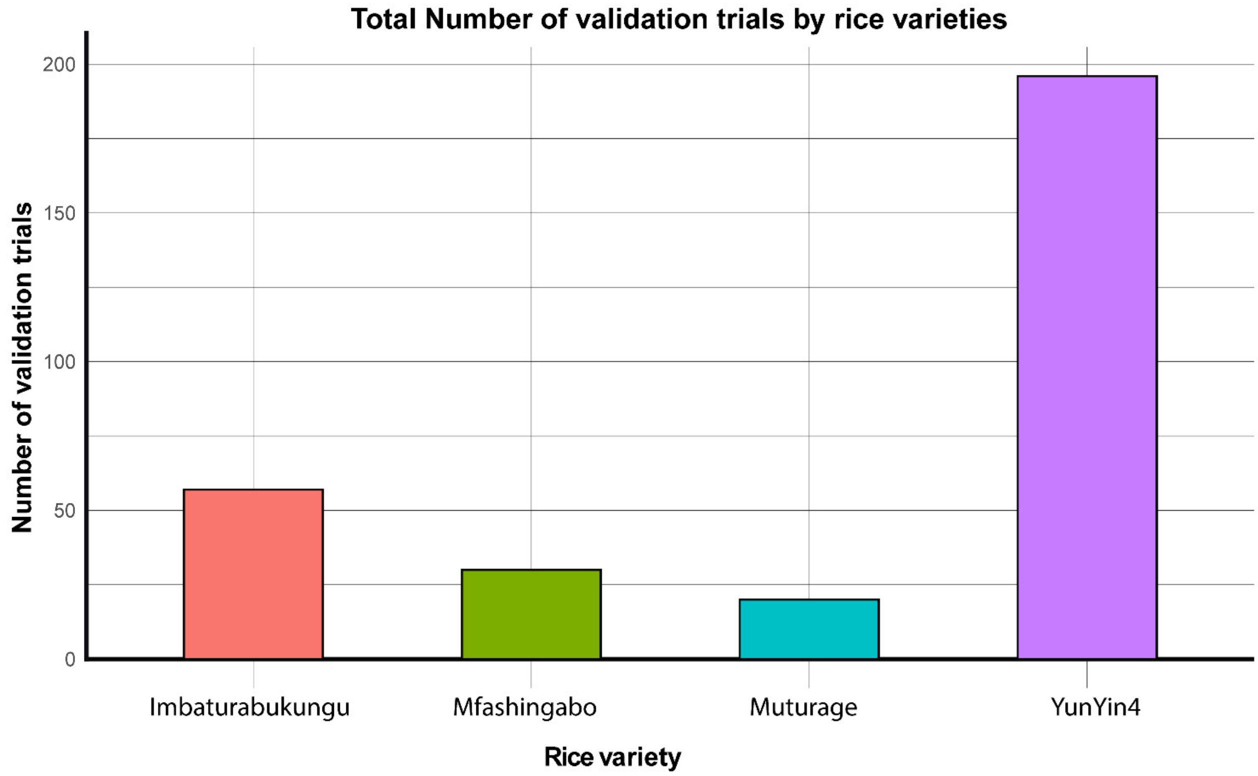


Figure 1: Validation trial locations within different agroecological regions in Rwanda and the respective varieties used for each trial.

In the trials conducted in Rwanda, four commonly cultivated rice varieties were planted, with the 'YunYin4' variety prominently featured across most plots, exceeding 100 trials. Conversely, the 'Muturage' variety exhibited the lowest representation among the selected varieties, as illustrated in **Figure 2**.

Figure 2: Number of validation trials where rice varieties were planted across Rwanda.



Different marshlands were used across different agroecological regions in Rwanda as demonstrated in **Table 1** to ensure wide, robust, and total coverage of Rwanda's environs. To ensure the capture of variability and reduction of bias, at least 10 farmers in each marshland were selected.

Table 1: Marshlands selected for the validation trials on rice

Agoecologocal Zone (AEZ)	District	Marshland	Number of validation trials
Eastern plateau	Gatsibo	Kanyonyomba	20
	Rwamagana	Cyaruhogo	20
Eastern Savana	Nyagatare	Cyabayaga	40
Granitic ridge	Muhanga	Rugeramigozi	30
Bugesera	Bugesera	Rurambi	20
Central plateau	Huye	Rwasave	20
	Huye	Rusuri	30
Imbo	Rusizi	Bugarama	40
Mayaga	Huye, Gisagara and Nyanza	Cyiri	30 20
	Gisagara	Mirayi	30
Total			300

Background to the validation treatments and experimental design

Three distinct treatments were evaluated across multiple fields, each representing different fertilizer application approaches. These treatments included two optimized fertilizer application strategies, namely the Improved Blanket Recommendation (IBR) and Site-Specific Recommendation (SSR), alongside the conventional Blanket Recommendation (BR). The IBR and SSR approaches were specifically designed to enhance fertilizer application efficiency, aiming to achieve yields either 20% higher than those attained with the BR method (SSSR) or equivalent to the current BR yields (IBR). To facilitate field identification and monitoring, colour-coded plots were utilized, with BR plots marked in blue, IBR plots in yellow, and SSR plots in red. The field layout and plot identification scheme of all the trials are depicted in **Figure 3**, providing a visual representation of the experimental design and plot allocation within the fields. The assignment of the treatments within each trial location was random across different farmers. Furthermore, the instruments utilized for plot identification and yield assessment are illustrated in **Figure 4**, offering insights into the methodologies employed for data collection. Following the harvesting process, data about plot yields and treatment outcomes were promptly uploaded to the ONA platform, ensuring real-time access to crucial information for subsequent analysis and decision-making processes. This systematic approach to data management and analysis facilitates comprehensive evaluation and comparison of the different fertilizer application strategies, ultimately informing agricultural practices and policy formulation for enhanced crop productivity and sustainability.

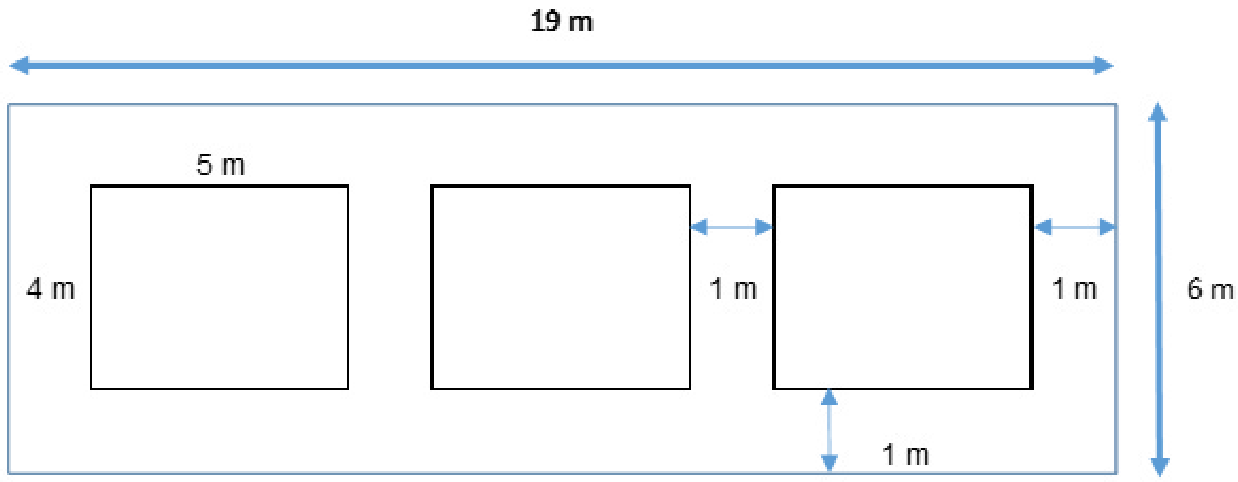


Figure 3: Rice validation plot design and dimensions

Figure 4: Trial labelling and yield measurement in the field.

Economic Analysis

A more in-depth economic analysis was beneficial to assess the cost-effectiveness and profitability of SSR compared to BR and IBR. A detailed understanding of the financial implications for farmers, including input costs, potential yield gains, and return on investment, provides policymakers with valuable information for decision-making. In this report, an economic analysis was conducted with the backdrop understanding of the cost of fertilizer and market income from one ton of rice. In all cases, both yield increase and profit were calculated considering 550 RWF/kg of rice and 675 RWF/kg of fertilizer. By consistently using the same baseline values for rice price and fertilizer cost throughout the calculations, the report ensures uniformity and comparability across different scenarios and analyses. This approach helps in accurately assessing the impact of different fertilizer recommendations on both yield increase and profit, providing policymakers and stakeholders with reliable and actionable information for decision-making.

Rice validation results

Data Exploration

Field data collected on the harvesting day was directly uploaded to the ONA platform, facilitating efficient data management and accessibility. This dataset is accessible from https://ona.io/iita_nrm/211050/752552. Subsequently, the data underwent thorough summarization and analysis utilizing the R-platform. The code utilized for this analysis is accessible on the CGLABS platform in the following directory: ~/agwise-responsefunctions/dataops/responsefunctions/Scripts/useCase/UseCase_Rwanda_RAB/Rice/RAB_Rice_ValidationData.R. Additionally, the code has been committed to the AGWISE-EIA GitHub repository, accessible via the following link: https://github.com/AgWISE-EiA/responsefunctions/commit/fc833a01fd6d816cbddc8f428591d672b88980a5.

To ensure consistency and comparability, the yields obtained from the validation trials were standardized to 14% moisture content and converted to equivalent yields in tons per hectare. The data was visualized using boxplots, density plots, histograms, pie charts, and empirical cumulative distribution functions. These analyses were instrumental in elucidating key insights and trends within the dataset, facilitating informed decision-making and interpretation of results. In the process of analyzing the data from the three trials conducted, it was necessary to refine the dataset by identifying and removing outliers. High yields beyond the anticipated range were removed as they may indicate anomalies in the experimental conditions or data collection process, while excessively low yields, typically below a threshold of one kilogram per hectare, were considered potentially erroneous or negligible for the study. By excluding these extreme data points, we obtained a more representative and reliable depiction of the yield distribution across the trials. To visually represent the distribution of yields across the three trials, histograms were constructed and are presented in **Figure 6**.

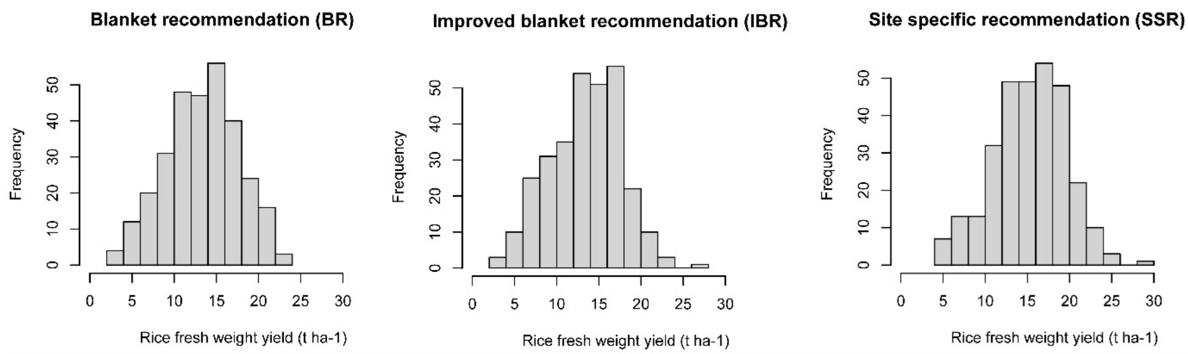


Figure 6: Frequency of yield distribution across the three validation trial plots i.e., blanket recommendation (BR), Improved blanket recommendation (IBR) and site-specific recommendation (SSR).

Most fresh weight yield ranges observed across the trials fell within the range of 10 to 15 tons per hectare, indicating a consistent performance across different experimental conditions. In contrast, the mean dry weight yields ranged between 4.5 to 6 tons per hectare, suggesting variations in yield density across the trials. Notably, the SSR exhibited higher mean yields compared to both the BR and IBR, as illustrated in **Figure 7**. A density plot analysis revealed a significant overlap between the BR and IBR methods, implying comparable performance despite differences in fertilizer input, with IBR receiving a lower fertilizer input compared to BR. Conversely, the density plot for SSR shifted noticeably to the left, indicative of its superior performance over both BR and IBR methods.

Statistical analyses conducted, including ANOVA and Tukey post hoc tests, confirmed the observed trends. There was a significant difference in yields between SSR and both BR and IBR methods ($p < 0.05$), highlighting the superiority of SSR. However, no significant difference was found between the BR and IBR methods ($p > 0.05$), suggesting similar performance levels between these two methods despite differences in fertilizer input. These findings underscore the efficacy of the SSR method in enhancing rice yield.

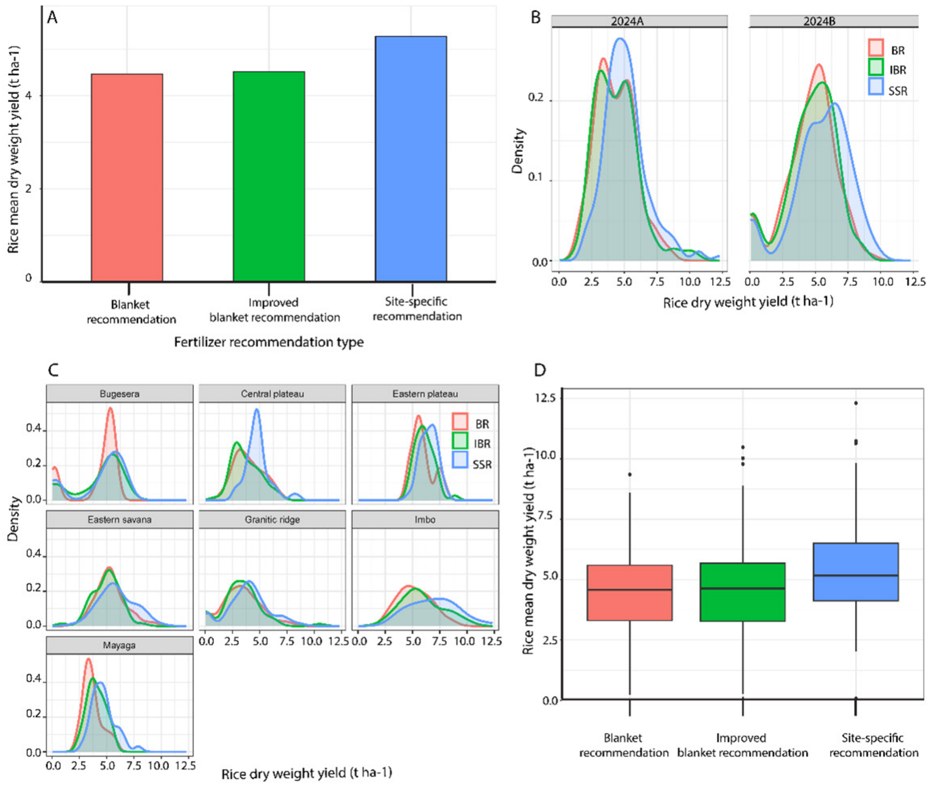


Figure 7: Summarized dry weight yield for the blanket recommendation (BR), Improved blanket recommendation (IBR) and site-specific recommendation (SSR) using **A**) bar plots, **B**) seasonal density plots C) agroecological zone density plots and **D**) boxplots.

Influence of Agroecological zones (AEZs) on fertilizer recommendations

Across almost all AEZs, SSR consistently demonstrated superior performance compared to other methods. This trend underscores the effectiveness of SSR in enhancing rice yields across diverse agricultural landscapes. Furthermore, the observed yield responses exhibit notable variability across different agroecological zones, indicating the influence of environmental factors and local conditions on crop productivity. Particularly, the Central and Eastern Plateau regions, as well as Mayaga, exhibit a pronounced SSR effect, highlighting the significance of tailored recommendations in optimizing yields within these zones. Interestingly, Bugesera presents a distinctive low response pattern compared to other regions, suggesting unique agro-ecological dynamics or specific contextual factors influencing yield outcomes (**Figure 8**). Further investigation into the underlying factors driving this distinct response in Bugesera could provide valuable insights into targeted agricultural interventions and management strategies in this area.

However, disaggregating the fertilizer recommendations across AEZs and respective rice varieties revealed nuanced patterns (**Figure 9**). In the Eastern Savannah region, there is evidence of a variety effect, suggesting that different rice varieties respond differently to fertilizer application practices. This suggests the importance of tailoring fertilizer recommendations based on the specific characteristics and requirements of each rice variety to optimize yield outcomes effectively. Mayaga demonstrates consistent and stable performance across both varieties, implying that the fertilizer recommendations implemented in this region are well-suited to meet the needs of the diverse rice varieties cultivated. This stability underscores the reliability of fertilizer application practices in Mayaga, contributing to consistent yield levels. The performance of the Yunyin4 variety exhibits variation across different AEZs, suggesting that the effectiveness of fertilizer recommendations may vary depending on the specific agroecological conditions and environmental factors present in each zone. This variability underscores the importance of considering local agroecological dynamics when designing and implementing fertilizer strategies tailored to specific rice varieties. Overall, these findings underscore the complexity of fertilizer response in rice cultivation, highlighting the need for targeted and context-specific fertilizer recommendations to optimize yield potential across diverse agroecological zones and rice varieties.

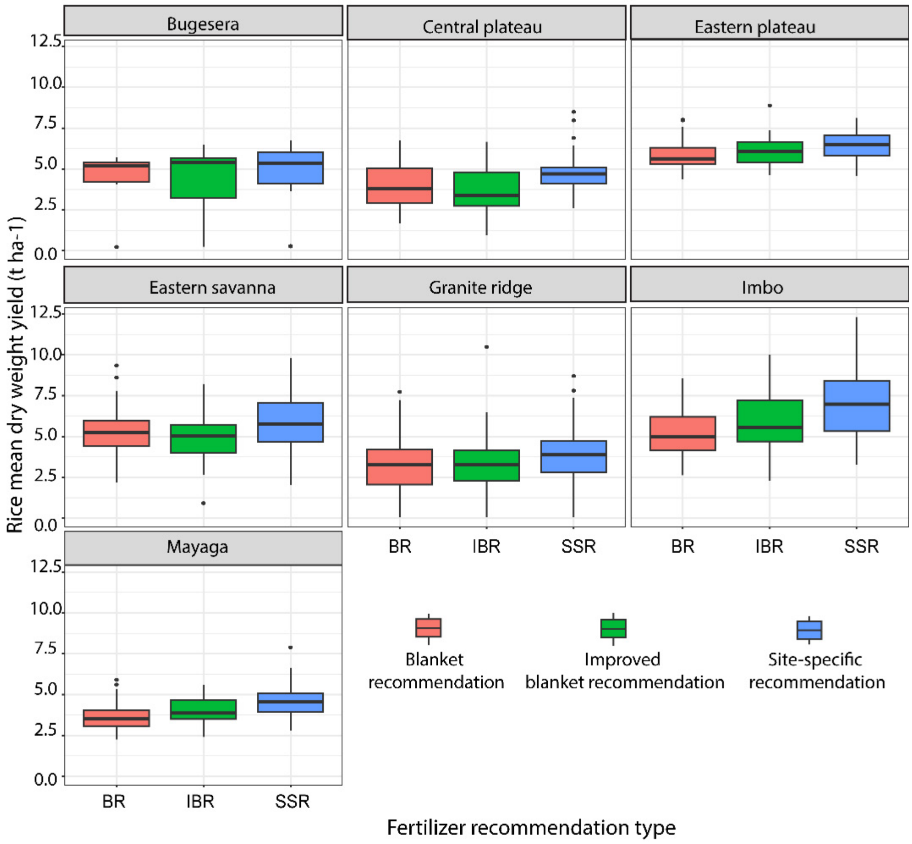


Figure 8: Yield response and performance of the blanket recommendation (BR), Improved blanket recommendation (IBR) and site-specific recommendation (SSR)in rice fertilizer recommendation trials across the agro-ecological zones (AEZ) in Rwanda.

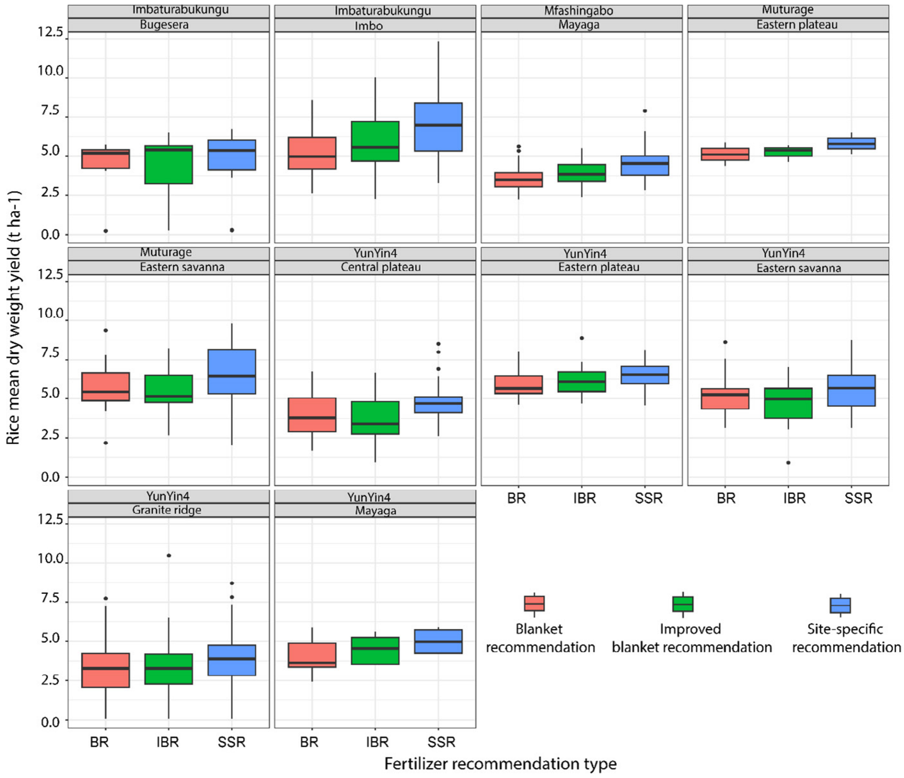


Figure 9: Yield response and performance of the blanket recommendation (BR), Improved blanket recommendation (IBR) and site-specific recommendation (SSR)in rice fertilizer recommendation trials using different varieties across the agroecological zones (AEZ) in Rwanda.

Cumulative yield distribution

The empirical cumulative distribution of yield differences between SSR, BR and IBR provide valuable insights into the potential yield gains achieved by different fertilizer application strategies (**Figure 10**):

1. Approximately 84% of farmers are expected to experience a yield gain over the conventional blanket recommendation (SSR-BR, indicated by the red line). This suggests that the SSR approach yields favourable results for most farmers, indicating its efficacy in enhancing rice yields compared to traditional BR.
2. Around 60% of farmers are projected to achieve a yield gain over the BR using the IBR (IBR-BR, represented by the blue line). While IBR demonstrates a lower percentage of farmers achieving yield gains compared to SSR, it still represents a substantial portion of farmers benefiting from optimized fertilizer recommendations.
3. Approximately 50% of farmers are expected to attain a 20% increased yield above the blanket using the SSR+20% (SSR, depicted by the green line). This highlights the potential for significant yield improvements with SSR, particularly for farmers seeking substantial increases in rice yields.

Therefore, these findings underscore the varying degrees of effectiveness associated with different fertilizer application strategies and emphasize the importance of tailored recommendations to maximize yield gains and improve overall agricultural productivity.

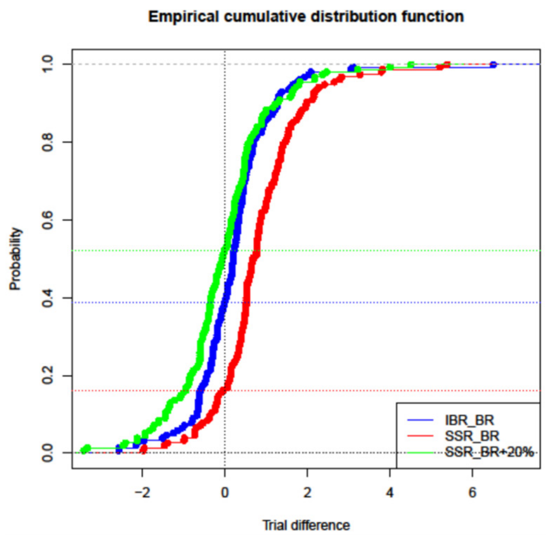


Figure 10: A generalized comparison of the attainable yield differences among the three fertilizer recommendations (blanket recommendation (BR), Improved blanket recommendation (IBR) and site-specific recommendation (SSR))

Cumulative yield distribution disaggregated by AEZ and rice varieties (IBR-BR).

The yield difference between IBR and BR, disaggregated by AEZ and rice varieties, revealed diverse outcomes (**Figure 11**).

1. In the Central Plateau, Mayaga, and Imbo regions, approximately 75% of farmers are expected to experience a yield increase using IBR compared to BR. This suggests the effectiveness of IBR in enhancing yields across these AEZs, potentially attributed to optimized fertilizer application strategies tailored to local conditions.
2. In the remaining AEZs, varying percentages of farmers are projected to achieve yield increases with IBR, ranging from about 60% to 40%. This variability underscores the influence of AEZ-specific factors on the effectiveness of fertilizer recommendations, highlighting the need for context-specific approaches to maximize yield gains.
3. It's crucial to consider cases where farmers experience a negative yield effect with IBR. While these instances may initially appear unfavourable, they should be viewed in terms of overall cost-effectiveness. For some farmers, the potential savings resulting from lower fertilizer costs may outweigh the loss due to reduced yields, particularly in scenarios where input costs are a significant consideration (**Figure 11C**). By considering both yield increases and cost-effectiveness, agricultural stakeholders can optimize resource allocation and enhance overall farm profitability and sustainability.

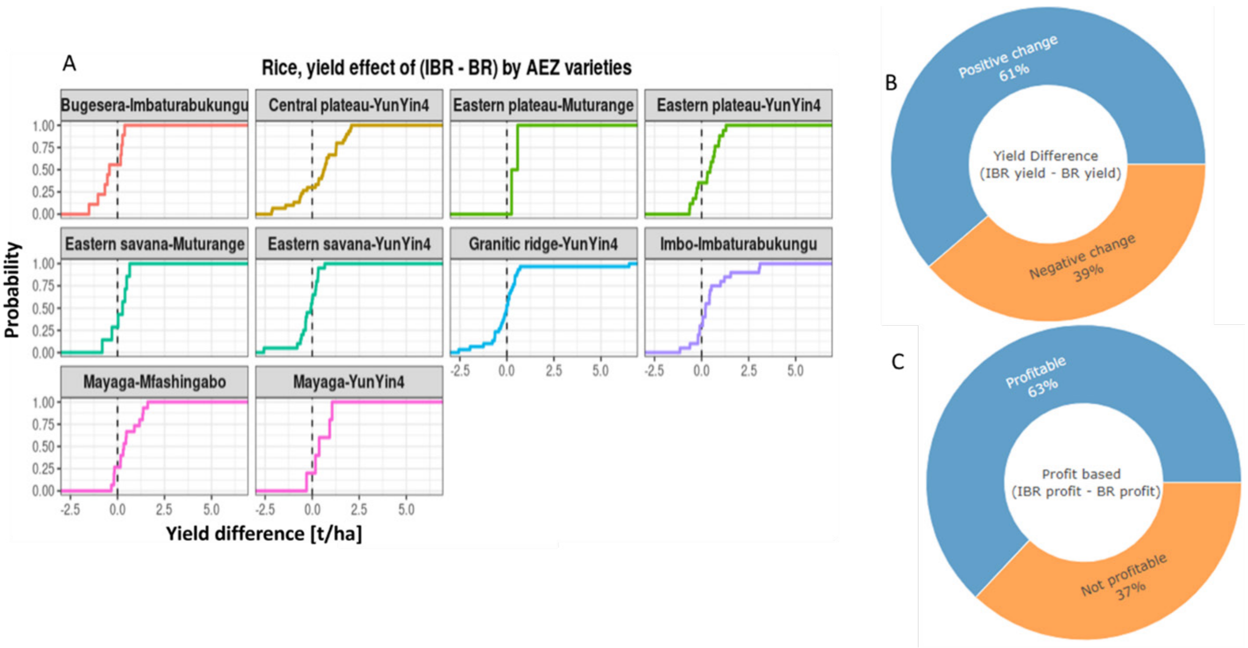


Figure 11: A) The yield difference between Improved blanket recommendation (IBR) and blanket recommendation (BR), disaggregated by agroecological zone (AEZ) and rice varieties, **B)** the percentage yield difference between IBR and BR, **C)** the percentage profitability difference provided by IBR over the BR using 550RWF/kg of rice and 650RWF/kg of fertilizer input.

Cumulative yield distribution disaggregated by AEZ and rice varieties (SSR-BR).

The yield difference and profitability between SSR and BR disaggregated by AEZ and rice varieties are shown in **Figure 12**.

1. In the Central Plateau, Granitic Ridge, Mayaga, and Imbo regions, a significant majority of farmers, at least 90%, are projected to experience a yield increase using SSR compared to BR. This indicates the substantial effectiveness of SSR in enhancing yields across these AEZs, likely due to tailored fertilizer recommendations aligned with local conditions.
2. In the Eastern Plateau, approximately 75% to 80% of farmers are expected to observe a yield increase with SSR. While still substantial, this percentage is slightly lower than in other regions, suggesting potential variability in the response to SSR across different AEZs.
3. Bugesera presents the least favourable scenario, with only 50% of farmers experiencing a yield increase with SSR. This highlights the importance of understanding local agroecological dynamics and adapting fertilizer recommendations accordingly to optimize yield outcomes effectively.
4. Overall, approximately 84% of farmers are projected to achieve a yield increase and make a profit from using SSR compared to BR (**Figures 12B and C**). However, 16% of farmers may suffer a yield loss and experience financial setbacks. These findings underscore the importance of considering both the potential benefits and risks associated with adopting SSR. Additionally, SSR is expected to result in a yield increase of 20% or more compared to BR for the majority of farmers. This significant improvement further emphasizes the potential of SSR to enhance rice yields and promote profitability in rice cultivation.

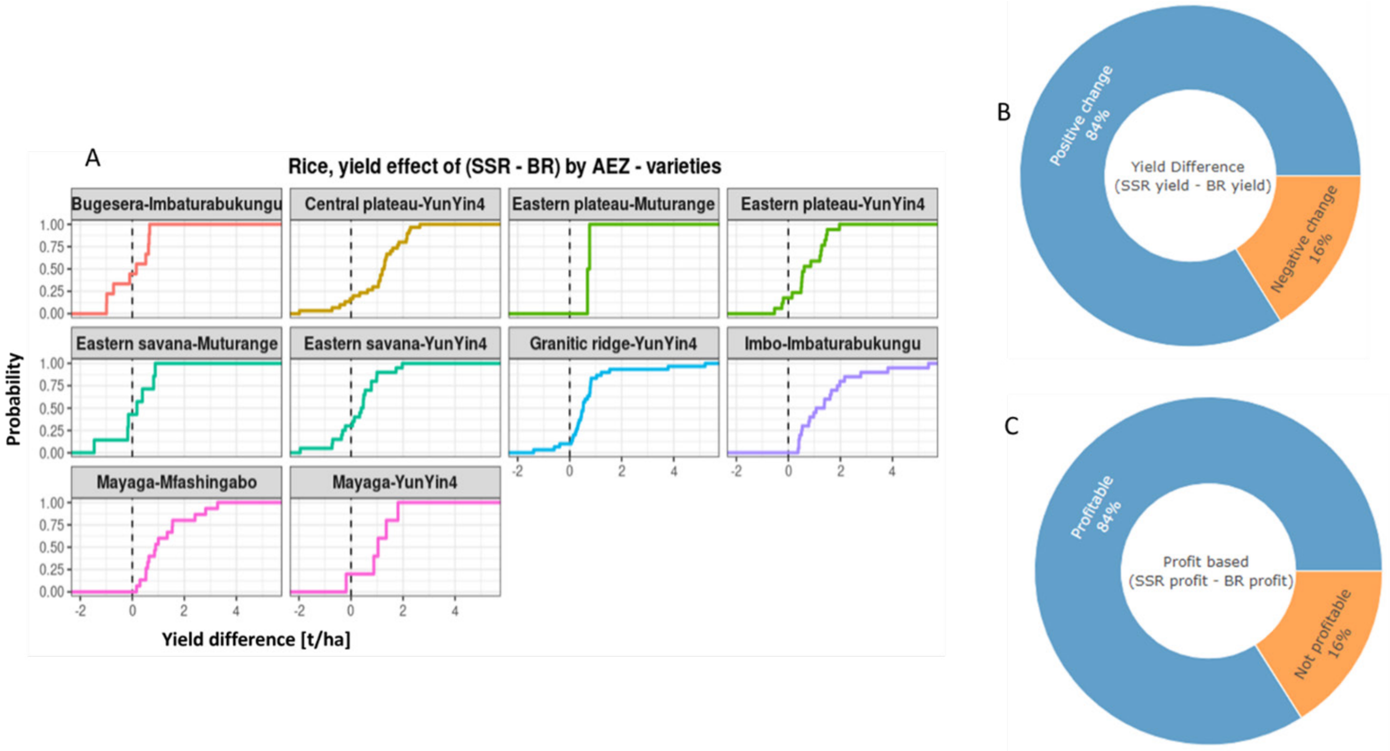


Figure 12: A) The yield difference between site-specific recommendation (SSR) and blanket recommendation (BR), disaggregated by AEZ and rice varieties, **B)** the percentage yield difference between SSR and BR, **C)** the percentage profitability difference provided by SSR over the BR using 550RWF/kg of rice and 650RWF/kg of fertilizer input.

The success rate of achieving a 20% yield increase using the site-specific recommendation.

The success rate of achieving a 20% yield increase varies across different regions. In the best-case scenario, achieved by over 75% of farmers, Mayaga and the Central Plateau demonstrate exceptional performance (**Figure 13 A**). This suggests that most farmers in these regions can achieve significant yield improvements, exceeding the targeted 20% increase with the implementation of appropriate agricultural practices, possibly including SSR. However, in the worst-case scenario, no farmers in Bugesera were able to achieve a 20% yield increase. This highlights the challenges and limitations faced in this region, potentially due to unfavourable agroecological conditions or other contextual factors that hinder yield improvement efforts. These findings reiterate the importance of considering regional differences and tailoring agricultural interventions to specific local contexts to maximize success rates and promote sustainable agricultural development.

The detailed breakdown of yield outcomes comparing SSR+20% to the BR are demonstrated in **Figure 13.**

1. Forty-eight percent of farmers achieve at least a 20% or more yield increase using SSR compared to BR (**Figure 13B**). This indicates that nearly half of the farmers experience substantial improvements in yield, meeting or exceeding the targeted 20% increase with SSR implementation.
2. Fifty-two percent of farmers, however, did not achieve a 20% yield increase. This suggests that slightly over half of the farmers did not reach the desired level of yield improvement with SSR compared to BR.
3. Thirty-two percent of farmers experienced a yield increase with SSR, although it falls short of the targeted 20% improvement over BR yield. Despite not reaching the specified threshold, these farmers still benefit from yield increases compared to using the conventional BR method.
4. Regarding profitability 16% get less yield with SSR than with BR (**Figure 13 C**).

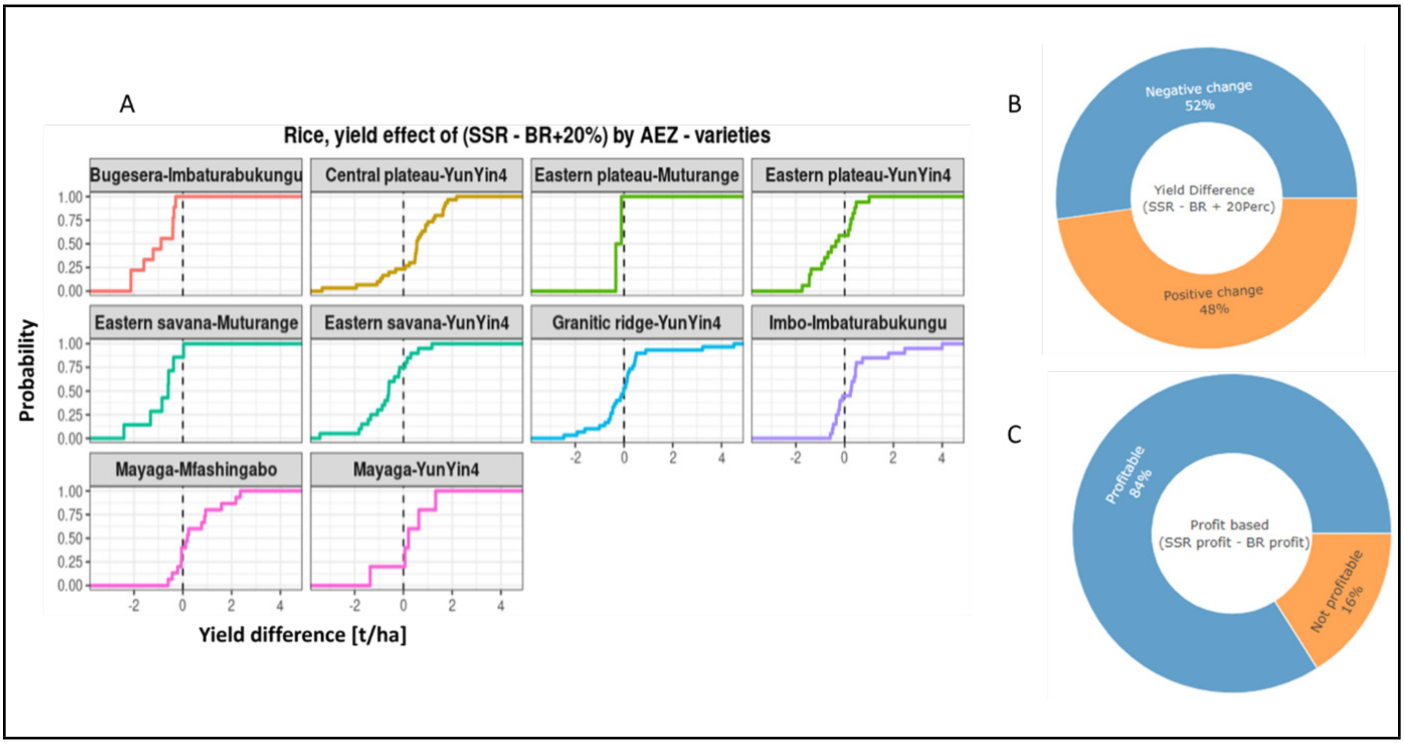


Figure 13: A) The yield difference between site-specific recommendation (SSR)+20% and blanket recommendation (BR), disaggregated by agroecological zone (AEZ) and rice varieties, **B)** the percentage yield difference between SSR+20% and BR, and **C)** the percentage profitability difference provided by SSR+20% over the BR using 550RWF/kg of rice and 650RWF/kg of fertilizer input.

Overall, although not all farmers achieve the promised 20% increase over BR yield, a significant majority (84%) realize a profitable yield increase with SSR. This indicates that the SSR approach remains beneficial for many farmers, contributing to improved agricultural productivity and profitability.

Conclusions

In conclusion, the findings from the validation trials on fertilizer recommendations present invaluable insights for government policymakers seeking to optimize agricultural productivity and sustainability in Rwanda. The demonstrated effectiveness of SSR compared to BR underscores the potential of precision agriculture techniques to address the diverse needs of farmers across different agroecological zones. As such, policymakers are encouraged to prioritize the integration of digital tools, such as the Rwanda Soil Information System (RwaSIS), into extension services to facilitate the dissemination of tailored fertilizer recommendations.

Based on these findings, several recommendations can be proposed for government policymakers. Firstly, there is a pressing need to scale up the implementation of SSR-based fertilizer recommendations, leveraging partnerships with research institutions and private sector stakeholders to ensure widespread adoption among smallholder farmers. Additionally, investment in digital infrastructure and capacity-building initiatives is essential to enhance the accessibility and usability of agricultural data, empowering farmers to make informed decisions and optimize resource allocation. Furthermore, targeted interventions should be designed to address specific challenges faced by farmers in regions with unique agroecological dynamics, such as Bugesera, through tailored extension services and support mechanisms.

Overall, by embracing evidence-based policymaking and fostering collaboration between stakeholders, government policymakers can effectively leverage the findings from these trials to drive sustainable agricultural development and improve livelihoods for Rwandan farmers. By prioritizing the adoption of site-specific recommendations and investing in digital innovation, Rwanda can harness the full potential of its agricultural sector to achieve food security, economic prosperity, and environmental sustainability for generations to come.

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