



REPUBLIC OF RWANDA
RWANDA AGRICULTURE AND ANIMAL RESOURCES
DEVELOPMENT BOARD (RAB)



Huye-Rwanda

RAB ANNUAL REPORT FOR THE YEAR 2023/2024

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LIST OF ACRONYMS

BBTD – Banana Bunchy Top Disease
BXW – Banana Xanthomonas wilt
CATAS – Chinese Academy of Agriculture Science
CBD – Coffee Berry Disease
CBSD – Cassava Brown Streak Disease
CFU – Colony-forming unit per gram
CMD – Cassava Mosaic Disease
CYMMIT – International Maize and Wheat Improvement Center
DVM –...Decentralized Vine multipliers for sweet potato
DUC – Distrincness, Uniformity and Stability
EGS – Early Generation Seed
EPN – entomo-pathogenic nematodes
FAW – Fall Army Worm
FFS – Farmer Field School
GAP – Good Agronomic Practices
HCoE – Hoericulture Center of Excellence
ICIPE – International center for Insect Physiology and Ecology
IPM – Integrated Pest Management
MLN or MLND – Maize Lethal Necrosis Disease
NPT – National Performance trials
NST-1 – National Strategy for Transformation
OFSP –Orange Flesh Sweet Potato
OECD - Organization for Economic Cooperation and Development
QDS – Quality Declared Seed
RBA – Rwanda Broadcasting Agency
RNDP - Rwanda National Dairy Platform
RSB – Rwanda Standard Board
RYAF – Rwanda Youth for Agribusiness Forum
SNP - single-nucleotide polymorphism
SAH – semi-autotrophic hydroponic
SEDO – Socio-economic Development office at cell level
SME – Small and Medium Enterprise
TLB – Turicum Leaf Blight
UPOV – The International Union for the Protection of new Varieties of Plants
UR-CAVM –University of Rwanda, Colledge of Agriculture and Veterinary Medicine
WCR – World Coffee Research VCU (soya)

FOREWORD



Agriculture forms the important part of Rwandan economy with the majority of the population depending on it for living. In FY 2023-2024, Agriculture and Livestock sectors contributed 25% of the National GDP with annual growth rate of 7%. The current Agriculture Policy aims to promote market oriented and professional agriculture, to achieve increased yields, better quality and quantity of agricultural produce using modern technologies and innovations.

Rwanda Agriculture and Animal Resourced Development Board aims to develop technologies to increase yield and reduce losses to improve food security and income from agriculture and livestock. The research and extension activities in the Fiscal Year 2019-2020 were guided by key National policy documents – National Strategy for Transformation (NST-1) and Strategic Plan for Agriculture Transformation (SPAT-4), prioritizing crop and livestock intensification with increased irrigation and mechanization, addressing climate change and improving storage and postharvest handling.

I have a pleasure to introduce this annual report which shares the key achievements and milestones targeting to develop technologies that improve food security, generate income, create jobs, and improve wealth, particularly for small-scale farmers. The achievements described in this report include research and technology transfer for Crops, Livestock, Land Husbandry, Irrigation and Mechanization Departments and SPIU – Single Project Implementation Unit. Agricultural production within Rwanda Agriculture Board (RAB) is primarily carried out across in strategically 12 stations located in various districts of the country. These stations are central to executing a range of key research and seed production activities as well as livestock breeding and key laboratories for crops and livestock management at national level which are designed to enhance agricultural productivity and sustainability and manage any disease outbreaks.

RAB coordinates efforts working closely with various partners in Agricultural sector, namely, agro-dealers and NGOs to increase input use, training of frontline extension agents and mobilizing farmers for timely preparation and implementation of the seasons. Integration of RAB staff, Local Government and private sector was a key strategy for increasing agriculture production, supply, distribution and delivery of inputs, namely, fertilizers and seeds to strengthen the entire agriculture value chain. RAB Board of Directors would like to appreciate support given to RAB by the Government through MINAGRI, local government agencies, private sector, NGOs and CBOs, other local and international partners. I also thank RAB management team and staff for their dedication to achieve institutional targets that contribute to National Development Goals.

Dr. Ndambe Nzaramba Magnifique
Chairperson of the Board of Directors of RAB

EXECUTIVE SUMMARY



The Rwanda Agriculture and Animal Resources Development Board (RAB) is integral to advancing Rwanda's agricultural sector, focusing on increasing productivity, enhancing food security, and promoting sustainable farming practices. Our initiatives are closely aligned with national strategies such as the National Strategy for Transformation (NST1) and the Strategic Plan for the Transformation of Agriculture (PSTA-4), which aim to develop a resilient agricultural economy through innovative collaboration across public and private sectors.

In FY 2023-2024, Rwanda demonstrated a strong commitment to boosting agricultural productivity through several strategic initiatives. A notable highlight is the Crop Intensification Program (CIP), which has effectively provided farmers with improved seeds in adequate quantities, leading to greater productivity and improved livelihoods for many Rwandans. The government, through the Ministry of Agriculture and Animal Resources (MINAGRI), has fostered an enabling environment for private sector investments in seed production and marketing. This effort has significantly increased the availability of early generation seeds (EGS) produced by RAB and supplied to private seed multipliers, ensuring farmers have access to high-quality and high-yield varieties. This Annual Report for FY 2023-2024 presents a comprehensive overview of RAB's activities and accomplishments over the past fiscal year, highlighting our commitment to advancing agricultural research, technology transfer, irrigation, and mechanization. Below are the key achievements across our various programs, along with some challenges that remain:

The **Cereal Program** reported significant advancements in maize, rice, and wheat production initiatives. Key achievements include the selection of eight new hybrid maize varieties with traits like fall armyworm tolerance, production of over 219.7 kg of breeder seeds, engagement of 13,933 farmer promoters (with 95% selecting high-performing maize), preparation of three new rice varieties across 63 demonstration plots, and the introduction of nine new wheat genotypes that achieved an average yield of 3,801 kg/ha. However, challenges arose with ensuring consistent seed production and addressing environmental stresses like drought.

The **Pulses and Oil Crops Program** aims to enhance the productivity of legume crops, particularly beans and soybeans. Notable achievements include the evaluation of nine bean lines and five soybean lines for potential release, the establishment of 6,768 demonstration plots (3,696 for beans and 3,072 for soybeans), and average yields of 1.83 t/ha for bush beans, 3.1 t/ha for climbing beans, and 1.74 t/ha for soybeans. Yet, challenges such as accessing farmers for yield assessments and adverse weather conditions impacted overall crop performance.

The **Roots and Tubers Program** focused on developing resilient varieties and enhancing production of Irish potatoes, sweet potatoes, and cassava. Key achievements included advancing three climate-resilient potato varieties to pre-release, producing 105,500 high-yielding sweet potato plantlets, and generating 120,127 cassava plantlets, achieving an average yield of 21.3 t/ha. However, delays in crop maturation affected data collection and limited budgets hindered training and extension activities.

The Banana Program addressed major production constraints, achieving the introduction of 11 new banana varieties resistant to fusarium wilt and the rehabilitation of 11,813.38 hectares of banana plantations. A total of 2,745 farmers were trained in banana rehabilitation and pest/disease control. Despite these successes, challenges included limited awareness among farmers regarding disease management, necessitating further training initiatives.

The RAB Horticulture Program made substantial progress in enhancing fruit and vegetable production, as evidenced by the on-farm evaluation of new hot pepper varieties that outperformed common varieties. Notable achievements included training 2,745 farmers, benefiting 4,499 participants through Farmer Field Schools (FFS), and establishing seed production plots for passion fruit. However, challenges such as adverse weather impacting trials and the threat of soil-borne diseases in greenhouse tomatoes posed ongoing issues.

In the area of biotechnology, the RAB **Plant and Microbial Biotechnology Program** saw significant advancements, highlighting the successful production of 2,035,810 potato plantlets and 12,450 banana plantlets. The program also produced 5,700 packets of rhizobium inoculants. Nevertheless, challenges arose regarding budget constraints for training and the management of disease pathogens affecting crops.

The **Crop Protection Program** achieved significant milestones in enhancing food security through integrated pest management strategies, with approximately 75% of farmers adopting sustainable practices. The program provided training to over 10,000 farmers, conducted around 90 field visits for monitoring, and distributed about 1,700 liters of pesticides. Persistent challenges included the need for continued education on sustainable practices and pest outbreaks threatening yields.

For the **Traditional Export Crops Program**, significant advancements in the coffee and tea sectors were noted, including the introduction of 28 new coffee varieties with high yield potential exceeding 4.8 kg/tree. Moreover, 3,500 kg of genetically pure coffee seeds were produced, enabling the potential reproduction of 8.5 million seedlings. The program also developed site-specific fertilizer recommendations, leading to a projected yield increase of 20% for coffee.

The **Crop Postharvest and Processing Division** reported a 175% increase in dried produce through drying machines, exceeding targets by 24,536 metric tons, while market access linked to local cooperatives reached 167,555 metric tons. Despite this success, challenges persisted, including limited market linkages for smallholder farmers and the need for enhanced awareness regarding aflatoxin contamination.

Overall, the **Seed and Fertilizer Program** successfully distributed a total of 4,156,332 kg of seeds in Season 2024A, primarily maize, soybeans, and wheat, with additional distributions in Season 2024B. The program achieved total annual fertilizer consumption of 78,061,476 kg, although over-reliance on mineral fertilizers raised concerns.

RAB achieved a total **Seed production** of 811,148.6 kg through its 12 stations, with a notable performance in maize and beans. Challenges included climate variability affecting yields, insufficient irrigation facilities, and a shortage of high-quality planting materials, underscoring the need for increased investments in irrigation and farm machinery.

In **agricultural extension services**, RAB trained 18,481 extension staff and mobilized over 2 million farmers in the Smart Nkunganire system. However, logistical issues and variability in crop

yields across regions remained challenging. Similarly, the **RAB Genetic Resources Management Program** successfully conserved 1,650 plant genetic resources and 403 local animal genetic resources, despite constrained funding limiting planned activities.

The **Animal Resources component** saw significant achievements, with 978 farmers trained in pasture management, although challenges remained related to environmental conditions and funding shortfalls. The **Ruminant Program** trained over 978 farmers while achieving an assessment of grazing land carrying capacity and substantial production of crop residues. Despite successes, environmental fluctuations and resource limitations hindered full potential.

Noteworthy advancements occurred in the **Monogastric Program**, particularly in pig farming facilitated by artificial insemination, which saw a preference for AI over natural mating among 93% of surveyed farmers. The **Veterinary Services** department made impressive strides in vaccination efforts, with over 2.2 million animals vaccinated, yet faced ongoing needs for public awareness and improved diagnostic facilities.

In **aquaculture**, significant milestones included the production of over 52 million fish fingerlings and training for 1,737 fish farmers in best practices. Meanwhile, the **Apiculture and Commercial Insect Program** trained 200 master beekeepers, although there was a need for standardization across different hive types due to variability in honey production.

The **National Animal Genetic Improvement Center (NAGIC)** focused on enhancing cattle genetics, producing 188,049 doses of bovine semen, while the Animal Resources Processing and Biotechnology Division achieved significant milestones in the dairy and livestock sectors, training 419 dairy value chain actors and processing over 93 million liters of milk.

The **Integrated Soil Fertility Management Program** achieved impressive results, including the construction of over 142,000 hectares of radical terraces. Yet, challenges persisted regarding soil health management and the need for better communication with farmers. The **Analytical Laboratory for Soil, Plant, and Water Program** conducted comprehensive soil surveys, revealing critical nutrient deficiencies. Finally, the **Irrigation Program** made strides with the rehabilitation of 200 hectares of marshland and the management of over 3,500 hectares by youth cooperatives, although challenges related to climate impacts emerged. The **Agricultural Mechanization Program** saw progress as well, mechanizing nearly 9,700 hectares, despite the need for additional machinery.

The **Rwanda Dairy Development Project (RDDP)** successfully distributed 1,594 hectares of forage and trained 290 facilitators, while the Commercialization and De-risking for Agricultural Transformation Project (**CDAT**) resulted in significant advancements, including 4,177 hectares adjusted through land husbandry practices.

In brief, this Annual Report for FY 2023-2024 illustrates RAB's commitment to achieving agricultural productivity and food security in Rwanda through targeted programs and initiatives.

Dr. Telesphore Ndabamenye
Director General

I.CROP INNOVATION AND DEPARTMENT

1.1 Cereal Program

1.1.1 Maize

New cereal crop varieties selected or proposed for future release

Eight new maize hybrid varieties comprising six tolerant to fall armyworm, one tolerant to drought and one extra-early maturity were selected from previous evaluations to be officially released, registered on the national variety catalogue and ultimately to be used by farmers because of the specific traits they carry. Six of them belong to RAB while two were obtained from CIMMYT under specific license. The RAB new cultivars were obtained by combing CIMMYT and RAB parent inbred lines (Table 1, Photo 1).

Table 1: New cultivars from crossing CIMMYT and RAB parent inbred lines

No	Names	Type of hybrid	Origin of P1	Origin of P2	Origin of P3	Specific traits	Origin
1	RHMM2003	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	RAB
2	RHMM2005	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	RAB
3	RHMM2012	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	RAB
4	RHMM2014	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	RAB
5	FAWTH2001	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	CIMMYT
6	FAWTH2003	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Fall armyworm tolerant	CIMMYT
7	RHMM2015	Three-Way Cross	CIMMYT	CIMMYT	CIMMYT	Drought tolerant	RAB
8	RHMM2027	Three-Way Cross	CIMMYT	RAB	RAB	Extra-early maturity	RAB

The preparation of the eight new maize hybrid varieties was conducted at Cyabayaga and Rubona RAB research stations in 2024 A and 2024 B seasons through producing enough seeds, describing the parent inbred using UPOV (International Union for the Protection of New Varieties of Plants) guidelines and formation of the parent single cross hybrids.

Description of the parent inbred lines using the UPOV guidelines

Ten parent inbred lines: CML576, CML334, CML330, CML332, CKDHL0089, CML543, CKSB10008, CKDHL120348, CKDHL166087 and CM442 were planted in Cyabayaga and Rubona sites in 2024 A season for description using UPOV guidelines for checking the distinctiveness and the uniformity of the parent. They were also planted in the season 2024 B for checking the stability of the characters. The UPOV guidelines for maize crop has around 40 traits. The eight new maize hybrid varieties have in total 24 parent inbred lines. However, only 10 have been described because the varieties share parent inbred lines and include the parent released and widely grown hybrid varieties. Those released parent inbred lines are fully described.



Photo 1: RHMM2012 maize variety tolerant to fall armyworm at 56 days, Rubona (left); fall armyworm susceptible variety at 56 days, Rubona (right)

Parent inbred line seed increase

The seed increase of nine parent inbred lines was conducted in Cyabayaga site in 2024 A and 2024 B seasons. A total of 18.4 kg of seeds were produced in the season 2024 A whereas it is expected to 51.4 kg of seeds after harvesting the season 2024 B in July 2024 (Table 2). The seeds of the parents will be used to start the seed production when the hybrid varieties will be officially released. Both the seeds of the parent inbred lines, the parent single cross hybrid and the three-way cross hybrid are required for testing the DUS (Distinct Uniform, Stable) for the variety and its parents.

Table 2: Maize seed increase from nine parental inbred lines

No	Name of the parent inbred line	Quantity of seeds produced in 2024 A	Quantity of seeds (kg) expected after harvesting the season 2024 B	Total
1	CML576	3.2	5	8.2
2	CML334	3.3	4	7.3
3	CML330	2.5	3	3.5
4	CML332	0.5	3	3.5
5	CKDHL0089	1.1	4	5.1
6	CML543	1.3	3	4.3
7	CKSB 10008	3.2	5	8.2
8	CKDHL120348	1.6	3.5	5.1
9	CKDHL166087	1.7	2.5	4.2
Total		18.4	33	51.4

Formation of the parent single cross hybrid maize varieties

The formation of the parent single cross hybrid varieties was conducted in Cyabayaga site in 2024 A and in 2024 B seasons. A total of 2.66 kg of seeds were obtained in the season 2024 A whereas a total of 3.5 kg is expected after the harvest of the season 2024 B in July 2024 (Table 3). The

seeds of the parent single cross hybrid varieties will be used in 2025 A to describe these parents and to produce seeds of the three-way cross hybrid varieties.

Table 3: Formation of eight parent single cross hybrid maize varieties

No	Names of the parent single cross	Quantity of seeds (kg) produced in 2024 A	Quantity of seeds (kg) expected after harvesting the season 2024 B	Total
1	CML576/CML442	0.36	0.5	0.86
2	CML334/CML442	0.27	0.4	0.67
3	CML576/CML488	0.29	0.3	0.59
4	CML576/CML488	0.41	0.5	0.91
5	CKDHL0089/CML543	0.43	0.6	1.03
6	CKDHL120348/CKDHL166087	0.25	0.4	0.65
7	CML444/CML489	0.31	0.4	0.71
8	CML539/RML0011	0.34	0.4	0.74
Total		2.66	3.5	6.16

Evaluation of new maize hybrid varieties with superior traits

Thirteen new mid altitude maize hybrid varieties were formed in the previous seasons by combining CIMMYT and RAB inbred lines while targeting extra-earliness, drought and Maize Lethal Necrosis (MLN) traits. Furthermore, 37 new high altitudes maize hybrid varieties were formed in the previous seasons by combining CIMMYT and RAB inbred lines as well and targeting specifically extra-earliness trait.

The 13 new maize hybrid varieties for mid altitude were evaluated in comparison with two commercial checks: RHM1407 and RHM1409 in Cyabayaga (Nyagatare) (Photo 2), Mahama (Ngoma), Rubona (Huye) and Bugarama (Rusizi) sites in the Season 2024 A (September 2023-February 2024) and 2024 B season (February-July 2024). At the same time, the 37 new maize hybrid varieties were evaluated in comparison with three commercial checks: RHHM1520, RHHM1601 and RHHM1611 and conducted in Rubona (Huye), Rwerere (Burera), Kinigi (Musanze) and Tamira. The trials of the season 2024 A season have been harvested and data analyzed to be included in this report whereas the trials of 2024 B season in mid altitudes sites have been harvested, but the data are not yet available for analysis and the trials in Kinigi and Tamira are still the field.

Grain yield (t/ha at 15 % grain moisture) was the major agronomic trait recorded. Grain yields were obtained by weighing the total number of ears harvested in a plot and obtaining the fresh weight in kg (FW). At the same time, a sample of kernels was taken in the middle of ten selected ears and was used to determine the grain moisture in % (GM) using a portable moisture-meter.

Ears were thereafter dried at constant grain moisture, weighted to have the dry weight (DW) in kg and then shelled to obtain the grain weight (GW) in kg. Taking A as the distance (in m) between rows and B the distance (in m) between hills at planting, C the length (in m) of harvested rows, and D the number of rows harvested, grain yield (GY) in t/ha at 15% of grain moisture was

obtained by the following formula: $GY = 10 \times \frac{FW}{A \times (B + C) \times D} \times \frac{100 - GM}{100 - 15} \times \frac{GW}{DW}$.

Table 4: Three promising maize varieties evaluated from mid altitude trials in FY2023-24

No	Names	Anthesis (d)	Silking (d)	ASI (d)	TLB	Grain yield (t/ha)	% increase from best check
1	RHMM1702	66.1	67.9	1.8	2.3	8.15	15.9
2	RHMM2325	71.0	72.2	1.2	2.3	8.13	15.6
3	RHMM1823	69.8	71.2	1.4	2.4	7.28	3.6
4	RHM1409	68.1	69.2	1.1	2.3	7.03	
5	RHM1407	67.7	68.9	1.1	2.5	6.65	
Means		68.5	69.9	1.4	2.3	7.45	
C.V. (%)		2	2.2	72.1	12.3	24.8	
F		48.52	38.71	1.95	1.58	3.79	
P		<0.001	<0.001	0.029	0.096	<0.001	

ASI: Anthesis-Silking Interval

TLB: Turcicum Leaf Blight disease

Other agronomic traits observed included anthesis (d), silking (d), Anthesis to Silking Interval (ASI) (d), plant height (m) and Turcicum Leaf Blight (TLB) disease severity rating (1-5) (scale 1 to 5). The anthesis was recorded by considering the number of days from planting to when 50 % of the plants in the plot shed pollen. Silking was recorded in days after planting by considering the number of days from planting to when 50 % of plants in the plot showed silks. The ASI was obtained by the difference between silking and anthesis. The plant height was measured in m on ten selected plants in the plot from the plant base up to the point where the tassel started to branch and TLB severity rating was recorded using a scale of 1 to 5 where “1=Absence of symptoms”, “2=Low presence of symptoms”, “3=Moderate symptoms”, “4=Heavy symptoms, the whole plant bears the symptoms except the panicle” and “5=The whole plant is very heavily infested including panicle, plants are dying”.

Table 5: Four promising maize varieties evaluated from high altitude trials in FY 2023-24

N	Names	Anthesis (d)	Silking (d)	ASI (d)	Plant height (m)	TLB	Grain yield (t/ha)	% increase from best check
1	RHMH2305	101.2	103.4	2.3	1.84	2.4	8.35	8.9
2	RHMH2315	108.3	111.3	2.9	1.76	2.5	8.10	5.7
3	RHMH2301	105.6	107.9	2.3	2.05	2.5	8.03	4.7
4	RHMH2308	105.9	108.8	2.9	1.71	2.1	7.83	2.1
6	RHMH1601	110.3	112.6	2.3	1.82	2.5	7.66	-
7	RHMH1520	112.8	116.1	3.3	1.86	2.5	6.26	-
8	RHMH1611	111.6	114.4	2.8	1.76	2.8	6.04	-
Mean		106.8	109.3	2.5	1.78	2.7	6.57	-
C.V. (%)		2.3	2.3	37.6	7.5	14.5	21.9	-
F		20.81	20.67	3.44	8.65	10.52	6.65	-
P		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-

ASI: Anthesis-Silking Interval

TLB: Turcicum Leaf Blight disease

In the season 2024 A, significant differences were observed between varieties ($P < 0.001$) in all mid altitude and high altitude trials for anthesis, silking, plant height, ASI for high altitude only, TLB for high altitude trials only and grain yield. The differences between varieties were significant at $P = 0.029$ for TLB in mid altitude trials while they not significant for ASI ($P > 0.05$). In mid altitude trials three promising new maize hybrid over yielded the best checks (Table 4) whereas in high altitude four promising new maize hybrid cultivars over yielded the best check (Table 5).



Photo 2: Maize variety resistant to *Turcicum Leaf Blight* (TLB) disease (left) and susceptible variety (right), Cyabayaga (Nyagatare), 2024 A season

New maize inbred lines and their development to high level of inbreeding

Around 190 inbred lines were advanced to high level of inbreeding through pedigree methods or were involved in seed increase with the final reduction to 108 inbred lines (Table 6).

Table 6: Maize inbred lines advanced to high levels of inbreeding or involved in seed increase

No	Type of materials	Number	Procedures	Final number	Germplasm
1	S1 inbred lines for high altitudes	82	Advancing S1 inbred lines to S2 stage	30	Open Pollinated Variety ROMH171
2	S3 and S4 inbred lines for mid altitudes	43	Seed increase of 14 orange and 29 white kernels inbred lines introduced from CIMMYT-Zimbabwe	20	Various germplasm
3	S4 inbred lines for mid altitudes	6	Advancing S4 inbred lines to S5 and seed increase	6	ECAVL16, ECAVL1/ECAVEL16, Extra-early population
4	S6 inbred lines for mid altitudes	10	Advancing S6 inbred lines to S7 and seed increase	10	ECAVL16, ECAVL1/ECAVEL16, Extra-early population
5	S5 inbred lines for high altitudes	13	Advancing from S5 to S6 stage	6	Cross between Pool9a and Pool4C0 introduced from CIMMYT-Mexico
6	S8 inbred lines	18	Seed increase	18	Version of Pool 8a with white kernels, Pool 9a, populations developed from local ecotypes
7	Provitamin A yellow kernel inbred lines	18	Seed increase	18	Various germplasm from CIMMYT
Total		190		100	

The germplasm of the inbred lines in development included Open Pollinated Varieties, local populations developed by using local ecotypes and the crosses of local germplasm with the germplasm introduced from CIMMYT. The advancement to high levels of inbreeding is always accompanied with the reduction in number of inbred lines in order to have adequate number easily handled in crossing and the discarding of inbred lines with defects, very susceptible to diseases or non-adapted to local conditions. The seed increase of inbred lines aimed at having enough seeds to undertake the next steps of studying the combining abilities through test-crosses or mating designs crosses.

Breeder’s seed production of maize hybrid varieties widely grown by farmers

The breeder’s seed production from parent inbred lines of six maize hybrid varieties being widely grown by farmers was performed in Cyabayaga, Musanze and Rubona sites. The six maize hybrid varieties widely grown by farmers are: RHM1402, RHM1407, RHM1409, RHM1520, RHM1601 and RHM1611 (Table 4). A total of 219.7 kg of breeder’s seeds were produced (Table 7). The continuous supply of breeder’s seeds to the seed value chain helps sustaining the seed sector and prevent the certified seed shortage.

Table 7: Breeder’s seeds of maize hybrid varieties widely grown by farmers or in seed production

No	Codes	Hybrid variety for which the inbred line is parent	Sites of production	Quantity of seeds (g)
1	P001	RHM1402	Cyabayaga, Musanze	9.5
2	P002	RHM1402, RHM1407, RHM1409	Cyabayaga, Musanze	21.4
3	P003	RHM1407	Cyabayaga	25.1
4	P004	RHM1407, RHM1409	Cyabayaga	31.5
5	P005	RHM1402, RHM1409	Cyabayaga	6
6	P006	RHM1520, RHM1601, RHM1611	Musanze, Cyabayaga	43.5
7	P007	RHM1601	Musanze, Cyabayaga	27.1
8	P008	RHM1601, RHM1611	Cyabayaga, Musanze	14.8
9	P009	RHM1611	Musanze, Rubona, Cyabayaga	10.5
10	P010	RHM1520	Musanze, Cyabayaga	10.1
11	P011	RHM1520	Musanze, Cyabayaga	19.6
Total				219.1

In the three consecutive seasons 2023 A, 2023 B and 2024 A around 10,815.1 tonnes of seeds were distributed for planting. RAB maize hybrid varieties provided 6282.4 tonnes (58.1 %) while the varieties of the regional seed companies provided 4532.7 tonnes (41.9 %). The varieties RHM1407 and RHM1409 contributed 4,873.0 tonnes (45.1%) of seeds. RHM1407 contributed alone 3,041.1 tonnes (28.1%) whereas RHM1409 provided 1831.9 (16.9 %) (Figure 1). The contribution of RAB maize hybrid varieties require a sustainable breeders’ seed production system and the provision each year of consequent quantity of seeds.

Demonstration of RAB maize hybrid varieties widely grown by farmers

The demonstration plots with farmer promoters were conducted at cell level where all Farmer promoters of a Cell planted one variety. Each farmer promoter was given seeds of a variety and

mineral fertilizers for planting a single plot of 10 m×10m (100m²). The quantity of seeds was 0.3 kg per farmer promoter, the quantity of DAP (18-046-0) was 1 kg per farmer promoter and the quantity of urea was 1 kg per farmer promoter. Six RAB maize hybrid varieties being under wide dissemination including three for mid altitude: RHM1402, RHM1407 and RHM1409 and three for high altitudes: RHHM1520 RHHM1601 and RHHM1611 were used in the demonstration plots (Table 8). A total of 13,956 farmer promoters distributed in all districts implemented the demonstration plots.

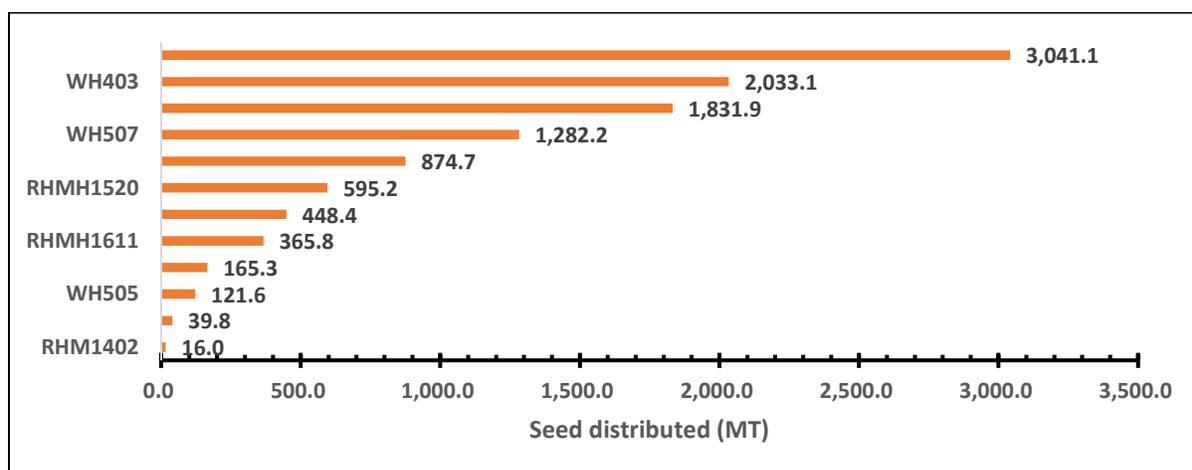


Figure 1: Distribution of maize certified seed for planting in the 2023A, 2023B and 2024A.

However, 13,933 (99.8%) farmer promoters completed them and provided the feedback on their choice of varieties using the following criteria: 1) Excellent variety, with all needed attributes and high yielding, it is the variety of our choice and from now we will grow it; 2) Good variety, with some of needed attributes, it is fairly yielding, and we will grow it as an alternative if there are no other options; 3) Worse variety with poor yield, it lacks the needed attributes, we cannot accept it. About 3,804 farmer promoters harvested RHM1409, 2,998 harvested RHM1407, 2,005 harvested RHHM1611, 1,920 harvested RHHM1601, 1,781 harvested RHM1402 while 1,375 harvested RHHM1520 (Figure 2). A total of 13,236 (95.0) farmer promoters made the varieties their first choice, 482 (3.5 %) their second choice and 215 (1.5 %) their third choice (Figure 3).

Table 8: RAB maize varieties used in the demonstration plots

N	Names	Ecology	Specific traits	Status
1	RHM1402	Mid altitude	Drought and MLN tolerant	Grown at low extent
2	RHM1407	Mid altitude	Drought and MLN tolerant, TLB and MSV resistant	First variety to be grown by farmers
3	RHM1409	Mid altitude	Drought and MLN tolerant, TLB and MSV resistant	Second variety to be grown by farmers
4	RHHM1520	High altitude	MLN tolerant, early	Grown at low extent
5	RHHM1601	High altitude	MLN tolerant, early	Grown at low extent
6	RHHM1611	High altitude	Early maturity	Grown at low extent

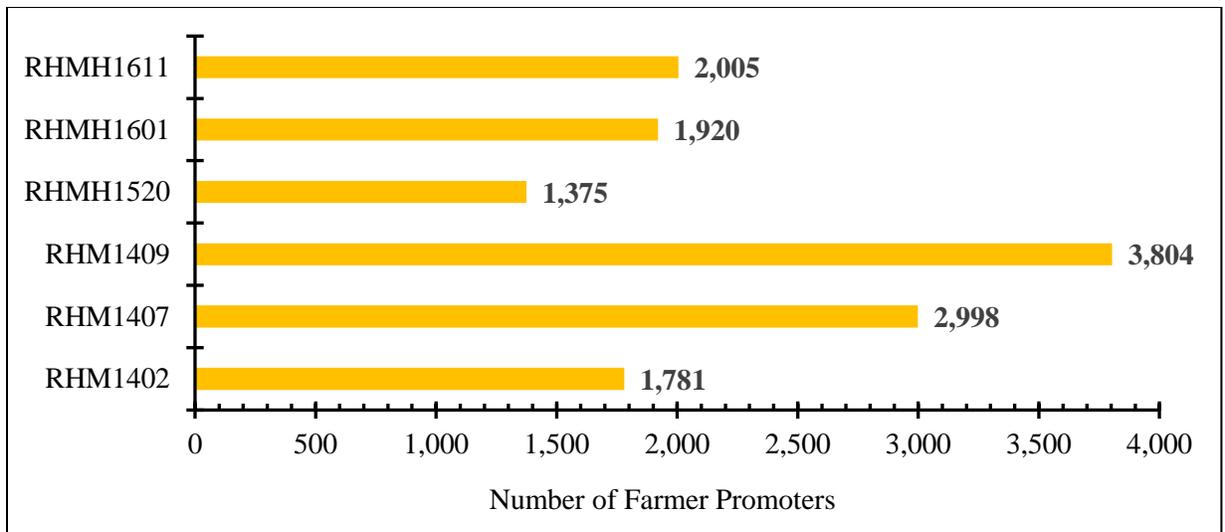


Figure 2: Number of farmer promoters who harvested each variety

In general, all the varieties in the demonstration plots were highly appreciated and farmers' promoters made them their first choice. The variety RHM1407 was the most preferred as 99.2% of farmers' promoters made it their first choice. More than 98.0% appreciated the varieties RHM1407, RHM1409, RHM1601 and RHM1611 as their first choice (Figure 3).

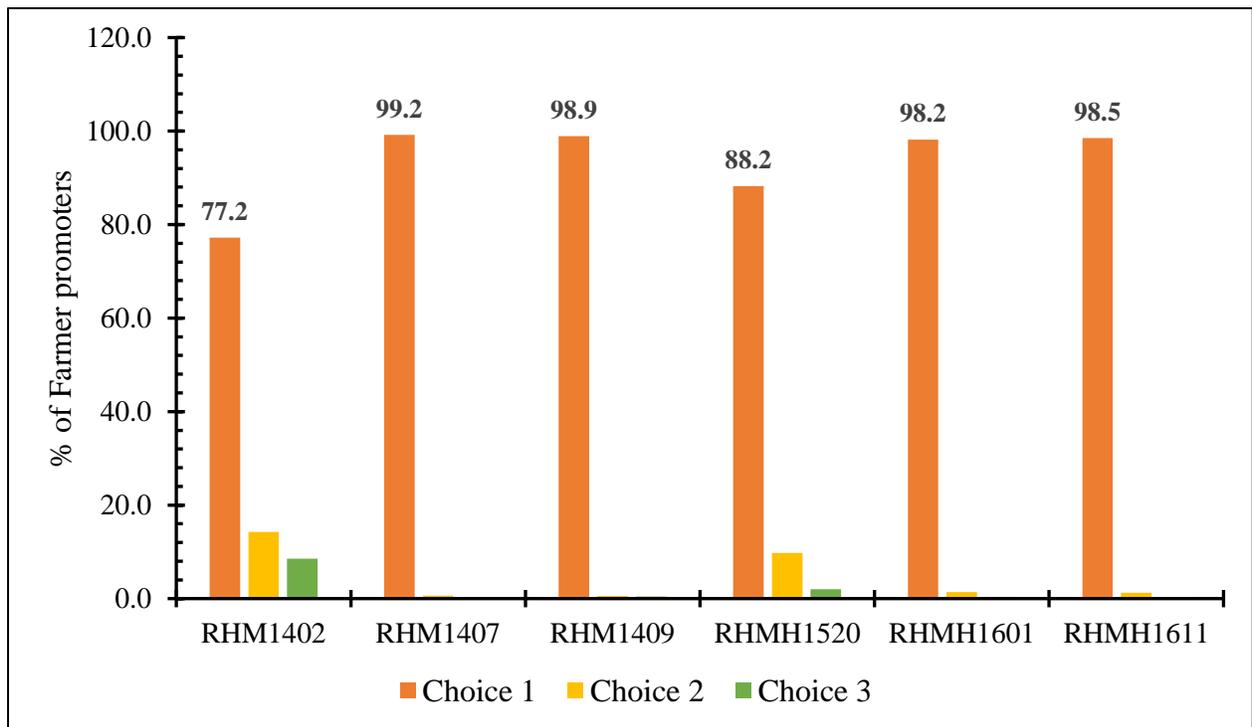


Figure 3: Distribution of choices per variety

Evaluation of conservation agriculture practice with champion farmers

A total of 435 selected champion farmers (CFs) with at least one (1) champion farmer per Sector conducted the conservation agriculture experiments. The Champion farmers were supervised by their respective Sector Agriculture Officers (SAOs). Each champion farmer planted two treatments side by side: **Treatment 1:** Mulching + minimum tillage = Conservation agriculture practice (CAP); **Treatment 2:** Standard practices (SP) = No mulching + full tillage as commonly practiced = Standard practice (SP). Each treatment was planted on a plot size of 10.5 m × 10 m = 105 m². This plot was made of 15 rows of 10 m length planted at spacing of 0.75 m between rows and 0.50 m between planting stations. The planting rows were perpendicular to the side measuring 10.5 m and parallel to the side measuring 10 m (Figure 4). The plant stand was two seedlings per planting station and a planting density of 53,868 plants per ha. The rows and the planting stations were marked while applying organic manure one week before sowing or when applying lime two weeks before planting. The planting rows were perpendicular to the side measuring 10.5 m and parallel to the side measuring 10 m (Figure 4). The minimum tillage was achieved through:

- controlling the weeds in the treatment 1 (CAP) by scraping the soil when weeds were freshly emerging from the soil;
- during planting, by slightly and gently opening the soil and making a hole for planting without significant disturbance of the soil, then depositing the required fertilizers and required seeds by avoiding the contact of seeds with fertilizers;
- The mulching was applied at seeding by using any source of materials such as crop residues and grasses and ensuring that the soil of the plot was completely covered.
- The no-mulching status was achieved by removing any crop residue and remaining of plants while ploughing including roots and stalks. Furthermore, the field was toughly free of weeds, by removing them including uprooting them as soon as they appeared in the field.
- The full tillage was done as usually practiced comprising the first and the second ploughing. The weeding was conducted as commonly practiced by removing them including uprooting as soon as they appeared in the field.

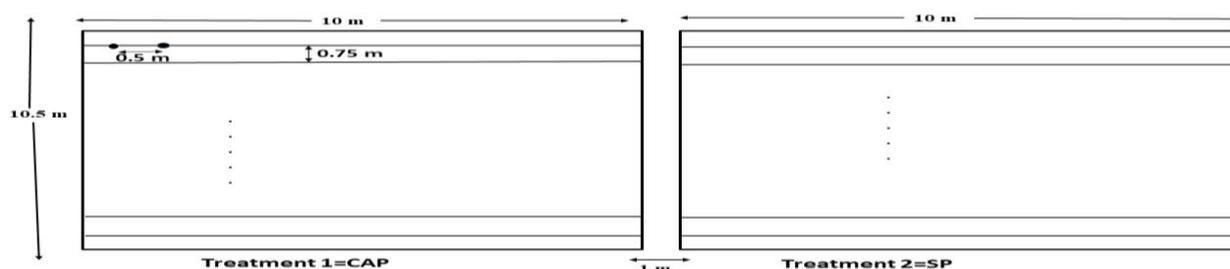


Figure 4: Spacing in conservation agriculture experiments

In the treatment 1 (CAP), the lines of the rows were displayed by ropes and the planting holes were marked using a steak. In the treatment 2 (SP), the rows were drawn in the soil and the planting stations were marked in the each drawn row.

Common agricultural practices

Lime application Lime was applied two weeks before sowing. It was used in field plots having a soil pH equal or below 5.5. In the treatment 1 (CAP), it was applied while marking the planting stations. The planting rows were displayed by a rope or similar materials while digging the soil was completely avoided. Then, the planting stations were displayed by a steak in each row. A content of a cover of content Fanta bottle (4 g) was placed in the hole created by the steak used to mark the planting stations. In fact, the recommendation is the application of 750 kg of lime per ha or 0.75 kg per are. In the treatment 2 (SP), lime was broadcasted in the plot before ploughing. It was incorporated in the soil by ploughing (first and second ploughing). It was applied 750 kg/ha of lime or 0.75 kg per are as well.

Organic manure application The organic manure was applied one week before planting using rate of 10,000 kg per ha or 100 kg per are. This is equivalent to two handfuls of manure per planting hole. In the treatment 1 (CAP), the soil was slightly and gently opened by making very minimum and necessary soil disturbance and the planting hole was gently dug using hands or a steak in each marked planting station. Thereafter, the content of two handful of organic manure was placed in the planting hole by making sure not to disturb the soil.

In the treatment 2 (SP), a hole having approximately a depth of 5 cm was dug in each planting station using the usual tools such as a hoe and a steak. A content of two handful of organic manure was placed in this planting hole.

Application of a mixture of DAP (18-46-0) and urea (46-0-00) at planting

At planting a mixture of 1 kg of DAP and 1 kg per are or 100 kg of DAP and 100 kg per ha are were applied at sowing. This quantity is equivalent to the content of two (2) Fanta bottle covers (4 g for each cover and 8 g for two covers) per planting station. In the treatment 1 (CAP), this content was gently and precociously placed on the top of organic manure by not distributing the structure of the soil. Then, soil was added on the top of the mixture for preventing the contact of the seeds with mineral fertilizers. In the treatment 2 (SP), the content of two (2) Fanta bottle covers of the mixture was put on the top of the organic manure in the planting hole up to 3 cm-depth. Then soil was put on the top of the mineral fertilizers to avoid the contact of seeds with mineral fertilizers.

Weeding

In the Treatment 1 (CAP), the soil was scraped when the weeds were emerging from the soil and the weeds were removed while they were still very young and fragile whereas in the treatment 2 (SP), the weeds were thoroughly removed as they come in field from planting up to dough stage.

Top dressing

The top dressing was performed in both treatments six to seven weeks after plant or when the plants were at eight (8) leaves stage (V8) using 100 kg of urea (46-0-00) per ha or 1 kg of urea per are. This is equivalent to the content of one (1) Fanta cover per planting station. In the treatment 1 (CAP), the soil was slightly and gently opened around the plants at a distance of approximately

7 cm from where plants were standing and the quantity of urea equal to the content of one (1) Fanta bottle cover placed around the plants in the planting station. Then the opened soil was gently and precariously closed. In the treatment 2 (SP), a row with 2 cm to 3 cm of depth was dug around the planting hole a distance of 7 cm from this hole and the quantity of urea equal to the content of one (1) Fanta bottle cover was spread in that row. There after the row was covered with soil.

Varieties

The varieties were the maize hybrid cultivars usually grown by farmers including RHM1407, RHM1409, RHMH1520, RHMH1601, RHMH1611, WH403, WH507 and WH605. The same variety was planted on the two treatments side-by-side in each champion farmer field.

Data recording

1-Planting date: The date when the two treatments were planted at each champion farmer was recorded. The two treatments had to be planted on the same day at each champion farmer.

2- Anthesis (ANT)(d): It was the time, recorded in days (d) after sowing, between sowing date and when 50 % of plants per plot shed pollen.

3- Silking (SIL)(d): It was the time, recorded in days (d) after sowing, between sowing date and when 50 % of plants per plot showed silk emergence.

4- Anthesis-Silking Interval (ASI) (d): The difference between silking and anthesis;

5-Plant height (HT)(cm): It was determined by considering 5 to 10 plants selected at random in each treatment and measuring the distance (cm) from the soil (plant base) to the point where tassel starts to branch and thereafter calculating the average.

Grain yield

Harvested plot: During harvest the two rows at the borders of each elementary plots were discarded and hence it remained only 13 rows per plot. Furthermore, the two planting stations at the ends of each row were ignored as well. Hence, only 19 planting stations per each row were harvested.

Field weight (FW) (kg): All the ears of the harvested plot were taken from the stalks. After removing the husks, the weight in kg of the di-husked ears of each treatment was directly taken.

Grain moisture content at harvest (GM) (%): A grain sample from a bulk of ears by following the moisture-meter specifications was taken and used to measure the grain moisture content at harvest on the same day with the field weight.

Weight of ears after drying or dry weight (DW): This was the weight recorded in kg when ears harvested in each treatment were completely dried before shelling them.

Weight (GW) (kg): The grain weight was measured after shelling by weighting all the grains in kg obtained from each treatment.

Grain yield (kg/ha at 15% grain moisture content): Taking A as the distance (in m) between rows and B the distance (in m) between planting stations at harvest, C the length (in m) of harvested rows in harvested plot (in the present experiment the 9 m), and D the number of rows harvested

(in the present experiment 13), FW: field weight at harvest (in kg), GM: grain moisture content at harvest (in %), DW the dry weight (in kg) after drying the ears and GW, the grain weight (in kg) obtained after shelling, the grain yield (GY) in kg/ha at 15% of grain moisture content was obtained by the formula:

$$GY = \frac{FW \times 10000}{A \times (B+C) \times D} \times \frac{100-GM}{100-85} \times \frac{GW}{DW}. \text{ The grain yield in t/ha was: } : GY = \frac{FW \times 10}{A \times (B+C) \times D} \times \frac{100-GM}{100-85} \times \frac{GW}{DW}.$$

Remarks: If the ratio GW/DW called shelling ratio was not known, it was replaced by 0.8. Hence the formula to calculate the grain yield at 15 % grain moisture content became:

$$GY(kg/ha) = \frac{FW \times 10000}{A \times (B+C) \times D} \times \frac{100-GM}{100-85} \times 0.8 = GY = \frac{FW \times 10000}{A \times (B+C) \times D} \times \frac{100-GM}{15} \times 0.8$$

$$\text{or } GY(t/ha) = \frac{FW \times 10}{A \times (B+C) \times D} \times \frac{100-GM}{15} \times 0.8.$$

A total of 435 farmers conducted the experiments. However only 393 (90.3 %) completed them. Some experiments were destroyed, others champion farmers planted another crop than maize while some of them plant a different variety on the treatment 1, than on the treatment 2. Around 267 (67.9%) Champion Farmers were males whereas 126 (32.1 %) were females. Around 145 champion farmers were more than 50 years, 80 had an age between 46 years and 50 years, 82 between 41 and 45, 49 between 36 and 40, 24 between 31 and 35, 9 between 26 and 30. Only 4 champion farmers had age between 20 and 25 (Figure 5).

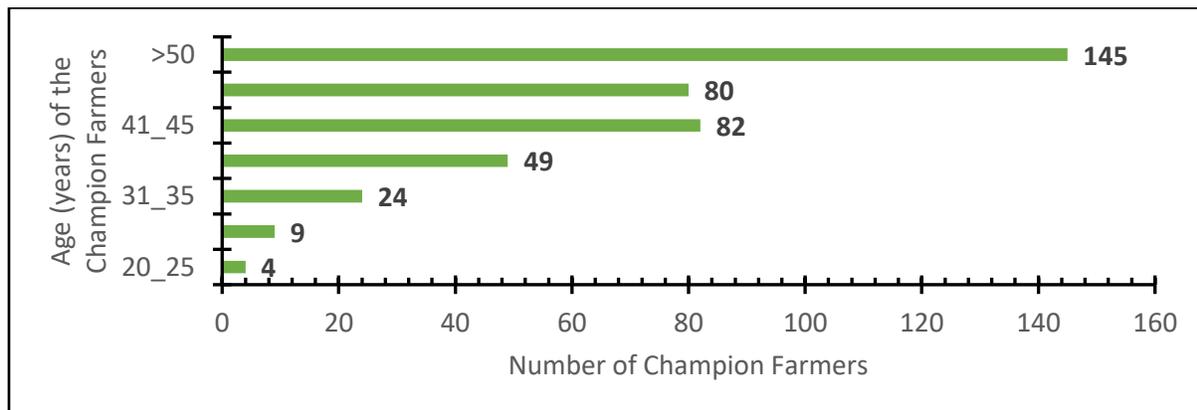


Figure 5: Age of Champion Farmers that conducted the experiments on conservation agriculture

A total of 104 champion farmers recorded all the traits that included anthesis, silking, ASI, plant height, TLB severity rating and grain at 15 % grain moisture content. A total of 155 recorded anthesis, silking, ASI and plant height, and 174 of them recorded the grain yield only. Moreover, 219 champion farmers (55.7%) reported variety used in the experiments whereas 174 did not report any variety (Figure 6).

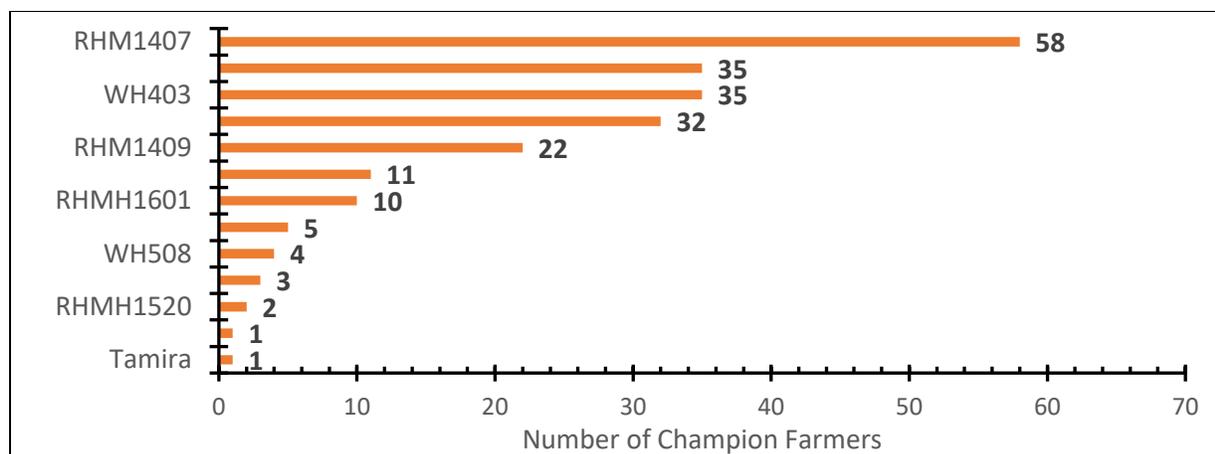


Figure 6: The maize hybrid varieties used in conservation agriculture experiments

A paired samples t test was conducted to compare the conservation agriculture practice with the standard practice for anthesis, silking, ASI, plant height and grain yield. The test showed that the anthesis and silking under conservation agriculture was significantly inferior ($P < 0.001$) to those under the standard practice. However, the ASI under conservation agriculture was not different ($P = 0.057$) to that under standard practice (Table 9). The results confirmed that the conservation agriculture practices reduced significantly the anthesis and the silking (Table 10).

Table 9: Paired samples t test for conservation agriculture practice and standard practice

No	Trait	Null hypothesis	Alternate hypothesis	t	DF	P
1	Anthesis	Anthesis of varieties under CAP is equal to that under SP	Anthesis of varieties under CAP is inferior to that under SP	9.52	213	<0.001
2	Silking	Silking of varieties under CAP is equal to that under SP	Silking of varieties under CAP is inferior to that under SP	10.06	213	<0.001
3	ASI	ASI of varieties under CAP is equal to that under SP	ASI of varieties under CAP is superior to that under SP	1.59	213	0.057
4	Plant height	Plant height of varieties under CAP is equal to that under SP	Plant height of varieties under CAP is superior to that under SP	14.88	207	<0.001
5	Grain yield	Grain yield of varieties under CAP is equal to that under SP	Gain yield of varieties under CAP is superior to that under SP	19.39	277	<0.001

Table 10: The means of anthesis, silking, ASI, plant height and grain yield under conservation agriculture and standard practice

Parameter	Conservation agriculture practice					Standard practice				
	ANT	SIL	ASI	PHT	GYD	ANT	SIL	ASI	PHT	GYD
Mean	77.1	79.6	2.5	2.57	5.32	79.3	81.9	2.6	2.30	3.75
STD	14.8	14.8	1.1	0.54	2.35	15.0	15.0	1.0	0.54	1.74
Number	214	214	214	208	278	214	214	214	208	278
SE	1.0	1.0	0.1	0.04	0.14	1.0	1.0	0.1	0.04	0.10
Max	114	117	8	3.96	13.51	116	119	8	3.43	12.76
Min	40	43	0	1.30	1.49	40	43	0	1.00	1.34
Range	74	74	8	2.66	12.02	76	76	8	2.43	11.42

STD – Standard deviation; SE – Standard error; ANT: Days to Anthesis; SIL – Days to Silking; PHT – Plant Height, m; ASI: Anthesis-Silking Interval, days; GYD: Grain yield (t/ha)



Photo 3: Conservation agriculture for Maize (CA) versus standard practice (SP), RAB demonstration plots, FY 2023-24

The t-test indicated that the plant height under conservation agriculture was significantly superior ($P < 0.001$) to that under standard practice implying that the conservation agriculture increases the plant height of varieties. Moreover, the same test indicated that grain yield under conservation agriculture was significantly superior ($P < 0.001$) to that under standard practice indicating that conservation agriculture increased grain yields (Table 10, Photo 3).

The anthesis under conservation agriculture was 2.2 days earlier than that under standard practice and the silking under conservation agriculture was 2.3 days earlier than that under standard practice. The plant height was 0.3 m greater than that under standard practice while the grain yield under conservation agriculture surpassed that under standard practice for 1.57 t/ha (Table 10). The results showed that the conservation agriculture shortened anthesis and silking and increase the plant height and the grain yield. In conclusion, the conservation agriculture reduced the growing cycle, increase the growth and the grain yield of maize.

Demonstration of RAB maize hybrid varieties widely grown by farmers

The demonstration plots with the Farmer Promoters were conducted at cell level where all the Farmer Promoters of a Cell planted one variety. Each Farmer Promoter was given seeds of a variety and mineral fertilizers for planting a single plot of 10 m×10m (100m²). The quantity of seeds was 0.3 kg per farmer promoter, the quantity of DAP (18-046-0) was 1 kg per farmers' promotor and the quantity of urea was 1 kg per farmers' promotor. Six RAB maize hybrid varieties being under wide dissemination including three for mid altitude: RHM1402, RHM1407 and RHM1409 and three for high altitude: RHMH1520 RHMH1601 and RHMH1611 were used in the demonstration plots (Table 11). A total of 13,956 Farmer Promoters distributed in all Districts of Rwanda except Kigali City implemented the demonstration plots. However, around 13,933 (99.8 %) Farmer Promoters completed the demonstration plots and provided the feedback on their choice of varieties using the following criteria: 1) The variety is excellent, it has the needed

attributes, it is high yielding, it is the variety of our choice and from now we will grow it; 2)The variety is good, it has some needed attributes, it is fairly yielding, we will grow it as an alternative if there are no other options; 3) The performance of the variety is worse, it is poorly performing, it lacks the needed attributes, we cannot accept it.

Around 3,804 farmer promoters harvested RHM1409, 2,998 harvest RHM1407, 2005 harvested RHM1611, 1920 harvested RHM1601, 1,781 harvested RHM1402 while 1,375 harvested RHM1520 (Figure 7). A total of 13,236 (95%) farmer promoters made these varieties their first choice, 482 (3.5 %) their second choice and 215 (1.5 %) their third choice.

Table 11: RAB varieties used in the demonstration plots

No	Names	Ecology	Specific traits	Status
1	RHM1402	Mid altitude	Drought and MLN tolerant	Grown at low extend
2	RHM1407	Mid altitude	Drought and MLN tolerant, TLB and MSV resistant	First variety to be grown by farmers
3	RHM1409	Mid altitude	Drought and MLN tolerant, TLB and MSV resistant	Second variety to be grown by farmers
4	RHMH1520	High altitude	MLN tolerant, early	Grown at low extend
5	RHMH1601	High altitude	MLN tolerant, early	Grown at low extend
6	RHMH1611	High altitude	Early maturity	Grown at low extend

MLN – Maize Lethal Necrosis disease; TLB – Turicum Leaf Blight disease

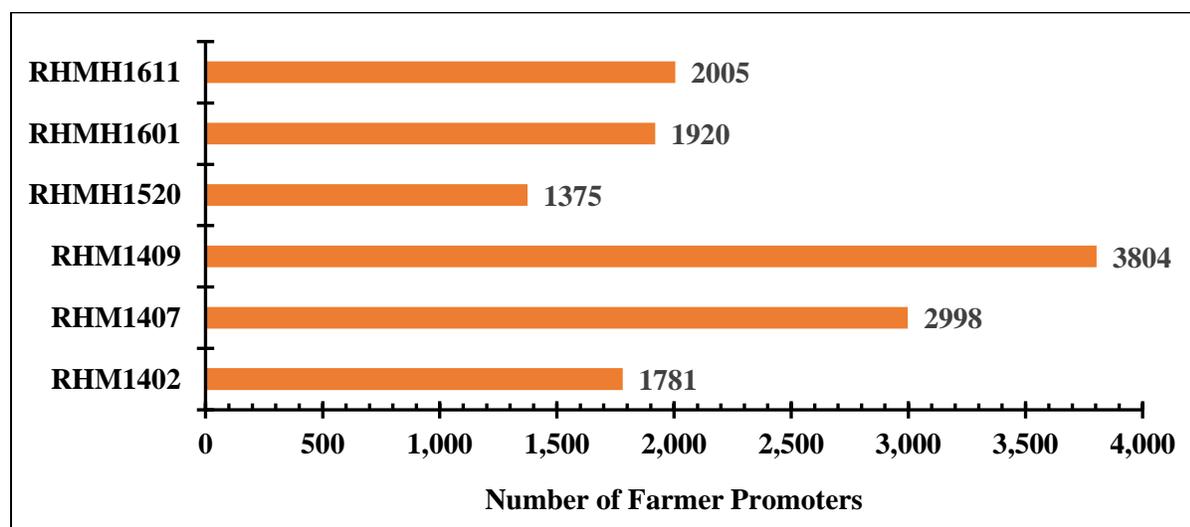


Figure 7: Number of farmer Promoters that harvested each variety

All varieties in the demonstration plots were highly appreciated and farmer promoters having made them as first choice (Figure 8). The variety RHM1407 was the most preferred as 99.2% of farmers' promoters made it their first choice. More than 98% appreciated the varieties RHM1407, RHM1409, RHM1601 and RHM1611 as their first choice (Figure 8).

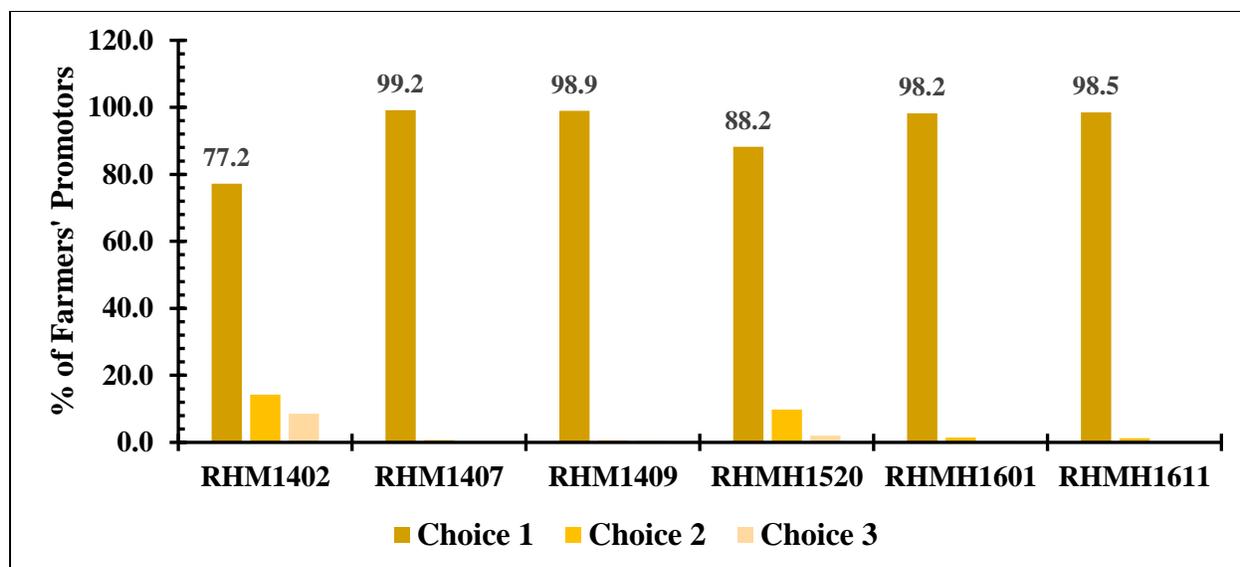


Figure 8: Distribution of choices per variety

Estimation of maize productivity

Criteria used to select Districts in which to conduct maize yield was assessed: The District of Nyagatare, Gatsibo, Kayonza, Kirehe, Musanze, Gakenke, Burera and Gisagara were used to estimate the current maize productivity because of the following factors: Contribution of high percentage of maize grains to the nation maize production in the year 2023; Presence of large famers or maize farmers' cooperatives that have consolidated land; Presence of maize fields in mono-cropping under good management practices because the fields with intercropping or mixed crops, fields under poor management, fields affected by drought or any other stresses are not to be considered; District having maize fields meeting the minimum of good agricultural practices (use of improved seeds, use of mineral or and organic fertilizers, correct spacing, control of weeds etc.).

Sampling method: The sampling methodology and the estimation of the yield followed the following steps: Get a tape or any tool than can be used to measure a length like a stick of 1 m; Choose the fields preferentially in consolidated sites, big farms maize cooperative' fields where improved agriculture practices (use of fertilizers, improved seeds, recommended spacing etc.) have been used; Visit the potential sites to be used for the assessment and agree with the owners of the plot the date of harvest; During harvest, consider the field to be sampled and go somewhere inside the fields; Avoid the parts of the fields under erosion, drought, extremely severe nutrient deficiency, especially nitrogen deficiency, flooded parts etc. Determine a square with a side of 5 m. The surface of the square is 25m² (Figure 9); Count the number of plants in that square; Count the number of ears in that square; Choose at random in that square 3 to 10 ears depending on the agreement with the owner of the fields; Remove them from the stalks and take their weights in kg (do not remove the husks); Get the average weight of an ear by dividing the obtained weight by the number of considered ears.

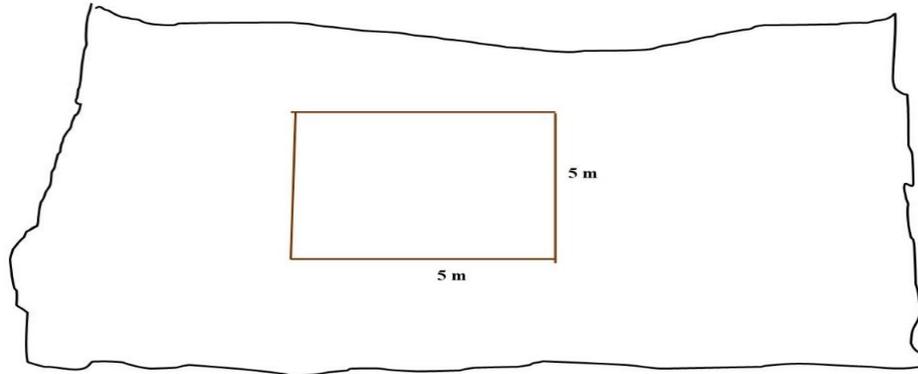


Figure 9: Maize yield square

Estimation of yield in kg/ha for this site by the following formula:

- Grain yield (kg/ha) = Average ear weight × number of ears from the square × 400 × 0.28;
- Grain yield (t/ha) = Average ear weight × number of ears from the square × 0.4 × 0.28.

Remarks

- 1) 400 is the yield conversion coefficient from 25 m² to one hectare (1 ha);
- 2) 0.28 is the reduction coefficient of the yield in weight of ears to yield in weight of grains.

Estimation of the grain maize yield: A total of 131 samples were collected in five Districts: Nyagatare, Gatsibo, Kayonza, Kirehe, Musanze, Gakenke, Burera and Gisagara on land area equal to 6,892 ha. Around 14,490 ears were measured. The average grain yield was calculated to be 5,138.0 kg/ha (5.14 MT/ha) with the maximum value of 9708.2 kg/ha (9.71 MT/ha) and a minimum value of 2,361.0 kg/ha (2.36 MT/ha) giving a range of 7347.2 kg/ha (7.35 MT/ha). The standard deviation was 1,420.1 kg/ha (1.42 MT/ha) while the standard error of means was 124.1 kg/ha (0.12 MT/ha). Therefore, the grain yield of maize in consolidated land is estimated to be 5.14±0.12 MT/ha.

1.2.1 Rice

Preparation of new rice varieties for official release

The nurseries of Teta 24-1, Teta 24-2, Keza were established for developing descriptors using UPOV guidelines for future release. The UPOV guidelines for rice crop has 65 traits. The description of these varieties was completed and showed that the plant culm was intermediate less than 105 cm whereas the tillering was classified as high with more than 15 panicles per plant. The flowering dates was around 100 days after sowing which fitted with rice ecologies in Rwanda and maturity of around 150 days after sowing. All the three varieties are long grain and translucency. Additionally, Keza is aromatic. Those traits will make the local rice more competitive in market with imported rice from Tanzania and Asian countries. The descriptors and the performance in previous evaluations trials were used to submit these three rice varieties for official release.

New long grain or aromatic rice varieties in adaptability trials

The experiments were conducted in Cyili and Cyimpima research sites located in Gisagara District in Southern Province and Rwamagana District in Eastern province. Ten new rice lines (including 1 check) were tried in advanced yield trials. The design was randomized complete block design. The spacing between plots was 50 cm and the plant density per plot was 25 plants per square meter. The fertilization was done using the NPK (17-17-17) and urea (46-0-0) by 80 kg of nitrogen, 37 kg of phosphorous and 37 kg of potassium per ha. The NPK was used as basal whereas urea was top dressing and splitting two applications in two specific stages of growth. The plots were watered in intermittence during the whole cycle of the plants. The following traits were recorded. They included yield (t/ha), plant culm, panicle length, panicles number per plant, flowering date, maturity date and grain size. The results showed that five varieties: KF210077, KF210055, KF210054, KF210053, KF210029 were high or equally yielding than the check KIGOLI 89-2. KF210055 had a culm length more than 110 cm meaning it may lodge in case of heavy wind. The maturity of the tested cultivars was intermediate medium. Four varieties had high tillering ability with number of panicles superior to 20 panicles per hill. KF210053, KF210054, KF210055 and KF 210057 were long grain varieties and showed high yielding potential (Table 12).

Table 12: Performance of 10 new rice varieties in adaptability trials

No	Variety	Paddy yield (t/ha)	Culm length (cm)	Flowering (days)	Number of panicles per hill	Panicle length (cm)	Maturity (Days)	Grain size
1	KF210076	4.3	81.0	103	19.6	20.8	136	Long
2	KF210010	4.0	78.6	108	16.6	18.8	147	Long
3	KF210077	6.7	79.0	112	16.8	22.2	136	Long
4	KF210053	6.9	67.6	108	11.8	20.6	136	Long
5	KF210057	6.4	80.8	112	22.2	21.2	147	Long
6	KF210021	5.1	81.5	112	17.4	19.8	147	Medium
7	KF210054	7.5	76.6	108	20.6	20	136	Long
8	KF210029	6.7	72.6	112	15.4	20.2	136	Medium
9	KF210055	7.2	114.6	108	16	22.4	136	Long
10	KF210078	5.3	81.4	112	18.8	20.4	146	Long
11	Kigoli 89-2	6.7	100.4	103	18.6	19	136	Short
Means		6.1	83.1	109	17.6	20.5	140	

Formation on new rice aromatic lines

Table 13: Number of F1 rice seeds obtained by crossing aromatic with local adapted varieties

No	Crosses	Pollination time	Number of seeds harvested
1	Keza X RBN 22-1	94	50
2	Keza X RBN 20-6	94	7
3	RBN017 X ART347-1-1-1	98	24
4	RBN017 X ART 143-95-B-1-B-B	98	22
5	RBN017 X AR19E019-F4-33-1	97	15
7	KEZA X KF 20040	94	25
8	Basmati 370X KF20040	94	15
9	RBN 14 X KF20040	96	12
10	Agasaro 13-1 X KF 20040	93	17
Total			187

Parents for crossing with aroma traits were selected: KF20040, RBN 22-1, RBN 20-6, ART347-1-1-1, ART143-95-B-1-B-B, AR19E019-F4-33-1 (males) with Keza, RBN017, Basmati 370, RBN 14 and Agasaro 13-1 (local female parents). These crosses will target aroma where parents KF20040, Keza and RBN 17 are highly aromatic. The 10 new populations obtained through crossing with rice parents with aroma constitute are key source of rice aromatic varieties (Table 13).

Early generation seed production from rice varieties

Rice early generation seeds (EGS) comprise breeder's and pre-basic seeds. However, currently only breeder's seed were produced for rice varieties widely grown by farmers. The rice breeder's seeds help to sustain the rice value chain via supply for basic seed production. A total of 204 kg of breeder's seed were produced from 21 varieties and they will be used to produce pre-basic seeds next year (Table 14).

Table 14: Breeder production from rice varieties widely grown by farmers

No	Variety	Quantity(kg)	No	Variety	Quantity(kg)
1	Yun Yin	12	12	Imbaturabukungu	11
2	Umujagi	10	13	Muturage	5
3	Yun Er Tian	8	14	Rumbuka	5
4	Yun Keng	6	15	Nemeyubutaka	7
5	V30	10	16	Ndamirabahinzi	7
6	Gakire	8	17	Mpembuke	3
7	Fashingabo	11	18	Fashingabo	16
8	Insindagirabigega	10	19	Imbaturabukungu	20
9	Mbakungahaze	6	20	Twigire	16
10	Tubuka	11	21	Basmati	16
11	Buryohe	6		Total	204

Table 15: Demonstration plots on long grain and aromatic rice varieties

N	Coop or Marshland (Site)	Varieties	Number of plots
1	Huye/Rwasave/KOAIKWA	Agasaro 24-3, Teta24-1, Teta24-2, Umujagi	4
2	Huye/Rusuli/Cooprroz Rusuri	Agasaro24-3, Teta24-1, Teta24-2	3
3	Huye/Migina/ubumwe Tumba	Umujagi, Muturage, Rumbuka, Fashingabo Umutebo, Cyuzuzo, Mbakungahaze, WAT	8
4	Gisagara/Migina//KOABINYA	Umujagi, V30, Umutebo, Cyuzuzo, Gwiza, Mbakungahaze	6
5	Kamonyi/CORIMU	Teta24-1, Teta24-2, Agasaro24-3	3
6	Ngoma/CORIMI	Teta 24-1, Teta 24-2, Agasaro 24-3	3
7	Kayonza/Gacaca	Teta 24-1, Teta 24-2, Agasaro 24-3	3
8	Bugesera/Gashora	Teta 24-1, Teta 24-2, Teta 24-3	3
9	Ngoma/Gitinga	Teta 24-1, Teta 24-2, Teta 24-3, Agasaro 24-A, Icyerekezo 24-A	5
10	Gasabo/Kabuye	Teta 24-1, Teta 24-2, Agasaro 24-3	3
11	Bugesera/CORINYABURIBA	Teta 24-1, Teta 24-2, Agasaro 24-3	3
12	Rwamagana/Rugende	Teta 03-1, Teta 06-1, Teta 10-2, Kigoli 13-1	4
13	Bugesera/Rurambi	Teta 24-1, Teta 24-2, Agasaro 24-3	3
14	Rwamagana/TWIBUMBE/Bugugu	Teta 24-1, Teta 24-2, Agasaro 24-3	3
15	Rwamagana/TWIBUMBE/Buriba	Teta 24-1, Teta 24-2, Teta 24-3	3
16	Rwamagana/TWIBUMBE/Cyuruhogo	Teta 24-1, Teta 24-2, Teta 24-3	3
17	Rwamagana/TWIBUMBE/Cyimpima	Teta 24-1, Teta 24-2, Teta 24-3	3
Total: 17 sites			63 demo-plots

Demonstration plots on aromatic rice varieties

The demonstration plots were established with selected rice cooperatives in 17 sites (marshlands). A total of 21 rice varieties were involved in the demonstration plots. They include three new rice varieties: Agasaro 24-3, Teta24-1 and Teta24-2 submitted for official release. The three varieties are long grain type. Furthermore, Agasaro 24-3 is aromatic. A total of 63 demonstration plots were conducted (Table 15) and the cooperatives much appreciated the three rice varieties submitted for official release.

Estimation of rice productivity

The yield assessment was conducted in 12 Districts namely Nyagatare, Gatsibo, Kayonza, Ngoma, Bugesera, Gasabo, Kamonyi, Nyanza, Gisagara, Ruhango, Huye and Rusizi. The staff from RAB service providers including Yalla, Yalla and Yean, rice agriculture officers from cooperatives and RAB staff were involved in data collection. The methodology used for the yield estimate was a two-step method involving sampling the crop and calculate the yield with emphasis on stratification. The sampling was based on zones within the cooperatives and plots within zones. Twenty plots were selected and each plot had 0.05 ha to cover 1 ha per variety. The measurements considered were plot size, production received per plot, grain moisture content used to estimate the grain yield at 14%. The average yield per category of rice paddy was estimated as follow: long grain 5.24 MT/ha, medium 4.97 MT/ ha and short grain 4.86 MT/ha. In general, the average yield was estimated to be 5.01 MT/ha. These yield estimates were used for paddy pricing for season 2024 B at farm gate where short grain price was fixed at 500 Frw/kg, medium grain 505 Frw/kg, long grain 515 Frw/kg and Basmati 775 Frw/kg.

1.1.3 Wheat

Preparation of new wheat varieties for official release

Nine genotypes were selected from different screening nurseries or different yield trials introduced from CIMMYT-Mexico. These nurseries and trials included Elite Spring Wheat Yield Trial (ESWYT), International Bread Wheat Screening Nursery (IBWSN) and Stem Rust Resistance Screening Nursery (STEMRRSN). Nine genotypes were selected based on higher grain yield potential, tolerance to abiotic stresses such drought, resistance to major pests and diseases such as rusts, powdery mildew, fusarium head blight, short stature to avoid the damages caused by lodging, and many other desirable traits (Table 16).

The nine selected genotypes were planted with the local check, Gihundo, in Rwerere, Kinigi and Nyamagabe sites in 2024 A and 2024 B seasons. The experimental was the randomized completely block design (RCBD) in three replications with 3x4m plot size, the seeds were hand-drilled in six rows of two meters long and spaced at 0.20 m per plot. Data have been collected on plant vigor, number of days to booting, heading, flowering and physiological maturity stages, pests and diseases resistance, plant height, tolerance to lodging and drought stresses, potential yield, head size and shape, seed traits and many of other traits found in UPOV guidelines to describe the varieties candidate for future release. The descriptors of the season 2024 A are available while those of 2024 B will be available after harvest in July 2024.

Table 16: New wheat varieties selected from nurseries and introduced from CIMMYT-Mexico

No	Source of genotype		Pedigree
1	36 th ESWYT	115	KACHU*2/BECARD
2	37 th ESWYT	133	KACHU/SAUAL*2/3/TACUPETO F2001/BRAMBLING//KIRITATI
3	39 th ESWYT	144	NADI#1*2/3/MUTUS/AKURI #1//MUTUS
4	50 th IBWSN	1039	FRET2/KUKUNA//FRET2/3/YANAC/4/FRET2/KIRITATI/5/2*UP2338*2/S HAMA/3/MILAN/KAUZ//CHIL/CHUM18/4/UP2338*2/SHAMA
5	51 st IBWSN	1143	KINGBIRD #1//INQALAB 91*2/TUKURU/3/BECARD/FRNCLN
6	52 nd IBWSN	1076	FD08114/BECARD #1//BOKOTA
7	11 th STEMRRSN	6081	KFA/2*KACHU/5/WBLL1*2/4/BABAX/LR42//BABAX/3/BABAX/LR42//BA BAX/6/KFA/2*KACHU
8	13 th STEMRRSN	6168	KENYA SUNBIRD/KACHU*2//BORL14
9	14 th STEMRRSN	6142	PASTOR//HXL7573/2*BAU/3/WBLL1/4/SOKOLL/3/PASTOR//HXL7573/2 *BAU/5/2*BORL14

New wheat populations in multi-location trials

Multi-location trials were conducted on the populations and lines selected in previous nurseries and trails introduced from CIMMYT-Mexico (Table 17). The trials were conducted in Rwerere, Kiningi and Musanze sites. In each type of nursery, the variety Gihundo was used as check. The experimental design was in balanced lattice design with two and three replications for preliminary and advanced yield trials, respectively. Plot size was 2m x 1.2m, the seeds was hand-drilled with 4 rows of 2m long and spaced at 0.20 m per plot. Data were collected on plant vigor, plant height, days to booting, heading, flowering, physiological maturity, disease reaction, lodging, drought tolerance, potential yield, seed size, seed color and other desirable traits.

Table 17: Number of wheat genotypes from nurseries and trials in Rwanda

N	Nursery name	Number of genotypes evaluated
1	SAWYY (23 rd , 24 th , 26 th , 27 th)	14
2	IBWSN (50 th , 51 st , 52 nd)	13
3	STEMRRSN (11 th , 13 th , 14 th)	16
4	ESWYT (36 th , 37 th , 39 th)	12
5	ESWYT (40 th , 41 st , 42 nd)	15
6	HRWYT (25 th , 27 th)	11
7	HRWYT (29 th)	10
8	SAWSN & HRWSN	13
9	IDYN (51 st , 53 rd)	9
10	Combined nurseries	12
11	AYT 8 POP.	8
	Total	133

Evaluation of wheat planting dates

This study aimed to determine best planting time across wheat growing areas of Rwanda under the continuous climate change and to update the recommendations of wheat good agricultural practices specifically the proper planting time. Experiments on planting dates were established in 2024A and B in three locations, namely, Musanze, Rwerere and Nyamagabe (Table 18). They

were set up in six staggered planting periods such that early, middle and late planting periods were tested. An interval of 15 days between planting dates was used starting on 1st September. Two varieties, namely Nyaruka and Gihundo, were used and planted in a plot size of six rows of two-meter length and a spacing between rows was 0.20 m. There were two replications for each of the six planting dates. Data were collected on agronomic parameters including the number of days of emergence, booting, heading, flowering and maturity, and plant vigor, number of tillers per plant and grain yields. The analysis was done by using Genstat software package (GenStat 20th Edition). The combined analysis of variance over the three locations and six planting dates for grain yield showed significant differences ($p < 0.001$) among varieties, locations and planting dates. The double interactions effects were also significant ($p < 0.001$) while the triple interaction was not significant ($p > 0.05$).

Table 18: Yield of wheat varieties at different planting dates

Planting dates	Kinigi			Nyamagabe			Rwerere			Overall mean
	Gihundo	Nyaruka	Mean	Gihundo	Nyaruka	Mean	Gihundo	Nyaruka	Mean	
3 September 2023	2.029	4.296	3.163	2.788	3.269	3.029	3.658	4.306	3.982	3.391
18 September 2023	2.929	3.511	3.220	1.538	3.077	2.308	2.398	2.883	2.641	2.723
2 October 2023	2.200	3.361	2.781	1.538	3.558	2.548	1.360	1.479	1.420	2.249
17 October 2023	2.326	2.979	2.653	1.923	3.340	2.632	0.725	1.394	1.060	2.115
2 November 2023	1.965	3.097	2.531	3.183	2.842	3.013	0.550	0.971	0.761	2.101
17 November 2023	1.474	2.323	1.899	3.462	2.404	2.933	0.525	0.521	0.523	1.785
Means	2.154	3.261	2.708	2.405	3.082	2.744	1.536	1.926	1.731	2.394

Planting on 3rd September resulted in highest yield (2,391 kg/ha) while late planting on 17th November resulted in lowest yield (1.785 kg/ha) (Table 19). The linear regression of planting date onto grain yield showed that the slope of regression was negative and significant at $p < 0.001$ implying delaying planting wheat decreases the grain yield. The coefficient of correlation was very high and significant implying that the planting date impacted significantly on grain yield. These observations lead to conclude that wheat must be planted as early as possible (Figure 10).

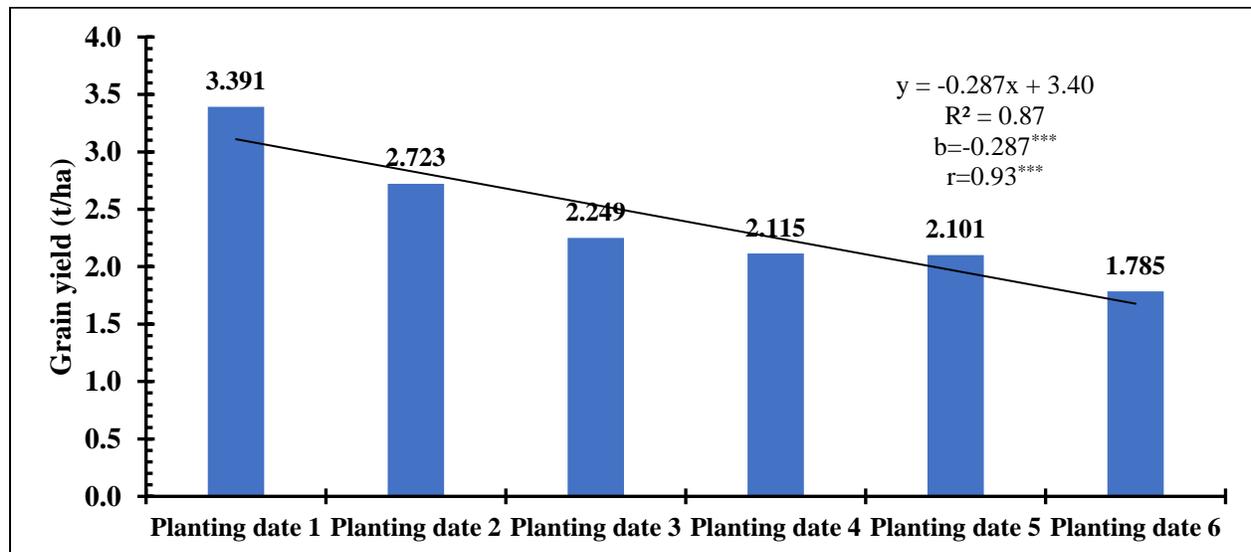


Figure 10: Grain yield of planting dates: 1-2 Sept.; 2-18 Sept. 3-2 Oct.; 4-76 Oct.; 5-1 Nov.; 6-17 Nov

Wheat productivity assessment

The determination of the wheat grain yield using the yield squares was conducted in the bigger sites of Gicumbi, Musanze and Burera Districts. It consisted of:

- Getting a tape or a stick to measure a length of 1 m;
- Choosing in the wheat field of the target site the fields preferentially presenting relative uniformity in terms of fertility gradient and appearance of the plants, choosing as much as fields where improved agriculture practices (use of fertilizers, improved seeds, recommended spacing etc.) have been used;
- Choosing a field where wheat panicles are at the grain filling stage;
- In the field, considering the field to be sampled and going somewhere inside the fields;
- Avoiding the parts of the fields under erosion, drought, extremely severe nutrient deficiency, especially nitrogen deficiency, flooded parts etc.;
- Avoiding the edges of the fields;
- Determining a square with a side of 1 m such that the surface of the square be of 1m²;
- Counting the number of panicles that will be harvest in that site while avoiding the panicles that will be empty and thus, that will not be harvested;
- Counting the number of panicles in that square; counting well-formed panicles, panicles that will be harvested;
- Choosing randomly in that square 5 panicles;
- Removing them from the stalks and then measuring them;
- Getting the average weight on a panicle by dividing the weight of all panicles in the square and the number of ears;
- Estimating the yield in kg/ha for this site by the following formula:
 - Grain yield (kg/ha) = Average panicle weight × number of panicles from the square × 10,000 × 0.027
 - Grain yield (t/ha) = Average panicle weight × number of panicles from the square × 10 × 0.27.

A total of 22 samples were collected in three Districts growing wheat: Burera, Gicumbi and Musanze on land area equal to 265 ha. The average grain yield was calculated to be 3,801 kg/ha (3.0 8MT/ha) with standard error of means was 178.3 kg/ha (0.18 MT/ha). Therefore, the grain yield of wheat in consolidated land is estimated to be 3.80±0.18 MT/ha.

1.2 Pulses and Oil crops program

The Pulses and Oil Cops Program comprises most of the legume crops such as common bean, soybean, groundnut and peas. These are important for both human and animal consumption. They also establish symbiotic relationships with rhizobium bacteria and fix atmospheric nitrogen, thus improving agricultural productivity. Although these crops offer potential solution to food insecurity, malnutrition, and poverty reduction in Rwanda, their productivity is still very low compared to their potentials. This situation is mainly due to none use of improved varieties, none/limited use of fertilizers, pest and diseases, postharvest losses, climatic variability leading to drought and flooding, etc. For these reasons, efforts have been made to develop and release new generation of high yielding and resilient varieties, produce and avail adequate breeder, pre-

basic and basic seeds thus enabling access of required seeds to the smallholder farmers. To increase awareness and adoption of the new bean and soybean varieties, demonstration plots have been established across the country and radio talks have been delivered on community radios. This report highlights key activities conducted in the fiscal year 2023/2024.

Main achievements as per action plan 2023/2024 Fiscal Year:

Nine (9) bean lines and five (5) soybean lines have been evaluated and are ready for submission to the National Variety Release committee for official release. A report for their submission is under development;

The productivity of beans and soybeans was assessed using yield squares techniques. Average yield of bush bean obtained from sampled 128 fields was 1.83 t/ha. The average yield of climbing bean assessed in 21 fields was 3.1 t/ha ,while for soybean, an average yield of 1.74 t/ha was obtained in 54 sampled fields;

A total of 6,768 demo plots have been established. These include 3,696 demo plots of beans and 3,072 demo plots of soybean;

A total of nine (9) radio talks have been delivered through different community radios (RC Huye, RC Nyagatare, RC Musanze and RC Rubavu);

One (1) paper has been published and other draft papers are at advanced stages.

1.2.1 Soybean

Soybean research evaluated new varieties meeting consumer preferences and prepared them for submission to the National Variety Release Committee, and conducted productivity assessment using same methodology as for beans (see section 1.2.2).

National Performance Trials (NPT) for soybean

NPTs aim to determine agronomic potential of new variety before release. Five soybean varieties (Table 19) were evaluated for two seasons (2024A and 2024B). The trials were set up in different agro-ecological zones (AEZs) of Rwanda in On-farm trials as well as in three RAB stations (Rubona, Ngoma and Nyagatare). The varieties were evaluated as per Union for the Protection of new Varieties (UPOV) of plants scheme for DUS and VCU. Data on flower color, pubescence color, plant height, lodging and days to maturity were recorded. At harvesting, grain yield, seed size and color were recorded. A report is under preparation and will be submitted to the National Variety Release Committee for consideration.

Table 19: Characteristics of the five developed soybean varieties

Variety Code	Mean yield (MT)	Days to maturity	Zone	Special attributes
S4243	2500	100	Low to mid-altitude	Resistant/tolerant to diseases
S3301	2400	104	Low to mid-altitude	Resistant/tolerant to diseases
S0107	2600	104	Low to mid-altitude	Resistant/tolerant to diseases
S3348	2700	101	Low to mid-altitude	Resistant/tolerant to diseases
S3303	2100	103	Low to mid-altitude	Resistant/tolerant to diseases

1.2.2 Beans

National performance trials (NPT)

During the NPT trials, candidate varieties were planted alongside with existing varieties (checks) and performance gauged to ensure only superior varieties are released for commercialization. Five climbing bean varieties (RWVR 6920; RWVR 6034; RWVR 6536; RWVR 6538 and RWVR 6541) and 4 bush bean varieties (RWR 6061; RWR 6063; RWR 6065; and RWR 6069) were evaluated and characterised for two seasons (2024A and 2024B) in different agro-ecological zones. These varieties were compared with RAB improved common bean varieties (MBC23, RWV1129 and NUA 566) and a local mixture variety as checks and were evaluated in 6 RAB research stations (bush bean in only 3 stations but climbing bean in all the 6 stations) and at 15 on-farm sites covering the major common bean growing areas.

Variety performance: All the 9 varieties outperformed ($p \leq 0.05$) both checks for most traits evaluated (Tables 20, 21, 22). The tested varieties were high yielding and well adapted to major growing areas in Rwanda. Nine genotypes were intermediate in flowering and maturing, with 35-45 and 45-60 days to flowering for bush type and climbing type respectively while for maturity period they ranged from 78-85 and 87-110 days to maturity for bush and climbing type respectively. Most of them were resistant/tolerant to major evaluated diseases.

Table 20: Mean Yield (kg/ ha) of tested Climbing bean genotypes

Environment	Local check	RAB check	RWV 6920	RWVR 6034	RWVR 6536	RWVR 6538	RWVR 6541
Burera/Cyanika	1826.1	2120.7	4241.4	3063.2	3298.9	3652.3	3534.5
Gahunga site	1708.3	2120.7	4241.4	3063.2	3298.9	3652.3	3534.5
Gakenke/Gakenke Sector	2827.6	2002.9	3416.7	2650.9	2297.4	2297.4	2415.2
Kagamba /Gicumbi	1885.1	2179.6	2827.6	2945.4	2945.4	3416.7	3534.5
Karongi/Rubengera Sector	2898.3	2073.6	3416.7	2721.6	2368.1	2368.1	2485.9
Karongi/Twumba Sector	2827.6	3181.0	3628.7	3593.4	3475.6	3416.7	3357.8
Musanze/Cyuve Sector	2945.4	3298.9	4123.6	3946.8	2415.2	2415.2	2533.0
Musanze/Kinig Sector	2827.6	3181.0	3298.9	2945.4	3770.1	3817.2	2709.8
Musanze/Muhoza Sector	3181.0	3298.9	3416.7	3004.3	3829.0	3829.0	2768.7
Ngororero/ Ngororero Sector	3157.5	2332.8	2073.6	2980.7	2627.3	2627.3	2745.1
Nyabihu/Rugera Sector	3039.7	2214.9	2097.1	2862.9	2509.5	2509.5	2627.3
Nyagatare	5183.9	6833.3	4594.8	6362.1	7069.0	6362.1	6715.5
Rubavu/Rubavu	1531.6	3534.5	3416.7	3239.9	3063.2	3534.5	3416.7
Rubavu/Rubavu Sector	3039.7	2214.9	2097.1	2862.9	2509.5	2509.5	2627.3
Rubavu/Rugerero Sector	3122.1	2356.3	2238.5	2945.4	2650.9	2639.1	2768.7
Rubona/Huye	3387.2	3681.8	2503.6	6185.3	3976.3	5301.7	4712.6
Rubungo	2557.4	3522.7	2102.7	3471.9	2673.2	3060.5	3741.8
Rulindo/Rusiga Sector	3004.3	2179.6	2061.8	2827.6	2474.1	2474.1	2592.0
Rutsiro/Gihango Sector	3063.2	2238.5	2120.7	2886.5	2533.0	2533.0	2650.9
Rutsiro/Rufungo Sector	2933.6	3287.1	3063.2	2756.9	2403.4	2403.4	2521.3
Rwerere	6597.7	4182.5	6892.2	6421.0	6362.1	5890.8	5301.7
Min Yield	1531.6	2002.9	2061.8	2650.9	2297.4	2297.4	2415.2
Max Yield	6597.7	6833.3	6892.2	6421.0	7069.0	6362.1	6715.5
Mean Yield	3025.9	2954.1	3232.1	3511.3	3264.3	3367.2	3299.7

Table 21: Mean yield (kg/ ha) of tested bush genotypes

Environment	Local check	RAB check	RWR 6061	RWR 6063	RWR 6065	RWR 6069
Nyagatare	1178.2	2356.3	2356.3	2356.3	2356.3	2356.3
Rubona	1642.4	2732.2	3691.2	2366.9	2212.6	2184.3
Rubungo	3203.8	2640.5	2184.0	3218.4	3526.2	3555.1
Min Yield	1178.2	2356.3	2184.0	2356.3	2212.6	2184.3
Max Yield	3203.8	2732.2	3691.2	3218.4	3526.2	3555.1
Mean Yield	2008.1	2576.3	2743.8	2647.2	2698.4	2698.6

Iron and zinc content: The best climbing bean variety was RWVR 6536 which recorded a high Fe content of 107ppm with an overall mean of 96ppm, while the RAB check recorded a potential of 71ppm and a mean of 62.9ppm. For bush bean, the variety, RWR6061 had a highest Fe content of 66.5ppm and a mean of 65.3ppm while the RAB check showed a Fe content of 62.6ppm and a mean of 60.8ppm (Tables 22, 23).

Table 22: Mean Fe and Zn content of tested climbing bean varieties

	Local check		RAB check		RWV 6920		RWVR 6034		RWVR 6536		RWVR 6538		RWVR 6541	
	Microelement content, mg/kg													
Location	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
Musanze	58.4	28.1	61.4	29.2	80.5	32.0	98.7	35	95.2	36.7	90.4	32.5	92.4	32.1
Ngoma	58.6	28.4	64.6	30.1	71.1	31.8	84.0	32	92.4	35.0	79.5	30.6	77.6	31.5
Nyagatar	55.0	28.3	61.3	27.4	75.9	30.1	79.2	30.6	80.6	34.6	89.2	32.1	80.2	35.5
Rubona	53.4	30.3	56.2	28.6	66.6	33.5	95.2	35	104.2	46.7	90.4	34.7	89.3	35.5
Rwerere	61.4	28.7	71.2	31.5	72.4	26.7	86.2	32	107.6	35.0	98.2	32.0	90.2	31.6
Min	53.4	28.1	56.2	27.4	66.6	26.7	79.2	30.6	80.6	34.6	79.5	30.6	77.6	31.5
Max	61.4	30.3	71.2	31.5	80.5	33.5	98.7	35	107.6	46.7	98.2	34.7	92.4	35.5
Mean Fe	57.36	28.76	62.94	29.36	73.3	30.82	88.66	32.92	96	37.6	89.54	32.38	85.94	33.24

Table 23: Mean Fe and Zn content of tested bush bean varieties

	Local check		RAB check		RWR 6061		RWR 6063		RWR 6065		RWR 6069	
Location	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
Ngoma	55.4	25.6	59.9	25	66.5	28	58.3	27	61.3	31.8	65.1	29
Nyagatare	55.4	25.6	59.9	25	66.5	28	58.3	27	61.3	31.8	65.1	29
Rubona	54.8	27.3	62.6	22.8	63	28.6	55.8	26.5	59	31.8	64.3	28.8
Min	54.8	25.6	59.9	22.8	63	28	55.8	26.5	59	31.8	64.3	28.8
Max	55.4	27.3	62.6	25	66.5	28.6	58.3	27	61.3	31.8	65.1	29
Mean	55.2	26.2	60.8	24.3	65.3	28.2	57.5	26.8	60.5	31.8	64.8	28.9

The 9 varieties evaluated (5 climbers and 4 bush bean) had high yield, high iron content and were tolerant to major bean diseases compared to the checks. They will be proposed for release by RAB to the National Variety Release Committee.

Measurement of bean and soybean productivity

Crop productivity depends on many factors. It is mostly dependent on interaction between plant Genotype (variety), Environment and Management. If one of the above elements is not met, the productivity of a give crop becomes very poor. In order to obtain the productivity of soybean and beans in farmer’s fields, we measured the productivity of the two crops in their major production zones during 2024 A season using yield squares method.

For beans, the Northern Province was not sampled as the crop had not yet matured at the time of sample collection (Field yield assessment). For soybean, in most of the growing areas, the crop had not yet matured at the sampling time as well. This is because of late planting due to the delay of rains at the beginning of the season. We sampled 128 fields for bush beans (Table 24), 21 fields for climbing beans (Table 25) and 54 fields for soybean (Table 26). Fields in consolidated sites, big farms and cooperative’ fields were chosen, assuming that in these fields, good agriculture practices (use of fertilizers, improved seeds, recommended spacing, pests and diseases management etc.) have been applied.

In each field, a sampling area (square) of 5 m x 5 m was considered (for fields less than 10ha). All the plants in that square were harvested, threshed, winnowed to separate them from debris and the weight of the grains from that square was determined using a weighing balance (Grain yield/net plot) (Photo 4). The grain moisture content for the sampled sites was immediately determined using electronic moisture meter; and used at the time of determining the final grain yield. The final grain yield was expressed at 13% standard moisture content for beans and soybeans. After collecting data in the field, the productivity (grain yield) in kg/ha at 13% moisture content was computed as follow: Grain yield (kg/ha): ((Harvest yield per net plot x 10,000/25) X (100-Harvest moisture))/ (100-13).Where: -Harvest yield per net plot: yield measured in the sampled area of 25m². Harvest moisture is the moisture content measured after harvesting; and 13 is the standard moisture content for commercial bean and soybean.



Photo 4: Demarcation of the sampling area (Top left), Threshing (Top right), Moisture content measurement (Bottom left) and yield determination (Bottom right)

Productivity results for bush beans: The results presented are from data collected in 128 fields across different Districts. The results showed that the yield across sites ranged from 0.6 to 3.5t/ha, with a mean yield of 1.83 t/ha (Table 24). The table below shows the yield calculated from plots sampled equally on an area of 25m². The variability in yield observed is due to many factors including: differences in management practices, water availability, pest and diseases management and varieties planted. The lowest yields for bush beans were observed in Nyagatare, followed by Huye and Gatsibo respectively. The poor yields observed in some sites are due to drought that occurred after planting and this has led to poor germination and low plant population density.

Table 24: Productivity of bush bean

No	District	Number of fields sampled	Bean type	Max yield (t/ha)	Min yield (t/ha)	Average yield (t/ha)
1	Nyagatare	46	Bush	2.7	0.6	1.8
2	Gatsibo	25	Bush	3.3	1.1	1.7
3	Ngoma	6	Bush	3.2	1.6	2.0
4	Kirehe	13	Bush	2.3	1.3	1.8
5	Rwamagana	5	Bush	3.5	1.5	2.5
6	Bugesera	10	Bush	1.9	1.2	1.6
7	Nyanza	5	Bush	1.8	1.4	1.6
8	Huye	8	Bush	2.7	1.1	1.9
9	Gisagara	4	Bush	1.8	1.6	1.6
10	Rusizi	6	Bush	2.0	1.6	1.8
Grand mean (t/ha)		128				1.83

Productivity results for climbing bean: It is worth to note that the Northern Province constitute the major climbing bean growing area: and was not included in the presented results. Twenty one sampled fields showed that the yield across sites ranged from 2.4 to 4.5 t/ha, with a mean yield of 3.1 t/ha (Table 25). The table below shows the yield calculated from plots sampled equally on an area of 25m². The reasons for variability in yield observed are the same as the ones reported for bush bean.

Table 25: Productivity of climbing bean measured

N	District Name	Number of climbing bean fields sampled	Bean Type	Max yield (t/ha)	Min Yield (t/ha)	Average Yield (t/ha)
1	Gatsibo	6	Climbing	3.9	2.4	3.3
2	Karongi	8	Climbing	4.5	2.6	3.1
3	Huye	2	Climbing	3.2	3.1	3.1
4	Rubavu	3	Climbing	3.0	2.7	2.9
5	Nyamasheke	2	Climbing	3.3	2.9	3.0
Grand mean (t/ha)		21				3.1

Productivity results for soybean: The 54 sampled fields showed that the yield across sites ranged from 0.7 to 3.5 t/ha, with a mean yield of 1.74 t/ha (Table 27). The table below shows the yield calculated from plots sampled equally on an area of 25m². The variability in yield observed is due to many factors including: differences in management practices, pest and diseases management, the varieties planted, water availability since the season was characterized by dry spells at the beginning of the season and towards the maturity period.

Table 26: Productivity of soybean measured

N	District Name	Number of soybean fields sampled	Max yield (t/ha)	Min Yield (t/ha)	Average Yield (t/ha)
1	Nyagatare	9	3.5	1.4	2.5
2	Gatsibo	7	2.3	0.9	1.8
3	Kayonza	4	1.8	1.0	1.4
4	Ngoma	3	2.1	1.8	2.0
5	Kamonyi	4	1.9	0.7	1.5
6	Nyanza	7	2.4	1.2	1.7
7	Huye	7	3.1	1.1	1.5
8	Gisagara	8	1.8	1.1	1.5
9	Rusizi	5	2.5	1.0	1.8
Grand mean (t/ha)		54			1.74

Challenges: During the exercise of measuring the productivity of beans and soybean, it was really difficult to get farmers that were ready for harvesting their crops. In addition, the maturity days differ depending on planted variety, regions and planting dates. This situation was complicated more the planning for productivity determination. The presented data can be considered as partial especially for climbing beans and soybeans since in many sites harvesting was not yet done at the harvesting time. We also observed that many sites were affected by drought at the beginning, at flowering and podding stages and towards the maturity period. Such situation has led to poor performance of the two crops hence poor yields due to late planting, poor germination, flower abortion, etc.

Extension activities

Demonstration plots To enhance farmers' capacity and create awareness on new bean and soybean varieties, farmer promoters, FFS, SEDOs, Agro-dealers and Sector agronomists have been mobilized, trained and received seeds and fertilizers to establish 3,696 demonstration plots of beans and 3,072 demonstration plots of soybean in FY 2023-24 (Photo 5).



Photo 5: Training of farmer promoters (top left), Farmer promoters receiving seeds and extension materials (top right), demonstration of line making and fertilizer application (bottom left) and staking method for Climbing bean (bottom right)

Training focused on good agriculture practices including the use of Rhizobium, inorganic and organic fertilizers, line spacing, planting rates, weeding time, pest and diseases management and postharvest handling. After the training, participating farmers received training material. A total of 12 high yielding and better nutrition varieties were promoted for beans and 8 for soybean.

Promotion of the new varieties through radio talks: The pulses and oil crops program organized and delivered 9 radio talks on different community radio stations during the FY2023-24 (Table 27). The talks focused on harvesting and postharvest handling techniques, good agricultural practices including the use of inorganic and organic fertilizers, line spacing, planting rates, weeding, pest and diseases management for both beans and soybean. In addition, the talks aimed at promoting the newly released bean and soybean varieties for their quick adoption by farmers. Nine radio talks were delivered on Radio Communautaire (RC) Huye, RC Musanze, RC Rubavu & RC Nyagatare.

Table 27: Radio talks delivered on different community radio stations (RC)

No	Radio Station	Date	Topic	Responsible
1	RC Musanze	27/07/2023 and 24/01/2024	Season 2024A harvesting, postharvest handling techniques and good agricultural practices (GAP), pest and diseases management as well as the preparation for season 2024B.	Rumongi Alfred, Murwanashyaka Edouard, Hakizimana Jacques & Rukundo Aimable
2	RC Huye	19/09/2023 and 24/01/2024	Season 2024A harvesting, postharvest handling techniques and good agricultural practices (GAP), pest and diseases management as well as the preparation for season 2024B.	Dr Edouard Rurangwa and Hakuzimana John
3	RC Rubavu	17/08/2023 and 01/02/2024	Season 2024A harvesting, postharvest handling techniques and good agricultural practices (GAP), pest and diseases management as well as the preparation for season 2024B.	Rumongi Alfred & Rwakayanga Leandre
4	RC Nyagatare	05/09/2023 and 16/01/2024	Season 2024A harvesting, postharvest handling techniques and good agricultural practices (GAP), pest and diseases management as well as the preparation for season 2024B.	Gasigwa Evariste, Aurore Mukampabuka & Kayumba John
5	Radio Mariya	11/09/2023	Season 2024A harvesting, postharvest handling techniques and good agricultural practices (GAP), pest and diseases management as well as the preparation for season 2024B.	Mugiraneza Dieudonne

1.3 Roots and Tubers Program

1.3.1 Irish potato

Variety development

Preparation of the advanced potato genotypes for release During FY 2023-24, three varieties from local breeding program were advanced to the variety pre-release steps. Those varieties are KIN 18.150, KIN 18.190, KIN 18.253 genotypes (**Photo 6**). Prior to the release those varieties have to be cleaned up to eliminate the viruses which could infected potato new varieties during trails in the open field exposure. This step is very important because any potato genotype cannot be officially released before it is virus free planting material and it is in the form of tissue culture.



Photo 6: New potato varieties for release

Table 28: List of evaluated tetraploid bio-fortified potato clones

No	Clone	Total Tuber Yield (t/ha)	Fe (mg/kg)	Zn (mg/kg).	Dry matter (%)
1	CIP312637.132	18.11	20.4	40.3	24.05
2	CIP312507.311	19.45	18	35.6	24.32
3	CIP312764.013	19.49	13.3	34.1	22.94
4	CIP312721.169	18.46	18	30.4	22.3
5	CIP312621.069	17.72	21.6	32.1	23.05
6	CIP312735.253	18.79	18.9	36.7	25.33
7	CIP312725.048	17.12	19.8	34.8	21.44
8	CIP312725.057	20.02	18.9	25.7	20.22
9	CIP312507.312	18.04	16.2	26.9	22.57
10	CIP312721.038	18.02	21.9	28.6	20.18
11	CIP312682.042	18.54	21.2	32.9	20.77
12	CIP312721.286	15.49	18.5	30.2	23.81
	<i>Mean</i>	18.27	18.89	32.36	22.58
	<i>SE</i>	0.346	0.70	1.23	0.48

Fe: Iron, Zn: Zinc, SE: Standard error.

Screening of new potato clones with climate resilience and meeting farmer preference: The following trials were conducted in FY 2023-24 - Observation Trials (OTs), preliminary yield trials (PYTs) and advanced yield trials (AYTs), Multi-location trials (MTs), National Performance Trials (NPTs) and distinctiveness, uniformity and stability test (DUS) for variety release. A total of 45 potato clones have been selected for advancement to the next stage of variety selection.

Establishment of multi-location trials of bio-fortified potato: Twelve potato advanced and pre-selected clones were planted and harvested at Kinigi, Rwerere and Gakuta research stations (Table 28). The establishment of multi-location trials of advanced potato clones were conducted with objective of the determining agronomic performance of developed bio-fortified potato clones for the different agro-ecological zones of Rwanda. Consequently, a study was conducted to: i) Assess disease resistance of the bio-fortified potato clones and ii) Assess yield related traits of those potato clones.

Breeder seed production of new heat tolerant potato clones

The following potato clones in the table 2 were imported from CIP Lima and were planted in the screen house for the purpose to generate enough potato mini-tubers to establish subsequent trials. These clones are diseases resistant and drought tolerant (Table 29). For each clones, about 500 mini-tubers were produced during the 2024B season.

Table 29: Climate resilient potato clones

#	Clones	Skin color	Virus Resistance		Tolerance		Population
			PVX	PVY	Heat	Drought	
1	CIP308474.153	Red/Cream			T		B3C3
2	CIP308478.59	Cream			T		B3C3
3	CIP308480.334	Cream	ER		T		B3C3
4	CIP308482.163	Pink	ER	ER	T		B3C3
5	CIP308487.390	Red	ER		T		B3C3
6	CIP308488.198	Red	ER		T	T	B3C3
7	CIP308489.367	Cream			T		B3C3
8	CIP308497.212	Red	ER		T		B3C3
9	CIP308498.280	Cream	ER		T		B3C3
10	CIP308518.201	Pink			T		B3C3
11	CIP312887.075	Red	ER	ER	T		LBHT x LTVR
12	CIP312895.056	Cream	ER	ER	T	T	LBHT x LTVR
13	CIP312896.009	Cream			T	T	LBHT x LTVR
14	CIP312896.012	Cream	ER	ER	T		LBHT x LTVR
15	CIP312899.078	Red	ER	ER	T		LBHT x LTVR
16	CIP312903.013	Red			T	T	LBHT x LTVR
17	CIP312913.022	Cream	ER	ER	T		LBHT x LTVR
18	CIP312913.121	Cream/Pink			T		LBHT x LTVR
19	CIP312914.053	Pink			T		LBHT x LTVR
20	CIP312925.108	Cream			T		LBHT x LTVR
21	CIP312903.066	Cream			T		LBHT x LTVR

Establishment of potato demonstration plots

During 2023-24, two types of demonstration plots were established: Community demonstration plots (29) and new potato variety demonstration plots (73). Community demoplots were big in size (0.5-2ha) and aimed for dissemination of planting material after harvest. New variety demoplots were small (less than 0.5 ha) and targeted variety testing and adoption.

Establishment of community demo plots of new potato released varieties

Currently, 11 new potato varieties were released, new variety demonstration plots were established to enhance dissemination and adoption (Table 32). A total of 24 big community demo plots of 4 new varieties were established in 6 locations during 2020A (Table 30 & 31).

Table 30: Potato yield in Community demonstration plots in 2024A

Variety/ Site	Musanze (t/ha)	Kayonza (t/ha)	Ngoma (t/ha)	Kirehe (t/ha)	Burera/ Volcanic (t/ha)	Burera/Buberu ka (t/ha)	Mean (t/ha)
Cyerekezo	38.5	32.6	38.8	23.2	28.4	30.3	31.9
Ndamira	-	25.7	27.3	-	19.2	25.8	24.5
Kazeneza	36.1	28.5	34.5	23.1	39.9	28.8	31.8
Nkunganire	-	25.6	26.3	21.1	19.0	16.9	21.8
Means (t/ha)	37.3	28.1	31.7	22.5	26.6	25.4	27.5

Table 31: Number of Community demonstration plots for potato in 2024B

No		Nbr of members	Area (ha) covered	Variety used
1	Twongerumusaruro/ Byimana	24	0.75	Ndamira and Cyerekezo
2	Impala/ Isangano	32	0.25	Ndamira
3	Tugirubukungu/ Isangano	215	0.5	Cyerekezo
4	Abihuje/ Isangano	26	0.5	Cyerekezo
	Total number	297	2	

Table 32: Demonstration plots for new varieties 2024A season

No	District	Sectors	Demo plots	Farmer s	Variety yield kg/ha			
					Ndamira	Cyerekezo	Nkunganire	Kazeneza
1	Rubavu	3	3	3	16,000	26,500	14,500	18,750
2	Nyabihu	3	3	3	19,867	23,450	16,575	26,523
3	Musanze	5	5	5	19,262	36,756	18,675	34,296
4	Burera	5	5	5	19,225	20,765	13,650	30,200
5	Gakenke	6	7	7	16,346	21,300	16,520	19,500
6	Gicumbi	1	3	3	13,540	22,425	18,439	17,325
7	Rulindo	2	2	2	17,641	21,345	16,163	18,652
8	Rwamagana	1	1	1	18,633	25,750	17,320	16,435
9	Kayonza	5	22	22	22,650	25,256	18,650	21,340
10	Ngoma	1	1	1	23,636	33,625	26,250	32,000
11	Kirehe	1	1	1	-	23,100	23,200	21,100
	Total number	30	50	50				

Productivity measurement for potato on consolidated sites

During the FY 2023-24, productivity assessment was conducted in main potato growing areas in land consolidated sites. (Table 33). 19.0 t/ha was estimated as the current potato yield for marketable size. The yield assessment was carried out in potential potato production districts including Rubavu, Nyabihu, Nyamagabe, Musanze, Burera, Nyaruguru, Gicumbi and Rutsiro (Table 33). The average of planting density (plants/m²), marketable tubers (kg/m²), and no marketable tubers (kg/m²) were calculated. The marketable yield tubers (t/ha), and no marketable tubers (t/ha) was estimated by the following formula:

$$\text{Marketable yield tubers (t/ha)} = \frac{\text{Marketable tubers (kg/m}^2\text{)} * 42\,000 \text{ plants/ha}}{\text{Planting density (plants/m}^2\text{)}}$$

Table 33: Potato tuber yield (t/ha) assessed in main potato growing areas, FY 2023-24

District	N. farmers	N. samples	N.plants in 1m2	Weight (t/ha)		Yield (t/ha)	Varieties
				Marketable	Non-marketable		
Burera	8	21	5.7	26.3	1.9	28.2	Kinigi, Kirundo, Ndamira, Rwagume
Gicumbi	10	50	5.86	10.7	5.5	16.2	Cruza, Kirundo, Karilos, Rwagume
Rubavu	14	35	4.7	30.0	2.0	31.8	Ndamira, Kazeneza, Kinigi and Kirundo
Musanze	6	25	5.8	29.9	2.0	31.9	Kinigi, Gikungu, Kirundo, Nyagatuku
Nyamagabe	9	45	5	14.3	9.7	24.0	Cruza, Kinigi
Nyaruguru	5	30	5	9.2	8.1	17.3	Cruza
Nyabihu	14	70	5.7	15.7	6.6	22.3	Kirundo, Kinigi, Gikungu
Rutsiro	7	35	5	15.8	6.9	22.7	Cruza, Cyerekezo, Rugero, Kinigi
Mean yield				18.99	5.34	24.30	

The potato growers covered during the survey were 73 in nine districts and the total samples were 311. The average marketable potato tubers yield was 19.0 t/ha and no marketable was 5.3 t/ha, the total productivity was 24.3 t/ha.

1.3.2 Sweet potato

Production and distribution of Early Generation Seeds (Pre-basic) sweet potato

Using Rapid Multiplication Techniques (RMT), 19 best bet high yielding, white, yellow and Orange Sweet potato varieties (OFSP) are multiplied and maintained at Rubona TC Lab. In total, 105,500 plantlets of pre-basic high yielding and promising sweet potato varieties RWSP 2000-154, RWSP 2003-038, RWSP Purple, Terimbera (RW11-2560), Vita, Kabode, Beauregard were the most produced in SC, in TC, SC and sandponics at Rubona. 33.4 MT of cuttings of basic seed were produced at Mututu research station and availed in different districts.

National performance and participatory variety selection trials

Through participatory variety selection in demo plots, Farmer Field School and Model Farmers, high yielding varieties were selected and promoted in various districts with focus in drought

prone area of Kayonza district under KIIWP project. Five varieties: Awassa 83, RwaSP-130, Kabode 12, Kabode 13 and Rukundo were cleaned and used in the National Performance trials for season 2024B. One NPT with 3 replicates has been set up in 3 locations ([Table 34](#)).

Table 34: Sweet potato yield (t/ha) in FFS demonstration plots during the season 2024A

Variety/Site	Flesh Color	Kabarondo	Ruramira	Gahini	Means
Kabode	O	20.4	15.4	12.1	16.0
Vita	O	15.4	14.3	11.8	13.8
Ukerewe	C	14.3	3.5	10.4	9.4
Local	W	4.9	5.7	6.8	5.8
<i>Means</i>		<i>13.75</i>	<i>9.73</i>	<i>10.28</i>	<i>11.25</i>
<i>SE</i>		<i>3.23</i>	<i>3.00</i>	<i>1.22</i>	<i>2.28</i>

Kabode and Vita had highest yield in all sites in FFS demo plots ([Table 35](#)), and mean yield for three new varieties was 13.1t/ha while local check yielded 5.8t/ha. New varieties were appreciated for yield by most farmers all locations ([Photo 7](#)).



Photo 7: Harvesting sweet potato by FFS groups at Kabarondo (left) and Ruramira (right)

Table 35. Sweet potato yield (t/ha) in Model Farm at Kayonza during season 2024A

Variety	Flesh color	Production (tonnes)	Yield (t/ha)
Kabode	Orange	9.65	20.98
Vita	Orange	5.87	15.43
Giramata	White	2.14	15.28
Akararakadenda	Creme	2.54	12.70
Wadada	White	1.19	10.82
Means		5.05	16.10
SE		1.75	1.74

Kabode, Vita and Giramata were the highly yielding varieties with 20.98, 15.43 and 15.28 t/ha, respectively ([Table 35](#), [Photo 8](#)). The local checks (Akararakagenda and Wadada) were the least performing varieties compared to the promoted one in term of roots but with the highest vines production. This confirms its name (Akararakagenda) meaning that the vines keep growing during

night. Farmers selected the highest ones for their cultivation and highly appreciated them due to their dual purpose attribute (for both roots and vines). Vines are well indicated for animal feed.



Photo 8: Harvesting the sweet potato Model Farm in Mwiri sector 2024A

Decentralized Vine Multipliers Training for seed multipliers

Sweet potato is vegetatively propagated crop where vines are planted after harvest to establish new fields. New farmers are engaged in vine production, which results in scarcity of planting material for sweet potato. RAB encourages interested farmers to engage in vine production. These farmers are called Decentralized Seed Multipliers. In collaboration with RYAF, 80 participants from 53 cooperatives were identified as interested to start vine business. They were trained in Kayonza under KIIWP II project (Photo 9). Later, another DVM training was conducted in Rubavu and Rutsiro under RWARRI project with emphasis on OFSP varieties to fight the severe malnutrition in those districts.



Photo 9: Training of cooperatives in GAP at Kayonza

During 2023-2024 FY, 63 FFS of sweet potato, 39 demo plots and 2 Model Farms of Twitezimbere and Impala cooperatives were formed to promote OFSP. A total of 1762 farmers were trained in their communities and cooperatives on sweet potato Good Agricultural Practices (GAP) with focus on Seed preparation. Land preparation, Planting, Fertilization, Identification of weeds, Hilling up and weeding; Diagnosis of pests and diseases symptoms, Management of pests and diseases; Harvesting and Postharvest management. In addition, farmers completed the long season training of Agro-Ecosystem Analysis (AESAs). A total of 21.38 MT of roots production were

harvested in the sweet potato Model Farm, 16.63 MT were sold to local markets whereas 4.75 MT shared between the cooperative members for consumption purpose. In addition, 12.98 MT of vine seeds were distributed to different cooperatives. 76 cooperative members and 17 farmer groups, 382 households benefited of new planting materials of high yielding of OFSP to withstand the drought in the East Province.

Awareness creation on sweet potato

3 talks on sweet potato technologies and nutrition were conducted and spotted through RBA and radio 10. GAPs were also taught through radio media. Leaflets and promotion material were distributed. Around 5,000 promotion materials were distributed to farmers.

1.3.3 Cassava

Variety development

Variety development in cassava aims to obtain new high dry matter content with high quality flour that meet end user preferences and are resistant to major virus diseases - cassava brown streak virus disease (CBSV) and cassava mosaic virus disease (CMD).

Cassava new varieties under Distinctness, Uniformity, and Stability (DUS) trials Five pre-released cassava varieties (NAM 130, PWANI, MH 2005/0091OP/12, RBN018/025 and RBN018/028) are under characterization in DUS trials at Muhanga and Mututu sites where morphological and physiological data were being collected for 6, 9 and 12 months after planting.

Adaptability trials

Four new cassava varieties are being tested for adaptability as Genotype by Environment interaction (GxE) trials to evaluate the performance of different cassava genotypes across diverse environmental conditions at three sites (Rubona, Mututu and Nemba) (Table 36).

Table 36: Major disease scores on cassava new varieties at 3 locations 6 MAP in 2024A

Clones	Mututu		Nemba				Rubona					
	6CMDi (%)	6CMDs	6CBSDi (%)	6CBSDs	6CMDi (%)	6CMDs	6CBSDi (%)	6CBSDs	6CMDi (%)	6CMDs	6CBSDi (%)	6CBSDs
Mkumba/2	0	1	5.5	3	0	1	0	1	0	1	2	3
NASE14/1	0	1	18.5	3	0	1	0	1	0	1	11	3
Control	0	1	6.5	3	1	3	0	1	4	3	4	3
Eyope x Ndamirabana/7/2	1	3	8	3	0	1	0	1	0	1	0	1
Mkumba/3	0	1	8	3	0	1	0	1	1	2	0	1

CMDi – Incidence of CMD; CMDs – Severity of CMD; CBSDi – Incidence of CBSV; CBSDs – Severity of CBSV. ‘6’ means data were taken at 6months after planting

Advanced Yield Trial (AYT) of cassava new varieties

The main purpose of these trials were to assess and select high-yielding cassava varieties with desirable agronomic traits such as disease resistance, drought tolerance, and quality attributes. Under the CDAT project funds, advanced yield trials were established at 3 agro ecological zones

(Nemba, Rubona and Mututu) to evaluate their agronomic performance and provide access to improved cassava varieties that can boost productivity and profitability.

At Rubona station, the CMD incidence was low (1%) for three varieties while only one variety showed high CBSD foliar incidence with 14% and severity score 3 (Table 37). At Nemba site, only two varieties showed high CBSD foliar incidence with 8 and 10%, CMD incidence was very low less than 2%. At Mututu site, also two varieties showed high CBSD foliar incidence with 10 and 15%, CMD incidence was low six months after planting (Table 38).

Table 37: Cassava mosaic status in new cassava advanced yield trials 6 MAP Season A 2024

No	Clones	Mututu		Nemba		Rubona	
		6CMDI (%)	6CMDs	6CMD (%)	6CMDs	6CMDi (%)	6CMDs
1	Ndamirabana/7 x KBH2006/026/6	0	1	0	1	0	1
2	Ndamirabana/7 x KBH2006/026/10	0	1	0	1	0	1
3	Ndamirabana/7 x KBH2006/026/11	1	3	0	1	0	1
4	Ndamirabana/7 x Gahene/2/2	2	3	0	1	1	3
5	Ndamirabana/7 x Gahene/2/3	0	1	0	1	0	1
6	Ndamirabana/7 x NASE14/2	0	1	0	1	0	1
7	Ndamirabana/7 x Gatuku/1	0	1	0	1	0	1
8	Bulk13 X Ndamirabana/7/1	0	1	0	1	0	1
9	Ndamirabana/7/1	1	3	0	1	0	1
10	Gahene local/1	0	1	0	1	0	1
11	Ndamirabana/7 X Gacyacyali/2	0	1	1	2	1	3
12	NAM130	2	3	1	3	1	3

Table 38: Cassava Brown streak virus status in new cassava clones 6 MAP Season A 2024

N	Clones	Mututu		Nemba		Rubona	
		6CSBSDi (%)	6CSBDs	6CSBSDi (%)	6CSBDs	6CSBSDi (%)	6CSBDs
1	Ndamirabana/7 x KBH2006/026/6	0	1	0	1	0	1
2	Ndamirabana/7 x KBH2006/026/10	0	1	0	1	0	1
3	Ndamirabana/7 x KBH2006/026/11	0	1	2	2	2	3
4	Ndamirabana/7 x Gahene/2/2	15	3	0	1	0	1
5	Ndamirabana/7 x Gahene/2/3	0	1	0	1	0	1
6	Ndamirabana/7 x NASE14/2	0	1	10	3	14	3
7	Ndamirabana/7 x Gatuku/1	2	3	0	1	0	1
8	Bulk13 x Ndamirabana/7/1	0	1	0	1	0	1
9	Ndamirabana/7/1	1	4	0	1	0	1
10	Gahene local/1	0	1	8	3	0	1
11	Ndamirabana/7 X Gacyacyali/2	0	1	1	2	0	1
12	NAM130	10	3	0	1	0	1

Demonstration plots and demand creation trials for new varieties

Two types of demonstration plots were conducted (community demo plots and small demo plots for demand creation trials). A total of 42 demo plots were established (20 demo plots for demand creation, 8 for new varieties, 6 for good agronomic practices and 8 for fertilizers demonstration). The demo plots were established at five different cassava growing districts covering the southern and eastern provinces. 9 new varieties (Mkombozi/3, Gahene/2/6, Gahene/2/3, GHR019/001, Kalawe/1, Yezaso/3, IBA141097/5, RBN018/025, and RBN018/28) were demonstrated. These trials will stimulate farmers' interest of using clean seed and create awareness and generate demand for cassava clean seed. Currently, agronomic data were collected at 6 months after planting and the harvest data will be report in the next annual report.

Seed production for high yielding and disease tolerant/resistant cassava varieties

Cassava basic and certified seed fields During FY2023-24, 2 ha of basic seed were planted in three RAB Stations (Muhanga, Rubona and Rubirizi), while 6 ha and 16 ha of certified seed fields (mother gardens) were established at Rubona and Ngoma stations (**Photo 10 and 11**).



Photo 10: Cassava mother garden Nyawera Site in 2024A



Photo 11: Cassava macro propagation under SAH and Screen house at Rubona

Pre-basic seed through macro propagation under SAH and screen houses During FY2023-24, a total of 120,127 plantlets from high yielding and disease tolerant cassava clones were macro-

propagated in Semi-Autotrophic Hydroponic (SAH) and using node stem cuttings in screen house. These materials are considered as pre-basic seeds.

Mapping and monitoring of clean disease-free cassava production fields: A total of 124ha field of QDS cuttings were assessed from cassava local production across the country, mainly in Southern and Eastern provinces to support the delivery of farmer-affordable QDS seed (**Photo 12**). This is a continuous activity and after its completion, a completed list of clean seed producers should be disseminated in all districts to enable cassava growers to localize the source of clean seeds.



Photo 12: Cassava QDS seeds in Southern province 2024 B season

Cassava productivity assessment in consolidated sites

During FY2023-24, cassava productivity was assessed in most growing districts such as Ruhango, Kamonyi, Nyanza and Bugesera districts. The average yield was 21.3t/ha. Bugesera presented the highest yield (**Table 39**).

Table 39: Cassava productivity 2023-2024 for most growing districts

Districts	# of Samples	Weight (kg)		Total weight kg/plant	Yield t/ha
		Marketable	Non marketable		
Kamonyi	123	1.9	0.1	2.05	20.5
Ruhango	145	1.6	0.4	2.09	20.9
Nyanza	138	1.8	0.3	2.15	21.5
Bugesera	173	1.6	0.7	2.26	22.6
<i>Means</i>		<i>1.73</i>	<i>0.3</i>	<i>2.14</i>	<i>21.38</i>

Capacity building of cassava seed multipliers and other stakeholders

The training of 42 cassava seed multipliers (24 males and 18 females) from Rusizi, Nyamasheke, Gisagara, Nyanza, Ruhango, Muhanga, Kamonyi, Bugesera, and Kayonza Districts was conducted in order to enhance their knowledge and skills in producing high-quality cassava planting material, ensuring the availability of healthy and disease-free seeds (**Photo 13**).

During FY2023-24, 80 farmers from cooperatives were trained in cassava seed system, from research to seed multipliers, all requirements needed to be seed multiplier were explained, also diseases and pests affecting cassava and their management was provided (**Photo 14**).



Photo 13: Training in the cassava screen house management



Photo 14: Training of farmers field facilitators

In total, 53 FFS Facilitators of cassava from Ndego, Rwinkwavu and Kabare Sectors were awarded certificates in recognition of their farming skills, which was a great pride to their families (Photo 15).



Photo 15: FFS Facilitators graduation ceremony, May 2024

1.4 Banana Program

Among current constraints to banana production in Rwanda the main are Banana Bunchy Top Virus transmitted by aphids (*Pentalonia nigronervosa*), Banana Xanthomonas wilt, and banana fusarium wilt. Therefore, banana research and technology transfer are focused on development of improved production technologies, pest/disease control and building skills for good production for banana farmers. Key Program activities during this fiscal year 2024-24 were:

introduction of new varieties; conducting banana rehabilitation campaigns; organization of farmer trainings on banana rehabilitation and pest/disease control; seed producers training on clean production; technical assistance for pest and disease control; banana disease surveillance; production of extension material; and broadcasting of banana messages through radio and TV live talks.

Introduction of new varieties

A total of 11 new banana varieties were introduced from IITA, Nigeria in October 2023. They are originated from EMBRAPA, Brazil, and all belong to short-fruit type intended to replace Kamaramasenge, a local short-fruit variety with tender sweet flavor and susceptible to fusarium wilt. The new varieties have tolerance or full resistance to fusarium wilt. They were planted in field at Rubona in January 2024 (Photo 16), and will be evaluated for yield traits and fusarium wilt resistance.



Photo 16: New banana varieties of Kamaramasenge type planted in evaluation trial at Rubona

Banana rehabilitation campaigns

Banana rehabilitation campaigns were conducted jointly with the respective districts which have selected banana crop for district Imihigo. The sites for banana rehabilitation are selected during July-August, and the campaigns are conducted before annual crops are planted in banana fields or throughout of the wet season A and B. Community councils were key partners to conduct sensitization campaigns prior to banana rehabilitation. Banana plantations have been rehabilitated through community mobilization campaigns and field visit farmer to farmer (Photo 17, 18).



Photo 17: Banana rehabilitation work in Gakenke (left) and Ngoma (right)



Photo 18: Banana rehabilitation work (left); demonstration of single stem removal for BXW control (right)

In many sites farmers have the banana plantation as priority crop and are keen to improve their banana production. There are sites where rehabilitation activities come at request of the communities stating the need of banana rehabilitation from farmers and partners. The total of banana area rehabilitated in 2023-24 was 11,813.38 ha (Table 40).

Table 40: Banana area rehabilitated during FY 2023-2024 per province

Western Province		Eastern +Kigali Province		Southern Province		Northern Province	
District	Area (ha)	District	Area (ha)	District	Area (ha)	District	Area (ha)
Rusizi	1,402	Rwamagana	552	Muhanga	310	Burera	20.1
Nyamasheke	88	Bugesera	425	Ruhango	157.9	Gakenke	398.2
Nyabihu	70	Kayonza	523.8	Nyanza	612.6	Gicumbi	1,069.9
Rubavu	761	Ngoma	688	Gisagara	462.5	Musanze	45.4
Rutsiro	34.4	Kirehe	523.8	Huye	1.2	Rulindo	574.9
Karongi	296.4	Nyagatare	671	Nyamagabe	22		
Ngororero	155	Gatsibo	557.3	Nyaruguru	11.9		
		Kicukiro	10.8	Kamonyi	162.3		
Total	2,807.8		4,006.9		2,891.2		2,107.5

Farmer trainings on banana rehabilitation and pest/disease control

During the year 2023-24, a total of 2,745 farmers, where 1,642 were men and 1,103 were women, were trained on banana rehabilitation, good banana management practices, major diseases and pests and their control. The most widespread disease was banana Xanthomonas wilt, and the most widespread pests were thrips. Among the farmers trained, 904 farmers were from Southern Province (481 men and 423 women); 1,754 farmers from Eastern Province (1,113 men and 641 women); and West: 87 farmers from Western Province (48 men and 39 women). The trainings consisted in two parts including the theoretical part in meeting room, and the practical part in field. Other groups of farmer promoters, which were trained on use and reporting via BXW App last year under ICT project support received technical support during this year through physical visits and phone calls to assist in BXW reporting and data collection.

Seed producers training on clean production

RAB is implementing PROSSIVA project aiming to promote seed production in Africa, and banana in Rwanda by strengthening banana seed production value chain. A total of 80 seed producers were selected across the country, and 77 of them were trained in clean seed production (Table 41). Clean seed production protocol was developed and shared with the trainees.

Table 41: Banana seed producers trained under PROSSIVA project, FY 2023-24

Western Province		Eastern Province		Southern Province		Kigali City	
District	Farmers	District	Farmers	District	Farmers	District	Farmers
Rusizi	3	Rwamagana	6	Kamonyi	4	Kicukiro	1
Nyamasheke	2	Bugesera	5	Ruhango	2		
Rubavu	2	Nyagatare	2	Gisagara	6		
Nyabihu	1	Gatsibo	23	Muhanga	7		
Ngororero	2	Kirehe	1				
		Ngoma	5				
		Kayonza	5				
Sub-total West	9	Sub-total East	47	Sub-total South	19	Sub-total Kigali	1

Total number of seed producers trained in banana plant material production : 77

Technical assistance for pest and disease control

During the reporting year, Banana program has received many requests from individual farmers, sector agronomists and farmer promoters to attend various disease and pest outbreaks. Following these requests, thrips outbreak spots were identified in Kamonyi and Gatsibo district. Farmers in the affected fields received advice on thrips control. Furthermore, Agropy private partner has availed pyrethrum-based biopesticide to apply on thrips, and sites for new trial were identified on farm in Kamonyi and Gatsibo.

Banana disease surveillance

As the mean temperature is raising, new disease vector spread accelerates. In 2022, banana bunchy top survey was reported in Kamonyi and Nyarugenge districts. During the reporting year 2023-2024, new surveillance was conducted. A total of 31 banana fields were visited. A total of 18 fields were infected by Banana Bunchy Top Disease and 8 fields were free from the disease (Photo 19; Table 42). The area covered was Kigali City (Gasabo, Nyarugenge and Kicukiro

districts), and Northern Province (Gakenke district). The BBTD was a serious threat in Gakenke where all 5 banana fields were entirely infected.



Photo 19: Banana in Gakenke (left) and Gasabo (right) with bunchy top symptoms, Dec.2023

Table 42: Number of fields visited during December 2023 with BBTD symptoms

District	with BBTD	without BBTD	Total fields visited
Nyarugenge	10	4	14
Gasabo	8	4	12
Gakenke	5	0	5
Total	18	8	31

Few farmers recognized that banana plants are sick. All farmers in the affected districts had little knowledge about this disease, and they need training on BBTD management. The recommended control practices consist in the following: identification of plants affected by the BBTD; uprooting and burying all plants immediately after symptom appearance. New material for planting should be originate from the clean banana fields: for example, certified seed multipliers and RAB.

Seed production via macro-propagation

Macro-propagation is one of the most convenient and relatively cheap methods of rapid multiplication for banana. It requires to use suckers from mother gardens. Sucker preparation activities begin in wet season (May to July) and banana seeds are produced and available for planting during the wet season (September to November) (**Photo 20**).



Photo 20: Medium-size suckers used for macro-propagation (left), banana plantlets in macro-propagator (center), and weaned plants in nursery (right)

During FY 2023-24, a total of 500 suckers were produced for demonstration purpose at Ngoma station macropropagator. The method consisted in decortication of 6-months old corms to release dormant buds, which start to grow after the central growing point of the corm is destroyed. The corms are placed in sawdust wooden box and covered by plastic and start to produce plantlets after 1.5 months up to 6 months. The place of multiplication is called macro propagator. In 10 to 18 weeks, a healthy corm produces 8 to 25 seedlings/banana plantlets (Photo 20).

Table 43: Banana demonstration plots for conservation agriculture

Farmer	Sector	Cell	Village	Varieties	N. plants	Area (ha)
Bugesera 0.1 ha						
Jean Pierre	Mwogo	Rurenge	Kaziramire	FHIA17, Injagi, Nkazikamwa, G. Michel	60	0.054
Annet	Nyamata	Rwakibilizi	Rwakibilizi	Injagi	50	0.045
Kicukiro 0.67 ha						
Ladislav	Masaka	Rusheshe	Kagese	Injagi, FHIA17, plantain	500	0.45
Theophile	Masaka	Rusheshe	Cyankongi	FHIA17	85	0.08
Damascene	Masaka	Rusheshe	Cyeru	Mpologoma	60	0.054
Nshimyimana	Masaka	Gitaraga	Kajevuba	Injagi	56	0.05
Bosco	Masaka	Masaka	Kitabi	Injagi	45	0.04
Gasabo 2.2 ha						
RAB-Rubungo	Ndera	Musave	Ramba	Plantain	120	0.11
Enock	Ndera	Mukuyu	Jurwe	Nkazikamwa, Injagi	40	0.04
Jacqueline	Ndera	Kibenga	Tumurere	Injagi, Nkazikamwa	40	0.04
Kayonza 0.1 ha						
Emerthe	Nyamirama	Shyogo	Nyacyonga	Injagi&FHIA	40	0.04
Josiane	Nyamirama	Mburabuturo	Gihima	Injagi, Nkazikamwa	50	0.05
Ngoma 0.45 ha						
RAB station	Musamvu	Nyakabungi	RAB station	Injagi Mpologoma, Nkazikamwa, FHIA 17, FHIA25, plantain	500	0.45
Rwamagana 0.05 ha						
Angelique	Fumbwe	Mataba	Mataba	Injagi	50	0.05
Gatsibo 0.5						
Paul	Kabarore	Kabarore	Bihinga	Injagi, Nkazikamwa, Icyerwa	50	0.045
Ngororero 0.2 ha						
Bonaventure	Nyange	Gaseke	Gaseke	Kamaramasenge	82	0.07
Patrice	Matyazo	Gitega	Gataka	Kamaramasenge	59	0.06
Vincent	Muhororo	Rugogwe	Murambi	Kamaramasenge	35	0.03
Total area under demonstration plots on conservation agriculture practices: 3.18 ha; total – 18 plots						

Banana demonstration plots for Conservation Agriculture

A total of 42 banana demoplots (Tables 43 and 44) were established during 2022 and 2023. The firstly established plots are at flowering stage, and data will be collected at harvest while other plots are still very young (Photo 21). The key management practices for conservation agriculture include zero tillage, manual weeding, de-leafing, de-suckering and mulching. The total number of plots is 18 with total area of 3.18ha.



Photo 21: Variety demoplots: planted in Dec.2022 (left), and in Dec. 2023 (right)

Table 44: Banana demoplots for locally preferred varieties

Farmer	Sector	Cell	Village	Banana variety	N. plants	Area (ha)
Kicukiro						
Kazungu	Masaka	Gako	Gicaca	Injagi	65	0.062
Kayonza						
J.Baptiste	Rukara	Rwimishinya	Kinungall	Injagi	66	0.06
Ngoma						
Augustin	Remera	Bugera	Kumukiza	Injagi, Nkazikamwa, Mpologoma	50	0.045
Eustache	Remera	Ndekwe	Rukore	Injagi, Nkazikamwa, Mpologoma	50	0.045
Rusizi						
Faustin	Gihundwe	Kagara	Rukohwa	Injagi, Mpologoma	50	0.045
Theophile	Gihundwe	Kagara	Kivoga	Injagi	50	0.045
Immaculee	Nkanka	Rusunyu	Kangazi	Injagi	50	0.045
Ignace	Nkanka	Muyange	Kangazi	Injagi, FHIA 17	35	0.03
Trogene	Rwimbogo	Ntenyi	Rubugu	Injagi	102	0.09
Emmanuel	Nzahaha	Peru	Rwinzuki	Injagi, FHIA 17	50	0.045
Joseph	Nzahaha	Peru	Rwinzuki	FHIA 17	50	0.045
Ernest	Nzahaha	Peru	Rwinzuki	FHIA 17	50	0.045
Gaspard	Nzahaha	Kibirezi	Rwinzuki	Injagi	120	0.11
Albert	Kagano	Kiziba	Rwesero	Injagi	80	0.09
Uzziel	Macuba	Kigandi	Vugangoma	Injagi, plantain	50	0.045
Muhanga						
Wellars	Nyarusange	Ngaru	Rukamiro	Injagi, Poyo	53	0.045
Gitima	Muhanga	G.S Gitima	Tyazo	Injagi, Imizuzu, Mpologoma	101	0.09
Severin	Kabacuzi	Kamiranzogra	Kibyimba	Injagi	80	0.07
Agnes	Shyogwe	Kinini	Kinyami	Injagi, FHIA17, FHIA 25	47	0.04
Nyanza 0.11						
Runyombyana	Muyira	Gati	Ruyenzi	Injagi, FHIA 17, plantain	100	0.09
Edouard	Cyabakamyi	Karama	Gatongati	Injagi, FHIA 17, plantain	330	0.27
Rosalie	Busoro	Munyinya	Karambi	Injagi, Poyo	209	0.18
Huye						
RAB-Rubona	Rubona	Kiruhura	Rubona	Injagi, Kamaramasenge, Gros Michel, plantain	414	0.36
Musanze						
Aliane	Muko	Mburabuturo	Ntendo	Injagi, FHIA 17, plantain	100	0.09

Another set of demonstration plots was established to show best banana varieties and encourage their use in the respective areas. This activity was supported by PROSSIVA project aiming to improve banana seed value chain and encourage local production of clean banana planting material. The total area of demonstration plots with best varieties is 1.945 ha.

Production of extension material

Four extension materials were developed and produced: leaflet on macro-propagation, banana *Xanthomonas* wilt and its control; banana bunchy top disease; thrips and their control. A total of 600 copies were produced.

Broadcasting of banana messages through radio and TV live talks

Several radio talks were prepared and delivered in live format. A total of 11 radio talks were given (3 on RC Rusizi; 3 on RC Huye; 2 on RC Huguka; 2 on RBA Kugali, and 1 on Radio Izuba). The topics were on banana rehabilitation, agronomic practices, pest and disease control (BXW and thrips) and the use of BXW App for BXW control and reporting. One live talk on Rwanda Television was delivered in Kigali on 14/5/2024 about Banana production, postharvest and climate change challenges and coping strategies.

1.5 Horticulture Program

RAB Horticulture Program has made significant strides in advancing horticultural development in FY 2023-24. The key activities focused to enhance fruit and vegetable production, improve pest and disease management, and strengthen the capacity of farmers and stakeholders across Rwanda. The details of these activities are below.

On-farm evaluation of introduced pepper varieties for their growth and yield

Sites for on-farm evaluation trials were identified after conducting visits to various locations in Bugesera, Rwamagana, Nyanza, and Kayonza districts. The selection process was guided by specific criteria: identifying an actively engaged farmer cooperative already involved in hot pepper production, securing available land not previously used for hot pepper or related crops in the preceding season and ensuring access to irrigation water. Two sites met these criteria: Bushenyi (Rugarama cell, Mareba sector) in Bugesera, and Kiburara (Cyaribare cell, Kabare sector) in Kayonza district. The selected sites have farmer cooperatives-KOIMUMA and GIKADINI in Bugesera and Kayonza, respectively already engaged in hot pepper production.

The trial was established in Mareba and Kabare sites, respectively. The lines evaluated were AVPP0105 and AVPP9905 which are from *Capsicum annuum* species, obtained from World Vegetable Center. Commonly grown commercial varieties i.e. Red long cayenne and Teja were also included as local check/ control for comparison. All agronomic practices were followed as recommended. Observation of the performance of the varieties was done in collaboration with the farmers. Data collected included Plant height; Number of primary branches; Number of fruits per plant; Average fruit Yield (g/plant); and Total Fruit Yield (t/ha). Kabare site all data on growth and yield were collected and the trial terminated. However, at Mareba site the trial was destroyed by the heavy hailstorm rains in mid-December and terminated prematurely.

Results from season 2024A at Kabare site showed significant ($P < 0.05$) difference between the varieties in terms of growth and yield parameters. Plants from Teja variety were significantly taller than Long cayenne and the introduced lines. While for the number of primary branches, Teja and Long cayenne had more branches compared to AVPP0105 and AVPP9905 (Table 1). Generally, the commercially grown varieties i.e. Long cayenne and Teja (used as a local checks) produced a greater number of fruits per plant (225.5; 184.2) compared to the introduced lines AVPP0105 (90.9) and AVPP9905 (39.1), respectively. In spite of the commercially grown varieties having a greater number of fruits per plants, fruits harvested from the introduced lines were heavier than the ones from commercially grown varieties (Table 1). This is supported by fact that the average yield per plant (g), per plot (kg) and per hectare (tons) of introduced lines were between 1.6-2.0 times higher compared to Long cayenne and Teja varieties (Table 45, Figure 12). Introduced lines (AVPP0105, AVPP9905) performed better in terms of growth and yield compared to the commonly grown commercial variety (Long cayenne and Teja). Efforts need to be made in collaboration with NAEB to look for potential market for these promising lines.

Table 45: Average value of growth and yield components of introduced and commercial hot pepper lines/varieties evaluated on-farm in season 2024A at Kabare sector, Kayonza district

Line/Variety	Plant Height (cm)	No. Primary Branches	No. of Fruit/Plant	Yield/Plant (g)	Yield/Plot (kg)
AVPP0105	69.0±1.9 ^b	7.1±0.3 ^b	90.9±6.9 ^b	1140.2±58.1 ^a	22.6±1.9 ^a
AVPP9905	65.7±2.5 ^b	5.3±0.2 ^c	39.1±4.9 ^c	1117.5±89.8 ^a	19.9±2.5 ^a
Long Cayenne	70.3±2.6 ^b	8.6±0.4 ^a	225.5±18.7 ^a	500.7±43.5 ^b	12.4±0.5 ^b
Teja	113.5±2.2 ^a	8.3±0.4 ^{ba}	184.2±12.5 ^a	496.7±25.8 ^b	12.1±0.8 ^b
<i>P value</i>	<.0001	<.0001	<.0001	<.0001	0.0039

Means with the same letter (s) within a column are not significantly different at $P < 0.05$, Tukey test

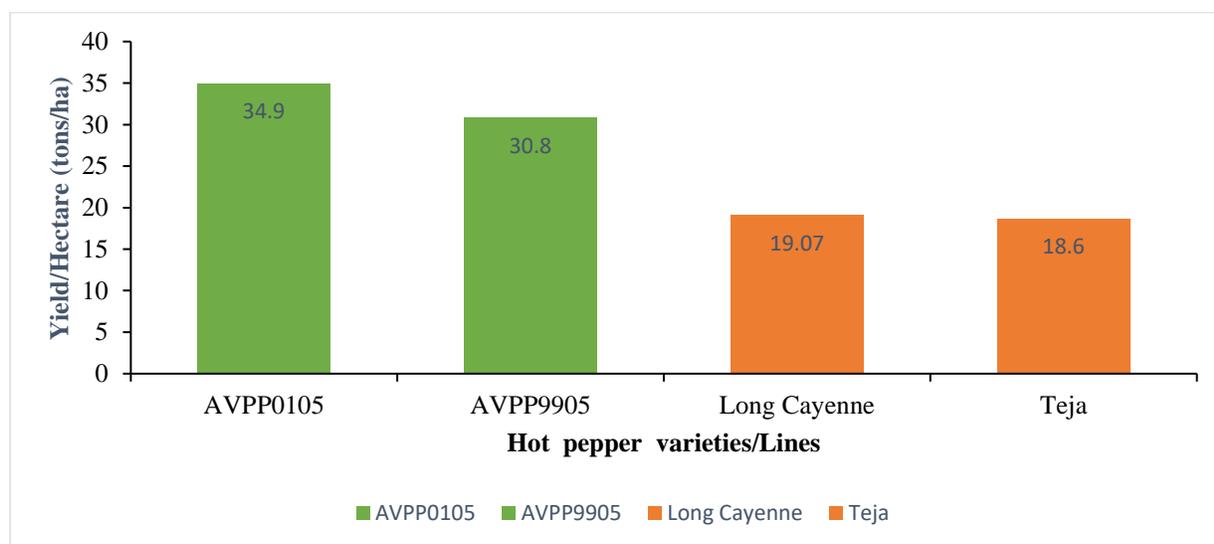


Figure 11: Yield per hectare of the hot peper varieties evalauted on-farm at Kabare sector in Kayonza district

Evaluation of grafted tomato for resistance to bacterial wilt under greenhouse

The World Vegetable Centre (WorldVeg) has won IITA financing for a project titled "Accelerated Innovation Delivery Initiative (AID-I): Great Lakes Project". In turn, WorldVeg and RAB have agreed to collaborate to complete the Project to the best of their abilities. Tomato grafting was among the main technologies promoted as soil-borne diseases are currently attacking tomato crop, mainly in greenhouse with rotation is complicated and there are no pesticides available to handle them.

Identification of greenhouse tunnels infested by pathogens to demonstrate grafting Preliminary visits were done in four areas, including Rwamagana, Nyanza, Kayonza, and Rulindo, with the goal of detecting greenhouses affected with soil-borne diseases. In the field, the RAB team had discussions with the greenhouse owners about their previous experiences with soil-borne diseases, including whether they had observed wilting symptoms in current or previous crops. 25 greenhouses were inspected, with 13 selected for soil sampling for laboratory examination. Sub-samples were obtained from various corners of each greenhouse and combined to form a composite soil sample (Photo 22). Fifteen soil samples were collected, transferred to the laboratory, and kept at room temperature until analysis.



Photo 22: Soil sampling from greenhouses suspected to be infested with soil borne diseases

Confirmation of presence of *Ralstonia solanacearum* in the samples was performed using Potato dextrose agar (PDA) and the sub-culture was done on selective medium containing 2,3,5-triphenyltetrazolium chloride (TZC)-casein-peptone-glucose agar (Photo 23). A positive control was included in sub-culturing of the isolates to confirm the obtained results and data recording was done after 24 and 48-60 hours. Results indicated the presence of *R. solanacearum* in all visited greenhouses. Based on severity of the wilting symptoms observed in the field, number of greenhouse structures available in an area and accessibility to the main road, two greenhouses (in Rulindo and Rwamagana) were selected to be used for demonstrating grafting technology in management of soil-borne diseases.

Samples were collected in different districts (A= S1 – S5: Nyanza; B= S6 -S8: Rulindo; C= S9 – S11: Rwamagana; D= S12 -S15: Kayonza). Virulent colonies of *R. solanacearum* strains on TZC medium have irregular shape, mobile, humid and displays a reddish/pinkish spot in the middle of the colony and whitish edge. They are easily observed against light.

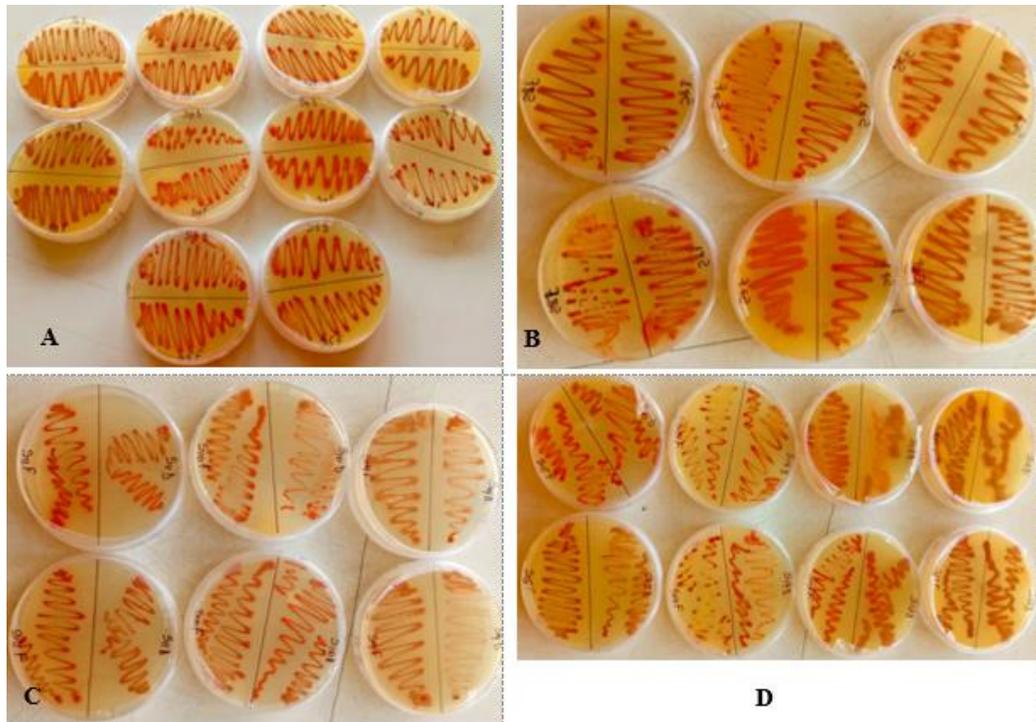


Photo 23: Bacterial growth and typical characteristic of colonies of *Ralstonia solanacearum* on TZC medium

Preparation of grafted tomato seedlings: Step 1: Preparation of seedlings (rootstocks and scions) In preparation of seedlings to be used for demonstrating grafting technology in management of soil-borne diseases, five tomato rootstock varieties, including three (R3034-3-10-N-UG; HAWAII 7996; BF OKITSU 101) introduced from World Vegetable Centre, one (SHELTER RZ) from Holland Greentech, and another wild species (*Solanum aculeastrum*) collected locally, were sown on August 22, 2023, with each containing approximately 500 seeds (Table 46). A week later, 3000 seeds of the indeterminate variety (Tomato Montezul) were sown to supply scions for grafting. All types were monitored and maintained in a single greenhouse at RAB's Horticulture Centre of Excellence in Mulindi, Kigali.

Step 2: Grafting: Tomato grafting was done during the period from 23rd to 25th September 2023 with guidance of an Expert from World Vegetable Centre, Mr. Nickson Gervas Mlowe. The grafted seedlings were placed in healing chamber to ensure high success rate (Photo 24).



Photo 24: Grafting of tomato Monteazul RZ F1 on 5 different rootstock (left); Healing chamber for grafted tomato plants (right)

Table 46: Rootstocks and scions used in grafting of tomato

No	Rootstock	Scion	Number of grafted seedlings
1	HAWAII 7996	Monteazul RZ F1	408
2	R3034-3-10-N-UG	Monteazul RZ F1	409
3	BF OKITSU-101	Monteazul RZ F1	381
4	Shelter RZ F1	Monteazul RZ F1	433
5	<i>Solanum aculeastrum</i> (wild species collected locally)	Monteazul RZ F1	445

Follow up visits were conducted at Rulindo and Rwamagana where the greenhouses are located. This was to provide technical backstopping on management of tomato in the greenhouses and to monitor how the grafted and non-grafted tomato plants were responding to soil-borne diseases in the greenhouses. In both sites, the non-grafted tomato plants showed symptoms of bacterial wilt but the symptoms were more severe in the greenhouse located in Rulindo (Photo 25). Tomato plants in Rwamagana site also showed symptoms of blight and the farmers were provided fungicides to control the disease.



Photo 25: Grafted (right) vs non-grafted wilted (left, yellow flesh) tomato seedlings, Rulindo

Based on data analysis from tomato grown on different rootstocks (HAWAII 7996, BF OKITSU 101, SHELTER RZ, and *Solanum aculeastrum*) and ungrafted Mrembo transplanted in different

greenhouses, it was discovered that the OKITSO rootstock was more resistant to bacterial wilt than the other varieties used. Thus, it is recommended for use by farmers as a rootstock for grafting tomato.

Maintenance of new and existing mother gardens for scion and root stock production

New avocado orchards were established at Rubona (1ha) and Ngoma (0.5ha) with Hass and Fuerte to expand scion production. New germplasm fields with 35 avocado varieties were established in Rubona (0.5ha) and Musanze (0.5ha) for conservation. Routine germplasm maintenance activities were carried out in existing and newly established orchards of various species (avocado, mango, citrus, and apple) located across RAB stations, including Rubona, Muhanga, Rwerere, Tamira, Musanze, Nyagatare, Ntendezi, Ngoma, Mulindi, and Rubilizi.

The existing orchards served as source of quality planting material for grafting (scions). Avocado, mango and citrus scions were harvested and distributed to different beneficiaries including government projects, private companies, NGOs, individual farmers and nursery operators (Table 47). Key orchard management includes weeding, application of organic and inorganic fertilizers, regular pruning, application of pesticides and data collection on growth parameters.

Table 47: Harvested and distributed mature scions in different RAB Stations, FY 2023-24

N	RAB Station	Species	Area (Ha)	Number of mature scions	Number of scions
1	Rubona, Musanze, Mulindi	Avocado	11.65	400,000	155,000
2	Mahama, Bugarama, Nyagatare, Mulindi	Mango	3.31	150,000	30,000
3	Mulindi, Musenyi	Citrus	2.30	100,000	20,000

Training of nursery operators

During FY 2023-24, training for fruit and vegetable nursery operators on fruit tree grafting, vegetable seedling production and nursery management were conducted at the Horticulture Centre of Excellence at Kigali-Mulindi. The trainings were led by RAB horticulture scientists and technicians. The focus of the training was to ensure the availability and distribution of high-quality seedlings for vegetable and fruit trees. In total, 182 (136 -fruit and 46 - vegetable) nursery operators from various districts across Rwanda participated in the training (Photo 26 and 27). The districts represented included Huye, Kayonza, Musanze, Rwamagana, Gakenke, Rusizi, Muhanga, Gasabo, Kicukiro, Bugesera, Nyanza, Ngoma, Burera, and Gicumbi. The topics covered on grafting were: Avocado harvesting and grain removal for planting rootstock, harvesting scions and grafting techniques. While for raising vegetable, seedlings included acquisition of quality seeds, establishing vegetable nurseries, sowing tips, care of saplings in the nursery and disease management.



Photo 26: Harvesting scions and practicing grafting



Photo 27: Theory session on vegetable nursery and Vegetable nursery at HCoE

FFS training of hot pepper farmers

Training for hot pepper farmers involved in FFS work was delivered in Kayonza with support of KIIWP/II project. The topics were good agronomic practices and disease management. Trainees were identified in collaboration with the district cash crop officer and sector agronomist during consultative meeting with farmers involved in pepper cultivation. This initiative resulted in the formation of 11 FFS groups and the election of 22 FFS facilitators. Theoretical sessions on the FFS approach were conducted, enabling these 22 elected farmers to grasp the methodology before delving into a comprehensive seasonal training covering the whole pepper crop cycle.

FFS training of vegetable and fruit farmers

Vegetable farmers were trained through Farmer Field School (FFS) in Murama, Kabarondo, Rwinkwavu and Mwiri sectors of Kayonza district under KIIWP/II project. In the same project, vegetable ToT was established at Ndego in order to train FFS facilitators in vegetable production. The FFS is equipping 26 FFS groups and each group has at least between 25-30 farmers while on TOT in Ndego, 27 FFS facilitators are being trained. They are being trained on integrated crop management knowledge applicable to vegetables such as cabbage, onions, beetroots, amaranths and carrots in order to enhance their capacity such that they can increase production. In this regard, seven FFS plots were established in Rwinkwavu, eight FFS plots in Murama, six FFS plots in Kabarondo and five FFS plots in Mwiri sector.

In addition, a model farm of watermelon (1ha) was established in Ndego sector and Pineapple macro-propagation unit for TOT was established also at Ndego also in order to train pineapple seedlings producers. In summary, 246 FFS facilitators were trained (refresher course) on fruit trees production management and trained 3,432 farmers. As practical, all these farmers conducted management activities in their own orchard such pesticides application, fertilizer application, pruning, weeding, irrigation, intercropping and harvesting.

In vegetable production, 55 FFS facilitators were trained and trained 726 farmers on different vegetable production techniques using FFS approach. In vegetable production also, 26 new FFS facilitators were trained in Ndego sector in order to reinforce vegetable production in this area. Pineapple seedlings production was introduced in Ndego sector also where 14 FFS facilitators are being trained on Pineapple macro-propagation.

In total during FY 2023-24, a total of 4,499 FFS facilitators and farmers were trained on fruits and vegetable production, and they have been involved in conducting management activities in their own orchards and farms.

Passion fruit and tamarillo clean seed production

Passion fruit and tamarillo seed production plots was established in Rubona, Nyamagabe, and Rwerere RAB stations. The plot size used were 0.3ha (371 passion fruit plants) and 0.22 ha (554 tamarillo plants) in Rubona; 0.4ha (1016 tamarillo plants) in Nyamagabe, and 0.69ha (1,443 tamarillo plants) in Rwerere. Routine activities for the maintenance of the fields such as weeding, pests and diseases control, fertilizer application, pruning, plant training and data collection were done regularly. The plants have reached fruiting stage, and seed will be harvested soon. A total of 13,5kg passion fruit seed was collected, and of: 340 kg passion fruit and 1,888 kg tamarillo fruits was produced for consumption. For Rwerere and Nyamabe, harvesting has not yet started.



Photo 28: Plantation of tamarillo seed production at Rwerere

Development and dissemination of extension materials for fruits and vegetables

Extension materials serve the purpose of conveying a straightforward message to encourage a specific group, such as farmers, to modify their practices. In the past several years, horticulture program has developed several extension materials that are useful to transfer horticultural innovation/technologies to the end users. Various forms of extension materials have been developed: books, booklets, leaflets, green and yellow lists, factsheets, IPM guides. These are

being used by researchers and frontline extension officers during training to deliver the message to farmers, while others are directly used by farmers themselves. Through these trainings, and from the feedback from farmers and various stakeholders who have used these extension materials, it was observed that some improvement of these materials is required. Thus, a workshop was organized to update and fine-tune existing extension materials for different thematic areas on horticultural crops to be printed in preparation for future training as well as agri-show. More than 300 extension materials were updated, validated and produced by the Horticulture Program.

1.6 Plant and Microbial Biotechnology Program

The RAB Plant and Microbial biotechnology program aims to develop biotechnology innovations to sustain the agriculture production in Rwanda. This program has four research components, namely, (1) Tissue culture, (2) Mushroom production, (3) Plant pathology and Molecular Biology and (4) Bio-fertilizers. Each component has its own research facilities and team. Each research team carries various activities fitting within three scopes namely routine activities to ensure the visibility of the program in research station, promotion of biotechnology innovations, and research to develop innovations. Currently, the RAB Plant and Microbial biotechnology program accommodates nine staff.

1.6.1 Plant tissue culture

Plant tissue culture laboratories are mandated to develop In vitro protocols of vegetative propagated crops and extension of all technologies developed. This yearly report includes mainly banana and cassava conservation trials, tamarillo embryogenesis experiments, and mass production of Potato and cassava distributed from April to the end of June 2024 as defined in annual planning.

Design and test new In vitro protocols for tamarillo

Tamarillo embryogenesis was initiated in July 2023 to study the effect of fructose on somatic embryogenesis. Tamarillo seeds were extracted from fruits collected from field germplasm, dried, and germinated in greenhouse at RAB-Rubona. After 50 days leaves were collected from plants and transferred to the plant tissue culture laboratory for initiation. The second leaf from the top (meristematic) was used for further culturing on MS medium. The modified MS medium was used and supplemented with BAP 11.25mg/L, Myo-inositol 100mg/l. Treatments of this study were (1) 20gr Sucrose, (2) Fructose (15g/L), (3) Fructose (20g/L), (4) Fructose (25g/L), (5) 15g/L fructose + 5g/L sucrose, (6) 20g/L fructose +5g/L sucrose, and (7) 25g/L fructose + 5g/L sucrose.

After 30 days from initiation of tamarillo leaf discs were incubated in a dark room, callus was successfully formed, and embryos were also developed sixty days from initiation day (**Photo 29**). Germinated plantlets were multiplied in three sub-culturing for 90 days to increase the number of plantlets according to treatments (**Photo 30**). Weaning stage was from April to June 2024. (**Photo 30**).



Photo 29: Initiated leaf discs (left), embryo developed (center))and germinated plantlet (right)



Photo 30: Tamarillo plantlets being multiplied from medium in the lab flasks (left), hardening (2nd left), weaning in small pots (3rd left) and ready-to-plant material (right)

Development and optimization of protocols for in vitro conservation of cassava

Cassava conservation experiments were conducted. Cassava was kept on a half MS medium with 2.5% mannitol but without growth regulators to evaluate conservation for one year without sub-culturing (**Photo 31**). Banana (Injagi variety) was also maintained on medium with 4% mannitol to keep stock for rapid multiplication for the beginning of season (**Photo 31**).



Photo 31: Conservation of banana after 4 months (left); and Cassava after 3 months (right)

In vitro production and distribution of potato, cassava, and sweet potato

In vitro production included Irish Potato, Banana, Cassava, and Sweet potato. The target was to produce 1,000,000 potato, and 10,000 of each of banana, cassava and sweet potato. The actual production and dissemination was 2,035,810 plantlets for potato, 12,450 plantlets of banana

currently, cassava 10,000 plantlets against 14,337 cassava and 11,339 plantlets of sweet potato (Table 48).

Table 48: Produced and disseminated plantlets in FY 2023-24

Crop	Plantlets distributed				Total
	Q1	Q2	Q3	Q4	
Potato	726,350	236,910	910,770	161,780	2,035,810
Banana	6,450	0	6,000	0	12,450
Cassava	6,327	0	6,311	1,699	14,337
Sweet Potato	5,780	0	5,559	0	11,339

1.6.2 Bio-fertilizer production

Bio-fertilizers, particularly those containing Rhizobium bacteria, can be a game-changer in enhancing agricultural productivity. The initiative by the laboratory of bio-fertilizer production in Rwanda to identify and authenticate rhizobium isolates, mass-produce rhizobium inoculants, and train farmers on bio-fertilizers is commendable. This promotes sustainable farming practices and contributes to food security in the region.

Identification of new bio-fertilizer strains

A total of 43 rhizobium strains in roots including 37 peas and 6 soybean sampled were isolated from peas at Huye to their morphological and biochemical characterization and further authentication under greenhouse conditions (Photo 32).



Photo 32: Rhizobia isolates tested for plant nodulation

Mass production and distribution of rhizobium

A total of 5,700 packets of rhizobium inoculants were produced in 2023-24 (Table 49).

Table 49: Number of introduced and disseminated packs with Rhizobium inoculants in 2023-24

Strain for crop	Number of Rhizobium packs produced					Number of Rhizobium packs disseminated				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
Soybean	600	300	2000	2,100	5,000	416	250	1,200	697	2,563
Bean				700	700					
Total	600	300	2000	2,800	5,700	416	250	1,200	697	2,563

Candidate strains were cultivated and multiplied using a fermenter under optimal growth conditions. The quality of the inoculants was tested before mixing with appropriate carriers. A total of 2563 packets of rhizobium inoculant were distributed to the farmers.

Training of farmers

A total of 200 farmers were selected in Ruhango and Huye for bean and soybean cultivation. They have been trained on rhizobium biofertilizer application during both seasons, 2024A&B (Photo 33).



Photo 33: Farmers trained on the use of bio-fertilizers (left) and helping to establish demonstration plot (right)

Demonstration plots on use of bio-fertilizers

A total of four demonstration plots for bio-fertilizers were established at Ruhango and Huye, and they will serve for trainings and observation up to crop harvest. Involving 200 farmers in the process and providing them with hands-on experience in inoculating soybean and bean seeds before planting, the bio-fertilizer production sub-section is not only enhancing their understanding of the technology but also empowering them to adopt it in their farms.

1.6.3 Mushroom production

In FY2023-24, a total of 75,000 mushroom tubes and 36,000 spawns were produced and distributed to different stakeholders who are mainly mushroom growers (Table 50, Photo 34). Both mushroom tubes and spawns are mycelium grown on the substrate and colonize the whole tube.

Table 50: Produced and distributed mushroom tubes and Spawns in 2023-24

	Q1	Q2	Q3	Q4	Total
Mushroom tubes	24,000	15,000	16,000	20,000	75,000
Mushroom spawns	8,000	7,000	8,000	10,000	36,000
Total	32,000	22,000	24,000	30,000	108,000



Photo 34: Mushroom tubes (left) and tertiary spawns (right)

Design and test new substrate formulation of mushroom

The performance of yellow oyster and *Agrocybe* mushroom growing was well evaluated the yield was good on the station field trials. One new substrate formulation is designed as follows: beans straw 45%, cotton husk 38%, rice bran 15%, lime 2%, and water content 60-65%. It has been tested on station trials and was successful (**Photo 35**). According to the formula, we weighed each component and mixed the dry materials. Then we Put the lime powder into the water and then mix properly. After we put this mixture into the dried material. Finally, we checked the water content by verifying whether the mix was dry or not, after mixing we compressed the substrates by hand, and if water did not drop out between the fingers that means is appropriate quantity of water was used.



Photo 35: Substrate preparation (Left) and yield of the new variety (Right)

Train farmers on mushroom production

In collaboration with the US Peace Corps Rwanda and southern province during the open day and, 120 people were trained in mushroom farming (**Photo 36**).



Photo 36: Training on mushroom cultivation in different areas

A total of 45 farmers, and technicians were trained on oyster mushroom spawn and tube production in collaboration with the Chinese Academy of Agriculture Science (CATAS) (Photo 37).



Photo 37: Training on mushroom cultivation



Photo 38: Trained farmers and Local government agronomists

A total of 124 farmers and technicians from the local government were successfully trained on oyster mushroom spawn and tube production (**Photo 38**). The major challenge identified was the lack of budget allocated for training farmers and extension follow-up on the field and conducting research activities.

Demonstration plots of mushroom production

To show good example of mushroom cultivation, encourage and expand mushroom production, two demonstration plots of yellow oyster, and *Agrocybe* mushrooms were established at RAB-Rubona (**Photo 39**).



Photo 39: Established demo plot on station trials

1.6.4 Plant Pathology and Molecular Biology laboratory

Collection, isolation, characterization and conservation of tomato and coffee pathogens

Tomato and coffee plant samples were collected for identification of fungal/bacterial isolates. Aseptic procedures have been followed to avoid contamination. The collected bacteria suspensions have been diluted and incubated, then individual colonies have been selected (**Photo 40**). The initial characterization was done based on differences in their cell wall structure. The final step was to examine the slide under light microscopy using immersion oil and bacteria appeared Pink- red so they are gram-negative bacteria.

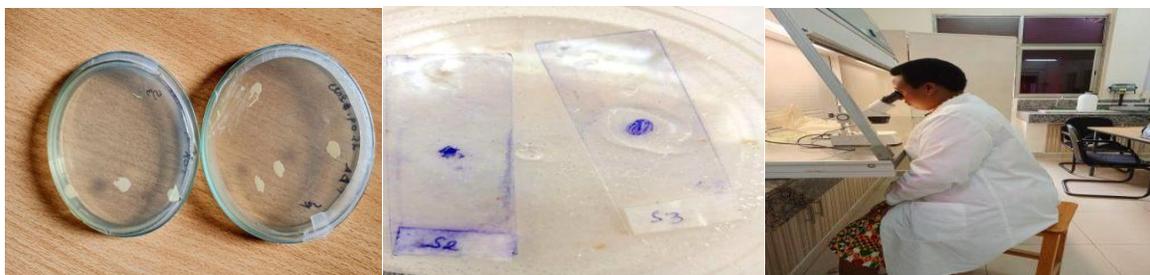


Photo 40: Bacteria Colony (left), Gram staining slides (center), microscopy observation (right)

Ten bacterial isolates and pure cultures were conserved at -80°C in liquid culture broth amended to 40% glycerol for further use or other research activities.

Isolation and characterization of coffee berry disease pathogens

This study aimed to isolate, identify and characterize the pathogens associated with Coffee Berry Disease (CBD) in Rwanda. The majority of Arabica coffee-producing areas are situated at high altitude with high humidity and low temperature, which are optimal for the development of *C. kahawae*. The study area was Rubona and Nyamasheke. This population was divided into strata based on known coffee varieties. There are seven known varieties in Rubona fields. Within each stratum (known variety), coffee plants were randomly selected for sampling. This ensures each known variety has a fair chance of being included in the study. In addition to the known varieties, the presence of unknown coffee varieties was acknowledged in both Rubona fields (1 variety) and Nyamasheke district (1 variety). To account for these unknown varieties, random sampling was employed to select representative plants from each location. 7 randomly selected coffee plants from different known varieties and one that was selected from an unknown variety. These varieties are namely: BM139, IPR107, Oroazteca, Ruiru 11, Parainemea, RAB C-15, and Geisha.

Colletotrichum kahawae was isolated from diseased coffee berries with active CBD lesions. The infected coffee berries with active lesions (sunken and dark lesions) were selected for fungal isolation. For fungal identification, advanced mycelia were transferred aseptically to freshly prepared potato dextrose agar PDA. The advanced mycelium was taken from the margin of a five-day-old culture by using a sterile scalpel.

Morphological characterization of *C. kahawae* and pathogenicity test A total of 11 pathogen colonies were isolated and used in pathogenicity test (8 colonies from Rubona and 3 from Nyamasheke) and characterized (Table 51). Isolated fungi were introduced into coffee berries and the subsequent disease symptoms were observed (Photo 41, 42 and 43).



Photo 41: Healthy young green coffee berries used in pathogenicity

Petri dishes containing berries for control were taken for each variety and had not been inoculated. Instead of inoculum, sterile distilled water was used and in the same amount. After 14 days, the observation was made and the infected berries were used to re-isolate *C. kahawae* based on Koch's postulates.

Table 51: Colony color of *Colletotrichum kahawae* isolates

N	Variety	Colony color on PDA media	
		Observed side	Reverse side
1	BM 238	Dark gray cottony, Whitish cottony	Dark gray, Pale white
2	IPR107	Dark gray cottony	Pale yellow
3	OROAZTECA	Dark gray cottony, whitish cottony	Dark yellow, pale brown
4	PARAINEMA	Gray cottony	Reddish orange
5	RUIRU11	Dark gray cottony	Dark gray
6	RAB C15	Gray cottony	Blackish gray
7	GEISHA	Light gray cottony	Dim gray-
8	Unknown from Huye	Gray cottony, whitish cottony, dark gray cottony	Reddish orange, black, pale yellow
9	Unknown from Nyamasheke	Whitish cottony, gray cottony	Pale yellow, dark gray

Pure colonies were selected after 14 days and pathogen was re-isolated following the described above procedure.

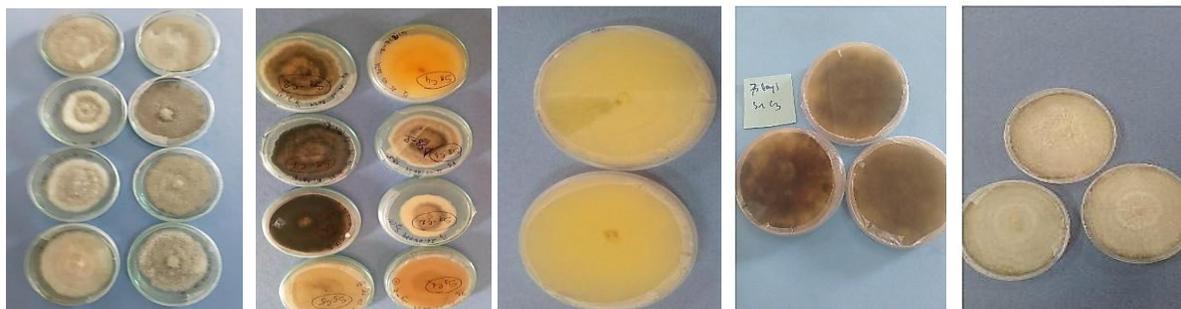


Photo 42: Pure colonies obtained from Rubona (two left photos) and Nyamasheke samples (three right photos)

Table 52: The number of infected berries after several different days

Coffee variety	CBD-infected berries after 7 days (12/4/2024)	CBD-infected berries after 10 days (15/4/2024)	CBD-infected berries after 14 days (19/4/2024)
BM139	10%	40%	46%
IPR107	6.6%	20%	26.6%
Orozteca	16.6%	23.3%	60%
Parainema	0%	3.3%	10%
Ruiru 11	0%	0%	16.6%
C15	16.6%	26.6%	66.6%
Geisha	10%	16.6%	23.3%
Unknown from Huye	16.6%	23.3%	60%
Unknown from Nyamasheke	10%	20%	56.6%



Photo 43: Inoculated berries developed CBD symptoms

Pathogenicity tests were done and infection level from the isolated pathogens on green coffee berries were observed at 7, 10 and 14 days after inoculation (Photo 43). Progressive infection was observed on coffee berries, and between 10 and 60% of berries were infected by CBD (Table 52). The highest infection was observed on Oroazteka variety and Unknown cultivar from Huye (both 60% affected berries), and the lowest was observed on Parainema variety (Table 52).

Cassava virus disease indexing from Cassava Confined trials

Cassava leaf samples were collected from confined cassava field trials established in Rubona, Mututu, and Musenyi at 12 months after planting (12 MAP) for molecular detection of CBSV and UCBSV. The sampling was done on cassava plants with or without clear CBSD symptoms and plants were selected following the Z-shaped pattern. From each plant, leaf samples were taken from older leaves, starting with the third leaf down from the top on the main stem and continuing downwards. Duplicate samples were collected for each plant. Leaf samples were then placed in 50 ml falcon tubes containing activated silica gel and a similar copy of leaf samples was pressed between clean newsprint sheets before transport to the laboratory of RAB Rubona for analysis. A total of 131 leaf samples were collected in Rubona (48), Mututu (35) and Musenyi (48).

Extraction of total RNA, synthesis of cDNA, and PCR analysis Cetyl trimethyl ammonium bromide (CTAB) method was used for the extraction of RNA following the method described by Xu et al. (2010) and modification from Lodhi et al., (1994). Complementary DNA (cDNA) was synthesized from RNA samples using ProtoScript II Reverse Transcriptase kit following the manufacturer's instructions. The quality and integrity of RNA/cDNA were checked using the Nanodrop machine and gel electrophoresis respectively. The synthesized cDNA samples were kept at -20°C before its amplification. Complementary DNA templates were subjected to polymerase chain reaction using specific primers targeting CBSV and UCBSV (Mbanzibwa et al., 2011) to detect the viruses in cassava leaf samples and distinguish the presence of two strains.

Two viruses (UCBSV and CBSV) were detected and they were confirmed as single infections or as co-infections in different samples collected at different sites. For instance, in Rubona, 1/6 samples of the control (NASE 14) showed the co-infection and presence of both viruses while the infection was 1/6 for CBSV in Mututu and 1/6 samples were infected by UCBSV in Musenyi. Interestingly, the samples collected from lines 222 and 34 were negative for both UCBSV and CBSV (Table 53, Photo 44).

Table 53: Number of samples infected with UCBSV and CBSV

Location	Lines	Number of samples with UCBSV and CBSV	Number of samples infected by UCBSV	Number of samples infected by CBSV
Rubona (n=6)		1/6	0	0
Mututu (n=6)	NASE 14	0	0	1/6
Musenyi (n=6)		0	1/6	0
Rubona (n=7)		0	1/7	1/7
Mututu (n=4)	TME 14	0	3/4	1/4
Musenyi (n=6)		0	2/6	2/6
Rubona (n=6)		0	2/6	0
Mututu (n=6)	189	0	0/6	0
Musenyi (n=6)		0	0/6	0
Rubona (n=4)		0/4	0	0
Mututu (n=4)	222	0/4	0	0
Musenyi (n=6)		0/6	0	0
Rubona (n=6)		0	2/6	0
Mututu (n=4)	33	0/4	0	0
Musenyi (n=6)		0/6	0	0
Rubona (n=6)		0	1/6	0
Mututu (n=4)	35	0/4	0	0
Musenyi (n=6)		0	0	1/6
Rubona (n=6)		1/6	3/6	1/6
Mututu (n=6)	82	0	0	0/6
Musenyi (n=6)		0	0	1/6
Rubona (n=6)		0/6	0	0
Mututu (n=5)	34	0/5	0	0
Musenyi (n=6)		0/6	0	0

CBSVs PCR Analysis from Mututu and Musenyi at 12MAP

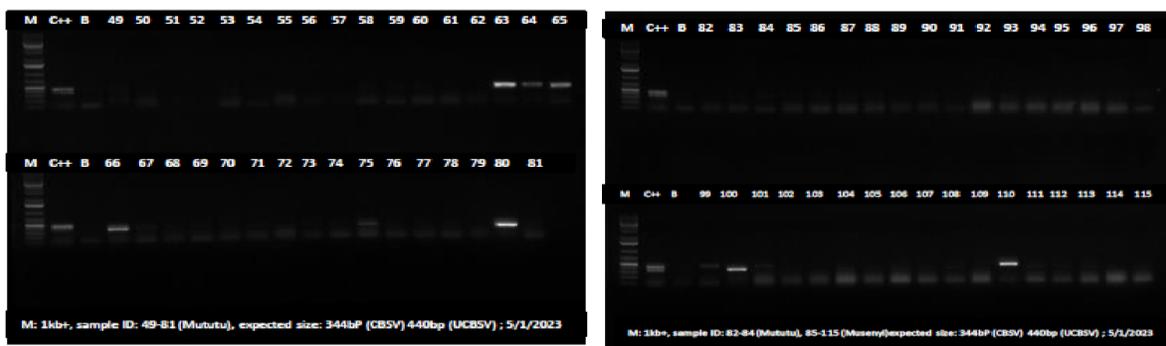


Photo 44: Gel electrophoresis image indicating the presence/absence of UCBSV and CBSV in cassava leaf samples collected in Rubona, Mututu and Musenyi

TV and Radio Spots

Two TV spots were produced, one about use of rhizobia by farmers, and the second spot was on the process of preparing clean and healthy coffee seeds from the lab to the greenhouse handling procedures. One radio talk was done on mushroom production.

1.7 Crop Protection Program

During FY2023-24, Crop Protection Program focused on enhancing food security, increasing agricultural productivity, and promoting sustainable farming practices. Key initiatives included pest and disease control, developing and evaluating new Integrated Pest Management strategies for major pests and diseases, training programs for farmers and frontline extension agents, dissemination of technology and information, mobilization campaigns, collaboration with international agricultural research institutions, publication and resources mobilization.

Integrated Pest Management (IPM): The IPM strategies were rolled out across all major agricultural regions, integrating biological, cultural, mechanical, and chemical controls. Approximately 75% of farmers adopted IPM practices, reducing reliance on chemical pesticides and fostering environmental sustainability.

Surveillance and Monitoring

The pest and disease surveillance system was conducted for better real-time data collection and analysis. This included surveillance of Banana Bunchy Top Disease (BBTD), Fall armyworm (FAW), Maize Lethal Necrosis Diseases (MLND) and maize ear rot. The results showed that BBTD was present in Southern, Western, Northern and Kigali City provinces, especially rapidly spreading in Kigali City and moving to the East, the main banana production area ([Photo 45](#)).



Photo 45: Banana affected by Bunchy Top virus, Nyarugenge, December 2023

For FAW, this was present in all visited sites with an incidence of 55%; while the incidence of MLN disease was 7.6%. The survey showed that maize ear rot is present in all agro-ecological zones, and the morphological characterization showed that Rwanda has different strains of maize ear rot ([Photo 46](#)).



Photo 46: Pathogen culturing showing diversity of the colonies (left) and maize ear rot (right)

Distribution of insecticides

Mono-cropping systems under Land Consolidation often result in sudden pest and disease outbreaks. Therefore, chemical control is promoted as the easiest and most rapid way to address the problem after pest or disease has caused significant damage, although it is not sustainable. Therefore, procurement of pesticides was done timely, and approximately 1,700 liters of insecticides were distributed to support farmers for the management of major pests and diseases hampering their production.

Farmer and frontline extension agents training programs

Over 10,000 farmers and frontline extension agents (farmer promoters, FFS groups, and sector agronomists) received training in crop protection techniques for control of Fall Army Worm (FAW), farming practices, and its control (Photo 47). The training covered pest identification, IPM, safe handling and application of pesticides. These included monitoring, identification and management of FAW.



Photo 47: Training of farmers and frontline extension agents on monitoring, identification, and management of FAW

Another training was organized for farmers and farmer promoters in Gahara sector, Gatsibo district on pest and disease management of beans and maize (Photo 48).



Photo 48: Training on pest management of beans and maize in Gahara Sector, Gatsibo District

Training on EPN mass production, harvest, formulation and application: Recent research demonstrated efficacy of entomo-pathogenic nematodes (EPN) for pest control for various crops. RAB has recently developed protocol for mass propagation of some of entomo-pathogenic nematode species. Therefore, capacity building focused on EPN mass production, harvest, formulation, and application was organized for scientists, technicians and master students from RAB, UR-CAVM, AgroPy, and IPRC-Huye. A total of 13 (10 females) scientists (including 10 females), technicians, and master students from RAB, UR-CAVM, AgroPy, and IPRC-Huye were trained on techniques of in vitro solid culture of EPN following participatory practical training methods ([Photo 49](#)).



Photo 49: Training on EPNs mass rearing, post-harvest handling and storage

Mobilization campaigns

RAB has organized awareness campaigns to help farmers to manage the major pests and diseases using the best methods to reduce their infestation. These included mobilization campaigns for the management of FAW using natural enemies, bio-pesticides and push-pull technologies. This mobilization focused mainly on land consolidated sites under maize production ([Photo 50](#)).



Photo 50: Mobilization of farmers for IPM in FAW management and hand-picking of FAW

Another campaign on the management of major pests and diseases of fruits organized was to create awareness on good agricultural practices for Mango, Avocado and Citrus using IPM practices for orchard management, pest and disease control (**Photo 51**).



Photo 51: Use of pruning to reduce pest and disease incidence

Campaign for the management of tomato pests and pesticide-safe use handling and storage was done to improve the skills and knowledge of tomato farmers in terms of using pesticides for better protection of their health and environment (pesticide-safe use and handling).

Campaign on the management of Banana Xanthomonas wilt (BXW) has been organised in Gisagara district (Kibirizi, Musha sectors), Nyanza district (Kigoma, Muyira and Mukingo sectors) and Huye district in Huye sector (**Photo 52**).



Photo 52: Onsite training campaign and awareness raising at Mamba sector, Gisagara

Workshops and Seminars

The team of the crop protection program attended more than 10 workshops and seminars held and organized by different institutions. The focus included pest and disease management, sustainable agricultural practices, validation of studies on pest management and updates on regulatory frameworks.

Extension Services

Extension services were enhanced, providing farmers with timely advice and support. Extension agents reached out to approximately 80% of the farmers through different dissemination and communication strategies such as radio, online media, and online new papers to reach communities to improve their ability to manage pests and diseases effectively. Approximately 90 field visits were conducted on calls and helped in the early detection of outbreaks, facilitating prompt response and control measures. Field visits were conducted to assess the status of major pests and diseases and give advice to farmers.

Crop Protection program has participated in National Annual Agri-show, where 5 technicians, 634 farmers, 43 agronomists, 7 researchers, 12 consultants, 74 students, 5 Agro dealers and 7 journalists have visited the stand of Crop Protection Program especially, Push Pull technology (Photo 53). All visitors received the extension materials on the establishment and benefits of push-pull technology and management of major pests and diseases.



Photo 53: From left to right Farmer group from Rutsiro district receiving information on pest management; visitors receiving explanation on push pull.

Radio talks and online media

Crop protection program conducted 16 live radio talks on IPM against pests and diseases of major crops, the use of natural enemies and biopesticides. Messages were aerated to radio such RBA, RTV, RC Huye, Rusizi, Nyagatare, Radio Maria Rwanda and Radio Izuba.

New Research projects

New research proposals were submitted and their funding was approved by different development partners:

- Mycotoxins and food safety and security in Rwanda: Understanding the biology and epidemiology of maize ear rots for sustainable maize production funded by Swedish University of Agricultural Sciences.
- Scaling regenerative black soldier fly farming innovations with vegetable push-pull cropping systems for One Health in Rural Kenya, Rwanda and Uganda”, Funded by IKEA Foundation

Mass rearing of parasitoids against mango mealybugs to undertake classical biological control

A continuous mass rearing of parasitoids against mango mealybugs are undergoing with the search of appropriate and suitable hosts of mango mealybugs to maximize its production and mass rearing (Photo 54).



Photo 54: Mass rearing and selection of host plant (mango, citrus, banana) and mass rearing of parasitoids

Evaluation of EPNs against FAW in maize and Tomato Leaf Miner (TLM)

The activity was done under the project entitled “Development of modern biological control solutions for sustainable management of destructive invasive insect pests of maize and tomato for better food security, safety and nutrition in Rwanda”. The biocontrol products were based on local beneficial insect-killing nematodes, also called entomo-pathogenic nematodes (EPNs) that have proven highly virulence and are entirely safe to humans, livestock, crops and the environment. The program has managed mass production of EPNs and produced (both *in vivo* and *in vitro*) about 2.5 billion live EPN nematodes of different species.

Nine available EPNs isolates, local and international, were mass-produced and maintained in the laboratory, biological control agent pilot facility at Rwanda. For *in vivo* mass production of EPNs, the diet protocol of the Greater wax moth, *Galleria mellonella* was optimized using locally low-cost available material. In addition, the optimum temperature of *Galleria* larvae for the best propagation of different EPNs isolates was determined. The optimum conditions such as temperature were revealed at + 20 degrees. Out of the 10 tested EPN formulations, 3 have shown promising results i.e. Xanthan gum biopolymer (Gel), Alkylpolyglucoside (surfactants) and Rape seed oil against FAW and TLM.

Evaluation of Push pull and formulated bio-pesticides for the management of FAW

On-station and on-farm effectiveness trial of push-pull against Fall armyworm and the evaluation of the effectiveness of bio-pesticides (MAZAO Achieve and MAZAO detain) Produced by ICIPE) for the management of FAW were conducted (Photo 55).



Photo 55: Scouting of FAW in push-pull trial by RAB staff (Left) and Monitoring of FAW with pheromones traps (Right)

Efficacy trials of new pesticides for the management of major pests

Agropy 5EW and Agropy EWC plus are new insecticides on the local market and evaluated for controlling FAW in Rwanda. Both of these products are pyrethrum-based insecticides containing pyrethrin as the active ingredient and they were tested against other pests such as spider mite, aphids and banana thrips. On the other hand, field efficacy trials of chlorothalonil and Problad products have been carried to test their different doses in comparison with the farmer's standard product "Dithane (50g/20L)" to control late blight in potatoes and tomatoes.

Evaluation of the effectiveness of drones in insecticide application

Evaluating the effectiveness of drones in insecticide application involves assessing various factors related to application coverage, efficacy in pest control, environmental impact, and cost efficiency. Using drones for the application of pesticides in efficacy trials offers several advantages, including precision targeting, reduced environmental impact, and improved efficiency (Photo 56).



Photo 56: Use of drones in insecticide applications for the management of FAW

Millipede control

Millipedes damage young plant seeds by drilling tunnels and eat the roots of a wide variety of plants. They attack bulbs and tubers and enlarge holes left by slugs, wireworms and other pests. The attacked plants species are beans, cabbage, carrot, corn, potatoes, strawberry, and tomatoes. Damage from millipedes is mostly encountered under extreme conditions, either in wet conditions when the soil is soggy, or excessive drought. Secondary fungal infections happen on damaged plant parts as the result of millipede damage. However, millipedes are very important for the formation of humus. They cause damage only when there are too many of them. Their sudden population build up may be result of soil disturbance and change in soil microbiota caused by climate change.



Photo 57: Millipede damage to potato tubers

To develop strategy how to manage millipede outbreaks, trials were established in three sites Rubavu, Rwamagana and Nyamagabe stations. The tested treatments were the combinations of organic manure, lime, mineral fertilizers and seed coating with Imidacloprid, systemic insecticide affecting nervous system. Preliminary results showed that seed dressing with Imidacloprid was the most efficient treatment to kill millipedes and prevent their damage.

1.8 Traditional Export Crops Program

Coffee and tea are traditional export crops and are expected to remain important in the future. During the last five years, Rwanda's exports have increased at an annualized rate of 9.7%, and coffee and tea represent more than 20% of the country's total export earnings. The emphasis is now to increase share of fully washed coffee and the number of tea factories. Coffee productivity per tree was set to increase from 2.8kg to 4kg; and tea productivity from 7 tonnes/ha to 8 tonnes/ha. This will involve an expansion of the cultivated areas, replacement of old trees and increased fertilizer use from 7,000 tonnes to 9,000 tonnes per year as well as the adoption of the innovations to adapt to climate change.

1.8.1 Coffee

Coffee research and technology transfer activities focused on variety development; support to coffee seed sub-sector; integrated soil fertility management; IPM packages for coffee and capacity building for field extension officers. In efforts to address current and future challenges in the coffee supply chain in Rwanda, there is a need to transform coffee farming from subsistence farming to more market-led high productivity systems. The deployment of new coffee varieties needs, imperatively, to consider farmer's and market preferences to maximize the return on investment from multi-actor stakeholders. Modern varieties play a big role in boosting agricultural productivity by bringing desired traits that are mean to meet farmers and consumers preferences in a sense of demand-driven variety development. The key areas in demand-led variety development are yields and quality attributes, tolerance to major biotic and abiotic stresses (pests, diseases, nutrient use efficiency) and climate change adaptation.

Variety introduction

Introductions are one of ways to speed up the varietal development programme and release as population improvement allows the creation of populations involving varieties of different origins and possibly distinct genetic structures. Based on the adaptation, primary Introduction, variety is well adapted to the new environment, released for commercial cultivation without any alteration in the original genotype whereas secondary introduction. Introduced variety may be subjected to selection & hybridization to isolate a superior variety. Based on utilization, for direct Introduction, new variety takes no time for establishment and in indirect introduction new variety takes some time for establishment. RAB is a partner in World Coffee Research's International Multi-Location Variety Trial. WCR located and gathered 31 top-performing coffee varieties from 11 suppliers around the world. The varieties, most of which have never been tested on a broad basis [3], were distributed to coffee-growing countries, for long-term evaluation on research plots. Twenty-eight of these varieties are being evaluated in Rwanda for yield, quality and tolerance/resistance to biotic and abiotic stresses in three different locations of Rwanda.

Development and deployment of hybrid coffee varieties

Because coffee is a tree crop that takes 2-3 years to mature, breeding new varieties has traditionally been a slow process taking up to 20 years. However, new varieties are needed quickly to cope with changing weather patterns, increasing temperatures, and thus new disease and pest outbreaks. For many crops, the commercial agriculture relies on F1 hybrids known for

increased vigour and superior quality. They are relatively new to coffee farmers and industry, but the future of coffee is likely to include them. F1 hybrid vigor for coffee can translate into everything from higher yields to wider climate adaptability, to resilience in the face of stresses like disease (e.g., coffee rust), frost, or drought-coupled with the reduced time from breeding to commercial release compared with traditional pure line varieties. Therefore, RAB in partnership with World Coffee Research (WCR) has developed and tested 43 F1 hybrids for the exploitation of the hybrid vigor along the whole coffee value chain.

Both 28 new coffee varieties (28) and 43 F1 hybrids were evaluated for yield, quality and multiple stress tolerance in multi-environmental trials in three different locations; Rubona (Huye), Mwitto (Nyamasheke) and Gahororo (Ngoma) representing major coffee growing areas and agro-ecological conditions. Field performance of each of the varieties and F1 hybrids was evaluated through GGE biplot analysis to assess adaptability and stability across the study location. Multivariate biplots was performed to identify correlation between variables.

Yield and quality of new coffee varieties: The analysis of adaptability and stability of different varieties for yield (Figure 13 left) showed which varieties had narrow, site-specific adaptability and can perform well in few sites (variety names in angles). Such varieties are called vertex varieties: IPR107, SLN 5B, S4808, Paraneima and Pacamara. The varieties located out of angles and inside of polygon have wide adaptability: these are RABC 15 (local variety), Batian, S795, Geisha and AB3 on Figure 13 left. Comparison of cup quality (consumer preferences) vs yield (Figure 13 right) showed the best varieties combined both, excellent cup quality and high yield and falling in the category of excellent specialty coffee (S4808, SLN5B, EC16, Paraneima, Marsellessa, Batian, S975, SLN28, and Ruiru 11).

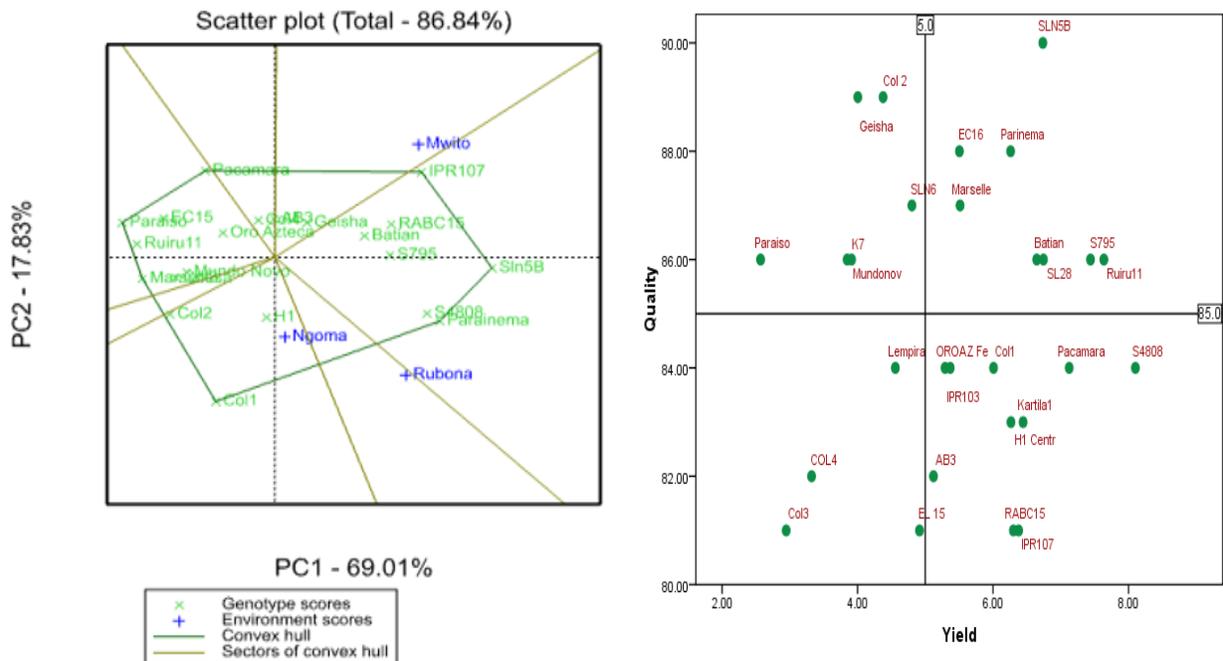


Figure 12: Adaptability and stability analysis of new coffee varieties (left) and graph showing performance of new varieties for yield and quality attributes (right)

The widely accepted definition of specialty coffee is coffee scoring 80% or above on the scale used on the Specialty Coffee Association Cupping form. Coffee that scores 85–89.99 is graded Excellent, while coffee scoring 80–84.99 is graded as Very Good. In the latter category fall high yielding varieties such as S4808, Pacamara, Oro Azteca, IPR107, Kartila and H1.



Photo 58: Physical appearance of new coffee varieties under this varietal development programme

Performance of new coffee hybrids for yield and quality

A total of 40 new coffee hybrids were evaluated for yield and cup quality. As with evaluation of F1 hybrids described above, the analysis of adaptability and stability of different hybrids for yield and quality attributes showed that BM139x5A, HarrarxRuiru-11, W020B, W040B, W070B, BM139x6A, W29MA, W100B showed site specific adaptability (vertex varieties), and other hybrids had high yield potential across environments, thus they had wide adaptability. The multivariate biplot (Figure 14) revealed best hybrids for yield and quality attributes falling in the category of excellent specialty coffee: W32, Harrar, Ruiru 11, BMX6A, BM 5A, W050B, W30MA, W31GL, W33GL, W0700, BW15LA, W42H, W29MA and W060B (Photo 59). These hybrids recorded the yield potential higher than 4.8 kg/tree – the target set in the NST-1.

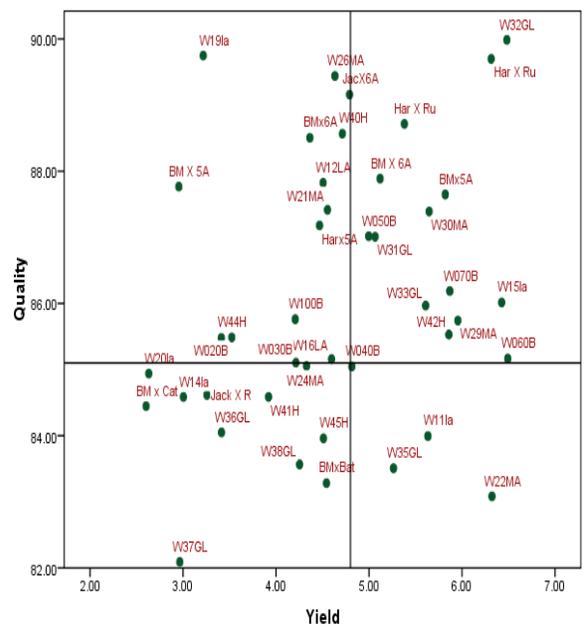


Figure 13: Yield and quality performance of F1 hybrids



Photo 59: Typical appearance of high yielding F1 hybrids

Best performing varieties and F1 hybrids will be submitted to the release process as the existing trials will serve as DUS and VCU. For F1 hybrids it will be required to put in place a good and affordable strategy multiplication as farmers will not be able to collect seeds on F1 hybrids.

Coffee seed production

RAB remains the main producer for coffee seed and seedling production, processing marketing and distribution in Rwanda. Hence there is a remarkable deficit of quality planting material for coffee expansion. Multiplication and distribution of improved and adapted coffee varieties in each agro-ecological zone, therefore, deserves special attention to promote sustainable and commercial coffee production, processing and marketing towards coffee quality management.

Purification of potential commercial coffee varieties

Quality control (QC) and quality assurance (QA) are key in deploying high quality seed. The efficiency of other inputs depends largely on the quality of seed planted. This includes physical, genetic purity and seed health. QC involves testing of seed material in the process of seed production or breeding using all available seed testing methods, including germination, seed viability, seed vigor, phenotypic and morphological traits based grow-out tests, and implementation of biochemical and/or molecular marker based testing.

New method of seed testing that analyzes the presence of single-nucleotide polymorphism (SNP) markers has become the testing approach of choice for variety identification in plants. SNPs based variety cleanup was completed in Q2. Variety cleanup programme was completed for the following commercial varieties: RABC15, Batian, Geisha, Pacamara, Paraneima, Jackson x Ruiru, BM139X Harrar, BM139X Sln6, AB3 and H1 (Centro Americano). True to type seedlots were established at Rubona station and will serve as source of basic seeds in years to come (**Photo 60**).



Photo 60: Newly established true to type seed gardens

Production of genetically pure coffee seeds

Even if the major coffee seed harvest season happens in Season B, RAB has already established 6 ha of genetically pure seed lots at Rubona, Ntendezi and Ngoma stations. During the course of Season 2024B, a total of 3,500kg of basic clean seeds were produced and distributed comprising of commercial varieties (BM 139, Jackson 1257 and RABC 15). This amount of seeds will contribute to the production of at least 8,500,000 seedlings in the process of establishing true-to-type seed stock for private coffee seed multiplication and coffee rejuvenation in other hand. Seeds were distributed to coffee companies and cooperatives in various regions of the country for the nursery development and participation in coffee rejuvenation.

Assessment of spatial variability of soil physical and chemical properties

There is increasing concerns about the sustainable management of soil fertility due to current blanket fertilizer recommendations of NPK across all the coffee growing sites in Rwanda. Characterizing the spatial variability of the soil chemical properties, particularly in cultivated areas, provides relevant information for a more rational fertilizer use efficiency. A site-specific soil test-based nutrient management system ensures the judicious use of fertilizers by contributing to sustainable and economic production without polluting the soil resources. Soil samples were collected in 21 different locations (top and subsoil) around the country to assess spatial variability of chemical and physical properties and hence the development of site-specific fertilizer recommendations. About 90% of coffee feeder roots occur mainly in the top 30 cm below ground. Consequently, soil composite samples were taken at this depth of 20 cm (topsoil) and 50 cm (subsoil) according to universal soil sampling protocols for coffee as described by (<https://cropnuts.helpscoutdocs.com/article/885-soil-sampling-procedure-for-coffee>) (Figure 15). Soil sampling strategy was set on the distributional uniformity of composite samples in each coffee field on a diagonal shapes 5 sub-samples.

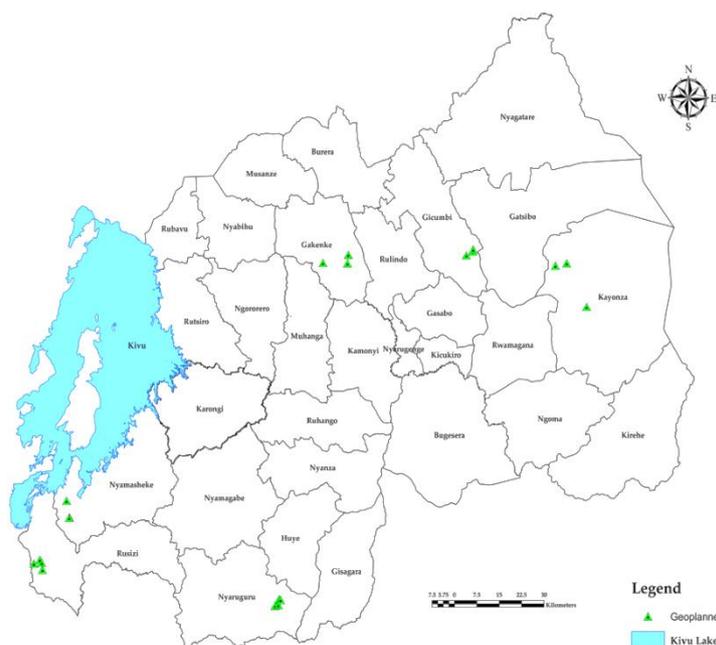


Figure 14: Geo-referencing of sample sites (green dots)

Samples were collected in Rusizi, Nyamasheke, Nyaruguru, Gakenke, Gicumbi District and Kayonza- thus a total of 20 samples with top and subsoil samples (40 samples in total). Soil analysis and subsequent site specific fertilizer recommendations were performed using procedures available at Crop Nut Kenya (Site specific fertilizer recommendations were developed according to procedures used by Cropnut laboratories located in Naironi Kenya (<https://cropnuts.com/laboratory-analysis-services/>)). Soil spatial variability of major soil chemical properties was observed (Table 54).

Table 54: Spatial variability of soil chemical properties in test environment

Districts	pH	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Organic Matter (%)	Sulfur	Boron	Manganese
Gakenke	5.1	0.18	8.99	238	4.19	18.75	0.2	11.27
Gicumbi	5.7	0.17	36.8	386	35.05	17.55	1.56	0.41
Kayonza	5.8	0.17	14.53	212.2	4.40	14.46	0.88	65.50
Nyaruguru	4.8	0.14	9.20	5405	26.8	21.55	1.37	0.14
Rusizi	5.2	0.22	25.43	347.75	5.07	80.77	0.505	41.57

Development of site-specific fertilizer recommendations for coffee farming systems

Fertilizers are required in commercial production systems because of removal of nutrients from soil with each crop harvest, which is also the case of coffee in Rwanda. The higher the harvest is or the poorer the soil is more nutrients are required for replenishment to maintain yields. If yield increase is targeted, higher fertilizer rates should be applied for economically viable crop production. Based on soil survey results, site-specific fertilizer recommendations were developed (Table 55).

Table 55: Fertilizer recommendations developed for different districts

District	Grams per tree			Kg per ha			
	Manure	Lime	NPK (22.6.12+3S+B+Z)	NPK (22.6.12+3S+B+Z)	Manure	Lime	
Gakenke	9,000	7,520	270	360	12,000	10,000	
Gicumbi	13,925	7,520	308	410	18,500	10,000	
Kayonza	8,250	7,520	257	340	11,000	10,000	
Nyamasheke	30,317	7,520	270	360	40,333	10,000	
Nyaruguru	13,938	7,520	293	388	7,925	10,000	
Rusizi	7,500	7,520	258	340	10,000	10,000	

Because of Rwanda coffee fertilizer program, a blend known as 22.6.12 +3S +B +Zn is the only one on the market, recommendations took on that type of blend. Specific fertilizer recommendations were developed for districts (Table 55).

The results of this study update the 2012 fertilizer recommendations that set recommended dose of mineral fertilizer at 200 g per tree. Table 55 shows significant increase in the updated recommended doses of mineral fertilizers. These new recommendations are expected to increase coffee yield by 20% according to estimates. However, the results of this study need to be confirmed and supplemented by the crop response trials. Proper fertilizer programmes will finally serve as a breakthrough in maximization of coffee productivity per tree and hence contribute to coffee farming profitability, income generation, and overall improvement of livelihoods.

1.8.2 Tea

Multi-environment characterization of tea germplasm for yield and quality

Tea in Rwanda is grown in diverse agro-ecologies at the Southern, Western, and Northern Provinces of the country. Tea productivity (yield and quality) is a function of genotype, environment and management. Rwandan tea farmers typically had very few choice of varieties.

Therefore, to enlarge the genetic base of tea for increased productivity, RAB and partners identified and imported 17 different tea clones from different suppliers across the world (Table 56). The trial was established in Mata, Ntendezi, SORWATHE, ASSOPTHE and Ntendezi. The trial aims to evaluate yield and quality potential of different clones in multiple environment to further recommend specific clones for specific agro-ecological conditions of Rwanda. Data were collected on yield and quality attributed and submitted to analysis through GGE biplots (Table 56).

The analysis of adaptability and stability of different tea clones with regards to yields and quality attributes are illustrated on the polygon view and biplot analysis (Figure 16). Yield recordings on long-term coupled with quality and assessment of tea clones and analysis indicated that some clones produced high leaf fresh weight and were responsive to favorable environments. Based on the mean yield, six clones can be selected and released for commercial planting in different tea growing areas and these includes clone TRFK 54/40, TRFK 301/4, SFS 110, SFS 204, TRFK 303/577, TRI 475 and TRFK 301/4. The overall mean performance ranged from 1948 and 2185 kg /ha for clone SFS 204 and TRFK 54/40, indicating that these clones are the promising over all four environments. Regarding quality assessment, analysis also has indicated that the six clones present good cup quality. These clones illustrated narrow and broad adaptability potential within the 4 study locations as indicated by Figure 16.

Table 56: New tea clones evaluated during FY 2023-24

N	Clone name	Origin	Variety type	N	Clone name	Origin	Variety type
1	1TRFK 301/5	Reunion	Cambod	18	UTK401658A	Unilever/ Kenya	Assam
2	TRFK 100/5	Rwebitaba, Uganda	Assam	19	TRFK301/6	Kenya	Assam
3	BB35	Kericho, Kenya	Cambod	20	TRFK 371/3	OP of AHP S15/10	Assam
4	TRFK 10/342	Kericho, Kenya	Assam	21	SFS 110	Malawi	Assam
5	TRFK 12/56	Kericho, Kenya	Assam	22	SFS 204	Malawi	Assam
6	SFS 150	Kenya	Assam	23	G 364	Malawi	Assam
7	TRFK 54/40	Kericho, Kenya	Assam	24	BNB5	Malawi	Assam
8	TRFK 12/12	Kericho, Kenya	Assam	25	K27	Kericho, Kenya	Assam
9	PC/81	Malawi	China	26	TRFK 7/3	Ambangulu, Tanzania	Assam
10	TRFK 301/4	Reunion	Cambod	27	TRFK 6/8	Kericho, Kenya	Assam
11	SFS 475	Malawi	Assam	28	TRFK 11/4	Kericho, Kenya	Assam
12	UTK900244B	Unilever/Kenya	Assam	29	TRFK6/10	Kericho , Kenya	Assam
13	TN 14/3	Kenya	Cambod	30	G9	Congo	China
14	TRFK 303/577	OP of TRFK 6/8	China	31	TRFK 12/19	Kericho, Kenya	Assam
15	BB10	Kenya	Cambod	32	TRFK 31/11	Ambangulu, Tanzania	Assam
16	MARTIMI	Unilever/ Kenya	Assam	33	B1/57	Congo	China
17	TRFK 31/8	Kenya	Assam	34	Bu 105	Congo	China

Best clones in terms of yield and quality parameters are illustrated in the Figure 16. Clones appearing in the upper right quadrant of the biplot (Figure 16) should be highly considered for variety release. They include TRFK 54, TRFK 301, TRFK 301, TRFK475 and TRFK 12 (Photo 61). The results of this study generate critical knowledge for tea producers and agronomists about how tea clones respond to different soil and climatic conditions, including extreme environments, which mimic the changing climate tea growers are seeing in tea-producing regions of Rwanda. Researchers will identify key traits that have allowed different varieties to adapt to different environmental conditions, which will lay the groundwork for major advances in coffee breeding, climate adaptation strategies, and future research.

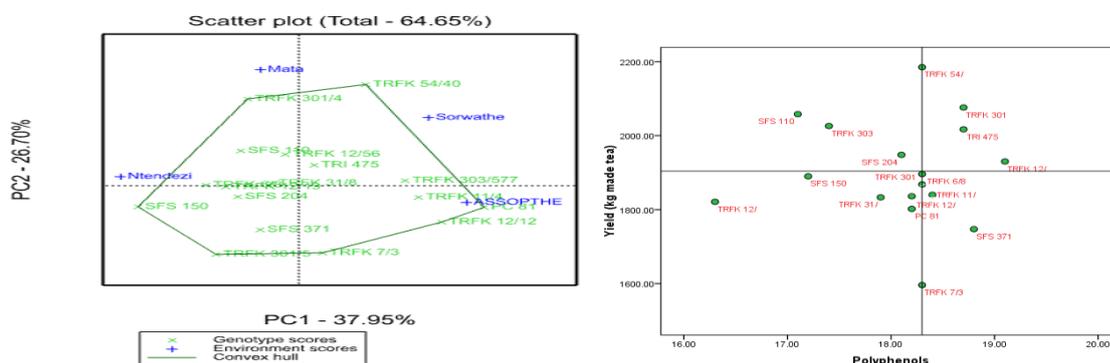


Figure 15 : Adaptability of different tea clones in different environments (left) and yield and quality characteristics of different tea clones (right)



Photo 61: One of trial sites located at Rulindo District and hosted by Sorwathe

1.9 Crop postharvest and processing division

The division aims to develop and disseminate post-harvest technologies to reduce losses, improve the quality of produce and ensure market competitiveness. It aims to (i) improve postharvest handling through post-harvest infrastructures promotion, technology development and dissemination and (ii) to develop technologies for storage, processing, quality, value addition and nutritional preservation of agricultural products. Key targeted interventions of the Division for FY 2023-24 and shown in [Table 57](#).

Crop Harvesting and Post Harvesting Handling

Post-harvest management includes handling, storing, and transport of agricultural commodities after harvest. For cereals and pulses, post-harvest activities may include drying and sorting or threshing as well. After harvest, the main challenge is to preserve quality, quantity, and safety of the commodities.

Table 57: Indicators and key achievements for Post-harvest Division in FY 2023-24

Indicator	Baseline	Target				Total Annual	Total achieved	% achieved
		Q1	Q2	Q3	Q4			
Indicator: Post-harvest losses reduced and Quality of produce improved for CIP crops								
Number of sheeting/tarpaulins purchased	12,000		500			500	5,500	1100.0%
Number of temporary shelters mobilized	5,000		500	2,000	1,000	3,500	14,941	426.9%
Quantity (Mt) dried by drying machines	11,921			8,000	6,000	14,000	24,536	175.3%
Number of radio and TV spots produced and disseminated	6		3		3	6	6	100.0%
Number of LUC sites mobilized on improved harvesting and post harvesting handling good practices	13,404		6,702	6,702		13,404	15,984	119.2%
Number of Trainings/workshops on use of fruits and vegetable dryers	30		15	15		30	30	100.0%
Number of Drying machineries (dryers cereal fruits and vegetables) well managed and timely maintained	3			3		3	3	100.0%
Indicator 2: Access to market of agriculture commodities under LUC sites were facilitated								
Minimum prices fixed (maize and rice)	2		1	1		2	2	100.0%
MT of CIP crops linked to markets	124,000	15,000	35,000	50,000	15,000	115,000	167,555	145.7%

The key activities were conducted by the Division were: Mobilization on good postharvest management practices and provision of post harvest's equipment; Building the capacity of farmers on drying the fruit and vegetables; Monitoring the postharvest process of different crop across the country; Linkage the farmers with the potential market (Table 56).

Public awareness

Radio and TV were prepared and broadcasted to create awareness and to build the capacity on the postharvest management (Photo 62).



Photo 62: Delivery of radio and TV programs on best postharvest practices

Linking the production with the potential market

Agriculture sector in Rwanda remains largely fragmented, with many smallholder farmers, and weak market linkages to traders. Market-oriented production and aggregation is weak, and producers lack basic data and market information, including standardized quality criteria required by the processors. During the fiscal year, Crop Postharvest and Processing Management division implemented the following activities: Set up of the temporary Aggregation point, and organizing the management of production; Linking the farmers with the potential market: through sharing the information on available production with the potential buyers, the farmers were able to sell their production at set price; Promotion of Contract Farming: before the harvest many cooperatives had already signed the contract with the buyers.

Postharvest equipment

The introduction of post-harvest technologies has been taken place in order to minimize the agriculture production loss both in quantity and quality. RAB has provided the mobile dryers under the Seed and Fertilizer subsidies program to the different private companies (Table 58) that play a big role in improving quality of the harvested grains and purchasing production.

Table 58: List of private partners received grain driers

Private operator	District	Sector	Number of Drier	Crop	Capacity	Company target (tonnes)	Dried quantity (tonnes)	
							Q3	Q4
Cob driers for seed								
Tri-Seeds	Masoro	Ndera		2 Maize seeds	6MT/day	3000	3930	3497.5
E&B	Kayonza	Mukarange		1 Maize seeds	6MT/day	280	0	112.0
				3		3280	0	3609.5
Mobile driers for consumption maize								
EAX Co.	Bugesera	Mayange		1 Maize	10MT/4h	2,000	2341	80.0
RGCC	Kayonza			1 Maize	10MT/4h	400	200	390.0
Isoko Trade Co.	Nyagatare	Ryabega		1 Maize	10MT/4h	1,000	1160	0.0
Nyagatare Rice Co.	Nyagatare	Ryabega		1 Maize	10MT/4h	2,000	710	0.0
Vision Storage Facility Co.	Kayonza	Nyamirama		1 Maize	10MT/4h	1,500	1200	3652.6
Vision Storage Facility Co.	Gatsibo	Kiramuruzi		1 Maize and bean	10MT/4h	2,000	2500	1406.3
Moved to EAX Nyanza	Nyanza			1 Maize	10MT/4h	200	20	290.0
Family Maize flour co.ltd	Gisagara	Kibirizi		1 Maize	10MT/4h	3,000	666	132.9
Tubura	Kayonza	Mukarange		1 Maize	10MT/4h	1,000	387	591.2
KOTIKORI LTD	Rusizi	Bugarama		Maize	10MT/4h	500	380	0.0
Bright	Rusizi	Bugarama		Maize	10MT/4h	400	400	0.0
Sub-total			9			14000	9964	6543.0

Crop Processing and Food Quality Management Program

The Program conducts research on storage, processing, quality, value addition, nutritional preservation of agriculture products, and food safety. The protocols were developed to train farmers/cooperatives on processing technologies, Nutrition improvement using nutrients dense foods through Nutrition Sensitive Agriculture and cooking demonstration. Besides, food safety awareness focused on Aflatoxins and Fumonisin and how to mitigate them was conducted through radio talks and extension material dissemination.

Training of farmers on nutrition sensitive agriculture

National Household survey of 2019-2020 has reported 7 Districts with higher malnutrition rates: Burera, Musanze, Nyabihu, Rubavu, Ngororero, Nyamasheke and Nyaruguru. We selected three of them (Huye, Gisagara and Nyanza) to conduct nutrition training. Each year Crop Processing and Food Quality Management Program conducts research on nutrition and provides training on food preparation ([Photo 63](#)). The training was conducted for teaching parents, especially mothers of children of under 5 years old and health care staff, on how to prepare healthy meals. RAB developed training material to improve nutrition status using nutrient-dense food.



Photo 63: Cooking demonstration 2023-2024

A total of 60 women were trained on diverse recipes and principles of good nutrition with the locally available food products. Training included food preparation, cooking demonstration and hygiene sanitation. Twenty-eight children consumed the recipes developed with their mothers. Use of women groups and nutritional education is one of the ways to eradicate malnutrition.

Product development, demonstration, sensory evaluation, exhibition

Under the 16th Agrishow, the Division prepared more than 10 products, which were exhibited. Various visitors were trained on baking using blended flours (wheat blended with cassava or sweet potato). The bakery products that were processed from blended flours include cakes, biscuits, bread. Maize and sorghum were also used to process breads and cakes. Fruits and vegetables are also important for the human nutrition and income for the farmers. During the Agrishow, fruits juice and dried fruits and vegetable were processed and exhibited. The adoption of these technologies has the potential to improve the respective value chain. Agrishow exhibition played a vital role in fostering innovation and driving positive changes in the agriculture and food processing sectors.



Photo 64: Processing products exhibition 2023

Canned vegetables: processing, quality analysis and sensory test

Sterilization and pasteurization are main techniques of food conservation. Canning is one method of sterilization that consists of packing, airtight sealing and heating the food with the purpose of preservation. This study conducted participatory research on vegetable canning to identify vegetables suitable for canning. The assessment of canned vegetables and fruits, namely tomatoes, carrots, eggplants, mango and pineapples, was done for shelf life and chemical analysis were repeated after 5 months.



Photo 65: Food conservation research at UR/ Busogo laboratory, 2024

The microbiology data collected from canned food included Total counts (CFU/g), Total coliforms (CFU/g), Yeast and molds (CFU/g) and Salmonella (CFU/g). Physico-chemical parameters recorded were Titratable acidity (%), Vitamin C (mg/100g) and Beta carotene (mg/100g). The shelf life of canned carrots, eggplants, mango and pineapples can be extended to more than 5 months as none of the microbiological contamination data studied was detected. Meanwhile, the tomatoes showed contamination after 3 months of conservation, but salmonella was not detected. *Clostridium botulinum*, a bacteria with botulinum toxin, the main problem with improper sterilization of canned food, was not studied here. Canned food science is advanced in Northern hemisphere countries where it can be stored in flasks up to three and more years. Therefore, study will be repeated to confirm the canned vegetables and fruits shelf-life duration and sensory evaluation will be done thoroughly.

Capacity building on food inspection, HACCP and food quality management system

Food inspection and Hazard Analysis Critical Control Point (HACCP) are among the key methods for checking food quality. Six Staff of Crop Post Harvest and Processing Division learned about ISO 22000 on Food Safety Management System following the link below: <https://alison.com/course/iso-22000-2018-elements-of-food-safety-management-system-fsms>.

Identification and selection of food processing SMEs

Training and coaching was organized by Quality audit service, RSB and RAB to upgrade the technical capacity and knowledge of the SMEs in processing standards and quality requirements developed by RSB and to disseminate practical guides on various food products. Also, the availability of knowledgeable and qualified technicians is among the standard requirements. Technical knowledge gaps exist across the food processing enterprises. In order to maximize the potential of the food processing sector, it is important that all actors involved in food processing to be equipped with the knowledge and tools to improve the quality and safety of food products. Four SMEs involved in food processing were identified and selected for training in food processing. Twelve SMEs were given technical assistance: Family Maize Flour and Gisagara Agro-Business Industries; APODER Ganira; ProSource Nutrition; Corn mill plant, Muhanga Food Processing Industry; UMUMA Processing Flour; Mbale; CARL; NutriPo; Irahoza Emillia and DELMU Ltd. A guiding document on HACCP was used as guidance during coaching.

Study on aflatoxin in maize: samples collection, samples preparation

Aflatoxins are naturally occurring fungal by-products that contaminate crops especially cereals and oilseeds and the contamination may occur in the field and after poor storage in

humid conditions. Aflatoxins cannot be removed from affected grains and cause acute chronic sickness and growth impairment in children. These fungi may infect maize, peanuts, sorghum, cassava, spices. Mitigation measures require a comprehensive approach targeting field production, harvesting, storage, processing and logistics practices bringing together the public and private sectors to reduce food losses and increase the availability of healthy and nutritious food. Research showed that with mechanical damage, higher moisture content of grains and higher temperature of the store house, associated aflatoxin levels were also increased.

The aim of this study was to create awareness of the key market operators and maize cooperatives about mycotoxin and how to mitigate aflatoxins in maize and guide identified cooperatives in application of good post-harvest practices. The study assessed aflatoxin contamination in maize grains among big buyers in maize from market and stores selected in the country, and identified aflatoxin causing factors in maize from market and stores. A total of 300 maize grain samples were collected from 15 Districts: Kirehe, Gatsibo, Nyagatare (Eastern Province), Musanze, Rulindo, Gicumbi (Northern Province), Ruhango, Nyanza, Kamonyi (Southern Province), Nyamasheke, Rubavu, Rusizi (Western Province) and Nyarugenge, Gasabo and Kicukiro (Kigali city).

The maize samples collected were grain 47% and flour 53%. A questionnaire was used to collect information on storage conditions, duration of storage and awareness about aflatoxin problem. The assessment included season 2024A and 2024B. The results showed that a total of 22% of the collected maize grain samples has aflatoxin levels above the maximum permissible level of contamination in maize (according to the EU standards). A total of 51% respondents were aware of aflatoxin contamination in food. The earlier studies reported 7.3% awareness in 2018, and 40.3% in 2020 (Niyibituronsa et al., 2018 and Niyibituronsa et al; 2020), which shows increased awareness. More efforts for aflatoxin mitigation are needed at market level. Farmers need to be aware and taught how they can improve knowledge on mycotoxin mitigation. For this reason, the monitoring of aflatoxin levels and strict regulation of grain storage is mandated in Rwanda.

Build a Workshop for Food Processing and Nutrition

RAB is planning to build a workshop for food processing and nutrition research and technology demonstration. The workshop is targeted for analysts, compilers, food data generators and users of food composition database programs, teachers of nutrition and nutritional aspects of food chemistry. The activities to construct the workshop for food processing and nutrition started in June 2024, and contract with construction company was released out in June 2024 and expected for completion in October 2024.

Capacity building and dissemination of agriculture products

Live radio live talk to disseminate results on processing of agriculture products was done on 10 November 2023, at RBA (https://podcasters.spotify.com/pod/show/radio-rwanda/episodes/CRS-NABAFATA-NYABIKORWA-MU-KWIHUTISHA-UBUHINZI-BUGEZWEHO-KWIHAZA-MU-BIRIBWA-NO-KURWANYA-IMIRIRE-MIBI_e2bo7d2). Detailed information on technologies and practices disseminated on different products developed was delivered during the talk. The farmers were requested to adopt the agricultural technologies to increase production and improve nutrition status of their children and other family members; that there is a need to fight against the stunting among under 2 children because is still high

in their districts. The focus on young girls and women underlined the need to consume foods rich in Iron like High Iron Beans to fight against anemia. High-iron beans were recommended for home consumption. The second radio talk was about the importance of vegetables in diets and all topics from the first talk (<https://podcasters.spotify.com/pod/show/radio-rwanda/episodes/GUTEZA-IMBERE-UBUHINZI-BWIMBOGA-NIMBUTO-e2fqbli>)

Aflatoxin awareness material

One leaflet and one poster on aflatoxins and their mitigation were developed showing the different steps of postharvest handling where aflatoxins occur and what are the best practices after harvesting to avoid them.

1.10 Seed and Fertilizer Division

1.10.1 Seed Production

Seed production activities at RAB are designed to provide quality seed in support of National seed system and Crop Intensification program, which emphasizes the critical role of providing farmers with improved seeds in sufficient quantities. This approach is designed to boost the productivity of essential crops, ultimately enhancing the livelihoods and outcomes for Rwandan farmers. To facilitate the production and supply of improved seeds, the government, via the MINAGRI has created a conducive environment that encourages private sector investment in seed production and marketing. As a result, there has been a significant increase in the availability of early generation seeds (EGS) produced by RAB, which are then supplied to private seed multipliers. Seed production at RAB is carried out across 12 stations located in different agro-ecological zones.

Seed production in the season 2024 A

In the season 2024A, a total of 164.6 hectares across 12 RAB stations were reserved for the production of various seed categories. This included 33.9 ha for pre-basic and 130.9 ha for basic seed production of maize, soybean, beans, wheat, Irish potato and rice. A total of 811,149 kg of seed were produced.

Table 59: Seed production in RAB stations in 2024A

Crop	Category	Area planted (ha)	Expected production (kg)	Seed (kg)	Screened as consumption, kg	Produced (kg)
Maize	Pre-basic	3.5	2,650	3,529	193	3,722
Soybean	Pre-basic	3.31	3,691	7,977	30	8,007
Beans	Pre Basic	4.65	3,483.9	3,769.5	2,125.8	5,895.3
Wheat	Pre-basic	2.2	2,200	1,062	816	1,878
Irish Potato	Pre-Basic	20.2	130,677.40	126,747.00	44,221.8	172,690.80
Rice	Pre-basic	0.04	109	206	6	243.5
Total Pre-basic		33.9	142,811.2	143,290.5	47,392.6	192,436.6
Maize	Basic	20	10,000	9,229.5	7,062	16,291.5
Soybean	Basic	13.9	11,080	6,689	1,443	8,132
Beans	Basic	26.4	21,295.5	14,403.5	10,516.8	24,188.3
Wheat	Basic	17.1	15,630	10,590	3,818	14,408
Irish Potato	Basic	53	442,789	390,848.4	139,213.8	553,658.2
Rice	Basic	0.5	1,823.9	1868	0	2,034
Total Basic		130.9	502,618.4	433,628.4	162,053.6	618,712
Grand Total		164.8	645,429.6	576,918.9	209,446.2	811,148.6

After screening for quality and removing consumption quality class, a total of 576,919 kg of seed were harvested (all crops together), or 143.3 t for pre-basic and 433.6 t for basic seed (Table 59). Fortunately, there were minimal adverse environmental conditions, which contributed to an increase in production in season 2024A.

Seed production in the season 2024B

Since harvesting and processing activities are still ongoing at most of RAB's stations, the production figures provided in this report are based on estimated production for season 2024 B. To maintain the production of EGS and ensure a steady supply of improved seeds to farmers, plans were made and executed for the 2024B season to produce sufficient pre-basic and basic seeds. This effort aimed to generate the necessary EGS for producing an adequate number of certified seeds for the 2025A season. Initially, 136.4 ha were allocated for various seed categories in the 2024B season, including 80.55 ha for pre-basic seed production and 55.85 ha for basic seed production across key crops. During implementation, 106.2 ha were planted, comprising 76.1 hectares for pre-basic seeds and 30.03 ha for basic seeds, with an expected yield of 27,703.8 kg of seed (Table 60).

Table 60: Seed production in RAB stations in 2024B

Crop	Category	Area planted (ha)	Expected production (kg)	Seed (kg)	Screened as consumption, kg	Produced (kg)
Maize	Pre-basic	2.73	1,365	92	0	0
Beans	Pre-basic	8.36	22,480	3,214	12,480	4,462
Soybean	Pre Basic	2.06	1,648	2,192	342	2,534
Wheat	Pre-basic	26.1	76,260	0	0	0
Irish Potato	Pre-Basic	35.7	238,760	5,781.20	997	10,818.40
Rice	Pre-basic	1.194	3,918	3,030	1775	4,063
Total Pre-Basic		76.144	344,431	14,309.2	4,362	21,877.4
Maize	Basic	1	500	40	30	70
Soybean	Basic	11.51	9,660	8,550.6	2,452.8	11,002.4
Beans	Basic	3	2,400	1,873	132	4,884
Wheat	Basic	5	5,000	0	0	0
Irish Potato	Basic	8.35	83,500	0	0	0
Rice	Basic	1.17	3,870	2,931	1775	3,949
Total Basic		30.03	104,930	13,394.6	4,389.8	19,905.4
Grand Total		106.174	449,361	27,703.8	8751.8	41,782.8

Pre-basic seed

According to the production plan for season 2024B, 86.9 ha were initially designated for growing pre-basic seed. However, only 76.1 ha were planted (Table 60). As updated by end of August for seed processing activities, and handling, total seed quantity has reached 54,323 kg in August 2024 vs the reported 42,782.8 kg in June 2024. From this, approximately 14,309.2 kg of pre-basic seeds were obtained for different crops. The production targets for pre-basic seeds were largely achieved. Despite efforts to meet the overall target for basic seed production, most sites at different stations struggled to achieve their expected targets due to adverse climate conditions. The early onset of sunny in the middle of season 24B which caused the diminishing productivity the most commodities. Beans and potatoes were particularly affected, with their yields falling well below expectations. Irrigation efforts were implemented to address the situation, resulting in a good output.

Basic seed

In 2024B, basic seed production was planned on 96.8 ha, but 89.9ha were planted (Table 60). Following the harvesting and processing stages which are ongoing for most commodities as similar to the pre-basic, a total of 83,587 kg of seeds were produced, including 44,156 kg of high-quality seed. Similar to pre-basic seed production, the production targets for basic seeds were achieved except for beans and potato which had adverse effects of the drought.

Certified seed production

RAB supports private seed multipliers by providing access to foundation seed stock, technical assistance and quality control services, thus supporting certified seed production (Table 61). This ensures that the certified seeds produced by private multipliers meet stringent quality standards and are widely available to farmers across the country.

Table 61: Certified seeds produced by private seed multipliers in FY 2023-24

Crop	Seed quantity produced in 2024A (kg)	Seed quantity produced in 2024B (kg)
Beans	121,875	267,600
Soybean	118,549	45,000
Maize	4,943,722	1,277,250
Rice	310,957	373,285
Seed potato	26,178,276.4	23,388,495
Wheat	27,039	770,820

Mobilization, coordination and capacity building of local seed producers

Field visits, consultative meetings and workshops for private seed multipliers were organized to coordinate and promote certified seed production, organize and provide marketing support, and offer technical assistance for seed production and processing. One visit has been done to evaluate hybrid maize seed production by private seed multipliers in Nyagatare and Gatsibo. The challenge faced in pollen synchronization during seed production, particularly, in the production of three-way hybrids was discussed. Key issues mentioned were poor grain filling due to insufficient synchronization between male and female flowering, planting during the off-season, and technical shortcomings in hybrid seed production. If not addressed, it can lead to inconsistent results, genetic drift risks, and potential long-term genetic erosion. The field report of this visit underscores the need for improved technical expertise and better synchronization practices to enhance hybrid seed production outcomes.

Technical reason behind seed production failures

Due to insufficient rain during planting and soil had no enough water capacity that could make maize seeds to germinate accordingly the staggering is assumed null, and not good as required, this made the staggering of male maize family of inbred lines that were planted 3 days before females to be not effective, which resulted to the same germination date of males and females, this resulted to tassels developed before silk, silk should come before tassels to allow proper synchronization. The insufficient period of staggering in planting which resulted to same germination date between male family and female family were at higher percentage, affected yield at a higher negative percentage as shown in figure below. The maize cobs lining

were randomly placed to cob-shell very irregularly with missing grains, remember lines on the cob is normally straight on the normal cob-shell. The life time of pollen on tassels is 4 days, and tassels develop very first than silk.



Photo 66: Good pollination after right prediction of pollen silk nicking of maize cob (left), and bad pollination resulting from poor prediction of pollen silk nicking of maize cobs (right)

On **Photo 66**, right, '**A**', the first silk of the base cob erupted when tasseling was insufficient while the upper side of the cob had enough tassels although the distribution of pollen was random, at '**B**' the life time of the cob characterized by insufficient pollen distribution and the whole silk life didn't get enough pollen that resulted into few haphazard kernels on the cob regularly distributed. On '**C**' have the same pollen distribution properties of '**A**' but at list the pollen was enough compared to A region, if the synchronization could have been taken care of at '**C**', the yield wouldn't have been affected much, the primary indication of synchronization is tried and error method, inter and intra staggering is very much lacking, as it is done many times in the silk life, the genetic drift can take place due to rhythmic contamination. The prediction the future situation of seeds should be revised. The observation in the breeding value of hybrid development in the seed companies requires training, the recommended activities to lean seriously is pollen synchronization, staggering both inter and intra staggering to maximize pollen availability, planting date is not staggering date, the staggering date is the time of planting where sufficient amount of water in the soil is available to start germination, when the soil moisture is not sufficient to start germination, the staggering planted time is considered null, therefore intra staggering is initiated to support staggering in the null stage. The cases of seed companies do not consider the null stage of staggering, which results in poor synchronization of pollen silk overlapping.

Meeting with bean seed producers

RAB has organized meeting with Bean seed multipliers to identify the reason of low productivity. The meeting was held on 17th August, 2023. The participants discussed on bean production constraints and how to overcome them. The participants reported that there are some businessmen who call individuals involved in beans value chain asking them where to find beans seeds for supplying to farmers supported by some NGOs. The meeting concluded that the seed must be distributed only by seeds producers who are experienced in seed

production to avoid the distribution of poor quality of seeds. Key resolutions were to conduct mobilization on use of improved bean seed in districts; increase awareness to use improved seed; Seed price must be negotiated in between seed producers and buyers; Pulses and Oil crop Program seed technicians are requested to visit beans seed stores of seed producers in order to assess the current quantity status and quality of bean seeds. RAB would develop an integrated strategy and mobilize ongoing projects like CDAT, AGRA and CIAT would support seed producers.

Horticulture Seed production

Fruit and vegetable seed production was done at RAB through harvest of scions and grafting, as well as seed collection.

Scion production: The scions of different fruit trees were harvested and distributed for grafting to individual nursery operators, cooperatives and organisations. The most popular varieties were Hass and Fuerte of avocado and Tommy Atkins, Zillate and Kent for mango as they have high market demand. A total of 31,260,850 scions, have been produced in different RAB Stations (Table 62). Private orchards have been identified with high potential to supply scions of good quality. The table below show the number of scions produced by RAB orchards.

Table 62: Scions produced in RAB stations during FY 2023-24

RAB Station	#of scion's apples	#of scion's Mango	#of scion's Avocado	#of scion's Citrus
Musanze	500	0	200,000.00	0
Rwerere	500	0	250,000.00	0
Tamira	0	0	-	0
Gakuta	0	0	-	0
Rubona	0	150,000.00	300,000.00	20000
Muhanga	0		30,000.00	0
Ntendezi	0	0	0	0
Ngoma	0	500,000.00	100,000.00	0
Nyagatare	0	200,000.00	500,000.00	20,000.00
Rubirizi	0	100,000.00	500,000.00	50,000.00
TOTAL	1000	950,000.00	1,880,000.00	90,000.00

Besides, a total of 28,339,850 scions were produced and distributed by fruit trees growers who have orchards with high potential to supply scions of good quality.

Maintenance of the existing RAB orchards

Orchard maintenance was done in all field to assure good scion production. The total area of RAB orchards is 17.1 ha and private orchards 161 ha (Table 63).

Table 63: Area of RAB orchards (all stations together)

Crop	RAB fruit trees Orchards (ha)	Private fruit trees Orchards (ha)
Avocado	6.05	81.65
Mango	3.85	70.45
Citrus	1	8.87
Apple	2.71	0.05
Tree tomato	2	
Passion fruit	1.5	
Total	17.11	161.02

Establishment of tree tomato and passion fruit mother gardens for seed production

In Rwanda, the unavailability of clean seeds for Tree tomato and Passion fruit is a major problem to farmers due to diseases. The existing commercial seed companies in Rwanda don't have Tamarillo and Passion fruit seedlings or seed source. Thus, farmers use seeds from their own production or buy mature fruits from the local market. To overcome this challenge, new mother gardens have been established to supply clean seeds to the beneficiaries in near future (Table 64) in addition to the existing orchards to harvest seed (Table 65).

Table 64: New mother gardens established in RAB stations

Site	Crop	Planting date	Number of plants	Area (ha)	Plants status
Gakuta	Tamarillo	October 2023	2500	1	Plants are young and healthy
	Passion fruit	October 2023	800	0.5	Plants are young and healthy
Gishwati	Tamarillo	November 2023	2500	1	Plants are young and healthy
	Passion fruit	November 2023	820	0.5	Plants are young and healthy

Table 65: Quantity of fruit and vegetable seed Produced in RAB stations

Site	Crop	Seed harvested, kg
Seed fruits		
Muhanga	Tamarillo	16
	Passion fruit	5
Gishwati	Tamarillo	14
Musanze	Passion fruit	8
Indigenous vegetables		
Gakuta	Nightshade	21
Gakuta	Spider plant	27

Monitoring and backstopping of private fruit orchards to check seed standards

Private fruit trees orchards with the potential to supply scions and rootstocks were visited to check quality scion and rootstock production. The refresher courses consist on different good agricultural practices (GAP) such as: weeding, organic and inorganic fertilizer application, mulching, pests and diseases management and the use of pesticides. A total of 120 sites/sources with the potential to supply rootstocks for Avocado & Mango across the country have been assessed and a total of 72 private orchards with the potential to supply quality scions for Avocado, Mango, Citrus have been visited and assessed (Photo 67).



Photo 67: Orchard visited at Rukumbeli (left) and at Rukoma sector (right)

In addition, the mapping and assessment of different sources of rootstock for Avocado and Mango have been done. Therefore, a total of 150 sites were visited and assessed by Horticulture Seed Technical team jointly with Horticulture program staff.

Capacity building for private nursery operators

Fruit tree and vegetables seedlings production requires specialized knowledge for nursery establishment and management. The seedlings should be of right varieties, healthy and free from pests and diseases. A training of private nursery operators was organized under CDAT project at Mulindi Horticulture Center of Excellence, 11-14 June 2024. It aimed to improve knowledge and build skills on grafting techniques, production of vegetable seedlings technical and nursery management. A total of 132 nursery operators including females and males have participated (Table 66), and other group was certified for nursery operation (Table 67).

Table 66: Training of private nursery operators by gender and age group in 2023-24

Type of participants	Total participants				Total
	Females		Males		
	15-29	30+	15-29	30+	
Fruit Nursery operators					
Group 1	6	12	3	12	33
Group 2	1	7	4	23	36
Group 3	6	4	5	19	34
Vegetable nursery operators	1	14	1	13	29
Total participants trained	14	37	13	62	132



Photo 68: Practice on grafting (left) and scion harvest (right)



Photo 69: Theory session on vegetable nursery training (left) visit of vegetable nursery (right)

Extension material dissemination

Two sets of extension material on modern horticultural practices have been developed jointly by Seed and Fertilizer Division and Horticulture Program to provide guidance to nursery

operators, farmers, cooperatives and extension agents. It included booklets, leaflets for fruits and vegetables. The material focused on good varieties, crop requirements (climate, soil, nutrient), seedling preparation in nursery, management of seedlings from nursery up to transplanting into the field, field preparation before transplanting, management of planted fruit trees (pruning and training), pest and disease control, harvesting and packaging facilities. The material was distributed to the beneficiaries involved in production of fruit trees and vegetable seedlings.

Technical support and training of private nursery operators

To improve and sustain the supply of adequate seed MINAGRI has encouraged private sector actors for seed production and marketing of horticultural crops. Field visit, consultative meetings, marketing support were organised to visit private seed multipliers and assist with various seed production issues. Technical backstopping on nursery management has been provided to 44 private nursery operators through field coaching (Table 67, Photo 72).



Photo 70: Visit of COPEHOPE Nursery (left) and Rukumberi nursery (right)

We recommend to conduct frequent inspections of all field to detect and manage diseases, pests or other issues. Regular trainings are needed for to promote professionalization of farmers involved in seed production.

Special Food Security Interventions in FY 2023-24 by the Government of Rwanda

To facilitate early preparation and implementation of the season 2024B, the Government of Rwanda donated fertilizers to farmers to boost the production and stimulate the use of inputs among farmers for priority crops and increasing yields and food security. RAB organized the distribution of fertilizers (DAP 16-48-00) across the country for better ongoing of the season 2024B in collaboration with Rwanda Fertilizer Company. A total of 1,340.061 tons of DAP were planned for distribution in all districts. The distributed quantities were 1,219.7 tons, and the remaining quantity is 120.361 tons. Distribution took 6 days (from 14-20 March 2024, Table 68). The activities happened at 2 warehouses of Rwanda Fertilizers Company located in Bugesera and Gasabo. Some districts faced the logistics issues which caused perturbation on distribution plan, that's why some districts took more than one day to correct their fertilizers. Besides, Nyamagabe district has not collected the allocated amount of fertilizers causing 120.36 tons to remain in stock.

Table 67: Certified nursery operators for fruit crops on Rwanda

N	Name	Organization	District	Sector	Contact
1	Gatete Jean Bosco	Individual	Nyanza	Rwabicuma	0788214110
2	Habumugisha Germain	Cultivate and Harvest Ltd	Rwamagana	Musha	0781596413
3	Sibomana Emmanuel	Vision Garden Ltd	Rwamagana	Musha	0781632705
4	Nteziryayo Jean Pierre	Save Good Environment Ltd	Bugesera	Rilima	0789665029
5	Bampimbaho Valens	Bavakure Farms Ltd	Nyanza	Muyira	0789340217
6	Ishimwe Sylvine	ISHIMWE Farm Ltd	Rwamagana	Kigabiro	0787182162
7	Mujawayezu Angelique	IRDA Ltd	Kamonyi	Gacurabwenge	0788590643
8	Sezibera Callixte	ECOTAM	Huye	Rusatira	0788490234
9	Karema Godefrey	New Vision Company	Nyanza	Busasamana	0788635570
10	Baraya Pierre Celestin	Individual	Nyabihu	Jomba	0788743574
11	Mukangarambe Josephine	Eden planting materials Ltd	Muhanga	Muhanga	0788884129
12	Mukamwezi Joyce	Cooperative Amahoro	Nyagatare	Nyagatare	0786304194
13	Kageruka Jean Damascene	Coop KAJU	Bugesera	Juru	0783305486
14	Emmanuel Turabumuremyi	Umukumbuza Ltd	Huye	Tumba	0783183823
15	Habanabakize Elie	Individual	Kirehe	Nyamugari	0783237774
16	Ndabakize Jean de Dieu	Modern Grafting Fruit Ltd	Bugesera	Mwogo	0786205005
17	Ndagijimana Jean	Individual	Musanze	Nyange	0783026288
18	Busobozi Martin	Farm Master Services Ltd	Rwamagana	Muyumbu	0784971338
19	Muvara Valens	Avocado Highland Coop	Burera	Kivuye	0785788668
20	Hategekimana Antoine	AFAJ Ltd	Nyagatare	Tabagwe	0788493298
21	Nkuriye Kayumba Joan	JOANKU Farms Ltd	Nyagatare	Katabagemu	0787149648
22	Niyobuhungiro Jean Sauveur	KICO Ltd	Burera	Gahunga	0788767891
23	Mutemberezi Maurice	New Life Vision Ltd	Huye	Mbazi	0784352002
24	Twagiramungu Samson	Individual	Nyamashoke	Macuba	0783179138
25	Nzayinambaho Eulade	ABS Technology Ltd	Karongi	Gishyita	0788519222
26	Kabera Benoit	Individual	Ngoma	Mutenderi	0783753207
27	Sibomana Jean Paul	Go Green Nursery Trees Ltd	Ruhango	Ruhango	0782144680
28	Umwali Kayumba Gisele	Wings Holding Ltd	Gasabo	Kimironko	0788303807
29	Musafiri Theophile	AGRIWIN Ltd	Gasabo	Rusororo	0782260419
30	Nikuze Christine	DALILA Family	Kicukiro	Nyarugunga	0786245625
31	Niyibizi Gilbert	Melius Farms	Ngoma	Rukumberi	0783545492
32	Pascal Ntawurikura	Rwanda Youth Seed Coop	Muhanga	Shyogwe	0788243078
33	Kamanzi Francois	COPEHOPE	Muhanga	Nyamabuye	0788841315
34	Uwicyeza Consolee	Blessed seeds Ltd	Kicukiro	Niboyi	0788477876
35	Niyonzima Samuel	Umukingo Business Co Ltd	Rusizi	Bugarama	0785536775
36	Umurerwa Jeanne	Blooming Nursery Ltd	Kicukiro	Niboyi	0788303142
37	Niyitegeka Fulgence	NRM Company	Rwamagana	Muyumbu	0786996908
38	Karemera Emile	AGRO FOOD NET Ltd	Kamonyi	Musambira	0788356225
39	Rugerindinda Jacques	Green Treasuries (RGT) Ltd	Nyamagabe	Kamegeri	0788622625
40	Murwanashyaka Vincent	Individual	Huye	Kigoma	0788218223
41	Mukamuganga Lucie	SOEVI Ltd	Nyamagabe	Gasaka	0788769831
42	Uwamahoro Josephine	KoTMR	Bugesera	Rilima	0782938383
43	Minani Protogene	BEPC Ltd	Gisagara	Save	0788528368
44	Ntwali Callixte	Coop Dufitubushake	Kayanza	Rwinkwavu	0788230388

Table 68: Distribution of DAP to the Districts under Special intervention of GoR in 2024B

N	District	Amount of DAP donated to the district (Kg)	Amount of DAP collected (kg) by date					
			le 14/3/24	15/3/24	16/03/24	18/3/24	19/3/24	20/3/24
1	Bugesera	11,450						
2	Gatsibo	145,950	90,000	55,950				
3	Kayanza	84,350	84,350					
4	Kirehe	171,700		80,000	50,000	41,700		
5	Ngoma	26,400		18,500				
6	Nyagatare	302,900		131,400	130,000	41,500		
7	Rwamagana	23,950		23,950				
8	Karongi	28,950						28,950
9	Ngororero	30,500				30,500		
10	Nyabihu	27,500						
11	Nyamasheke	20,000				20,000		
12	Rubavu	15,350						
13	Rusizi	15,500						
14	Rutsiro	21,270				21,250		
15	Burera	199,650				105,000	74,650	20,000
16	Gakenke	8,000				8,000		
17	Gicumbi	52,950				52,950		
18	Musanze	8,350						
19	Rulindo	6,150					6,150	
20	Gisagara	25,400				25,400		
21	Huye	4,000				4,000		
22	Kamonyi	41,850				41,850		
23	Muhanga	12,550				10,000	2,550	
24	Nyamagabe	29,500						
25	Nyarugenge	2,600		1,000		1,200		400
26	Kicukiro	5,650				5,650		
27	Gasabo	17,641					1,900	0,950
	Total	1,340,061	74,350	310,800	80,000	409,000	5,250	60,300

RAB Intervention for making organic fertilizers

RAB has promoted organic manure preparation in different stations (Table 69).

Table 69: Manure prepared at RAB stations during FY 2023-24

N	Station	No of pits /heaps	Quantity Produced in MT
1	Gishwati	36	360
2	Rwerere	100	2,300
3	Tamira	3	32.5
4	Musanze	7	70
5	Nyamagabe	52	520
6	Gakuta	50	350
7	Ngoma	0	0
8	Nyagatare	0	0
9	Muhanga	49	343
10	Rubona	0	0
11	Ntendezi	40	160
12	Rubilizi	11	143
	Total	348	4,278.5

Seed quality testing

National Seed Testing Laboratory conducted seed testing and in field. Seed testing aimed to assess germination capacity and purity in terms of variety mix, presence of weed seeds, extraneous matter and moisture content.

Table 70: Seed testing done for each seed category

Crop	Number of samples by seed category grains					
	Breeder	Prebasic	Basic	Certified	QDS	NA
Maize	0	34	48	556	0	9
Beans	20	51	114	26	3	0
Soybean	0	101	120	82	6	0
Wheat	0	4	37	55	2	0
Rice	0	40	99	154	3	0
Castor oil bean	0	0	3	0	0	0
Cabbage	0	0	0	0	0	1
Carrot	0	0	0	0	0	2
Peas	0	0	1	0	0	0
Total	20	230	422	873	14	12
Grand total	1571 samples					

All tests were done according to ISTA (International Seed Testing Association) rules governing seed sampling and testing. Field control tests were used to monitor the identity and purity of a variety (hybrid or non-hybrid) at various stages in the seed multiplication thereby assuring the National Designated Authority that the quality of seed produced in the OECD (Organization for Economic Cooperation and Development) Schemes is at satisfactory level.

Post-control is a term normally applied to variety verification of Certified Seed which is not further multiplied. It is called post-control, because the result is not available until after the seed has been certified. Post-control tests are nevertheless valuable, because they monitor how efficient the seed production process has been in maintaining varietal purity and identify ways in which the system might be improved. By allowing comparisons between plants grown from the seed lot produced and those grown from the Standard Sample, the National Designated Authority can monitor quality and give assurance that the minimum standards are being upheld.

Seed testing in laboratory: The tests of purity, moisture content and germination were done on the total number of 1,571 seed samples (Table 70). To improve seed control, seed inspectors may bring samples for post-control plots tests that number of tests would increase. The refresher trainings are also needed to harmonize our activities, according to updated international requirements.

Seed testing in field: The land for Maize and Bush beans control plots for field testing of seed was in Bugesera (RICA). For climbing beans, it was done at Ruhunde site, RAB-Rwerere, Burera District. In total, the 222 field tests were performed: 128 plots on hybrid maize; 30 plots on bush and 64 on climbing beans.

1.10.2 Seed distribution

Seed and Fertilizer Program at RAB is in charge of agricultural subsidies – mineral fertilizers and seed distribution. Considering crop importance and cultivated areas, the largest seed distribution was for Maize (a total of 14 varieties including hybrids). In the Season 2024A, a

total of 4,086,114 kg of seed were distributed for maize, 59,215kg for soybean and 11,000 kg for wheat (Table 72).

During season 2024 B, seeds were distributed for maize, wheat and soybean. The largest seed distribution was for maize (15 varieties distributed including hybrids). In the season 2024B, seeds were distributed for maize (1,453,774 kg), wheat (256,600 kg), and soybean 42,118 kg (Table 73 and 74). For maize, 299,775 kg seed distributed were highland varieties (20.6%), and 1,153,999 kg were lowland varieties (79.4%). Total seed quantity distributed for Season 2024 A was 4,156,332 kg, and for season 2024B it was 1,752,492 kg (Table 75).

Table 71: Field tests for maize and beans done in FY 2023-24

Crop type	Variety	Number of reference samples	Number of samples of testing	Sub-Total	Total number of plots
Hybrid maize	CML 445	1	4	5	10
	CML 448	1	1	2	4
	CML464X216	1	3	4	8
	CML 202 (P008)	1	1	2	4
	APIS 610	1	1	2	4
	H 628	1	1	2	4
	ETGM 601	1	1	2	4
	RHM 1407	1	2	3	6
	RHM 1409	1	3	4	8
	WH 403	1	4	5	10
	RHMH 1601	1	2	4	8
	CML 464X463	1	2	3	6
	CML 464	1	1	2	4
	WH 508	1	2	3	6
	WH 504	1	2	3	6
	WH 301	1	2	3	6
	WH 101	1	2	3	6
	RHMH 1520	1	2	2	4
	WH 605	1	3	4	8
RHMH 1611	1	4	5	10	
Bush beans	NUA 566	1	7	8	16
	RWR 2245	1	1	2	4
	RWR 3194	1	4	5	10
Climbing beans	MWIRASI	1	3	4	8
	KIGONDO	1	4	5	10
	MBC 23	2	6	8	16
	RWV 2350-2B	1	5	6	12
	RWV 3317	2	2	4	8
	NYIRAMAGORORI	1	1	2	4
	RWV 1129	1	2	3	6
Total					222

Table 72: Seed distribution by RAB in 2024A

District	Maize seed														Other seed			
	RHM 1407	RHM 1409	RHM 1402	RHM 1520	RHM 1601	RHMH 1611	WH 101	WH 505	WH 504	WH 301	WH 403	WH 507	WH 605	API 610	ETG	Soy bean	Wh eat	
Eastern Province																		
Bugesera	160,970	1,940					10				42,598	6,774			300		6,483	
Rwamagana	96,991	3,416					304	182	280		53,311	5,514					1,266	
Kayonza	125,069	28,950						175	560		65,637	10,647	416				460	
Gatsibo	200,105	548						60	10		142,839	23,934		800				
Ngoma	67,912	23,842	202								110,256	13,804					700	
Kirehe	33,703	14,808						200	20		177,654	35,140					29,486	
Nyagatare	59,424	300					50	6,052	360	290	685,887	26,908		11,330			1,500	
Northern Province																		
Burera		400		500	3,560	6,054											47,068	
Musanze				46,632	200	3,490											14,730	9,000
Gakenke	400	168		4,844	4,116							200	46,423					
Gicumbi	10,760	4,821		2,060	1,560		68	710			9,745	13,855	24,562				1,150	
Rulindo	19,933	11,698		2,085	650			356			562	13,743	35,030					
Southern Province																		
Kamonyi	22,590	44,168	10,762	1,674							1,284	21,390					4,919	
Muhanga	6,321	14,731	150	374	750						160	18,648	340					
Ruhango	19,170	19,460	170	430							11,564	24,596						
Nyanza	27,052	21,894									3,750	40,974						
Huye	23,412	57,694	4,560								1,266	45,785					1,250	
Gisagara	120,519	78,712	150			10		1,524	94		11,626	36,721			50		13,700	
Nyaruguru	660	17,362		900	9,048	3,150						15,686	7,310					
Nyamagabe	6,800	10,674		1,000	6,109	138						14,487	11,693					
Western Province																		
Rusizi	36,848	22,939			1,620			3,120				37,686						
Nyamasheke	24,448	3,547			80							25,318	2,640				5,450	
Ngororero	4,150	25,190		1,000	2,056			340				10,292	13,832					
Nyabihu	-	12,034		4000								2,950	36,196				2,000	
Karongi	600	22,944			500							26,706	18,860					
Rutsiro	2,000	13,770		900	10	37,342					39,949	9,958	21,146					
Rubavu				51,013	128	6,770						3,130	13,892					
Kigali City																		
Gasabo	40,828	2,845						2,845			10,910	8,233					520	
Kicukiro	19,940	4,800						2,002			150	450						
Nyarugenge	8,332	1,990									2,576	24						
Total	1,138,937	468,645	15,994	117,412	30,387	56,944	432	14,826	1,324	290	1,331,775	493,738	293,722	12,130	350	65,734	12,150	

Table 73: Maize seed distribution during the season 2024B

District	WH-101	WH-301	WH-403	WH-504	WH-505	WH-507	WH-508	WH-605	RHM1402	RHM1407	RHM1409	RHMH1601	RHMH1611	RHM1520	APIS610	ETG601
Eastern Province																
Bugesera	-	-	20,214	-	-	2,922	-	-	-	81,000	19,690	-	-	-	-	-
Rwamagana	58	80	10,142	-	16	1,284	-	-	570	14,552	3,858	-	-	-	-	-
Kayonza	100	324	20,848	39	-	2,135	-	-	2,000	64,376	7,485	30	-	-	-	-
Gatsibo	1,165	734	17,842	-	-	6,818	-	-	-	44,790	9,130	-	-	-	-	700
Ngoma	-	-	2,752	-	-	20	-	-	-	1,419	12	-	-	-	-	-
Kirehe	-	-	10,764	-	-	2,900	-	-	-	1,198	6,100	-	-	-	-	1,000
Nyagatare	18,766	21,235	90,329	3,300	-	90,329	-	-	-	97,426	64,740	-	-	-	10,293	300
Northern Province																
Burera	-	-	-	-	-	-	1,180	16,652	-	-	-	100	3,976	-	-	-
Musanze	-	-	-	-	-	-	244	15,372	-	-	-	-	9,274	55,150	-	-
Gakenke	-	-	-	-	-	2,260	-	12,680	-	639	700	-	5,050	754	-	-
Gicumbi	-	-	2,904	-	244	4,886	-	11,884	900	5,654	2,456	3,394	2,618	706	-	-
Rulindo	-	-	192	-	988	3,572	-	4,688	300	7,818	13,476	-	-	1,436	-	-
Southern Province																
Kamonyi	-	-	244	-	26	3,006	-	-	3,922	3,914	9,082	-	-	4,296	-	-
Nyamagabe	-	-	-	-	-	6,484	-	3,382	-	-	12,118	336	-	2,500	-	-
Gisagara	-	-	1,057	-	-	15,400	-	-	-	10,690	15,360	-	-	-	-	-
Ruhango	-	-	250	-	-	7,490	-	-	150	8,104	6,938	-	-	72	-	-
Nyaruguru	-	-	-	-	-	814	-	606	-	290	1,300	50	50	-	-	-
Muhanga	-	-	-	-	-	5,054	-	1,194	530	2,080	12,080	-	-	50	-	-
Nyanza	-	970	-	-	-	13,625	-	-	-	8,046	10,150	-	-	-	-	-
Huye	-	200	-	-	-	6,904	-	-	1,700	8,678	20,254	-	-	-	-	-
Western Province																
Rusizi	-	-	-	-	-	2,790	-	-	-	1,460	1,962	-	-	-	-	-
Nyamasheke	-	-	-	-	-	2,650	-	336	-	5,314	1,430	100	-	-	-	-
Ngororero	-	-	-	-	-	5,784	-	21,330	-	10,392	33,510	-	-	1,500	-	-
Nyabihu	-	-	-	-	-	2,476	720	27,677	-	5,500	-	-	5,000	-	-	-
Karongi	-	-	-	-	-	3,037	-	1,094	-	1,000	7,186	30	-	-	-	-
Rutsiro	-	-	-	-	-	8,784	-	18,684	-	-	6,000	-	16,890	54	-	50
Rubavu	-	-	-	-	-	8,122	394	14,837	-	-	-	300	18,500	4,174	-	-
Kigali City																
Gasabo	96	1,100	1,000	-	197	5,538	-	-	4,300	18,682	1,308	-	-	-	-	-
Nyarugenge	-	512	-	-	434	774	-	-	-	5,456	640	-	-	-	-	-
Kicukiro	50	50	-	-	1,240	-	-	-	-	7,230	1,000	-	-	-	-	-
Total	20,235	25,205	193,478	3,339	3,145	215,858	2,538	150,416	14,372	415,708	267,965	4,340	61,358	70,692	10,293	2,050

Table 74: Seed distribution for Soybean and Wheat in Season 2024B

District	Soybean				Wheat								All crops 2024B
	Rwasoy 20-8	Rwasoy 20-5	Rwasoy 20-3	Sb24 -CS	Rwasoy 20-8-QDS	Rwasoy 20_8-CS	Gihundo -QDS	Gihundo -CS	Kibatsi -CS	Nyaruka -CS	Rebe- raho-CS	Majyam- bere_CS	
Eastern Province													
Bugesera	500	400	-	150	-	2,495	-	-	-	-	-	-	127,371
Rwamagana	225	-	-	-	600	-	-	-	-	-	-	-	31,385
Kayonza	100	350	-	-	-	-	-	-	-	-	-	-	97,787
Gatsibo	1,428	800	-	-	-	1,775	-	-	-	-	-	-	85,182
Ngoma	-	-	250	-	-	-	-	-	-	-	-	-	4,453
Kirehe	-	-	19,010	-	-	-	-	-	-	-	-	-	40,972
Nyagatare	2,250	-	-	-	-	275	-	-	-	-	-	-	414,183
Northern Province													
Burera	-	-	-	-	-	-	-	22,500	-	4,450	-	3,000	51,958
Musanze	-	-	-	-	-	-	-	9,850	-	18,800	-	3,800	112,490
Gakenke	-	-	-	-	-	-	-	8,000	-	6,000	-	2,100	38,183
Gicumbi	-	-	-	-	-	-	9,500	-	-	-	-	7,500	52,646
Rulindo	400	-	-	-	-	-	-	-	-	-	-	-	32,870
Southern Province													
Kamonyi	250	400	-	-	-	-	-	-	-	-	-	-	25,140
Muhanga	-	-	-	-	-	-	-	-	-	-	-	-	20,988
Ruhango	-	-	-	-	-	-	-	-	-	-	-	-	23,004
Nyanza	-	-	-	-	-	-	-	-	-	-	-	-	32,791
Huye	350	-	-	-	-	50	-	-	-	-	-	-	38,136
Gisagara	2,700	-	-	-	-	800	-	-	-	-	-	-	46,007
Nyaruguru	-	-	-	-	-	-	-	4,000	100	200	-	2,000	9,410
Nyamagabe	-	-	-	-	-	-	-	56,050	200	11,500	-	6,750	99,320
Western Province													
Rusizi	-	-	-	-	-	2,960	-	-	-	-	-	-	9,172
Nyamasheke	-	-	-	-	-	510	-	-	-	-	-	-	10,340
Ngororero	-	-	-	-	-	-	-	5,000	-	-	5,000	10,000	92,516
Nyabihu	-	-	-	-	-	-	-	37,900	-	3,000	10,000	5,000	97,273
Karongi	-	-	-	-	-	-	-	-	-	-	-	-	12,347
Rutsiro	-	-	-	-	-	-	-	3,550	-	850	-	-	54,862
Rubavu	-	-	-	-	-	-	-	-	-	-	-	-	46,327
Kigali City													
Gasabo	800	2,290	-	-	-	-	-	-	-	-	-	-	35,215
Nyarugenge	-	-	-	-	-	-	-	-	-	-	-	-	7,912
Kicukiro	-	-	-	-	-	-	-	-	-	-	-	-	9,570
Total	9,003	4,240	19,260	150	600	8,865	9,500	146,850	300	44,800	15,000	40,150	1,759,710

CS – certified seed; QDS – quality declared seed

Table 75: Summary of seed quantities distributed per crop, 2023-24

Crop	Quantity of seed 2024 A	Quantity of seed 2024 B
Maize	3,976,906	1,460,992
Soybean	65,734	42,118

Wheat	12,150	256,600
Total Seeds (kg)	4,054,790	1,759,710

1.10.3 Fertilizer distribution

During FY 2023-24, RAB Fertilizer program has distributed various types of mineral fertilizers: DAP, urea, NPK 17-17-17 and some blends. Seasonal distribution of mineral fertilizers is shown in Tables 76 and 77. Import of mineral fertilizers was in place from 2007 till very recently when the fertilizer factory was built. Under Crop Intensification Program the use of mineral fertilizers in land consolidated sites increases annually. This has implications for greenhouse gas emissions, but helps to raise agricultural yields. The current use of fertilizers in Rwanda is 78,061,476 kg per year (Table 78).

Table 76: Fertilizer distribution by RAB in 2024A

District	DAP	Urea	NPK-17	Kynoplus	Winner	Cereal	Amidas	Nitrabor	Total
Eastern Province									
Bugesera	533,100	381,150	244,750	350	14,200	-	-	500	1,174,050
Rwamagana	517,300	428,691	170,400	1,400	9,200	1,100	-	-	1,128,091
Kayanza	475,400	503,500	292,350		9,200	2,200	-	-	1,282,650
Gatsibo	736,800	913,850	232,700	4,250	25,000	111,000	-	1,000	2,024,600
Ngoma	643,050	559,800	162,400	-	-	24,600	-	200	1,390,050
Kirehe	949,962	629,525	147,911	-	2,000	4,800	-	-	1,734,198
Nyagatare	2,355,700	2,841,943	136,170	5,700	6,350	533,150	-	-	5,879,013
Northern Province									
Burera	616,365	299,400	988,700	150	133,050	27,700	-	19,775	2,085,140
Musanze	644,750	254,800	1,384,800	-	1,200	13,600	-	31,725	2,335,875
Gakenke	620,765	505,500	98,200	100	13,350	200	-	1,150	1,239,265
Gicumbi	279,623	159,800	219,100	-	35,800	11,400	-	1,350	707,073
Rulindo	311,400	328,950	157,689	-	118,100	600	1,300	18,525	936,564
Southern Province									
Kamonyi	121,130	221,000	43,600	650	4,000	50,850	-	-	442,230
Muhanga	206,700	142,150	65,850	50	550	-	-	-	415,300
Ruhango	77,000	124,050	51,500	-	-	36,500	-	-	289,050
Nyanza	153,850	152,850	77,250	1,600	-	-	-	-	385,550
Huye	223,350	292,350	182,200	1,450	1,500	11,900	-	-	712,750
Gisagara	327,750	378,200	190,050	1,350	2,050	107,800	-	-	1,007,200
Nyaruguru	584,400	322,900	139,100	2,650	150	650	-	-	1,049,850
Nyamagabe	363,650	364,850	498,550	400	78,800	52,900	-	8,425	1,367,575
Western Province									
Rusizi	573,550	652,450	362,450	-	3,000	112,900	-	-	1,729,000
Nyamasheke	527,900	389,050	145,200	-	1,000	-	-	-	1,063,150
Ngororero	404,237	245,940	266,750	200	125,400	18,750	-	8,700	1,102,277
Nyabihu	344,000	472,350	2,784,657	12,950	203,650	15,650	1,000	51,325	3,881,532
Karongi	450,950	365,700	98,300	-	-	-	-	-	918,950
Rutsiro	345,150	283,950	217,150	6,050	6,000	-	-	14,300	1,018,850
Rubavu	876,050	165,070	2,237,200	600	8,400	-	-	4,450	3,297,948
Kigali City									
Gasabo	120,900	202,600	111,700	-	800	2,550	-	-	438,550
Nyarugenge	11,650	30,050	4,400	-	6,000	1,300	500	-	53,900
Kicukiro	66,650	69,650	16,500	-	250	-	-	200	153,250
Total	14,664,582	12,682,569	11,732,577	39,650	796,955	1,142,100	2,800	161,625	41,022,858

Table 77: Mineral fertilizer distribution in Season 2024B

District	Urea	DAP	NPK 17-17-17	Nitrabor	Winner	Amidas	Otesha	Cereal	KCl (MOP)	Kynoplus (Urea_coated)	Sulfan	Tweze (NPK blend)	Total
Eastern Province													
Bugesera	432,950	586,050	284,600	-	16,300	3,150	-	-	2,100	1,450	-	49,700	1,376,300
Rwamagana	324,911	323,705	219,522	-	6,150	5,450	150	-	-	-	-	45,300	925,688
Kayonza	371,450	259,200	109,100	-	4,200	3,800	-	-	-	300	400	128,350	876,800
Gatsibo	528,100	294,500	149,850	-	28,350	47,150	-	33,300	52,000	700	-	109,650	1,243,600
Ngoma	163,350	63,994	169,485	-	-	-	-	-	-	-	-	-	396,829
Kirehe	298,200	159,162	181,801	-	400	4,800	-	-	-	-	-	32,850	677,213
Nyagatare	2,171,800	1,833,750	346,524	-	4,400	98,700	-	112,600	-	4,650	2,000	24,800	4,599,224
Northern Province													
Burera	174,300	457,250	1,024,750	36,775	78,100	300	49,600	-	-	700	-	446,950	2,268,725
Musanze	306,500	540,883	1,323,340	33,000	17,350	-	39,400	1,700	-	-	-	595,900	2,858,073
Gakenke	248,000	596,950	157,179	800	21,000	1,200	-	4,950	-	-	-	31,700	1,061,779
Gicumbi	155,850	192,151	326,300	500	8,800	1,800	-	-	-	-	-	5,400	690,801
Rulindo	279,650	212,900	286,900	12,075	65,300	5,700	200	1,000	-	23,600	200	12,800	900,325
Southern Province													
Kamonyi	208,150	88,235	61,531	25	3,000	8,250	-	63,050	-	8,250	-	15,750	453,191
Muhanga	102,400	131,550	80,250	-	-	-	-	-	-	-	2,600	250	323,250
Ruhango	143,583	169,100	71,000	-	-	500	-	38,000	-	500	-	1,500	324,683
Nyanza	173,850	105,492	153,744	-	-	-	-	-	-	-	-	-	433,086
Huye	229,700	135,200	187,047	-	200	4,900	-	7,800	-	4,900	550	8,250	574,797
Gisagara	138,866	138,366	259,303	-	-	63,750	800	123,400	-	63,750	600	2,050	833,202
Nyaruguru	451,640	451,240	165,300	-	-	-	-	-	-	-	-	74,300	874,490
Nyamagabe	418,681	417,981	651,300	14,425	63,000	26,300	14,850	12,350	-	26,300	3,000	7,950	1,534,844
Western Province													
Rusizi	437,600	346,750	526,950	800	14,500	-	-	-	-	-	-	-	1,325,900
Nyamasheke	244,900	403,800	176,050	-	-	2,000	-	-	-	-	-	1,100	827,850
Ngororero	264,411	431,318	266,100	1,950	140,800	-	-	9,500	-	-	-	100,500	1,214,279
Nyabihu	334,008	352,100	2,581,647	32,000	19,500	400	-	150	-	40,750	-	1,454,950	4,820,205
Karongi	148,073	293,978	129,635	-	-	-	-	-	-	-	-	17,400	589,086
Rutsiro	275,050	319,313	507,515	8,150	11,950	-	-	-	-	18,500	-	71,200	1,209,078
Rubavu	316,397	541,250	882,400	1,800	5,650	-	-	10,000	-	4,650	-	1,615,900	3,379,347
Kigali City													
Gasabo	184,050	90,250	85,400	200	-	600	-	-	-	2,000	-	38,850	403,400
Nyarugenge	16,200	8,850	7,100	200	2,750	1,000	-	-	-	400	-	-	36,500
Kicukiro	48,850	38,350	21,750	525	400	-	-	-	-	850	150	400	111,325
Total	9,323,304	9,885,218	11,397,073	143,225	512,100	279,750	104,850	417,950	54,100	112,550	9,500	4,904,250	37,143,870

The total quantity of mineral fertilizers distributed was 41,241,869 kg in Season 2023A, and 36,819,607 kg for Season 2023B (Table 78).

Table 78: Annual consumption of mineral fertilizers in Rwanda by type in 2023-24

Type of fertilizer	Fertilizer distributed in 2024A, kg	Type of fertilizer	Fertilizer distributed in 2024B, kg	Total in 2023-24, kg
DAP	14,464,582	DAP	9,885,218	24,349,800
Urea	12,682,569	Urea	9,323,304	22,005,873
NPK 17-17-17	11,732,577	NPK 17-17-17	11,397,073	23,129,650
Kynoplus	39,650	Kynoplus	112,550	152,200
Winner	796,955	Winner	512,100	1,309,055
Cereal	1,142,100	Cereal	417,950	1,560,050
Amidas	2,800	Amidas	279,950	282,550
Nitrabor	161,625	Nitrabor	143,225	304,850
Blended NPK 17-17-17 (Tweze)	-		4,904,250	4,904,250
Sulfan	-		9,500	9,500
MOP	-		54,100	54,100
OTESHA			104,850	104,850
Total 2024A	41,022,858	Total 2024B	37,143,870	78,166,728

1.11 Extension work by Crop Research & Innovation Department

RAB is in charge to lead national extension activities in close collaboration with the districts throughout of seasons A (September-December), B (February-June), and C (June-August). Under the implementation framework of the National Agricultural Policy, the support is given to land consolidated areas, which have reached now about 60% of the national cropland. The Districts identify sites for land consolidation, and the farming community decides on which of the annual crops to be grown and how they will be rotated across the seasons. These crops are supported under RAB Crop Intensification Program, Seed and Fertilizer Division via Smart Nkunganire online system of ordering seed, fertilizer and declaring the crop to be grown as it is shown in [Table 79](#).

During the season 2024A, a total of 13,736 FPs, 1,781 FFS, 2,018 SEDOs, 548 Agro-dealers and 398 Sector Agronomists were trained in good agronomic practices for key priority crops, making a total of 18,481 out of 18,763 total staff of the extensionists at national level. The number of farmers reached and mobilized for registering in Smart Nkunganire System for input use in 2024A reached 2,001,538 persons. Season launching calendar was developed and implemented at each District level.

Table 79: Summary of targets, planted areas per crop in Rwanda (only land consolidated area)

Crop	Target area (ha), 2024A	Planted area (ha), 2024A	Target area (ha), 2024B	Planted area (ha), 2024B	Target area (ha), 2024C	Planted area (ha), 2024C
Maize	263,253	265,401	67,125	71,225	1,224	1,175
Beans	361,054	368,965	381,158	383,683	1,215.20	921
Cassava	61,423	60,387	44,818	43,798	34.4	34.4
Soybean	5,198	6,641	5,455	5,482	334.3	341.3
Rice	15,012	15,095	14,843	15,060	230	230
Irish Potato	61,332	61,941	56,707	56,009	6,001	5,928.20
Wheat	7,216	7,344	38,639	38,465	0	0

Vegetables	8,324	7,719	4,397	4,238	9,081.30	8,442.10
Total	782,812	793,492	613,141	617,959	18,126.9	17,072

More than 37,000 demonstration plots were established across country for all major crops (Table 80). The target number of demo plots planned was 21,212 for Season 2024A and 15,708 for the Season 2024B (Table 80).

Table 80: Demonstration plots established during FY 2023-2024 at national level per crop

Crop	N. of demo plots in 2024A	N. of demo plots in 2024B	Total
Maize	13,709	5,509	19,218
Beans	7,441	4,877	12,318
Cassava	641	355	996
Soybean	654	824	1,478
Rice	112		112
Irish Potato	1,166	814	1,980
Wheat	361	118	479
Vegetables	775		775
Banana	8	42	42
Total	24,864	12,497	37,398

During the season 2024B, a total of 13,508 FPs, 1,684 FFS, 1,951 SEDOs, 207 AG and 383 SA making a total of 17,739 out of 18,528 extensionists were trained in good agronomic practices for key priority crops, making a total of 17,739 out of 18,528 total staff of the extensionists at national level. The number of farmers reached and mobilized for registering in Smart Nkunganire System for input use in 2024A reached 1,279,206 persons out of 1,450,000 persons (estimated total number of households). Season launching calendar was developed and implemented at each District level. Crop Production for main crops and all seasons under CIP is shown in Tables 81-88 below.

Table 81: Maize cropping area targets and planted areas in 2023-24

Season	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	14,061	14,061	1,266	1,275	0	0
Gakenke	14,216	14,252	2,079	2,079	0	0
Gicumbi	5,140	5,690	3,919	4,267	0	0
Musanze	7,426	7,426	602	602	0	0
Rulindo	6,539	6,553	192	214	0	0
Northern P.	47,382	47,982	8,058	8,437	0	0
Bugesera	13,297	13,297	11,094	11,094	350	305
Gatsibo	16,017	16,166	1,876	1,876	0	0
Kayonza	10,408	10,408	2,607	2,607	30	30
Kirehe	25,000	24,721	1,526	1,526	0	0
Ngoma	20,900	20,900	343	343	50	50
Nyagatare	23,926	23,926	12,774	15,717	4	4
Rwamagana	17,082	17,198	418	420	17	17
Eastern P.	126,630	126,616	30,638	33,583	451	406
Gisagara	6,783	7,083	7,300	7,515	505	505
Huye	3,146	3,430	1,047	995	0	0
Kamonyi	5,338	5,338	376	664	0	0
Muhanga	3,800	3,800	839	843	0	0
Nyamagabe	10,955	10,955	1,979	2,025	1	0
Nyanza	2,710	2,907	890	944	265	265
Nyaruguru	8,990	8,994	30	30	0	0
Ruhango	1,300	1,300	1,100	1,177	0	0
Southern P.	43,022	43,207	13,561	14,194	770	770
Karongi	3,950	4,151	78	84	0	0
Ngororero	4,617	4,617	3,618	3,618	0	0
Nyabihu	5,024	5,024	4,541	4,541	0	0
Nyamasheke	13,302	13,302	331	331	0	0
Rubavu	3,000	3,112	2,900	2,937	0	0
Rusizi	9,846	9,797	209	209	0	0
Rutsiro	5,124	5,126	3,003	3,033	0	0
Western P.	44,863	45,129	14,680	14,752	0	0
Gasabo	870	981	114	185	0	0
Kicukiro	436	436	24	24	0	0
Nyarugenge	50	50	50	50	2	2
CoK	1,356	1,467	188	259	2	2
Total	263,253	265,001	67,125	71,225	1,223	1,178

Table 82: Bean crop area targets and planted areas in 2023-24

District	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	7,653	7,653	13,749	13,827	0	0
Gakenke	2,775	2,775	13,925	13,905	43.15	43.15
Gicumbi	20,250	20,396	16,946	18,243	0	0
Musanze	3,110	3,110	8,832	8,832	0	0
Rulindo	18,665	18,679	16,125	16,141	0	0
Northern P.	52,453	52,613	69,577	70,948	43.15	43.15
Bugesera	10,965	11,218	13,161	13,161	470	189.75
Gatsibo	4,078	4,373	18,943	18,943	0	0
Kayanza	19,378	19,378	18,082	18,082	18	18
Kirehe	8,715	10,572	23,828	23,828	0	0
Ngoma	20,984	20,984	21,519	21,519	340	340
Nyagatare	13,239	13,239	22,161	22,351	0	0
Rwamagana	15,703	15,703	16,297	16,297	21	21
Eastern P.	93,062	95,467	133,990	134,180	810	550.75
Gisagara	16,855	17,655	28,000	28,086	0	0
Huye	15,970	17,688	10,747	10,371	75.5	75.5
Kamonyi	21,230	21,230	10,139	11,003	71	67
Muhanga	22,731	22,731	18,106	18,106	48	48.6
Nyamagabe	11,250	11,250	10,288	10,299	54	54
Nyanza	15,400	15,857	15,550	15,352	41	38
Nyaruguru	31,000	32,149	11,500	11,571	35	35
Ruhango	12,552	12,552	8,003	8,155	42	37
Southern P.	146,987	151,111	112,333	112,943	366.5	355.1
Karongi	12,580	12,926	13,988	14,339	13	13
Ngororero	8,500	8,500	6,700	6,708	0	0
Nyabihu	12,176	12,176	4,462	4,462	0	0
Nyamasheke	13,237	13,237	12,002	12,002	0	0
Rubavu	5,425	5,553	5,075	5,081	0	0
Rusizi	8,165	8,165	14,992	14,992	0	0
Rutsiro	8,074	8,589	6,750	6,740	0	0
Western P.	68,157	69,146	63,969	64,323	13	13
Gasabo	114	142	870	870	0	0
Kicukiro	131	132	269	269	3	2.5
Nyarugenge	150	150	150	150	2	2
CoK	395	424	1,289	1,289	5	4.5
Total	361,054	368,761	381,158	383,683	1,237.65	966.5

Table 83: Cassava area targets and planted areas in 2023-2024

District	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	-	-	-	-	0	0
Gakenke	106.0	99.0	31.0	31.0	0	0
Gicumbi	55.0	65.0	53.0	61.0	0	0
Musanze	-	-	-	-	0	0
Rulindo	20.0	20.0	20.0	20.0	0	0
Northern P.	181.0	184.0	104.0	112.0	0	0
Bugesera	1,500.0	1,210.0	1,500.0	1,500.0	0	0
Gatsibo	492.0	468.0	228.5	223.0	0	0
Kayanza	2,150.0	2,150.0	76.0	76.0	0	0
Kirehe	800.0	796.0	16,845	16,839	0	0
Ngoma	1,500.0	1,500.0	15,000.0	15,000.0	0	0
Nyagatare	215.0	215.0	1,700.0	2,157.3	0	0
Rwamagana	833.0	808.0	40.0	40.0	0	0
Eastern P.	7,490.0	7,147.0	35,389.5	3,835.3	0	0
Gisagara	1,116.5	1,011.4	2,090.0	1,914.6	0	0
Huye	2,179.0	1,105.0	2,005.0	1,161.0	0	0
Kamonyi	7,000.0	7,000.0	1,386.0	1,402.0	0	0
Muhanga	2,363.0	2,363.0	888.5	860.4	0	0
Nyamagabe	2,020.0	2,020.0	2,025.0	2,025.0	34.4	34.4
Nyanza	2,855.0	2,942.5	1,595.0	1,418.5	0	0
Nyaruguru	-	-	-	-	0	0
Ruhango	10,935.0	10,935.0	5,855.0	5,943.0	0	0
Southern P.	28,468.5	27,376.9	15,844.5	14,724.5	34.4	34.4
Karongi	900.0	764.2	575.0	506.9	0	0
Ngororero	3,095.0	3,095.0	1,905.0	1,851.0	0	0
Nyabihu	-	-	-	-	0	0
Nyamasheke	12,434.0	12,434.0	1,425.5	1,425.5	0	0
Rubavu	-	-	-	-	0	0
Rusizi	8,119.0	8,114.0	8,119.0	8,119.0	0	0
Rutsiro	735.0	770.0	536.0	445.9	0	0
Western P.	25,283.0	25,177.2	12,560.5	12,348.3	0	0
Gasabo	-	-	-	-	0	0
Kicukiro	-	-	-	-	0	0
Nyarugenge	-	-	-	-	0	0
CoK	-	-	-	-	0	0
Total	61,423	59,885	63,898.5	63,020.1	34.4	34.4

Table 84: Soybean crop area targets and planted areas in 2023-24

District	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	-	-	-	-	0	0
Gakenke	-	-	-	-	10.5	10.5
Gicumbi	-	-	-	-	0	0
Musanze	-	-	-	-	0	0
Rulindo	-	-	-	-	0	0
Northern P.	-	-	-	-	10.5	10.5
Bugesera	129.0	137.0	136.0	136.0	40	32
Gatsibo	100.0	100.0	470.0	416.0	0	0
Kayanza	186.5	186.5	143.0	143.0	11	11
Kirehe	215.0	228.0	391.0	408.0	0	0
Ngoma	80.0	80.0	170.0	170.0	50	50
Nyagatare	200.0	200.0	200	243	48.5	48.5
Rwamagana	415.0	415.0	90.0	90.0	0	0
Eastern P.	1,325.5	1,346.5	1,600	1,606	149.5	141.5
Gisagara	237.0	390.8	768.0	770.4	150	150
Huye	158.0	160.0	229.0	218.0	19	19
Kamonyi	665.0	665.0	25.0	32.0	0	0
Muhanga	403.4	403.4	304.0	321.0	4	4
Nyamagabe	-	-	-	-	0	0
Nyanza	-	-	-	-	0	0
Nyaruguru	-	-	-	-	20	20
Ruhango	154.0	154.0	126.0	132.0	0	0
Southern P.	1,617.4	1,773.2	1,452.0	1,473.4	193	193
Karongi	-	-	-	-	0	0
Ngororero	572.0	572.0	411.0	411.0	47	47
Nyabihu	-	-	-	-	0	0
Nyamasheke	1,208.0	1,208.0	1,243.0	1,243.0	0	0
Rubavu	-	-	-	-	0	0
Rusizi	475.0	475.0	747.0	747.0	0	0
Rutsiro	-	-	-	-	0	0
Western P.	2,255.0	2,255.0	2,401.0	2,401.0	47	47
Gasabo	-	-	-	-	0	0
Kicukiro	-	-	-	-	0	0
Nyarugenge	-	-	2.0	0	0	0
CoK	-	-	2.0	0	0	0
Total	5,197.9	5,374.7	5,455	5,480.4	400	392

Table 85: Rice crop area targets and planted areas in 2023-2024

District	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	-	-	-	-	0	0
Gakenke	-	-	-	-	17	17
Gicumbi	-	-	-	-	0	0
Musanze	-	-	-	-	0	0
Rulindo	-	-	-	-	0	0
Northern P.	-	-	-	-	17	17
Bugesera	1247	1247	1104	1104	0	0
Gatsibo	1311	1311	1311	1311	0	0
Kayanza	1558	1558	1558	1558	0	0
Kirehe	816	816	816	816	0	0
Ngoma	1190	1190	1190	1190	0	0
Nyagatare	1980.46	1980.46	200	242.5	0	0
Rwamagana	420	420	420	420	0	0
Eastern P.	8,522.5	8,522.5	6,599.0	6,641.5	0	0
Gisagara	1264	1304	2536	2643	0	0
Huye	1330	1364	1364	1364	0	0
Kamonyi	563	563	563	563	0	0
Muhanga	230	230	221	221	0	0
Nyamagabe	-	-	-	-	0	0
Nyanza	430	438.55	705	707	0	0
Nyaruguru	-	-	-	-	0	0
Ruhango	559	559	682	696	0	0
Southern P.	4,376	4,459	6,071	6,194	0	0
Karongi	-	-	-	-	0	0
Ngororero	-	-	-	-	213	213
Nyabihu	-	-	-	-	0	0
Nyamasheke	400	400	400	400	0	0
Rubavu	-	-	-	-	0	0
Rusizi	1432	1432	1441	1441	0	0
Rutsiro	-	-	-	-	0	0
Western P.	1,832	1,832	1,841	1,841	213	213
Gasabo	200	200	250	301.5	0	0
Kicukiro	78	78	78	78	0	0
Nyarugenge	4	4	4	4	0	0
CoK	282	282	332	383.5	0	0
Total	15,012.46	15,095.51	14,843.00	15,060.00	230	230

Table 86: Irish potato crop area targets and planted areas in 2023-24

District	2024A		2024B		2024C	
	Target (ha)	Planted (ha)	Target (ha)	Planted (ha)	Target (ha)	Planted (ha)
Burera	7,419	7,419	6,967	6,998	1,045.9	1,045.9
Gakenke	-	-	-	-	243.6	143.6
Gicumbi	5,910	7,083	5,775	6,532	452	452
Musanze	3,100	3,100	3,970	3,600	360	360
Rulindo	1,128	1,138	886	775	0	0
Northern P.	17,557	18,740	17,598	17,905	2,001.5	1,901.5
Bugesera	-	-	-	-	0	0
Gatsibo	-	-	-	-	66	66
Kayonza	123	123	96	96	44.5	44.5
Kirehe	-	-	-	-	12	0
Ngoma	-	-	-	-	0	0
Nyagatare	-	-	-	-	48.5	45
Rwamagana	-	-	-	-	0	0
Eastern P.	123	123	96	96	171	155.5
Gisagara	-	-	-	-	3	3
Huye	-	-	-	-	34	34
Kamonyi	-	-	-	-	0	0
Muhanga	380	380	154	149	39	39.2
Nyamagabe	9,885	9,885	9,851	9,857	538.5	541.5
Nyanza	-	-	-	-	0	0
Nyaruguru	4,831	4,620	4,439	4,405	1,122	1,122
Ruhango	-	-	-	-	0	0
Southern P.	15,096	14,885	14,444	14,411	1,736.5	1,739.7
Karongi	1,370	1,417	810	566	126	131.2
Ngororero	5,837	5,837	2,763	2,763	504	505
Nyabihu	9,675	9,675	11,752	11,123	1,027	1,027
Nyamasheke	-	-	-	-	0	0
Rubavu	6,050	5,946	4,950	5,074	40	40
Rusizi	-	-	-	-	0	0
Rutsiro	5,624	5,282	4,294	4,071	79	78.9
Western P.	28,556	28,157	24,569	23,597	1,776	1,782.1
Gasabo	-	-	-	-	0	0
Kicukiro	-	-	-	-	0	0
Nyarugenge	-	-	-	-	0	0
CoK	-	-	-	-	0	0
Total	61,332	61,905	56,707	56,009	5,685	5,578.8

Table 87: Wheat crop area targets and planted areas in 2023-24

District	2024A		2024B	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	3,963	3,963.0	7,442	7,442.0
Gakenke	188.0	171.0	563.0	564.0
Gicumbi	1,740.0	1,885.0	2,672.0	2,840.0
Musanze	800	800.0	1,110	1,065.0
Rulindo	97	97.0	1,100	1,081.0
Northern P.	6,788.0	6,916.0	12,887.0	12,992.0

Ngororero	300	300	2,722	2,722
Nyabihu	128	128	4,678	4533
Western P.	428	428	7,400	7,255
Total	7,216.0	7,344.00	20,287.0	20,247.00

There was no wheat production in Southern and Eastern Provinces and other districts of Western Province, and where wheat was produced, there was no production in season C

Table 88: Vegetables crop area targets and planted areas in 2023-24

District	2024A		2024B		2024C	
	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)	Target (ha)	Planted area (ha)
Burera	147	147	254	261	132.9	132.9
Gakenke	25	25	30	25	127.2	208.6
Gicumbi	190	170	-	-	625.7	625.7
Musanze	30	30	30	26	203.3	200.9
Rulindo	165	165	62	52	372.5	360.2
Northern P.	556	536	376	364	1,461.6	1,528.3
Bugesera	220	198	-	-	1,440.2	2,429.2
Gatsibo	185	180	-	-	262	262.7
Kayanza	600	600	184	184	522.5	675
Kirehe	265	265	-	-	562	560.5
Ngoma	260	245	260	260	516.4	512.4
Nyagatare	2,158	2,158	1,179	1,541	689	663.3
Rwamagana	533	513	306	277	1,032	996.5
Eastern P.	4,221	4,159	1,929	2,262	5,024.1	6,099.6
Gisagara	71	40	88	67	655	655
Huye	174	-	-	-	420.9	420.9
Kamonyi	153	153	703	340	552	522
Muhanga	150	150	-	-	392.6	353.3
Nyamagabe	161	161	93	93	492.5	492.9
Nyanza	75	55	117	12	864.2	802.8
Nyaruguru	335	312	72	72	148.5	148.5
Ruhango	203	203	39	66	246.2	254.5
Southern P.	1,322	1,074	1,112	650	3,771.9	3,649.9
Karongi	250	-	-	-	359.4	364.1
Ngororero	120	120	35	35	158.5	158.5
Nyabihu	352	352	131	131	68	67.5
Nyamasheke	238	238	-	-	283.6	289.7
Rubavu	628	582	523	505	106.7	106.7
Rusizi	-	-	-	-	257	257
Rutsiro	105	-	-	-	97.5	94
Western P.	1,693	1,292	689	671	1,330.7	1,337.5
Gasabo	210	288	195	195	124.4	118.2
Kicukiro	262	262	35	35	147.4	138.9
Nyarugenge	60	60	60	60	41	41
CoK	532	610	290	290	312.8	298.1
Total	8,324	7,671	4,397	4,238	11,901.1	12,913.4

II. CROSS CUTTING PROGRAMS

2.1 Genebank

Genetic resources are fundamental to human well-being in agricultural development, poverty alleviation, health, nutrition, economic growth and their ecological services and functions. Sustainable agricultural production and food security for now and into the future are most

successful when based on well-conserved genetic resources, as broadly as possible. In this regard, during the FY2023-24, a total of 1,650 plant genetic resources and 403 local animal genetic resources were conserved. Most of the activities carried out were related to local plant and local animal genetic resources conservation.

2.1.1 Plant genetic resources

Under plant genetic resources, different activities were carried out as detailed in the sections below.

Exploration and collection of plant genetic resources

Plant genetic resources explorations and collections performed in the 2023-2024 fiscal year were focused mainly on local plant varieties under extinction. These were legumes, cereals, vegetables, roots and tubers plant genetic resources. A total of 254 plant genetic resources were explored and collected in different agro-ecological zones of Rwanda (**Photo 71**). All these plant genetic resources were then conserved for further seed increase/regeneration, characterization trials, germination and moisture content tests. After collection, accessions were registered, processed and specific accession numbers were assigned. During collection, passport data sheets were filled for proper data record, documentation and easy morphological characterization.



Photo 71: Photo showing some of the collected local bean varieties



Photo 72: Taking observations for morphological characterization of wheat (right) and bean accessions (left) at RAB Rwerere station

Morphological characterization of plant genetic resources

To document conserved plant genetic resources at the national gene bank, there is a need for appropriate characterization of plant accessions. In this regard, 121 plant genetic resources were morphologically characterized at Rwerere and Rubona stations (**Photo 72**). These comprised two sets of wheat plant genetic resources and one set per crop for maize, bean, peas and soybean plant accessions were also characterized. Data were mainly recorded on plant and agronomic characters, reproductive and yield parameters and disease reactions. The photos below highlight some plant accessions under characterisation data measurement.

Regeneration and seeds increase for plant genetic resources

For sustainable conservation, 236 accessions of plant germplasm collected were regenerated for seed increase in Nyagatare, Rwerere and Rublizi stations. They were mainly annual crops - cereals, pulses oil crops and vegetables. During regeneration, trueness to type was followed in order to keep genetic integrity of plant genetic resources under conservation (**Photo 73**).



Photo 73: Regeneration of finger millet(left) and Cowpea(right) at RAB, Musenyi site

Plant genetic resources conservation and viability monitoring

Plant genetic resources under mid and long-term conservation at Rwanda National Genebank are conserved in cold rooms as active and base collections. These plant genetic resources must be checked for their viability. Out of 1,650 plant genetic resources conserved, a total of 286 plant accessions conserved in active/base collections were evaluated for their germination (Photo 74) and the germination and moist content percentage were then calculated. The figures below illustrate different accessions in germination room test during viability monitoring of accessions conserved at Rwanda National Gene Bank at Rubona.



Photo 74: Conserved plant genetic resources under germination tests at Rubona station

Except conservation as active and base collections, conservation under field genebanks was also performed for 82 plant genetic resources at Rubona station. Field genebanks were for vegetatively propagated and perennial plant genetic resources comprising yam, taro, potato and finger potato (Photo 75). There were other field gene banks of coffee, banana and horticulture genetic resources managed under banana, Industrial crops and horticulture programs. The following photos illustrate the field gene banks of taro and yam under regeneration at Rubona.



Photo 75: Field genebanks of Taro (left) and Yam (right) at Rubona station

2.1.2 Animal genetic resources

Under animal genetic resources, major activities carried out were maintenance and phenotypic characterisation of conserved local cattle genetic resources. More details on this are discussed in the sections below.

Local animal genetic resources maintenance and conservation

Activities to care for and maintenance of 403 local cattle animal genetic resources comprising 265 Inyambo and 138 Inkungu breeds at Rubona and Nyagatare stations were carried out (**Photo 76**). Regular data on growth, production and reproduction were recorded.



Photo 76: Inkungu (left), Inyambo (right) breeds conserved at RAB Rubona and Nyagatare

Local animal genetic resources characterization

Large stock characterization was performed: 40 cows were characterized, and production data collected (**Photo 77**).



Photo 77: Inyambo local breeds characterized at Nyagatare station

During the 2023-24 fiscal year, through above-mentioned activities were performed under genetic resources management program, but some activities were not implemented. This is because there was a constraint on funds allocated to the program. This constrained the execution of some activities, including microbial conservation, maintenance of conservation infrastructures, and upgrading the internet connectivity at Rwanda National gene bank.

Additionally, the problem of limited staff hindered the execution of some specific activities to be carried out at Rwanda National gene bank. In this regards, as raised in various fora, there is need to avail funds and staff for genetic resources conservation related activities for a sustainable agriculture development.

III. ANIMAL INNOVATION AND TECHNOLOGY TRANSFER DEPARTMENT

The Animal Resources Department aimed at developing and improving animal resources in the country through research, innovation and technology transfer. The department oversees operations of different programs and division namely Ruminant, Monogastric, Veterinary services, Commercial insects and apiary, Aquaculture and fisheries programs & National Genetic Improvement, and Animal processing and biotechnology divisions.

3.1 Ruminants Animal Program

Carrying capacity of selected grazing land in Eastern province

The aim was to assess the carrying capacity of grazing land in the region, essential for maintaining ecological integrity and supporting local communities sustainably. The study area covers Nyagatare, Gatsibo, and Kayanza districts, representing a significant portion of Rwanda's cattle population. Data on above-ground biomass and chemical composition were gathered from 63 farm plots clustered into three categories, namely ≤ 10.9 ha; 11-20.9 ha and ≥ 21 ha across these districts. Also, crop residues produced in 2023 in the selected areas were collected. This calculation considered factors such as body weight, chemical composition of

natural pasture' above-ground biomass, as well as daily feed requirements. **Figure 17** shows the annual yield of various crop residues in metric tons (MT) of dry matter (DM) for the year 2023, classified by different types. Cereal stovers emerged as the predominant crop residues across both cropping seasons (202AA and 2024B), with maize stovers recording the highest yield among all categories, totalling 183,672 MT. Following closely were bean haulms, with a combined yield of 76,706 MT. Conversely, other cereal stovers exhibited the lowest yield, totalling 1,729 MT, with a notably higher yield in season A (1,254 MT) compared to season B (474 MT).

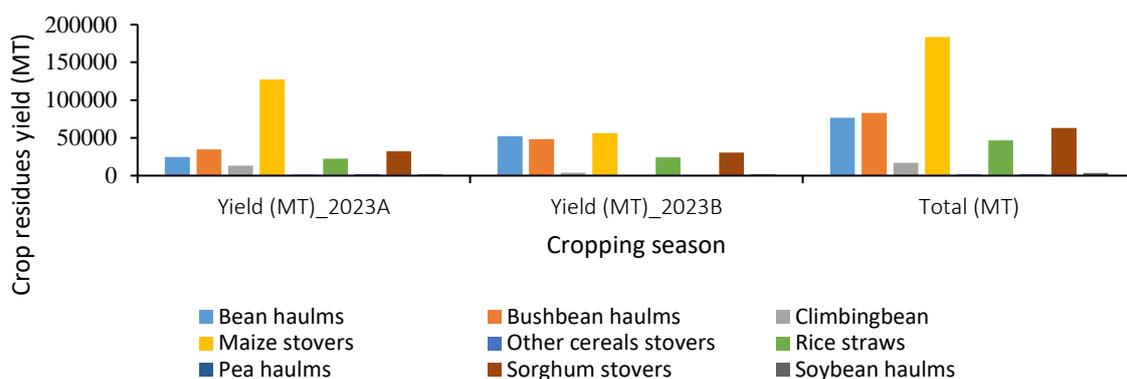


Figure 16: Seasonal crop residues production in dry matter in selected Eastern districts

Table 89 shows significant differences in the measured parameters across various plot sizes and seasons. Dry matter (DM) exhibited significant differences across both plot sizes and seasons ($P < 0.0001$). Similarly, crude protein (CP) showed significant differences across plot sizes and seasons ($P < 0.0001$). While neutral detergent fibre (NDF) did not exhibit significant differences across plot sizes ($P = 0.1090$), it did across seasons ($P < 0.0001$). Conversely, acid detergent fibre (ADF) showed significant differences across both plot sizes and seasons ($P < 0.05$). Moreover, a significant interaction was observed between plot size and season for DM and CP ($P < 0.0001$). Likewise, the interaction between plot size and season was significant for NDF ($P < 0.0001$) and ADF ($P = 0.0085$) (**Table 89**).

Dry matter (DM) measured in kilograms per hectare (kg/ha/year) across different plot size categories showed that the 11-20.9 ha plot size category had the highest DM, followed by the ≥ 21 ha category, while the ≤ 10.9 ha category had the lowest DM yield. Tropical Livestock Unit (TLU), showed that the available biomass in the plot of 11-20 ha could feed only the TLU for a period of 60 days while the plot of ≤ 10 ha could only feed for 40 days.

Table 89: Average characteristics of grazing land production in the Eastern Province

Plot size	Season	DM (kg/ha)	CP (g/kg DM)	NDF (g/kg DM)	ADF (g/kg DM)
11-20.9	Dry	205.5	60.4	732.2	449.6
	Rainy	657.8	66.6	661.7	414.0
≤ 10.9	Dry	116.5	59.2	732.8	467.6
	Rainy	510.1	68.1	648.2	412.3
≥ 21	Dry	135.4	55.4	756.3	463.0
	Rainy	591.4	65.4	642.9	422.8
Sign.	P	<.0001	<.0001	0.1090	0.0024
	S	<.0001	<.0001	<.0001	<.0001
	P*S	0.3428	0.0465	<.0001	0.0085

The results from this study highlights the significance of effective crop residue utilization, tailored management strategies, and sustainable grazing practices to optimize livestock nutrition and productivity. In addition, implementing these findings can promote long-term sustainability and resilience in Rwanda's eastern savannah, particularly in Nyagatare, Gatsibo, and Kayonza districts.

Super-ovulatory response and embryo yield in Friesian, Inyambo, and crossbreeds

The aim was to evaluate the success rate of Embryo Transfer (ET) in recipient cows of pure Friesian, Inyambo and crossbreeds under both station and field conditions in Rwanda. Over the 8-month period between 2018 and 2019, 32 donor cows were super-ovulated, inseminated, and flushed. A total of 208 recipient cows and heifers were synchronized, of which 127 successfully qualified to receive embryos. Jersey crossbreed embryos (n=46) were produced at the Rwanda Agriculture and Animal Resources Development Board (RAB) research farms located at Songa and Kinigi stations, in Huye and Musanze Districts, respectively. Additionally, frozen Jersey embryos imported from the United Kingdom (n=81) were used to compare the outcomes of fresh versus frozen-thawed ET in RAB research farms and private smallholder farms in the Nyanza and Musanze districts. The results showed a pregnancy rate (PR) of 36.2% (n=46), with a higher success rate for fresh embryos at 54.3% (n=25) compared to 25.9% (n=21) for frozen-thawed embryos. There was a significant difference in PR between RAB farms [44.8% (n=30)] and smallholder farms [26.7% (n=16)].

Most recipient-related factors, including breed, body weight, age, parity, postpartum interval, presence of corpus luteum (CL) on the day of progesterone-releasing intravaginal device (PRID) insertion, estrus intensity, and quality of CL on ET day, did not significantly affect PR ($P > 0.05$). However, body condition score ($P = 0.04$), farm ownership ($P = 0.03$), and embryo type ($P < 0.01$) significantly influenced PR (Table 90). The study concluded that ET can be successfully applied under the current rearing conditions in Rwanda.

Table 90: Farm, body condition score, and embryo type association with bovine ET PR for the transferred embryos in 127 recipients

Studied parameters	Total transferred(n)	Pregnant (day 52)	Pregnancy rate (%)	p-value
<i>Farm ownership</i>				
Public (RAB farms)	67	30	44.8	0.03
Private (SHFs)	60	16	26.7	
<i>Body condition score¹</i>				
2.5	12	6	50	0.04
3	62	15	24.2	
3.5	39	17	43.6	
4	14	8	57.1	
<i>Oestrus intensity</i>				
Clear heat signs	119	42	35.3	0.4
Silent heat	8	4	50	
<i>Embryo type</i>				
Fresh	46	25	54.3	P < 0.01
Frozen	81	21	25.9	

Factors affecting the success rate of artificial insemination

The present study was conducted to assess factors affecting the effectiveness of AI in smallholder dairy production systems in Gicumbi, Nyanza, and Rwamagana districts. A total of 257 cows and heifers belonging to 234 farmers were assessed and recruited for artificial insemination. The Results showed that average AI success rate in the study area stands at 45.1%. Age between three to six years (p-value 0.002) and natural oestrus (p-value 0.000) showed higher conception rate in this study. Similarly, the presence of three oestrus signs and time for artificial insemination showed a positive association with conception rate. The current study showed that natural heat detection, age of the cow, proper time for insemination, heat signs management, and breeds would be taken into consideration in breeding programs to increase AI success rate.

Small ruminant breeding stock

The flock, stationed at Gishwati Research Centre, has grown from the initial stock of 50 ewes and 5 rams in 2021 to a total of 44 males and 71 females, not including those distributed through the outreach program. Data to assess performance in terms of both reproduction and production is being collected. In the outreach program, a total of 7 males and 20 females have been disseminated to farmers (**Photo 80**).



Photo 78: Merino Sheep breeding stock at RAB - Gishwati

Additionally, Boer and Galla goats were introduced as improver breeds, and through crossbreeding with indigenous goats, a larger amount of data has been generated at Karama Farm. Data cleaning is currently underway to assess the performance of different goat genotypes (**Photo 81**). In the outreach program, a total of 79 goats have been distributed to farmers.



Photo 79: Different goat Galla x local crossbreeds at Karama farm, RAB - Nyagatare

Forage planting and seed production

For the fiscal year 2023/2024, the target for new forage planting was to plant 10,000 ha of improved forage grasses and legumes across the country. A total of 11,718 ha of new improved fodder plots were established (Figure 18). The ruminant programme worked with its stakeholders including RDDP, sector animal resources officers (SAROs), NGOs, individual farmers and farmer cooperative to achieve the target. The collaboration with districts enabled smooth implementation and achievement of the target. To achieve the target, we used a participation approach where all the stakeholders were involved. Also, farmers through farmers field schools, farmer facilitators and farmer cooperatives were the major approach to meet the target. Apart from these, forage campaigns for each cropping season were used to encourage farmers to establish forages. There was a launch of planting forages in the majority of districts, especially where RDDP is operating (Photo 80). Also, radio talk on the importance of forages were aired from all RBA and private radios in Rwanda. After, the planting, monitoring of forage management and reporting were followed.



Photo 80: Launch of seasonal forage planting in Eastern Province

For the fiscal year 2023/2024, the area of land planted with improved forages was estimated at 11,718 hectares, representing 117.2% of the target. This success was due to the effective coordination of forage cultivation activities, combined with a prolonged rainy season from September 2023 to May 2024. The coordination involved thorough weekly reporting. Additionally, the commitment of farmers to planting improved forages for better feed availability was a key driver in achieving this target. Large areas of land planted with forages were found in the districts under the RDDP program, like Nyagatare, Kayonza, Musanze, Burera, just to name a few. However, other districts, including Nyamasheke, Gisagara, Rulindo, Gakenke, Ngoma, and Rusizi, also planted significant acreages of improved forages (Figure 18, 18).

Regarding forage species, *Chloris gayana* was the most extensively planted, particularly in the Nyagatare and Kayonza districts, followed by Napier grass, which was most commonly planted in Burera, Musanze and Nyabihu districts during the 2023/2024 year (Figure 19) .

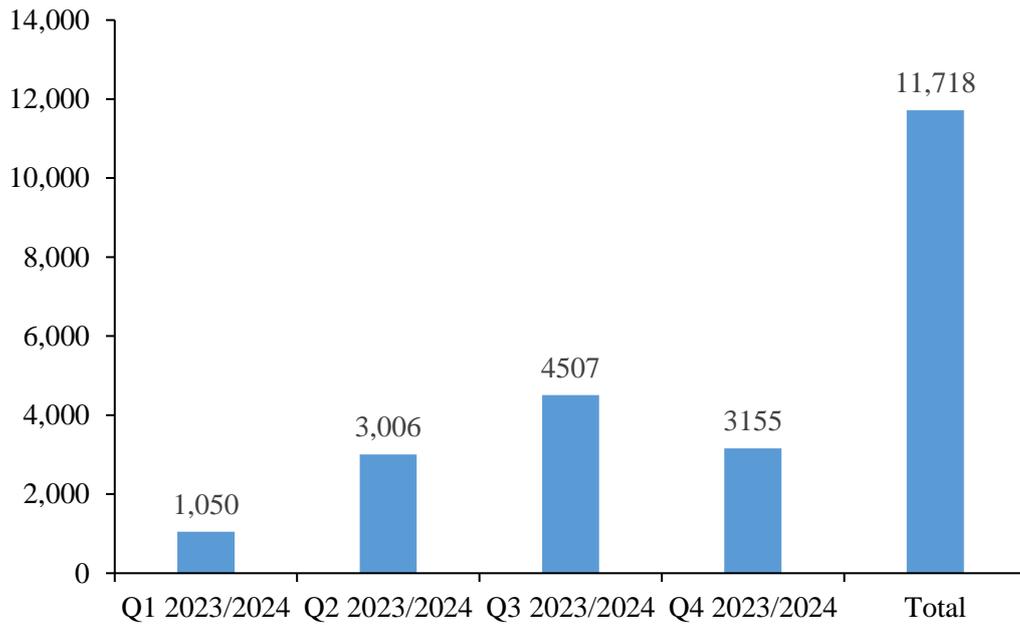


Figure 17: Forage acreage achievements for the fiscal year 2023-2024

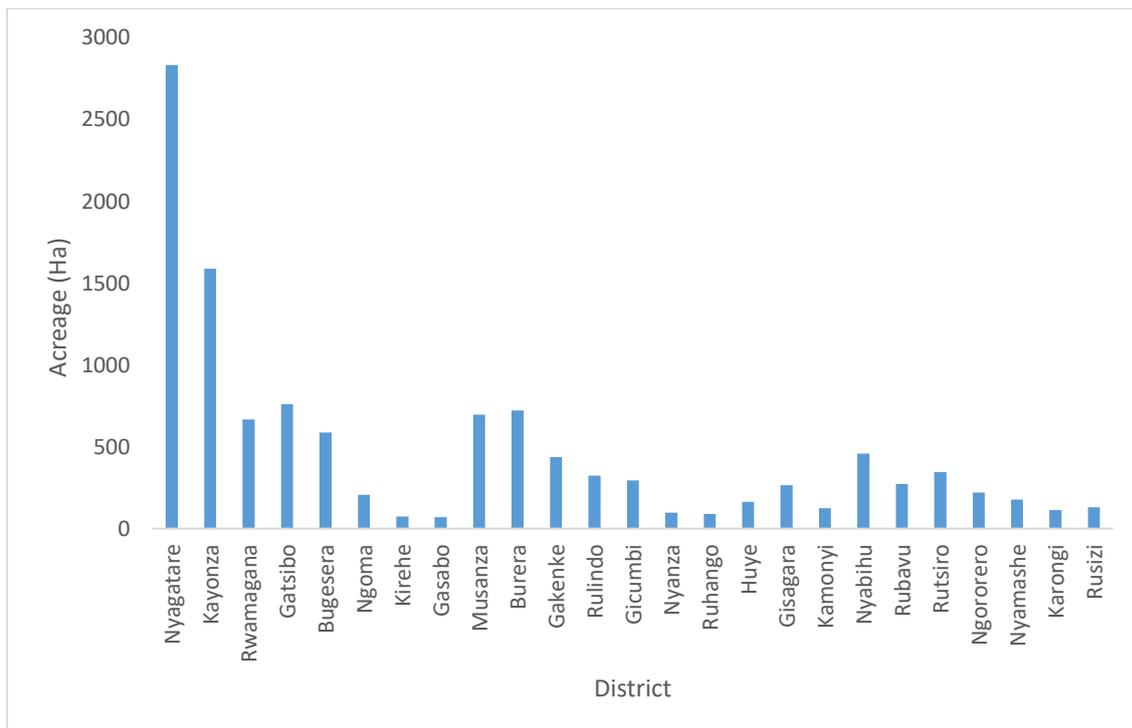


Figure 18: Areas planted with improved forages by district in the fiscal year 2023-2024

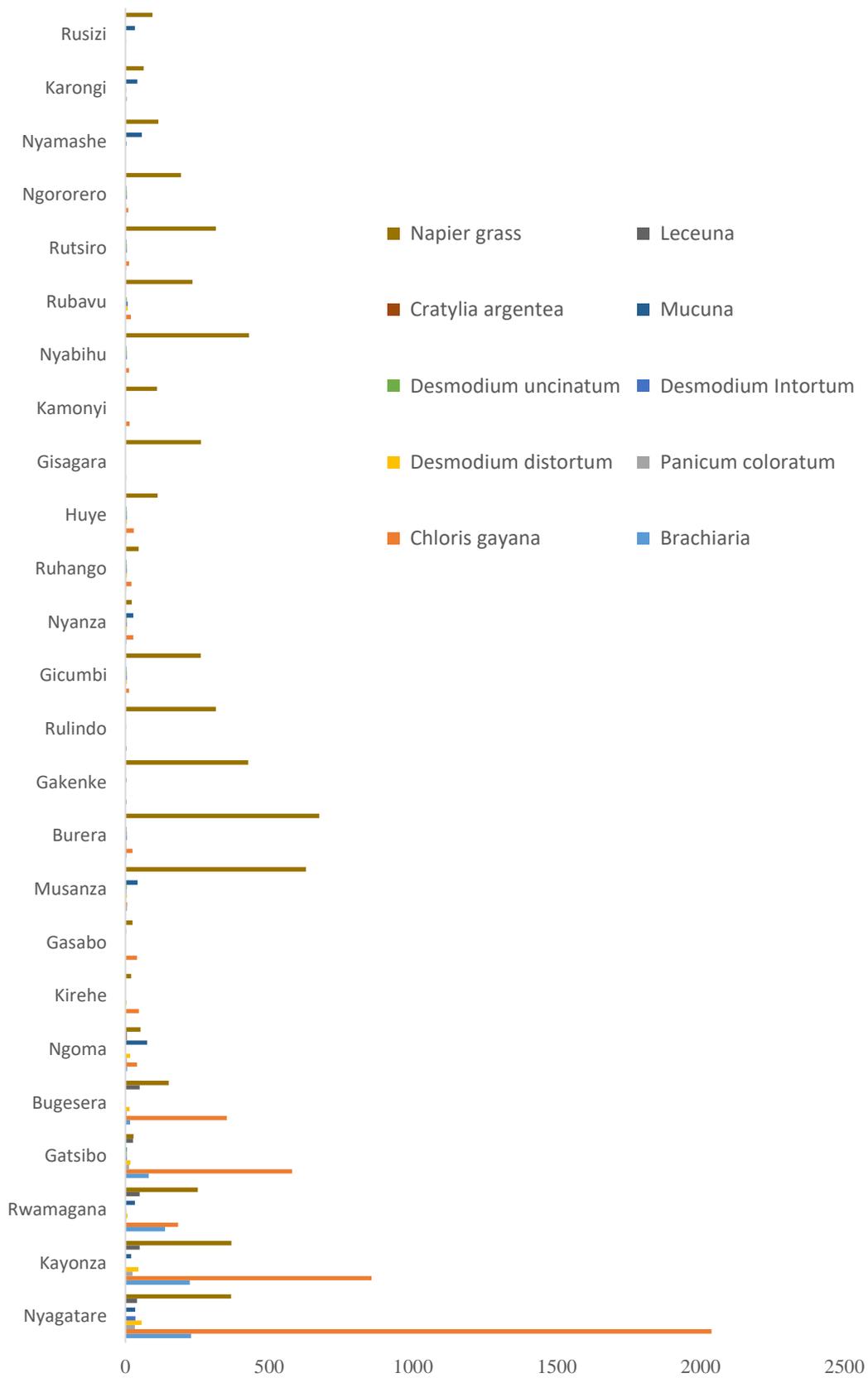


Figure 19: Forage species by district in the fiscal year 2023-2024

The trend in improved forage cultivation shows that there was increase in land size where by June 2024, it was estimated at 32,269 ha, versus 18,000 ha targets of PSTA 4, representing 179.3% (Figure 20). Major improved forages established included forage grasses, namely *Brachiaria* species and varieties, *Chloris gayana*, *Panicum* species and Napier grass (Photo 81) whereas forage legumes included *Mucuna* species, *Desmodium* species, *Leucaena diversifolia*, *Lablab* sp., *Cratylia argentea* and *Canavalia brasiliensis* (Photo 82).

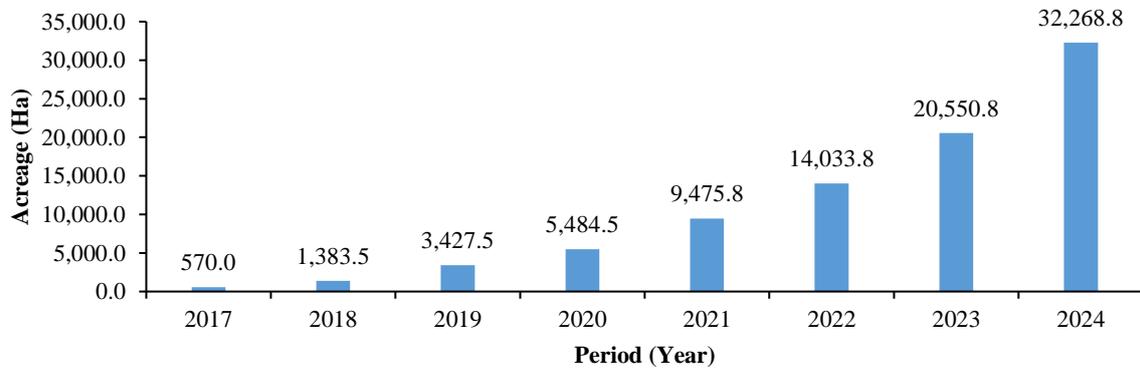


Figure 20: Cumulative acreage of improved forage by June 2024



Photo 81: Improved forage grasses



Photo 82: Improved forage legumes

Table 91 shows the forage seeds and vegetative materials produced, respectively for the fiscal year 2023-2024. High forage seeds produced was for *Chloris gayana* (23.8 tons) because it is the grass much preferred, especially in Eastern province of Rwanda. For cuttings and rooted tillers (splits) Napier grass and *Brachiaria* grass were the highest producers (Error! Reference source not found.91). This is also due to their high demand by ruminant livestock farmers across the country. Among the forage legumes, seeds of *Mucuna* sp. were also produced and at least 2.4 tons were recorded.

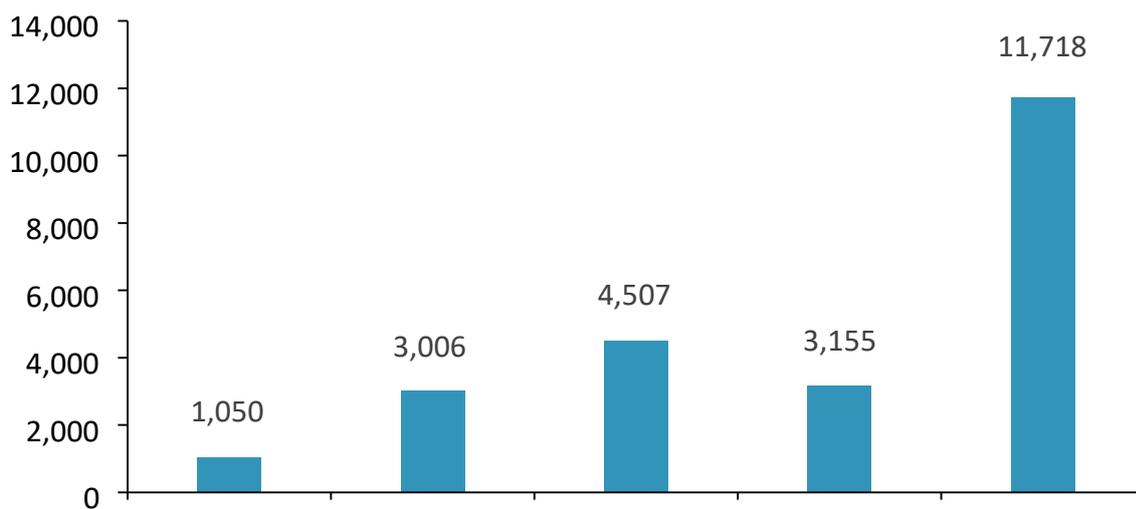


Figure 21: Forage acreage achievements for the fiscal year 2023-2024

Table 91: Forage seed produced for the fiscal year 2023-24

Forage type	Forage species	Seed produced (kg)				Total annual
		Q1	Q2	Q3	Q4	
Grasses	<i>Chloris gayana</i>	4,874	5,280	6,780	6,908	23,842
	<i>Panicum CIAT 155</i>	7	-			7
	<i>Cenchrus ciliaris</i>	2				2
Legumes	<i>Mucuna pruriens</i>	483	-	345	1,600	2,428
	<i>Desmodium distortum</i>	114	103	147	25	389
	<i>Leucaena diversifolia</i>	49	103	102	80	334
	<i>Lablab sp.</i>			68		68
	<i>Cratylia argentea</i>			79	21	100
	<i>Canavalia brasiliensis</i>			24		24
TOTAL		5,529	5,486	7,545	8,634	27,194

Q1,2,3,4: Quarters

Training on forage conservation

Training on hay production was organized for Eastern districts, and a total of 1,656.5 tonnes of hay with total dry matter estimated at 1,325.2 tons were produced during the fiscal year 2023-24 (Photo 83).



Photo 83: Hay production (Bales) for the fiscal year 2023-24

2.1.7 Livestock Farm Field School and climate smart practices

More than 978 farmers were trained on pasture/grazing management across the country. The achievement is estimated at 244.5% because the target was 400 farmers (Photo 84). It is expected that these will be extension agents at proximity in or near their village.



Photo 84: Training of farmers on pasture/grazing management in Eastern province

Other climate smart feed technologies were promoted through training of farmers. This were the production and use of hydroponic foddors (Photo 85).



Photo 85: Training farmers of the production and use of hydroponic foddors

To address the water needs for livestock at Karama Farm in the RAB Nyagatare district, the programme collaborated with partners to construct a farm pond using a dam sheet, providing water for Inyambo cattle and goats at Karama Farm. Currently, this water source is capable of sustaining more than 800 animals (Photo 86).



Photo 86: Water supply to Inyambo cattle and goats at Karama farm/RAB Nyagatare

3.2 Mono-gastric Animal Program

3.2.1 Evaluation of pig artificial Insemination and its delivery services using Zipline drones

The present study aimed to evaluate the Artificial Insemination (AI) in pigs and its service delivery using zipline drones in Rwanda. The study evaluated the pig farmers' perception on swine AI, assessed also the quality of boar semen collected from the 5 breeds used in Rwanda and determined the effect of zipline services on pig conception rate and litter size. During survey conducted in fifteen districts of Rwanda namely, Gakenke, Gicumbi, Huye, Kamonyi, Karongi, Kayonza, Muhanga, Ngoma, Nyamagabe, Nyamasheke, Rubavu, Rusizi and Rwamagana, A total of 339 respondents were interviewed in which 34.2% were females and 65.8% were males. The household percentage was 14.5% and 85.5% for females and males, respectively. The survey results show that the time in minutes travelled by zipline drones for semen transport (35.2 ± 13.6) did not significantly affect the litter size (Litter size = 8.4 ± 3.9 , female piglets = 4.1 ± 2.5 , Male piglets = 4.6 ± 2.6 ,) however, it significantly affected fertility ($P < 0.05$). Among the 339 respondents who were asked about the preference between AI and natural mating, 3 (0.85%) showed no preference, 323 (93%) preferred AI, 12 (3.4%) preferred 14 (4.9%) preferred both Artificial Insemination (AI) and Natural Mating (NM). Moreover, the farms that are managed by married household heads were high 285(84%) followed by those managed by single household heads 27(7.96%), Widow/Widower 24(7.09) and the last is 3 for divorced household heads.

Five genetically superior boars (Landrace, Large white, large white, pietrain and duroc breeds) located at Rwanda Agriculture and Animal resources development Board (RAB) Semen collection and distribution center were used during semen collection and analysis before being sent to Zipline Headquarters. The result showed that there was an association of breed with semen motility in which the Duroc breed showed the highest percentage of motility followed by Landrace, large white, pietrain and combrough, respectively. However, the breed showed no significant effect on Boar semen concentration. In Table 1, the seasons had a significant effect on semen motility, semen doses and semen concentration $p < 0.05$, but did not affect the volume of semen ejaculum ($P = 0.70$) the Long rainy season (LRS) showed the highest percentage of semen motility ($> 95\%$) and semen concentration (256.1 ± 84) while the Short Dry Season showed the highest sperm quantity, (190.2 ± 111.9) the long Dry Season (LDS) showed the highest number of semen Doses compared to other seasons (27.1 ± 10.1). Additionally, the age of boar did not significantly affect ($P = 0.132$) the semen concentration and semen motility $P = 0.169$ (Table 92). However, there was a significant association ($P < 0.05$) between boar age with semen doses and semen quantity from the results. It is recommended to establish more semen production centers and providing more training on pig management, Artificial Insemination and public awareness for the existence of Zipline drones boar semen delivery services.

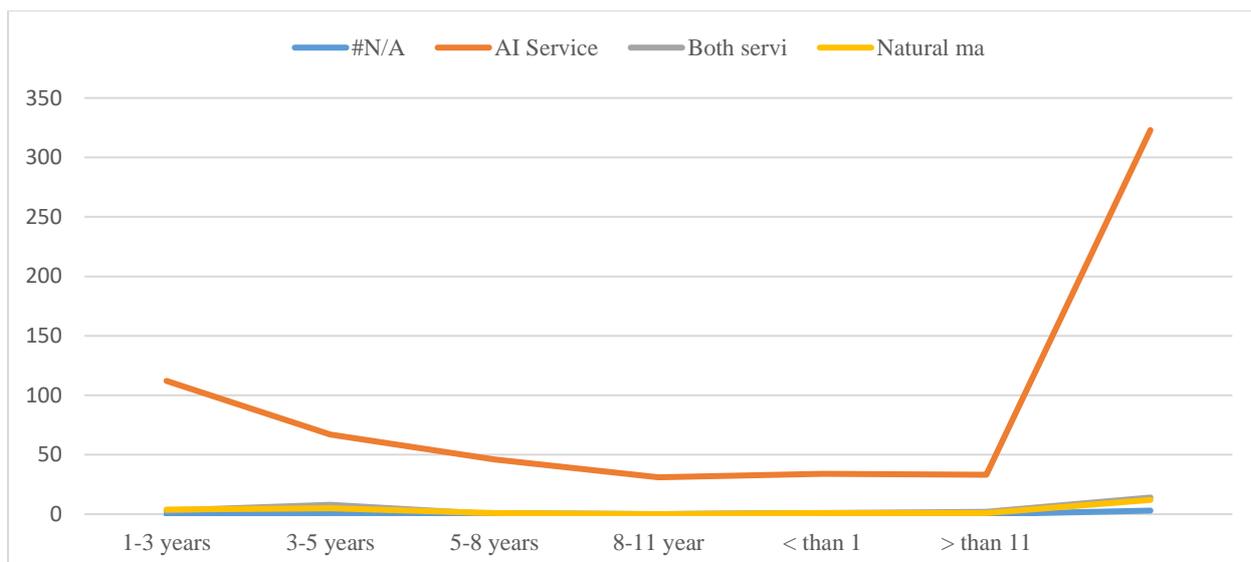


Figure 22: Pig farmers' experience Vs their preference in AI and natural mating

Figure 24 above indicates that, pig farmers' experience, did not affect preference of either AI or Natural mating ($P = 0.18$), Although, in the present study the difference was not significant ($p > 0.05$), there is rapid increase of preference of AI over natural mating as the number of years of experience of household heads in pig farm management increases to more than 11 years.

Table 92: The effect of breed on Boar semen Quality

N=511	Breed	Mean	Minimum	Maximum
Semen quantity, ml (P=0.00)	Large white	294.370±105.3	136.0	589.0
	Landrace	156.086±45.1	62.0	292.0
	Pietrain	163.197±40.2	80.0	341.0
	Duroc	102.019±41.4	30.0	250.0
	Combrough	162.500±38.8	82.0	205.0
Concentration (x109) (P=0.00)	Largewhite	216.864±53.8	107.0	320.0
	Landrace	226.704±84.6	22.0	652.0
	Pietrain	215.847±62.5	107.0	522.0
	Duroc	310.515±81.2	101.0	500.0
	Combrough	161.625±32.7	120.0	207.0
Semen motility (P=0.00)	Large white	91.000±2.4	80.0	95.0
	Landrace	88.778±4.6	60.0	95.0
	Pietrain	90.255±1.3	87.0	95.0
	Duroc	91.718±2.3	90.0	95.0
	Combrough	86.875±3.7	80.0	90.0
Semen Doses_100 MI (P=0.00)	Large white	36.037±12.3	6.0	56.0
	Landrace	18.846±18.8	3.0	44.0
	Pietrain	22.631±10.4	6.0	44.0
	Duroc	19.039±6.0	3.0	34.0

	Combrough	20.375±4.3	14.0	26.0
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The type of breed has significantly affected the semen motility, semen quantity, concentration and number of doses in such way that, Duroc breed contributed to high motile sperms (91.718±2.3), with high concentration (310.515±81.2) but with considerably smaller ejaculate volumes (102.019±41.4) (Table 93).

Table 93: The effect of Age on Boar semen Quality

N=511		Mean	Minimum	Maximum
Concentration (x 109) (P=0.132)	1 year old	231.48±97.8736	22.0	578.0
	2 year old	237.36±66.2006	101.0	652.0
	3 year old	254.62±87.521	109.0	522.0
Semen motility (%) (P=0.169)	1 year old	89.86±5.2372	60.0	95.0
	2 year old	90.41±1.4825	85.0	95.0
	3 year old	89.85±1.1952	80.0	90.0
Semen Doses_(100MI) (P<0.05)	1 year old	13.93±7.5101	3.0	40.0
	2 year old	27.05±11.3656	6.0	56.0
	3 year old	29.32±8.0049	9.0	48.0
Semen quantity (ml)/Volume (P<0.05)	1 year old	143.61±62.439	30.0	318.0
	2 year old	178.36±86.716	60.0	589.0
	3 year old	201.25±89.352	62.0	545.0

The age of boar did not significantly affect (P=0.132) the semen concentration, Semen progressive motility (P=0.169) (Table 93). However, the age showed a significant effect (P<0.05) on boar semen doses and semen quantity, significantly while there is an increase of semen quantity/volume with the age of boars and sperm quantity from the first year, second year and third year. The survey indicated that farmers have high preference on AI over natural mating.

3.2.2 Conception rate and litter size of sows subjected to natural service versus artificial insemination

This study investigates the conception rate and litter size of sows subjected to natural service versus artificial insemination in swine breeding across five districts in the Northern Province of Rwanda: Musanze, Gakenke, Rulindo, Burera, and Gicumbi. A total of 583 breeding sows and gilts, representing four breeds namely, Landrace (n=190), Landrace x Pietrain (n=331), Large White (n=26), and Local breed (n=36) were monitored from March to December 2019 across three agricultural seasons. The sows varied in age from 0.7 to 4.3 years. Data collected included estrus type (induced: n=252, natural: n =331), mating type (AI: N=258, natural service: n=327), number of mating (1 service: n =359, 2 services: n =164, 3 services: n =60), age, parity, conception rate (CR), gestation length, litter size, and piglet survival rate. The study analyzed the effects of breed, age, farm, service type, number of services, and season on CR, litter size, weaning rate, and piglet sex. The average CR was 0.93 ± 0.25, not affected by sow parity but significantly influenced by boar age and the number of mating services. Sows with higher parity showed increased stillbirths. The piglet survival rate was 92.2%, with variations in weaned piglets per sow reflecting litter size differences. AI technology in swine breeding demonstrates substantial benefits, notably influenced by boar age and mating frequency. This research highlights the AI potential to enhance conception rates and manage litter sizes effectively.

Table 94: Influence of key factors on the conception rate of sows

Factor	Conception rate (%)		
	Mean	Std. Deviation	P-Value
Age sow (year)	1.28	0.63	0.26
Age boar (Year)	2.05	0.98	<u>0.05</u>
Parity (Number)	1.26	1.39	0.96
Services (Number)	1.49	0.68	<u>0.03</u>

Table 94 summarized findings on the variation of the conception rates in sows after insemination or natural service. It was indicated that the age of boar and the number of services has significantly affected the conception rates in sows, with respectively $P=0.05$ and $P=0.03$. There was no effect of the age of sow, neither that of the number of sow parity on their chances of being successfully inseminated. In conclusion, the number and timing of services were crucial, with most sows receiving one insemination. For improved outcomes, farmers should focus on optimal farm management, robust record-keeping, and promoting at least two AI procedures per oestrus cycle.

3.2.3 *Tagetes patula* effect as pigment in laying hen diets:

The egg yolk pigmentation of *Tagetes patula* flower was evaluated when used graded levels with a balanced laying bird's diet. A total of 150 laying birds were randomly divided into five groups, 30 laying hens per group cage. The experimental period lasted four weeks. During this period, the birds had free access to feed and water. Test diets were commercial layer feed with or without *Tagetes patula*: 0 (control), 10, 20, 30 or 40 g kg⁻¹ marigold petals (*Tagetes patula*). Feed intake and egg production were recorded on daily basis and egg-yolk color was examined using natural vision. Four yolks per diet were evaluated every three days during the experimental period. Results showed that 20 g of Marigold (*Tagetes patula*) petals per Kg of feed was the optimum level of inclusion in poultry diets for egg yolk pigmentation. At the level of 40 g kg⁻¹ marigold petals, there is a tendency of the egg yolk to become orange rather than yellow. After four successive days of feeding marigold petals in the diet, the yellow color was visible in the egg yolk while after 12 days of feeding commercial layer feed without marigold in the diet; the yellow color was not visible and resembled as the same as control diet. Therefore, marigold petals could be used in the layers diet for egg yolk pigmentation to improve the quality of eggs for the market. This study was conducted in the poultry research farm at RAB, Muhanga station. In this study, one hundred fifty 24-week-old Hyline-10 laying hens were randomly assigned to five groups with three replicates of 10 birds each (30 laying hens per group) and fed a diet supplemented with 0 (control), 10, 20, 30 or 40 g kg⁻¹ marigold petals (*Tagetes patula*) for four weeks. The results showed that 20 g of Marigold (*Tagetes patula*) petals per Kg of feed seems to be the best level of inclusion in poultry diets for egg yolk pigmentation (Photo 87 and 88).



Photo 87: Eggs with no treatment (left); with 10% (center) and 20% tagetes in chicken diets



Photo 88: Eggs with 30% (left) and 40% (center) in chicken diets, and field of tagetes (right)

At the level of 40 g kg⁻¹ marigold petals, there is a tendency of the egg yolk to become orange rather than yellow. This type of egg yolk color is not preferred by consumers in Rwanda. It is concluded that the level of 20 g kg⁻¹ of marigold (*Tagetes patula*) petals was found to be sufficient for pigmentation for egg value-added product. It is inferred that incorporation of marigold as a wholesome feed additive for layer chickens under confinement has beneficial effects on enrichment of carotenoid pigments in egg yolk and improvement of color of egg yolk that is most preferred by consumers in Rwandan markets. Further, nutritional security and health of the community will be improved through consumption of these pigment enriched with yellow xanthophyll, mainly lutein and zeaxanthin. Lutein and zeaxanthin are powerful antioxidants that promote eye health by protecting eyes from free radical damage.

3.2.4 Genetic characterization of four indigenous chicken breeds

The aim was to enhance the genetic improvement of indigenous chickens in Rwanda through phenotypic and genetic characterization to identify superior populations. Phenotypic data and blood samples were collected from indigenous chickens domesticated in four dominant agro-ecological zones in Rwanda. A factorial experimental design was used to examine management system, phenotypic and genetic traits of production. A selection of participant farms was randomly done but villages close to big cities and commercial harbors were not selected. We then assessed phenotypic traits of 1,080 indigenous chickens and took morphometric measurements and whole blood samples of 120 chickens from twelve districts, to cover all the four indigenous chicken types of Rwanda, viz: Inshenzi (Normal IC), Sekaganda/Inganda (Dwarf IC), Imirangi/Umurangi (Naked neck) and Indayi (Adapted IC).

The findings showed 23 related genes from the morphometric measures (head, wattle and beak length) by using SNP markers and 22 nearest genes from blood samples based on the

highest genetic potential in terms of indigenous chicken production. Four different genotypes were discriminated by low homozygosity of 0.140088 for Imirangi and 0.15327 for Inshenzi; while a low similarity of 0.022467 between Imirangi and Inshenzi from the genetic distance than two others (Inganda and Indayi).

Among the four genotypes of IC in Rwanda, the Imirangi and Inshenzi showed the highest genetic potential in terms of production traits (egg and body weight) than Indayi and Inganda. With this information, the selection of indigenous chickens with high genetic potential for production traits is possible and further provides insights for a breeding program of indigenous chickens with a national outlook.

3.2.5 Evaluation of Indigenous chicken performances under intensive management system

After analysis of the weight from day old up to nine weeks for Indayi, Inganda, Imirangi and Inshenzi, the results showed that at nine week the Indayi breed grew faster than another breed (Table 95, Photo 89, Figure 25), with 618, 489, 316 and 385 grams of live weight, respectively.

Table 95: Growth performance of four Indigenous chickens in 9 weeks

Breed	Day old	Weeks								
		1	2	3	4	5	6	7	8	9
Imirangi	29.77	60.93	101.36	138.47	179.02	205.25	247.09	297.79	331.76	316.69
Indayi	34.85	76.58	135.25	180.78	230.79	283.6	370.37	455.93	536.15	618.53
Inganda	27.82	65.51	108.85	158.03	204.04	247.07	319.83	381.83	443.17	489.33
Inshenzi	20.84	40.83	94.36	141.08	175	217.19	289.95	312.26	370.89	385.34

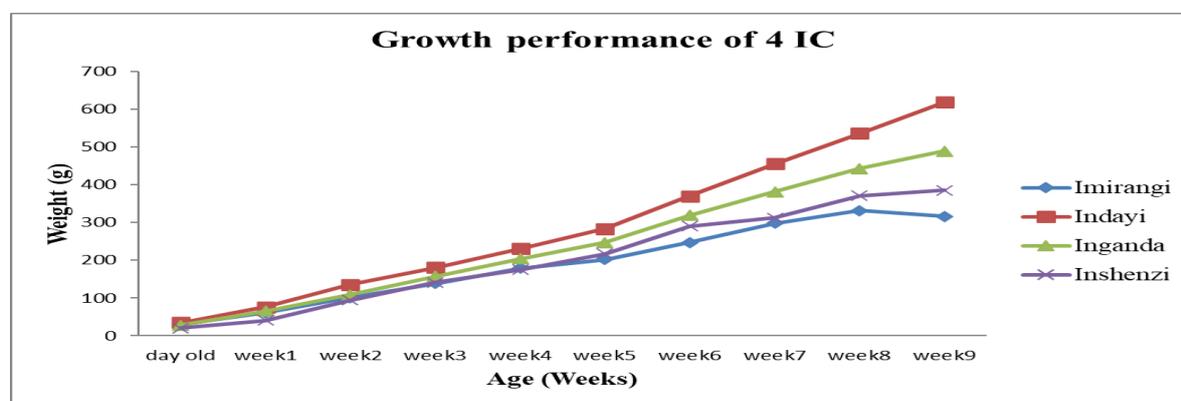


Figure 23: Growth performance of four types of indigenous chicken (IC)



Photo 89: Chicken breeds and their measurement

3.2.6 Installation of SynField X3 & SynAir at RAB-Muhanga

SynField is a type of monitoring equipment for chicken farms. It was introduced in Rwanda under the NESTLER Project (<https://nestler-project.eu/>). The systems consisting of 2 SynField X3 head nodes and 2 SynAir nodes, were installed at chicken farm of RAB Muhanga Station. Deployed in a chicken feeding facility, SynField's nodes are equipped with sensors to monitor the environmental conditions, as well as the air quality characteristics (Photo 90). The sensor measurements are transmitted to the SynField online platform, enabling users to access real-time data and statistical information from any location.

The professional air quality monitoring system SynAir supports a plethora of sensors capable to detect and measure air quality characteristics such as temperature, relative humidity, barometric pressure, CO₂, particulate matter (PM 1.0, PM 2.5, PM 4, PM 10), total volatile organic compounds (VOC), NO₂, CO, O₂, Ozone, and NO₂. Essential for optimizing production and ensuring livestock well-being, air quality monitoring allows proactive identification of potential stressors. Furthermore, through the SynField platform the user can set alerts to be automatically notified in case any of the criteria set are met. This empowers producers to intervene promptly, mitigating adverse impacts on productivity and animal health. SynAir, as a state-of-the-art air quality monitoring system, not only safeguard and enhances overall productivity but also promotes environmentally responsible farming practices. Synelixis leads innovation through SynField's ongoing development, integrating advanced technologies to provide producers with digital tools that boost production while prioritizing environmental conservation. SynField underscores Synelixis' dedication to advancing sustainable and efficient farming, striking a balance between increased yields and ecological responsibility. As SynField progresses, it stands poised to become a crucial asset for producers seeking to optimize operations and contribute to a more resilient and environmentally conscious agricultural sector.



Photo 90: Installation of SynField X3 & SynAir at Muhanga RAB station, Rwanda

3.2.7 Pig Genetic improvement

Pig farming in Rwanda, is principally for income, food and manure used for agriculture to improve crop productivity. Pig genetic improvement have been promoted by importing live exotic pig breeds and pig frozen semen to improve pig farming sector for national demand and multinational sales. The imported breeds were Landrace, Large white, Duroc, Pietrain and Comborough meant for improving our local breed and maintain pure breed pigs for multiplication, fattening breeds for slaughter to cater for local and international demands. For pig genetic improvement much have been done in increasing pig population and quality of breed as well, by establishing A.I centers for semen production and dissemination of semen using drone/ZIPLINE to the needy farmers. The total semen produced in the country is 45566 semen doses and 38441semen doses were used for inseminating sows.

Distribution of exotic Boar to AI centers: In order to increase the good genetic breed of pigs, RAB has identified 6 centers which are CPPA Kisaro, Vision Agri-business Ltd at Gicumbi/Kageyo; Pig farming on grands scale at Bugesera/Ntarama, Muyumbu pig breeding farm Ltd for which exotic boars were distributed for further semen collection for AI centers (Photo 91).



Photo 91: Semen collection from Boar in AI center (left), and processing of pig semen (right)

Swine semen delivery by drones: RAB with support of Enabel project has started a pilot project to use drones to deliver swine semen to veterinarians for use in artificial insemination to facilitate farmers' access to improved breeds and boost the pig industry (Photo 92). Since

illustrates the number of medium and big farmers identified and mapped in each district (Figure 26 and 27). The medium pig farmers identified and mapped in the country were 1,164 and the big pig farmers were 134 making a total of 1,298. The small-scale farmers were not identified as they are many and their identification would require to organize community meetings and this will be done near future and with help of local leaders.

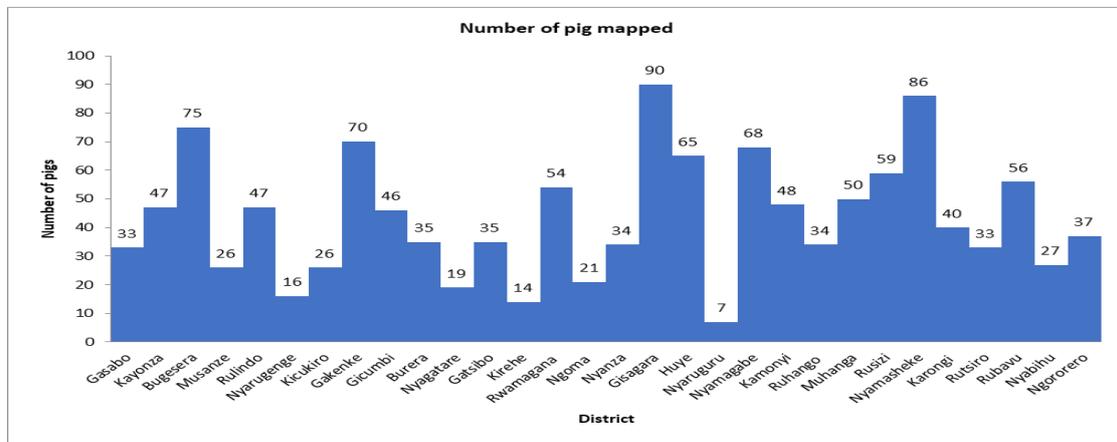


Figure 25: Number of pigs mapped in districts

3.2.9 Capacity building of poultry farmers

A total of 291 poultry facilitators trained were technically monitored and assisted. All the trained poultry facilitators formed their groups that are being trained for different components following the poultry farmer field school methodology (Photo 93 and 94). At least 582 groups of farmers were formed by poultry facilitators, with at least 14,550 poultry group members. Monitoring process and the follow up of facilitators and their groups formed were based on helping them and facilitating them to implement the lessons learnt during the training period to their respective groups, and way forward for the sustainability of the formed groups.



Photo 93: Hands on training on brooding of chicken



Photo 94: Hand on training on mixing feeds for feed formulation

3.3 Veterinary Services

3.3.1 Vaccination

Vaccination against major economically important and zoonotic animal diseases (Foot and Mouth Disease, Lumpy Skin Disease, Black Quarter/Anthrax, Brucellosis, Rift Valley Fever and Rabies) was performed (Photo 95; Table 96). Awareness campaigns about the need of vaccination of livestock for disease prevention were organized. Other diseases such as Mastitis, Tick borne diseases, Helminthiasis, Tse-Tse fly and Trypanosomiasis were controlled by treatments.



Photo 95: Vaccination campaign for swine (left) and cattle (right)

Table 96: Number of livestock vaccinated in Rwanda in FY 2023-2024

Animal species	Type of vaccine	Number of animals vaccinated
Cattle	Against Foot-and-Mouth disease	243,660
Cattle	Against Lumpy Skin disease	1,344,737
Cattle	Against Black Quarter	828,411
Cattle	Against brucellosis	92,382
Cattle	Against Rift Valley Fever	1,281,546
Goats	Against Rift Valley Fever	983,933
Sheep	Against Rift Valley Fever	264,133
Dogs	Against rabies	13,164

3.3.2 Disease diagnostic in laboratory

Diagnostic was done in the Laboratory Unit for Virology, Bacteriology, Serology, Protozoology-Entomology, Helminthology, and Pathology sections using identification of bacteria through ELISA, Rose Bengal and molecular tests (Realtime PCR). The Unit is composed of Central Veterinary Laboratory located at Rubirizi (Photo 96) and Satellite laboratories located in Ngoma, Nyagatare, Huye and Rubavu.



Photo 96: Laboratory testing and its equipment

3.3.3 Epidemio-surveillance

The aim was to monitor animal diseases status within the country for early detection and prevention (Table 97).

Table 97: Occurrence of animal disease in epidemio-surveillance samples in FY 2023-24

	Animal Species	Disease tested	Total of samples tested	Number of positive cases	Prevalence (%)
1	Poultry	ASF	447	1	0.20
2	Poultry	AI	370	0	0
3	Poultry	Av.salm	370	74	0.20
4	Poultry	NCD	370	100	27
5	Bovine	FMD	403	7	1.70
6	Bovine	RVF (Cattle)	306	0	0
7	Bovine	Mastitis	200	101	50.50
8	Caprine	PPR (goat)	760	41	5.30
9	Ovine	PPR (sheep)	34	2	6%
10	Swine	S.erysipelas	443	73	16.50

ASF- ; AI – Avian Influenza; Av.salm – Avian salmonellosis; NCD Newcastle disease- ; FMD – Foot and mouth disease; RVF – Rift valley fever; PPR - ; S.erysipelas – swine erysipelas disease

3.3.4 Permit delivery

Permits are delivered to allow movement of live animals, biological material, animal products and farm accessories. These permits are delivered after inspection of the safety of the products and verification if the destination and origin are safe in order to avoid the spread of diseases. The total of 510 exports permits were delivered, 376 import permits delivered and 810 permits for transit delivered. A total of 153 permits were done internally. Permits are requested using electronic system. Physical inspection is done at borders particularly at Kigali International Airport where RAB has permanent staff for inspection.

3.3.5 Quality control of semen

New Equipment for semen quality control was acquired by RDDP project (Photo 97 and 98). The semen can be collected by an artificial vagina (AV), using a teaser bull or dummy cow, on collection area and transported to the laboratory for processing. With the CASA (Computer Assisted Semen Analysis) System for semen analysis allows the accurate, repetitive and automatic assessment of the following sperm parameters: Motility; Concentration; Morphology; Vitality and Acrosome reaction. To ensure accelerated genetic improvement, a proportion of bovine semen used in Rwanda is imported mainly for farmers to benefit from higher genetics of bulls of higher genetic merit “Super bulls” and Sexed semen to increase the genetic diversity of our breeding stock. Through partnerships between RAB and Jersey Island.



Photo 97: Freezing machine (left), Printer (center) and water bath (right) acquired by RDDP



Photo 98: Teaser bull (left), semen collection (center), dummy cow for semen collection (right)



Photo 99: Evaluation of Sperm parameters for semen quality evaluation

To ensure good quality of semen, which is distributed to the districts and sectors through RAB stores, the motility of the semen ready to leave Songa Bull centre must be rechecked. With the Dynescan a mobile machine providing the quality control standard for semen quality assessment (**Photo 100**) that can be used by anyone across the livestock production industry. It is the technology capable of measuring the lifetime of semen motility in quasi- in-vivo conditions, thus providing new insights into the behavior of spermatozoa prior to conception.



Photo 100: Dynescan machine (left) and semen quality control (right) at sector level

3.3.6 Production of Liquid Nitrogen

RAB produced liquid nitrogen through two plants of liquid nitrogen at Rubona and Kigali (**Photo 101**) to ensure production of liquid nitrogen that is used in semen storage and artificial insemination.



Photo 101: Liquid Nitrogen Plants Rubirizi (left) and Rubona (right)

The Rubona liquid nitrogen plant produced a total of 95,716 liters of liquid nitrogen and 93,204 liters distributed especially in Southern and Western Province. The Rubirizi liquid nitrogen plant produced 64,435 liters and distributed around 63,840 liters especially in Northern, Eastern and the City of Kigali provinces for the storage of semen and carry out of bovine artificial insemination.

3.3.7 Bovine artificial insemination and capacity building

A total of 109,209 cows were inseminated and 40,652 calves were born from Artificial Insemination. A total of 110 animal science technicians have been trained on bovine artificial insemination technique and 60 of them were qualified as Inseminators (**Photo 102**).



Photo 102: Training in artificial insemination

3.3.8 Multiple Ovulation and Embryo Transfer (MOET)

In FY 2023-24, we have chosen four cow donors for flushing (embryos harvest) from RICA, and during this exercise, the yield was 19 embryos; and some of them with good quality, have been transferred in four cows. In FY 2023-24, Embryo Transfer was performed in 17 cows and heifers using frozen embryos at RAB Songa station. Thus in total 21 cow and heifers were transferred embryos.

3.4 Aquaculture and Fisheries

3.4.1 Comparative study of growth of Nile tilapia strains

The aim was to investigate the effect of commercial feed from fine fish factory on the growth performance of three strains of the Nile tilapia, *Oreochromis niloticus*: the Normal Male Tilapia from Gishanda fish farm (NMT) located in the Eastern zone, the fingerlings from Kivu Tilapia located in the western zone and the fingerlings from Kivu Choice located in the southern zone of Rwanda. Each strain was triplicated in 5m³ hapa within pond water system and nine (9) hapas were used in this study, the culture period was 90days and the main objective was to evaluate the growth performance and feed utilization for those different strains of Nile tilapia (*Oreochromis niloticus*). Fish were feeding with 42% protein level from Fine fish factory located in Eastern zone. After 90 days the results show that for Normal Male Tilapia (NMT) Produced from YY crossed with natural female, the mean final weight and weight gain, differed significantly ($P < 0.001$) compared to both strains from Kivu Choice and Kivu Tilapia. Data show that the high final weight was obtained for the fish from Gishanda Fish Farm Hatchery (17.13 g/fish), while the Nile Tilapia from Kivu tilapia and Kivu Choice exhibited the final weight of 14.86g/fish and 14.01 respectively. However, specific growth rate (SGR) and survival rate did not show a significant ($P > 0.05$) difference between those three tilapia strains. The Tilapia from Gishanda Fish Farm (22.12g feed/fish) had higher feed intake but lower FCR (1.37). This is because higher growth performance and less FCR values were observed in Normal Male Tilapia fish. It concludes that the crossing between natural female and YY tilapia is a paramount important and the distribution of these fingerlings could improve the productivity for the farmers.

3.4.2 Installation of SynField X3 & SynAir in Nkungu site

The second SynField installation in Rwanda took place in Nkungu Aquaculture and Fisheries Research site, at the location of the second trial P.RWA.2 of the NESTLER pilot. The SynField systems comprises of 2 [SynField X3](#) head nodes and 2 [SynWater](#) nodes. These devices are equipped with sensors to monitor and record prevailing environmental conditions in an aquaculture feeding facility. The SynWater devices measure and monitor critical water quality

characteristics such as water temperature, water pH, dissolved oxygen (DO), electric conductivity (EC) and oxidation reduction potential (ORP). Monitoring the quality of water is essential for optimizing production practices and ensuring the well-being of aquatic organisms in aquaculture. A continuous assessment of key parameters enables aquaculture producers to proactively identify potential environmental stressors, allowing for timely interventions to mitigate adverse impacts on productivity and animal health.

3.4.3 Fish fingerlings production

In total 52,848,070 fingerlings were produced from Fine fish Tilapia hatchery, located in Rwamagana district, Frefish Tilapia hatchery, located in Rwamagana district, Fishfingers Tilapia hatchery located in Rwamagana district, La Flamine hatchery (Carp hatchery), located in Kayonza district, Rwafil Tilapia hatchery, located in Gatsibo district, Gishanda Tilapia hatchery, located in Kayonza district, Dufatanye Tilapia hatchery, located in Nyanza district, Kivu Choice located in Gisagara district, Nkungu fish farming site, located in Nyamagabe, Pure Natural Fish Ltd located in Nyamasheke district, Kivu Tilapia hatchery, located in Rusizi district and Rwasave hatchery, located in Huye district.

3.4.4 Trainings on aquaculture and fisheries

A total of 1,737 fish farmers (57 trained as facilitators and 1,680 as members of cooperatives in clusters) were trained on aquaculture good practices. In addition, 26 farmers were trained on utilization of Black soldier flies and its utilization in fish feed formulation.

3.5 Commercial insects

3.5.1 Assessment of beekeeping value chain

The traditional hives exhibit a wide range of honey production, though less extreme than traditional hives, with a maximum of 25 kg, and a mean yield of 14.77 kg. The standard deviation of 28.19 kg suggests moderate variability in honey production. This indicates that while there is some inconsistency, it is less pronounced than in traditional hives. The Kenya top bar hive shows a wide range in the amount of honey harvested, from 0 kg up to 45 kg per hive per season with a mean yield that is relatively modest at 25.17 kg. This suggests that, while some beekeepers may produce high amount of honey, the majority do not. A high standard deviation of indicates significant variability in honey production among traditional hives. This large variability might be due to differences in hive management, environmental factors, or hive conditions. Langstroth hives show the most consistent production range, from 0 to 80 kg per hive per season with a mean yield at 30 kg and the lowest standard deviation of 11.36 kg, indicating that Langstroth hives have the least variability in honey production (Table 98; Figure 28; Photo 103).

Table 98: Productivity and gross margin analysis for the production systems per season

Type of Hive	Total output (kg/hive/season)	Mean price (Rwf/kg)	Total revenue : (Rwf)	Total costs (Rwf)	Profit margin (Rwf)
Traditional	14.77	3757.3	55495.32	15000	40495.32
Kenya Top Bar	25.17	4043.5	101774.90	16954.3	84820.60
Langstroth	30.00	5038.5	151155	20003.8	131151.2

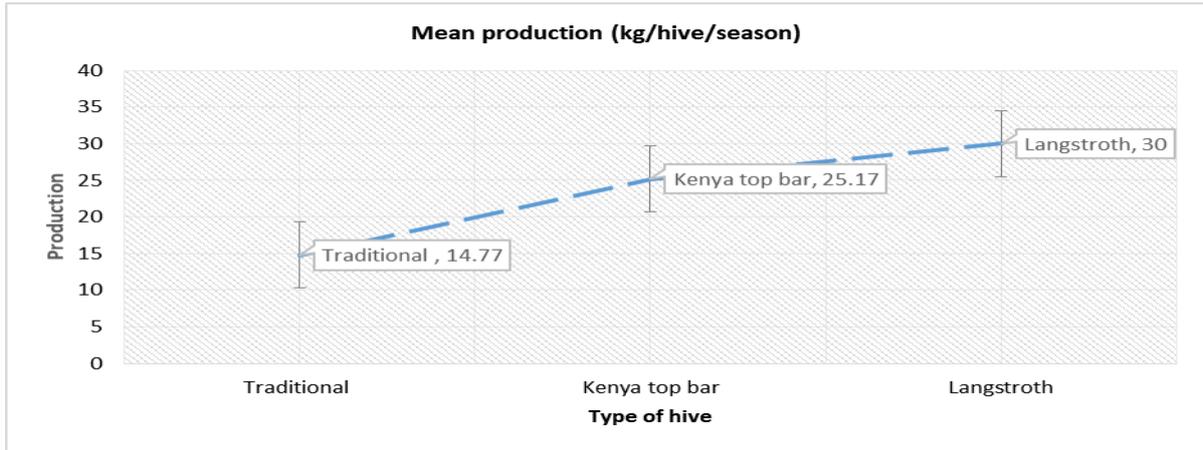


Figure 26: Average production among three types of hives



Photo 103: Modern hives (left) versus traditional hives (right)

3.5.2 Trainings

A total of 200 master beekeepers were trained on Beekeeping Equipment Maintenance and Record Keeping in bee rearing (Photo 104). The session was completed by the Practical Task consisting on field visit for Hive Inspection Techniques, Hands-on Hive Inspection, and Beekeepers' Assessment. They were trained on bee products covered include the production of bee propolis, bee pollen, bee bread, royal jelly, and bee venom.



Photo 104: Training of master trainers in bee keeping

3.6 National Genetic Improvement Division

The National Animal Genetic Improvement Center (NAGIC) is the division under the Animal Resources Development Directorate in RAB that is in charge of livestock improvement in Rwanda, particularly the focus has been on cattle genetic improvement. The bovine genetics in Rwanda is in constant improvement to increase high yielding genetics, improve efficiency of reproductive technology service delivery, and increase capacity building of stakeholders on different aspects of livestock breeding and service delivery.

3.6.1 Production and distribution of quality and genetically superior bovine semen

Currently, the Songa bull stud hosts a team of 8 best bulls (2 Friesians ; 2 Fleckvieh; 2 Jerseys (**Photo 105**), 1 Inyambo and 1 Inkungu bulls) and 5 young local breeds (Inyambo and Inkungu) males being reared to be bulls that will produce semen to be conserved as part of the Genebank. Holstein-Friesian, Jersey and Fleckvieh bulls are kept to produce semen that are distributed across country to ensure fast dissemination of superior genetics and faster genetic improvement, while Inyambo and Inkungu bulls are kept with a purpose of breed conservation.



Photo 105: Dairy breeding bulls producing semen - Holstein Friesian (left) and Jersey (right)

3.6.2 Breeding bulls maintenance for semen production and germplasm conservation

A number of breeding bulls were maintained at RAB Songa station for semen production and germplasm conservation (**Photo 106**).



Photo 106: Breeding bulls for semen conservation - Inkungu (local breed, left) and Fleckvieh (dairy and meat, German breed)

3.6.3 Semen production

In order to ensure the availability of bovine semen of good quality, every fiscal year RAB through National Animal Genetic Improvement (NAGIC) fixes the target of semen to be produced. A total of 188,049 semen doses were produced, processed, stored, and accessible to all farmers.

3.7 Animal processing and Biotechnology Division

3.7.1 Training of milk dairy value chain actors on milk hygiene

A total of 419 dairy value chain actors were trained as lead trainers on appropriate techniques for quality and safety milk testing (Table 99, Photo 107, 108). These trainings were conducted as part of the “Impact of Traditional Practices on the Quality and Safety of Post-Production Handling in the Milk Value-Chain in Rwanda” project, implemented by RAB in partnership with the University of Rwanda and Alabama A&M University, USA.

Table 99: Status of training of dairy value chain actors on milk quality and safety testing

Period	Target	Quarterly achievement	Achievement percentage
Quarter 1: July – Sept 2023	100	102	102%
Quarter 2: Oct. – Dec. 2023	100	106	106%
Quarter 3: Jan. – March 2024	100	108	108%
Quarter 4: Apr. – June 2024	100	103	103%
Total	400	419	105%



Photo 107: MCC staff trained on Milk quality testing Nyanza milk shed



Photo 108: Practical training of MCC staff on Milk quality testing

3.7.2 Enhancing the utilization capacity of milk collection centres

A total of 93,271,077 litres of milk have been channeled through the existing MCCs (Table 100). The quantity of milk collected through MCCs increased from 20,735,190 litres in the first quarter to reach 24,267,090 litres during the fourth quarter, representing an MCC utilisation rate of 55.8%.

Table 100: Evolution of milk aggregation through MCC in FY 2023/24

Period	Collected milk (L)	MCC's utilisation capacity (%)
Quarter 1: July – Sept 2023	20,735,190	47.70%
Quarter 2: Oct. – Dec. 2023	24,082,380	55.40%
Quarter 3: Jan. – March 2024	24,186,418	55.60%
Quarter 4: Apr. – June 2024	24,267,090	55.80%

3.7.3 Review of raw milk pricing scheme

As a result of this assessment, the price of raw milk delivered to Milk Collection Centers (MCCs) was increased from the initial 300 Rwf per liter to 400 Rwf per liter, effective from July 2024.

3.7.4 Rwanda Milk Collection Enhancing Project

In light of the growing national milk production and the significant investments made by the Government of Rwanda (GoR) in the dairy sector, particularly the newly constructed milk powder processing plant with a capacity of 650,000 liters per day, the current cooling capacity of milk collection establishments—estimated at 483,000 liters per day—was deemed insufficient to accommodate the projected national milk collection, which is expected to reach 1,000,000 liters per day upon the completion of the milk powder processing plant. Several activities were implemented, including the identification and validation of sites for the construction of new milk collection establishments. Additionally, the technical

specifications for the dairy equipment to be supplied were prepared. The first shipment of dairy equipment is expected to arrive by the end of 2024.

3.7.5 Meat value chain trade competitiveness project

Through the Rwanda Meat Value Chain Trade Competitiveness Project, implemented by RAB and MINICOM, various activities were conducted to enhance the competitiveness of the meat value chain. A total of 30 districts were supported in acquiring meat inspection kits to assist district and sector veterinarians in conducting quality and safety inspections for meat within their localities.

3.7.6 Social protection: Distribution of Cows and Small stock to youth and women

In order to reduce malnutrition, increase income of youth and vulnerable groups in local areas by creating job to unemployed youth and women, GIRINKA & **Small stock project** were developed and modernize the small animal industry in Rwanda. The cattle and pig numbers are increasing due to efforts deployed by the GoR to support vulnerable families, youth and other interventions initiated by NGOs, Civil societies to assist poor families. In that context 17,717 cows; 3,353 pigs and 94,643 poultry were distributed to poor families in 2023/24.

3.7.7 Livestock population and its products

Livestock population Livestock sub-sector has become increasingly productive over the past years; in this fiscal year 2023/2024, the population for cattle has increased by 12% (1,449,888 in FY 2021 up to 1,646,882 cattle in the FY2024) (Table 101). Small stock population has increased by 13% for poultry from 2021 up to 2024. The increase of cattle, poultry and pig numbers is due to efforts deployed by the GoR to support vulnerable families and other interventions initiated by NGOs, Civil societies to assist poor families.

Table 101: Animal population size by species in Rwanda

Category	2021	2022	2023	2024
Cattle	1,449,888	1,575,703	1,644,692	1,646,882
Goats	2,844,001	2,348,895	1,995,636	1,889,024
Sheep	601,836	501,548	440,214	467,808
Pigs	1,441,077	1,498,721	1,123,075	1,320,109
Rabbits	801,490	817,519	656,153	609,065
Poultry	5,442,152	5,496,574	6,047,215	6,304,470

3.7.8 Cattle breed composition

Currently, the cattle in Rwanda are 25% pure exotic breeds, 59% cross breeds and 16% local breeds (Table 102).

Table 102: Cattle breeds in Rwanda in 2020-2024

Years	2020	2021	2022	2023	2024
Pure Exotic breeds	175,952	238,698	362,472	393,926	411,721
Cross breeds	701,222	765,480	855,434	929,665	971,660
Local breeds	416,593	367,650	231,982	252,112	263,501

3.7.9 Animal products

Rwanda is recording growth in livestock production due to various policy interventions including Girinka program, Genetic improvement, and distribution of small stocks, animal feeding, animal health, capacity building and livestock infrastructures development. The productions of animal products have been increasing over the years (Tables 103, 104). This is attributed to different programs supporting the development of the livestock sector. The table below illustrates the trend of animal products production.

Table 103: Trend of animal products 2021-2024 in MT

Product	2021	2022	2023	2024
Milk	891,326	999,976	1,043,758	1,045,015
Meat	174,904	183,649	188,628	189,779
Fish	36,047	43,560	46,495	47,205
Eggs	8,272	8,665	17,344	20,211
Honey	5,800	6,135	6,486	6,508

Table 104: Meat Production in Rwanda

Meat Production	2021	2022	2023	2024
Beef	56,593	64,693	66,268	66,354
Caprine	33,053	34,051	31,703	28,962
Ovine	9,305	9,319	8,818	8,925
Poultry	37,351	41,751	50,319	54,145
Rabbit	9,248	9,498	8,681	8,003
Pork	23,137	24,337	22,839	23,410
Total	168,687	183,649	188,628	189,799

IV. LAND HUSBANDRY DEPARTMENT

4.1 Integrated Soil Fertility Program

During the 2023-2024 fiscal year, the Integrated Soil Fertility Management program activities focused on establishment of radical and progressive terraces, conducted study on soil acidity distribution nationwide, evaluated response of different crops to lime and organic manure, and developed Soil Information Management System and Land, Soil and Crop Hub with partners.

4.1.1 Establishment of radical and progressive terraces

The financial execution of radical and progressive terrace construction was supported by earmarked transfers from MINAGRI and other initiatives. The technical implementation was carried out by district agronomists, who were responsible for identifying sites, mobilizing beneficiaries, supervising and monitoring the work, and reporting on progress. By the end of FY 2023-24, a cumulative 142,318.7 hectares of radical terraces were completed, surpassing the annual target of 142,129 hectares, resulting in 100.1% achievement. For progressive terraces, 1,031,282.84 hectares were completed against a target of 1,029,150.25 hectares, reflecting 100.2% achievement. Table 105 shows the achievements vs targets.

Table 105: Areas of radical and progressive terraces developed during FY 2023-24

	Target areas of radical terraces	Areas of radical terraces constructed	Targets of Progressive terraces	Areas of progressive terraces established
Ha				
Total	3,611	3,740	20,793	22,428
Cumulative baseline		138,579.00		1,008,855
Cumulative achievement		142,319		1,031,283

4.1.2 Soil acidity distribution study for lime investment plan

To evaluate the current soil nutrient status, a nationwide soil survey was conducted across agricultural land. This survey involved collecting soil samples using a spatial sampling design, with sampling points spaced 1 km apart to ensure the representativeness of the entire country. At each designated point, soil samples were carefully collected at depths of 0-20 cm and 20-50 cm.

Table 106: Distribution of different levels of soil acidity per district

District	Extremely acidic (ha)	Strongly acidic (ha)	Very strongly acidic (ha)	Total (ha)
Bugesera	63.9	19,010.5	9,904.4	28,978.8
Burera		12,493.1	2,693.7	15,186.8
Gakenke	2,742.3	7,705.0	12,502.0	22,949.3
Gasabo	2,855.9	23,136.3	10,359.1	36,351.3
Gisagara	238.9	22,240.3	3,131.6	25,610.8
Huye		16,953.2	2,316.6	19,269.8
Kamonyi	4,682.6	21,630.1	17,849.0	44,161.7
Kayonza		2,924.3	191.8	3,116.0
Kicukiro		819.2	17.3	836.5
Kirehe		14,662.9	2,557.1	17,220.0
Muhanga	1,583.0	17,583.6	6,579.6	25,746.2
Musanze	115.9	1,955.4	1,384.9	3,456.2
Ngoma	127.8	11,625.1	1,266.1	13,019.0
Ngororero	3,702.7	14,100.8	19,464.9	37,268.4
Nyabihu	2,224.6	24,373.7	4,612.0	31,210.3
Nyamagabe	3,065.5	20,455.1	17,253.6	40,774.2
Nyamasheke	1,354.6	16,409.9	6,652.7	24,417.1
Nyarugenge		32.6		32.6
Nyaruguru	2,029.6	13,322.0	18,905.6	34,257.2
Ruhango		14,122.3	1,840.6	15,962.9
Rulindo	1,511.6	14,191.2	9,736.6	25,439.4
Rutsiro	6,075.6	11,565.0	11,633.5	29,274.2
Rwamagana		5,476.8	255.5	5,732.3
Total	32,374.5	306,788.2	161,108.1	500,270.8

Geographic coordinates were recorded using GPS devices to accurately locate each sampling site for subsequent analysis. The soil samples were then analyzed for pH using a standard 1:2.5 soil-to-water ratio. Scientific research (Sánchez, 2019; Kamprath, 1970) suggests that lime application is recommended when soil pH falls below 5.5. At this pH level or higher, most exchangeable aluminum is precipitated, making lime application less effective and potentially wasteful. Instead, other inputs, such as manure, can be used to maintain soil pH at acceptable levels, ensuring optimal crop yields. The map below illustrates areas with pH levels below 5.5, where lime application is necessary. Figure 1 shows the delineation of areas with three critical levels of soil acidity—strongly acidic, very strongly acidic, and extremely acidic—that will require lime and other soil amendments to improve crop productivity. Table 106 provides the total area for each soil acidity category across different districts in Rwanda, and the extent is shown on Figure 29. Areas with slight to moderately acidic soils can be managed using organic manure and other low-cost soil amendments, such as ash.

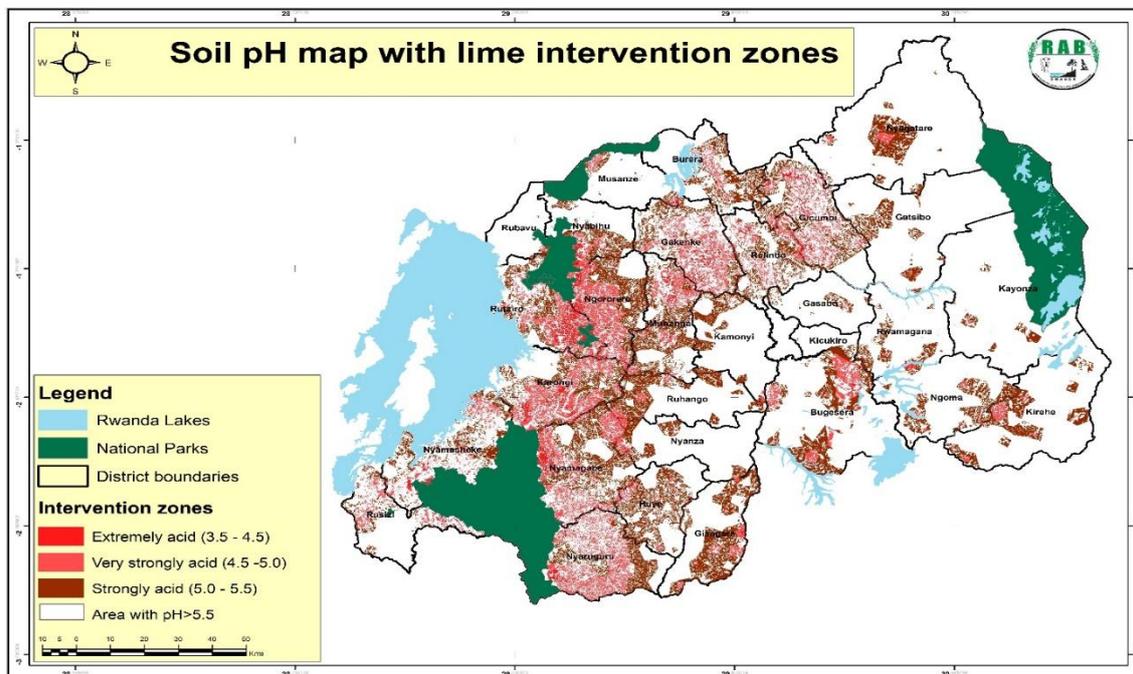


Figure 27: Map of soil acidity critical areas

4.1.3 Crop yield response to lime and organic manure in smallholder farming systems

Crop yield response to lime: In attempt to develop precise lime recommendations, an on-farm experiments were established in Nyaruguru, Ngororero, and Burera to evaluate yield responses to different lime rates, which were 0; 1; 2; 3; 4.5; 5.5 and 7 t/ha. The replicates were three or more depending on farm size. The test crops included beans, wheat, and maize, which were commonly grown in these areas. Lime applications increased crop yield starting from 1 t/ha, however, the highest yield increased was with 4.5 t/ha of lime (Table 107).

Table 107: Effect of lime rate on mean crop yield in three districts

Lime rate (t/ha)	Nyaruguru	Ngororero		Burera
	Bean	Wheat	Potato	Potato
	Mean crop yield (t/ha)			
0	2.1 c	2.1 a	12.3 b	9.9 d
1	2.3 bc	2.6 a	14.7 ab	12.4 c
2	2.4 b	2.9 a	17.2 ab	15.3 b
3	2.4 b	3.3 a	18.9 ab	17.0 ab
4.5	2.5 ab	3.7 a	20.0 a	18.0 a
5.5	2.6 ab	3.5 a	20.0 a	19.3 a
7	2.8 a	3.1 a	20.4 a	18.4 a
CV (%)	5.0	23.75	24.1	8.32
LSD	0.3481	ns	7.0774	2.4121

Crop yield response to organic manure

To address this issue, a series of trials evaluating organic manure application rates were conducted in the districts of Nyaruguru, Nyamagabe, Karongi, Burera, Rulindo, and Huye. The tested organic manure rates included 0 (control), inorganic fertilizer alone, and rates of 2.5, 5, 7.5, 10, 12.5, 15, 20, and 25 t/ha (referred to as T1, T2, ...T10). These trials have begun generating data, which have been analyzed, synthesized, and results have been produced (Figure 30). This report presents the data and results from the Burera, Karongi, Huye, and Nyaruguru districts.

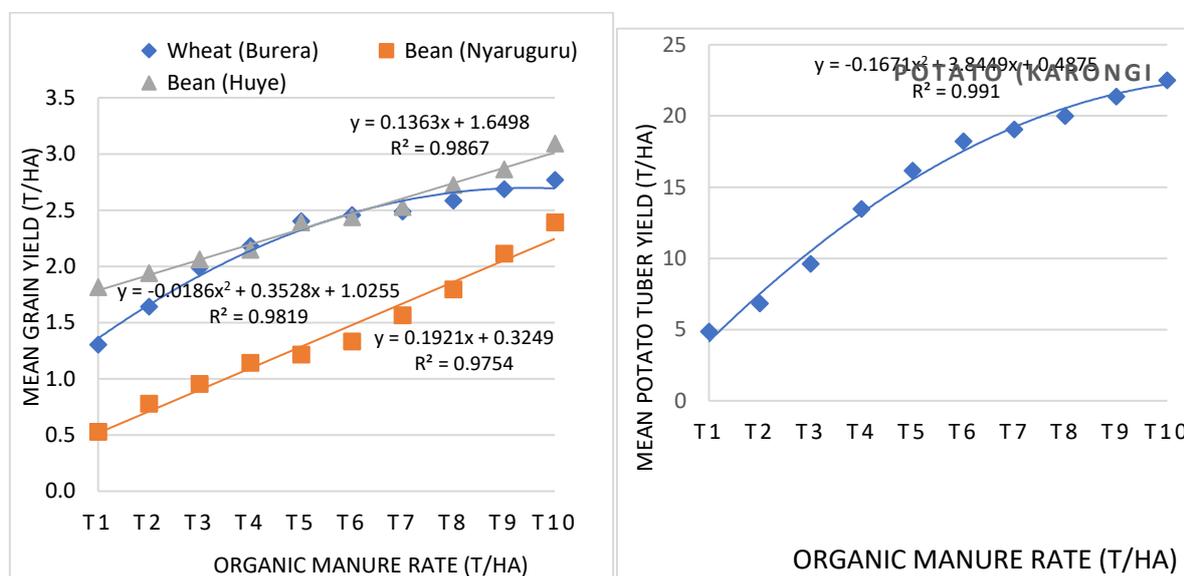


Figure 28: The response of food crop yields on organic manure rates in different districts

The results indicate that potato yields increased with higher rates of organic manure across all districts. For beans in Huye and Nyaruguru, the yield response was linear, while for wheat in Burera and potatoes in Karongi, the response followed a quadratic pattern. These findings confirm that organic manure is essential for boosting yields. An economic analysis will be conducted to determine the optimal application rate.

4.1.4 Fertilizer recommendation for Irish potato and rice in Rwanda

Rice: Three treatments were tested in each Agro-ecological Zone (AEZ) in Rwanda: two new optimized packages (SSR1 and SSR2) and the current blanket recommendation (BR) (Table 108). The BR plot was marked with the color blue, SSR1 with red, and SSR2 with yellow. SSR1 represents an enhanced blanket fertilizer recommendation aimed at achieving a yield 20% higher than that of the BR, while SSR2 aims to achieve the same yield as the BR but with a lower fertilizer investment. Fertilizer recommendations tested were consistent across all AEZs, as the variation in fertilizer response has been found to be minimal across these zones. Validation trials were conducted during the 2024A and 2024B seasons across various marshlands in different rice agro-ecological zones in Rwanda.

The analysis revealed that new NPK fertilizer recommendation (108N, 17P, and 14K) significantly increased rice yield by 1 to 1.3 t/ha in the Imbo, Central Plateau, and Mayaga agro-ecological zones compared to the current blanket recommendation (NPK: 80N, 15P, and 28K) (Tables 109, 110). However, in the Eastern Savanna, it only increased yield by 540 kg/ha, and it did not result in a significant yield increase in the Bugesera and Eastern Plateau zones (Table 108, Photo 109). The current blanket recommendation remains the most effective in the Eastern Plateau. The reduced rate of NPK: 73N, 11P, and 10K was the best in the Bugesera.

Table 108: Best-bet fertilizer recommendations evaluated for rice

Best-bet package	Basal (kg/ha)	application	Top dressing (kg/ha)		
			1st	2nd	3rd
	NPK 17-17-17	DAP	Urea		
 SSR-1: Improved blanket recommendation targeting 20% yield increase over current blanket recommendation (all AEZs)	100	45	60	60	60
 SSR-2: Improved blanket recommendation targeting similar yield as achieved with current blanket recommendation, at reduced cost (all AEZs)	70	30	40	40	40

The improved recommendation of NPK: 108N, 17P, and 14K yielded a net benefit of 663,125 RWF, 718,122 RWF, 690,630 RWF, and 283,626 RWF in the Imbo, Central Plateau, Mayaga, and Eastern Savanna zones, respectively, compared to the current blanket recommendation. Reducing the fertilizer application rate from 300 kg to 220 kg/ha in Bugesera increased yield by 305 kg/ha and recorded the highest net benefit of 238,475 Frw per hectare. In the Eastern Plateau, the current blanket recommendation increased yield by 1.01 t/ha and 0.43 t/ha compared to the reduced rate (NPK: 73N, 11P, and 10K) and the improved recommendation (NPK: 108N, 17P, and 14K), respectively.



Photo 109: Rice validation trials in Imbo and Mayaga AEZ

Table 109: Rice response to different fertilizer rates in different AEZ

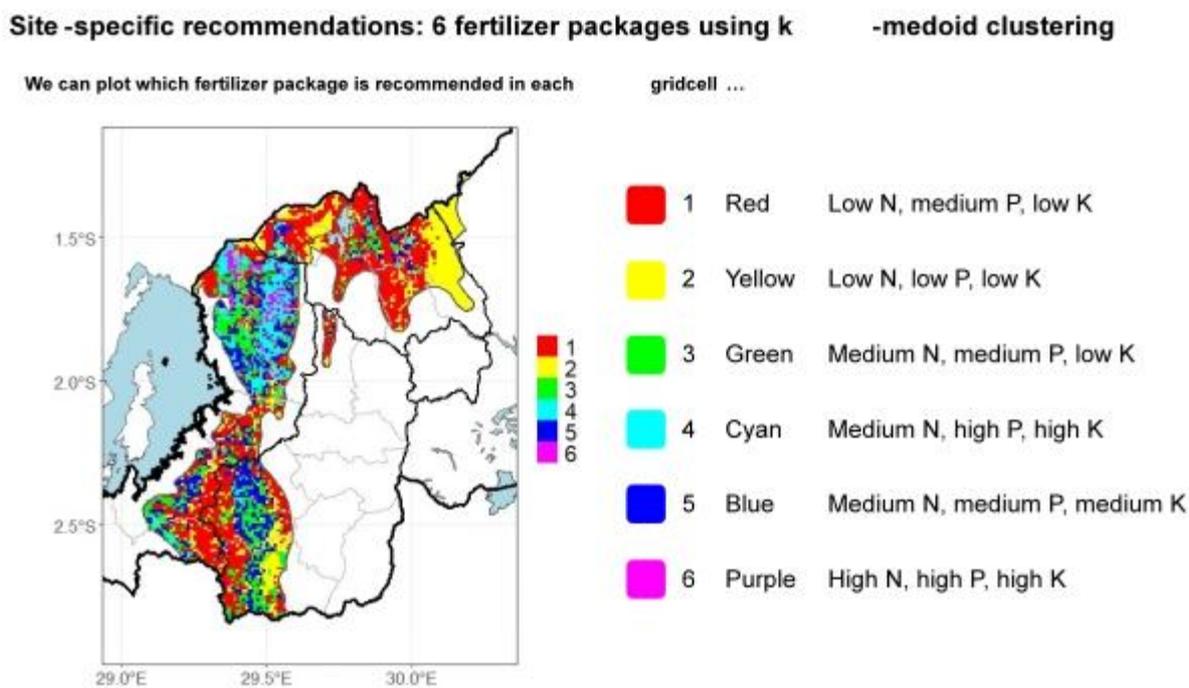
Agro-ecological zones	Nutrient kg/ha	Grain yield_t_ha
Central plateau	NPK: 80N, 15P, and 28K	4.21C
	NPK:108N, 17P, and 14K	5.54A
	NPK: 73N, 11P, and 10K	4.81B
Eastern plateau	NPK: 80N, 15P, and 28K	8.67A
	NPK:108N, 17P, and 14K	8.24AB
	NPK: 73N, 11P, and 10K	7.66B
Eastern savanna	NPK: 80N, 15P, and 28K	7.17B
	NPK:108N, 17P, and 14K	7.81A
	NPK: 73N, 11P, and 10K	6.76B
Mayaga	NPK: 80N, 15P, and 28K	5.97B
	NPK:108N, 17P, and 14K	7.25A
	NPK: 73N, 11P, and 10K	6.18B
Bugesera	NPK: 80N, 15P, and 28K	7.74B
	NPK:108N, 17P, and 14K	8.48A
	NPK: 73N, 11P, and 10K	8.047AB
Imbo	NPK: 80N, 15P, and 28K	7.16B
	NPK:108N, 17P, and 14K	8.57A
	NPK: 73N, 11P, and 10K	7.34B

Table 110: Rice fertilizer recommendation across different agro-ecological zones

Agro-ecological zone	Fertilizer application rate (kg/ha)			Total (kg/ha)	Nutrients applied(kg/ha)		
	NPK 17:17:17	DAP	Urea		N	P	K
Eastern plateau	200	0	100	300	80	15	28
Central plateau	100	45	180	325	100	17	14
Eastern savanna	100	45	180	325	100	17	14
Mayaga	100	45	180	325	100	17	14
Imbo	100	45	180	325	100	17	14
Bugesera	70	30	120	220	73	11	10

Irish potato: SSR1 represents an enhanced blanket fertilizer recommendation aimed at achieving a yield 20% higher than that obtained with the standard blanket recommendation. This improved recommendation was tested uniformly across all Agro-Ecological Zones (AEZs),

as average fertilizer response has shown minimal variation between these zones. However, due to significant variation in fertilizer response within individual AEZs, SSR2 will focus on testing site-specific best-bet packages. For SSR2, one out of six fertilizer packages was selected as the most suitable option for each specific location. A total of 6 site-specific recommendations were developed for soil clusters of potato growing areas (Figure 31).



Fertilizer and nutrient application rates for the fertilizer treatments

		DAP rate kg/ha	NPK 17:17:17 rate kg/ha	urea rate kg/ha	N rate kg/ha	P rate kg/ha	K rate kg/ha
1 RED		109	77	159	106	28	11
2 YELLOW		75	98	141	95	22	14
3 GREEN		131	93	212	137	33	13
4 CYAN		131	236	175	144	44	33
5 BLUE		100	159	166	121	32	22
6 PURPLE		134	197	336	212	42	28
BLACK		0	300	0	51	22	42
GREY		50	50	100	64	14	7
WHITE		100	100	150	104	28	14

Figure 29: Site specific recommendations for Irish potato producing areas: Map of soil clusters (upper image), and six fertilizer rates under evaluation (below image)

The validation trials conducted during the 2024A and 2024B seasons covered three potato agro-ecological zones: Birunga, Buberuka Highlands, and the Congo Nile Watershed Divide. Data were collected electronically and analyzed. Overall, site-specific fertilizer formulas (SSR) yielded higher results compared to the current blanket recommendation across all zones.

In Birunga, the IBR formula (104N, 28P, and 14K) increased potato yield by 3.4 t/ha compared to the blanket recommendation (51N, 22P, and 42K), while the SSR formula (137N, 33P, and 13K) increased yield by 4.2 t/ha (Table 111). In the Congo Nile Watershed Divide, the SSR formula (144N, 44P, and 33K) resulted in a yield increase of 4.79 t/ha compared to the blanket recommendation, though no significant difference was observed between IBR (104N, 28P, and 14K) and SSR (144N, 44P, and 33K). Despite high yield and profitability, SSR requires a larger investment. The IBR formula also boosted yield by 3.8 t/ha in the Congo Nile Watershed Divide, offering high profits.

In Buberuka Highlands, there was a significant difference between SSR (106N, 28P, and 11K) and IBR (104N, 28P, and 14K), with both outperforming the current blanket recommendation (Table 111). The IBR formula showed a higher return on investment and is recommended for adoption in Birunga and the Congo Nile Watershed Divide. Farmers with sufficient investment capacity may also consider using SSR (137N, 33P, and 13K) in Birunga.

Table 111: Potato fertilizer recommendation across AEZ

Agroecol.zone	Fertilizer application rate, kg/ha				Nitrients applied, kg/ha		
	NPK 17-17-17	DAP	Urea	Total	N	P	K
Cong-Nile Watershed Divide	100	100	150	350	104	28	14
Buberuka Highlands	77	109	159	345	106	28	11
Birunga	93	131	212	436	436	33	13
	100	100	150	350	250	28	14

4.1.5 Land, Soil and Crop (LSC) Hub Rwanda

The LSC hub was developed by RAB under DESIRA project. It facilitates effective access to land soil and crop information data, making existing resources better findable, accessible, interoperable and reusable (Figure 32). The LSC hub supports improved decision-making for climate-smart agriculture at local, national and regional levels. The focus is on two use cases: soil fertility management and soil water conservation. The LSC hub can be accessed at <https://rwanda.lsc-hubs.org/> and a map viewer is also available at <https://rwanda.lsc-hubs.org/map/>. The system is being updated with new LSC information.

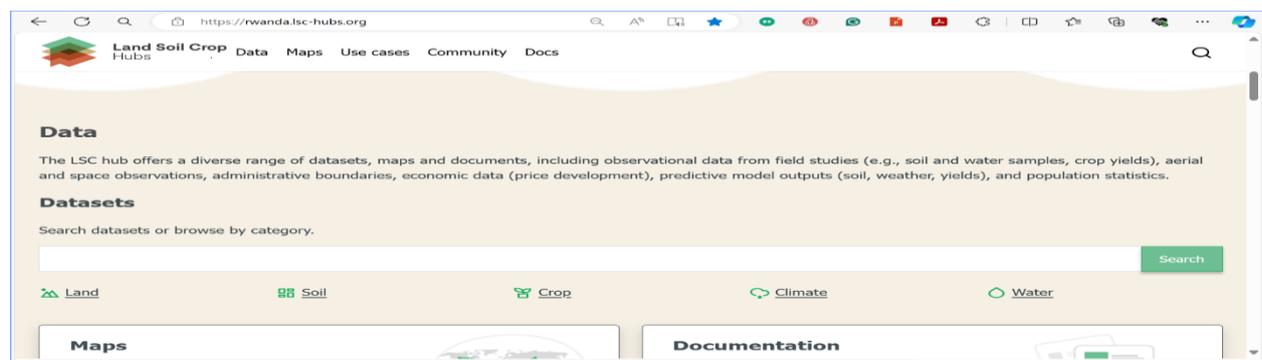


Figure 30: Over view of the LSC Data components of the LSC Hub Rwanda

The LSC hub offers a diverse range of datasets, maps and documents, including observational data from field studies (e.g., soil and water samples, crop yields), aerial and space observations, administrative boundaries, economic data (price development), predictive model outputs (soil, weather, yields), and population statistics (Figure 33). The LSC data entered in the system are categorized in Land, crop and soil datasets and by spatial scope (Global, Continental, National, Sub-national, catchment and plot).

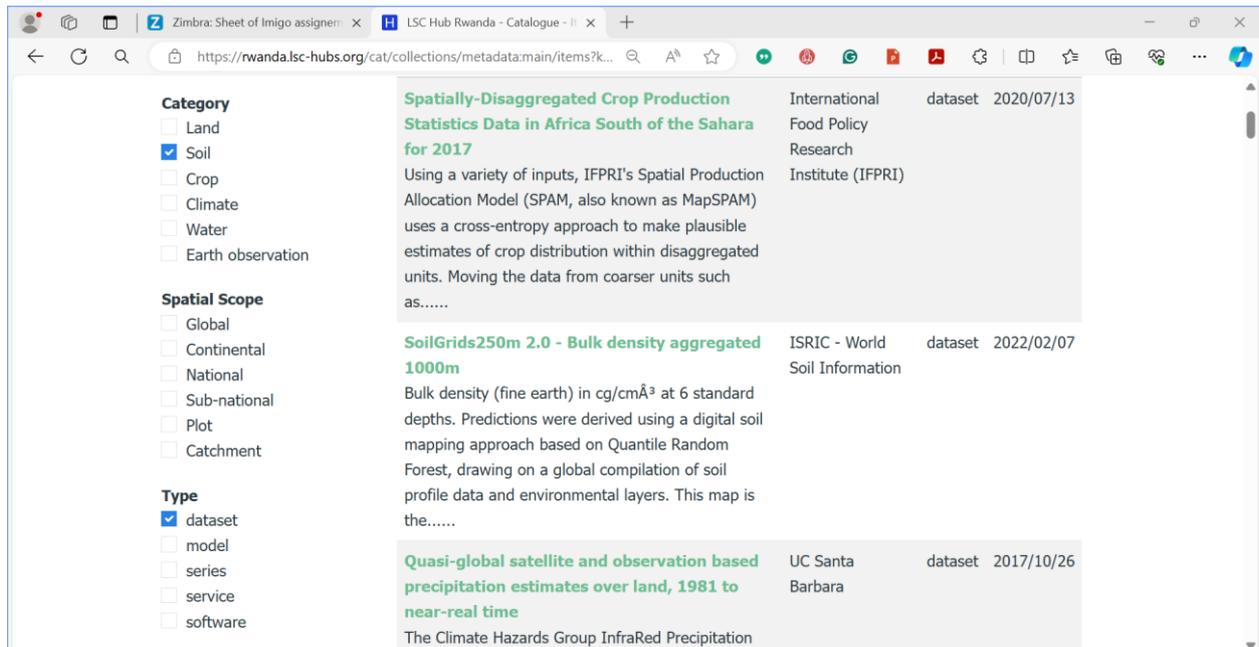


Figure 31: Land soil and crop datasets are compiled and entered in the system

Analyzed data in the Rwanda LSC Hub

At national level, 75 datasets have been identified and the inventory and compilation are ongoing. Efforts are being made to have all datasets with (rich) metadata. Metadata have to be compiled manually or can be harvested in case of datasets that are available through other catalogue services (e.g. <http://data.isric.org>).

4.1.6 Rwanda Soil Information Services System

The Rwanda Soil Information System (RwaSIS) is a software platform developed by RAB in partnership with Rwanda Space Agency and MINAGRI and funded by BMGF. It was designed to manage and store soil and crop data, with the goal of producing updated and dynamic soil fertility maps on a national scale. The system provides fertilizer and lime recommendations tailored to farmers' soil nutrient needs and baseline soil fertility conditions. Key features of RwaSIS include management and storage of soil and crop data; generation of updated and dynamic soil fertility maps nationally; provision of intelligent fertilizer and lime recommendations; functionality for farmers to determine appropriate application rates for crops and soil types; integration with other established extension systems via APIs, including the Smart Nkunganire System (SNS), Smart Kungahara System (SKS), Land Administration Information System (LAIS), and CROM-DSS.

CABI, a partner in the RwaSIS project, along with the project team, has prepared and submitted a landscape assessment report. This report evaluates the enabling environment

necessary for effective data sharing and sustainable data management for Rwandan soils and the RwaSIS. CABI shared the initial set of Soil and Agronomy Data Mandatory Standards and Guidelines with the Steering Committee through the project coordinator and subsequently with other stakeholders. Feedback from various stakeholders has been addressed, and the guidelines are now available for RAB and MINAGRI to review and discuss before implementation, as they may evolve over time. The system has been developed, and data are being reloaded.

Currently, RwaSIS provides comprehensive data on soil composition, crop specifics, erosion patterns, and recommendations for fertilizers and lime. This resource supports policymakers and farmers in making informed decisions, enhancing agricultural productivity, and promoting sustainable land use. By offering detailed insights into soil characteristics, crop information, and targeted recommendations, RwaSIS facilitates evidence-based decision-making. While the system is operational, it requires ongoing maintenance and the appointment of dedicated staff. Additionally, a public communication specialist is needed to enhance the system's visibility (<https://rwasis.rab.gov.rw/portal>).

4.2 Plant and Soil Analytical Laboratory

4.2.1 Soil survey for Nyaruguru District

Nyaruguru district is known as one of the most good insecure because of poor soils. Its predominant soil type is Oxisols which are acidic with high iron content and deficient in most essential plant nutrients. The acidic nature of these soils poses significant challenges for agriculture and requires special attention due to their high levels of degradation. The CARAVAN Project has funded a comprehensive soil study in Nyaruguru district, Southern province. This study aimed to develop detailed soil fertility map focused on maize consolidated sites, providing crucial information for agricultural management and soil improvement strategies. Laboratory analysis of the collected samples was done to determine soil properties and nutrient levels.

Soil sampling methodology

Soil samples were collected across different sectors of Nyaruguru district. Development of GS coordinates was organized into a systematic grid pattern of 50 ha. Grid soil samples were taken within the grid cell or at intersection points between grid cells, consisting of 8-10 cores per sample taken within a 370 m at 30 cm depth. To represent soil variability within a field, the grid sample points were organized into a systematic grid-rectangle sampling pattern.

Laboratory analysis methodology

Soil samples were subjected to analyse pH (H₂O), Electrical Conductivity, Texture (Particle size distribution, Cation Exchange Capacity, Exchangeable cations (Ca²⁺, K⁺, Na⁺ and Mg²⁺), Available Phosphorus, Soil Organic Carbon and Total Nitrogen. Soil pH water was determined in 1:2.5 soil suspensions in distilled water using a glass electrode. Exchangeable calcium, magnesium and potassium was extracted using 1M of ammonium acetate (NH₄C₂H₃O₂) and determined by atomic spectrophotometry absorption. Cation exchange capacity (CEC) was determined using 1M ammonium acetate (NH₄C₂H₃O₂) saturation followed by titration with 0.01 M sulfuric acid (H₂SO₄) of the NH₄⁺ displaced by K⁺ (Moberg, 2001). Organic carbon was determined by the dichromate oxidation procedure (Okalebo et al., 2002). Mineral nitrogen

was determined using potassium chloride KCl 2M extraction and followed by the Kjeldahl distillation and titration of 0.001M (H₂SO₄) (Okalebo et al., 2002). Available phosphorus was determined by extracting 0.03 M ammonium fluoride and 0.025M hydrochloric acid based on the Bray 1 method (Okalebo et al., 2002). The soil texture class determination, soil electric conductivity and aggregate stability were measured following updated methods proposed by FAO soil description guidelines (2006) and the Laboratory Methods of Soil and Plant Analysis, 2nd Ed. (Okalebo et al. 2002).

Soil analysis results

Results showed that the soil is very acidic and needs liming (Table 112; Figure 34). There are deficiencies in several key nutrients: calcium, magnesium, nitrogen, phosphorus, and potassium. The soil has moderate organic carbon content but could benefit from additional organic matter. The soil texture is mainly sandy clay loam, which could benefit from organic matter addition to improve water holding capacity, and no salinity issues were detected.

Table 112: Soil results and nterpretations

Parameter	Results Interpretation	Observation
pH, Exch. acidity	94.1 % of the area is very acidic	Liming is needed for this agricultural acidity
Ca ²⁺	54 % of the area is low	Calcic amendmets are needed through liming
Ec	100% of the area is not saline	There is no action on salinity issue
Mg ²⁺	68.4% of the area is low	Magnesium amendment is needed through liming
Total Nitrogen	95 % of the area is low	Nitrogen inputs are needed to be increased during cultivation season
Organic C	91.1% of the area is Moderate Humic	Organic manure is needed in this soil
Texture	92% of the three sites is sandy clay loam	Amend the soil with organic manure can increase water holding capacity
Avail.P	94 % of the area is low	Inputs of Phosphorus compounds are needed
K ⁺	90% of the total area is low	Additional Potassium inputs are needed

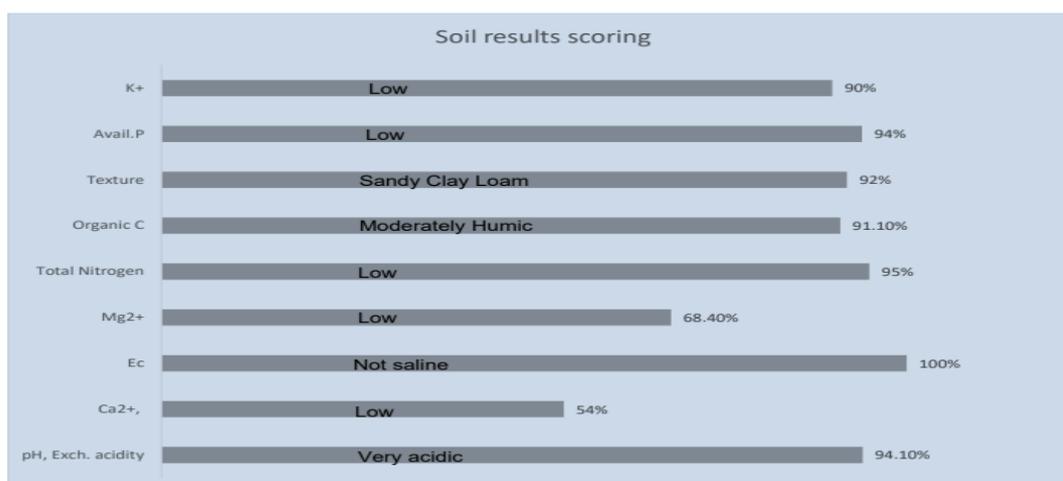


Figure 32: Soil analysis results on major nutrients

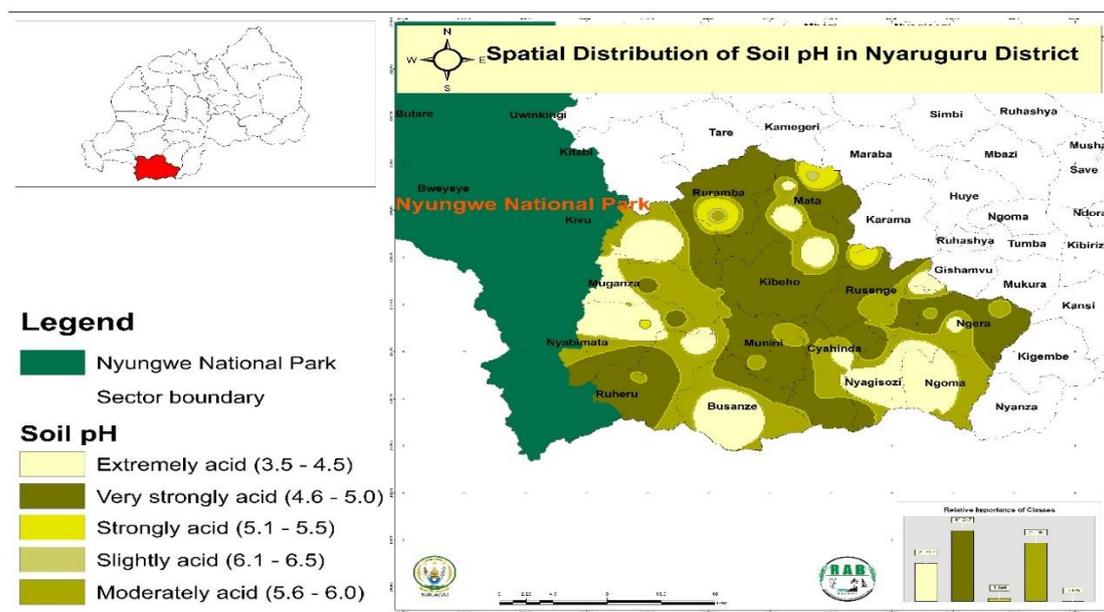


Figure 33: Soil fertility map showing soil pH levels in different sectors of Nyaruguru District

Overall, the soil requires a comprehensive management plan to address acidity and nutrient deficiencies. This would likely involve liming, use of organic matter and supplementing mineral crop-specific fertilizers. This study provided a scientific basis for targeted interventions for Nyaruguru district to alleviate soil acidity and provide recommendations on fertilizer quantity to improve nutrient levels.

4.2.2 Samples analyses from partners and clients

These analyses were carried out on soil, plants, lime and travertine samples to provide service to various partners, both individuals and organizations working within agriculture sector, from private or public (Table 113).

Table 113: Number of samples analyzed from July 2023-June 2024

N	Type of samples	Number of analyzed samples	Parameters analyzed
1	Soil	2041	pH, acidity, nitrogen, Phosphorus, Potassium, Organic carbon, Sulfur, Calcium, Magnesium, Sodium, Electrical conductivity, Exchangeable Acidity, Soil texture, Bulk density
2	Travertine	26	pH water, fineness, moisture content, MgO, and CaO
3	Plant	1248	Fibers; Proteins, Calcium, Magnesium

4.3 Irrigation Program

Crop and livestock production in Rwanda are vulnerable to water-related stress, resulting in significant production losses. The Government of Rwanda has identified irrigation as a sustainable solution to reduce dependence on rain-fed agriculture and mitigate climate change risks. The Irrigation program has significantly contributed to the achievement of PSTA-4 targets for the FY 2023-24 through development, rehabilitation and management of hillside and marshland irrigation schemes, increasing the area of land under SSIT.

To achieve these commitments, urgent and quick development of marshlands with high potential for irrigation and mobilization of farmers toward the agricultural transformation process was initiated. The MINAGRI developed various irrigation schemes through different programs like the Quick Wins Marshlands Development Program (QWMDP), the Rural Sector Support Project (RSSP), and the Land Husbandry, Water Harvesting, and Hillside Irrigation Project (LWH). However, significant damage to irrigation infrastructures and poor management of these schemes were identified shortly after their development mainly due to extreme weather events such as floods and excessive sedimentations, lack of ownership among farmers, lack of water users' organizations financial and technical capacity for maintenance, etc.

Among the constraints encountered, some were related to climate change and extreme weather events (floods, water shortages in developed and operating schemes, reservoir depletion, and excessive erosion). These events led to the destruction of irrigation infrastructure and increased energy demands for pumping in hillside projects. Overcoming these challenges required innovative solutions, technical support, and enhanced project management practices.

To alleviate the effects, every year the Government of Rwanda increases efforts in the development of new schemes, rehabilitation of damaged ones and capacity-building strategies in operation and management of developed schemes. The activities of Irrigation Program focused on development of hillside and marchland irrigation schemes, expansion of small-scale irrigation (SSIT), rehabilitation and maintenance of the existing irrigation infrastructures on hillside and marchlands, and assistance to youth cooperatives in management of irrigation schemes.

4.3.1 Development of Hillside & Marshland Schemes (ETI Project)

The target of MINAGRI under PSTA-4 is to increase the area under irrigation from 48,508 ha to 102,284 ha between 2018 and 2024 (Table 114). In FY 2023-24, RAB planned to develop 4,421 ha of hillside and marshland in the Eastern Province, Kirehe District, Mahama Sector, under the Export Target Modern Irrigation Project (ETI), with an 80% completion target (Mahama I and Mahama II).

Table 114: Activities of Mahama 1 and Mahama 2 projects in FY 2023-24

Project per Lot	Activities planned	Activities undertaken
Mahama Lot I	<ul style="list-style-type: none"> Construction of the Site Establishment facilities at Mahama, Construction of Intake and associated Structures, Procurement & Supply and Installation of Center pivot, Sprinkler, and pipe hydrant Hose System. 	<p><i>The overall progress is at 57.2%, with the following activities;</i></p> <ul style="list-style-type: none"> The site establishment was completed The construction of the intake with associated structures and procurement are in progress.
Mahama lot II	<ul style="list-style-type: none"> Construction of the Site Establishment facilities at Mahama Construction of Intake and associated Structures, Procurement & Supply and Installation of Center pivot, Sprinkler 	<p><i>The overall progress is at 32.9%, with the following activities;</i></p> <ul style="list-style-type: none"> The site establishment was completed Storage tank and sedimentation tank construction activities are in progress and booster pumps installed

The ETI project aims to transform previously underutilized or difficult-to-cultivate lands into productive agricultural areas through the implementation of efficient pumping and gravity irrigation systems. The objectives of Mahama I and Mahama II projects are to develop and manage efficient irrigation systems for hillside and marshland areas; to improve water usage efficiency and agricultural productivity; and to enhance the livelihoods of local farmers by providing them with reliable irrigation infrastructure. The development of Mahama Lot I and Lot II reached 56% and 34% completion, respectively, although the target was 80%. This progress was made despite challenges such as contractor delays and payment issues with the Exim Bank of India.



Photo 110: Intake and storage construction activities at Mahama Lot I

The development and management of the Mahama I and Mahama II hillside and marshland irrigation schemes is a significant step towards improving agricultural productivity in Rwanda. Although there have been financial and technical delays this year, addressing challenges and maintaining stakeholders' full engagement is crucial to ensure the successful completion of the project and realize their full potential benefits for the local communities.

4.3.2 Small-Scale Irrigation Technology

The Small-Scale Irrigation Technology (SSIT) was initiated to support farmers in improving crop yield through better access to affordable irrigation technologies. It provided farmers with essential irrigation materials, including pumps, pipes, sprinklers, and drip systems, at a subsidized price (75% for solar-powered systems and 50% for other systems). In FY 2023-24, new SSIT projects were developed in the Eastern province region which is likely to be mostly affected by drought. The activities focused on mobilization of farmers to adopt SSIT, and development of new areas under irrigation.

Mobilization of farmers to adopt Small-Scale Irrigation Technology was organized. Farmers needed to know more about the SSIT opportunity and were mobilized through media (Radio Rwanda), meetings organized by the local government, radio talk (Radio Rwanda), and field demonstration sessions. During mobilization, 3,500 farmers were encouraged to form groups or cooperatives to collectively purchase subsidized SSIT kits.

New area was developed under irrigation. The total area under small-scale irrigation from different districts has expanded through subsidies and achieved 531.6 ha. Through other

initiatives, 796 ha were irrigated during the campaign of irrigation intervention against drought that happened in Season 2024A. Equipment used were strategic stocks reserved for irrigation others were provided by FAO to support farmers cooperatives in all districts of Southern province. In total irrigated area equals 1,327.6 hectares over the target of 1,276 hectares was developed (Photo 108, 109).



Photo 111: Irrigation Water application in Small-scale irrigation technology (SSIT)

4.3.3 Rehabilitation and management of irrigation Schemes

Rehabilitation of Bugarama Marshland: Bugarama lowland marshland (Rusizi, Southwestern Rwanda) with fertile soils and warmer climate is known for good agricultural production, especially for rice developed about 40 years ago. The marshland experienced heavy rains in the wet (March to May and September to December) seasons and water shortage in the dry season. The main challenges in the scheme are the frequent innovations in the field caused by riverine and flash floods during the rainy seasons, and infrastructure damaged by floods and excessive sedimentation.

In FY 2023-24, the targets were to rehabilitate and upgrade 100% of the marshland and damaged irrigation facilities. This was achieved : a total of 200 ha of marshlands were restored in Bugarama. The undertaken activities consisted in restoration and extension of main canals; construction of gabions at Katabavuga and Rubyiro sites to protect the river banks and protection of eroded river downstream and Cyarukara. Restoration and extension of the main Canals was done at Kizuro and Rubyiro (Nyakiziringa region) where main canals were reshaped and restored by removing sediments and extended to Bugarama sector (KEHMU Cooperative) to increase the cultivated area.

Construction of gabions at Katabavuga and Rubyiro sites was done to protect the river banks. The gabion was constructed wall to the left side of wear within the 150m of linear length and its related work (Photo 112). At Cyarukara, protection of the eroded river downstream was done, and energy dissipator structures were established to protect against erosion and future destruction of the main canal (Photo 113).



Photo 112: Gabion wall in Rubyiro and Katabavuga sites, Bugarama



Photo 113: Protected canal at Cyarukara site, Bugarama

4.3.4 Management of irrigation schemes by youth companies

For better efficiency, MINAGRI has established the Irrigation Water Users Associations (IWUAs) as outlined in Ministerial Order No. 001/11.30 of 23.11.2011. Under the proximity coaching concept, RAB has engaged Horticulture in Reality Cooperative (HoReCo), Yalla Yalla Group, and YEAN Ltd as Service Providers to enhance the capacity of Irrigation Water Users Organizations and farmers' cooperatives participated in establishment of irrigation calendars, mobilization for community work, updating water users' lists, setting up farm management demonstration plots, and provided training in Good Agricultural Practices, conducted watershed management campaigns, organized season preparation meetings, facilitated field visits to other irrigation schemes, and arranged training of trainers for farmer promoters. The overall performance of service providers is satisfactory with targets met. A total of 3,541 hectares of marshland were successfully operated, managed, and maintained by youth cooperatives. However, issues in implementation, coordination, and resource management were identified. Some IWUOs lack understanding of their responsibilities under the Irrigation Management Transfer Agreement (IMTA), leading to operational challenges. Additionally, the absence of DISC and SISC implementation in some districts weakens oversight and collaboration, resulting in poor efficiency - poor documentation, inadequate reporting, registration issues, low water fee collection, and limited farmer participation. Some schemes lack the necessary irrigation infrastructure.

Table 115: Target indicators and achievements of Irrigation Program for FY 2023-24

Expected Output	Indicator	Target	Achievement	Comments
Assessment of irrigation schemes	Inception Report	3	3	Completed
Capacity and skills improved	Training manuals produced	27	27	Completed
	Farmers trained	601	605	Completed
Installation of demonstration plots	Demo plots	731	881	Completed
Farmers coached on GAP	% of farmers adopting GAP	85	83.1	
Agricultural productivity increased	Productivity of Rice	6 T/Ha	6.27 T/Ha	Service providers were trained on methodology for productivity estimation
	Productivity of Maize	6T/Ha	5.25T/Ha	
Post-harvest handling and market linkages enhanced	Number of contract farming signed by farmers/coops	153	90	
	Number of farmers attending Community Work	100	85.36	
Management and maintenance of irrigation infrastructures improved	Amount of water fees collected (Frw)	301,000,000	99,000,000	Low water fee collection was due to delay in payment from buyers and rice factories
	% of infrastructure well maintained	100	86.1	

4.3 Rehabilitation and management of Hillside irrigation

Effective maintenance and management of irrigation schemes are crucial for ensuring their sustainability and productivity. In 2023-24, the skilled technical team implemented hillside irrigation through the government-funded Irrigation Projects (GFI). The monitored and operated hillside schemes were the following: Nasho (600ha), Gashora (750ha), Rurambi (1000ha), Ngoma 22 (300ha), Kagitumba and Matimba (900ha), and Gako (2,377ha).

Regular maintenance was effectively carried out through various interventions, including repair of defective facilities and rehabilitation of damaged irrigation infrastructure by replacement, despite the aging of many of the schemes. Additionally, irrigation schedules were strictly monitored to ensure optimal water distribution, minimize water losses and conserve energy and optimize yields. With adoption of smart irrigation technologies and rigorous maintenance schedule, water use efficiency has significantly improved, leading to reduced loss of available water and better crop performance. Regular maintenance and infrastructure upgrades ensured the reliability and longevity of irrigation systems, minimizing disruptions to water supply. The combined effects of better water management, modernized equipment, and farmer training resulted in higher crop yields and improved quality, contributing to food security and economic stability in the regions served.

Nasho irrigation scheme

scheme (600 Ha), situated in Kirehe District, is divided into three lots. It operates as an electricity-powered pumping system with two distinct mechanisms: one system pumps water

to a reservoir, from which it irrigates the fields using gravity, while Lot II employs a direct pumping system for irrigation

Gashora Irrigation Scheme

Located in the district of Bugesera, Gashora marshland is an irrigation and drainage scheme of 750 ha of gross command area developed in 2016 by MINAGRI/PAIRB. The site has two pumping stations for irrigation and drainage purposes respectively named SP1 & SP2. SP1 has four pumps of 22kW, 990m³/h and 4m head operating in 3+1 mode. SP2 has two pumps of 30kW, 990 m³/h and 5m head.

Rurambi irrigation scheme

Rurambi marshland, located in Bugesera District, is a 1,000-hectare irrigation and drainage scheme developed in 2012 through the PADAB project. The site features two pumping stations, SP1 and SP2, which serve irrigation and drainage purposes. SP1 is equipped with four pumps, each with a capacity of 40 kW, 1,876 m³/h, and a 4 m head, operating in a 3+1 configuration. SP2 operates similarly, with two pumps of 40 kW, 1,876 m³/h, and a 5 m head. In FY 2023-24, extensive canal lining projects to prevent water seepage and the introduction of precision irrigation techniques to optimize water usage were implemented. Additionally, training programs were provided to farmers on effective irrigation management.

Ngoma 22 irrigation scheme

The Ngoma 22 hillside and marshland irrigation scheme, located in Ngoma District, spans 300 hectares and was developed in 2016 as a grant aid project from Japan, symbolizing the friendship and cooperation between Japan and Rwanda. The scheme covers 265 hectares of hillside and 35 hectares of marshland. It includes a dam with a capacity of 960,000 m³, serving as the primary water source. The Ngoma 22 hillside irrigation system is equipped with three regulating tanks, four concrete main canals, 225 secondary canals, 868 hydrants, and a pump station with five pumps, each with a capacity of 11 kW, delivering 140 m³/h with a head of 24 meters. The pump station operates in a 4+1 configuration under the electrical grid and a 3+2 mode when using the solar system, pumping water from the reservoir dam to an upper regulating tank of 1,500 m³, which has solar panels installed on its top slab. The key achievements included installation of advanced water filtration systems to enhance water quality and prevent clogging of irrigation lines, while routine maintenance was carried out to ensure the durability of the irrigation infrastructure.

Gako Irrigation Scheme

Gako Irrigation Scheme, located in Bugesera District within Kamabuye and Mayange Sectors, is a government-funded project covering a gross command area of 2,377 hectares, with a net irrigated area of 1,325 hectares. This area is divided into two blocks: 158 hectares irrigated by sprinklers and 1,167 hectares by a center pivot system. Situated in the Bugesera dry belt, the scheme relies on Cyohoha South Lake as its sole viable water source. The system includes a pontoon intake with three submersible pumps operating in a 2+1 configuration, each with a capacity of 45 kW, 900 m³/hr, and a head of 11.55 meters. Additionally, a pumping station with six booster pumps operates in a 5+1 configuration, each with a capacity of 200 kW, 350 m³/hr, and a head of 140.08 meters. This indirect pumping system is designed to lift irrigation water from the pumping station to three steel water tanks with a total capacity of 12,330 m³ (4,110 m³ each). The irrigation pressure at the field level is maintained by the water volume and the elevation difference between the reservoir and the field it supplies.

Kagitumba and Matimba Irrigation Scheme

Kagitumba and Maitumba and Matimba Irrigation Schemes, located in Nyagatare District is a government-funded project covering a gross command area of 900 hectares. Maintenance activities included rehabilitation of pumping stations and reinforcement of canal embankments. Community engagement initiatives were also undertaken to promote sustainable water use practices. As a result, the scheme's reliability was improved, leading to stable crop production cycles and enhanced farmer confidence in irrigation systems.

Kagitumba and Matimba Irrigation Schemes, located in Nyagatare District is a government-funded project covering a gross command area of 900 hectares. Maintenance activities included rehabilitation of pumping stations and reinforcement of canal embankments. Community engagement initiatives were also undertaken to promote sustainable water use practices. As a result, the scheme's reliability was improved, leading to stable crop production cycles and enhanced farmer confidence in irrigation systems. The main challenge was managing the water allocation during peak demand periods. Strategies were developed to prioritize critical irrigation needs. To build on the successes of the past year, it is recommended to invest further in technology by expanding the use of smart irrigation and automation systems to improve water efficiency and reduce labor demands. Strengthening farmer training programs is crucial, with increased frequency and scope to ensure that farmers and water user associations are well-equipped to handle maintenance and management tasks independently. Additionally, implementing advanced monitoring tools will provide real-time data on irrigation infrastructure conditions, allowing for proactive maintenance and minimizing the risk of breakdowns. Finally, fostering collaborative management models by enhancing partnerships between government agencies, local communities, and private sector entities will help distribute the responsibilities and costs of maintaining irrigation schemes more effectively.

In the FY 2023-24, important progress was made in developing and managing irrigation schemes nationwide, particularly with the Mahama I and Mahama II projects. Despite encountering challenges that resulted in a completion rate of 72%, below the anticipated 80%, significant advancements were achieved in both hillside and marshland irrigation schemes. Key accomplishments included the rehabilitation of 200 hectares of marshlands in Bugarama and the effective operation and management of 3,541 hectares of marshlands by youth cooperatives across the country. Additionally, we exceeded the target for Small-Scale Irrigation Technology (SSIT) by increasing the land area to 1,327.6 hectares, surpassing the goal of 1,276 hectares. We also produced four technical reports to monitor and evaluate various irrigation schemes, providing essential data for future rehabilitation efforts.

The main challenges faced included climate change impacts, such as floods damaging irrigation infrastructure, excessive sedimentation in canals and reservoirs, water shortages, and reservoir depletion. Other difficulties included higher pumping energy costs for hillside projects, coordination issues among stakeholders, and budget constraints. To ensure continued progress and sustainability, it is recommended to enhance stakeholder collaboration, increase budget allocations, and adopt innovative technologies to improve project efficiency. Strengthening communication and coordination among stakeholders, along with enhancing farmers' technical skills and ownership, will be crucial for the ongoing success of irrigation initiatives. In conclusion, this year's projects have significantly improved

agricultural productivity and enhanced the livelihoods of local farmers. The insights and recommendations from this report will guide future projects, ensuring continued progress and sustainability in irrigation efforts.

4.4 Mechanization Program

Agricultural mechanization program started in 2009-2010 and aims to promote mechanization options for farmers, develop local skills, and enhance capacity in agricultural mechanization, including post-harvest activities. According to PSTA IV, the aim was to have 50% of farm operations mechanized by 2024. To reach this target, the mechanization program collaborates closely with private entities involved in mechanization, including farm machinery hiring service providers, local farm machinery dealers, and manufacturers.

The main activities of the program include: (i) conducting extensive mobilization efforts through farm machinery demonstrations in partnership with service providers, (ii) facilitating connections between farmers and mechanization service providers where needed, (iii) monitoring and inspecting the mechanization services offered by private companies, (iv) encouraging private companies (including youth organizations) to invest in mechanization by organizing study tours and showcasing the potential of mechanization, and (v) carrying out scheduled repair and maintenance of RAB farm machinery by ensuring the availability of spare parts, lubricants, and other workshop supplies.

The Program activities in FY 2023-24 were focused to expand access to mechanization services and increase the area of land cultivated using mechanized methods through use of the existing RAB tractors, monitoring and inspecting the land serviced by private mechanization providers, and conducting demonstrations, testing, and trainings.

Annual achievements

Sixteen tractors were well-maintained and kept in working condition, with the exception of four tractors that are awaiting spare parts, which will be available in the next fiscal year. A total of 9,698 hectares were mechanized, primarily for land preparation, planting, and harvesting. This was accomplished through the efforts of 59 mechanization service providers, including companies, cooperatives, and individual farmers (Table 116).

Eight demonstrations, training sessions, and testing activities were conducted to promote mechanization. These introduced various farm operations, such as post-harvest handling using a mobile grain dryer in Kayonza, a baler machine for forage conservation, and training on farm machinery for land preparation, baling, and transportation to dairy cooperatives that acquired machinery through an RDDP matching grant. Additionally, there was a demonstration of rice threshing and winnowing using a locally-made machine at Rurambi Marshland in Bugesera District. In collaboration with MINAGRI, a consultative meeting was held on January 11, 2024, to discuss innovation exchange, best practices, challenges, and solutions for enhancing and expanding agricultural mechanization services in Rwanda's agriculture sector. Financial institutions have participated, presenting their products related to financing the agriculture.

Table 116: Achievement against the annual action plan fiscal year 2023-2024

Output	Indicator	Annual Target	Achievements	Comments
Access to mechanization services and area mechanized increased	Number of Farm machineries well managed and timely maintained	16	16	Tractors located in different RAB stations were maintained and repaired
	Ha covered under Farm machinery hiring services by Mechanization service providers	9,000	9,698	The area of land under mechanization has expanded due to the increased availability of tractor hiring services.
	Number of small agricultural machines purchased	10	0	This activity was postponed to next fiscal year
	Number of Demonstration plots established	8	8	Demonstrations, testing, and training were carried out. on various farm operations using adapted machinery, including land preparation and post-harvest handling in the Bugesera, Kayonza, and Gatsibo districts.

Demonstrations, testing, and training were carried out on various farm operations using adapted machinery, including land preparation and post-harvest handling in the Bugesera, Kayonza, and Gatsibo districts (Photo 114). Mobile driers for rice with capacity of 10 tonnes per day were demonstrated in different rice schemes (Photo 115), and more details can be found in Postharvest division report (this book). As an example, locally manufactured threshers were promoted (Photo 116). These machines can thresh and winnow at the same time. This reduces the losses and keep the quality of paddy rice. The farmers adopted the machine at Rurambi rice scheme.



Photo 114: Demonstration, testing and training on land preparation farm machinery at Gatsibo & Kayonza district to the cooperatives which owner farm machinery through SAIP Matching grant



Photo 115: Demonstration of Mobile drying for rice at COTCORI. This machine has a capacity of drying 10 ton of rice to the desired moisture content for storage purpose to avoid post-harvest losses



Photo 116: Demonstration of locally manufactured combine thresher for rice, 2024A, Bugesera

To achieve the mechanization targets set by PSTA IV, it is essential to increase the number of tractors and implementation support. A financial strategy must be developed, offering affordable, tailored products to encourage more cooperatives, youth companies, and individual farmers to secure loans for acquiring farm machinery, either for personal use or for offering services through equipment hire. Furthermore, the establishment of a Center of Excellence in farm mechanization should be expedited and made operational. This center will address capacity building, support local manufacturing industries, and oversee regulation and research and development to enhance the level of agricultural mechanization.

To improve access to agricultural mechanization for farming community must be sustained and gradually transitioned to the private sector. Thus, a comprehensive policy and strategy

should be developed to guide the promotion of agricultural mechanization. Incentives are needed to increase demand among farmers who wish to mechanize their operations, similar to those offered for other agricultural inputs. These incentives will stimulate the agricultural mechanization industry by encouraging the establishment of farm machinery dealers, ensuring the availability of spare parts and after-sales services, attracting financial institutions to support farm machinery as profitable ventures, and creating more employment opportunities for the youth.

V. SINGLE PROJECT IMPLEMENTATION UNIT

5.1 World Bank Projects

5.1.1 Commercialization and De-risking for Agricultural Transformation project (CDAT)

The Project aims to increase the use of irrigation and commercialization among producers and agribusiness firms in the value chains of Horticulture, Rice, Bean, Maize, Irish potato and Cassava, and to increase access to agricultural finance (Table 117). The World Bank approved \$300 million in financing under the International Development Association’s (IDA’s) grant, credit, and Scale-Up Window to help the Government of Rwanda. The MoU agreement was signed in May 2022 between the Republic of Rwanda and International Development Association (IDA)/World Bank. Subsidiary Project Agreements were also signed on 10th May 2022 between International Development Association (IDA)/World Bank and the two implementing agencies, RAB and BRD. The Project started in July 2022 and will end in April 2027.

Project Components

The project is implemented through 4 components;

Component 1: Value Chain and Infrastructure Development focuses on strengthening market and value chain linkages and improving land use efficiency for commercial production. It is also building up demand for financial services that can unlock investments to modernize and grow the agri-food sector. It has 3 subcomponents; (1.1) *Irrigation rehabilitation and development*; (1.2) *Land husbandry* and (1.3) *Innovation and services for agri-business development*

Component 2: Agricultural Finance and Insurance; is designed for addressing the supply-side of financial services for agriculture, by leveraging and deploying private sector capital and strengthening the provision of instruments to de-risk the sector. The component has 2 subcomponents; (2.1) *Scaling up agricultural finance* and (2.2) *Strengthening agricultural insurance*.

Component 3: Contingency Emergency Response allows for the rapid reallocation of credit uncommitted funds in the event of an eligible emergency

Component 4: Project Management

Table 117: CDAT Project milestones

Description	Target
Area for Irrigation development and rehabilitation	17,673 ha
Area for Land husbandry	10,986 ha

Number of Irrigation sites	37
Number of Districts for Irrigation and Land Husbandry interventions	16 (Muhanga, Ruhango, Nyanza, Huye, Nyaruguru, Gisagara, Kayonza, Bugesera, Gatsibo, Nyagatare, Kirehe, Gicumbi, Nyamasheke, Rusizi, Gasabo and Kicukiro).
Overall project intervention area	Countrywide, (specifically for Matching Grants, Credit Line and Agricultural Insurance).
Estimated number of beneficiaries	235,977 households for Site Specific Cooperatives and Agribusiness firms (11% of Rwanda's 2.1 million farming households).
Agricultural Finance Beneficiaries	2,235 Households
Crop Insurance Beneficiaries	575,000 Households
Livestock Insurance Beneficiaries	75,000 Households

Project Achievements

Value Chain and Infrastructure Development

Irrigation rehabilitation and development: Procurement process for design, supervision and work started across multiple sites. The selected consultancy firms perform design studies for 4 sites with 5 more sites at the final stage of procurement. The process to hire firms to carry out works supervision for 12 sites with advanced design studies has already been initiated. The terms of reference to carry out Environmental and Social Impact Assessment studies and produce the Environmental and Social Management Plans (ESIA/ ESMP) for all the sites were cleared by the World Bank. The procurement process to get firms to carry out ESIA/ESMP studies for 12 sites is ongoing with 10 sites already contracted. The procurement for the firm to prepare a resettlement action plan for Bugarama marshland is ongoing while the contract for assets valuation for all the sites was signed. Additionally, the project trained Water Users Associations representatives on operation and maintenance of irrigation infrastructures in different irrigation schemes. A total of 1,529 (1,169 men and 360 women) participants from 14 irrigation sites were trained in sustainable irrigation practices.

Land husbandry activities and on the way in Water catchments and Command area catchments in Nyagatare, Kayonza, Gatsibo, Kirehe, Bugesera, Muhanga, Ruhango, Nyanza, Gisagara, Huye, Nyaruguru, Rusizi and Nyamasheke. The implementation of all land husbandry works is done through community approach, where the local community is in charge of implementing all activities. The land husbandry works include; bush clearing, pegging, construction and protection of drainage systems (cut-off drains, water ways and gullies), lining and check dams fixing, construction and protection of radical or progressive terraces, application of lime and compost. During FY 2023-24, a total of 4,177.5 ha were amended with land husbandry technologies including 1,791.1 ha of radical terraces and 2,386.4 ha of progressive terraces (ditches). In addition, 2,588.9 tons of lime and 14,826.4 tons of compost were supplied.

Innovation and services for agri-business development: Under Innovation and services for agri-business development, the objective of the subcomponent is to increase value addition and marketability by addressing critical constraints that directly affect the commercialization

of the targeted value chains. The project will finance matching grants to facilitate access to production and agribusiness assets, service provision and technical assistance to commercial producers and agribusinesses, and investments in the development of technology and capacity in the public seeds system that underpins the private seeds supply chains. This subcomponent is implemented in collaboration with the stakeholders (Business Development, RAB, NAEB, Districts and farmer cooperatives). During the period under reporting, the activities were carried out to strengthen market-oriented seed system through RAB; Backstop value chains actors in marketing; Implement matching grant facility; and preparation manual for Innovation Challenge Fund.

Strengthening market-oriented seed system The CDAT project aims to strengthen the market-oriented seed system. A fully established and functioning market-oriented seed system will lead to an increase in the adoption of innovative and climate resilient seeds production. Through RAB, the project is financing the following interventions in this area: (i) developing, testing, and establishing demo plots for new varieties of seeds and climate resilient agronomic practices; (ii) training and piloting new climate-smart technologies, including measures specifically targeting/involving women; and (iii) scaling up and production of good quality breeder, pre-basic, and basic seed.

Maize value chain

The activities to support maize value chain were: development of new and production of drought tolerant varieties; scaling out of pre-basic and basic seed production; strengthening the capacity of maize farmers' field school facilitators; and detection and prevention of aflatoxin and maize mycotoxins. A total of 67 new maize hybrid varieties with drought or maize lethal necrosis or fall armyworm tolerance and extra earliness were evaluated, selected, and advanced to further development stages. For Early Generation Seeds (EGS), 401 kg of breeders' seeds, 2,120 kg of pre-basic seeds, and 21,790 kg of basic seeds for inbred lines of RAB hybrid varieties widely grown by farmers, including farmers in the CDAT project area, were produced. Then, 220 farmers were trained on maize best agricultural practices through FFS approach. Efficacy trials of aflasafe RW01 were conducted, and the results obtained were used to officially release and register this aflasafe for use in controlling aflatoxins in maize.

Horticulture Value Chain

The activities aimed to improve the availability of seeds, rootstocks, and scions of preferred varieties of fruits and vegetables, selected and evaluated high yielding hot pepper varieties, and provided technical assistance to private actors and farmers. New orchards were established with 2 avocado, 14 mango and 6 citrus varieties. New avocado germplasm field was established with 33 varieties. The existing fruit orchards were also maintained and scions harvested and distributed for grafting: 155,000 scions of avocado, 30,000 of mango, and 20,000 scions of citrus. Two new better performing hot pepper varieties (AVPP0105, AVPP9905) were selected and out-yielded the commonly grown commercial varieties (Long Cayenne and Teja). For capacity development, 182 nursery operators were trained on harvesting scions, grafting techniques, seed establishment, sowing tips, sapling care, and disease management. A total of 22 FFS facilitators and 41 farmers were trained on hot pepper good agricultural practices.

Cassava Value Chain

Cassava value chain activities focused on the development of new high dry matter content and disease resistant cassava varieties, EGS production, scaling of pre-basic and basic seed

production, and the Distinctness, Uniformity and Stability (DUS) trial. As results, preliminary yield trials were established at Nemba and Mututu sites with 32 elite clones selected in clonal trials, and advanced yield trials of 12 high yielding, high dry matter content and disease resistant varieties were also established at Rubona, Mututu and Nemba sites. In addition to these clones, five pre-released cassava varieties (NAM 130, PWAN, MH 2005/0091OP/12, RBN018/025 & RBN018/028) are under DUS trials at two sites. For EGS, 11,285 plantlets of six best high yielding and disease tolerant cassava clones were multiplied in RAB screen houses, while 5,715 plantlets of five best high yielding and disease tolerant cassava clones were macro propagated in semi autotrophic hydroponic. Also, a new mother garden of 1 ha of basic seeds was established at Nemba site, Bugesera, while 6 ha of certified seeds were established at Rubona.

Bean Value Chain

The activities were done to evaluate and select elite bio-fortified bean varieties with preferred market classes, produce breeder, pre-basic and basic seeds, training of seed multipliers in advanced seed production technology, and training of farmers on good agronomic practices and post-harvest handling technologies. A total of 798 segregating lines (bush and climbing lines) were selected, and advanced to different stages of bean variety development scheme. Then, 23 promising bean varieties were selected among 68 varieties introduced from the regional nursery. For EGS, a total of 73,618.5 kg of improved seeds, including 3,137 kg of breeder, 16,595 kg of pre-basic and 53,886.5 kg of basic seeds were produced. For capacity building, a total of 113 seed multipliers and agronomists were trained on appropriate bean agriculture practices. Also, a total of 2800 farmer promoters were trained and received training materials, established bean demonstration plots and trained their neighbors.

Potato Value Chain

Potato value chain activities focused on the development and multiplication of new climate resilient potato varieties that meet farmer preferences, EGS production, and the evaluation of potato productivity in the potato growing areas. A total of 66 potato clones were selected through observation, preliminary yield, advanced yield, multilocation, national performance trials, as well as DUS test. For EGS, 1,063,157 mini-tubers, 41,922 kg of pre-basic, 145,651 kg of basic seeds were produced. Finally, the yield assessment was carried out in potential potato production regions of the country, and overall yield obtained was 24,300 kg/ha, with 19,000 kg/ha as the yield for marketable products and 5,300 kg/ha as the yield for non-marketable products.

Rice Value Chain

Rice value chain activities evaluated adaptability of new introduced long and aromatic lines, increasing the availability of EGS, and in rice stakeholders' capacity development. A total of five long and aromatic rice lines KF 210077, KF 210055, KF 210054, KF 210053, and KF 210029 were selected among 35 newly introduced rice lines. For EGS, more than 400 kg, 1200 kg, 29,000 kg of breeder, pre-basic, and basic seeds were produced. A total of 40 agronomists in charge of rice seed production in cooperatives were trained on the law governing seeds and plant varieties in Rwanda, rice seed production techniques, rice pest and disease management, harvest and postharvest handling, rice crop water requirements and management, and fertilizer efficient use.

Backstopping of value chain actors in marketing

The CDAT project aims to strengthen market linkages and value addition (such as through processing), to facilitate trade and increase value accrued to its beneficiaries. To achieve this, the project finances the interventions related to technical assistance to private value chain actors to meet Sanitary and PhytoSanitary (SPS) and other quality requirements of the market, with an additional focus on new food safety and SPS risks that may emerge from and be exacerbated by climate change. As NAEB has mandate to promote export promotion and strengthen market linkage, the project signed agreement with NAEB to ensure that the producers from CDAT intervention areas are linked to domestic, regional and international markets.

Through this agreement (MoU), NAEB will;

- Hire a marketing company for Rwandan horticulture produce. Hired service provider will perform following task.
- Provide support to farmers and exporters for the third-party certification to meet different market standards (Global GAP, Organic certification, etc.)
- Support specialized quality export infrastructure (equipment's, testing facility, maintenance, lab accreditation)

During the period under reporting, NAEB carried out the following;

- Signed Memorandum of understanding with Rwandan embassy in UK, United Arab Emirates and Qatar to become market niches of Rwandan produce.
- Recruited market facilitators in United Kingdom and United Arab Emirates (Dubai) and Qatar (Doha)

Implementation of Matching grant facility

A joint team composed of BRD, RAB-SPIU and BRD carried out project awareness campaigns on matching grant across all 30 Districts of Rwanda. This was followed by the first call for application on matching grant conducted in July 2023. As a result, 472 business plans were received with a total amount of Frw 15.31 billion. As of end June 2024, the evaluation of all 472 applications was completed and out of 472 applications, 187 were approved with a total amount of Frw 6.43 billion, 51 were given conditional approval with a total amount of 1.96 billion while 234 application were rejected with a total amount 6.90 billion.

Implementation of innovation challenge fund facility

Rwanda Agriculture and Animal Resources Development Board through its SPIU worked with Ministry of ICT to prepare the manual for the innovation challenge fund which was approved by the World Bank. As a result, the disbursement conditions for this facility was lifted in May 2024. With the support of the Ministry of ICT, RAB-SPIU also initiated the procurement for a technical assistant to handle innovation challenge sub-component.

Component 2. Agricultural Finance and insurance

Scaling up agricultural finance. Under Scaling up agricultural finance, the subcomponent objective is to set the foundation for expanding the supply of affordable financial services and products, especially credit in the agriculture sector, thereby enabling investment and,

ultimately, agricultural transformation. The subcomponent finances the credit line for production and post-harvest finance and institutional capacity development (TA) for participating financial institutions, which will contribute to a sustainable provision of financial services and products.

During the period under reporting, BRD has on boarded fourteen Participating Financial Institutions (PFIs); five commercial banks, four MFIs, and five SACCOs to which BRD has committed Frw 15.5 billion. The total commitment to clients and PFIs stands at Frw 16.2 billion. Disbursement to PFIs stands at Frw 6.9 billion while disbursement to end borrowers by PFIs is Frw 6.1 billion.

Strengthening agricultural insurance. Under strengthening agriculture insurance, this subcomponent aims to strengthen the quality and effectiveness of agriculture insurance offered through the NAIS, which seeks to de-risk the agricultural sector using market-based insurance mechanisms and Finetech solutions. The subcomponent seeks to address these challenges by: (i) providing technical assistance to the private sectors to enhance their capacity to design and deliver appropriate agriculture insurance products to smallholder farmers through NAIS; (ii) supporting the public sector to strengthen agriculture data collection and storage and make it available for agriculture insurance use; (iii) investing in financial literacy and insurance awareness programs for Rwandan farmers with specific emphasis on reaching-out to women-headed farming households to ensure equal access to NAIS products and programs; and (iv) supporting deployment of Finetech solutions.

To this end, the following activities have been accomplished during the fiscal year; Trainings were conducted by NAIS to educate RAB station managers, extension officers (including District Agriculture Inspectors, District Veterinary Officers, Directors of Agriculture Unit at District level, farmers' cooperative staff and agents of insurance companies on various aspects of the NAIS scheme including the need for crop and livestock insurance, climatic conditions of the district, procedure of enrolment, role of insurance companies, claims process etc. During the period under reporting, 368 (309 males, 59 females) livestock professionals and 968 (694 Males & 274 Females) crop professionals received training agriculture insurance aligned with NAIS products.

Project supported agriculture insurance uptake through premium co-financing where World Bank supported Government of Rwanda to support farmers to access agriculture insurance products through subsidy where farmers pay 60 % of the premium and Government pays 40% through World Bank support. As a result, 50,622 animals have been insured and 9,009.94 hectares of crops covered under TEKANA Program. The Financial risk placed to private sector insurer and re-insurer is equivalent to 92,520,200,000 Frw in livestock and in crop 44,320,342,197 Frw. In addition, the Project together with the Chief Digital Office based in MINAGRI worked on NAIS digitalization and the architecture was developed and shared with the World Bank for review. The proposed model is aimed at creating the foundation of agriculture sector digitalization from end to end value chain management.

5.1.2 Sustainable Agricultural Intensification and Food Security Project (SAIP)

Project funding: The grant agreement totaling 32.2 million USD (initial and additional financing) was signed between the World Bank, acting as administrator of the Global Agriculture and Food Security Program, and Republic of Rwanda for the financing of Sustainable Agriculture Intensification and Food Security Project (SAIP) (Table 118).

Table 118: SAIP project complementary funding

Donor name	Amount (in million USD)
1. GAFSP SAIP Initial Financing	26.3
2. GAFSP SAIP Additional Financing	5.98
3. GoR (Counterpart)	4
4. Beneficiaries' contribution	2.67
Total	38.95

Other important information

- Project ID Initial project: P164520 & Additional Financing: PAD4317. Grant Number: TFOA8221
- Date of approval: 14 September 2018 & Date of signature: 19 September 2018
- Date of effectiveness: 14 December 2018 & Additional Financing: 15 December 2021.
- Initial closing date: 31 August 2023 & New closing date: 31 August 2024

Objectives of the Project:

The project objective is to increase agricultural productivity, market access, and food security of the targeted beneficiaries in the project areas. The project has 4 development objective-level indicators namely; (i) Percentage increase in harvested yield of targeted crops, (ii) Percentage increase of produced commodities in targeted value chains marketed by participating producers; (iii) Food Consumption Score and (iv) Number of farmers adopting improved agricultural technology, disaggregated by gender.

Project Components

The project is implemented through three mutually reinforcing technical components: Component 1: Institutional Strengthening, Agriculture Productivity Enhancement and Nutrition Improvement; Component 2: Irrigation and Water Use Efficiency; and Component 3: Market Linkages and Value Addition Investment Support. The fourth and last component 4 is Project Management and Technical Assistance.

The first component is strengthening selected farmer organizations for improved agricultural productivity and healthier household nutrition. It has 3 subcomponents; (i) Strengthening farmer organizations, (ii) Agricultural productivity enhancements and (iii) Improving nutrition outcomes at household level.

Component 2 promotes technology and best practices for increased availability and efficient use of water for irrigation to increase crop productivity and increase farmers' resilience to

climate volatility. It is implemented under 2 subcomponents; (i) Improved efficiency and expansion of existing irrigation schemes and (ii) Strengthening irrigation capacity.

The third component enhances market linkages and value addition by strengthening the capacity of farmers’ organizations and other value chain actors and by improving their access to finance. It has 2 subcomponents; (i) Capacity building to foster market linkages and (ii) Investment support to market linkages. The fourth component is supporting all aspects of project management including (a) management and coordination, (b) monitoring and evaluation (M&E), (c) communication and knowledge sharing, (d) TA, and (e) a grievance redress system (GRS). It has 2 subcomponents; (i) Project management and (ii) Technical assistance.

Targeted Value Chains: The project is targeting 4 value chains namely; (i) Maize, (ii) Beans, (iii) Irish Potatoes, (iv) Horticulture (Table 119).

Areas of interventions: At its start, the project was being implemented in selected sites located in 8 Districts namely; Nyanza in Southern Province, Karongi, Rutsiro and Nyabihu in Western Province, Rulindo in Northern Province, Rwamagana, Kayonza and Gatsibo. With the Additional Financing, the project interventions were scaled up to 3 more sites namely Ngoma 22 in Ngoma District, Rwangingo in Gatsibo District, Nyabirasi in Rutsiro District and Cyungo-Base in Rulindo District.

Table 119: SAIP Project targets

Description	Targets
Increase of harvested yield of targeted crops	17%
Increased produced commodities in targeted value chain marketed by participating producers	25%
Food consumption score among project beneficiaries	36
Households reached with agriculture assets and services and adopting improved agriculture technologies	45,688 households
Producers’ organizations supported	2,397
Individuals receiving improved nutrition services and products	230,000
Area provided with new/improved irrigation or drainage services	2,900 ha (1,200 ha new and 1,700 ha from the existing schemes)
Individuals benefiting from small scale irrigation interventions	2,400
Waters users paying water fees	9,330
Metric tons processed through post-harvest infrastructures established with project support	23,088 tons
Farmers’ organization-buyers’ linkages established	38
Credits mobilized by farmers and farmers’ organization	400,000 USD

Project Achievements during FY 2023-2024

Component 1: Institutional Strengthening, Agriculture Productivity Enhancement, and Nutrition Improvement.

Farmers organization: Project beneficiaries increased from 44,104 (19,769 females and 24,335 males) to 47,040 (20,436 women and 26,604 men). Supported producer-based

organizations increased from 2,217 to 2,397 in part due to higher participation in the Matching Grants and Small-Scale Irrigation Technology (SSIT) Programs. Net revenues of supported cooperatives increased by 5.2 percentage points (from 68.4 percent in 06/2023 to 73.6 percent in 06/2024) thanks to the capacity building programs & support.

Productivity enhancement: During the reporting period, considering the data from season B 2024, Maize productivity was increased from 3.3 to 3.8 tons per ha, beans productivity remains at 2 tons per ha and the Irish potato yield is at 19 tons. The productivity of horticultural crops was also increased as follow; (i) Chili productivity increased from 11.05 tons per ha to 11.07 tons per ha, (ii) Tomato production increased from 18.2 tons per ha to 18.3 tons per ha, (iii) Onion yield increased from 17.2 tons per ha to 17.49 tons per ha and, (iv) French beans yields increased from 6.78 tons per ha to 6.8 tons per ha for season C 2023 to Season A 2024, respectively. Under climate smart agriculture practices, the number of greenhouses constructed are 53 making the total number to increase from 132 greenhouses to 185 greenhouses.

Nutrition: For continued improvement of nutritional outcomes among targeted beneficiaries, the project distributed 9,564 chickens to 2,391 households during 2023-2024. The program has facilitated the increase of accessibility and availability of eggs for animal food consumption promotion among beneficiaries. Additionally, during the FY 2023-2024, 19,960 mushroom tubes; 4,700 kg of iron fortified bean seeds, 12,000 kg of soya bean seeds and 250,000 sweet potato cuttings were distributed to 1,996; 940; 1,200 and 166 households respectively. In order to increase availability of healthy and diverse plant-based food, the project spearheaded the mobilization efforts along with seeds support from the project resulted in the construction of 2,381 kitchen gardens at household level and 23 model kitchen gardens at ECDs.

Component 2: Irrigation and Water Use Efficiency.

The area under SSIT established during the year is 91.7 ha (increased from 1,275.3 ha in June 2023 to 1,367 ha in June 2024) and the area with improved water use efficiency is 536 ha (from 1,165 ha in June 2023 to 1,701 ha in June 2024). The number of farmers supported during the year is 251 farmers (increased from 2,200 in June 2023 to 2,451 in June 2024). The number of Water Users paying water fees are 1,617 (increased from 6,274 to 7,891). The area of buffer zone protected with trees and shrubs is 102.7 ha (increased from 165.3 ha in June 2023 to 268 ha in June 2024)

Component 3: Market Linkages Value Addition Investment Support

During the reporting period the Project through matching grant constructed 63 greenhouses across project intervention sites.

The Project also continued to do a follow up of different project supported through matching where a total of 235 different business plans are under implementation. The business plans are grouped into 3 categories with a total of 13.6 billion Rwandan Francs including beneficiaries' contribution of 3.8 billion and the SAIP contribution of 9.8 billion.

The 3 categories are (i) Primary production, (ii) post-harvest handling and (iii) value addition. **The primary production** is mainly targeting protected agriculture where a total of 185 greenhouses (169 medium sized of 240 square meters each and 16 big sized of 540 square meters each) were constructed and are under production. The main crops currently grown in

greenhouses include: tomatoes, sweet pepper, sweet melons and cucumber. Under primary production, the project has also promoted the use of agriculture machinery through acquisition of 46 tractors and 47 power tillers. These machines not only being utilized by the owners but rather do rental services to other farmers. Another category is mobile irrigation rental services that started with a trial of 3 companies that belong to youth in agribusiness, operating in Gatsibo, Kayonza and Rwamagana.

Post-harvest handling: Beneficiaries have been supported with 23 post-harvest handling facilities including storages, dryers, warehouses, pack houses, cooling facilities (cold room and cold trucks) in order to reduce post-harvest losses while ensuring the quality of produce.

Value addition: Under value addition, the beneficiaries were supported with 30 agro processing plants construction including food transformation such as fruits or vegetables processing, maize flour processing, animal feeds, cooling or drying different agricultural products and funding of equipment and machinery to improve food preservation, food safety. This funding from the grant has impacted on employment creation, income increase, labour saving and food security while creating market for project beneficiaries inside and outside of the intervention areas. Moreover, to meet the market quality, SAIP has supported with certification to one beneficiary in Ngoma who is in pineapple and avocados processing called 1000 Hills Products Rwanda Ltd. The beneficiary has complied in different certificates needed by the market such as Global GAP, HACCP, Organic, Fairtrade and S-Mark.

5.1.3 Sustainable Agricultural Productivity and Market Linkages Project (SAPMP)

The project Development objectives are to contribute to Sustainable Development Goal 2.3 by 2030: To double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment through project milestones (Table 120). KOICA contributed approximately \$10 million to the SAPMP project, with an additional \$2 million from the Government of Rwanda and \$0.5 million from WFP, totaling \$12.5 million. This budget is allocated to support the Government of Rwanda in implementing the Sustainable Agriculture Productivity and Market Linkages Project, aimed at achieving its objectives. The Record of Discussions was signed on September 29th, 2020, by representatives of both governments, including the Country Director of the Korea International Cooperation Agency (KOICA) and the Minister of Agriculture and Animal Resources (MINAGRI), with acknowledgment by the Minister of Finance and Economic Planning (MINECOFIN). The project officially commenced on January 1st, 2021 and the scheduled closing date is December 31st, 2026.

Project Outcomes

Outcome 1. The agricultural productivity of farmers at project sites increased.

- Output 1.1 Farm land created or expanded
- Output 1.2 Increased farming capacity and technologies
- Output 1.3 Strengthened farmers' organizations

Outcome 2. The marketability of agriculture products from project sites improved.

- Output 2.1 Improved post-harvest management capacity
- Output 2.2 Broaden access to market and financial services

Targeted Value Chains

The project is targeting 6 value chains namely; (i) Horticulture, (ii) Rice, (iii) Bean, (iv) Maize and (vi) Cassava.

Table 120: SAPMP Project Milestones

Description	Target
Area for Irrigation development and rehabilitation	600 ha
Area for Land husbandry	500 ha
Post-harvest facilities	2 Storages and 4 drying ground

Project Achievements

Marshland rehabilitation and development (600 ha)

During the period under reporting, the procurement for the marshland rehabilitation and development with 600 hectares divided into two (2) lots was concluded and the contracts awarded. The implementation of works will start soon after issuing of the commencement letter.

Sustainable Land Management on Hillside (500 ha, including 100 ha of terraces, 300 ha of Ditches and 100 ha of afforestation)

The Project implemented land husbandry works on 500 ha around the marshland to be developed in the previous fiscal years and during the period under reporting, the project continued with the maintenance of the constructed terraces through collaborative efforts between local authorities and beneficiary cooperatives, ensuring that the area treated is regularly maintained for erosion control. Agroforestry species from project established nurseries continue to be planted along terraces embankments for stabilization and erosion control.

Rural Investments for Economic Infrastructures

In order to ensure proper post-harvest handling and reduce on post-harvest losses, the project constructed 2 Storages and 4 drying ground in the previous fiscal year. During the harvesting of season 2024A, 200 tons of maize were collected and stored in the newly constructed storage facilities, creating an opportunity to connect cooperatives with contract farming agreements with East Africa Exchange (EAX) and other buyers.

Increased farming capacity and technologies

In FY 2023-24, the project established 22 Farmer Field School (FFS) plots (total area of 16.3ha) supporting the concerned value chains. These plots provided a valuable learning platform for farmers to gain practical knowledge and hands-on experience leading to significant improvement in both production and productivity across the sites.

5.2 IFAD Projects

5.2.1 Rwanda Dairy Development Project (RDDP)

The RDDP is a six-year project implemented by MINAGRI and RAB. The project is co-financed by IFAD and the Government of Rwanda to support dairy value chain. The project operated between December 2016 and June 2023. The cost of the RDDP project was 65.1 million US

dollars. In 2022, a one-year extension and additional financing for USD 3,734,045 were approved to scale-up some of the activities and respond to emerging challenges: increasing market demand and effect of climate change, and to generate critical lessons learnt to be integrated in the design of the second phase of RDDP.

The RDDP aims to contribute to pro-poor national economic growth and improve the livelihood of resource-poor rural households focusing on food security, nutrition and empowerment of women and youth in a sustainable and climate-resilient dairy value chain development. Specifically, the project seeks to increase competitiveness and profitability of the dairy sector for the provision of quality products from small-scale producers to domestic and regional consumers, thus improving their livelihoods, food security and nutrition whilst building overall resilience. The Project target is to reach about 100,000 resource-poor rural households, of whom 80,000 in dairy farming (mostly zero-grazing) and 20,000 in national wealth ranking system (Ubudehe), and consistent with the targeting strategy laid off-farm activities along the dairy value chain. Taking into account revisions made in the out in the RB-COSOP, the target groups of the project will comprise the following: 51,800 smallholder dairy farmers in the zero-grazing system; 22,200 smallholder dairy farmers in the semi-extensive grazing systems with up to 10 cows; 6,000 Girinka beneficiaries, who will receive a cow in-calf, and pass on the first heifer to a qualifying neighbor; 15,400 young farm assistants aged 15 to 24 working as wage labourers (mainly male) in many dairy farms, especially in female-headed households with no male adults.; 5,400 rural women, aged 15-35 (child-bearing age), will benefit from new economic opportunities and creation of small off-farm business opportunities; Other beneficiaries will include: 640 Livestock Farmer Field School (L-FFS) facilitators; 450 producers of forage seeds and vegetative planting materials; 175 vets, 72 community animal health workers and AI technicians; members of dairy cooperatives; milk collectors and traders; and dairy processors.

The Project area comprises 14 districts - East (Nyagatare, Gatsibo, Rwamagana, and Kayonza), North (Gicumbi, Burera, and Musanze), West (Nyabihu, Ngororero, Rubavu and Rutsiro) and South (Nyanza, Huye, and Ruhango) selected on: (i) current level of cattle population and milk production; (ii) current and projected market development potential, including investments in milk collection centers, dairy processing plants, animal feed factories, and evolving domestic and export market linkages; and (iii) level of poverty, food insecurity and malnutrition. The Project is organized in four components: (i) Climate-smart dairy production intensification; (ii) Producer organization and value chain development; (iii) Institutional and policy development and (iv) Project management and coordination.

Key Annual Achievements for FY 2023-24

The project distributed different forage varieties and planted area covered is 1594 ha as forage fields. A total of 290 facilitators were trained on L-FFS methodology and dairy cattle husbandry techniques; 209 facilitators were trained in Market analysis and business management during the refresher trainings. Fifteen staff from SPIU (12 Field Coordinators and 3 staff from SPIU headquarters) and 8 L-FFS Master trainers were trained in Farmer Market School Approach. Some L-FFS groups graduated into Cooperatives that are involved in livestock inputs and milk trading. Two Facilitators created forage seed companies. Vaccine storage equipment (fridges, coolboxes) were purchased and distributed for Gatsibo and Ngororero. A total of 10,000 doses of anaplasmosis vaccines and 74,660 doses of ECF vaccines

were purchased and delivered to RAB. Laboratory equipment including ELISA reading machine, RT-PCR Machine and nucleic acids extractor were purchased and placed to Rubirizi National Veterinary Laboratory. Bull Station, parking and residential house for Veterinary Doctors were built in RAB Songa, and street lights, laboratory and installed. Equipping the center with laboratory equipment, office furniture, Farm materials and connection of internet was completed.

The construction of residential house for Veterinary doctors has been completed at RAB Songa. The equipment for new inseminators was bought and distributed to beneficiaries. The beneficiaries were 65 inseminators who were trained on Artificial Insemination. A total of 3300 sexed semen were procured and handed over to RAB for distribution. Mastitis prevention was expanded to Burera and Musanze districts; 834 farms have been reached at Burera district; 875 cows have been screened for mastitis infection; the prevalence was found at 51.7% while in existing zones of intervention the prevalence in majority zones were below 30%. Resulting from higher prevalence that were found to Burera; a mobilization campaign was done to Burera and Musanze whereas 439 attendances was recorded including 357 males and 82 females.

Four (4) well-performing MCCs to SMEs were supported to comply with environmental aspects. These MCCs are (1) KIDACO, located in Huye; (2) Gwizumukamo-Busoro, located in Nyanza; (3) Iwacu-Zirakamwa, located in Musanze, and (4) Giramata-Gakamba, located in Nyabihu. Five newly formed cooperatives of milk sellers and transporters were trained in governance and financial management (FM). Cooperatives trained were made of milk sellers and transporters from Gicumbi and Gatsibo Districts. Five cooperatives were coached with the aim to produce optimal performance and improvement of cooperatives on governance and management. A total of 1,164 rain-water harvesting Dam-Sheets were procured and installed for farmers: Nyagatare: 892, Gatsibo: 59, Kayonza: 107 and Rwamagana: 6.

The audit focused on compliance with Laws and financial principles. Audited cooperatives were from Rubavu (2); Nyabihu (1), Musanze (1) and Ruhango (1). District dairy platforms were formed and operational in collaboration with Rwanda National Dairy Platform. The remaining 16 districts had established dairy platforms via MINAGRI support. The impact study was conducted and final report was completed.

5.2.2 The Partnership for Inclusive Small Livestock Markets (PRISM) Project

The PRISM Project is a partnership program implemented by RAB, Heifer International and VSF Belgium and jointly funded by IFAD and ENABEL. It started 2021 and it will end in 2026. PRISM is financed by: (i) the GoR with USD 3.31 million (about 7.3% of total costs), (ii) Districts with USD 0.66 million (about 1.4% of total costs), (iii) IFAD with USD 14.90 million (about 32.7% of total costs), (iv) ENABEL with USD 17.4 million (about 38.2% of total costs), (v) Banks with USD 1.29 million (about 2.8% of total costs), (vi) Heifer International with USD 4.68 million (about 10.2% of total costs), (vii) Beneficiaries with USD 2.38 million (about 5.2% of total costs), and (viii) private sector with USD 0.99 million (about 2.2% of total costs). The project operates with three components: i) Climate-smart intensification of small livestock

production; ii) Support to Small Livestock Value Chain Development; and iii) Policy support and coordination.

The Project aims to reduce poverty by empowering poor rural men, women and youth to participate in the transformation of the Rwanda livestock sector and to enhance their resilience; to improve food and nutrition security and incomes of poor rural households through better performance of the value chains. The project operates in 15 districts selected based on the incidence of poverty and food insecurity and having comparative advantage small livestock value chains: North (Gicumbi, Gakenke, Rulindo Burera and Musanze), West (Nyamasheke, Karongi, Ngororero, Rutsiro and Nyabihu) and South (Nyamagabe, Gisagara, Nyaruguru, Huye, and Ruhango). Based on the national wealth ranking system (*Ubudehe*), and consistent with the targeting strategy, outlined in the *Country Strategic Opportunities Programme*, PRISM targets 26,355 poor rural households, belonging to *Ubudehe* categories 1, 2 and 3.

The project targets to reach 33,750 beneficiaries trained on Poultry, 15,000 on Pig, 6,581 on Goat and 5,063 on Sheep management; 67,500 chickens distributed to farmers as original placement and 270,000 chicken through Pass on Gift; 3,000 pigs distributed to farmers as original placement and 12,000 pigs through Pass on Gift; 13,162 goats and 10,126 sheep distributed to farmers; 6,750 farmers supported with fodder cuttings; 23,400 farmers supported with vegetable seeds to establish kitchen gardens; 36,750 poultry houses, 3,000 swine houses, 3,375 goats' houses and 3,375 sheep houses constructed; 549 Champions and 4,952 Self Help Groups (SHG) members trained and coached in Gender Approach Learning System (GALS); 50 sheep breeding stock established; Gishwati station for sheep reproductive nucleus rehabilitated; 15 proximity veterinary posts/clinics constructed, equipped and operational; 15 District livestock markets rehabilitated/ constructed; 10 public pig slaughter slabs constructed, equipped and operational; 3000 rainwater harvesting facilities established at household level.

Key Annual Achievements FY 2023-24

A total of 3,375 farmers were trained on goat and sheep management. This training equips them with essential knowledge and skills in proper animal husbandry to ensure the well-being of the livestock they will receive. Throughout the year, Heifer has distributed solar kits to 1156 households, comprising 497 males (43%) and 659 females (57%). About 4,950 Pass- On Gift (PoG) farmers were trained in the Values Based Holistic Community Development (VBHCD) model. PRISM in collaboration with Heifer International managed to select and train 549 as Gender Approach Learning System (GALS) champions. A total of 6648 goats have been procured and distributed to 3,414 households 13,500 chicken purchased and distributed to farmers in project intervention zones. 624 female pigs purchased and distributed to farmers across the 15 districts of which females are: 333, males: 291and youths: 135.Among them, there were 187 female-headed households. A total of 500 rainwater harvesting were distributed at Household level. About 3,375 individuals received animal fodder across the 15 districts; these includes 1966 females, 1409 males and 894 youths. Among them, there were 997 female-headed households. A total of 7562 individuals received vegetable seed (*Amaranthus*, *Carrots* and *Beetroot*) across the 15 districts to support and initiate the activity for establishing vegetable kitchen gardens at household levels; these includes 4308 females, 3254 males and 1851 youths. Among them, there were 2134 female-headed households. PRISM in collaboration with Heifer has distributed solar kits to 1156 households, comprising 497 males (43%) and 659 females (57%).

5.2.3 Kayonza Irrigation & Integrated Watershed Management

Kayonza Irrigation and Integrated Watershed Management Project (KIIWP-2), phase 2, is being implemented since April 2022 and it will end in June 2028. Project is funded by IFAD and is coordinated by SPIU of RAB. The intervention area comprises nine drought-prone sectors in Kayonza District, namely Gahini, Kabare, Kabarondo, Murama, Murundi, Mwiri, Ndego, Ruramira and Rwinkwavu. This area has been selected on the basis of its high vulnerability to drought and its high poverty and food insecurity levels. The area has untapped potential water resources, which if fully utilized would significantly improve crop production, climate resilience, food security and nutrition.

The KIIWP responds to the urgent demand from the Government of Rwanda to tackle drought-related issues hit by a severe drought in the Eastern Province and (ii) conduct the feasibility study and environmental and social impact assessments (ESIA) while validating the irrigation schemes ahead of large irrigation and farm business development projected under the phase 2 (KIIWP2). The first phase of the project was completed in September 2023 and its Project Completion Report has been disclosed. The total cost of KIIWP2 is estimated at US\$61.0 million of which IFAD contributes US\$21.8 million and cofinancing from the Government of Spain of US\$28.0 million. The Government of Rwanda will contribute to US\$8.1 million, mainly in the form of tax exemptions. The beneficiary contributions, in-kind and in-cash, are estimated at US\$2.1 million. Cordaid will contribute US\$650,000, mainly for component B, while its partners are organized to support small and medium-sized enterprises and microfinance institutions through loans for an estimated US\$372,000.

It is expected that smallholder farmers will see an improvement in household food and nutrition security, income, and asset ownership, particularly amongst vulnerable groups including women-headed households and youth. KIIWP's goal will be achieved through the development of sustainable, profitable and intensive small-scale agricultural activities supported through Public Private Producers Partnerships (4Ps) whenever opportunities exist in the selected project sites and areas.

The **Development Objective** is to "Improve food security and incomes of 40,000 rural households on a sustainable basis and build their climate resilience". KIIWP will improve the resilience of smallholder farmers to droughts and effects of climate change through increased levels of production and productivity of selected food and cash crops, livestock and improved market access and business development. The main expected outcomes and outputs of the project include (i) improved access to land, forests, water and water bodies for production purposes; (ii) increased acreage of farmland under water-related infrastructure; (iii) increased acreage of farmland under climate resilient management and practices; (iv) increased capacity of smallholder farmers and local government to sustainably manage natural resources and climate-related risks; (v) enhanced use by farmers (including youth) of technologies, equipment and infrastructure adapted to smallholder agriculture; and (vi) increased farmers' economic benefits from market participation and increased sales. KIIWP2 activities are organized into three components as follows: Component A: Strengthening resilience to drought, Component B: support to farm business development and component, and C: institutional development and project coordination.

The targeted **project area** comprises the nine drought-prone sectors of Kayonza District in the Eastern Province of Rwanda namely Gahini, Kabare, Kabarondo, Murama, Murundi, Mwili, Ndego, Rwinkwavu and Ruramira. These areas are relatively hot, with limited rainfall

compared to the rest of the country, averaging 900 mm per year, but they have good potential for irrigation.

For the closing of KIIWP phase I, in this fiscal year; 1,300 hectares of established land husbandry works, 1,337 hectares of orchards, 15 valley dams/tanks, 20 boreholes constructed and rehabilitated in Murundi, Gahini, Mwiri and Ndego Sectors (very drought zones) continued to be maintained and 12 security guard houses have constructed on bore's sites to increase the ownership and sustainability.

Expected outputs for the KIIWP project, phase 2

Component 1: Strengthening Resilience to Droughts

- Under Sub-component 1.1: 1,950 ha of catchment areas will be protected and developed, in addition to the reforestation of 2,000 ha with trees. In addition, the Environmental and Social Management Plans (ESMPs) identified in the ESAs will be implemented.
- Under Sub-component 1.2, on the basis of the development costs and feasibility assessment of irrigation schemes conducted under KIIWP1, KIIWP2 aims to implement 2,285 ha of irrigation command area. The Infrastructure Management Institutions will be enhanced, including the Sector Steering Committees, Hydrographic Basin Committees, and Irrigation Water User Organizations.
- Under Sub-component 1.3, climate smart agriculture practices and technologies would be promoted in the irrigated and catchment areas, using the Farmer Field School (FFS) approach. The Project would also support the Farmer Promoters, and promote adapted farm mechanization, and Climate- and Nutrition Smart Technologies.

Component 2: Support to Farm Business Development

- Sub-component 2.1 include:
 - (i) 8,000 smallholder farmers in FFS received FaaS training,
 - (ii) 500 FFS members and 50 Agriculture Cooperatives received business development coaching and have bankable business plans. Based on these business plans, the Project will cofinance privately-owned and managed investments of individual smallholders, cooperatives and/or private sector companies through a Performance-based Matching Grant Scheme
- Sub-component 2.2 would link farmers and cooperatives to markets using agribusiness linkages and public-private partnerships. Expected outputs will include:
 - (i) 8,000 smallholders have improved access to markets
 - (ii) 10,000 smallholders have improved access to financial services 1/33 with support from the Inter Church Organization for Development Cooperation (ICCO/ Cordaid) and other partners,
 - (iii) 2,500 smallholders use agricultural insurance products

In addition, the targeted groups would be given access to inclusive financial services, provided by local financial institutions. Finally, smallholders would be supported to access agriculture insurance products offered under the National Agricultural Insurance Scheme (NAIS).

Component 3: Institutional Development and Project Coordination

- Sub-component 3.1 will support the formulation of policies, laws and regulations related to intervention areas of the Project. In addition, based on a needs

assessment, institutional support would be provided to implementing entities at national and district levels.

- Sub-component 3.2 will finance project coordination, monitoring and valuation (M&E), knowledge management (KM) and communication.
- Sub-component 3.3 would be a zero-budget, designed to provide swift response in the event of an eligible emergency event such as the global COVID-19 pandemic.

Key achievements

Strengthening Resilience to Droughts - Catchment rehabilitation and protection

Land husbandry activities in catchments Under Sub-component 1.1: 1,950 ha of catchment areas will be protected and developed. To date, 350 ha that were planned during last fiscal year are completed and provisional hand over provided. 400 ha were planned during this fiscal year 2023-2024 and still ongoing whereas 326.25 ha including 195.25 ha of progressive terraces and 131 ha of bench terraces. Cumulatively, 657.17 ha over 1950 ha planned are completed. 875 tons of lime and 3500 tons planned to be applied on 350 ha were supplied and applied. 314.4 tons of compost over 1500 tons planned were supplied and applied on 400 ha and the remaining quantity will be applied in season A 2025. From the beginning of KIIWP2, a total of 1507 farmers benefited from land husbandry activities including 624 females, 883 males and 101 youth whereas 455 were trained about land husbandry implementation and maintenance including 160 females, 295 males and 54 youth. During 2023-2024 FY, 89 technicians received refresher training on land husbandry technical implementation in addition to 100 technicians trained last fiscal year to ensure better quality of works.

Upstream protection for Gishanda and Kanyegenyega dam (reforestation) 100,756 seedlings of fruits covering 500 hectares (Avocado: 89,788, Mango: 6,068, Passion fruit: 4900) were prepared, transported up to farm gate and planted by project beneficiaries; in addition to land terracing related activities, KIIWP2 is targeting to implement reforestation related activities over 2,000 ha with trees plantation. , 670,000 forestry trees are already planted covering 150.52 hectares out of 150 hectares planned to be planted in this fiscal year. The total area to be planted which is equivalent to 150.52 hectares and scattered across 4 sectors as follow: (Ndego 59.34/60ha, Kabare 23.3/20ha, Rwinkwavu: 30.26/30ha, Murama : 18.12/20ha, and Kabarondo: 19.50/20ha).

Community competition for Natural Resources Management

A total of 49 farmers have benefited from the study trip organized and conducted in two batches. Out of 49 total beneficiaries, 19 were females against 33 males and 12 were youth. The participated farmers were selected from the already existing cooperatives/associations, FFS facilitators, youth representative preferably National Youth council coordinator at sector level, 2.5 technical management committee. The visited project sites were: Beekeeping farm in Nyagatare District; Black soldier flies (BSF) rearing at UR-Nyagatare campus and at individual farmer in Musanze District; Hydroponic fodder farming techniques at Uruhimbizi Kageyo Cooperative (UKC) in Gicumbi District; Vermicomposting site at UR-Busogo Campus; and Seedlings production and their marketing at Mulindi site, Kigali city.

Upon their arrival on the site, Farmers learnt about the required investments, technologies and best practices (infrastructures, equipment, material) for modernizing the presented project activities/operations. At the closing date of the study trip, each participant was given with a form to fill-in in order to collect their feedback. After collecting and analysis the provided information, the following were concluded: The participants have acquired a good understanding on countrywide existing best practices in promoting the income generating activities while promoting/conserving the environment and Natural Resources in general

Participants are aware about the required investment (equipment, infrastructures) for starting and or upgrading different NRM project/businesses. They gained knowledge, information and tips on market penetration, especially to those who were challenged by market access. Each beneficiary managed to choose at least one project basing on his/her interest the one they are committed to go back in their respective village and start to implement/upgrade or expand.

Implement the Environment, Social and Climate Management Plans (ESCMPS) The implementation of most of the activities planned under the ESCMPs linked with irrigation schemes to be developed have not yet started due to the delays in the commencement of schemes development works. However, some activities started. For example, Grievance Redress Mechanism committees were formed and trained. In total 331 members (118 females and 213 males and 68 youth) of grievance redress mechanisms committees were trained.

Moreover, the activity of electing Grievance Redress Mechanism Committees at 15 valley dams/tanks is still ongoing. A total of 22 newly elected GRMCs including 15 at valley dams, 4 at new Land Husbandry sites and 3 at Ndego and Kabare prospective irrigation sites.

Infrastructure development: On the basis of the development costs and feasibility assessment of irrigation schemes conducted under KIIWP1, KIIWP2 aims to implement 2,285 ha of irrigation command area. The Infrastructure Management Institutions will be enhanced, including the Sector Steering Committees, Hydrographic Basin Committees, and Irrigation Water User Organizations. For this sub-component the tender process for the recruitment of international company for the review of the detailed designs of Ndego irrigation scheme and conduct the Resettlement Action Plan for Kanyeganyege Irrigation Scheme, have initiated and are at evaluation stage.

Formation and capacity building scheme steering committees: Three steering committees are now operational; including one at District level committee and two at scheme level committees (Kanyeganyege and Rwinkwavu orchard schemes). Catchment management committees (level 3) were elected as initial step of steering committee formation.

Formation and Strengthening of Sub-catchment committees: Through a Memorandum of understanding between RAB and Rwanda Water Resources Board for the implementation of KIIWP II, 30 catchment committees were formed of which 1 committee at Nile Akagera Lower (NAKL) level one catchment, 3 committees at Kadiridimba, Ihema and Nasho catchments level 2.5 and 26 committees at level 3 sub-catchments. All these elected committees will help in planning and implementation of different project activities for the protection of different catchments.

Irrigation Water User Organisations: A total of 106 participants attended two study tours. The first was conducted on 18th April, 2024 tour in Murundi sector and Inyange Industries in Kigali, with 28 people including KIIWP Staff, Dairy Cooperatives leaders, Sector BDPO and Dairy Cooperatives staff recruited through the support of KIIWP. This tour aimed induction of newly recruited staff for operation and management of valley dams and boreholes developed under KIIWP-1. The second tour was organised on 9-10 May, 2024 with 78 Participants including KIIWP Project staff, District staff, Kanyeganyege prospectives irrigators, local leaders

participated in the study tour in Ngoma 22 irrigation scheme similar to Kanyeganyege scheme to be developed.

Enhancing Climate Smart Agriculture Practices and Technologies

Farmer Field School roll out, promoters and demo plots establishment: A study tour was organized with 58 participants; including 20 facilitators on maize and vegetables, 18 on beans and soybeans, 17 facilitators on cassava and Irish potato and 3 cooperatives representatives and support offices. The methodology used during the study tour focused on field Visit, meeting with farmer groups, discussion with FFS facilitators and Cooperatives committees, sharing experience, faced challenges, and mitigation measures. The facilitators are committed and able to transmit learnt technologies, organizing farmer groups and ensure development of smallholder farmers and valorization of available land. In addition, it is expected the improvement in the training and accurate information transmitted to farmers during the training. During season 2024B, the Project established different model farmers for staple crops such as maize (1), bean (1), sweet potatoes (2), Irish potato (3), and watermelon (1). Eight model farms (0.5 -1 ha each) were established with help of farmer cooperatives (1 model farm per cooperative and crop). A total of 397 demo plots were established, 202 in season 2024A, and 195 in 2024B: beans (26), soybeans (26), potato (43), maize (25), sweet potato (43), and vegetables (32). The demo-plots showed the technologies: improved seeds, fertilizers, GAP and their benefits (high yields); they were used for training of farmer groups using FFS approach and interactions with scientists, extension staff and development partners. They aimed to allow farmers to observe step by step how, to plant seeds in line, what quantities of fertilizer to use, how to apply them, how to weed, how and when to control pests and diseases, when and how to harvest and handle after harvest.

PICSA training

Following its introduction to Rwanda, the methodology was adopted by the IFAD funded projects as tool for supporting smallholder farmers to make informed decisions further to cope with climate risks and disaster. The operationalization of the tool was done through a Memorandum of understanding between Rwanda Meteorology agency and RAB/SPIU of IFAD Funded Projects on behalf of KIIWP project. Following the provision made at the time of project design, the PICSA approach is being implemented along with Farmer Field school approach whereby FFS facilitators are being targeted under Training of trainer's sessions (ToTs). Once graduated, the trained FFS facilitators will have to go back in their respective communities and train their fellow colleagues (mainly members of their FFS groups). A total of 164 FFS facilitators (78 females, 84 male)s were trained on Participatory Integrated Climate Services for Agriculture (PICSA). The trainees enhanced their skills on how to use PICSA approach; increased knowledge in agro-meteorology information products; interpreted weather forecasts at different time scales; plan and made decision on weather forecasts; increased their level of awareness of weather and climate information; provided their feedback on weather and climate information; received and used weather and climate information in their planning on daily activities.

Inputs for farmer's initial support

During this Fiscal year KIIWP2 intervened in providing inputs as an initial support to farmers. In total 20 tons of hybrid seeds of maize, 80 tons of DAP, 80 tons of urea ,31.5 tons of fortified

beans, 2,777,770 of vines of orange sweet potatoes have been purchased and distributed to the farmers to increase the productivity, production and income.

Supporting Backward and Forward Market Linkages

Support access to Market access: A workshop on farming as a business was organized. The workshop was conducted within three sessions held between March 12-13, March 18-19, and March 20- 21, 2024. Each session on average accommodated 90 participants to come up with a total of 270 facilitators (132 (49%) female and 138 (51%) male which includes three disabilities of which two are males and one female). Moreover, through RYAF partnership, 15 young graduates have been deployed to 15 cooperatives and remaining 7 young graduates have been deployed to support in production of fruit's trees. On the other hand, 7 groups from project intervention area were supported to exhibit their products in 16th National Agri-show and 100 project' beneficiaries visit the agriculture show to learn different technologies exhibited by different partners.

Support access to financial services: The training took place at Midland Hotel, Kayonza on 07-08th March 2024. It brought together 61 participants from KIIWP2 intervention areas and value chains including 48 cooperative leaders and 13 cooperative support staff from the Rwanda Youth in Agribusiness Forum (RYAF). The group composition reflected a 26% and 74% female and male participation rates respectively. A refresher training for farmer field school facilitators was conducted to set implementation modalities which Guide the FFS during season 2024A such as formation of Farmer groups, establishment of FFS plots, development of FFS curriculum. In total 286 facilitators trained on maize, potato and sweet potatoes, bean and soybeans, cassava, vegetables have been received a refresher training.

Institutional Development and Project Coordination

A MoU between KIIWP-2 project and partners (MINAGRI, RAB, RCA, Rwanda Water Resources Board, RYAF, Rwanda Meteo Agency and the BDF) have been signed. The workshops with the exporters of fruits have been organized at Ministry level and field visit was organized in Kayonza District (Field tour).

VI. PLANNING, MONITORING AND EVALUATION

VI. SUPPORT SERVICES

6.1 Planning, monitoring and evaluation (PM&E) unit

Planning, monitoring and evaluation unit has the mandate of developing technical tools for planning and managing data collection, analysis, and use. The PM&E process expands the logframe to identify key information requirements for each indicator and summarizes the key monitoring and evaluation tasks for the existing strategic plan (2020-2024) (Table 121). It helps staff to determine if the proposed indicators can effectively measure the results linked to the single action plan. A good application of monitoring and evaluation rules helps the institution to tackle accurate information from achieved and under implementation activities; information that are used for further planning, learning and accountability.

Table 121: National calendar of PM&E activities during FY 2023-24

National planning and Budget planning	Budget allocation	Districts
September 2023		
*Issuance of 2023-24 BL JSR ToRs; *Coordinate preparation of CCAs mainstreaming checklists	*CBMs retreat; *Preparatory SWGs meetings; *Prepare CCA mainstreaming checklists	*CBMs retreat
15-31 October 2023		
*Issuance of the 1 st PBCC to Bas; *Conduct refresher training for BAs on the PFM reforms and planning procedures & 1st PBCC; *Guide MDAs on planning requirements for the upcoming MTEF period & on the budget baseline based on the costing methodology; *Guide on 2022/23 Backward Looking Joint Sector Reviews (ToRs; technical/ quality support for reports, meetings); *Technical support for BAs to answer questions on baseline calculation	*Receive 1 st PBCC *Participate in training *Calculate the budget baseline *Conduct 2022/23 Backward Looking Joint Sector Review activities (prepare and submit draft reports to MINECOFIN; *Meetings)	*Receive 1 st PBCC Participate in training *Organize community participatory planning sessions
1-15 November 2023		
*Organize central and local government virtual consultative meetings in collaboration with MINALOC/LODA to agree on costing methodologies and provisional targets for the upcoming three FYs; *Assess the submitted baseline calculations and require amendments, if necessary; *Coordinate the PBCC annexes submissions & quality assurance; Consolidate the BA specific baselines into a total expenditure budget baseline;	*Participate in meetings; **Submit to MINECOFIN the final calculation of budget baseline; *Interact with MINECOFIN in case of clarification and amendment requirements on budget baseline; *Submission and Quality assurance of concerned PBCC annexes submissions	*Participate in meetings; *Calculate budget baseline; *Consider interventions done, District own revenues, NGO support; *Interact with Sector to clarify/amend requirements on budget baseline; *Submit budget baseline including CG priorities done at decentralized level; *Submit PBCC annex
15-30 November, 2023		
Guide MDAs during Data entry of action plans, investments in IFMIS in line with agreed budget baseline costing	Data entry for action plans/ investment in IFMIS as with budget baseline costing agreed by MINECOFIN	Data entry for action plans, investment in IFMIS as per budget base-line costing agreed with LODA. MINECOFIN
23-30 November, 2023		
Prepare PBOP draft with proposed strategic priority areas, projects and indicative budget ceilings	Consult BAs on expected sector priorities	Consult on expected sector and district priorities
15-31 December, 2023		
*Quality assurance of action plan in IFMIS based on budget baseline; *Budget revision; *Guide MDAs in budget revision of 2023/24 to ensure compliance with proposals from budget revision; *MINECOFIN submits indicative expenditure ceilings (total and BA specific) to Cabinet for approval as part of the PBOP	*Improve action plan and investments in IFMIS based on feedback from MINECOFIN; Budget revision; *Update action plans to ensure that 2023/24 plans/investment are aligned with budget revision; *Submit to MINECOFIN a detailed budget estimates and proposals for costed corrective action.	Same as left
7-14 Jan. 2024 (after Cabinet approval)		
MINECOFIN issues a PBOP and updated macroeconomic forecast, proposed strategic priority areas and projects, total and BA specific expenditure ceilings.	*Review Action plans in line with approved PBOP recommendations; *Prioritize expenditure to comply with set ceiling.	**Prioritize expenditure to comply with set expenditure ceilings.
23 Jan. – 15 February 2024		
*Organize Ministerial Planning Consultations Organize and hold a Public Investment Committee and LGPAC meetings for Central Government MINECOFIN submits indicative expenditure ceilings (total and BA specific) to Cabinet for approval as part of the PBOP	*Participate in Ministerial Planning Consultations; *Review Action plans in line with Planning Consultations and PIC recommendations	*Review Action plans in line with Planning Consultations and LGPAC recommendations
15-28 February 2024		
*MINECOFIN issues a second BCC which, based on the Cabinet approval of expenditure ceilings in the PBOP, instructs on drafting the budget estimates; *Guides and supports BAs to prioritize within set expenditure ceilings	*Review Action plans in line with Planning Consultations, PIC recommendations and BCC ceiling; *Develop costed proposals for corrective action in case existing programs and projects cannot be fully covered within set expenditure ceilings.	*Review Action plans in line with LGPAC recommendations and BCC ceilings; *Develop costed proposals for corrective action in case existing programs and projects cannot be fully covered within set expenditure ceilings.
21Feb.- 7 March .2024		
*Organize and hold Ministerial budget consultations	*Participate in the Ministerial budget consultations	*Interact with MINALOC, LODA, MINECOFIN to clarify or amend plans in IFMIS
National planning and Budget planning	Budget allocation	Districts
7-14 March, 2024		
*Guide and support BAs to adjust action plans and investment based on (i) recommendation from Ministerial planning & budget consultations and PIC and (ii) requirements of prioritizing expenditure as expressed in the indicative expenditure ceilings. *Guide and support BAs to prioritize within set expenditure ceilings.	*Incorporate recommendations from Ministerial budget consultations into priority setting within set expenditure ceilings.; *Submit to MINECOFIN by end of March revised draft action plans and investments in IFMIS; *Prioritize expenditure to comply with set expenditure ceilings; *Develop costed proposals for corrective action in case existing programs and projects cannot be fully covered within set expenditure ceilings; *Submit to MINECOFIN by end of February detailed draft budget estimates/proposals for costed corrective action.	*Submit draft district plans in IFMIS to MINALOC, LODA and MINECOFIN by end of March; *Prioritize expenditure to comply with set expenditure ceilings; * Develop costed proposals for corrective action in case existing programs and projects cannot be fully covered within set expenditure ceilings; *Submit to MINECOFIN by end of March detailed draft budget estimates and proposals for costed corrective action.
7-14 March 2024		
*Issue guidelines and roadmap for 2024/25 Imhigo and share it with Bas; *Review and disseminate Sector priorities and targets to be implemented by Districts for 2024/25	*BAs prepare draft 2024/25 Imhigo and share with MINECOFIN; *Share to MINECOFIN Sector priorities/targets to be implemented by Districts for 024/25	*Internal consultation with the District Stakeholders to identify priorities to be captured in Districts Imhigo; *Internal District consultations and review of sectoral priorities and targets.
April 2024		

*MINECOFIN prepares the BFP (with final expenditure ceilings); *MINECOFIN submits draft budget & BFP to Cabinet & Parliament. *Organize meetings with central & local governments, MINALOC/LODA to harmonize 2024/25 Imihigo priorities & targets; *Provide quality assurance of 2024/25 Imihigo; * Internal consultation with the District Stakeholders to identify priorities for District Imihigo; *Internal District consultations and review of sectoral priorities and targets.* Issues ToR for 2024/ 25 Forward Looking Joint Sector Reviews (FLJSR) and participates in FLJSR meetings; *Elaborate 2024/25 FLJSR calendar	Participate in consultative meetings with Central government to harmonize priorities and targets for 2024/25 Imihigo Incorporate the feedback from MINECOFIN on 2024/25 Imihigo from MINECOFIN *Develop FL JSR roadmaps	Participate in consultative meetings with Central government to harmonize priorities and targets for 2024/25 Imihigo Districts/CoK prepare draft 2024/25 Imihigo and share with MINECOFIN. Incorporate the feedback from MINECOFIN on 2024/25 Imihigo
May-June, 2024		
*Participate in the 2024/25 FLJSRs meetings; *Technical support/quality assurance for the 2024/25 FLJSR draft reports; *Parliamentary budget hearings; *Responds to issues from Parliamentary review; *Finalize Public Investment Programme; *Final budget approval – Finance Law (+ Districts Budgets Approval)	*Hold 2024/25 FLJSR meetings; *Submit to MINECOFIN signed 2024/25 FLJSR reports; *Participate in Parliamentary budget hearings; *Incorporate recommendations from Parliament; *Alignment of Action Plans' targets with budget allocated and Imihigo	*Participate in Parliamentary budget hearings; *Incorporate recommendations from Parliament; *Alignment of Action Plans' priorities and targets with budget allocated and Imihigo
July-August 2024		
*End 2023/24 FY Imihigo, projects annual reporting; *2023/24 Imihigo End year Evaluation; *2024/25 Imihigo finalization; *2024/25 Imihigo Validation;* Preparation for 2024/25 Imihigo signing event	*End 2023/24 FY Imihigo, projects annual reporting; 2023/24 Imihigo End year Evaluation; *2024/25 Imihigo finalization; *Participate in 2024/25 Imihigo signing	*End 2023/24 FY Imihigo, projects annual reporting; *2023/24 Imihigo End year Evaluation; *2024/25 Imihigo finalization; *Assure 2024/25 Imihigo signing

BA – Budget Agency; BCC – Budget Call Circular; BFP –Budget Framework Paper; BLJSR – Back Looking Joint Sector Review; CSO – Civil Society Organisations; FLJSR – Forward Looking Joint Sector Review; IFMIS – Integrated Finance Management Information System; LGPAC –Local Government Public Accountants Committee; MDA – Ministry, District and Agency; PBOP – Planning and Budget Call Circular; PIC – Public Investment Committee; SWG – Sector Working Group;

6.2 Legal advisory services

The role of legal advisory services is to advise the senior management of RAB to comply with regulations in force to prevent unnecessary legal issues and provide equal treatments to beneficiaries. The following tasks have been executed during this financial year by RAB legal advisory services during this fiscal year: Drafting and editing different draft bills and other Legal documents as requested; Rendering legal opinions and advice the Institution in matter related to the Acts, Agreements and any other commitments of RAB before its signature; Conducting preliminary investigations on litigious affairs in which RAB is involved; Representing RAB in justice sectors; and Requisition and follow up of RAB Land Titles.

6.3 Human resources management

Human resource management unit assures that rules and regulations governing public servants, ethics, entitlements and conditions of service and standard operational procedures regarding their daily responsibilities are respected. To ensure the effective HRM, RAB top management organised different meetings during FY2023-24 whereby HR related issues were raised and solved. Performance appraisals for all staff for the FY2023-24 were conducted, all staff were evaluated and based on the score received a bonus was given to performing staff, in addition to that during the celebration of lobar day, the best performer staff of the year was congratulated and awarded. In FY2023/24, RAB had a total of 297 staff ([Table 122](#)).

Table 122: RAB staff in FY 2023-24

Level	Total	Women	Men	% women employees
Top Management (DG, DDGs, CFO)	4	3	1	75%
Senior Management (HoDs, DMs)	8	3	5	38%
Director level	24	3	21	12.5
Professional Staff	202	64	138	31.6
Support staff	59	30	29	50.8
Total	297	103	194	35%

VII. NATIONAL REPORTING

7.1 NDC reporting for Agriculture

Rwanda is committed to achieve reduction of greenhouse gas emissions by 38% by 2050. To achieve this, several mitigation and adaptation options for greenhouse gas savings in agriculture were developed (Table 122). Although rigorous reporting system is under development at MINAGRI, RAB has been able to contribute to a number of mitigation and adaptation indicators in FY 2023-24.

Table 123: Progress achievements for NDC indicators in Agriculture, FY 2023-24

Project	Activity	Indicator	Achieved in FY 2023-24	Comments
Mitigation				
Crop production and biomass	Collect production volumes per crop	Volume of crop biomass from the reported yields	Reported by NISR, SAS reports	Production per crop is reported by NISR Seasonal Agricultural Survey
Livestock population	Report livestock numbers per species	Number of livestock per species	Reported	This report, page 159.
Nutrient use efficiency	Compost application (t/ha)	Quantity (tonnes) and area applied (ha)	4,278.5 tonnes produced by RAB	This report p.113 (for RAB); MIS-MINAGRI (for districts), NAEB (for tea and coffee)
	Deep fertilizer application and biomass use in rice production	Area with deep fertilizer application (ha); quantity of pellets applied (tonnes or kg)	NA	Data not collected, but survey of rice cooperatives could be done for use of pellets and rice biomass
Soil and water conservation	Terracing	Area of terraced land (ha)	New terraces established in 2023-24: 3,740ha radical and 20,793ha progressive terraces 22,428ha total); cumulative area:138,106.5 ha	This report, area reported on p. 160. RAB report on annual achievements 2for 2023-24, available as excel from RAB PME.
	Crop rotation	Area of cropland under rotation (ha)	705,726 ha under rotation	This area are equal to land consolidation sites that RAB is following up with districts and which are reported on p.121 of this report
	Banana-coffee intercropping	Area of intercropping (ha)	NA	Data not collected at RAB, but NAEB is currently running a project to promote it
	Conservation tillage	Area under conservation agriculture (ha)	4.3 ha maize and 3.2 ha banana under CA	The CA practice if not disseminated yet, data are not collected, good yield for maize obtained in research demoplots (Ref. this report for Maize and Banana).
Livestock husbandry	Improved fodder	Fodder area (ha)	11,718 ha	This report for fodder area planted - p.137; but

		Number of cows receiving high quality fodder		no data collected for number of cows with improved fodder
Livestock species	Improvement of livestock species	Percentage of crossbred livestock at national herd species	25% pure breed exotic cows; 59% crossbreeds; 16% local cows	This report, p.159.
Mineral fertilizers	Mineral fertilizer production and distribution	Quantity of each fertilizer type used by farmers	Reported	This report, pp. 119-121
Adaptation				
Develop climate resilient crops and promote climate resilient livestock	Variety improvement	Number of climate resilient crop varieties developed; Percentage of farmers adopting resilient crop/ varieties	21 varieties ready for release: 8 for maize; 10 for wheat; 3 for rice	RAB report in excel on Annual achievements for FY 2023-24, available from RAB PME unit
Develop climate resilient postharvest and value addition facilities and technologies	Capacity of storage constructed in metric ton (MT)	Number of shelters; Number of sheetings purchased; Capacity to dry grains (tonnes)	3,500 temporary shelters mobilized; cumulative: 14,941 shelters; 1,000 sheetings supplied; 14,000 t grains dried by drying machines	This report p. 98; RAB report in excel on Annual achievements for FY 2023-24, available from RAB PME unit
Strengthen crop management practices (prevention, diagnostic, surveillance and control)	Disseminate improved crop management practices	Number of farmers using surveillance tool (Fall Armyworm - FAW Database, BXW apps, etc.)	19,452 farmers received training on improved crop management practices	RAB report in excel on Annual achievements for FY 2023-24, available from RAB PME unit
Develop sustainable land mgt practices (soil erosion control; landscape management)	Establish soil protection measures	Area of Land under erosion control measures and used optimally (ha)	Reported	Reported under mitigation (only terraces); This report p. 160
Expand irrigation and improve water management	Irrigation establishment	Number of hectares under irrigation within IWRM framework	New area under irrigation: 4,044ha; cumulative: 138,106.5ha	This report p.171; RAB report on Annual achievements for FY 2023-24, available from RAB PME
Expand crop and livestock insurance	Promote livestock insurance	Number of cows under insurance	NA	MINAGRI, reported in MIS
Climate finance (Green Economy)				
	Activities		Amount, million USD	Comments
Domestic climate finance (direct/indirect)	NA	NA	NA	Data are expected to be available in new IFMIS
International climate finance (grants)	NA	NA	NA	Data are expected to be available in new IFMIS
International contribution to finance mitigation measures	NA	NA	NA	Data are expected to be available in new IFMIS

VIII. PUBLICATIONS

Year 2023

Abayisenga, J. C., Mbaraka, S. R., Nkurunziza, C., Shema, M. J., Murenzi, F., Rucamumihigo, F. X., Neeru J, P.Rushemuka, **Cyamweshi R.A. & Ndikumana, I. (2023)**. Effect of Soil Application of Stabilized Ortho Silicic Acid Based Granules on Growth and Yield of Rice (*Oryza sativa* L.). *Communications in Soil Science and Plant Analysis*, 54(4), 444-452.

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Habimana, S., Mukamuhirwa, A., Mbaraka, S. R., **Ndikumana, I.**, & Habinshuti, J. P. (2023). Performance Evaluation of Upland Rice (*Oryza Sativa* L.) Genotypes in Three Agro-Ecological Zones Of Rwanda. *International Congresses of Turkish Science and Technology Publishing*, 457-460.

Harerimana, T., Hatungimana, E., **Hirwa, C. D. A.**, & **Niyireba, R. T. (2023)**. Effect of hydroponic wheat fodder supplementation on dry matter intake and growth performances of piglets. *Scientific African*, 19, e01507.

Hitimana, E., Sinayobye, O. J., Ufitinema, J. C., Mukamugema, J., Rwibasira, P., Murangira, T., **Mvuyekure M.**, ... & **Ngabonziza, J. (2023)**. An Intelligent System-Based Coffee Plant Leaf Disease Recognition Using Deep Learning Techniques on Rwandan Arabica Dataset. *Technologies*, 11(5), 116.

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RAB Research (as per RAB Mandate) conducted in Fiscal Year 2023-2024 and published

Program	Research title versus RAB Research mandate (RAB staff in bold)	Type of document
Mandate 1. Fundamental and applied research that promotes agriculture and animal resources as well as their derived products		
DDG Agriculture	Gold, M., Niermans, K., Jooste, F., Stanford, L., Uwamahoro, F. , Wanja, M., ... & Nishimwe, K. (2023). Conversion of mycotoxin-contaminated maize by black soldier fly larvae into feed and fertilizer. <i>Journal of Insects as Food and Feed</i> , 1(aop), 1-14.	Paper
Crop Department	Senge, M. , Ouedraogo, M., Kagabo, D., Singh, M., & Landmann, T. (2023). Establishing an Agro-Advisory Committee (AAC) and its role in the management of FAW and Striga forecasting: Case of Rwanda.	Paper
Cereals	Silva, J. V., Jaleta, M., Tesfaye, K., Abeyo, B., Devkota, M., Frija, A., Habarurema I. , ... & Baudron, F. (2023). Pathways to wheat self-sufficiency in Africa. <i>Global Food Security</i> , 37, 100684.	Paper
Cereals	Habimana, S., Mukamuhirwa, A., Mbaraka, S. R., Ndikumana, I. , & Habinshuti, J. P. (2023). Performance Evaluation of Upland Rice (<i>Oryza Sativa</i> L.) Genotypes in Three Agro-Ecological Zones Of Rwanda. <i>International Congresses of Turkish Science and Technology Publishing</i> , 457-460.	Paper
Roots & Tubers	Armando, E. J., Nduwumuremyi, A. , Hanyurwimfura, D., & Gatera, O., (2024). A Novel lot-Ai Hybrid Kalman Filter Models for Agricultural Parameters Estimation. <i>Available at SSRN 4695741</i> .	Paper
Roots & Tubers	de Sousa, K., van Etten, J., Manners, R., Abidin, E., Abdulmalik, R. O., Abolore, B., Nduwumuremyi A. ... & Zaman-Allah, M. (2024). The tricot approach: an agile framework for decentralized on-farm testing supported by citizen science. A retrospective. <i>Agronomy for Sustainable Development</i> , 44(1), 8.	Paper
Roots & Tubers	Habimana, R., Habimana, J. P., Nyabinwa, P. , Manishimwe, R., Irimaso, E., Ntawubizi, M., Lajeune J., & Ferreira, J. P. (2024). Identification of Substandard and Falsified Veterinary Medicinal Products on the Rwandan Market Using the Global Pharma Health Fund Minilab®. <i>CEOS Vet Med Res</i> 2:1-20	Paper
Banana	Mugambi, S., Konlambigue, M., Gaidashova, S. , & Nyirahabimana, H. (2023). Banana market segmentation & value chain analysis for Rwanda: study report.	Paper

Postharvest program	Nyiranshuti A., Koskei, K., & Niyibituronsa, M. (2024) . Physicochemical and sensory evaluation of lemon grass leaves extracts enriched soy yoghurt from soybeans (Glycine max) milk. <i>Applied Research</i> , e202400013. https://doi.org/10.1002/appl.202400013	Paper
Land Husbandry Department	Jules MPORANA; Emmanuel MUSABYIMANA; Oswald SHYIRAMBERE; Leonidas DUSENGEMUNGU; Jacqueline TUYISENGE. "Study Report on Optimum Utilisation Plan of Ngoma 22 Irrigation Scheme." Volume. 9 Issue.9, September - 2024 International Journal of Innovative Science and Research Technology (IJISRT), www.ijisrt.com. ISSN - 2456-2165, PP:- 3220-3267, https://doi.org/10.38124/ijisrt/IJISRT24SEP1536	Paper
ISFM	Sugiyama, J., Sudo, N., Mukuralinda, A., Mujawamariya, P., Mukantwali, C., Ruganzu, V. , & Iiyama, M. (2023) . Evaluation of Food Security Using the Food Consumption Score in Rural Rwanda. <i>Journal of Asian Regional Association for Home Economics</i> , 30(1).	Paper
ISFM, Plant Biotechnology	Munyemana, J. , Kabano, I. H., Uzayisenga, B. , Cyamweshi, A. R. , Ndagijimana, E., & Kubana, E. (2024) . The role of national nutrition programs on stunting reduction in Rwanda using machine learning classifiers: a retrospective study. <i>BMC nutrition</i> , 10(1), 98.	Paper
DDG Livestock, Monogastrics	Ouma, E. A., Ntawubizi, M., Uwituze, S. , Lukuyu, B. A., Hirwa, C. D. A. , Marshall, K., & Karamuzi, D. (2024) . Profiting from pigs in Rwanda: Improving people's lives and livelihoods through more productive pig farming.	Paper
Ruminants	Perelli, C., Cacchiarelli, L., Mupenzi, M. , Branca, G., & Sorrentino, A. (2024) . 'Unlock the Complexity': Understanding the Economic and Political Pathways Underlying the Transition to Climate-Smart Smallholder Forage-Livestock Systems: A Case Study in Rwanda. <i>Economies</i> , 12(7), 177.	Paper
Ruminants	Schaedel, M., Ishii, S., Jungers, J., Venterea, R., Gutknecht, J., Paul, B., Mutimura M. , ... & Grossman, J. (2024) . Nitrogen Cycling Functional Gene Abundance and Potential Activity in Novel Perennial Forage Cropping Systems in Rwanda. <i>Available at SSRN 4351135</i> .	Paper
Ruminants	Schaedel, M., Majuga, J. C. N., Ishii, S., Jungers, J., Paul, B., Mutimura, M. , ... & Grossman, J. (2023) . Rhizosphere microbial community dynamics contribute to nitrogen fixation and forage quality in novel perennial intercrops in Rwanda. <i>Available at SSRN 4455825</i> .	Paper
Ruminants	Mugwaneza, D., Rwagasore, E., El-Khatib, Z., Dukuziyaturemye, P., Omolo, J., Nsekuye, O., ... & Manzi, M. (2024) . Factors Associated with Inappropriate Use of Antibiotics Among Animal Health Professionals in Selected Districts of Rwanda, 2021. <i>Journal of Epidemiology and Global Health</i> , 1-9.	Paper
Veterinary Laboratories	Musanayire, V. , & Dushimimana, J. de D. (2024) . Project Resources Management and Performance of Livestock Projects in Rwanda. A Case of Rwanda Dairy Development Project (RDDP) in Gicumbi	Paper

	District. <i>Journal of Entrepreneurship & Project Management</i> , 8(3), 26–36. https://doi.org/10.53819/81018102t2348	
Monogastrics	Harerimana, T., Hatungimana, E., Hirwa, C. D. A., & Niyireba, R. T. (2023) . Effect of hydroponic wheat fodder supplementation on dry matter intake and growth performances of piglets. <i>Scientific African</i> , 19, e01507.	Paper
Monogastrics	Ouma, E. A., Hirwa, C. , Ntawubizi, M., Uwituze, S. , Lukuyu, B. A., Marshall, K., ... & Dione, M. M. (2023) . The Rwanda pig value chains and ongoing initiatives.	Paper
Monogastrics	Niyiragira, V., Rugira, K. D., & Hirwa C.A.(2024). Optimizing pig artificial insemination with imported fresh semen: Key success factors. <i>African Journal of Pig Farming</i> 12(2): 1-8.	Paper
Aquaculture	Musoni, A., Uwizeyimana, C., Dusabemungu, G., Gatara, R., Nambajimana, P., Kanimba, A., Kayitesi, A. & Nyabinwa, P. (2023) . Effect of replacing dietary soybean meal with black soldier fly (<i>Hermetia illucens</i>) larvae meal on performance of Nile Tilapia (<i>Oreochromis niloticus</i>). <i>Livestock Research for Rural Development</i> , 35 (74).	Paper
Commercial Insects	Nganso, B. T., Ayalew, W., Wubie, A. J., Assefa, F., Belayhun, L., Ndungu, N. N., W.Mwiza ... & Subramanian, S. (2024) . Managed honey bee colony losses and causes during the active beekeeping season 2022/2023 in nine Sub-Saharan African countries. <i>bioRxiv</i> , 2024-04.	Paper
2. Research on the nature of forestry and agroforestry plants as well as plant varieties that are suitable for each area of the country		
ISFM	Cyamweshi, R. A. , Kuyah, S., Mukuralinda, A., Ngango, J., Mbaraka, S. R., Manirere, J. D., & Muthuri, W. C. (2023) . Farming with Trees for Soil Fertility, Moisture Retention and Crop Productivity Improvement: Perceptions from Farmers in Rwanda. <i>Small-Scale Forestry</i> , 22(4), 649-667.	Paper
ISFM	Cyamweshi, A. R. , Muthuri, C. W., Kuyah, S., Mukuralinda, A., Mbaraka, R. S., & Sileshi, G. W. (2024) . Pruning and green manure from <i>Alnus acuminata</i> improve soil health, and potato and wheat productivity in Rwanda. <i>Agroforestry Systems</i> , 98(2), 269-282.	Paper
Pulses	Niykiza, D. , Hewezi, T., Gill, T., Sams, C., Burch-Smith, T., & Pantalone, V. (2024) . Adaptability evaluation of US-developed soybean recombinant inbred lines in Rwandan conditions.	Paper
Roots & Tubers	Rukundo, P., Ndacyayisenga, T. , Vandamme, E., Nshimiyimana, J. C., & Thiago, M. (2024) . Performance of tetraploid biofortified potato clones in Rwanda. <i>Crop Science</i> , 64(3), 1284-1293.	Paper
3. Research on horticulture		

Plant biotechnology	Akiri, M., Mbugua, F., Njunge, R., Agwanda, C., Gurmessa, N. E., Phiri, N. A., Musebe R., JP Kalisa, B.Uzayisenga & Karanja, D. (2024). Intervention Options for Enhancing Smallholder Compliance with Regulatory and Market Standards for High-Value Fruits and Vegetables in Rwanda and Zambia. <i>Sustainability</i> , 16(14), 6243.	Paper
Coffee	Hitimana, E., Kuradusenge, M., Sinayobye, O. J., Ufitinema, C., Mukamugema, J., Murangira, T., Mvuyekure SM... & Ngabonziza, J. (2024). Revolutionizing Coffee Farming: A Mobile App with GPS-Enabled Reporting for Rapid and Accurate On-Site Detection of Coffee Leaf Diseases Using Integrated Deep Learning. <i>Software</i> , 3(2), 146-168.	Paper
Mushrooms (C-ARTDT)	Hu Y, Lu G, Lin D, Luo H, Hatungimana M , Liu B, Lin Z. (2024) Endophytic Fungi in Rice Plants and Their Prospective Uses. <i>Microbiology Research</i> . 15(2):972-993.	Paper
ISFM	Kuyah, S., Muthuri, C., Wakaba, D., Cyamweshi, A. R. , Kiprotich, P., & Mukuralinda, A. (2024). Allometric equations and carbon sequestration potential of mango (<i>Mangifera indica</i>) and avocado (<i>Persea americana</i>) in Kenya. <i>Trees, Forests and People</i> , 15, 100467.	Paper
Horticulture	Uwiringiyimana, T., Habimana, S., Umuhozariho, M. G., Bigirimana, V. P., Uwamahoro, F., Ndereyimana, A. , & Naramabuye, F. X. (2024). Review on Okra (<i>Abelmoschus esculentus</i> (L.) Moench) Production, Nutrition and Health Benefits. <i>Rwanda Journal of Agricultural Sciences</i> , 3(1), 71-87.	Paper
4. Research on climate change, its impact on agriculture, animal resources, and strategies on how to address them		
ISFM	Ndayisaba, P. C. , Kuyah, S., Midega, C. A. O., Mwangi, P. N., & Khan, Z. R. (2023). Push-pull technology enhances resilience to climate change and prevents land degradation: Perceptions of adopters in Western Kenya. <i>Farming System</i> , 1(2), 100020.	Paper
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DG	Rushingabigwi, G., Ishimwe, G. B., Irasubiza, E., Sugira, V. M., Bakunzibake, P., Ndabamenye, T., ... & Vodacek, A. (2023) . Design and Simulation of a Flood Forecasting and Alerting System: A Focus on Rwanda. In <i>2023 Photonics & Electromagnetics Research Symposium (PIERS)</i> (pp. 905-911). IEEE.	Paper
Roots & Tubers	Devkota, K., Dusingizimana, P., Cherif, M., & Nduwumuremyi, A. (2024) . Enhancing Maize Yield and Economic Viability Through Conservation Agriculture in Eastern Rwanda's Semi-Arid Regions. Available at SSRN 4853720.	Paper
ISFM	Kuyah, S., Muthuri, C., Wakaba, D., Cyamweshi, A. R. , Kiprotich, P., & Mukuralinda, A. (2024). Allometric equations and carbon sequestration potential of mango (<i>Mangifera indica</i>) and avocado (<i>Persea americana</i>) in Kenya. <i>Trees, Forests and People</i> , 15, 100467.	Paper
C-ARTDT	Li J, Lei Y, Wen Y, Zhu J, Di X, Zeng Y, Han X, Que Z, Hatungimana M , Rensing C, et al. (2024) Short-Term Effects of Cenchrus fungigraminus/Potato or Broad Bean Interplanting on Rhizosphere Soil Fertility, Microbial Diversity, and Greenhouse Gas Sequestration in Southeast China. <i>Microorganisms</i> . 12(8):1665.	Paper
Genebank	Niyibigira, T. , Mohammed, W., Tana, T., Lemma Tefera, T., & Rukundo, P. (2024). Sorghum farmers' perceptions of climate change, its effects, temperature and precipitation trends, and determinants of adaptation strategies in the central plateau zone of Rwanda. <i>Cogent Food & Agriculture</i> , 10(1), 2334999.	Paper
5. Research on diseases and pests that attack field and stored crops, put in place and implement appropriate control measures to prevent and control them		
Industrial crops	Hitimana, E., Sinayobye, O. J., Ufitinema, J. C., Mukamugema, J., Rwibasira, P., Murangira, T., Mvuyekure M., ... & Ngabonziza, J. (2023) . An Intelligent System-Based Coffee Plant Leaf Disease Recognition Using Deep Learning Techniques on Rwandan Arabica Dataset. <i>Technologies</i> , 11(5), 116.	Paper
Crop Protection	Machado, R. A., Bhat, A. H., Fallet, P., Turlings, T. C., Kajuga, J. , Yan, X., & Toepfer, S. (2023). <i>Xenorhabdus bovienii</i> subsp. <i>africana</i> subsp. nov., isolated from <i>Steinernema africanum</i> entomopathogenic nematodes. <i>International Journal of Systematic and Evolutionary Microbiology</i> , 73(4), 005795.	Paper
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Plant Biotechnology	Tambo, J. A., Uzayisenga, B. , Mugambi, I., Onyango, D. O., & Romney, D. (2023). Sustainable management of fall armyworm in smallholder farming: the role of a multi-channel information campaign in Rwanda. <i>Food and Energy Security</i> , 12(2), e414.	Paper
Plant Biotechnology	Tambo, J. A., Mugambi, I., Onyango, D. O., Uzayisenga, B. , & Romney, D. (2023). Using mass media campaigns to change pesticide use behaviour among smallholder farmers in East Africa. <i>Journal of Rural Studies</i> , 99, 79-91.	Paper
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Plant Biotechnology, Ruminants	Uzayisenga B, Mutimura, M. , Muthomi WJ. & Mwang'ombe A. O. W. (2024). Morphological and molecular characterization of the rust fungus, Phakopsora apoda causing leaf rust on Brachiaria grass in Rwanda. <i>African Phytosanitary Journal</i> , 4(1), 1-12.	Paper
6. Studies on soil characteristics and research on appropriate fertilizers and seeds that are suitable for each type of soil		
Program: ISFM (soil)	Hashakimana, L., Tessema, T., Niyitanga, F., Cyamweshi, A. R. , & Mukuralinda, A. (2023). Comparative analysis of monocropping and mixed cropping systems on selected soil properties, soil organic carbon stocks, and simulated maize yields in drought-hotspot regions of Rwanda. <i>Heliyon</i> , 9(9).	Paper
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C-ARTDC	Li J, Lei Y, Wen Y, Zhu J, Di X, Zeng Y, Han X, Que Z, Hatungimana M , Rensing C, et al. (2024) Short-Term Effects of Cenchrus fungigraminus/Potato or Broad Bean Interplanting on Rhizosphere Soil Fertility, Microbial Diversity, and Greenhouse Gas Sequestration in Southeast China. <i>Microorganisms</i> . 12(8):1665.	Paper
Roots & Tubers	Urinzwenimana C,, Borus, D., Niragire, I., & Ndacyayisenga, T. (2024) . Rwanda-Seed Potato Needs Assessment Report. Enhancing uptake of improved potato varieties through quality seed potato production and delivery mechanisms in Rwanda.(CIP Component of Pastta II) Project.	Paper