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Agronomic Practices, Favored Traits and Constraints of Cocoyam Production in the Southwestern Highlands Agroecological Zone of Uganda

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ABSTRACT

Although often neglected in agricultural research and development, Cocoyam (*Xanthosoma sagittifolium*) possesses considerable potential to improve household food and nutrition security while strengthening the resilience of smallholder farming systems. However, empirical evidence on farmers' production practices, preferred production traits, and production constraints remains limited in Uganda. This study assessed production practices, preferred production traits, and production constraints among cocoyam farmers in the Southwestern Highlands Agroecological Zone of Uganda. A cross-sectional survey involving 317 cocoyam farmers was conducted in Kabale and Kanungu districts using a multistage sampling approach. Data were collected using semistructured questionnaires and analyzed using descriptive statistics, Pearson's chi-square tests, and binary logistic regression. Cocoyam was predominantly cultivated in mixed cropping systems, mainly intercropped with banana, beans, and coffee under low-input smallholder agriculture. Suckers were the most preferred planting material, although farmers relied primarily on their own gardens and farmer-to-farmer exchange, highlighting the dominance of informal seed systems. Preference for large planting materials reduced the likelihood of selecting suckers (AOR = 0.09, 95% CI: 0.03–0.29) but increased the likelihood of selecting headsets (AOR = 3.29, 95% CI: 1.45–7.51). Production practices differed significantly between the two agroecological zones, with Kanungu characterized by greater use of wetlands, dry-season planting, ridge and line planting, monocropping and corms and cormels as planting materials, whereas Kabale exhibited greater fertilizer use, mixed cropping, and reliance on suckers. Larger cocoyam land size increased the likelihood of intercropping with coffee (AOR = 3.82, 95% CI: 2.15–6.78) but reduced the likelihood of intercropping with beans (AOR = 0.36, 95% CI: 0.21–0.61). Pest and disease incidence was generally low, while piecemeal harvesting and prolonged in-soil storage after maturity reflected the crop's importance as a living food reserve. Farmers prioritized drought tolerance, intercropping suitability, extended field longevity, and tolerance to poor soils as the most desirable production traits. The principal constraints were land shortage, lack of improved varieties, limited access to quality planting materials, declining soil fertility, and inadequate extension services. This study provides the first comprehensive empirical assessment of cocoyam production systems across contrasting agroecological environments in southwestern Uganda. The findings demonstrate that cocoyam is well adapted to diversified, low-input farming systems but that its productivity is constrained by a weak seed and extension systems and limited varietal improvement. The results provide evidence to guide farmer-oriented breeding, formal seed system development, and extension interventions aimed at improving cocoyam productivity and resilience in smallholder farming systems.

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1 | Introduction

Cocoyam (*Xanthosoma sagittifolium*) is among the neglected root and tuber crops cultivated primarily by smallholder farmers across tropical regions of Africa, Asia, and the Americas. Farmers mainly value cocoyam as it has the ability to perform under a wide range of environmental conditions while providing food, livestock feed, and supplementary household income. In addition, cocoyam contributes to food and nutrition security because its corms and leaves are rich in carbohydrates, dietary fiber, minerals, and vitamins [1–4]. Despite these attributes, cocoyam has received considerably less research, breeding and policy attention than major root and tuber crops such as cassava, sweet potato, and potato, resulting in limited technological development and low commercial exploitation.

Globally, cocoyam production has remained dominated by smallholder farming systems that rely basically on farmer saved seed and traditional agronomic practices. Existing research has largely focused on agronomic performance, genetic diversity, nutritional quality, and utilization of cocoyam, whereas comparatively little attention has been devoted to understanding farmers' management decisions and production behavior [5–7]. However, most published research has focused on the crop's nutritional composition, agronomic performance, genetic diversity, and utilization, with relatively less attention given to the human dimensions of production, particularly the factors influencing farmers' production decisions and management practices.

In Uganda, cocoyam is cultivated mainly by smallholder farmers, particularly in the Southwestern Highlands Agroecological Zone, where it contributes to household food security and complements diversified mixed farming systems [8]. The region is characterized by high population density, fragmented landholdings, declining soil fertility, and increasing climate variability, conditions that necessitate resilient crops capable of producing under resource-constrained environments. Nevertheless, cocoyam production remains largely informal, with limited access to improved planting materials, weak extension support, and poorly developed markets, all of which constrain productivity and wider adoption.

Despite the growing recognition of cocoyam as a climate-resilient crop, important knowledge gaps remain regarding its production under Ugandan smallholder farming systems. There is limited empirical evidence on how farmers select planting materials; organize cocoyam within mixed cropping systems; determine planting and harvesting practices; manage weeds, pests, and diseases; and allocate production resources under contrasting agroecological conditions. Similarly, little is known about the production traits farmers prioritize when cultivating cocoyam, including traits associated with productivity, climate adaptation, and compatibility with existing farming systems. Furthermore, the socioeconomic, agronomic, and institutional constraints which shape farmers' production decisions and limit cocoyam productivity have not been comprehensively documented. These knowledge gaps limit the development of farmer-responsive breeding programs, improved seed systems, context-specific extension recommendations, and evidence-based policies aimed at enhancing cocoyam production and commercialization. Understanding farmers' production behavior and preferences is fundamental to developing technologies that are both technically effective and readily adopted. Breeding programs require information on the traits farmers value most, while extension services and seed system interventions depend on a clear understanding of existing production practices and the constraints encountered by farming communities. Generating this evidence is particularly important in the Southwestern Highlands Agroecological Zone, where contrasting highland and relatively lower altitude production systems provide an opportunity to understand how agroecological conditions influence cocoyam production and management.

The study was guided by the following research questions: (i) What production practices do cocoyam farmers adopt in the Southwestern Highlands Agroecological Zone of Uganda? (ii) Which production traits do farmers prioritize? and (iii) What are the major production constraints affecting cocoyam production in the study area? Therefore, the study assessed the production practices adopted by cocoyam farmers, identified farmers' preferred production traits, and examined the major constraints affecting cocoyam production in the Southwestern Highlands Agroecological Zone of Uganda. The findings provide empirical evidence to guide farmer-oriented breeding programs, strengthen formal seed and extension systems, and support strategies for integrating cocoyam into climate-smart and sustainable agricultural development while enhancing household food and nutrition security.

2 | Materials and Methods

2.1 | Study Area Description and Sampling Frame

The study was conducted in the Southwestern Highlands Agroecological Zone of Uganda. This is because the area is one of the country's principal cocoyam-producing regions, where the crop is widely cultivated by smallholder farmers as part of mixed farming systems. The region spans a broad altitudinal gradient of 1262–3883 m above sea level (m a.s.l.), creating distinct agroecological conditions that differ in climate, soils, and cropping systems, thereby appropriate for evaluating cocoyam production under contrasting farming environments. The region is also characterized by high population density, severe land fragmentation, declining soil fertility, and experiences increasing climate variability, factors that threaten food security, and highlight the importance of resilient underutilized crops such as cocoyam. Despite the crop's contribution to household food security and rural livelihoods, limited scientific information exists on farmers' production practices, preferred traits, and production constraints across these contrasting production environments. Consequently, the study employed a multistage sampling approach combining purposive and simple random sampling [9]. The Southwestern Highlands Agroecological Zone was first stratified into two relatively distinct production environments based on elevation and dominant farming systems (Figure 1). The higher-elevation districts of Kabale, Kisoro, Rubanda, and Rukiga generally range from approximately 1800 to over 3000 m a.s.l. and are characterized by cooler highland conditions and farming systems dominated by annual crops such as potatoes, beans, vegetables, and sorghum. In contrast, the

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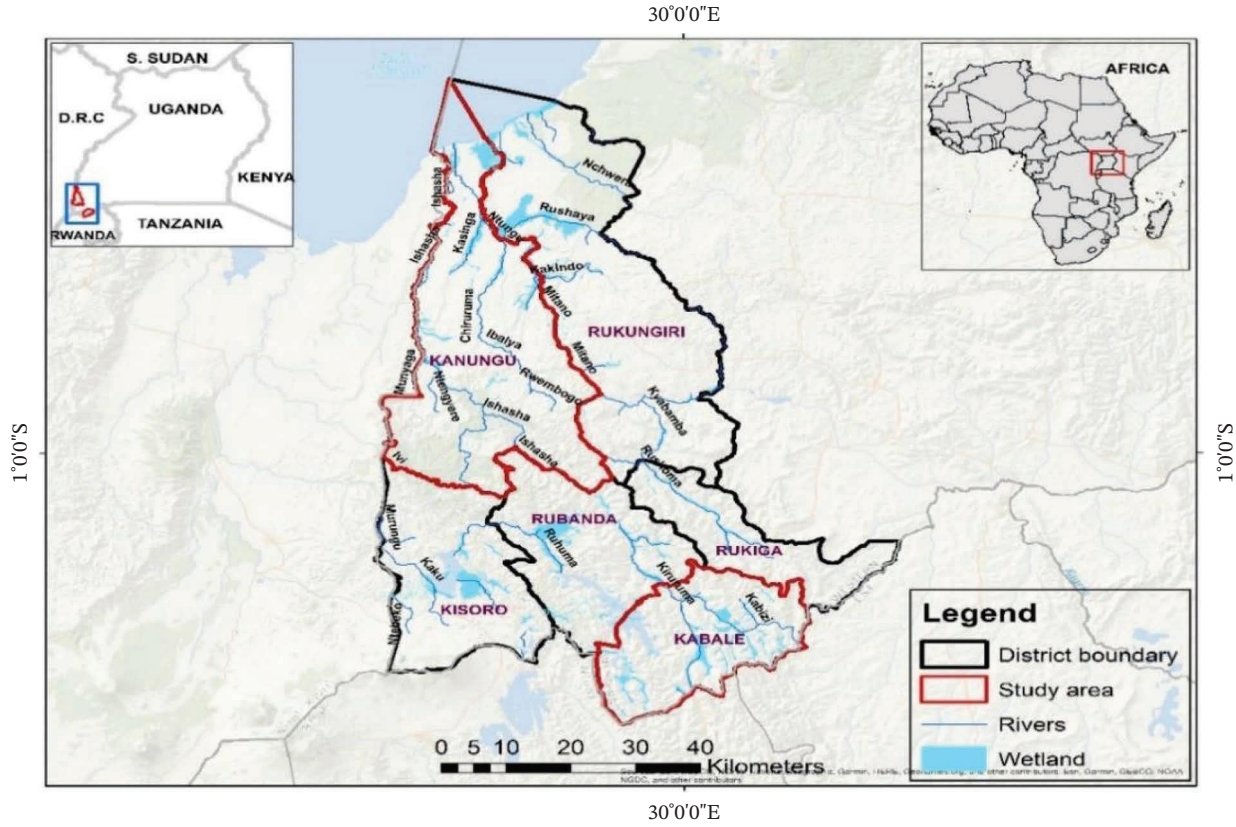


FIGURE 1 | A map showing the study area.

relatively lower-elevation districts of Kanungu and Rukungiri generally range from approximately 1262 to 2500 m a.s.l. and experience comparatively warmer conditions and are dominated by perennial cropping systems, particularly bananas and coffee [10]. To capture this agroecological variation, Kabale District was purposively selected to represent the higher-elevation production environment, whereas Kanungu District was selected to represent the relatively lower-elevation production environment. This sampling strategy aided comparison of cocoyam production across contrasting agroecological and farming system contexts. Within each district, two subcounties with the highest cocoyam production were selected using information from agricultural extension officers and local council leaders. At the village level, purposive selection targeted areas where cocoyam was commonly grown and where a relatively higher number of households engaged in its production. All cocoyam-growing households in the selected villages were included in the study, forming a census of cocoyam farmers within those villages. The final sample comprised 317 farmers (78 from Bugongi, 77 from Kanungu Town Council, 94 from Kibuga, and 68 from Maziba), with variation reflecting differences in cocoyam-growing household numbers across villages rather than random or proportional sampling.

2.2 | Study Area and Sampling Procedure

This cross-sectional survey was conducted in the Southwestern Highlands Agroecological Zone of Uganda, one of the country's key cocoyam producing regions. The region spans an altitudinal gradient of approximately 1262–3883 m a.s.l., creating contrasting agroecological conditions in terms of climate, soils, and cropping systems that are suitable for evaluating cocoyam production under different farming environments. It is also characterized by high population density, land fragmentation, declining soil fertility, and increasing climate variability. Despite cocoyam's importance to smallholder livelihoods and household food security, information on farmers' production practices, preferred traits, and production constraints across these contrasting environments remains limited.

A multistage purposive sampling approach was employed [9] to capture the diversity of cocoyam production environments. The Southwestern Highlands Agroecological Zone was first stratified into two contrasting production environments based on elevation and dominant farming systems (Figure 1). The relatively higher-elevation districts of Kabale, Kisoro, Rubanda, and Rukiga generally range from approximately 1800 to over 3000 m a.s.l. and are characterized by cooler highland conditions with farming systems dominated by annual crops such as potatoes, beans, vegetables, and sorghum. In contrast, the relatively lower-elevation districts of Kanungu and Rukungiri generally range from approximately 1262 to 2500 m a.s.l. and experience comparatively warmer conditions dominated by perennial cropping systems, particularly banana and coffee [10]. Kabale and Kanungu districts were purposively selected to represent the relatively higher- and lower-elevation production environments, respectively, thereby facilitating comparison of cocoyam production practices under contrasting agroecological conditions.

Within each district, two subcounties with relatively high cocoyam production were selected based on information provided by district agricultural extension officers and local council leaders. Two parishes were then selected from each subcounty,

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followed by two villages from each parish where cocoyam cultivation was common, resulting in four subcounties, eight parishes, and 16 villages. A cocoyam farmer was defined as a household that intentionally cultivated cocoyam for food, feed, or income generation, while households with naturally occurring or unmanaged cocoyam were excluded. All eligible cocoyam-growing households in the selected villages were surveyed, constituting a census of the target population. Consequently, no formal sample size calculation was performed, and the final sample of 317 farmers represented all eligible households identified during the village census.

The purposive selection of study sites ensured representation of the major cocoyam production environments in the Southwestern Highlands Agroecological Zone. Consequently, the inferential analyses were intended to compare the surveyed production environments rather than provide nationally representative estimates (Table 1).

2.3 | Data Collection

A semistructured questionnaire was developed following an extensive review of previous studies on cocoyam production systems, root and tuber crop management, and farmer surveys conducted in sub-Saharan Africa. The questionnaire covered respondents' sociodemographic characteristics, cocoyam production practices, preferred production traits, and production constraints. Before the main survey, the questionnaire was pretested with 20 cocoyam farmers outside the study area who possessed characteristics similar to those of the target population. The pretest evaluated the clarity, relevance, comprehensibility, logical flow, and completeness of the questionnaire. Based on respondents' feedback and recommendations from agricultural extension experts and university supervisors, ambiguous questions were revised, redundant items removed, and the sequencing of questions improved to enhance content validity and ease of administration. Similar questionnaire development and validation procedures have been recommended for agricultural behavioral and farm survey research [11, 12]. Enumerators were trained on the objectives of the study, interview procedures, ethical considerations, and consistent interpretation of questionnaire. Data were collected from **317 cocoyam farmers** selected from four subcounties: Bugongi ($n = 78$), Kanungu Town Council ($n = 77$), Kibuga ($n = 94$), and Maziba ($n = 68$), with two subcounties selected from each of the districts of Kabale and Kanungu. Face-to-face interviews were conducted using the revised questionnaire, which was administered in the local language to ensure clear communication and accurate responses. Participation was voluntary, and written informed consent was obtained from all respondents before data collection.

2.4 | Data Analysis

Data were first coded, cleaned, and thereafter analyzed using IBM SPSS Statistics Version 26. Descriptive statistics, including frequencies and percentages, were used to summarize respondents' sociodemographic characteristics, cocoyam production practices, preferred traits, and production constraints. Inferential statistical analyses were performed to examine relationships within the study population. Associations between categorical variables were evaluated using Pearson's chi-square tests. Binary logistic regression models were subsequently fitted to identify factors associated with selected cocoyam production practices. Variables included in the models were selected based on their biological relevance and evidence from previous literature. Regression coefficients (B), adjusted odds ratios (AORs), 95% confidence intervals, and p values are reported. Statistical significance was declared at $p < 0.05$.

3 | Results and Discussion

3.1 | Sociodemographic Profile of Cocoyam Farmers

Table 2 summarizes the sociodemographic characteristics of the respondents ($n = 317$). Females constituted the majority (59.0%), and sex distribution of respondents varied significantly across study sites. Most respondents were married (76.7%), while widowed individuals accounted for 16.7%. Educational attainment differed significantly across locations, with 30.9% having no formal education and primary education being the most common level. Farming was the dominant occupation (95.0%), and farmer group membership was relatively high (67.5%), though varying significantly by site. Most farmers had over 20 years of general farming experience (68.4%), whereas a smaller proportion (52.3%) had experience in cocoyam cultivation. Landholdings were small (about 0.1–3.9 acres for over 70% of farmers), and cocoyam was typically grown on small plots (0.1–0.5 acres for about 70%), indicating its complementary role in smallholder farming systems. Generally, the results show that cocoyam production is largely undertaken by experienced smallholder farmers, with women playing a prominent role. The predominance of farming as the main occupation, with generally small landholdings, indicates that cocoyam is produced within resource-constrained smallholder systems. The relatively lower cocoyam cultivation experience compared to general farming experience indicates that the crop is increasingly being integrated into existing farming systems. This trend likely reflects a strategic effort toward diversification; enhanced climate resilience given cocoyam's ability to withstand drought, pests, and diseases; and improved food security. Significant spatial differences in education levels, farmer group membership, farming experience, and cocoyam plot

TABLE 1 | Distribution of study sites and cocoyam farmers included in the survey.

District	Subcounty	Parishes (n)	Villages surveyed (n)	Cocoyam farmers (n)
Kanungu	Bugongi	2	4	78
	Kanungu Town Council	2	4	77
Kabale	Kibuga	2	4	94
	Maziba	2	4	68
Total	4 subcounties	8	16	317

Note: All cocoyam-growing households identified in the selected villages were included in the study; therefore, the reported numbers represent a census of cocoyam farmers within the selected villages.

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TABLE 2 | Sociodemographic characteristics of respondents in the study area.

Sociodemographic factors	Variables	Kabale *n*	Kanungu *n*	Total *n* = 317 (%)	χ^2	*p* value
Gender	Female	77 (41.2)	110 (58.8)	187 (59.0)	17.985	< 0.001
	Male	85 (65.4)	45 (34.6)	130 (41.0)		
Marital status	Single	4 (30.8)	9 (69.2)	13 (4.1)	3.431	0.33
	Married	130 (53.5)	113 (46.5)	243 (76.7)		
	Separated	4 (50.0)	4 (50.0)	8 (2.5)		
	Widowed	24 (45.3)	29 (54.7)	53 (16.7)		
Education level	None	72 (73.5)	26 (26.5)	98 (30.9)	34.332	< 0.001
	Primary	70 (46.4)	81 (53.6)	151 (47.6)		
	Secondary	14 (26.9)	38 (73.1)	52 (16.4)		
	Tertiary	6 (37.5)	10 (62.5)	16 (5.0)		
Household size	1–5 people	99 (49.7)	100 (50.3)	199 (62.8)	2.714	0.257
	6–10 people	63 (54.3)	53 (45.7)	116 (36.6)		
	≥ 11 people	0 (0.0)	2 (100.0)	2 (0.6)		
Primary occupation	Farming	159 (52.0)	147 (48.0)	306 (96.5)	2.784	0.249
	Formal employment	2 (33.3)	4 (66.7)	6 (1.9)		
	Informal employment	1 (20.0)	4 (80.0)	5 (1.6)		
Farmer group membership	Nonmember	24 (23.3)	79 (76.7)	103 (32.5)	47.2	< 0.001
	Member	138 (64.5)	76 (35.5)	214 (67.5)		
Agricultural experience (years)	≤ 10	14 (31.1)	31 (68.9)	45 (14.2)	17.801	0.003
	11–20	20 (36.4)	35 (63.6)	55 (17.4)		
	21–30	43 (56.6)	33 (43.4)	76 (24.0)		
	31–40	40 (60.6)	26 (39.4)	66 (20.8)		
	41–50	28 (58.3)	20 (41.7)	48 (15.1)		
	≥ 51	17 (63.0)	10 (37.0)	27 (8.5)		
Cocoyam farming experience (years)	≤ 10	29 (35.8)	52 (64.2)	81 (25.6)	17.966	0.003
	11–20	30 (43.5)	39 (56.5)	69 (21.8)		
	21–30	44 (59.5)	30 (40.5)	74 (23.3)		
	31–40	31 (68.9)	14 (31.1)	45 (14.2)		
	41–50	18 (58.1)	13 (41.9)	31 (9.8)		
	≥ 51	10 (58.8)	7 (41.2)	17 (5.4)		
Total farming land (acres)	0.1–1.9	43 (55.1)	35 (44.9)	78 (24.6)	19.684	0.001
	2.0–2.9	53 (60.2)	35 (39.8)	88 (27.8)		
	3.0–3.9	40 (57.1)	30 (42.9)	70 (22.1)		
	4.0–4.9	13 (46.4)	15 (53.6)	28 (8.8)		
	> 5.0	13 (24.5)	40 (75.5)	53 (16.7)		
Land under cocoyam (acres)	0.01–0.25	97 (75.8)	31 (24.2)	128 (40.4)	78.19	< 0.001
	0.26–0.50	49 (51.6)	46 (48.4)	95 (30.0)		
	0.51–0.85	1 (25.0)	3 (75.0)	4 (1.3)		
	0.86–1.10	13 (24.5)	40 (75.5)	53 (16.7)		
	> 1.10	2 (5.4)	35 (94.6)	37 (11.7)		

Note: Source: Field survey, 2025; *n* = number of respondents; (%) = percentage of respondents; χ^2 = chi-square.

allocation further highlight localized variations in adoption and production practices across the study area.

The significant demographic differences observed between Kabale and Kanungu provide important context for interpreting the variation in cocoyam production practices reported in subsequent sections. For example, differences in education level, farmer group membership, farming experience, and land allocation may partly explain the contrasting management practices observed between the two agroecological production environments. Higher levels of farmer group participation may enhance access to extension information and promote adoption of recommended practices, while differences in land resources and farming experience may influence cropping system choices, input use, and enterprise specialization. These socioeconomic differences, therefore, complement the effects of contrasting agroecological conditions in shaping cocoyam production systems.

3.2 | Cocoyam Production Practices

3.2.1 | Planting Materials Used, Preferred, and Their Sources

Table 3 shows the distribution of cocoyam planting materials used, preferred, and their sources across the study areas. The use

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TABLE 3 | Cocoyam planting materials used, preferred, and their sources.

Variables	Kabale *n* (%)	Kanungu *n* (%)	Total *n* (%)	χ^2 test	*p* value
Planting material used					
Suckers	156 (55.3)	140 (42.7)	296 (48.5)	4.57	0.033
Headsets	76 (27.0)	90 (27.4)	166 (27.2)	3.949	0.047
Corms	46 (16.3)	79 (24.1)	125 (20.5)	16.899	< 0.001
Cormels	4 (1.4)	19 (5.8)	23 (3.8)	11.28	0.001
Planting material preferred					
Suckers	98 (60.5)	94 (60.6)	192 (60.6)	0.001	0.978
Headsets	54 (33.3)	50 (32.3)	104 (32.8)	0.042	0.838
Corms	8 (4.9)	9 (5.8)	17 (5.4)	0.118	0.732
Cormels	2 (1.2)	2 (1.3)	4 (1.3)	0.002	0.965
Sources of planting material					
Own garden	146 (67.6)	139 (77.7)	285 (72.2)	0.017	0.895
Farmers	70 (32.4)	28 (15.6)	98 (24.8)	23.45	< 0.001
Wild	0 (0.0)	12 (6.7)	12 (3.0)	13.035	< 0.001

Note: Source: Field survey, 2025; n = frequency; χ^2 = chi-square statistic. Percentages are based on the total number of responses for each variable.

of cocoyam planting materials differed significantly between the two areas, with suckers predominating in Kabale, whereas corms and cormels were used more frequently in Kanungu. In contrast, farmers from both districts showed similar preferences for planting materials, with suckers being the most favorite followed by headsets. Planting materials were sourced mainly from farmers' own gardens, although sourcing from other farmers was more common in Kabale, while collection from wild occurred only in Kanungu.

The predominance of suckers can be accredited to their biological benefit since they have active buds and established meristematic tissues that encourage quick sprouting, strong early growth, high survival rates, and consistent field establishment under rain-fed conditions. These characteristics reduce the risk of establishment failure and enable faster canopy development, thereby making suckers principally attractive to cocoyam farmers. Headsets were also commonly used for their availability and ease of collection, whereas cormels and corms were less used as they are habitually reserved for consumption and livestock feed. The comparatively more use of corms and cormels in Kanungu may indicate seasonal shortages of suckers as well as differences in production systems. These findings are consistent with previous studies in cocoyam and other vegetatively propagated crops, which show that seeds with active growing points usually exhibit greater emergence and establishment, while farmers' choice of planting materials is mainly influenced by availability as was intended use [7, 13].

Farmers' preferences for cocoyam planting materials were similar with no significant statistical differences among the districts. This is indicative of a shared awareness that suckers are the most desirable planting material because they establish rapidly, have high survival rates, and produce vigorous plants, thereby reducing establishment failure and improving yield stability [14]. The greater use of corms and cormels in Kanungu, therefore, appears to reflect local availability of planting materials rather than differences in farmer preference. In informal seed systems, farmers commonly plant whichever propagules are available after harvest, particularly when suckers are scarce. Corms and cormels are easier to store and transport, allowing farmers to maintain production despite shortages of preferred seed. These findings suggest that farmers' planting material choices are driven primarily by the perceived performance, while actual use is constrained by local availability. Such flexibility is characteristic of cocoyam production systems, where planting materials are obtained mainly from farmers' own gardens or exchanged among neighboring farmers rather than through formal seed systems [7, 15].

Farmers obtained planting materials mainly from their own gardens, confirming the dominant role of informal seed systems in cocoyam production. While this pattern was similar across districts, Kabale farmers relied more on farmer-to-farmer exchange, whereas wild collection occurred only in Kanungu, indicating that natural populations remain supplementary sources of planting materials and genetic diversity. Although informal seed systems ensure a continuous supply of locally adapted propagules, repeated recycling without proper selection or sanitation may promote the accumulation of pests and pathogens, reducing planting material quality over time. These findings are consistent with reports that the absence of formal cocoyam seed systems remains a major production constraint in sub-Saharan Africa [7, 15]. Strengthening formal seed systems and improving access to clean planting materials would, therefore, enhance productivity while conserving valuable genetic resources.

3.2.2 | Cocoyam Planting Materials Selection Criteria

Binary logistic regression identified the factors influencing farmers' preference for cocoyam planting materials (Table 4). The models were statistically significant and explained 26.5% and 16.2% of the variation in preference for suckers and headsets, respectively, indicating moderate explanatory power. Planting material size was the strongest determinant of farmers' choice. Preference for large planting materials significantly reduced the likelihood of selecting suckers but increased the likelihood of selecting headsets, whereas preference for small planting materials showed the opposite relationship. These findings suggest that farmers associate larger propagules with greater food reserves, vigorous establishment, and improved crop performance, while smaller propagules, for instance, suckers, are preferred because they are readily available and easier to handle. Similar preferences for propagule size and quality have been reported in vegetatively propagated crops, where farmers' seed selection is largely driven by expected field performance and production objectives [15, 16].

Preference for pest-free planting materials significantly reduced the likelihood of selecting suckers, suggesting that farmers

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TABLE 4 | Binary logistic regression analysis of factors associated with farmers' preference for suckers and headsets as cocoyam planting materials.

Predictor	Suckers				Headsets			
	B	**SE**	**AOR (95% CI)**	***p* value**	**B**	**SE**	**AOR (95% CI)**	***p* value**
Availability	0.139	0.570	1.15 (0.38–3.51)	0.807	−0.277	0.514	0.76 (0.28–2.08)	0.59
Big size	**−2.362**	**0.570**	**0.09 (0.03–0.29)**	**< 0.001**	**1.192**	**0.420**	**3.29 (1.45–7.51)**	**0.005**
Medium size	−0.159	0.571	0.85 (0.28–2.61)	0.781	0.544	0.557	1.72 (0.58–5.13)	0.328
Small size	**2.923**	**1.039**	**18.60 (2.43–142.55)**	**0.005**	**−2.595**	**1.034**	**0.07 (0.01–0.57)**	**0.012**
Disease-free	−0.227	0.564	0.80 (0.26–2.41)	0.687	0.033	0.551	1.03 (0.35–3.04)	0.952
Pest-free	**−1.467**	**0.714**	**0.23 (0.06–0.93)**	**0.04**	0.846	0.671	2.33 (0.63–8.68)	0.207
Old	0.276	0.286	1.32 (0.75–2.31)	0.335	0.013	0.277	1.01 (0.59–1.74)	0.963
Young	1.036	0.566	2.82 (0.93–8.55)	0.067	**−1.634**	**0.632**	**0.20 (0.06–0.67)**	**0.01**
Model fit statistics								
Omnibus test X^2 (P)			69.17	< 0.001	39.26		< 0.001	
Nagelkerke R^2			0.265		0.162			

Note: Source: Field survey, 2025. Reference category = predictor not selected. B = regression coefficient; χ^2 = chi-square; R^2 = pseudo-R-squared (model explanatory power); p = overall model significance. Statistically significant estimates ($p < 0.05$) are shown in bold.
Abbreviations: AOR = adjusted odds ratio; CI = confidence interval; S.E. = standard error.

perceive suckers as having a higher risk of transmitting pests and diseases from the mother plant. Likewise, preference for younger planting materials significantly reduced the odds of selecting headsets, indicating that farmers associate younger propagules with greater vigor and rapid establishment. These findings support previous reports that the phytosanitary status and physiological quality of vegetative planting materials are key determinants of crop establishment, productivity, and sustainability [5, 16].

In contrast, although availability was the most frequently cited criterion in the descriptive analysis, it was not a significant predictor after adjustment for other planting material attributes. This suggests that farmers' final selection is influenced more by perceived quality than by access alone. Consequently, multiplication and dissemination programs should prioritize the production of large, healthy, and disease-free planting materials that align with farmers' preferences and improve productivity, thus enhancing the effectiveness of cocoyam commercialization initiatives [5].

3.2.3 | Cocoyam Cultivation Practices

Table 5 summarizes farmers' cocoyam cultivation practices including cultivation areas, planting time, planting methods, and fertilizer use in the two contrasting relatively high-altitude (Kabale) and relatively lower altitude (Kanungu) agroecological zones. Cocoyam cultivation practices varied significantly between the two locations indicating that farmers adapt production practices to local environmental conditions.

Upland cultivation dominated in both zones, accounting for 99.4% of farmers in Kabale and 92.8% in Kanungu, indicating that cocoyam is largely grown under well-drained upland conditions in southwestern Uganda. However, wetland cultivation was significantly more common in Kanungu than in Kabale, suggesting that farmers in the relatively lower-elevation areas make greater use of moist valleys moisture as they adapt to local environments and land scarcity. The predominance of upland cultivation further reflects cocoyam's compatibility with ease of management and integration into intercropping systems. These findings demonstrate that cocoyam production practices are strongly shaped by agroecological conditions, particularly topography, soil moisture, and drainage while also highlighting the crop's adaptability across contrasting production environments. Similar observations have been reported by Gelleh et al. [17] and Onyeka [4] who noted that *Xanthosoma sagittifolium* performs best in well-drained soils with adequate moisture but can adapt to a range of tropical agroecosystems depending on local environmental conditions.

Planting time differed significantly between the two districts, although rainy-season planting was the predominant practice overall (57.1% of responses) with no significant differences between the two districts. Dry-season planting was more common in Kanungu, likely reflecting its generally lower-altitude and coffee–banana production system, where perennial canopy cover may conserve soil moisture and permit earlier crop establishment. Kabale's high-altitude annual cropping systems on steep, erosion-prone slopes provide limited soil cover during the dry season, reducing soil moisture availability and prompting farmers to plant primarily at the onset of the rains to ensure successful crop sprouting and establishment. Approximately one-third of farmers planted at harvest time, with little variation between districts, indicating the widespread practice of recycling planting materials immediately after harvest to ensure continuous production and efficient land use. These findings demonstrate that planting decisions are largely shaped by local agroecological conditions, particularly rainfall patterns, temperature, and soil moisture availability. Similar observations have been reported by Eyasu et al. [7] and Osawaru and Ogwu [18], who noted that cocoyam establishment depends on adequate soil moisture and that planting is therefore commonly synchronized with the onset of the rainy season.

Planting methods differed significantly between the two contrasting agroecological zones. Flat-ground planting predominated (90.4% of responses) and was almost universal in Kabale, whereas ridge or mound planting was significantly more common in Kanungu than in Kabale. Similarly, line planting was

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TABLE 5 | Cocoyam cultivation practices.

Variables	Kabale *n*	Kanungu *n*	Total *n*	χ^2	*p* value
Areas of cultivation					
Upland	162 (99.4)	155 (92.8)	317 (96.1)		
Wetland	1 (0.6)	12 (7.2)	13 (3.9)	10.224	0.001
Time of planting					
Rainy season planting	143 (63.8)	144 (51.6)	287 (57.1)	1.983	0.159
Dry season planting	5 (2.2)	38 (13.6)	43 (8.5)	31.026	< 0.001
At harvest time	76 (33.9)	97 (34.8)	173 (34.4)	7.843	0.005
Planting method					
Flat ground planting	160 (98.8)	141 (82.5)	301 (90.4)	10.05	0.002
Mounds/ridges planting	2 (1.2)	30 (17.5)	32 (9.6)	28.658	< 0.001
Planting pattern					
Random planting	161 (99.4)	143 (85.6)	304 (92.4)	10.224	0.001
Line planting	1 (0.6)	24 (14.4)	25 (7.6)	24.099	< 0.001
Cropping system					
Mixed cropping	162 (98.8)	154 (88.5)	316 (93.5)	1.048	0.306
Monocropping	2 (1.2)	20 (11.5)	22 (6.5)	16.699	< 0.001
Fertilizer use					
No fertilizer use	99 (61.1)	137 (88.4)	236 (74.4)	30.979	< 0.001
Use fertilizer	63 (38.9)	18 (11.6)	81 (25.6)	30.979	< 0.001
Fertilizer types					
Organic fertilizer	63 (92.6)	18 (94.7)	81 (93.1)	30.979	< 0.001
Inorganic fertilizer	5 (7.4)	1 (5.3)	6 (6.9)	2.542	0.111

Note: Source: Field survey, 2025; Values are expressed as *n* (%). Percentages for Kabale, Kanungu, and total are column percentages of responses. χ^2 = Pearson's chi-square statistic; $p < 0.05$ indicates statistical significance.

practiced mainly in Kanungu, while random planting remained the dominant arrangement in both districts. These differences reflect adaptation to contrasting farming systems and environmental conditions. Kanungu's relatively lower-altitude, perennial banana, and coffee-based production systems favor ridges, mounds, and line planting to improve drainage, soil aeration, root development, and integration with companion crops, whereas Kabale's cooler relatively higher altitude environment, characterized by well-drained terraced fields and annual cropping systems, relies largely on flat-ground planting with minimal land preparation. The predominance of flat-ground and random planting further reflects the low-input nature of cocoyam production, where the crop is often considered secondary and receives limited labor and capital investment. However, evidence indicates that ridge or mound planting enhances drainage, root growth, and cormels yield, while line planting improves spacing, facilitates field management, and increases productivity [19–21]. Promoting these simple agronomic practices could, therefore, enhance cocoyam productivity without substantially increasing production costs.

Cropping systems differed significantly between the two contrasting agroecological zones. Mixed cropping overwhelmingly predominated, accounting for 93.5% of responses, with a higher proportion of farmers practicing it in Kabale than in Kanungu. In contrast, monocropping was relatively uncommon but occurred significantly more frequently in Kanungu than in Kabale. The predominance of mixed cropping demonstrates the central role of cocoyam in diversified smallholder farming systems of southwestern Uganda, where farmers commonly intercrop it with other annual and perennial crops to maximize productivity on fragmented landholdings. Cocoyam's shade tolerance, compatibility with perennial and annual crops, and low competition for resources make it well suited to these integrated systems. Mixed cropping also serves as an important risk-management strategy by improving resource-use efficiency, enhancing soil quality, strengthening resilience to climatic variability, and contributing to household food security and dietary diversity. The higher occurrence of monocropping in Kanungu may reflect relatively larger landholdings and greater commercialization, as well as the deliberate cultivation of cocoyam for soil fertility improvement before establishing other crops. These findings are consistent with previous studies from Uganda and other tropical regions, which report that cocoyam is predominantly cultivated in mixed cropping systems because of its adaptability, contribution to soil conservation, and compatibility with diverse cropping arrangements [7, 8, 22, 23]. Similar benefits of integrating cocoyam into diversified and agroforestry systems have also been reported by the authors in [24], who demonstrated improvements in resource-use efficiency, resilience, and farm productivity.

Fertilizer management differed significantly between the two contrasting agroecological zones. Only 25.6% of farmers applied fertilizers overall, with use being significantly more common in Kabale than in Kanungu. The relatively higher fertilizer use in

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Kabale is likely a response to greater land pressure, continuous cultivation, and accelerated soil nutrient depletion in the densely populated highlands, whereas farmers in Kanungu may depend more on inherent soil fertility and less intensive land use. Among fertilizer users, organic fertilizers accounted for over 93% of applications in both districts, while inorganic fertilizer use was negligible. Fertilizers were seldom applied directly to cocoyam but rather to companion crops, with cocoyam benefiting from residual nutrients, reflecting farmers' perception of the crop as low-input and the prioritization of scarce fertilizer resources for other crops considered to have higher value. The dominance of organic nutrient sources further highlights the integration of crop–livestock systems and limited access to mineral fertilizers among smallholder farmers. Although this practice reduces production costs, low fertilizer use has been identified as a major constraint to cocoyam productivity across sub-Saharan Africa [6, 25, 26]. Previous studies have also demonstrated that appropriate nutrient management, particularly through organic amendments, enhances soil structure, nutrient availability, moisture retention, and ultimately cocoyam growth and yield [19, 22, 27–29].

3.2.4 | Socioeconomic Drivers of Cocoyam Intercropping Decisions

Tables 6, 7, and 8 present the binary logistic regression models for factors associated with cocoyam companion crop selection. All five models were statistically significant explaining 14.3%–30.2% of the variation, indicating that although socioeconomic factors significantly influenced farmers' crop combination decisions, biophysical and institutional factors also have an effect.

The banana intercropping model was statistically significant and explained 15.8% of the variation in the outcome. Farmers with primary education and those belonging to farmer groups were less likely to intercrop cocoyam with bananas. The lower likelihood among farmers with primary education may reflect a shift toward more specialized production systems, although the influence of education is context-specific [30]. The reduced likelihood among farmer group members may indicate the influence of extension and training on enterprise choice, consistent with evidence that farmer groups improve access to agricultural information and extension services, thereby shaping technology adoption [30, 31].

The coffee intercropping model was statistically significant and explained 30.2% of the variation in the outcome. Cocoyam land size was the only significant predictor, with each additional acre increasing the odds of intercropping with coffee by approximately 3.8 times. This suggests that farmers managing larger cocoyam enterprises are more likely to integrate cocoyam into coffee systems to improve land-use efficiency and diversify farm income. The practice takes advantage of coffee's partial shade, which creates a favorable microclimate for cocoyam while utilizing the understory space, consistent with agroforestry systems that enhance resource-use efficiency, resilience, and productivity [22, 24, 32].

The binary logistic regression model for bean intercropping was statistically significant and explained 24.5% of the variation in the outcome. Farmers with secondary or higher education and those allocating larger areas to cocoyam were less likely to intercrop cocoyam with beans, suggesting a tendency toward more specialized production systems. The association between education and cropping decisions is context-specific, as education may facilitate the adoption of more market-oriented production strategies while reducing reliance on traditional mixed cropping systems [30]. In contrast, membership in farmer groups increased the odds of bean intercropping by approximately 82%, likely through improved access to extension, training, and information promoting legume integration for enhanced soil fertility, resource-use efficiency, and farming system resilience [31].

The cassava intercropping model was statistically significant and explained 14.3% of the variation in farmers' decisions. Older farmers were less likely to intercrop cocoyam with cassava, whereas farming experience increased the likelihood of this practice. These findings suggest that while advancing age may reduce willingness to adopt more complex intercropping systems, accumulated farming experience enhances the capacity to manage diversified production systems, consistent with the context-specific influence of age and the positive role of farming experience in technology adoption reported by Kule et al. [30]. However, the model exhibited convergence problems due to sparse observations or quasi-complete separation.

The sorghum intercropping model was statistically significant and explained 26.0% of the variation. Larger total farm size and greater farming experience increased the likelihood of intercropping cocoyam with sorghum, whereas increasing cocoyam land size reduced the odds of this practice. These findings suggest that larger farms are more likely to diversify cropping systems, while larger cocoyam enterprises tend to specialize in cocoyam production [33]. The positive effect of farming experience further highlights the importance of accumulated knowledge in managing intercropping systems [30].

3.2.5 | Cocoyam Diseases, Pests, Weeds, and Management Practices

Table 9 presents cocoyam diseases, pests, weeds, and their management practices. A small proportion of farmers reported diseases and pests affecting cocoyam, suggesting that biotic constraints were generally of low importance in the study area.

Among the reported diseases, blight was the most common, followed by root rot, leaf spot, and wilt. Disease occurrence differed significantly between districts, with root rot and wilt reported more frequently in Kanungu, whereas leaf spot accounted for a greater proportion of disease reports in Kabale. The higher incidence of root rot in Kanungu is likely associated with the district's relatively warmer and wetter production conditions, which favor the development and spread of soil-borne pathogens such as *Pythium* spp. responsible for cocoyam root rot. High soil moisture and poor drainage have been identified as major predisposing factors for root rot [34]. Although disease incidence was generally low, the occurrence of root rot and other diseases remains a potential production constraint, consistent with previous studies identifying these diseases as important factors limiting cocoyam productivity [4, 34]. Disease management relied heavily on cultural practices, with roguing accounting for 73.2% of responses and weed control 26.8%, differing significantly between districts. No farmers reported using chemical disease control, reflecting the low-input, subsistence nature of cocoyam production, and its limited agronomic investment. This suggests that cocoyam is well suited to low-input or

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TABLE 6 | Binary logistic regression analysis of factors associated with cocoyam intercropping with banana and coffee.

Variables	Banana			Coffee		
	B	AOR (95% CI)	*p* value	*B*	AOR (95% CI)	*p* value
Marital status	−0.496	0.61 (0.24–1.56)	0.303	0.594	1.81 (0.94–3.50)	0.077
Primary education	−1.354	0.26 (0.09–0.77)	0.015	0.559	1.75 (0.86–3.57)	0.124
≥ Secondary education	−0.349	0.71 (0.17–2.98)	0.635	0.589	1.80 (0.74–4.39)	0.195
Primary occupation	−0.298	0.74 (0.08–6.81)	0.792	−0.852	0.43 (0.12–1.55)	0.195
Age (years)	0.013	1.01 (0.97–1.06)	0.585	−0.027	0.97 (0.94–1.01)	0.105
Sex (male)	−0.384	0.68 (0.29–1.61)	0.381	−0.127	0.88 (0.48–1.61)	0.679
Farming land (acres)	−0.105	0.90 (0.72–1.12)	0.343	0.074	1.08 (0.93–1.24)	0.306
Cocoyam land (acres)	0.816	2.26 (0.79–6.46)	0.127	1.34	3.82 (2.15–6.78)	< 0.001
Farming experience (years)	−0.003	1.00 (0.95–1.04)	0.904	0.008	1.01 (0.98–1.04)	0.613
Cocoyam experience (years)	0.002	1.00 (0.98–1.02)	0.843	0.004	1.00 (0.99–1.02)	0.631
Farmer group membership	−1.618	0.20 (0.06–0.71)	0.012	−0.488	0.61 (0.35–1.09)	0.097
Omnibus test χ^2		25.06	0.009		78.98	< 0.001
Nagelkerke R^2		0.158			0.302	

Note: Source: Field survey (2025). *B* = regression coefficient. ≥ Secondary = secondary or higher education. Reference categories: married (marital status), no formal education (education), nonfarming (primary occupation), female (sex), and nonmember of a farmer group.
Abbreviations: AOR = adjusted odds ratio; CI = confidence interval.

organic production systems, although the minimal disease management also highlights the crop's neglected status despite the occurrence of diseases. Previous studies have similarly reported that disease management in cocoyam is generally inadequate because farmers either perceive the crop as naturally tolerant to most diseases or consider disease incidence too low to justify additional control measures [6, 8]. Strengthening farmer awareness of disease identification and promoting integrated disease management practices would help minimize disease spread while maintaining the crop's low-input production advantages.

Pest incidence was generally low as aphids accounted for 50% of pest observations, while mole rats and weevils each contributed 25%, with the latter occurring only in Kanungu, suggesting localized pest challenges possibly associated with banana–cocoyam intercropping. The low pest incidence may reflect both the crop's inherent tolerance and underreporting due to limited pest monitoring in smallholder systems, indicating that actual pest pressure may be underestimated. These findings further support the suitability of cocoyam for low-input production systems. Similar observations have been reported in previous studies,

TABLE 7 | Binary logistic regression analysis of factors associated with cocoyam intercropping with beans and cassava.

Variables	Beans			Cassava		
	B	AOR (95% CI)	*p* value	*B*	AOR (95% CI)	*p* value
Marital status	−0.132	0.88 (0.47–1.64)	0.679	0.656	1.93 (0.75–4.95)	0.174
Primary education	−0.429	0.65 (0.35–1.22)	0.181	0.197	1.22 (0.43–3.46)	0.713
≥ Secondary education	−1.375	0.25 (0.11–0.57)	0.001	0.762	2.14 (0.56–8.20)	0.266
Primary occupation	−0.076	0.93 (0.25–3.40)	0.909	19.022	Not estimable	0.999
Age (years)	0.021	1.02 (0.99–1.05)	0.181	−0.061	0.94 (0.90–0.99)	0.017
Sex (male vs female)	0.068	1.07 (0.61–1.88)	0.813	−0.29	0.75 (0.28–1.97)	0.557
Farming land (acres)	0.021	1.02 (0.89–1.17)	0.763	−0.161	0.85 (0.66–1.09)	0.207
Cocoyam land (acres)	−1.034	0.36 (0.21–0.61)	< 0.001	0.301	1.35 (0.77–2.37)	0.292
Farming experience (years)	−0.008	0.99 (0.96–1.02)	0.589	0.063	1.06 (1.02–1.12)	0.009
Cocoyam experience (years)	−0.004	1.00 (0.98–1.01)	0.625	0.005	1.01 (0.99–1.03)	0.594
Farmer group membership	0.598	1.82 (1.04–3.18)	0.036	−0.29	0.75 (0.32–1.74)	0.500
Model χ^2 (p)		64.22	< 0.001		21.85	0.026
Nagelkerke R^2		0.245			0.143	

Note: Source: Field survey (2025). Abbreviations and reference categories are in Table 6. The odds ratio for farming as the primary occupation in the cassava model was not estimable because of sparse observations, resulting in unstable parameter estimates.

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TABLE 8 | Binary logistic regression analysis of factors associated with cocoyam intercropping with sorghum.

Variables	Sorghum		
	B	AOR (95% CI)	*p* value
Marital status	−0.07	0.93 (0.30–2.91)	0.904
Primary education	0.924	2.52 (0.90–7.07)	0.079
Secondary + education	0.098	1.10 (0.22–5.52)	0.905
Primary occupation	−0.149	0.86 (0.08–8.96)	0.901
Age (years)	−0.008	0.99 (0.94–1.04)	0.752
Sex (male)	0.507	1.66 (0.60–4.56)	0.325
Farming land (acres)	0.257	1.29 (1.04–1.61)	0.021
Cocoyam land (acres)	−1.767	0.17 (0.04–0.68)	0.012
Farming experience (years)	0.047	1.05 (1.00–1.10)	0.047
Cocoyam experience (years)	0.011	1.01 (0.99–1.03)	0.236
Farmer group membership	1.188	3.28 (0.90–11.94)	0.072
Model χ^2 (p)		41.65	< 0.001
Nagelkerke R^2		0.26	

Note: Source: Field survey (2025). Abbreviations and reference categories are in Table 6.

which describe cocoyam as a relatively resilient crop affected by few pests with only sporadic outbreaks of aphids, weevils, caterpillars, and vertebrate pests occurring under favorable environmental conditions and inadequate field management [4, 34]. Pest control relied mainly on cultural practices, particularly roguing and weed control, with significant differences between districts. No farmers used chemical pesticides, reflecting low pest incidence and dependence on low-cost management options. The predominance of roguing suggests a reactive approach to pest management, consistent with previous studies showing that cocoyam is relatively less susceptible to insect pests than many other root and tuber crops, resulting in limited investment in pest control [6, 8]. Enhancing farmer awareness of pest surveillance and integrated pest management would support early pest detection and effective control while preserving cocoyam's low-input production system.

Blackjack (*Bidens pilosa*) and wandering jew (*Commelina benghalensis*) were the predominant weeds across both districts, while Macdonald's eye (*Galinsoga parviflora*) occurred significantly more frequently in Kanungu. Other weeds, including broadleaf wood sorrel (*Oxalis latifolia*), nut weed (*Cyperus rotundus*), black nightshade (*Solanum nigrum*), and amaranths (*Amaranthus* spp.), were reported at low frequencies with no significant district differences. The predominance of broadleaf weeds is likely attributable to the slow early growth and delayed canopy closure of cocoyam, which leaves the soil exposed to weed invasion. Previous studies have identified weeds an important constraint to cocoyam production, mainly during early growth stage [6, 35]. Weed management relied predominantly on traditional, nonchemical practices, with hand hoeing and hand pulling accounting for over 90% of responses. Hand hoeing was more common in Kanungu, whereas hand pulling predominated in Kabale, reflecting location-specific weed management strategies. Mulching and companion cropping also differed significantly between districts, while herbicide use remained negligible. The reliance on manual weeding highlights the low-input, labor-intensive nature of cocoyam production. Although environmentally friendly, manual weed control may constrain productivity where labor is limited. Previous studies have shown that cocoyam responds positively to timely weed management [27].

3.2.6 | Cocoyam Maturity, Postmaturity In-Soil Retention, and Harvesting Practices

The results presented in Table 10 illustrate cocoyam maturity time, duration in soil after maturity, and harvesting methods. The distribution of cocoyam maturity periods across the study locations was categorized into short-to-medium maturity (6–12 months) and long maturity (13–24 months) cycles.

Most farmers (95.5%) reported that cocoyam reached physiological maturity within 6–12 months, with no significant differences between the two agroecological zones. The similar maturity period suggests that farmers cultivate comparable, locally adapted landraces with consistent growth characteristics despite differences in production environments. The predominance of medium-maturing cultivars may reflect farmers' preference for varieties that balance timely food availability with adequate corm development. These findings are consistent with previous reports that most tropical cocoyam landraces attain physiological maturity within 6–12 months after planting [7, 36].

Approximately half of the farmers retained mature cocoyam in the soil for 7–12 months after physiological maturity, while about one-third harvested within 1–6 months, with no significant differences between districts. The widespread practice of in-soil storage reflects cocoyam's ability to remain edible for prolonged periods, allowing farmers to use the field as a living storage facility, reduce postharvest losses, and harvest according to household needs or market demand. The ability of some farmers to retain corms for more than 2 years further demonstrates the crop's resilience and value in enhancing household food security, consistent with reports of its excellent storage life [37].

Piecemeal harvesting was the predominant harvesting strategy across both districts, while single harvesting was significantly more common in Kanungu. The widespread use of piecemeal harvesting reflects cocoyam's ability to remain in the soil after maturity, enabling farmers to harvest as needed for household consumption or sale while maintaining the remaining corms as a living food reserve. The higher prevalence of single harvesting in Kanungu may reflect greater market orientation or integration with perennial coffee–banana production systems. Overall, piecemeal harvesting reduces postharvest losses, spreads labor requirements, and enhances household food security. The ability of cocoyam to remain in the soil after maturity supports piecemeal harvesting by protecting corms from adverse weather

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TABLE 9 | Cocoyam diseases, pests, weeds, and management practices.

Variable	Kabale *n* (%)	Kanungu *n*	Total *N* (%)	χ^2	*p* value
Diseases					
Blight	5 (45.5)	27 (50.9)	32 (50.0)	17.93	< 0.001
Root rot	1 (9.1)	16 (30.2)	17 (26.6)	14.701	< 0.001
Leaf spot	5 (45.5)	6 (11.3)	11 (17.2)	0.146	0.703
Wilt	0 (0.0)	4 (7.5)	4 (6.2)	4.234	0.04
Disease management					
Roguing	2 (66.7)	28 (73.7)	30 (73.2)	26.186	< 0.001
Weed control	1 (33.3)	10 (26.3)	11 (26.8)	8.05	0.005
Pests					
Aphids	3 (100.0)	5 (38.5)	8 (50.0)	0.608	0.436
Mole rats	0 (0.0)	4 (30.8)	4 (25.0)	4.234	0.04
Weevils	0 (0.0)	4 (30.8)	4 (25.0)	4.234	0.04
Pest management					
Roguing	3 (75.0)	13 (65.0)	16 (66.7)	7.059	0.008
Weed control	1 (25.0)	7 (35.0)	8 (33.3)	4.895	0.027
Weeds					
Bidens	149 (36.9)	146 (32.4)	295 (34.5)	0.604	0.437
Wondering jew	128 (31.7)	126 (28.0)	254 (29.7)	0.258	0.611
Macdonald's eye	41 (10.1)	91 (20.2)	132 (15.5)	36.365	< 0.001
Coach	47 (11.6)	50 (11.1)	97 (11.4)	0.393	0.531
Oxalis	29 (7.2)	31 (6.9)	60 (7.0)	0.227	0.633
Nut weed	10 (2.5)	6 (1.3)	16 (1.9)	0.876	0.349
Weed management					
Hand hoeing	143 (47.8)	152 (51.7)	295 (49.8)	11.762	0.001
Hand pulling	138 (46.2)	114 (38.8)	252 (42.5)	6.581	0.01
Companion crop use	5 (1.7)	15 (5.1)	20 (3.4)	5.821	0.016
Mulching	10 (3.3)	9 (3.1)	19 (3.2)	0.019	0.891
Herbicides	3 (1.0)	4 (1.4)	7 (1.2)	0.195	0.659

Note: Source: Field survey (2025). *n* = number of responses; % = percentage of responses within each category; multiple responses were allowed; χ^2 = Pearson's chi-square statistic.

conditions and maintaining a readily available food reserve for smallholder households [7, 21].

3.3 | Cocoyam Preferred Production Traits

Farmers' preferred cocoyam production traits were grouped into production system adaptation, agronomic performance, biotic stress tolerance, abiotic stress tolerance, and environmental service traits (Table 11). The order of preferred traits was drought tolerance, intercropping suitability, extended field longevity, tolerance to poor soils, and pest and disease resistance. Preference traits of extended field longevity, low seedbed requirement, tolerance to poor soils, and shade tolerance were significantly higher among farmers in Kabale than in Kanungu.

Among the production system adaptation traits, intercropping suitability was the most preferred, followed by extended field longevity, whereas low seedbed requirement was least preferred. The strong preference for intercropping suitability reflects the widespread practice of mixed cropping and the need to maximize land-use efficiency under severe land scarcity in both districts. This finding is consistent with previous studies showing that farmers value cocoyam for its compatibility with existing farming systems without requiring major changes in crop management [7]. Farmers in Kabale showed a significantly stronger preference for cocoyam with extended field longevity than those in Kanungu, likely reflecting the greater value of in-field storage under cooler highland conditions and seasonal food insecurity. The ability of cocoyam to remain in the soil for prolonged periods with minimal quality loss enables staggered harvesting, reduces postharvest losses, and strengthens household food security, making extended field longevity an important adaptive trait for smallholder farming systems [4, 7, 18, 21]. Preference for low seedbed requirement was significantly higher among farmers in Kabale, likely reflecting the district's steep terrain, where land preparation is labor intensive and prone to soil disturbance. Consequently, farmers favor crops that establish well with minimal tillage, reducing labor, and production costs. This preference aligns with cocoyam's ability to establish and grow

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TABLE 10 | Cocoyam maturity, postmaturity in-soil retention, and harvesting practices.

Variable	Kabale *n* (%)	Kanungu *n* (%)	Total *N* (%)	χ^2	*p* value
Maturity time					
6–12 months	123 (96.1)	134 (95.0)	257 (95.5)	0.176	0.675
13–24 months	5 (3.9)	7 (5.0)	12 (4.5)		
Time after maturity					
1–6 months	39 (24.1)	54 (34.8)	93 (29.4)	6.721	0.151
7–12 months	84 (51.9)	75 (48.4)	159 (50.3)		
13–18 months	7 (4.3)	4 (2.6)	11 (3.5)		
19–24 months	21 (13.0)	11 (7.1)	32 (10.1)		
Above 25 months	11 (6.8)	11 (7.1)	22 (7.0)		
Harvesting method					
Piecemeal harvest	161 (97.0)	152 (87.9)	313 (92.3)	1.105	0.293
Single harvest	5 (3.0)	21 (12.1)	26 (7.7)	11.515	0.001

Note: Source: Field survey 2025; *n* = number of respondents; % = percentage of respondents; χ^2 = chi-square.

well under minimal land preparation, making it well suited to low-input smallholder farming systems [6–8].

Within the agronomic performance category, tolerance to poor soils was the most preferred trait and differed significantly between districts, whereas high yield potential and weed competitiveness showed no geographical variation. Cocoyam was highly valued for its ability to produce satisfactory yields under low soil fertility conditions, with this trait being significantly more important to farmers in Kabale than in Kanungu. The stronger preference in Kabale likely reflects the severe soil degradation associated with steep slopes, continuous cultivation, and land fragmentation, coupled with limited access to fertilizers [38]. As the productivity of nutrient-demanding crops declines on degraded soils, cocoyam provides a resilient alternative because it can maintain acceptable yields on marginal lands with minimal fertilizer inputs, making it well suited to resource-constrained smallholder farming systems [1, 6, 7]. Preference for high yield potential did not differ significantly between districts, indicating that farmers across the agroecological zone place a similar value on this trait. This suggests that, rather than pursuing maximum productivity alone, farmers prioritize crops that combine high and stable yields under conditions of climatic uncertainty, declining soil fertility, and limited access to external inputs. Cocoyam is particularly valued because it produces substantial yields even under low-input management, with

TABLE 11 | Preferred cocoyam production traits.

Preferred traits	Kabale *n* (%)	Kanungu *n* (%)	Total *n* (%)	χ^2	*p* value
Production system adaptation traits					
Intercropping suitability	83 (15.5)	70 (16.7)	153 (16.0)	1.17	0.279
Extended field longevity	81 (15.1)	56 (13.4)	137 (14.4)	6.21	0.013
Low seedbed requirement	20 (3.7)	6 (1.4)	26 (2.7)	7.556	0.006
Agronomic performance traits					
High yield potential	30 (5.6)	31 (7.4)	61 (6.4)	0.112	0.738
Tolerance to poor soils	71 (13.2)	46 (11.0)	117 (12.3)	6.811	0.009
Weed competitiveness	22 (4.1)	14 (3.3)	36 (3.8)	1.628	0.202
Biotic stress tolerance traits					
Pest and disease resistance	51 (9.5)	63 (15.1)	114 (11.9)	2.888	0.089
Abiotic stress tolerance traits					
Drought tolerance	90 (16.8)	98 (23.4)	188 (19.7)	1.931	0.165
Shade tolerance	62 (11.6)	21 (5.0)	83 (8.7)	25.051	< 0.001
Waterlogging tolerance	13 (2.4)	6 (1.4)	19 (2.0)	2.426	0.119
Environmental service trait					
Soil erosion control	13 (2.4)	7 (1.7)	20 (2.1)	1.65	0.199

Note: Source: Field survey 2025; *n* = number of respondents; % = percentage of respondents; χ^2 = chi-square.

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planting materials obtained locally and minimal requirements for fertilizers and pest or disease control, resulting in low production costs. In addition, nearly all parts of the plant are utilized for food, animal feed, or traditional medicine, increasing its overall productivity and value per unit area. These characteristics have made high yield, coupled with production stability and multiple uses, a key factor driving the adoption of cocoyam by smallholder farmers in several African countries [6, 7]. Weed competitiveness received relatively few responses, suggesting that farmers placed lower priority on this trait. This may partly reflect the widespread use of manual weeding in the study area. Nevertheless, cocoyam's vigorous growth and dense canopy have been reported to suppress weed emergence by shading the soil [6].

Biotic stress tolerance traits included pest and disease resistance did not differ significantly between districts, suggesting that farmers perceive the trait as not very important. This is consistent with reports by Bammite et al. [6] and Tumuhimbise et al. [35], which indicated that cocoyam is affected by relatively few pests and diseases.

Among the abiotic stress tolerance traits, drought tolerance was the most preferred, followed by shade tolerance and waterlogging tolerance, with only shade tolerance differing significantly between districts. The strong preference for drought tolerance reflects farmers' increasing emphasis on climate resilience in response to unreliable rainfall and prolonged dry spells. In the largely rain-fed, low-input farming systems of the southwestern highlands, drought-tolerant cocoyam is valued for maintaining stable yields under moisture stress and enhancing household food security. Similar preferences for climate-resilient cocoyam traits have been reported across sub-Saharan Africa [1, 6, 7, 25]. Shade tolerance was significantly more preferred by farmers in Kabale, likely reflecting the greater importance of maintaining cocoyam productivity under the denser intercropping systems and limited land resources characteristic of the highland environment. Shade-tolerant varieties allow farmers to sustain yields under partial canopy cover without altering established cropping arrangements. This trait is particularly valuable in mixed cropping and agroforestry systems, where cocoyam is commonly grown with taller crops such as bananas and coffee, improving compatibility and land-use efficiency [7, 8, 22, 39]. Waterlogging tolerance received the few responses among the abiotic adaptation traits. The relatively low preference for waterlogging tolerance is consistent with the predominance of upland cocoyam cultivation in the study area, where few farmers grow the crop in wetlands. Nevertheless, waterlogging tolerance remains valuable for cultivation in poorly drained or seasonally flooded areas, providing farmers with greater flexibility to adapt to variable environmental conditions.

Environmental service trait of soil erosion control did not differ significantly between districts, suggesting that farmers primarily evaluate cocoyam based on its direct contribution to household production rather than its environmental benefits. Nevertheless, this trait has important ecological value, particularly in the study area's steep landscapes that are highly vulnerable to soil erosion. Cocoyam establishes rapidly, regenerates readily from different planting parts and maintains continuous ground cover through its broad canopy and extensive root system, which reduce surface runoff, protect the soil from the impact of heavy rainfall and wind, and minimize soil loss [7, 8]. Although these ecosystem services appeared to have limited influence on farmers' preferences, they represent an additional agronomic benefit that may be considered in extension efforts aimed at promoting sustainable land management.

3.4 | Cocoyam Production Constraints

Table 12 indicates that cocoyam production in the Southwestern Highland Agroecological Zone of Uganda faced multiple constraints categorized as socioeconomic (5), agronomic (5), biotic (3), abiotic (1), and institutional (1), with varying importance across study sites.

Among the socioeconomic factors, land shortage was the greatest constraint and occurred at similar levels in Kabale and Kanungu. Land shortage and scarcity are linked to high population density, which reduces per capita land availability and limits opportunities for cocoyam cultivation, as farmers tend to prioritize more popular staple and income-generating crops. Competition from other crops did not differ significantly between districts. In Kabale, cocoyam mainly competes with annual food crops, whereas in Kanungu, it competes with perennial crops such as coffee and banana. Due to its adaptability to shade and working as a cover crop, cocoyam is normally intercropped with other food and cash crops where it is always the minor crop in the system and experiences stiff competition for water and other soil resources [39]. Overharvesting of leaves was the only constraint that differed significantly between districts, occurring more frequently in Kabale, likely due to the greater use of cocoyam leaves as food and animal feed, which can reduce photosynthetic capacity and cormels development. Theft and low market demand were similar across districts, suggesting that they are widespread constraints that discourage prolonged in-field storage and limit farmers' incentives to expand cocoyam production beyond subsistence.

Among the agronomic constraints, the lack of improved varieties was the most frequently reported and did not differ significantly between districts, indicating a widespread challenge. Farmers continue to rely on traditional landraces propagated through informal vegetative systems due to limited breeding efforts and the absence of formal seed systems, a constraint similarly reported in Ghana and Togo [6, 34]. Limited planting materials were also common, although slightly more frequent in Kanungu. Dependence on recycled propagules restricts field expansion, increases the risk of pathogen accumulation, and reduces productivity, while the short storage life of planting materials and their competing use for food, feed, and planting further exacerbate shortages [1, 35, 40]. Herbicide-related crop damage and the perishability of planting materials were additional but less frequently reported constraints.

Biotic constraints did not differ significantly between Kabale and Kanungu, indicating that they are common across production systems despite differences in elevation and cropping patterns. Damage by domestic animals was the most important biotic constraint, followed by vermin attack and weed infestation. Crop damage was mainly caused by free-ranging pigs and chickens feeding on cocoyam leaves and corms. Although the generally low incidence of pests and diseases suggests that cocoyam is relatively resilient under smallholder conditions and well suited

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TABLE 12 | Constraints to cocoyam production by study area.

Variable	Kabale *n*	Kanungu *n* (%)	Total *n* (%)	χ^2	*p* value
Socioeconomic factors					
Land shortage	110 (17.4)	96 (17.9)	206 (17.6)	1.239	0.266
Competition from other crops	60 (9.5)	45 (8.4)	105 (9.0)	2.291	0.13
Leaves' overharvesting	64 (10.1)	38 (7.1)	102 (8.7)	8.156	0.004
Theft	55 (8.7)	43 (8.0)	98 (8.4)	1.43	0.232
Low market	38 (6.0)	42 (7.9)	80 (6.8)	0.556	0.456
Agronomic factors					
No improved varieties	59 (9.3)	57 (10.7)	116 (9.9)	0.004	0.948
Less planting material	34 (5.4)	43 (8.0)	77 (6.6)	1.965	0.161
Herbicide use	35 (5.5)	23 (4.3)	58 (5.0)	2.426	0.119
Perishable planting materials	8 (1.3)	8 (1.5)	16 (1.4)	0.008	0.928
Low yields	8 (1.3)	5 (0.9)	13 (1.1)	0.591	0.442
Biotic factors					
Domestic animals	46 (7.3)	35 (6.5)	81 (6.9)	1.408	0.235
Vermin's attack	20 (3.2)	25 (4.7)	45 (3.8)	0.931	0.335
Weeds attack	10 (1.6)	7 (1.3)	17 (1.5)	0.428	0.513
Abiotic factors					
Soil fertility decline	45 (7.1)	40 (7.5)	85 (7.3)	0.157	0.692
Institutional factors					
Low extension	42 (6.6)	28 (5.2)	70 (6.0)	2.845	0.092

Note: Source: Field survey 2025; *n* = number of respondents; % = percentage of respondents; χ^2 = chi-square.

to low-input production, damage by domestic animals and poor weed management remain important constraints to productivity.

Soil fertility decline was the only reported abiotic constraint and occurred at similar levels in Kabale and Kanungu, indicating that it is a widespread challenge across the study area. This reflects the combined effects of erosion on steep slopes, continuous cultivation, inadequate nutrient replenishment, and fragmented landholdings, consistent with the findings from potato production in southwestern Uganda [38].

The principal institutional constraint was limited extension services and did not differ significantly between Kabale and Kanungu, indicating inadequate extension support across the southwestern highlands. The limited policy recognition of cocoyam and prioritization of major crops by the few available extension workers restrict farmers' access to improved production practices, quality planting materials, soil fertility management, and market information. Similar findings have been reported elsewhere, where inadequate extension services constrain cocoyam production and commercialization [7, 34, 39].

3.4.1 | Study Limitations

This study employed purposive selection of districts, subcounties, and villages to ensure representation of the major cocoyam production environments within the Southwestern Highlands Agroecological Zone. Consequently, the findings should be interpreted as representative of the surveyed production environments rather than all cocoyam-growing areas of Uganda. In addition, although the sampling design was hierarchical, with farmers nested within villages, the binary logistic regression models treated respondents as independent observations and did not explicitly account for possible clustering at village level. Because only 16 villages and four subcounties were included, fitting reliable multilevel models were not considered appropriate due to the limited number of higher-level sampling units. Future studies should include a larger number of villages and apply multilevel or cluster-adjusted analytical approaches to better account for the hierarchical sampling structure.

3.5 | Conclusion

This study aimed to provide empirical evidence on the agronomic practices, farmers' preferred production traits, and production constraints of cocoyam (*Xanthosoma sagittifolium*) in the Southwestern Highlands Agroecological Zone of Uganda. The findings demonstrate that cocoyam production is predominantly cultivated within low-input mixed cropping systems, where farmers rely largely on informal seed systems, practice rainy-season planting, minimal fertilizer use, limited pest and disease management, piecemeal harvesting, and prolonged in-soil storage after maturity. Farmers consistently preferred traits associated with adaptation to local production conditions, particularly drought tolerance, intercropping suitability, extended field longevity, and tolerance to poor soils. However, cocoyam production remains constrained by land shortage, lack of improved varieties, declining soil fertility, limited access to quality planting materials, inadequate extension services, and weak market demand.

The observed differences in production practices between the higher- and lower-elevation production environments

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demonstrate that cocoyam management is influenced by local agroecological conditions. These findings provide a baseline for developing location-specific interventions aimed at improving cocoyam production in the Highlands of Southwestern Uganda Agroecological Zone.

Based on the study findings, efforts to improve cocoyam production should prioritize the development of varieties possessing farmers' preferred traits, strengthen access to quality planting materials through improved seed systems, promote appropriate agronomic practices, and enhance extension support. Future research should evaluate the agronomic performance of improved planting materials and management practices under different agroecological conditions and assess their effects on productivity and farmer adoption.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study can be obtained from the corresponding author upon request.

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