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Assessing Current Sorghum Agronomic Practices and Production Constraints in the Guinea and Sudan Savannahs of Ghana

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Abstract

Sorghum (*Sorghum bicolor* L. Moench) is a vital staple grain for both food security and income for smallholder farmers in the five northern regions of Ghana. Despite its nutritional and economic importance, yields are still below 2.0 tonnes per hectare due to biotic and abiotic factors. This study evaluated the agronomic practices, production constraints, and research priorities for Sorghum among smallholder farmers in the Guinea and Sudan savannahs. The study used semi-structured questionnaires to interview 80 experienced Sorghum farmers in four communities (Natugnia and Manyoro in the Guinea savannah and Manga and Narango in the Sudan savannah). Descriptive statistics, chi-square tests, and Kendall's coefficient of concordance were used for analysis. The results showed that males (72.5%) are the ones who manage the majority of Sorghum cultivation, with the majority of the farmers being married and between the ages of 30 and 39. While the adoption of improved varieties and crop rotation is limited and varied by community, the use of intercropping, organic fertilizers, no specific plant spacing, and weed control are commonly practiced. Positive correlations were found among practices such as pre-sowing seed treatment, crop rotation, soil conservation and residue management, and herbicide use. Poor soil fertility, inconsistent rainfall, and weed infestations were found to be the most significant production constraints. To increase Sorghum productivity, farmers prioritized research on poor soil fertility management (42.5%), climate adaptability (27.5%), and weed control (22.5%). The majority of respondents (87.5%) emphasized the importance of conducting research on sustainable farming practices. The findings highlight the need for targeted interventions that address soil fertility, climate resilience, and weed infestations, in addition to encouraging the adoption of improved agronomic practices, in order to increase Sorghum yields and ensure livelihoods in the Guinea and Sudan savannahs.

Keywords

Sorghum, Agronomic Practices, Constraints, Guinea and Sudan Savannahs

1. Introduction

Sorghum (*Sorghum bicolor* L. Moench), which grows in arid and semi-arid areas, is an essential cereal crop for dietary staples and food security [1]. The crop is primarily grown for subsistence by smallholder farmers in the five northern regions of Ghana [2]. Sorghum is a high-nutrient grain with 70% - 80% carbohydrates, 11% - 13% protein, 2% - 5% fat, 13% fibre, and 1% - 2% ash [3] [4].

Sorghum has recently gained popularity as an industrial crop. Industrial breweries have been using their grains in place of barley, which has allowed them to save money on foreign exchange while also providing additional revenue to local farmers [1] [5]. The Stover can also be used as a raw material to weave mats and baskets, which is a significant cottage business that helps rural women make money [6].

Despite its importance, yields in farmers' fields are under 2.0 tonnes/ha, far below the 4.5 to 5.0 tonnes/ha typical in developed countries [7] [8]. Current field trials showed that, with improved varieties and fertilizer, yields of Sorghum commonly exceed 1 t/ha (sometimes reaching 1.2 - 1.6 t/ha or more) [9] [10]. Recent district-level studies (2024-2025) for Tempane reported farmer yields are typically low but show clear gains when improved practices are adopted [11]. The livelihoods and food security of many smallholder farmers in northern Ghana are at risk due to these low yields [1] [12].

Climate vulnerability has a major impact on Sorghum production in the Guinea and Sudan savannahs due to the irregular rainfall patterns, low soil fertility, a lack of adoption of improved Sorghum varieties, limited access to improved seeds and fertilizers despite government subsidy programs, and a persistent *Striga* weed infestation that reduces yields by 30 to 50 percent. According to [13], despite Sorghum's enormous potential for malt production, a number of biotic, physiological, and edaphic limitations have resulted in extremely low productivity per unit area.

Among the biotic constraints limiting Sorghum productivity, the parasitic weed *Striga* commonly known as witchweed is particularly significant. *Striga* attaches to the roots of Sorghum plants, extracting water and nutrients, which severely stunts host growth, causes chlorosis and necrosis, and can lead to plant death. Yield losses due to *Striga* infestation can be as high as 65% or more, especially under drought conditions, making it one of the most damaging pests in Sorghum cultivation in sub-Saharan Africa [14]. Its resilience and adaptability complicate management efforts, exacerbating its threat to food security and farmer livelihood in the Guinea and Sudan savannahs of Ghana.

To boost Sorghum productivity in Northern Ghana, a number of tactics have been put forth and are presently being used, such as creating better cultivars, distributing premium seed, and using more fertilizer [15]. Even so, the crop's average yield in farmers' fields remains well below what can be attained, indicating that its full potential as a food security and cash crop remains largely untapped.

The Guinea and Sudan savannahs are impacted by soil infertility, which is a significant obstacle to Sorghum production. Many strategies have been proposed to increase Sorghum productivity on marginal soils. One of these is encouraging smallholder farmers to use fertilizer [7] [16]. Despite continued efforts, Sorghum farmers in Ghana and throughout Africa report low demand and little use of fertilizer [17] [18]. [19] state that this is primarily due to the high cost and unavailability of fertilizers in rural markets. Persuading smallholder farmers to fertilize the crop has proven challenging, even in the presence of fertilizers and subsidies [20] [21]. This implies that farmers' attitudes regarding the use of the agro-input may be influenced by factors other than its availability and affordability.

Another factor contributing to low Sorghum yields, especially in low-input cropping systems or subsistence farming systems, is the low adoption of improved Sorghum varieties by farmers in sub-Saharan Africa [22] [23]. For instance, improved Sorghum cultivars are grown on less than 2% of all farmed land in most of West Africa [24] [25].

From the perspective of smallholder farmers, who grow about 90% of Ghana's Sorghum [26] [27], it is vital to assess their current agronomic practices, production constraints, and issues that farmers would concur require further study in order to effectively address Sorghum production constraints. This information is crucial for developing plans that will boost the productivity of Sorghum grown by smallholder farmers in Ghana and across sub-Saharan Africa.

2. Materials and Methods

2.1. Study Site Description

A diagnostic case study was conducted in May/June, 2024, in four communities: Natugnia and Manyoro in the Kassena-Nankana Municipality, located at latitude 10˚45''N and Longitude 01˚06''W, and Manga and Narango in the Binduri district which lies on latitude 11˚1'0''N and longitudes 0˚16'0''W at an altitude of 249 m above sea level in the Upper East Region of Ghana (10˚45'0.00''N and 0˚45'0.00''E), which covers a land surface area of 8860 km^2, which is about 4% of the country (238534 km^2). The climate of the region is warm and Semi-arid, and the rainfall pattern is unimodal and characterized by a short rainy season from May to October/November with an annual mean rainfall of 950 mm, followed by a long dry season of six to seven months [1]. Temperatures are generally high (between 21˚ Celsius and 45˚ Celsius in the Guinea Savannah and (18˚ Celsius and 42˚ Celsius in the Sudan savannah). The natural vegetation in Binduri is mainly the Sahel savannah type with scattered shrubs, short grasses and trees compared to Guinea savannah woodland in Kassena-Nankana Municipal [1] [28]. The soil in the Guinea savannah has been described as savannah Ochrosols with Aeolian sandy loam according to the IUSS World Reference Base [29]. The soil in Binduri has been described as the Varempare Series, mainly sandy loam associated with homblende and granite.

2.2. Sampling Procedure and Sample Size

The study employed a multi-stage purposive sampling technique based on the dominance of Sorghum cultivation. The survey was conducted in four communities in the Guinea and Sudan savannahs (Kassena-Nankana Municipal and Binduri district, respectively), selected based on predominance in terms of Sorghum cultivation. In each district, two communities were purposely selected, and twenty farmers with experience in Sorghum cultivation were sampled in each community. The sample size for the analysis was calculated based on the Equation by [30].

$$n = \frac{N}{1 + N(\alpha)^2} \quad (1)$$

where n is the sample size, N is the total populace and α is the preferred level of accuracy.

$n = \frac{412}{1 + 412(0.1)^2} = 80$. Therefore, a total of 80 respondents were selected for the interview.

2.3. Research Design and Data Collection

The research was based on a quantitative approach. Despite using both primary and secondary data, the study gave primary data more attention. The primary data were collected through a semi-structured questionnaire by interviewing small-scale household farmers. The questionnaires contained both open-ended and close-ended questions. Household socio-demographic characteristics, Sorghum agronomic practices, production constraints, and farmers' research priorities were recorded.

2.4. Data Analysis

Data collected were analyzed using the Statistical Package for Social Sciences (IBM SPSS Statistics), Version 20. Pairwise correlation and chi-square tests were performed using the same computer package. Results were presented in the form of simple descriptive.

Farmers' perceived production constraints to Sorghum production were subjected to rank analysis using Kendall's coefficient of concordance (W).

The Kendall's concordance coefficient (W) is given as:

$$W = 12\left|\frac{\sum T^2 - \left(\sum T\right)^2}{m^2\left(n^2 - 1\right)}\right| \quad (2)$$

where T is the sum of ranks for each variable, m is the number of ranks and n is the number of constraints (variables) being ranked. Statistics using tables. The value of the W ranges between 0 and 1, with 1 representing perfect concordance between the farmers and 0 illustrating strong disagreement among the farmers in ranking the perceived production constraints.

3. Results

3.1. Household Socio-Demographic Characteristics

As shown in Table 1, the gender distribution shows that, with a mean of 72.5% male and 27.5 female, male respondents predominate in all communities. The male proportion of respondents is 65% in Kassena-Nankana communities (Natugnia and Manyoro), while it is 80% in both Binduri communities (Manga and Narango).

The majority of respondents (43.8% mean) are in the 30 - 39 age group (Table 1), with the 18 - 29 age group (26.2%) coming in second. While Narango has a comparatively higher percentage of younger respondents (40%) who are between the ages of 18 and 29, Manyoro has the largest number of respondents (35%), who are between the ages of 30 and 39. Relatively fewer responses fall into the older age groups (40 - 49 and 50 - 59).

Table 1. Household socio-demographic characteristics in each of the four communities.

Variables	Modalities	District/Municipal								
		Binduri				Kassena-Nankana				
		Manga		Narango		Manyoro		Natugnia		
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Mean (%)
Gender	Male	16	80	16	80	13	65	13	65	72.5
	Female	4	20	4	20	7	35	7	35	27.5
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Age	18 - 29	8	40	4	20	4	20	5	25	26.2
	30 - 39	7	35	9	45	13	65	6	30	43.8
	40 - 49	2	10	5	25	3	15	7	35	21.2
	50 - 59	3	15	2	10	0	0	2	10	8.8
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Marital status	Married	15	75	13	65	15	75	17	85	75.0
	Single	3	15	4	20	3	15	2	10	15.0
	Widowed	2	10	3	15	1	5	1	5	8.8
	Divorced	0	0	0	0	1	5	0	0	1.2
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**

Continued

Religious affiliation	**Christian**	**10**	**50**	**14**	**70**	**13**	**65**	**13**	**65**	**62.5**
	Muslim	4	20	2	10	2	10	2	10	12.5
	Traditionalist	6	30	4	20	5	25	5	25	25.0
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Employment status	Unemployed	2	10	2	10	5	25	1	5	12.5
	Farmer	18	90	18	90	15	75	19	95	87.5
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Respondent type	Household head	12	60	10	50	6	30	9	45	46.2
	Household representative	8	40	10	50	14	70	11	55	53.8
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Household size	1 - 2	1	5	1	5	0	0	0	0	2.5
	3 - 5	7	35	6	30	9	45	7	35	36.2
	6 - 8	8	40	6	30	6	30	4	20	30.0
	More than 8	4	20	7	35	5	25	9	45	31.3
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**

The average percentage of respondents is married (75%), with Narango having the lowest percentage (65%) and Natugnia having the highest (85%). The percentage of respondents who are single is 15%, widowed is 8.8%, and divorced is very low at 1.2%.

Christianity is the most common religion (62.5% overall), with Kassena-Nankana having the highest percentage at 70%. Muslims make up a minority (12.5%), while 25% of respondents identified as traditional religious.

Household heads represent 46.2% of the respondents, whereas the percentage of respondents who are household representatives is 53.8%.

The percentage of households with three to five people is 36.2%, and the percentage with six to eight people is 30%, and the percentage with more than eight people is 31.3%. Households of 1 - 2 people are uncommon (2.5%), larger households, especially in Natugnia, where over eight people make up 5% of households.

3.2. Sorghum Agronomic Practices

Table 2 indicates that the desire for different Sorghum varieties (DDSV), pre-sowing seed treatment (PSST), soil conservation, residue management (SCRM), integrated pest and disease management (IPDM), and herbicide (UH) usage are among the practices that do not significantly ($p > 0.05$) differ across communities.

However, the use of different Sorghum varieties (UDSV) (both local landraces and improved varieties) showed statistical difference across communities ($p = 0.010$). Narango exhibited the highest adoption rate of 60%, compared to 40% in

Manga and Manyoro (Table 2).

Community variation in crop rotation practices (PCR) is marginally significant ($p = 0.064$). In contrast to Narango and Natugnia (45%), adoption is notably higher in Manga and Manyoro (80%).

No significant differences were found (all $p > 0.99$), and some agronomic practices such as fertilizer usage (FU), plant spacing (PS), and weed control (WC), are almost universally adopted throughout all communities (100%, 99% - 100%, and 100% respectively). Similar to this, the majority (86%) of communities engage in intercropping (PI), with little variance across communities.

Table 2. Agronomic practices employed by Sorghum farmers across four communities.

		Binduri		Kassena-Nankana Municipal			
Variable	Pooled	Manga	Narango	Manyoro	Natugnia	Chi-Square	*p-value*
Sorghum varieties (both local and improved)	28 (35)	8 (40)	12 (60)	8 (40)		11.259	0.010**
Desire for different Sorghum varieties	76 (95)	20 (100)	18 (90)	20 (100)	18 (90)	0.593	0.898
Plant spacing	79 (99)	20 (100)	20 (100)	20 (100)	19 (95)	0.111	0.991
Pre-sowing treatment practice	54 (68)	14 (70)	15 (75)	14 (70)	11 (55)	1.333	0.727
Fertilizer usage	80 (100)	20 (100)	20 (100)	20 (100)	20 (100)	0.000	1.000
Crop rotation	50 (63)	16 (80)	9 (45)	16 (80)	9 (45)	7.259	0.064*
Soil conservation and residue management	38 (48)	11 (55)	9 (45)	11 (55)	7 (35)	1.630	0.653
Intercropping	69 (86)	17 (85)	17 (85)	17 (85)	18 (90)	0.111	0.991
Integrated pest and disease management	37 (46)	10 (50)	5 (25)	10 (50)	12 (60)	3.963	1.000
Weed control	80 (100)	20 (100)	20 (100)	20 (100)	20 (100)	0.000	1.000
Herbicide usage	41 (51)	8 (40)	12 (60)	8 (40)	13 (65)	3.074	0.380

Pooled = combined data of farmers surveyed across all four communities, values in parentheses are percentages of farmers practicing the variable within that group, Chi-Square and *p*-value are statistical test values evaluating differences across communities, Values without asterisk(s) are not significant.

3.3. Associations among Agronomic Practices

Correlations in Table 3 reveal pre-sowing seed treatment showed significant positive correlations with crop rotation ($r = 0.510$, $p < 0.01$), soil conservation and residue management ($r = 0.500$, $p < 0.01$), and herbicide usage ($r = 0.444$, $p < 0.01$).

Crop rotation is strongly correlated with soil conservation and management ($r = 0.737$, $p < 0.01$), integrated pest and disease management ($r = 0.408$, $p < 0.01$), and herbicide usage ($r = 0.329$, $p < 0.01$).

Additionally, soil conservation has a positive relationship with intercropping (r = 0.307, $p < 0.01$), integrated pest and disease management ($r = 0.373$, $p < 0.01$), and herbicide usage ($r = 0.327$, $p < 0.01$).

Soil conservation and residue management ($r = 0.404$, $p < 0.01$), crop rotation ($r = 0.298$, $p < 0.01$), pre-sowing seed treatment ($r = 0.285$, $p < 0.05$), and herbicide usage ($r = 0.244$, $p < 0.05$) are all positively connected with experimenting with different sorghum varieties.

Table 3. Relationships between Sorghum agronomic practices.

Variables	UDSV	DDSV	PS	PSST	PCR	SCRM	PI	IPDM	UH
UDSV	1.000								
DDSV	0.048	1.000							
	(0.672)								
PS	0.083	−0.026	1.000						
	(0.467)	(0.820)							
PSST	0.285*	0.208	−0.078	1.000					
	(0.010)	(0.064)	(0.491)						
PCR	0.298*	0.059	0.145	0.510*	1.000				
	(0.007)	(0.602)	(0.199)	(0.000)					
SCRM	0.404*	−0.011	0.107	0.500*	0.737*	1.000			
	(0.000)	(0.919)	(0.345)	(0.000)	(0.000)				
PI	0.065	0.075	−0.045	0.265*	0.291*	0.307*	1.000		
	(0.569)	(0.509)	(0.692)	(0.017)	(0.009)	(0.006)			
IPDM	0.213	−0.017	−0.121	0.162	0.408*	0.373*	0.079	1.000	
	(0.058)	(0.879)	(0.284)	(0.151)	(0.000)	(0.001)	(0.485)		
UH	0.244*	0.006	−0.110	0.444*	0.329*	0.327*	0.119	0.253*	1.000
	(0.029)	(0.960)	(0.333)	(0.000)	(0.003)	(0.003)	(0.293)	(0.024)	

**$p < 0.01$, **$p < 0.05$, *$p < 0.1$, UDSV = Have you experimented with different Sorghum varieties (both local and improved), DDSV = Do you wish to use different Sorghum varieties apart from what you have been planting, PS = Do you use plant spacing your cultivation, PSST = Do you follow any pre-sowing seed treatment practice, PCR = Do you practice crop rotation, SCRS = soil conservation and residue management, PI = Do you practice intercropping, IPDM = Do you employ any IPDM strategies, UH = Do you use herbicide in your Sorghum cultivation.

On the other hand, there is no significant relationship between the desire to use different varieties and other practices. However, there is a moderate correlation between intercropping and soil conservation and residue management ($r = 0.307$, $p < 0.01$), crop rotation ($r = 0.291$, $p < 0.05$), and pre-sowing seed treatment ($r = 0.265$, $p < 0.05$).

There are significant positive associations between integrated pest and disease management and soil conservation and residue management ($r = 0.373$, $p < 0.01$), and crop rotation ($r = 0.408$, $p < 0.01$).

Several practices, including pre-sowing seed treatment, crop rotation, soil conservation and residue management, integrated pest and disease management, and experimenting with different sorghum varieties, have positive correlations with the usage of herbicides (Table 3).

Desire for different varieties and plant spacing are two variables that do not significantly correlate with the majority of other practices.

3.4. Sorghum Production Constraints

The farmer reported constraints to Sorghum production across the four communities were ranked and analyzed using Kendall's coefficient of concordance (W). For each community, the W statistic showed moderate to strong agreement in ranking constraints. Manga ($W = 0.532$, $X^2 = 95.814$, $p < 0.001$), Narango ($W = 0.533$, $X^2 = 96.011$, $p < 0.001$), Manyoro ($W = 0.576$, $X^2 = 103.735$, $p < 0.001$), and Natugnia (W = 0.620, $X^2 = 111.589$, p < 0.001). Overall, combined ranking across the communities indicated a Kendall's W of 0.565 ($X^2 = 101.787$, $p < 0.001$), confirming significant agreement among farmers about the relative severity of constraints.

The most pressing issue overall is poor soil fertility, which ranks first in three of the four communities (Narango, Manyoro, and Natugnia) and second in Manga. It has the lowest mean rank of 1.82.

In every community, erratic rainfall patterns are consistently listed in the top three, making it the second most urgent concern (mean rank 3.32).

Although there is a significant difference between communities, weeds (4.15; Table 4), with Kendall's W = 0.565, ranking best in Manga and second in Narango but lower in Manyoro and Natugnia.

Inadequate water availability (4^{th} overall), a lack of access to high quality-seeds (5^{th}), pests and diseases (6^{th}) hold in between.

Farmers rank other limitations as less pressing or serious issues, such as lack of bullocks for ploughing (7^{th}), lack of technological support (8^{th}), market access and pricing (9^{th}), and labour shortage (10^{th}) (Table 4).

Table 4. Ranked farmer-reported challenges in Sorghum production across four communities.

	District/Municipal									
	Binduri				Kassena-Nankana					
Challenges	**Manga**		**Narango**		**Manyoro**		**Natugnia**		**Overall mean rank**	**Position**
	Mean rank	Position	Mean rank	Position	Mean rank	Position	Mean rank	Position		
Poor soil fertility	2.30	2nd	2.13	1st	1.40	1st	1.45	1st	1.82	1st
Insufficient water available	6.35	7th	5.50	7th	3.95	3rd	4.30	3rd	5.03	4th
Weed infestations	2.13	1st	3.40	2nd	5.75	5th	5.30	5th	4.15	3rd
Pests and diseases	5.70	6th	5.13	5th	6.40	7th	7.25	8th	6.12	6th
Lack of access to quality seeds	5.05	4th	5.45	6th	4.75	4th	5.00	4th	5.06	5th
Erratic rainfall patterns	4.28	3rd	3.95	3rd	2.75	2nd	2.30	2nd	3.32	2nd
Limited technological support	8.45	10th	8.50	9th	6.00	6th	5.45	6th	7.10	8th
Market access and pricing	7.20	8th	6.93	8th	8.35	10th	8.23	9th	7.68	9th
Lack of bullocks for ploughing	5.20	5th	4.78	4th	7.55	8th	7.13	7th	6.17	7th

Continued

Labour shortage	8.35	9th	9.25	10th	8.10	9th	8.60	10th	8.58	10th
N	20		20		20		20		20	
Kendall's Wa	0.532		0.533		0.576		0.620		0.565	
Chi-Square	95.814		96.011		103.735		111.589		101.787	
Df	9		9		9		9		9	
Asymp. Sig.	0.000***		0.000***		0.000***		0.000***		0.000***	

The highest score = 1 and the lowest = 10. Source: Field survey, 2024.

3.5. Priority Research Areas for Enhancing Sorghum Production

With 42.5% of respondents from all communities, poor soil fertility is the most commonly mentioned research need. The second most referenced study topic (27.5%) is climate variability. 22.5% of respondents said that weed infestation should be a major area of study. Research on inadequate inputs had the fewest record (7.5%) (Table 5).

Research on sustainable farming practices is viewed as "very important" by a significant majority of farmers (87.5% mean) across communities for the long-term viability of Sorghum cultivation. Just 12.5% of respondents think that research on sustainable practices is "important".

Table 5. Perceptions of farmers on key research areas for enhancing Sorghum production and the importance of sustainable farm practices in the two districts.

		District/Municipal								
		Binduri				**Kassena-Nankana**				
Variable	**Modalities**	**Manga**		**Narango**		**Manyoro**		**Natugnia**		
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Mean %
Research area (s) to enhance Sorghum production	Poor soil fertility	8	40	8	40	9	45	9	45	42.5
	Weed infestation	5	25	5	25	4	20	4	20	22.5
	Climate variability	6	30	4	20	7	35	5	25	27.5
	Inadequate inputs	1	5	3	15	0	0	2	10	7.5
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**
Importance of research for sustainable Sorghum cultivation	Very important	17	85	18	90	19	95	16	80	87.5
	Important	3	15	2	10	1	5	4	20	12.5
	Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**

Source: Field survey, 2024.

4. Discussion

In many rural Ghanaian societies, men are frequently the heads of households and main decision-makers. This is reflected in the preponderance of male respondents (72.5%, **Table 1**) across all communities [31]. However, the fact that there were a significant number of female respondents (27.5%) suggests that women are also important to agricultural and household management, which is in line with research by [32] that highlighted the contribution of women in northern Ghana. The distribution of household representatives (53.8%) and household heads (46.2%) indicates that different viewpoints within households were captured during data collection, which is crucial for comprehending the dynamics of intra-household decision-making [33].

There is a higher proportion of respondents in the 30 to 39-year age group (43.8%) than in the 18 to 29-year age group (26.2%), which is typical of rural agricultural communities in sub-Saharan Africa where the working-age population is the main source of farming labour [34]. The higher age group, 50 - 59 years, at 8.8%, may be a result of demographic shifts or migration patterns that affect labour availability and knowledge transmission [35].

Seventy-five percent of respondents were married, which is consistent with social norms in Ghana's rural areas, where marriage is an important institution that facilitates the establishment of households and the sharing of labour [36]. Single, widowed, and divorced people make up a lesser percentage. Their existence emphasizes the variety of household configurations that can influence vulnerability and resource distribution.

The most common religion was Christianity (62.5%), which was followed by traditional beliefs (25%) and Islam (12.5%). This pattern is indicative of the religious diversity seen in northern Ghana, where Islam and indigenous beliefs have coexisted with Christianity [37]. Access to community resources, social work, and farming methods can all be impacted by religious membership [38].

Local economies are agrarian, as evidenced by the vast majority of respondents (87.5%) identifying as farmers. The comparatively low unemployment rate of 12.5% might be a reflection of rural lives' emphasis on subsistence, as the majority of adults work in farming or associated occupations [34]. The need to understand socio-demographic elements while creating agricultural interventions is underscored by this heavy reliance on agriculture.

Household sizes were primarily medium to large. According to [39], extended family living arrangements that provide both labour and social support are frequently reflected in rural areas of Ghana, where large household sizes are typical. Nevertheless, large households can also experience more resource limitations, which could impact their ability to invest and ensure food security.

Significant differences exist between communities, with just 35% of farmers reporting employing both local landraces and improved Sorghum varieties. The adoption rate of Narango was highest at 60% (**Table 2**), indicating that this population had better access to or preferred varietal diversity. This finding is consistent with earlier studies showing that, in rural communities, access to improved seed types is frequently unequal due to factors like farmer awareness, extension services, and seed availability [40] [41]. In spite of this, a resounding 95% of farmers said they would like to use different Sorghum varieties, indicating that better germplasm is widely needed to increase resilience and production [42].

All the respondents across the communities practiced plant spacing using no specific measurements, which was almost universal (99%). According to [43], proper plant spacing is a well-established agronomic practice known to optimize resource use and increase yields. Similarly, 100% of respondents reported using fertilizer, particularly organic fertilizer, demonstrating strong adoption rates. This is noteworthy because the usage of fertilizer in sub-Saharan Africa's Sorghum agriculture is frequently restricted by access and cost [44]. The widespread fertilizer use in these communities indicates that input use techniques have been effectively disseminated, perhaps as a result of extension initiatives.

Overall, 63% of farmers practice crop rotation, with significant variation between communities. Adoption rates were higher in Manga and Manyoro (80%) than in Narango and Natugnia (45%). According to [45], crop rotation is essential for pests and diseases and preserving soil fertility.

Less than half of the farmers (48%) implemented soil conservation and residue management, with no significant differences between communities. Smallholder systems frequently have low adoption rates of these techniques because of labour shortages and low knowledge [43].

As a reflection of traditional mixed cropping systems that increase resource use efficiency and lower risk, intercropping was widely implemented (86%) (Beets, 1990). There was moderate uptake of integrated pest and disease management, as 46% of farmers used it. Lack of access to pest control inputs or a lack of understanding may be the cause of the comparatively low adoption of integrated pest and disease management [46].

The importance of weed control in Sorghum production was highlighted by the fact that it was 100% implemented everywhere. Although there were no appreciable variations within communities, just almost half of the farmers (51%) applied herbicides. According to [44], herbicides are excellent at controlling weeds, their use is often limited by issues with cost and safety.

Local landraces and improved varieties were tested, and the results indicated strong beneficial relationships with a number of important agronomic practices. Pre-sowing seed treatment, crop rotation, soil conservation and residue management, and herbicide use all showed positive correlations with variety experimentation. According to [31] and [45], these results imply that farmers who actively experimented with different Sorghum varieties are more likely to implement complementary crop and soil management strategies, demonstrating a comprehensive approach to Sorghum cultivation. This integrated adoption is in line with research showing that farmers who innovate in one area of farming typically implement several improved practices to increase resilience and overall productivity [46].

Intercropping, crop rotation, soil conservation and residue management, and herbicide use (**Table 3**) all showed strong positive associations with pre-sowing seed treatment. These correlations show that farmers who spend money on seed treatment also frequently use sustainable methods for managing pests and soil, which are proven to increase soil health, decrease pest incidence, and improve germination [43] [47].

Crop rotation was positively correlated with integrated pest and disease control, herbicide use, intercropping, and soil conservation and residue management. Crop rotation and soil conservation are closely related, which emphasizes how well they work together to manage pests and preserve soil fertility [45]. In a similar vein, intercropping and herbicide use were positively correlated with soil conservation, implying that farmers that implement conservation measures also frequently incorporate weed and pest control techniques.

The complementary nature of chemical and non-chemical pest control strategies was demonstrated by the positive correlation found between the usage of herbicides and integrated pest and disease management [48]. This relationship emphasizes how important it is to support integrated approaches, which blend multiple strategies for efficient pest control.

Poor soil fertility was shown to be the most significant challenge to Sorghum production. This result supports earlier research conducted in northern Ghana and other semi-arid regions, where crop productivity has been found to be primarily hampered by declining soil fertility brought on by continuous cultivation, nutrient depletion, and constrained access to fertilizers [49] [50]. The importance of soil fertility problems highlights how urgently nutrient replenishment plans and sustainable soil management strategies are needed.

Farmers' concerns about climate unpredictability and its detrimental consequences on crop yields and planting dates are reflected in the second-ranked overall category of erratic rainfall patterns. This is consistent with research showing how smallholder farmers in sub-Saharan Africa are particularly vulnerable to unstable rainfall patterns, which increase the risks to their livelihoods and food insecurity [51] [52].

Weeds third (4.15; **Table 4**), confirmed by Kendall's W = 0.565, were especially common in Manga and Narango. If not properly controlled, weeds drastically lower Sorghum yields by competing with Sorghum for nutrients, water, and light [53]. This problem is exacerbated by the labour-intensive nature of hand weeding and limited application of herbicides.

Limited access to high-quality seeds and insufficient water availability were also noted by farmers as significant obstacles. Sorghum production is limited by water constraints, especially during critical growth stages, while crop vigour and germination are impacted by seed quality [40] [41]. Pest and disease problems came in sixth overall, suggesting a moderate level of concern but emphasizing the need for better pest and disease management techniques.

Problems with labour shortages, market access and pricing, poor technological support, and a scarcity of bullocks for ploughing were lower. These factors affect total farm productivity and profitability even if there are less direct production limitations [44].

Farmers prioritize soil fertility (42.5%), climate variability (27.5%), and weeds (22.5%; **Table 5**), with 87.5% emphasizing sustainable practices research. This finding is consistent with extensive literature documenting soil fertility decline as a major constraint to crop productivity in semi-arid regions of Ghana [49] [50]. Research into efficient methods for managing soil fertility and restoring it is necessary because continuous cultivation without sufficient fertilizer replacement causes nutrient loss.

According to farmers, concerns about unpredictable rainfall, droughts, and their effects on crop yields and climate variability were the second most identified research area. This worry aligns with research that highlights the need for adaptable agricultural methods immediately and the susceptibility of smallholder farmers in northern Ghana to climate change [51] [52].

The importance of weed infestation as a biotic stressor that lowers Sorghum yields by competing for light, water, and nutrients was highlighted by its ranking third [53]. The comparatively lower priority given to inadequate inputs indicates that farmers view biophysical limits as more pressing issues, even though access to high-quality seeds and fertilizers is still crucial.

The vast majority of farmers in the communities said that research on sustainable farming practices was deemed "very important" for the long-term viability of Sorghum cultivation. The need for smallholder farmers to adopt techniques that preserve soil health, conserve resources, and improve resilience to environmental stressors is becoming increasingly apparent, as evidenced by this strong recommendation [43] [45].

Agriculture extension services play a significant role in translating these findings into practical support for smallholder Sorghum farmers by emphasizing education and farmer training focused on sustainable soil fertility management, climate-resilient practices, and integrated weed control [1] [11]. Extension programs tailored to local contexts can facilitate adoption of improved varieties and effective agronomic techniques by utilizing demonstration plots and farmer field schools. Meanwhile, policymakers should enhance input availability and affordability through subsidies and strengthened local seed systems, alongside investing in rural infrastructure to improve resilience against erratic rainfall and pest pressures. Coordinated actions between extension agents and policymakers are crucial for creating an enabling environment that fosters adoption of sustainable Sorghum production practices, thereby improving productivity and livelihoods in the Guinea and Sudan savannahs.

While this study provides valuable insights into Sorghum agronomic practices and production constraints, certain limitations should be acknowledged. The specific location focuses on only four communities within the Guinea and Sudan Savannahs of Ghana. This limits the ability to generalize the findings to other regions that may have different environmental and socio-economic contexts [1] [7].

Furthermore, the sample size of 80 Sorghum farmers, although adequate for exploratory analysis, may not fully capture the diversity and variability of farming practices and constraints among the broader population of smallholder Sorghum farmers in the region [11]. These factors may influence the external validity of the results, and thus caution is advised when extrapolating these findings beyond the studied areas. Further research involving larger and more geographically diverse samples is recommended to enhance the generalizability and applicability of the conclusion drawn.

Productivity and environmental sustainability in the face of climate change depend on sustainable practices, including conservation agriculture, integrated pest management, and effective water usage [50].

5. Conclusions and Recommendations

Sorghum production in the Guinea and Sudan savannahs is constrained by poor soil fertility, erratic rainfall, and heavy weed infestation, particularly *Striga*. Due to limited access to improved varieties, high-quality seeds, and inputs, yields remain poor even with the widespread adoption of fundamental agronomic practices such as organic fertilizer use, weed control, and no specific plant spacing. Farmers ranked soil fertility management, climate adaptation, and weed control as their top research and intervention areas. These problems threaten the crop's ability to provide food security and improve livelihoods in the region.

To improve Sorghum productivity, efforts should focus on enhancing soil fertility through both organic and inorganic amendments and improving access to affordable fertilizers. Development and dissemination of drought-tolerant Sorghum varieties and climate-smart practices are crucial to address rainfall variability. Integrated weed management strategies should be promoted through research and farmer training. Strengthening local seed systems and supporting the adoption of improved varieties will also be vital. Finally, promoting sustainable farming practices will ensure long-term productivity and resilience for smallholder farmers.

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Ethics Approval

Approved by the Graduate School, University for Development Studies, Tamale.

Consent to Participate

Verbal communication and oral interviews with Smallholder Sorghum famers.

Consent for Publications

All authors read and approved the manuscript for publication.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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