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Crop Yield and Fertilizer Use Among Farmers in Guinea Savannah and Transitional Zones of Ghana

IFDC FERARI Research Report No. 6

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MOHAMMED VI POLYTECHNIC UNIVERSITY

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CONTENTS

TABLES

FIGURES

ABBREVIATIONS

FERARI	Fertilizer Research and Responsible Implementation
PFJ	Planting for Food and Jobs
SoA	Sulfate of Ammonia

SUMMARY

To establish the farm yields beyond recall surveys, we sampled 160 farmer fields in the Guinea Savannah and Transitional zones of Ghana to (1) determine the farm yields for maize, rice, and soybean and (2) conduct a socioeconomic survey of the farmers and their farm activities. The major highlights from the findings include the following:

- Most farmers indicated that capital (income available for farming), rather than labor (family or hired labor) or time (farmer's own labor hours), was the most limiting production resource, with sufficient labor and time adequate for cultivating their crops.
- The use of fertilizer was absent among soybean farmers but high among maize and rice farmers.
- The major fertilizers used for maize and rice production were NPK 15-15-15, urea, and NPK 23-10-10+2MgO+3S+0.3Zn.
- Farmers did not generally use the recommended fertilizer application rates.
- Depending on the fertilizer type used, maize yield averaged 2.6-3.2 mt/ha, rice averaged 2.1-3.4 mt/ha, and soybean averaged 1.4 mt/ha.
- From the farmers' perspective, the major reasons for the existing yield gaps were labor, rainfall, and declining soil fertility. Most farmers also had faced production risks, including those related to health, environment, logistics and infrastructure, and finance and markets.
- A total of 1,566, 921, and 931 man hours were used for the entire production season per hectare of rice, maize, and soybean, respectively. The farmers indicted concerns over labor unavailability and its cost, and these resulted in the use of less labor than required for all farm activities.
- Rice production, especially planting and harvesting activities, was more labor intensive than maize and soybean production. For these activities (planting and harvesting), more female laborers were used on the rice farms than male laborers.

Farmers engaged in crop farming more as business rather than as subsistence. This high degree of commercialization creates opportunities to engage with input and output market actors more firmly.

CHAPTER 1: INTRODUCTION

1.1 Background

Farmers continue to play a significant role in the socioeconomic development of Ghana. Even though the farmers are smallholders and resource poor, they cultivate food to feed a significant proportion of Ghanaians. Nonetheless, their yields are often estimated to be suboptimal. This could be the result of an interplay of several factors, including the production climate, soil fertility, socioeconomic characteristics, and farm management decisions. Breaking the vicious cycle that sustains the yield gaps requires drastic actions that can generate positive gains from such interrelated factors. Since there is the potential for closing yield gaps, this has become a priority for many stakeholders in the agriculture sector. One example is the introduction of Planting for Food and Jobs program that has subsidized fertilizer and improved seeds for the farmers. Its aim is to offset the challenge of declining soil fertility and enhance the adoption of improved varieties that can withstand the production climate. With the increasing population, agricultural production in the country must double by 2050 if the food demand is to be met (van Loon et al., 2019).

Farmers make decisions based on the prevailing conditions, such as resource availability, production environment, and socio-cultural customs. Thus, a farmer's decision to cultivate a particular crop and allocate labor and capital to the farm is not made in vacuum. For instance, Mellon-Bedi et al. (2020) showed that personal satisfaction, eco-diversity, and eco-efficiency are the major motivational factors that influence the adoption of sustainable intensification practices, such as improved maize seeds, while uncertainty, absence of social support, and resource constraints limit adoption. Similarly, institutional factors, such as extension services, improve farmers' decisions (Mellon-Bedi et al., 2020). Knowingly or not, these decisions tend to have implications on their productivity.

Fundamentally, data on the crop yield and the characteristics of farmers are crucial for improving the design and implementation of policies that can improve the performance of the agriculture sector. For instance, information on yield gaps outlines the potential for agricultural intensification and its sustainability (van Loon et al., 2019). The Fertilizer Research and Responsible Implementation (FERARI) program's aim is to provide evidence-based information about agricultural households in the Guinea Savannah and Transitional zones of Ghana on the actual yields of the farmers over time so that interventions for sustainable agricultural intensification through innovative fertilization can be identified. To demonstrate the potential for farmers to increase their yields over current levels and offer education on how to achieve this, FERARI established a number of maize, rice, and soybean demonstration farms in specific districts of the two agricultural zones of Ghana. To achieve this objective and measure progress of the program, it is important to understand the potential yield difference between the demonstration farms and the farmers' own farms.

1.2 Objectives

The main objectives of this yield cut survey were to:

- Estimate the crop yield of farmers.
- Analyze the fertilizer use among farmers.
- Analyze the production decisions, labor use, and production risks among farmers.

CHAPTER 2: METHODOLOGY

The data were collected in the Guinea Savannah and Transitional zones of Ghana, specifically in the districts where FERARI has established demonstration farms. The data cover the 2020 production season. Farmers from 12 districts were interviewed (Table 1), and the locations of the selected farms are shown in Figure 1.

Table 1.   Frequency and percentage distribution of selected farmers by district

District	Frequency	Percentage
Tolon	11	6.9
Gushegu	17	10.6
Yendi	12	7.5
Mion	11	6.9
Saboba	12	7.5
Kumbungu	8	5.0
Savelugu	11	6.9
Zabzugu	19	11.9
West Mamprusi	12	7.5
West Gonja	7	4.4
Techiman	14	8.8
Sunyani West	5	3.1
Wenchi	21	13.2
Total	160	100.0

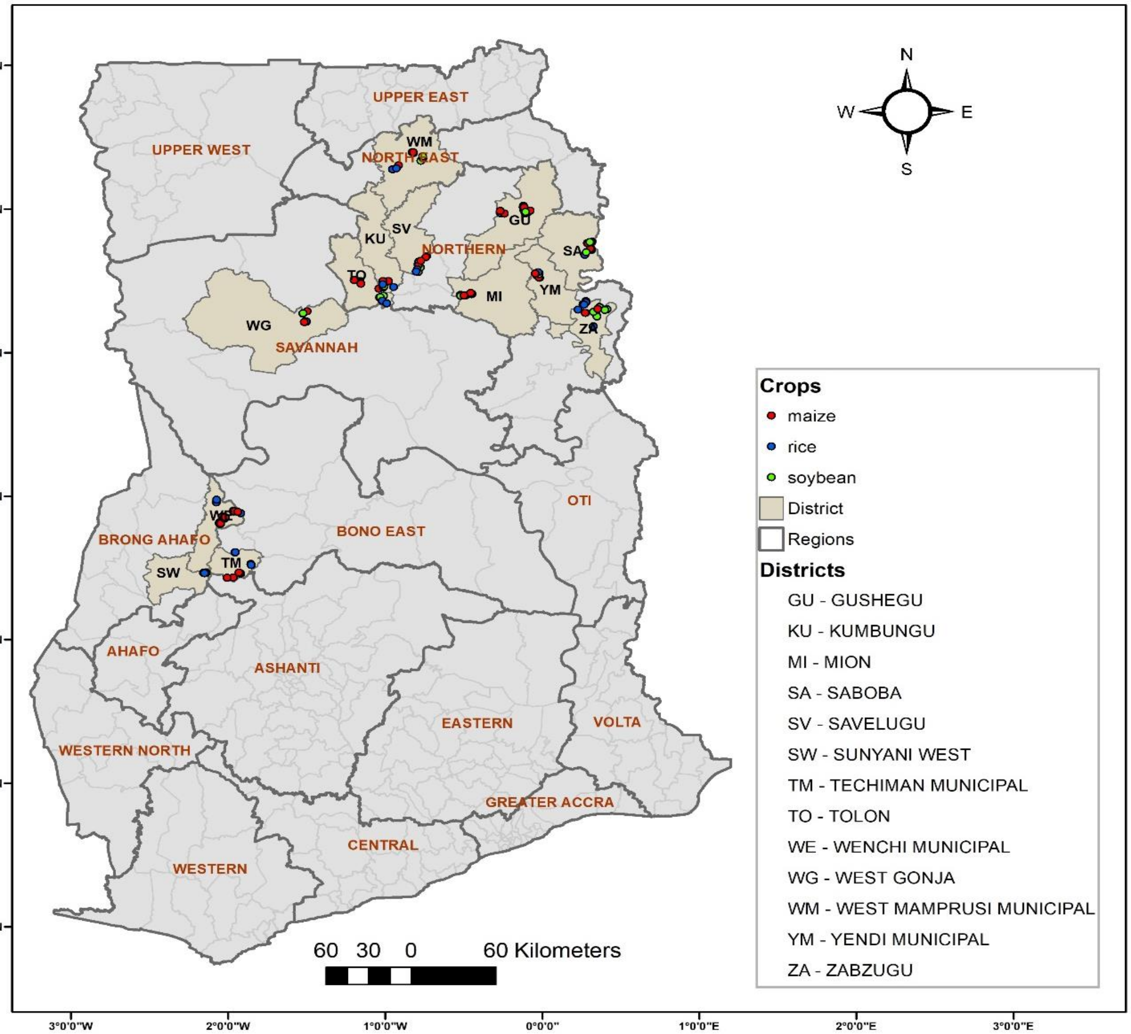


Figure 1. Map showing the location of selected farms

In terms of the sampling procedure, a total of 160 farmers who had crops ready for harvest were selected based on the proximity of the farm to the demonstration sites/communities or the farmer's involvement in FERARI's baseline study.

Under the supervision of FERARI staff, qualified technicians were contracted for the yield cut and survey. On each farm, data from three yield cuts of 2 m x2 m each were gathered. The data included plantstand/hill count, cob count and weight, paddy/grain weight, and stock/straw weight. Samples of grains and biomass were taken from each farm for processing and laboratory analysis. To understand the production process and relate the yield of farmers appropriately, the yield cut data were complemented by a socioeconomic interview on the farmers' production and labor decisions.

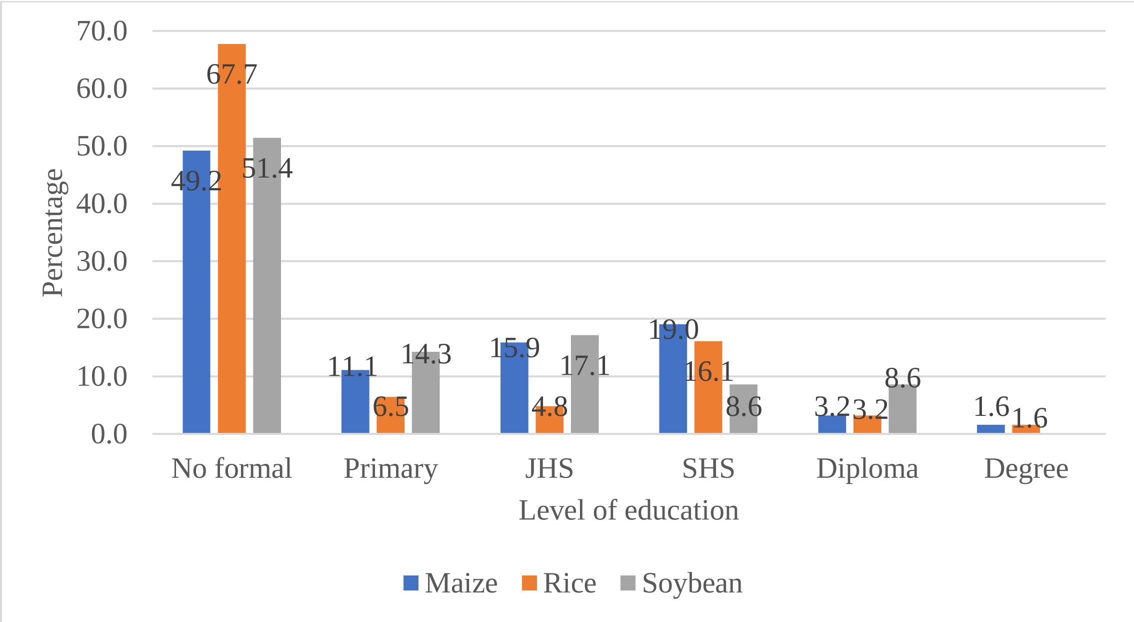
A technician interviewing a farmer

Yield cut data collection

CHAPTER 3: FINDINGS

3.1 Socioeconomic Characteristics of Farmers

Figure 2 shows the level of formal education of the selected farmers, which was very low. About 67.7% of the rice farmers had no formal education. While 1.6% of maize and rice farmers had a university degree, none of the soybean farmers had attained this level of education. More soybean farmers than other crop farmers had obtained a diploma. Formal education is important, especially as production becomes technologically advanced. Farmers with a formal education are able to search for and appreciate information for use on their farms better than those with a low level or no formal education.



JHS = junior high school; SHS = senior high school; Diploma = tertiary non-degree; Degree = university degree.

Figure 2. Percentage distribution of farmers' education level

The household distribution of the farmers is shown in Table 2. There was an average of about 11 members in a household. There were more members in the households of soybean farmers than the other crop farmers. Among the household members, about five members depended on other members of the household for their daily sustenance. Only about two of the economically active household members owned personal farms. These results suggest that the crop farmers must produce more to feed many household members who do not farm or who are dependent on other members of the family for their food and non-food needs.

Table 2. Household size distribution of the farmers

Crop Farmer	Household Size (#)		Dependents (#)		Own Farm (#)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Maize	10	5.0	4	2.6	2	1.4
Rice	11	5.1	5	3.9	2	1.6
Soybean	13	5.2	6	2.7	2	2.4
Combined	11	5.1	5	3.2	2	1.7

Table 3 details additional socioeconomic characteristics of farmers. One in every four or about three in every 10 farmers were youths, i.e., 15-35 years of age, which is consistent with national statistics showing 29.7% (31.3% in rural and 24.3% in urban areas) of persons engaged in agriculture are youths (GSS, 2020). This is important knowledge for promotional campaigns on youth in agriculture in the country. The results also show that nearly all of the farmers were male. Although farm ownership is generally an activity in which men participate in the region, the sampling procedure did not consider gender issues, which could explain the very low representation of female farmers. Nationally, males represent 64.5% of the people engaged in arable crop production (GSS, 2020). Nearly all of the farmers interviewed were household heads. This is higher than the national average of 79% of household heads involved in agriculture and is an important finding since household heads are the final decision makers of the families and may sometimes influence resource distribution, such as land and family labor, among members of the household. Access to institutional support was low, considering that less than 30% of the farmers had access to credit, belonged to a farmer-based organization (FBO), had access to extension services, engaged in contract farming, or lived in a community where there was a market.

Table 3. Socioeconomic characteristics of farmers

Variable	Frequency	Percentage
Age group		
Youths	41	25.6
Adults	119	74.4
Sex		
Male	152	95.0
Female	8	5.0
Household position		
Head	153	95.6
Spouse of head	2	1.3
Other member	5	3.1
Access to credit		
Access	30	18.8
No access	130	81.3
FBO membership		
Member	44	27.5
Non-member	116	72.5

Variable	Frequency	Percentage
Presence of community market		
Present	47	29.4
Not present	113	70.6
Contractual agreement		
Had a contract	24	15.0
Had no contract	136	85.0

3.2 Production Decisions

3.2.1 Source of Farmland

The source of farmland for the cultivation of the various crops is shown in Figure 3. Clearly, most of the farmers, especially the soybean farmers, cultivated their own lands. Also, the use of rented lands, mostly under crop sharing agreements, was slightly common among the rice and maize farmers. Considering that the farmers who cultivated their own land may have some knowledge on the suitability of their farmland for specific crops, this result may mean that the farmers allocated the right crop to the right farmland.

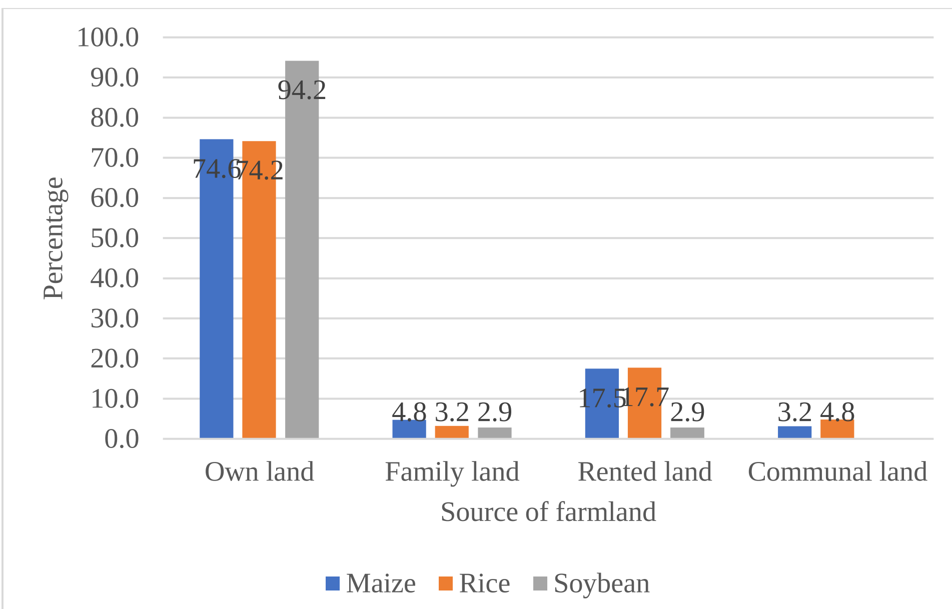


Figure 3. Sources of farmland

3.2.2 Primary Purpose for Crop Production

Figure 4 shows the primary reasons farmers engaged in the cultivation of each crop. Generally, most of the farmers indicated their primary purpose for engaging in crop farming was business rather than subsistence. Specifically, all the soybean farmers engaged in soybean production primarily for sales and not home consumption, while about 90% of the rice producers engaged in it for this purpose. The relatively lower proportion of maize farmers whose primary production aim was sales could be due to the fact that maize is the major staple crop in Ghana. Every household in the region consumes a maize food product. As a result, some of the farmers likely engaged in its production mainly for direct home consumption. The high commercial activity by the farmers is a good sign that the farmers would be willing to invest in their farms to increase their returns. Juxtaposing the high rate of commercial production with the fact that only 15% of the farmers are engaged in contract farming, in which market arrangements are agreed upon between the buyer and the farmer, means that most farmers sell their produce in the open market.

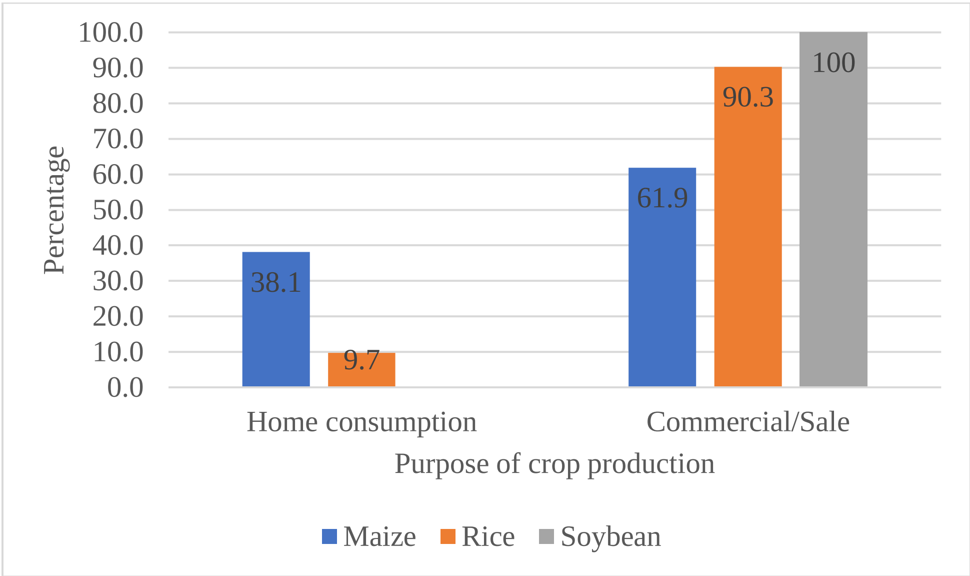


Figure 4. Primary purpose of crop production

3.2.3 Dietary and Income Importance of Crops to Farm Households

Table 4 shows the assessment of the crops based on their dietary and income importance to the farmers. About 56% of maize farmers and 74% of rice farmers indicated each crop had a very high dietary importance. Although not usually consumed by the farmers, about 71% of the soybean farmers indicated that the crop had a very high dietary importance. At the consumer level, soybean is mostly processed into food products, such as soy flour and kebab. About 79% each of rice and maize farmers and 80% of soybean farmers indicated that these crops were very important to their income needs. The farmers also ranked the three crops based on their income relevance. The majority of the maize farmers ranked maize as the most important cash crop, followed by rice and soybean. These findings indicate that these crops are crucial for the food and income needs of the farm households, and thus, their livelihoods are centered around these crops.

Table 4. Dietary and income importance of crops

Category	Maize		Rice		Soybean	
	Freq.	%	Freq.	%	Freq.	%
Dietary						
Very important	35.0	55.6	46.0	74.2	25.0	71.4
Important	28.0	44.4	16.0	25.8	10.0	28.6
Income						
Very important	49.0	77.8	49.0	79.0	28.0	80.0
Important	14.0	22.2	13.0	21.0	7.0	20.0
Rank for income relevance						
First	29.0	46.0	27.0	43.6	15.0	42.9
Second	21.0	33.3	30.0	48.4	17.0	48.6
Third	13.0	20.6	5.0	8.1	3.0	8.6

3.2.4 Farming Systems

The farming systems used by the farmers are presented in Figure 5. The left panel shows that most of the farmers cultivated more than one crop, especially maize and soybean farmers. The cultivation of more than one crop is often a characteristic of smallholder agriculture, as reported by staff of the Ministry of Food and Agriculture during farmer field days organized by FERARI. The right panel shows that most of the maize and rice farmers and all of the soybean farmers did not intercrop. About one in every five maize farmers intercropped. This indicates that most farmers grew multiple crops but as monocultures.

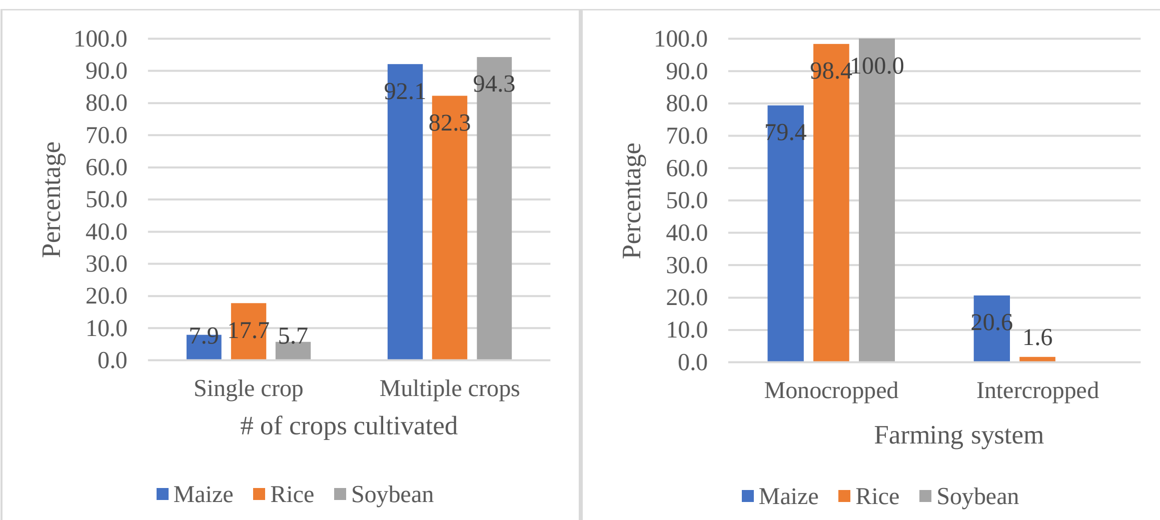


Figure 5. Farming systems of farmers

3.2.5 Farm Size and Farmer Classification

Figure 6 shows the average farm size and the classification of the farmers as a smallholder (≤2ha) or medium/large-scale farmer (>2ha). The average farm holding for the maize farmers was higher than that of rice and soybean farmers. The right panel shows that the majority of the farmers, especially the rice farmers, were smallholder farmers.

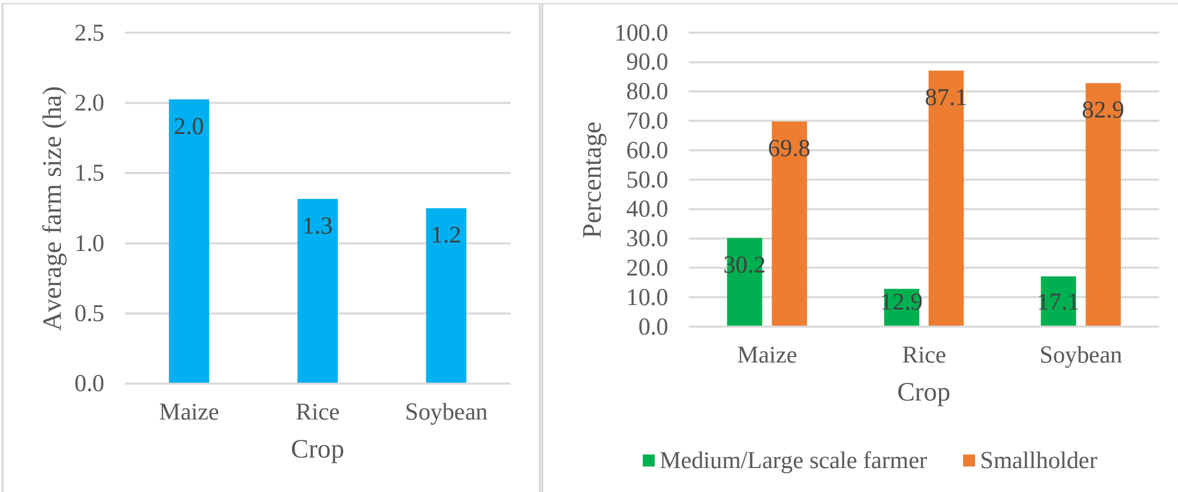


Figure 6. Average farm size and farmer classification

3.2.6 Perception of Soil Fertility

The farmers' perception of the fertility status of their farmland is shown in Figure 7. Very fertile means a farmer can produce maximum yield on the soil without external fertilizer. Fertile means that they can produce without fertilizer but obtains less than the expected yield. Less fertile means that they cannot produce a crop without external fertilizer. Even though over half of the farmers cultivating each crop indicated their farmland was fertile, the proportion was highest for rice farmers and lowest for soybean farmers. About 43% of soybean farmers indicated their farmland was very fertile. This indicates that maize and rice farmers were more likely to use fertilizer than soybean farmers. Juxtaposing Figure 7 with Figure 4 suggests that most farmers tend to allocate fertile soils to the cultivation of soybean as a way of increasing yields and, thus, income.

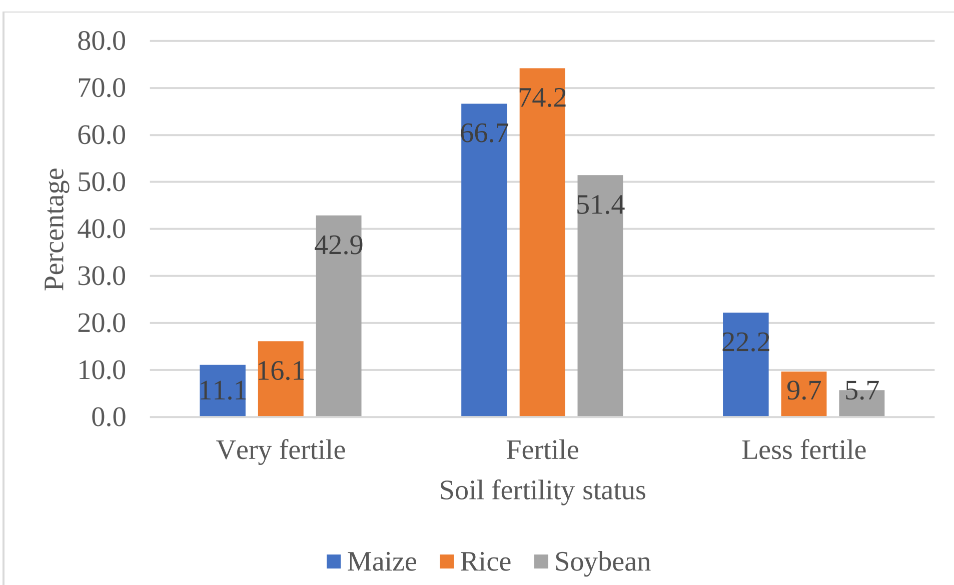


Figure 7. Farmers' perception of the fertility of their farmland

3.3 Adequacy of Resources for Crop Production

The farmers indicated the adequacy of capital (money for farming), labor (availability of family and hired labor), and time (farmers' available hours per day for farm activities) for the farm production as shown in Figure 8. More than 49% of maize farmers had insufficient capital for maize production, while about 92% of them had sufficient time to invest in their farm activities. The implication is that the major limiting resource for maize production was capital. For rice farmers, the time they could allocate to rice production was enough to ensure maximum yields. Nonetheless, about 31% and 15% of them indicated that there was insufficient capital and labor, respectively, for rice production. For soybean farmers, approximately 97% indicated having sufficient labor for producing their crop. Overall, the farmers expressed that they had enough time to invest in their farms because farming was their primary or sole occupation. However, capital adequacy was low, and justifiably so, because these are smallholder farmers with low incomes.

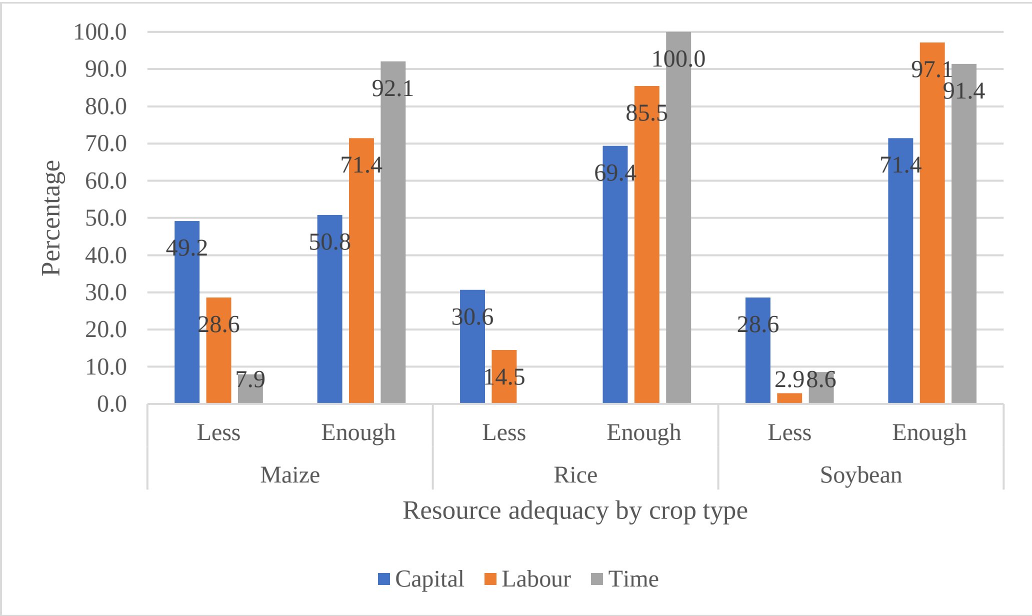


Figure 8. Percentage distribution of farmers' opinion on adequacy of resources for crop production

3.4 Fertilizer Use in Crop Production

3.4.1 Distribution of Fertilizer Users and Non-Users

Figure 9 shows the percentage distribution of the users and non-users of fertilizer in the production of the various crops. The majority of the maize and rice farmers used fertilizer. The use of fertilizer by soybean farmers was significantly low.

The distribution of users per specific fertilizer type is shown in Figure 10. The major fertilizers used by both maize and rice farmers were NPK 15-15-15, urea, and NPK 23-10-10+2MgO+3S+0.3Zn. The use of NPK 15-20-20+0.7Zn and sulfate of ammonia (SoA) was also relatively high among the maize farmers. Among the fertilizers, only NPK 15-15-15 and NPK 21-10-10+2S were not distributed under the Government of Ghana's Planting for Food and Jobs (PFJ) program in 2020. The regional distribution of fertilizer use is shown in Appendices 1-4.

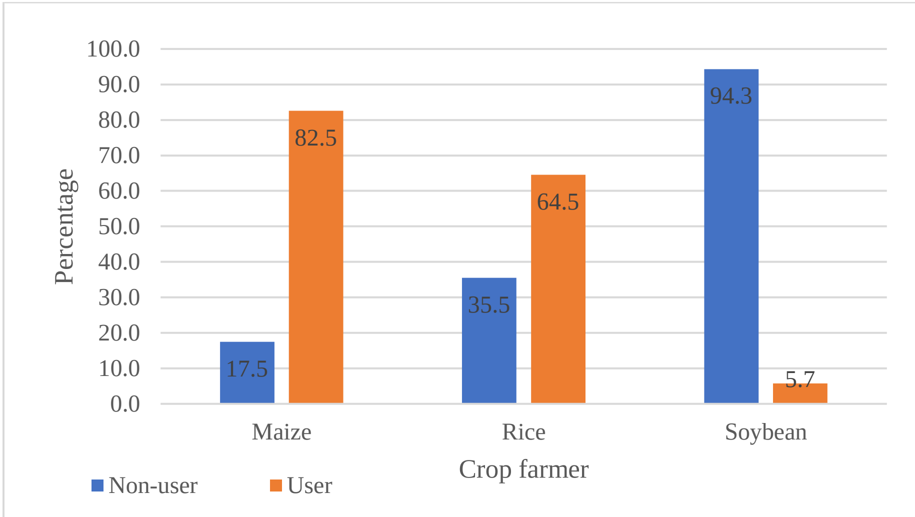


Figure 9. Percentage distribution of fertilizer users and non-users

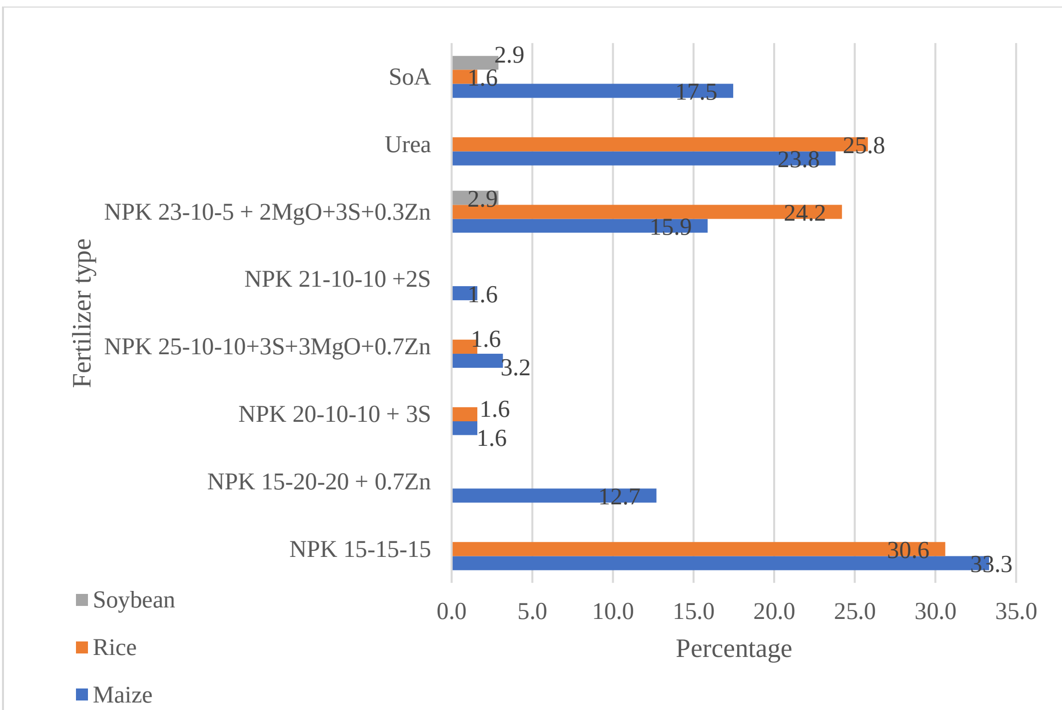


Figure 10. Percentage distribution of the types of fertilizer used in crop production

3.4.2 Quantity of Fertilizer Applied per Crop

Table 5 shows the descriptive statistics of the quantity of each fertilizer type applied by maize and rice farmers. The quantity of NPK 15-15-15 was the largest applied (493.8 kg/ha) by a farmer; on average, maize and rice farmers used 140.3 kg/ha and 186.7 kg/ha, respectively, of this fertilizer. NPK 15-20-20+0.7Zn is a new fertilizer blend that was introduced to farmers in the 2019 cropping season under the Government of Ghana's PFJ program. It is recommended for cereal crops, such as maize and rice, to be applied with urea. However, none of the rice farmers used this fertilizer on their farms. On average, rice farmers used a slightly higher amount of urea than maize farmers.

The Ministry of Food and Agriculture recommended that farmers use 300 kg/ha of NPK fertilizer with 100 kg/ha of urea for cereal production. Farmers used less than the recommended NPK application rate but used a little more than the recommended urea application rate. However, the data show that none of the farmers who used NPK 15-20-20+0.7Zn also used urea. Instead, 10 farmers who used NPK 15-15-15 also used urea, four farmers who used NPK 23-10-5+2MgO+3S+0.3Zn also used urea, and two of the farmers who used SoA also used urea on their maize or rice farm. These results indicate that the farmers did not use the recommended fertilizer types and application rates. More farmer education and sensitization on the use of recommended fertilizers is required to improve the efficient use of fertilizers.

Table 5. Quantity of fertilizer applied per crop

Fertilizer	Obs.	Mean (kg/ha)	Std. Dev.	Min (kg/ha)	Max (kg/ha)
Maize					
NPK 15-15-15	21	140.3	87.2	24.7	370.4
NPK 15-20-20+0.7Zn	8	124.4	69.6	46.3	246.9
NPK 20-10-10+3S	1	246.9	.	246.9	246.9
NPK 25-10-10+3S+3MgO+0.7Zn	2	246.9	0.0	246.9	246.9
NPK 21-10-10+2S	1	185.2	.	185.2	185.2
NPK 23-10-5+2MgO+3S+0.3Zn	10	120.9	69.0	30.9	246.9
Urea	15	105.1	74.2	12.3	246.9
SoA	11	62.9	42.3	9.3	154.3
Rice					
NPK 15-15-15	19	186.7	130.6	41.2	493.8
NPK 20-10-10+3S	1	12.3	.	12.3	12.3
NPK 25-10-10+3S+3MgO+0.7Zn	1	123.5	.	123.5	123.5
NPK 23-10-5+2MgO+3S+0.3Zn	14	113.2	73.0	30.9	246.9
Urea	16	118.1	76.3	30.9	246.9
SoA	1	77.2	.	77.2	77.2

3.4.3 Descriptive Statistics of Fertilizers Used and Associated Yield

Table 6 provides the descriptive statistics of the quantities of fertilizers used, apparent nutrients estimated from the fertilizer quantities, and associated yield of the farmers. The farmers are categorized based on the nutrient combinations derived from multiple fertilizers.

Maize farmers who used only NPK fertilizer applied 146.9 kg/ha, while those who used NPK+Zn applied 98.1 kg/ha. Maize farmers who used NPK+Zn+S (NPK 15-20-20+0.7Zn with SoA) applied the highest quantity at 285 kg/ha. In terms of apparent nutrients, NPK+Zn+S users applied 144.4 kg nutrients/ha. Nine maize farmers applied only urea to their farm at a rate of 108 kg/ha, for a derived amount of nitrogen of 50 kg/ha. The specific contribution of each nutrient to the apparent nutrients is shown in Table 6. Maize farmers who used NPK+S or NPK+S+Zn had the highest yield at about 3.2 mt/ha. Thus, there was a 0.4 mt/ha increase in maize yield above that of the fertilizer non-users. Since NPK+S and NPK+S+Zn fertilizers were applied in larger quantities than the other fertilizer types, it can be deduced that farmers would achieve the optimal yield if the correct quantity of fertilizer was applied. The data also suggest that the application of only urea fertilizer in maize production is unproductive, as there was no difference in yield from that of farms where no fertilizer was used. The scatter plot showing the linear trend of maize yield by the applied nutrients is shown in Appendix 5.

Among rice farmers, NPK 15-15-15 was applied at a higher average quantity of 259 kg/ha, while NPK+S (a combination of NPK 20-10-10+3S, SoA, and NPK 15-15-15) was applied in the lowest quantity of 83.3 kg/ha. The use of only urea fertilizer in rice production was also high, considering that six farmers applied only urea at a rate of 112 kg/ha. Correspondingly, NPK users applied the highest quantity of apparent nutrients at 117.2 kg/ha and obtained the highest yield of 3.4 mt/ha. Thus, rice farmers who applied NPK at a rate of 259 kg/ha had a 1.2 mt/ha increase in yield over those who did not use fertilizer. There was some level of increase in yield for all fertilizer combinations except NPK+Zn+Mg+S. The descriptive statistics of the nutrients are shown in Table 7. The scatter plot showing the linear trend of yield by the applied nutrient is shown in Appendix 6. The regional distribution of average fertilizer quantity, apparent nutrients, and yield is shown in Appendix 5.

The average yield for the soybean farmers was 1,412.9 kg/ha, with a range from 400 to 3,333.3 kg/ha. Since only two soybean farmers used fertilizer, the data on the relationship between their yield and fertilizer usage are not provided.

Table 6. Quantity of fertilizer used, apparent nutrients, and yield

Nutrient Combination	Sample	Fertilizer Applied (kg/ha)				Apparent Nutrients (kg/ha)				Yield (kg/ha)			
		Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Maize													
Non-users	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2577.0	687.4	1336.7	3800.0
NPK	13	146.9	119.9	30.9	432.1	66.5	54.6	13.9	196.9	2906.8	838.8	1666.7	4020.0
NPK+Zn	5	98.1	56.6	46.3	185.2	54.7	31.5	25.8	103.1	2623.5	957.5	1044.0	3576.7
NPK+S	8	251.3	108.0	86.4	432.1	112.6	48.9	38.9	194.4	3225.8	832.4	1766.7	3946.7
NPK+Zn+S	3	284.6	183.0	154.3	493.8	144.4	87.4	79.4	243.7	3214.4	405.4	2820.0	3630.0
NPK+Zn+Mg+S	12	162.5	110.3	30.9	432.1	75.9	54.6	13.9	211.0	2864.7	775.6	1720.0	4440.0
N	9	107.9	69.2	24.7	216.0	49.6	31.8	11.4	99.4	2568.5	598.8	1766.7	3513.3
NS	2	80.2	82.9	21.6	138.9	36.6	37.8	9.8	63.3	2933.3	1084.2	2166.7	3700.0
Total	63	132.5	121.7	0.0	493.8	61.9	57.2	0.0	243.7	2826.4	762.2	1044.0	4440.0
Rice													
Non-users	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2156.1	1021.2	825.0	3766.7
NPK	17	259.0	201.2	41.2	740.7	117.2	91.3	18.5	335.8	3356.3	1940.6	583.3	7166.7
NPK+S	2	83.3	100.4	12.3	154.3	37.4	45.4	5.3	69.4	2652.1	556.8	2258.3	3045.8
NPK+Zn+Mg+S	15	132.9	67.7	30.9	246.9	60.7	30.5	13.9	111.1	2059.9	854.0	879.2	4195.8
N	6	112.1	56.6	30.9	185.2	51.6	26.1	14.2	85.2	2764.6	998.9	1375.0	4000.0
Total	62	116.7	150.9	0.0	740.7	53.0	68.4	0.0	335.8	2536.8	1379.1	583.3	7166.7

Table 7. Mean quantity of apparent nutrients from fertilizers used by farmers

Nutrient	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (kg/ha)	S (kg/ha)	Mg (kg/ha)
Maize						
NPK	32.9	16.8	16.8	0.0	0.0	0.0
NPK+Zn	14.7	19.6	19.6	0.7	0.0	0.0
NPK+S	43.0	26.8	26.8	0.0	16.0	0.0
NPK+Zn+S	48.9	41.8	41.8	1.2	10.7	0.0
NPK+Zn+Mg+S	38.1	16.5	11.5	2.3	4.3	3.2
N	49.6	0.0	0.0	0.0	0.0	0.0
NS	28.0	0.0	0.0	0.0	8.5	0.0
Mean	*37.5*	*20.8*	*19.4*	*1.7*	*9.1*	*3.2*
Std. Dev.	*29.4*	*15.1*	*15.9*	*1.2*	*8.7*	*2.3*
Min	*4.6*	*3.1*	*1.5*	*0.3*	*0.9*	*0.6*
Max	*141.4*	*74.1*	*74.1*	*4.9*	*37*	*7.4*
Rice						
NPK	58.1	29.5	29.5	0.0	0.0	0.0
NPK+S	15.1	6.4	6.4	0.0	9.4	0.0
NPK+Zn+Mg+S	32.5	12.6	7.3	2.2	3.7	2.4
N	51.6	0.0	0.0	0.0	0.0	0.0
Mean	*45.4*	*20.7*	*18.4*	*2.2*	*4.3*	*2.4*
Std. Dev.	*41.3*	*17.5*	*18.4*	*1.5*	*4.3*	*1.5*
Min	*2.5*	*1.2*	*1.2*	*0.6*	*0.4*	*0.6*
Max	*187.7*	*74.1*	*74.1*	*4.9*	*18.5*	*4.9*

3.5 Reasons for Gap between Expected and Actual Yields

Figure 11 shows the farmers' opinions on the possible reasons for the gap between the actual yields obtained from their fields and the expected yields. Among maize farmers, the top three reasons for the yield gap were insufficient rainfall, insufficient manpower or labor, and soil degradation. For rice farmers, the top three reasons were insufficient manpower, weed infestation, and soil degradation. Soybean farmers cited insufficient manpower, insufficient agricultural land, and insufficient rainfall as the major challenges to achieving the expected yield. Generally, challenges with labor, rainfall, and soil were in the primary explanations for the lower than the expected yields. The farmers explained that they do not have the required labor at the right time for their farm activities, which affects their production decisions, including the adoption of good agronomic practices. As shown in Figure 8, about 29% of maize farmers indicated that they have less labor for maize production than needed. This could mean that the major challenge for many farmers is not necessarily the availability of the labor but its availability when needed. This is because farmers who provide hired labor services also operate their personal farms, and because they cultivate during the same periods, the activity required on their personal farms may coincide with that of other farmers who need their labor services. Similarly, they explained that rainfall has become erratic, and the amount is low; therefore, their crops do not receive the water required for higher yields. The farmers also indicated that their soils have become less fertile over the years, which has resulted in declining yields, especially for maize and rice. This justifies the need for external fertilization of crop soils to support production and improve yields. The lack of a produce market had little impact on attaining the potential yield.

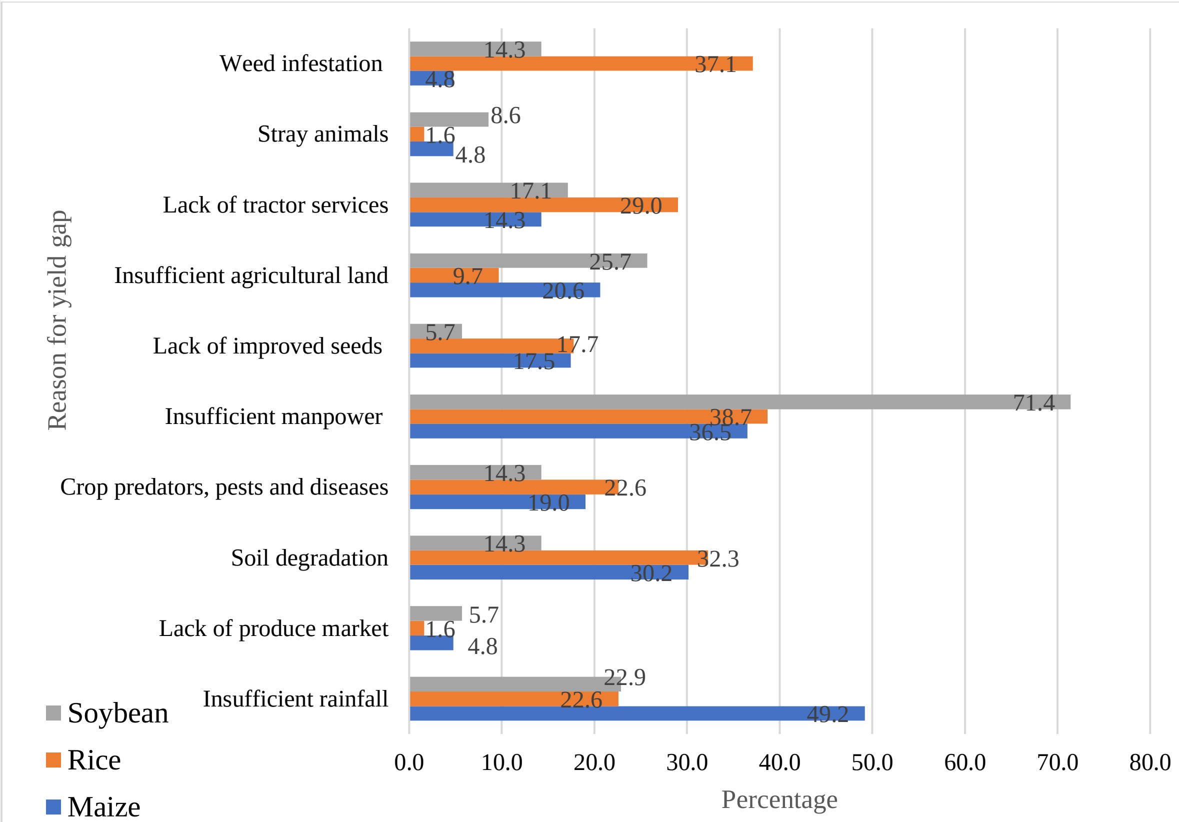


Figure 11. Reasons for gap between expected and actual yields

3.6 Assessment of Crop Production Risks

Farmers operate within several risks that affects their crop production. Table 8 shows the farmers' assessment of these risks. Most farmers, especially soybean farmers, have experienced input risks in which they bought an input that later appeared to have different characteristics than the farmer expected. For instance, some farmers indicated that they bought seeds that did not germinate properly although the seeds were labeled with brands they already knew about. Among the environmental (weather) risks, drought was commonly reported by the farmers. They indicated that the rains had stopped by the time their crops needed water, which affected their yield, which is consistent with Figure 11. While the rainfall was not sufficient for crop production, some of the rain was too heavy, leading to flooding of about 33.9% of rice farmers fields. The high flooding reported by rice farmers is due to the location of these farms in the lowlands. Pest infestation was reported more often among maize farmers than rice and soybean farmers.

The experience of conflict was low among the farmers, especially rice farmers. Conflicts, such as communal conflicts and herder-farmer conflicts, are detrimental to crop production because farmers may not be able to go to their farms, which could cause them to limit their level of investment (e.g., amount of money) in their farms. Regarding health risks, over two-third of the farmers had to stay off their farms for at least one day due to illness. Farm activities, such as weeding, require that the farmers be healthy enough to carry out the activities effectively. Therefore, sickness could affect the farm operations of the farmers, and if it occurs at a crucial time for a particular activity, such as fertilizer application or weeding, the effect becomes dire. Nonetheless, the majority of the farmers had active national health insurance cards, which can enhance the farmers desire to seek medical attention. The farmers revealed high logistics and infrastructure risks. Specifically, the farmers have limited storage space at home, poor roads, no means of transporting their produce to the market. This would be expected to affect the price and marketing of the crop produce. Access to financial credit and the presence of a market in the community were low.

Table 8. Farmers' assessment of crop production risks

Risk		Maize (%)	Rice (%)	Soybean (%)
1. Input risks		50.8	46.8	80.0
2. Weather	Drought	63.5	40.3	42.9
	Windstorm	12.7	11.3	0.0
	Flood	11.1	33.9	5.7
	Pest and disease	28.6	11.3	8.6
3. Conflict		14.3	4.8	34.3
4. Health	Absent from farm due to sickness	68.3	72.6	71.4
	Hazards from reptiles, sunburn, dehydration, or chemicals	38.1	21.0	22.9
	NHIS membership	61.9	69.4	80.0
5. Logistics and infrastructure	Enough storage facility	82.5	88.7	91.4
	Motorable road to a preferred output market	82.5	96.8	91.4
	Availability of transport for carting goods	82.5	91.9	91.4
6. Finance and market	Access to financial credit	7.9	8.1	11.4
	Presence of community market	25.4	12.9	2.9

3.7 Willingness to Adopt New Production Technologies

Farmers have practiced crop production for several years. Yet, there have been large yield gaps during this time. New production technologies are clearly needed. Table 9 shows that more than 90% of the farmers of all crops would be willing to adopt any new technology introduced to them. However, the farmers admitted different schedules for their adoption. The majority of the farmers can be described as early adopters, since they would be willing to immediately adopt any new technology with caution. This explains why farmers often adopt a new production technology alongside their old production systems.

Table 9. Willingness to adopt new production technologies

Response	Maize		Rice		Soybean	
	Freq.	%	Freq.	%	Freq.	%
Adoption decision						
No	3	4.8	1	1.6	3	8.6
Yes	60	95.2	61	98.4	32	91.4
Time of adoption						
Immediately and without any further consideration	5	8.3	2	3.3	3	9.4
Immediately but with caution	53	88.3	48	78.7	27	84.4
Not immediately but before most other farmers adopt	2	3.3	9	14.8	1	3.1
After the majority of other farmers have adopted	0	0.0	2	3.3	1	3.1

3.8 Labor Use in Crop Production

3.8.1 Personal, Family, and Hired Labor in Crop Production

Labor is a crucial component in crop production, especially as mechanized production is absent. For many activities, the availability and accessibility of labor are essential to the cultivation of various crops. Tables 10-12 and Figure 12 show the labor use in crop production.

Table 10 shows the reported production season (number of months in crop production) for the various crops and the farmers' labor allocated to farming. The production season covers land preparation through harvesting. The reported production season for all crops was approximately four months. While the production season varied from three to six months for maize and soybean, it varied from three to five months for rice. Generally, the production season varied due to differences in the type of seed cultivated by the farmer.

Table 10 also shows that the maize farmers went to their farm approximately five days a week, while rice and soybean farmers went to their farm approximately four days a week. Maize and rice farmers spent about six hours on the farm each day, while soybean farmers spent about five hours daily. In total, maize farmers spent more hours (106.4 hours) on their farms than the rice (98.6 hours) and soybean (91.7 hours) farmers. However, rice farmers spent more hours per hectare (151.6 hours) than the maize (151.6 hours) and soybean (118.8 hours) farmers. The rice farmers spent more hours per hectare than maize farmers because they cultivated a smaller land area (1.3 ha) than the maize farmers (2.0 ha).

Table 10. Production period, number of days spent on the farm, and total man days of farmers

Crop	N	Mean	Std. Dev.	Min	Max
Production season (months)					
Maize	63	3.8	0.8	3.0	6.0
Rice	62	3.8	0.6	3.0	5.0
Soybean	35	3.9	0.6	3.0	6.0
Workdays per week					
Maize	63	4.6	1.3	2.0	7.0
Rice	62	4.4	1.5	2.0	6.0
Soybean	35	4.4	1.6	2.0	7.0
Daily work hours					
Maize	63	5.8	2.2	2.0	9.0
Rice	62	5.9	2.0	2.0	9.0
Soybean	35	5.0	1.8	2.0	8.0
Total work hours/farm					
Maize	63	106.4	59.1	18.0	270.0
Rice	62	98.6	54.4	24.0	216.0
Soybean	35	91.7	58.4	20.0	210.0
Total work hours/ha					
Maize	63	108.3	116.6	7.9.0	622.2
Rice	62	151.6	147.9	7.1.0	800.0
Soybean	35	118.8	116.5	9.5.0	518.5

Table 11 shows the amount of family labor used in crop production. On average, soybean farmers used about seven family members for crop production, while maize and rice farmers used five and six family members, respectively. While all soybean farmers used at least two family members on their farms, two maize and one rice farmer did not use any family labor in their production. On average, each family member worked for about four days each week on maize and soybean farms and about five days each week on rice farms. The hours spent daily also varied from four hours on soybean farms to about six hours on rice and maize farms. Rice farmers used an average of 814 hours of family labor per hectare during the production season, while maize farmers used only about 396 hours of work per hectare.

Table 11. Number of family members and total man days of family labor used in crop production

Crop	N	Mean	Std. Dev.	Min	Max
# of family persons used per season					
Maize	61	4.9	2.5	1.0	13.0
Rice	61	5.5	2.7	2.0	13.0
Soybean	35	6.7	3.5	2.0	13.0
Family workdays/week					
Maize	61	4.1	1.5	1.0	7.0
Rice	61	4.7	1.5	1.0	7.0
Soybean	35	3.6	1.4	1.0	7.0
Family work hours/day					
Maize	61	5.5	2.1	2.0	9.0
Rice	61	6.0	1.8	2.0	9.0
Soybean	35	4.4	1.3	2.0	7.0
Total family work hours/farm					
Maize	61	442.9	362.2	36.0	1,344.0
Rice	61	607.7	486.3	96.0	2,496.0
Soybean	35	437.0	409.3	64.0	2,184.0
Total family work hours/ha					
Maize	61	395.8	454.1	17.8	3,200.0
Rice	61	814.2	760.1	28.4	3,200.0
Soybean	35	507.8	432.0	33.2	1,481.5

Table 12 shows the amount of hired labor used in the production of maize, rice, and soybean. Only about 60%, 61%, and 46% of the maize, rice, and soybean farmers, respectively, used hired labor on their farms. On average, rice farmers used about eight hired laborers per farm during the production season, while maize and soybean farmers used seven and five hired laborers, respectively, per farm. On average, maize and rice farmers used hired laborers on their farms for about four days a week during the production season, while soybean farmers used them for about three days each week. Each hired laborer used on maize and rice farms worked about six hours each day, while those on soybean farms worked about five hours each day. On average, hired labor was used for about 600 hours on rice farms and about 416 and 304 hours on maize and soybean farms, respectively. Thus, more hired labor was used on rice farms than maize and soybean farms.

Table 12. Number of hired laborers and total man days of hired labor used in crop production

Crop	N	Mean	Std. Dev.	Min	Max
# of hired labor per season					
Maize	38	6.6	4.2	2.0	15.0
Rice	38	8.0	8.6	1.0	36.0
Soybean	16	4.5	2.0	2.0	8.0
Hired labor workdays/week					
Maize	38	3.7	1.7	1.0	7.0
Rice	38	3.7	2.0	1.0	7.0
Soybean	16	2.9	1.4	2.0	7.0
Hired labor hours/day					
Maize	38	6.4	2.4	2.0	9.0
Rice	38	5.8	2.2	2.0	9.0
Soybean	16	4.8	1.4	3.0	8.0
Total work hours/production season					
Maize	38	741.8	771.7	48.0	2,700.0
Rice	38	616.0	735.3	24.0	2,880.0
Soybean	16	294.1	335.2	64.0	1,260.0
Total work hours/ha					
Maize	38	416.4	548.1	11.9	2,666.7
Rice	38	599.9	688.1	17.8	2,666.7
Soybean	16	304.4	335.3	19.0	1,185.2

Figure 12 shows the mean total hours (sum of personal, family, and hired labor) used in the production of each crop. On average, rice farmers spent more labor hours (1,565.7 man hours/ha in the production season) for rice production than maize (920.5 man hours/ha in the production season) and soybean (931 man hours/ha in the production season) farmers. Thus, rice production is more labor intensive than maize and soybean production. However, it is important to recall from Figure 8 that most of the farmers, especially soybean farmers, indicated having sufficient labor for their farms. Although all crops are manually produced, the activities in rice production are labor intensive, which is the reason for the high use of labor. For instance, planting and harvesting rice takes more time and labor than maize and soybean. Specifically, the data also reveal that about 11, 13, and 13 laborers were needed for land preparation, planting, and harvesting of rice, respectively, compared to 8, 9, and 8 laborers, respectively, required to perform similar activities on maize farms. The data also suggest that more labor than currently used by the farmers is needed to perform all activities. Considering that there is no significant difference in the importance of the income from the crops (Table 4), farmers' investment in more labor for rice production than the other crops was not because of its economic importance. Consistently, Ngeleza et al. (2011) established that rice production requires more labor (both quantity and cost) than maize production.

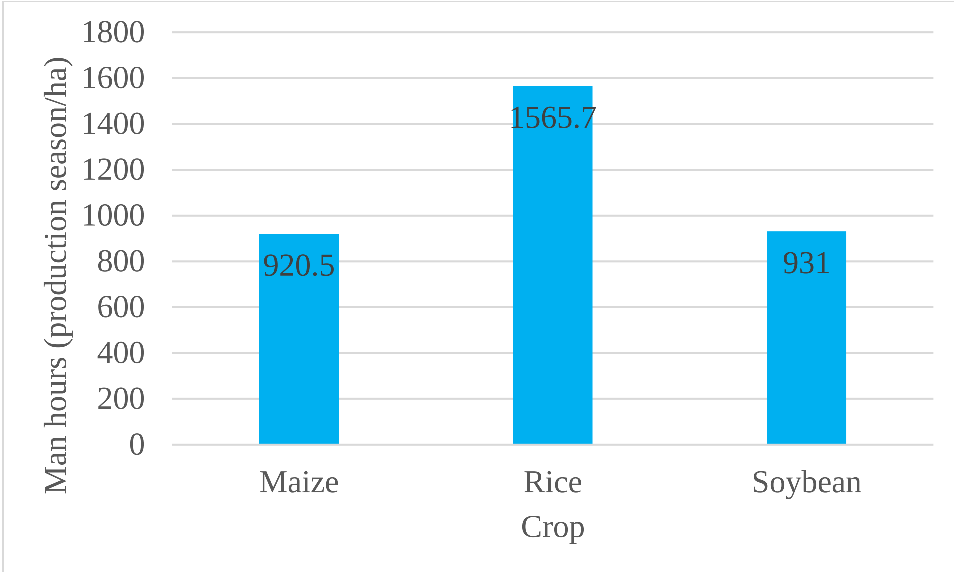


Figure 12. Mean number of man hours used in crop production per hectare

3.8.2 Mean Labor Hours Used for Farm Activities by Gender

Table 13 shows the mean hours used by both male and female laborers spent in the cultivation of a hectare of maize, rice, and soybean. There were variations in the male and female hours allocated to each crop and activity. For instance, land preparation for the cultivation of all three crops was largely a male activity. Generally, more labor hours were used on the various activities under rice production than for other crops. The use of female labor in rice production was high, especially in planting, fertilizer application, and harvesting activities. More labor hours were used for weed management and pest management, because most of the farmers used chemicals in controlling the weeds and the pests, which involves the use of knapsack sprayers. As shown in Figure 13, the number of laborers used on each activity was generally less than the number farmers revealed as adequate for such activities. The farmers allocated almost as many people for planting as the other activities, because planting must necessarily be performed in hopes of a crop output and farmers have much enthusiasm at the start of the farming activities. One major activity that farmers allocated lower than the required number of people was pest management.

Table 13. Mean number of labor hours allocated to farm activities per hectare by gender

	Maize		Rice		Soybean	
	Male	Female	Male	Female	Male	Female
Activity	(hours/ha)					
Land preparation	164.1	68.3	207.7	63.0	97.8	51.5
Planting	54.9	45.1	115.0	238.6	53.9	36.9
Weed management	85.8	54.2	119.8	35.1	66.4	21.6
Pest management	42.1	13.0	66.2	0.0	14.4	18.8
Fertilizer application	36.4	16.9	49.9	107.1	18.5	14.0
Harvesting	95.8	52.1	184.5	877.2	72.6	47.5

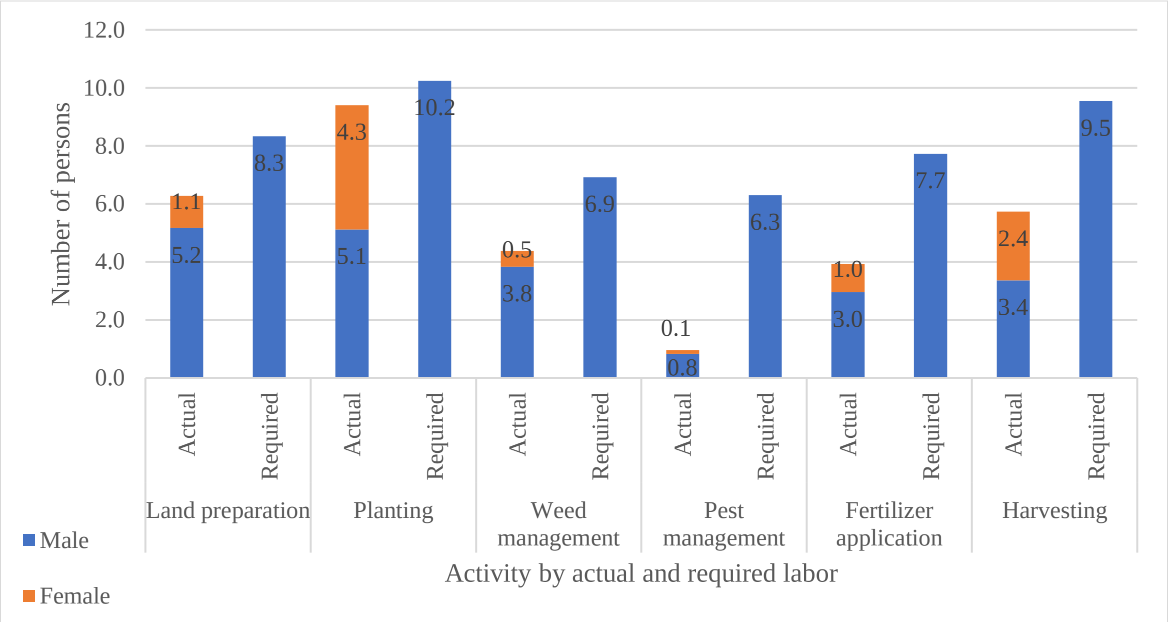


Figure 13. Labor required and actual labor used for each farm activity

3.8.3 Farmers' Perception of Labor Cost and Availability

Table 14 details the farmers' opinions on the availability and cost of labor for crop production. Most of the farmers, especially soybean farmers, indicated that labor was always not readily available. Instead, the majority indicated that labor was only available sometimes, while a few others indicated that it was difficult to find the labor. However, when asked whether they had enough labor to perform farm activities, the majority of the farmers indicated having sufficient labor. Even though some of the farmers indicated having adequate labor, they also commented that there would be no way to get extra labor, even if they needed it. About 84% of the farmers who indicated an inadequate labor supply mentioned that this had a negative effect on their yields.

While most of the maize farmers indicated that the cost of labor was high or very high, the majority of the rice and soybean farmers indicated that the cost of labor was reasonable. Most of the farmers also indicated that the cost of the labor had negatively affected their use of labor in crop production. This was especially high for maize and soybean farmers. Not all farmers engaged in only crop production. Some engaged in other non-farm economic activities, such as trading and tailoring. While fewer than half the maize and rice farmers engaged in crop production alone, most of the soybean farmers engaged in non-farm economic activities in addition to crop production, which may have affected their labor allocation to the farms.

Table 14. Farmers' perception of labor cost and availability

Response	Maize		Rice		Soybean	
	Freq.	%	Freq.	%	Freq.	%
Labor availability						
Readily available at any time	19	30.2	22	35.5	5	14.3
Available sometimes	38	60.3	35	56.5	27	77.1
Difficult to get	6	9.5	5	8.1	3	8.6
Access to adequate labor						
No	16	25.4	14	22.6	1	2.9
Yes	47	74.6	48	77.4	34	97.1
Effect of inadequate and untimely labor on output						
No	1	6.3	4	28.6	0	0.0
Yes	15	93.8	10	71.4	1	100.0
Level of cost						
Very high	5	7.9	0	0.0	1	2.9
High	30	47.6	24	38.7	16	45.7
Reasonable	27	42.9	38	61.3	15	42.9
Low	1	1.6	0	0.0	3	8.6
Effect of labor cost on effective labor use						
No	16	25.4	25	40.3	9	25.7
Yes	47	74.6	37	59.7	26	74.3
Engagement in non-farm activities						
No	35	55.6	36	58.1	13	37.1
Yes	28	44.4	26	41.9	22	62.9

CHAPTER 4: CONCLUSIONS

The report details the activities of maize, rice, and soybean farmers in the 2020 production season, which involved conducting yield cut of three quadrants of 2 m x 2 m on each farm and interviews using a questionnaire. The yield cut was necessary to establish the yield of farmers' fields and to understand their production systems. A total of 63 maize, 62 rice, and 35 soybean farms were visited, and the socioeconomic data on these farmers were collected. The findings of this study have led to the following conclusions.

Most of the farmers engaged in multiple cropping and monocropping systems. Although the farmers were smallholders, most of them engaged in crop production for commercial reasons rather than for direct home consumption. Among capital (amount of money), labor (family and hired labor), and time (availability of time for farm activities by the farmer) resources, capital was the least adequate for the cultivation of all three crops. This is consistent with the description of smallholder farmers as resource-poor farmers who do not have enough resources to invest in their farms. The results also established that the level of engagement of youths in farming was consistent with national estimates, as one in every four farmers was a youth.

Only two (5.7%) of the 35 soybean farmers used fertilizer on their farms. Fertilizer use was higher among maize farmers (82.5%) than rice farmers (64.5%). The major fertilizers used by both maize and rice farmers were NPK 15-15-15, urea, and NPK 23-10-10+2MgO+3S+0.3Zn. The use of NPK 15-20-20+0.7Zn and SoA was also relatively high among maize farmers. Overall, even though the fertilizers considered were mostly those recommended under the Government of Ghana's PFJ program, farmers used less than the recommended fertilizer application rates. The farmers who did not use any fertilizer indicated that fertilizers increased the cost of production, required more time for application, and were difficulty to apply, especially by side placement. On the other hand, the reasons the fertilizer users gave for using fertilizers included the potential to obtain higher yields, knowledge about the need to use fertilizers, sufficient skill in fertilizer application, and the fact that other farmers used them. The opportunity here is to identify entry points on how to address the challenges for the non-use of fertilizer.

Depending on the type of fertilizer used, the yield for maize averaged 2.6-3.2 mt/ha, rice averaged 2.1-3.4 mt/ha, and soybean averaged 1.4 mt/ha. This suggests yield gaps for the crops, and the farmers admitted that their major challenges in attaining the expected yields were related to labor, rainfall, and declining soil fertility. Several risks, including health, environmental, logistics and infrastructure, and finance and markets, were noted to affect crop production.

More labor was used for rice production than for maize and soybean. This could mean that rice production is more labor intensive than the other crops. Activities such as planting and harvesting of rice require more people to be engaged on the farms than for similar activities on maize and soybean farms. To offset this high labor requirement, some rice farmers tend to plow their seeds into the soil during land preparation. More labor was needed to adequately perform all crop production activities.

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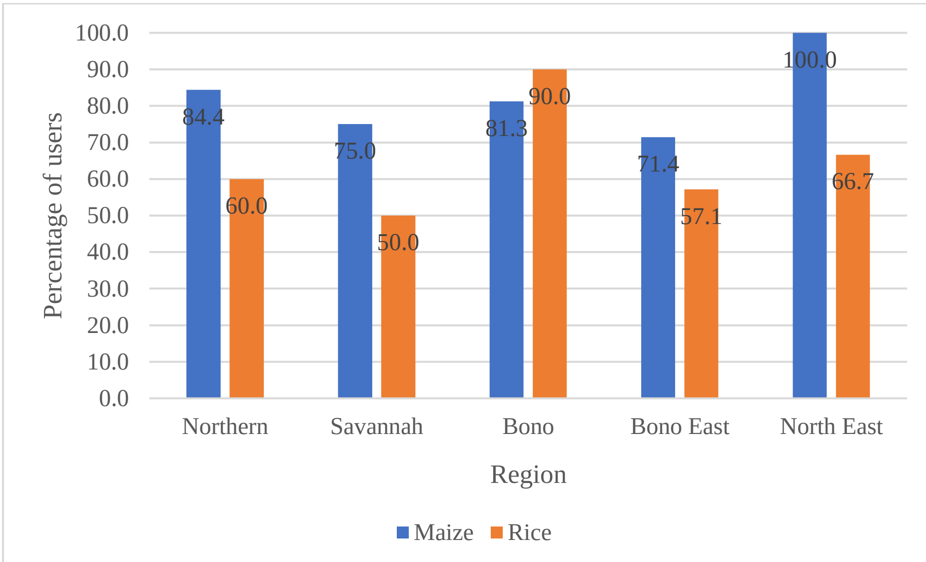
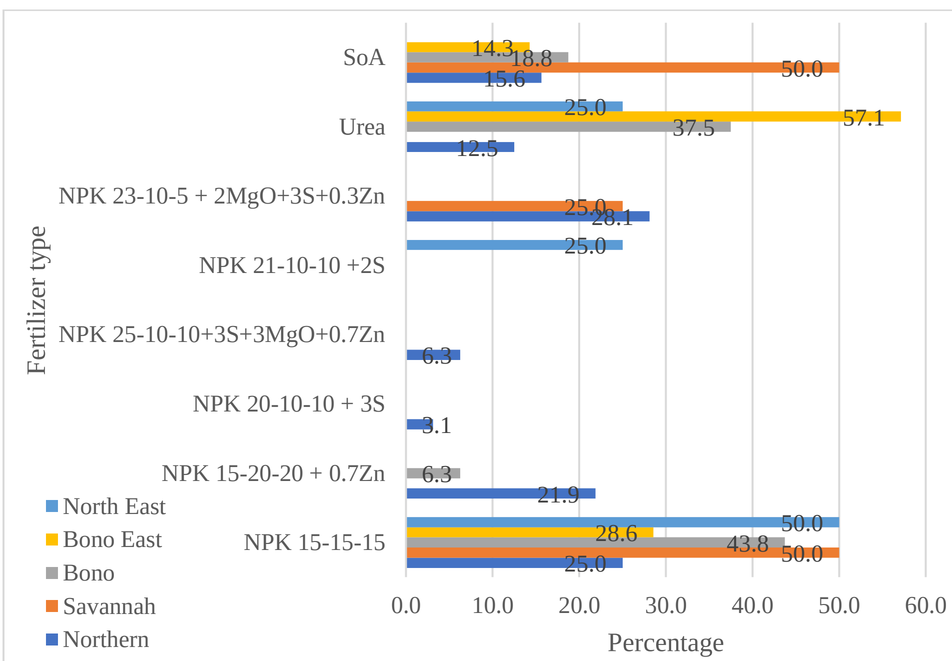
APPENDICES

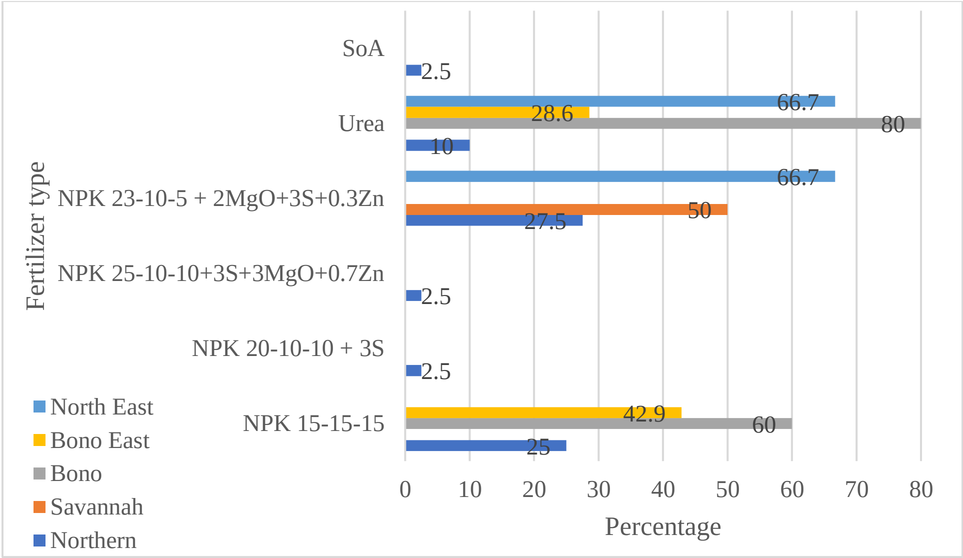
Appendix 1.   Fertilizer use by region



Appendix 2.   Types of fertilizer used for maize by region



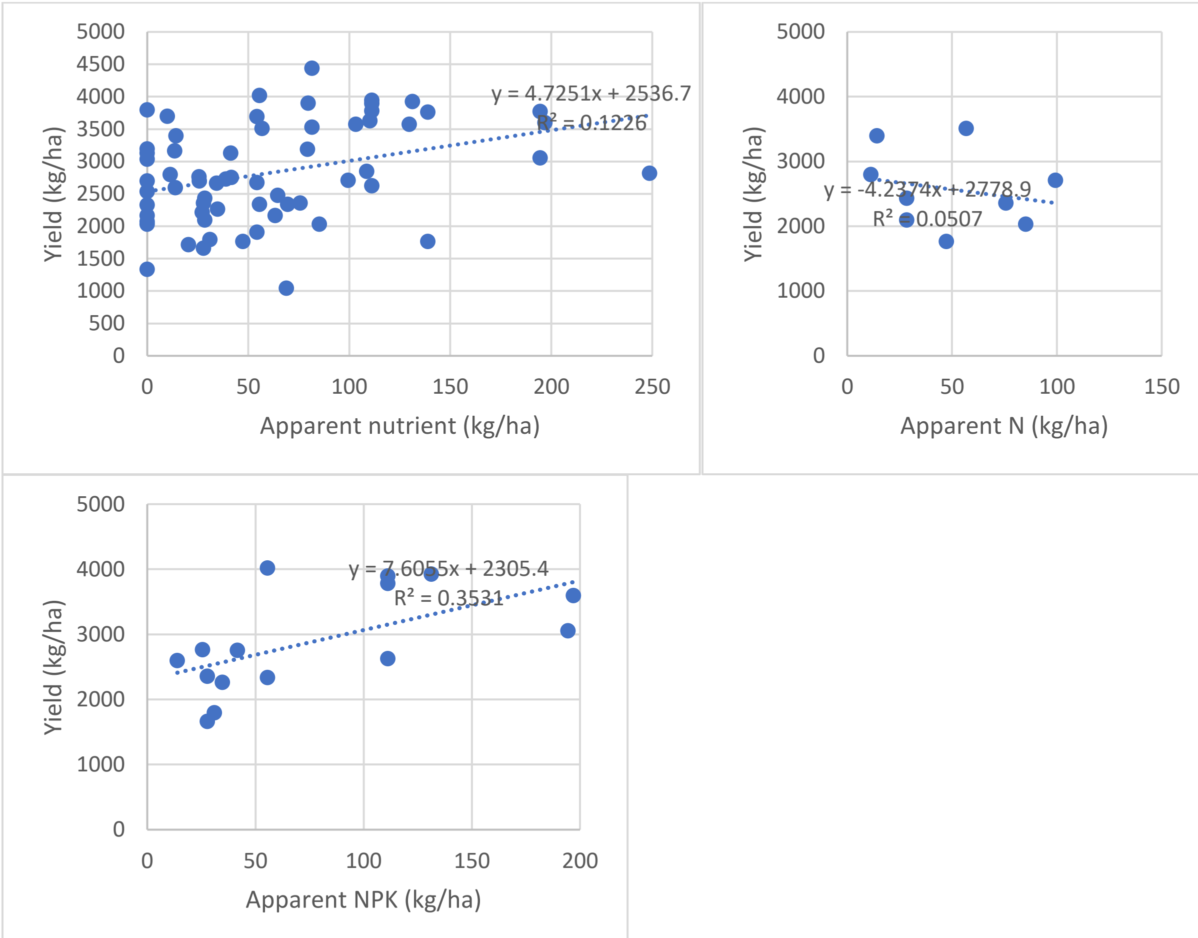
Appendix 3. Types of fertilizer used for rice by region

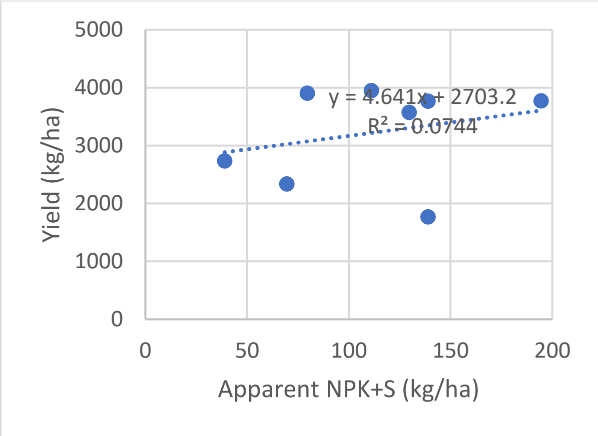


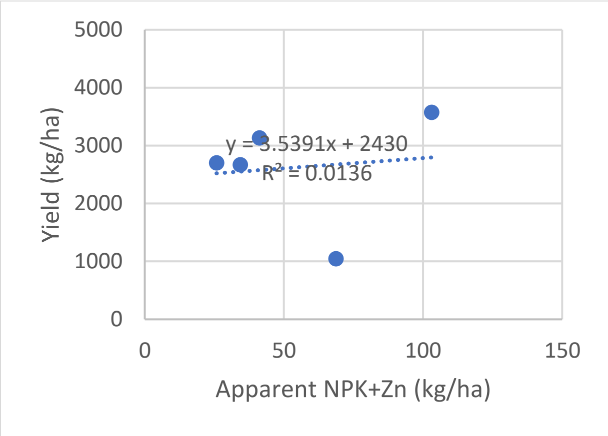
Appendix 4. Quantity of fertilizer applied and yield of maize by region

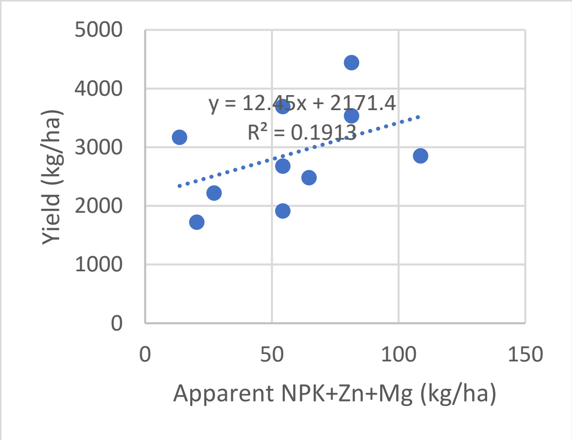
	Sample	Fertilizer Applied (kg/ha)	Apparent Nutrients (kg/ha)	Yield (kg/ha)
Bono				
Non-users	3	0.0	0.0	2,888.9
NPK	5	92.8	41.9	2,546.7
NPK+S	2	197.5	88.9	2,250.0
NPK+Zn	1	46.3	25.8	2,700.0
N	4	85.9	39.5	2,500.0
NS	1	21.6	9.8	3,700.0
Bono East				
Non-users	2	0.0	0.0	2,183.3
NPK	2	254.6	115.8	2,933.3
N	2	61.7	28.4	2,266.7
NS	1	138.9	63.3	2,166.7
North East				
NPK	2	169.8	76.4	3,271.0
NPK+S	1	185.2	79.6	3,903.3
N	1	123.5	56.8	3,513.3
Northern				
Non-users	5	0.0	0.0	2,455.3
NPK	4	149.2	67.5	3,161.7
NPK+S	3	342.9	154.3	3,705.6
NPK+Zn	4	111.1	61.9	2,604.3
NPK+Zn+Mg+S	11	173.0	80.9	2,968.7
NPK+Zn+S	3	284.6	144.4	3,214.4
N	2	190.3	87.6	2,535.0
Savannah				
Non-users	1		0.0	3,036.7
NPK+S	2	200.6	90.3	3,143.3
NPK+Zn+Mg+S	1	46.3	20.8	1,720.0

Appendix 5. Scatter plot analysis of maize yield trend by fertilizer nutrient combination

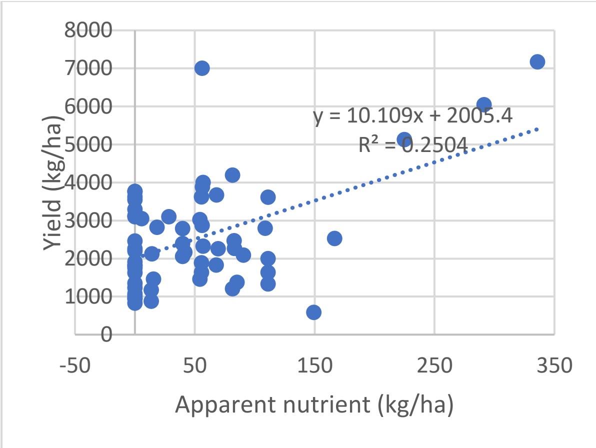


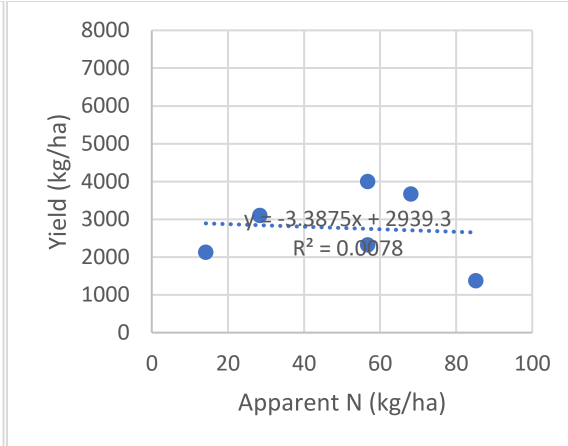

5000
4000
3000
2000
1000
0
Yield (kg/ha)
y = 4.641x + 2703.2
R² = 0.0744
0
50
100
150
200
Apparent NPK+S (kg/ha)

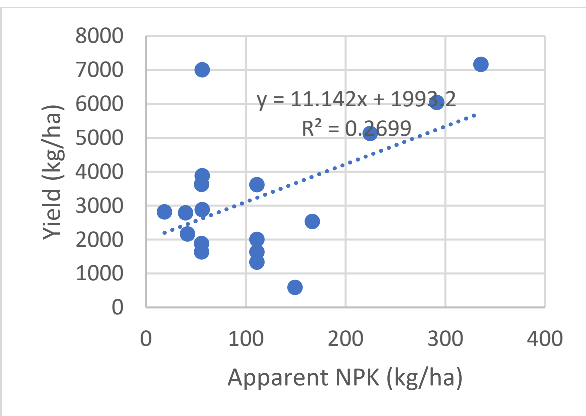

5000
4000
3000
2000
1000
0
Yield (kg/ha)
y = 3.5391x + 2430
R² = 0.0136
0
50
100
150
Apparent NPK+Zn (kg/ha)

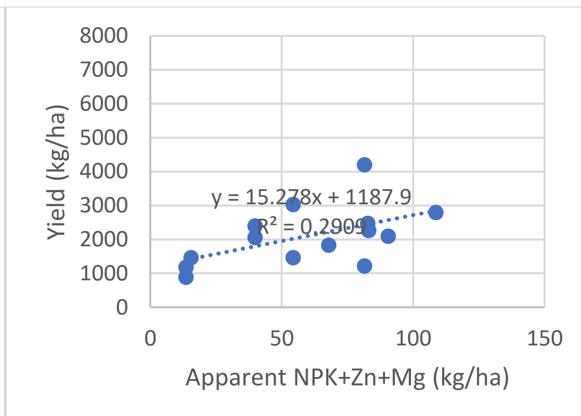

5000
4000
3000
2000
1000
0
Yield (kg/ha)
y = 12.45x + 2171.4
R² = 0.1913
0
50
100
150
Apparent NPK+Zn+Mg (kg/ha)

Appendix 6. Scatter plot analysis of rice yield trend by fertilizer nutrient combination









FERARI

FERTILIZER RESEARCH & RESPONSIBLE IMPLEMENTATION

FERARI is an international public-private partnership that builds science-based approaches to site-specific fertilization for widespread adoption by farmers in Ghana for improved food and nutrition security. This calls for a transformation of the fertilizer and food systems that must be driven by evidence-based agro-technical perspectives embedded in multi-stakeholder processes.

To support this transformation, the following institutions have partnered to implement the Fertilizer Research and Responsible Implementation (FERARI) program:

- International Fertilizer Development Centre (IFDC)
- Mohammed VI Polytechnic University (UM6P)
- OCP Group
- Wageningen University and Research (WUR)
- University of Liège (ULiège)
- University of Ghana (UG)
- University for Development Studies (UDS)
- Kwame Nkrumah University of Science and Technology in Kumasi (KNUST)
- University of Cape Coast (UCC)
- University of Energy and Natural Resources (UENR)
- Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) College of Agriculture Education
- Council for Scientific and Industrial Research in Kumasi (CSIR-SRI) and in Tamale (CSIR-SARI) and its subsidiary (CSIR-SARI-Wa)

FERARI operates in conjunction with the Planting for Food and Jobs program of the Government of Ghana (GoG) to embed development efforts into national policy priorities to reach impact at scale. It trains five Ph.D. and two post-doctoral candidates and dozens of master's-level students in building the evidence base for its interventions.

FERARI conducts hundreds of fertilizer response trials on maize, rice, and soybean, on-station and also with farmers, and demonstrates them to farmer groups in the northern and middle belt of Ghana. It conducts surveys among farmers and actors in the value chain to understand the drivers for use of fertilizers and other inputs and the marketing of the produce to enhance farm productivity and income. It helps the GoG to establish a Ghana National Fertilizer Platform, developing its soil mapping expertise toward an information platform.

The content of this report is the sole responsibility of the authors of the involved institutions portrayed on the front page.

IFDC

Developing Agriculture from the Ground Up