

Research Application Summary

Influence of agricultural technologies and practices on maize cropping system amongst small-scale farmers in Southern Mali

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Abstract

Small-scale farmers in Southern Mali who are mainly maize producers are facing many challenges in the uptake and accurate application of agricultural technologies. Maize production constitutes a significant opportunity for these farmers to ensure food security and adequate nutritional status and to reduce extreme poverty in rural areas. The expansion of land area under this staple crop is still increasing but the output of its production remains low. These constraints may be attributed to the particular maize varieties grown and climate variability coupled with declining soil fertility. The objective of this study was to contribute to understanding the uptake of modern agricultural technologies under the maize cropping system in Southern Mali. The study was carried out in three selected villages each located in a different agroecological zone in Southern Mali. A multistage sampling technique procedure was applied to obtain a sample size of 134 maize producers who were selected randomly. A semi-structured questionnaire was used to collect cross-sectional data from those selected maize producers. Descriptive statistics were used for data analysis. The results indicated that improved maize varieties, applying organic manure under land size allocated for maize, plough plus hand sowing, and plough plus sowing were practiced by 36%, 41%, 73%, and 34% of farmers, respectively. The share of maize cropping was 39%, 41%, and 62% in Beguene, Ziguena, and Nafegue, respectively. Grain yield of maize was around 1668 kg ha⁻¹ in Beguene, 1807 kg ha⁻¹ in Nafegue and 2114 kg ha⁻¹ in Ziguena. Policy intervention should be based on the dissemination of agricultural technology practices and enabling access to suitable agricultural equipment. Strengthening farmers' skills through training on good agricultural practices will enhance maize productivity and improvement of livelihood of small-scale farmers.

Key word: Agricultural technology, maize, production, Southern Mali

Résumé

Les petits agriculteurs du sud du Mali, qui sont principalement des producteurs de maïs, sont confrontés à de nombreux défis dans l'adoption et l'application précise des technologies agricoles. La production de maïs constitue une opportunité significative pour ces agriculteurs afin d'assurer la sécurité alimentaire et un statut nutritionnel adéquat et de réduire l'extrême pauvreté dans les zones rurales. L'expansion des terres consacrées à cette culture de base continue d'augmenter, mais le rendement de sa production reste faible. Ces contraintes peuvent être attribuées aux variétés particulières de maïs cultivées et à la variabilité climatique couplée à la baisse de la fertilité des sols. L'objectif de cette étude était de contribuer à la compréhension de l'adoption des

technologies agricoles modernes dans le système de culture du maïs dans le sud du Mali. L'étude a été menée dans trois villages sélectionnés, chacun situé dans une zone agro-écologique différente du sud du Mali. Une procédure d'échantillonnage à degrés multiples a été appliquée pour obtenir un échantillon de 134 producteurs de maïs sélectionnés de manière aléatoire. Un questionnaire semi-structuré a été utilisé pour recueillir des données transversales auprès des producteurs de maïs sélectionnés. Des statistiques descriptives ont été utilisées pour l'analyse des données. Les résultats ont indiqué que les variétés de maïs améliorées, l'application de fumure organique sur une surface allouée au maïs, le labourage à la charrue plus semis à la main, et le labourage combiné au semis à la charrue étaient pratiqués par 36%, 41%, 73% et 34% des agriculteurs, respectivement. La part de la culture du maïs était de 39%, 41%, et 62% à Beguene, Ziguena, et Nafegue, respectivement. Le rendement en grain du maïs était d'environ 1668 kg ha⁻¹ à Beguene, 1807 kg ha⁻¹ à Nafegue et 2114 kg ha⁻¹ à Ziguena. L'intervention politique devrait être basée sur la diffusion de pratiques technologiques agricoles et permettre l'accès à des équipements agricoles adaptés. Le renforcement des compétences des agriculteurs par la formation aux bonnes pratiques agricoles permettra d'améliorer la productivité du maïs et les moyens de subsistance des petits exploitants.

Mots clés : Technologie agricole, maïs, production, Mali du Sud

Introduction

In sub-Saharan Africa (SSA) agriculture remains the backbone of social and economic development. The sector plays a vital role in economic growth and constitutes the main pathway for smallholder farmers to overcome food insecurity, malnutrition and poverty (FAO, 2014). Mali is a landlocked and geographically diverse country located in the Sahel region. It is a low-income country, majorly a rural economy with a rapidly growing population. Crop farming, livestock and fisheries account for about a third of Mali's Gross Domestic Product (GDP) and contribute to more than 70 percent of the primary source of rural employment (FAO, 2017). Cereal production occupies over 80 percent of the total arable land and accounts for about 75 percent of total agricultural production. Cereals are largely produced for own consumption and only the surplus are marketed domestically. In addition, cereals (maize, sorghum and millet) stand for more than two-thirds of the country dietary energy supply and constitute the main staple food (FAO, 2017).

Despite being the main source of livelihood in Mali, the agriculture sector is faced with numerous challenges that limit the potential production. Hence to curb the problem of low productivity which results in low income, smallholder farmers opt for crop diversification strategies (Dembelé et al., 2018). The Government of Mali (GoM) has identified maize production as a food crop with high production potential with a fundamental role in alleviating food deficit. In addition, the GoM has decided to promote maize production in Southern-Mali by translating improved agricultural technological packages (IATP) from research for wide dissemination. Among these IATPs are improved varieties, application of organic and inorganic fertilizer, ploughing, etc (Teklewold et al., 2013; Kassie et al., 2015; Manda et al., 2016).

However, in numerous literatures, the uptake of IATPs depending on the location of the study presents diverse results and indicators of socioeconomic factors. A recent study on agricultural technology practices uptake reported that the farm characteristics, land size, education level and institutional constitute the main factors (Teklewold et al., 2013; Shiferaw et al., 2014). Despite these findings, there has been a steady decline in the rate of at which farmers use these modern agricultural practices (Assefa and Hans-Rudolf, 2016; Mottaleb, 2018).

This implies that advanced agricultural technologies and practices in maize production have not been widely disseminated, thus not well understood. Up till now, uptake of these IATPs have been limited due to unknown reasons. However, the yield per hectare remains low and threatens smallholder farmers' food security and income sources. This study aimed to understand the uptake of IATPs on maize cropping system amongst small-scale farmers in Southern Mali.

Methodology

Study area. The study was conducted in Southern Mali or cotton growing zone (Figure 1). The selection of the study zone is justified based on the importance on the potential of arable land allocated for maize cropping and diversified agriculture compared to rest of country. Three villages have been chosen each in three different agroecological zone based on their accessibility and level of maize cropping namely: Beguene in Old basin of cotton production located in Bla (Province) and characterized by the high pressure on the natural resources and cropping systems is based cotton-maize and rainfall between 600-800 mm per year. Ziguena (Sikasso Province) in the medium zone corresponds to the isohyet with 1000 -1100 mm of rainfall per year. Nafegue (Kadiolo province) located in sub humid zone is characterized by low population density and corresponds to the isohyet with more than 1200 mm per year and with less pressure on natural resources.

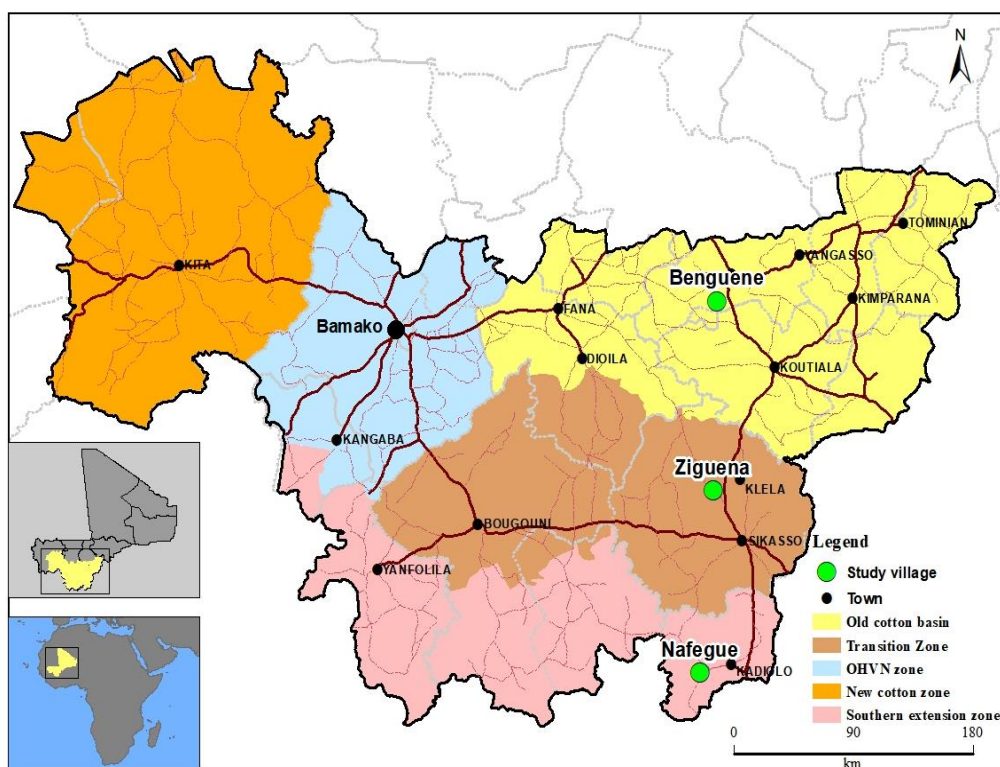


Figure 1. Location of study areas

Sampling technique. The population of interest constituted all farmers who practiced maize production in the three selected villages. The smallholder maize producers were the sampling unit for this study. A multistage sampling technique was used to get the desired sample size which involved a stratified and simple random sampling procedure. The first stage was the purposive selection of three communes with higher potential for maize production. At the second stage, one village from each commune was selected. Lastly, smallholder maize producers were selected randomly using a proportionate to size sampling procedure, (Yamane, 1967). The obtained sample size was 134 farming families. Primary data collection were used and based on cross sectional data. These primary data were collected through interviews using a structured questionnaire. The data were (i) socio-demographic of maize producers, (ii) the institutional factors, (iii) maize cropping system, (iv) land, and (v) livestock ownership, among others. The study used the descriptive statistics such as frequencies, mean, standard deviation, tables, graphics on smallholder maize producers' socio-economic characteristics. Inferential statistics were also used such as Chi-square for categorical variables and analysis of variance (ANOVA) for continuous variables. All data analyses were performed using STATA version 14.0.

Description of variables. The independent variables in this study include family farming and farmers' characteristics such as age of head of the family, family size, livestock ownership, education level, land size and agricultural equipment. In addition to these, institutional aspects such as access to agricultural credit, access to agricultural extension services, agricultural incomes, and off-farm income among others were included.

Farmer characteristics. These include family size, age of head of the family, education level of head of family farm, and the type of agricultural equipment in use were vital characteristics that influence decisions for agricultural technology practices mainly in Sub Saharan Africa (SSA).

Access to agricultural credit. Since agricultural credit play an important role in increasing or promoting agricultural production through credit in terms of access to agricultural inputs such as fertilizer, herbicides, insecticide and other inputs, this parameter was included (Langyintuo and Mungoma, 2008; Mariano *et al.*, 2012).

Access to agricultural services. Agricultural extension service is measured in this study by the number of contacts that farmers have with agricultural public service agent.

Agricultural equipment. Agricultural equipment such as plough, cart and seeder are important draught tools in agriculture mainly in absence of tractor and other machines. The possession of those tools may be expected to have positive effect on agricultural technology practices.

Results and Discussion

Farmer characteristics. Table 1 presents the results of this study on education level of sampled farmers and Chi-Square test. The majority of farmers, around 33%, 58% and 61 % in Beguene, Nafegue and Ziguena had no formal schooling level, respectively. Only 4%, 14% and 7% respectively had primary level of education. In the study zones, only 2 % of family heads had secondary level of education while others had gone to a Muslim school or obtained local language training.

Demographics. Table 2 shows the different means: age of head family, family size and number of households in the family. It also includes the result of one-way ANOVA test. The mean age of family heads was 54, 56 and 58 in Beguene, Nafegue and Ziguena respectively. The one-way ANOVA results revealed that there was no significant statistical difference in the mean of age. Similarly, the mean number of population and the mean of household were not statistically significant. In the study area, a family is composed of many households sharing all stuff and tasks such as farming activities, equipment and meals.

Farm characteristics. Table 3 presents results of analysis of farm size of cropping system in the study area. The means of size of cotton plots was 0.74 and 2 ha in Beguene and Nafegue respectively. The difference was statistically significant across villages with $p=0.000$. Regarding the maize, millet and sorghum, the mean farm size per village was statistically significant at 1% level each.

Agricultural equipment in the study area. Table 4 presents the agricultural equipment ownership in the study area. The average draught tools such as plough, sower and multi- plough were 4 tools per village. The carts in the area are of two types: donkey cart and ox cart. On average there was one cart per farming family. The F statistics was significant at 1 % level. This could be explained by the role of cart in agricultural production system in cotton growing zone. The average number of oxen possessed is almost the same across the villages. This is due the importance of animal power in agricultural production mainly due to the lack of machine such as tractor. The average size of breeding animals that a farming family owns was statistically significant at 5% level. This could be explained by the potential of the area for feeding and an availability of pasture. In cotton growing area, livestock rearing constitutes the heart of agricultural development. It contributes to all farming tasks such as ploughing, sowing, transport of organic manure to the field, transport of residues, the outputs of commodities and workers.

Table 1. Education level of respondents

Education level	Nafegue	Ziguena	Beguene	χ test
None formal school	57.78	61.36	33.33	14.90 *
Primary	4.44	13.64	6.67	
Secondary	0	0	2.22	
Muslim school	8.89	4.55	15.56	
Local language	28.89	20.45	42.22	

Note: *, significant at 10% level.

Table 2. Means of age, population and household

Variables	Nafegue		Ziguena		Begueue		F-test
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
Age family	55.8	13.83	58.36	14.93	54.22	16.24	0.86
Population	27.2	17.13	27.18	19.17	27.02	26.71	0
Number of households	3	2.024	4	2.52	3	3.51	0.16

Table 3. Mean size of principal crops per village

Crop (ha)	Nafegue		Ziguena		Begueue		F-test
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
Cotton	2.089	2.009	0	0	0.74	0.930	30.37
Maize	6.289	2.685	5.846	4.988	1	0.9519	
Millet	.622	.683	3.909	2.961	6.266	4.268	39.49***
Sorghum	1.13	.786	4.397	3.758	1.238	1.632	26,58***

Note: *** Denote significance at 1% level

Table 4. Main agricultural equipment ownership

Variables	Nafegue		Ziguena		Begueue		F- stat
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Drought tools	3.86	1.85	4.41	2.58	4.44	2.56	0.85
Carts	1.16	0.601	1.07	0.587	1.64	1.05	7.15***
Oxen	4.156	2.62	5.41	4.81	4.24	2.90	1.70
Other animals	12.09	18.57	18.37	28.19	6.56	9.87	3.80**

Note: ***; ** Denote significance at 1% and 5 % levels

Share of maize in cropping system in Nafegue area. Figure 2 presents the share of maize in the cropping system. Around 62% of total land cultivated is under maize while the millet, sorghum and cotton stand for 6%, 11% and 21% respectively. This large share of maize is due to the lack of agricultural inputs subsidy such as NPK fertilizer, Urea, insecticide and herbicide. In this village, in spite of access to agricultural inputs being an issue, producers tried to maintain cotton cropping since it is the main cash crop and constitutes the main source of revenue in this rural area of Southern Mali. Therefore, maize cropping is seen as an alternative crop to overcome food insecurity, and the surplus can be sold to meet family needs.

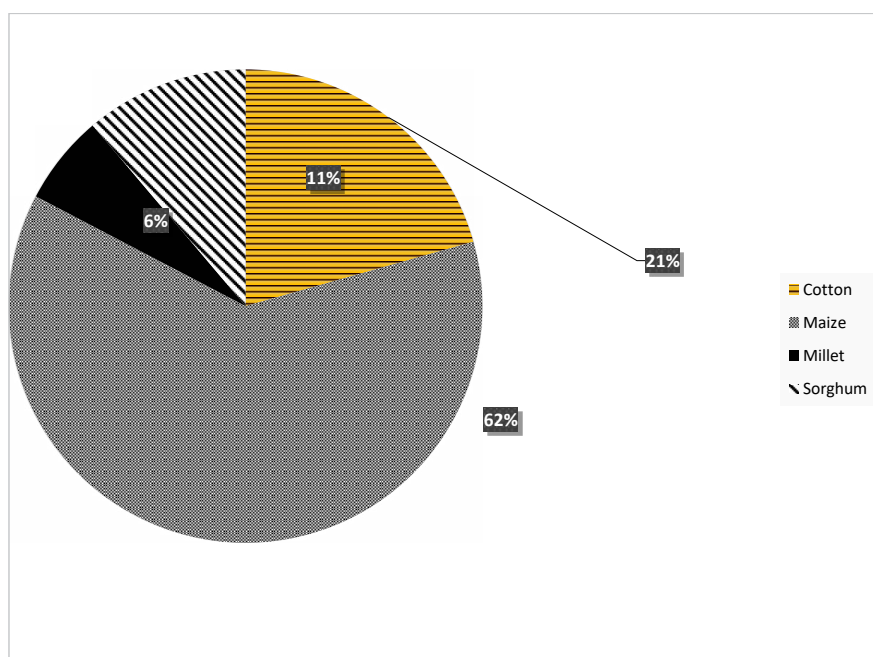


Figure 2. Share of maize in cropping system (Nafegue)

Share of maize cropping in Ziguena. Figure 3 presents the percentage of maize in the cropping system in Ziguena. In this village, producers boycotted cotton during this season 2020-2021 due to the lack of subsidy for cotton cropping inputs such as: NPK fertilizer, urea and pesticides. According to producers, without cotton inputs subsidy, there will be no cotton production. Consequently, cotton occupied 0% in the share of total land allocated for main crops. Maize occupied 41% followed by sorghum 31% and millet 28%. In other words, the village had focused on maize for food security of which only the surplus is sold for family expenses.

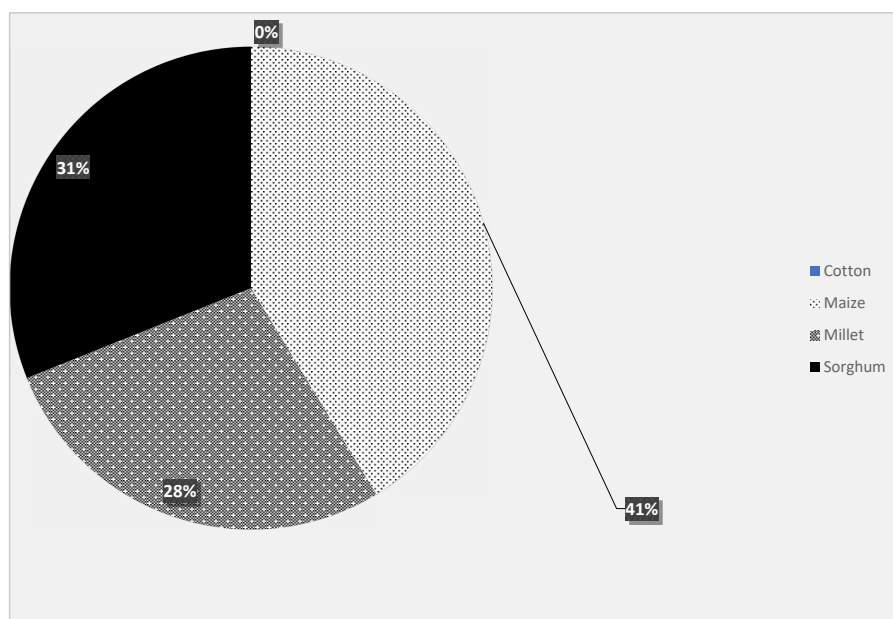


Figure 3. Share of maize in cropping system (Ziguena)

Share of maize in cropping system in Beguene. The share of main crop such as cotton, maize, millet and sorghum are shown in Figure 4. Maize stand for 39%, millet 32%, sorghum 20% and cotton 9% respectively. This village is located in old basin of cotton production zone and cotton constituted the main income generation activity. Due to that, producers maintained the cotton production in the cropping system even if there is decreasing yield. The staple food, maize, millet and sorghum together stand for 91 % in the total land cultivated. This zone is always under threat of climate variability, food insecurity, malnutrition and poverty. In order to reduce these threats, particularly food shortage, producers opt to increase the size of land dedicated to food crops. In the same line, the surplus of these food crops is sold for family expenditure such as health and school fees.

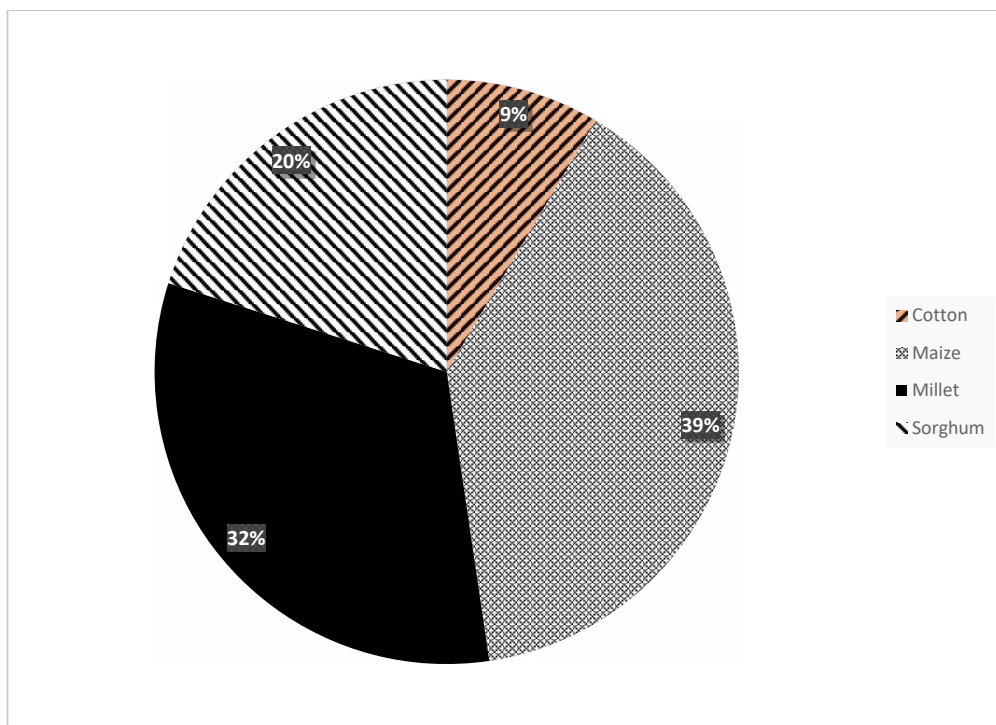


Figure 4. Share of maize in cropping system (Beguene)

Arable land size under maize in the study area. In the study zone, maize cropping occupies an important place in the production system mainly in terms of food security. The results are indicated in Table 6. About 37 % of the producers had land size under maize between 0 to 1.5ha. In other words, this category of producers are not well equipped and experience a lack of finance to purchase agricultural inputs. About 21% of the producers had land holding falling between 2 to 4 ha. The proportion of producers having land size under from 5 to 7 ha; 8 to 11 ha and 12 to 16 were estimated at 26%, 9% and 7% respectively. The importance of maize land size could be attributed to the boycott of planting cotton in the Southern Mali.

Table 6. Land size cultivated under maize

Land size under maize (ha)	Percent (%)
>=1,5]	36,57
[2-4]	20,90
[5-7]	26,12
[8-11]	8,96
[12-16]	7,46

Table 7. Agricultural technology practices

Technologies practices	Yes	No	χ^2 test
Improved seed	36	64	36. 296 ***
Organic manure	41	59	7.8162**
Plough+ hand sowing	73	27	24.819***
Plough-+sowing	34	66	21.786***

Note: **, *** denote significance at 5% and 1% level respectively

Agricultural technologies practices. Table 7 presents the results of main agricultural technologies practiced by the producers in the selected villages. About 64% of the producers sampled did not use improved seed of maize. The Chi-square statistics was statistically significant ($p=0.000$) at 1 % significance level. This could be attributed to the unavailability and limited access to improved maize seed at producer's level. In addition, the financial issues could be also another limiting factor of access to improved seed. For applying organic manure, about 41% said that they applied organic manure under maize. A Chi-square test was statistically significant ($p=0.0$) at 5% level. This statistical difference may be imputable to the boycott of cotton production this season by producers since the application of organic manure under maize crop is associated with cotton cultivation. The practice of plough plus hand sowing is a common practice in the study area. About 73% practiced this technology and there was a statistical significance ($p=0.000$) at 1% level. About the practice of plough plus sowing, 34% of producers applied this technology and the chi-square was statistically significant ($p=0.000$) at 1% level. This could be explained by the availability of agricultural equipment such as plough, seeder and oxen. This is consistent with scientific findings (Simtowe *et al.*, 2016; Mottaleb, 2018).

Maize input-output level per hectare and per village. Figure 5 shows the different outputs of maize and main inputs (complex cereals and urea per hectare) used under maize in the three selected villages. The maize yield varied across the villages from 1668 kg/ha in Beguene, 1807 kg/ha in Nafegue to 2144 kg/ha in Ziguene. This low yield recorded in each village may be attributed to the low use of improved seed since around 64 % farmers applied this technology and the other farmers re-used the same seed for new planting season. The quantity of NPK per hectare was 95 kg/ha in Ziguena, 100 /ha in Nafegue and 132 kg/ha in Beguene. In the same vein, the quantity of urea applied per hectare varied throughout the villages. All main inputs used under maize were

below the recommended quantity by the researchers and extension services which is 150 kg/ha for urea and 100 kg/ha for NPK for cereals, hence implying farmers are not sufficiently using these inputs. In addition, the boycott of cotton planting in 2020-2021 season by the farmers has also affected the use of maize inputs since farmers obtain the maize-subsidized fertilizers via cotton production.

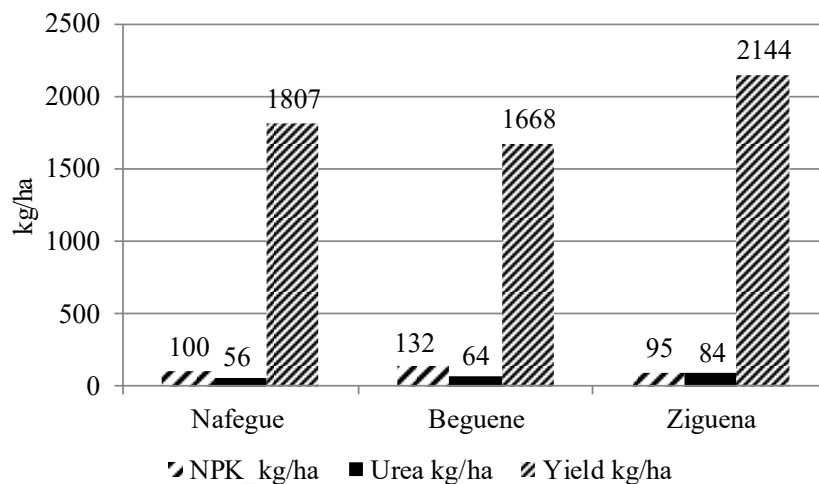


Figure 5. Maize input-output per hectare and per village

Conclusion

In the least developing countries, producers face multiple constraints such as low soil fertility, climate variability, food insecurity and low incomes from farm activities that resulted from low yield. Many studies have shown that the agricultural technology practices could play an important role in alleviating these constraints in rural areas. Farmers are limited by a number of factors such as arable land, agricultural equipment, livestock ownership. Maize cropping in the study zone constituted the main crop for food security, income generation among others. The findings of this study show that about 64% of maize producers did plant improved seed, 59% of producers did not apply organic manure under maize plot, 73% of producers practiced plough plus hand sowing and 66% of producers did not practice plough plus sowing. Also, the recommended quantity of inputs under maize were not respected due to the lack of subsidy imputable to the boycott of cotton production in this season of 2020-2021. The yield per hectare of maize varied across the villages around 1668 kg/ha, 1807 kg/ha and 2144 kg/ha in Beguene, Nafegue and Ziguena, respectively. The financial issues at the farmers' level impacts negatively the maize output in the study area. In the context of climate change, it is important for the stakeholders, researchers, agricultural extension services officers and farmers involved in the agricultural sector to promote and disseminate the agricultural technologies practices in order to find out a sustainable pathway of agriculture.

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