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Research Application Summary

# A survey on rice seed systems in Liberia

Dorley, O.S.,* Ochuodho, O.J., Auma, A.E. & Were, O.J.

University of Eldoret, School of Agriculture, Department of Seed, Crop and Horticultural Sciences, P.O. Box, 1125-3100, Eldoret, Kenya
***Corresponding Author:** odorley2012@yahoo.com

## Abstract

Rice is the staple food in Liberia, consumed by more than 90% of the population. However, its production is dominated by smallholder farmers relying on poor quality inputs that have for long time been considered the core hindrance to achievement of optimal yields. One of such inputs is seed. Accordingly, to evaluate the quality and production impact of seeds used by farmers in Liberia, this study was conducted to characterize the rice seed systems, field crop management, storage methods of the harvested rice grains and consequential infection by fungi. The study was accomplished through a mixed data collection method, comprising of interviews and Focus Group Discussions (FGD) in four major rice producing counties in Liberia. Three hundred (300) farmers were purposefully selected and eight Focus Group Discussions (FGDs) held. It was found that 94.7% of farmers sourced seeds through informal seed system channels. The study found that the grains meant for subsequent farming season seeds are stored in kitchen attic by 83.8% of the farmers, while 7.8%, 3.8% and 4.6% of farmers stored seeds in house, containers and sacks, jute bags, respectively. Land was found to strongly correlate with the yield than any other factor, $R^2$= 0.944, p=0.00119.6%. Lofa was found to be the main rice producer for the three years under study 2018, 2019, and 2020. However, the yield significantly varied across the rice production zones as indicated by Kruskal Wallis (KW) test conducted on quantity of shelled rice, H (3) =115.032, p=0.00, H (3) =125.84, p=0.001 and H (3) =125.603, p=0.001, respectively. Farmers in high rainfall regions were found to have high likelihood of experiencing fungal infestation on their stored grains however, only 19.6% of farmers are aware of healthy implications of consuming affected grains. Therefore, policies and support framework should be directed towards actualization of modern seed channels, extension services and awareness creation on different nodes of rice value chain.

Keywords: Fungal infestation, rice seeds, yield, Storage

## Résumé

Le riz est l'aliment de base au Libéria, consommé par plus de 90% de la population. Cependant, sa production est dominée par de petits exploitants qui dépendent d'intrants de mauvaise qualité qui ont longtemps été considérés comme le principal obstacle à l'obtention de rendements optimaux. L'un de ces intrants est la semence. En conséquence, pour évaluer la qualité et l'impact sur la production des semences utilisées par les agriculteurs au Libéria, cette étude a été menée pour caractériser les systèmes de semences de riz, la gestion des cultures de plein champ, les méthodes de stockage des grains de riz récoltés et les infections consécutives par les champignons. L'étude a été réalisée grâce à une méthode mixte de collecte de données, comprenant des entretiens et

des discussions de groupe (FGD) dans quatre grands comtés producteurs de riz au Libéria. Trois cents (300) agriculteurs ont été délibérément sélectionnés et huit groupes de discussion (FGD) ont été organisés. Il a été constaté que 94,7 % des agriculteurs s'approvisionnaient en semences par le biais de canaux informels du système semencier. L'étude a révélé que les céréales destinées aux semences de la saison agricole suivante sont stockées dans le grenier de la cuisine par 83,8 % des agriculteurs, tandis que 7,8 %, 3,8 % et 4,6 % des agriculteurs stockent les semences dans la maison, les conteneurs et les sacs, les sacs de jute, respectivement. La terre s'est avérée fortement corrélée au rendement plus que tout autre facteur, R2 = 0,944, p = 0,00119,6 %. Lofa s'est avéré être le principal producteur de riz pour les trois années à l'étude 2018, 2019 et 2020. Cependant, le rendement variait considérablement d'une zone de production de riz à l'autre, comme l'indique le test de Kruskal Wallis (KW) effectué sur la quantité de riz décortiqué, H (3) =115,032, p=0,00, H (3) =125,84, p=0,001 et H (3) =125,603, p=0,001, respectivement. Il a été constaté que les agriculteurs des régions à fortes précipitations avaient une forte probabilité de subir une infestation fongique sur leurs céréales stockées. Cependant, seuls 19,6 % des agriculteurs sont conscients des implications pour la santé de la consommation de céréales affectées. Par conséquent, les politiques et le cadre de soutien doivent être orientés vers l'actualisation des filières semencières modernes, les services de vulgarisation et la sensibilisation aux différents nœuds de la chaîne de valeur du riz.

Mots-clés : Infestation fongique, semences de riz, rendement, stockage

## Introduction

Lack of an established formal seed systems in Liberia is a major constrain in achieving sufficient crop production particularly rice (SDCA, 2016). The sluggish efforts in developing supportive infrastructure and policies are attributed to many interactive factors from the economic state of the country, civil war, and lack of concerted efforts amongst stakeholders - government, farmers, non-governmental organizations and other stakeholders towards modernizing the seed system. Currently farmers rely on the community seed systems for their planting materials acquired through traditional seed channels (MOA, 2014). Seeds circulating within such channels are of poor quality because of decline in genetic yield potential over many years of use (Finch-Savage, 1995). The seeds and planting materials sourced through community seed systems are also highly susceptible to diseases and pests and their tolerance to climatic and environmental stresses are usually low (McGuire and Sperling, 2016). Overreliance on such seeds by farmers has been a major factor contributing to the decline in crop productivity (SDCA, 2016). Rice has been the most affected crop given that it is highly depended upon as a staple food for the Liberian population (Luther *et al*., 2017).

Rice (*Oryza sativa* L.) is the most important cereal crop in terms of consumption and production globally, followed by maize and wheat (Cosslett and Cosslett, 2018). China is the leading rice producer worldwide with more than 200 million metric tons of rice grain in 2018 (FAOSTA, 2020), while Nigeria leads the Africa continent followed by Egypt in 2018, respectively (FAOSTAT, 2020). Consumption of rice is projected to increase due to the burgeoning population, and climate change restraining the production of alternative cereals.

In Liberia, rice is a preferred staple food (Hilson and Bockstael, 2012), dependent upon by more than 4,195,666 people (Republic of Liberia, 2019). Liberia rice's annual per capita consumption is estimated to be more than 140 kg per capita in 2010 (Chauhan *et al*., 2017), leading in Africa. The crop is mainly produced by smallholder farmers scattered across the country (Ashmun, 2020). Rice cultivation in Liberia is extensive, characterized by low inputs, which do not meet

the essential crop requirement in terms of best agronomic practices, technical, and post-harvest handling practices for the crop. This translates to an annual decline in yield. For instance, in 2018, grain production was 257,995 tons produced from 238,090 hectares of land averaging to 1.083603 compared to Nigeria 2.035084 tones (FAOSTAT, 2020).

In the past decade since the end of civil war (Vorrath, 2018), the area under rice production has steadily increased, and many people joined rice farming, making it the best sector employing more than 51% of the Liberian population (Knoema, 2019). In recent years concerted efforts by the Government, World Bank, and Non-Governmental Organizations have seen the rice sector receive support in terms of agriculture equipment and other inputs such as fertilizers as well as improved varieties (MOA, 2014). The efforts indicate acknowledgement by the stakeholders of the critical role of rice in Liberian national food security. Nevertheless, rice production has declined in comparison to the area under production despite the synergies created by value chain stakeholders and farmers' increased involvement (MOA, 2014). Therefore, this study was conducted to charaterize the rice seed system in in the main growing counties of Liberia. Selected variables were correlated to yield and perceptions of the farmers on various aspects of seed quality to help understand the production dynamics.

## Materials and Methods

The study was conducted in four (4) of the fifteen (15) counties of Liberia in the rice agro-ecological zones that is, Bong, Lofa, Montserrado, and Nimba. These counties are located in the Western, Central, Southeastern and Northern Regions of Liberia.

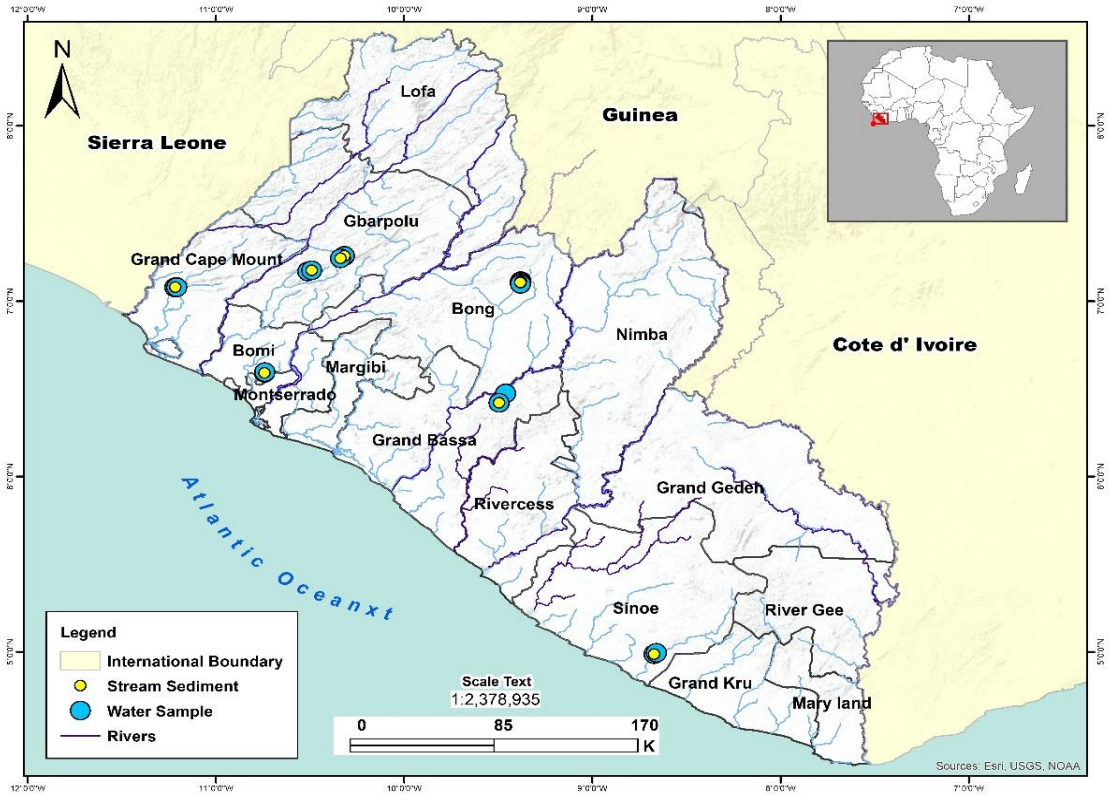


**Figure 1. Study Area Map of Liberia, EISI, 2019 (unpublished)**

Bong county is situated at a range of 8-75 meters above sea level. The county is located between 6 24' 7" N, and 7 25' 48" N longitude and 10 28' 34" W and 9 5' 38" W latitude. The county covers an area of 11846.931 km$^2$ (Schroth, 2015). Lofa County is categorized under two agro-ecological zones; Upper highland tropical forest and Northern savanna. It experiences bimodal rainfall seasons with an annual range of 700-2900 mm. Highlands of the county supports coffee and cocoa production while lowlands produce rice, plantain, cocoyam, among other crops (Schroth., 2015). Montserrado is the smallest county in Liberia covering an area of 1,912.7 km$^2$. It is located between longitude 6 12' 56" N and 6 49' 57" N and also lies between latitude 10 48' 48" W and 10 12' 0" W (LISGIS, 2008). The county experience a tropical climate driven by Harmattan winds (MCDA., 2008). Nimba County lies at an altitude range between 63-1730 meters above sea level and is situated at 5 49' 26" and 7 41' 46" N longitudes while 9 11' 43" and 8 16' 24" W latitudes. The county experience tropical climate categorized by alternating wet and dry seasons which is driven by inter-tropical convergence zoning (Schroth, 2015).

A cross-sectional study was conducted among the four counties, utilizing one-on-one interviews, sample observation and color coding of the fungal infections. Direct interviews were used to establish farmers' awareness regarding their activities on the enhancement and deterioration of rice seeds. Questions were developed to capture farmers seed quality status, seed fungal contamination, source of rice seeds, storage condition, and perception towards indigenous knowledge of seed preservation. Sample rice grain seeds were obtained from each participating farmer for subsequent characterization of the rice seed quality. Participating farmers were purposively sampled clustering them according to the county of resident. In total 500 farmers were sampled.

## Results and Discussion

Rice farming in Liberia is not biased towards one gender as depicted by the results; 49.8% and 50.2% of the farmers in the selected counties were men and women, respectively. However, Bong and Montserrado Counties had more men doing rice farming as shown by Figure 2.

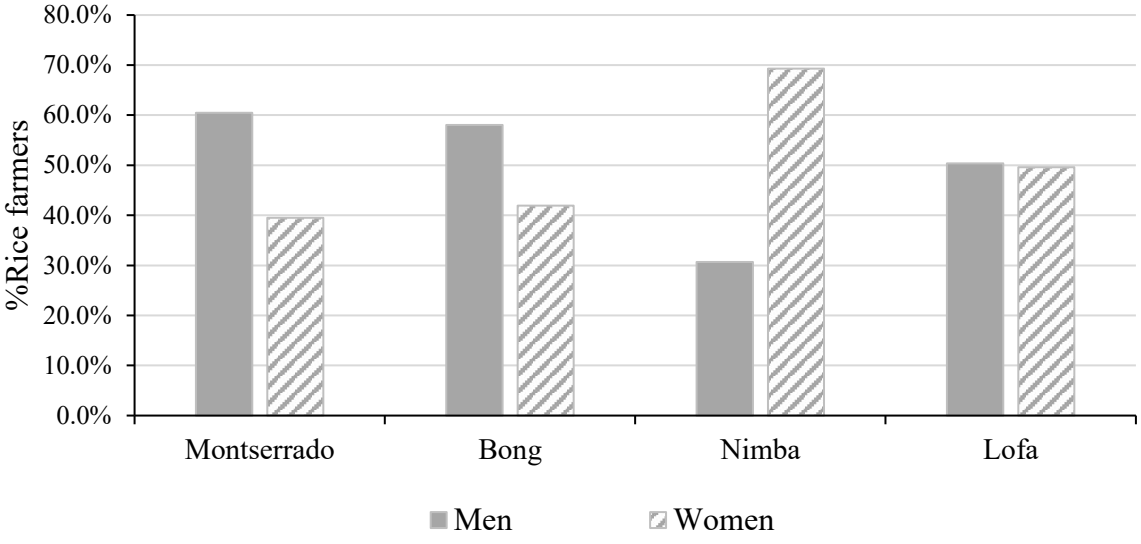


**Figure 2. Distribution of farmers in the four selected counties as per their gender**

The sector is dominated by farmers who have low level or no education accounting for 63.8% of farmers while 26.8% have achieved some secondary school education (either Junior high school or senior high school) and only 9.4% have tertiary education (post-secondary vocational training, and college degrees). Despite rice being the nation staple and almost every household allocating land for it, it is not the main source of income for the farmers; the study established that only 16.2% of farmers depend on the crop as their main household source of income. Other reported sources of incomes are shown in Figure 3. The study also found that in every household the farmer has on average 6±3(SD) dependants.

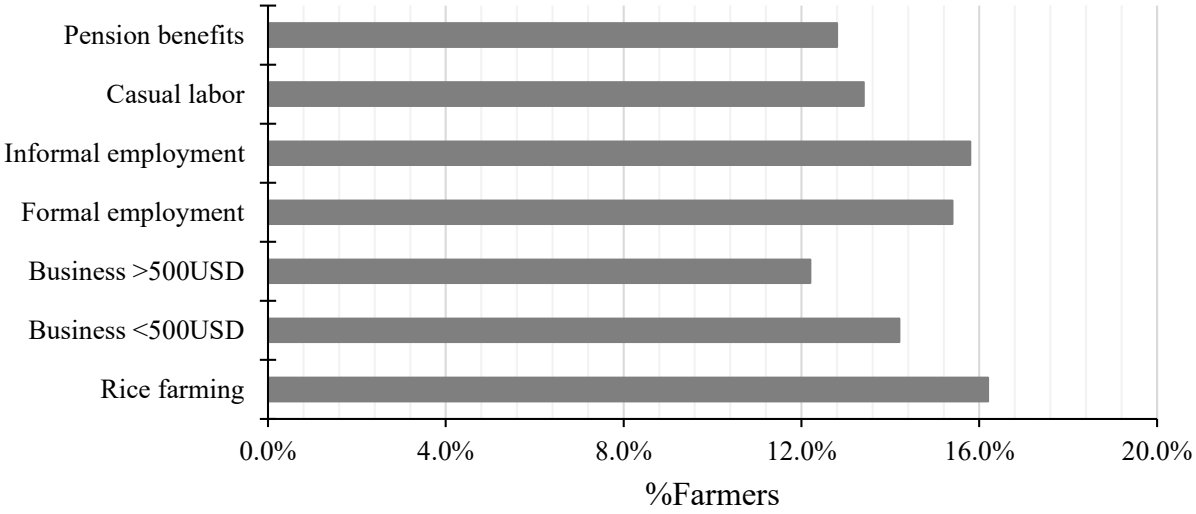


**Figure 3. The main household sources of incomes for the farmers doing rice production**

The study found that Liberian rice seed system is dominated by local channels of seed supply and maintenance. About 94.7% of farmers source their seeds from local open-air markets, borrow from neighbours or farmers saved seeds from the previous harvests. Only 5.3% of the rice farmers use certified seeds from agro-dealers and as agriculture aid from the Non-Governmental Organizations. The distribution channels of seeds is not pegged on farmer characteristics or county of residence as there exist no significant association between the factors and sources of seeds, as shown by Chi Square Test of Independence, $p>0.05$ and lambda ($\lambda$) association of 0.00.

The grains meant for next season planting are mainly stored in the kitchen attic as indicated by 83.8% of the farmers who practices it. The remain proportion; 7.8%, 3.8% and 4.6% of farmers stored their seeds in house attic, containers and sacks, respectively. Chi Square Test of Independence indicated significant association between the storage methods and farmers experience of fungal infections on their stored grains; $\chi 2(3) = 25.210$, $p < 0.001$, and Lambda ($\lambda$) association test of 0.164, indicating that farmers storing seeds in the kitchen attic experienced low fungal infections compared to the farmers using other storage methods.

The selected counties are nationally ranked as the major ricer producers; however, the production significantly vary from each other as indicated by Kruskal Wallis (KW) test conducted on quantity of shelled rice across the four in three years; H (3) =115.032, p=0.00 in 2018, H (3) =125.84, p=0.001 in 2019 and H (3) =125.603, p=0.001 in 2020. Among the four counties, Lofa dominates in rice production as shown by mean ranks in Figure 4 over the three years. The study found that

size of land allocated to rice production is the primary determining factor of yield and linearly correlates with the yield reported, for instance, in 2020 $R^2$= 0.944, p=0.001. Size of land allocation to rice in the four counties also varied significantly H (3) =140.344, p=0.001, with Lofa leading in the size of land allocated to rice. Apart from land, management aspects like fertilizer applications were also found to positively correlate with the yield obtained, as shown by Table 1.

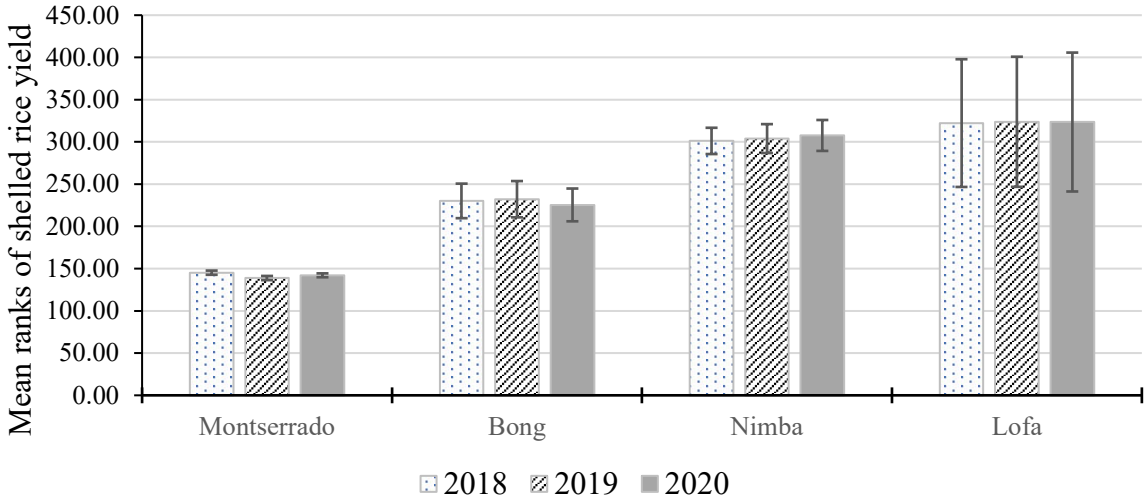


**Figure 4. Mean ranks of the shelled rice yield in the four counties of study. Error bars: standard deviation**

**Table 1. Correlation of rice yield in the counties of studies with predictive factors**

| | | Land under rice | Rice yield 2018 | Rice yield 2019 | Rice yield 2020 | Basal fertilizer | Topdressing fertilizer |
|---|---|---|---|---|---|---|---|
| Land under rice | $R^2$ | 1 | .914** | .940** | .944** | .141** | .134** |
| | p | | .000 | .000 | .000 | .002 | .003 |
| | N | | 499 | 499 | 499 | 500 | 500 |
| Rice yield 2018 | $R^2$ | | 1 | .953** | .950** | .433** | .398** |
| | p | | | .000 | .000 | .000 | .000 |
| | N | | | 499 | 499 | 499 | 499 |
| Rice yield 2019 | $R^2$ | | | 1 | .965** | .390** | .392** |
| | p | | | | .000 | .000 | .000 |
| | N | | | | 499 | 499 | 499 |
| Rice yield 2020 | $R^2$ | | | | 1 | .382** | .336** |
| | p | | | | | .000 | .000 |
| | N | | | | | 499 | 499 |
| Basal fertilizer | $R^2$ | | | | | 1 | .750** |
| | p | | | | | | .000 |
| | N | | | | | | 500 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Influence of farmers' characteristics (Education in Agriculture, age and county of resident), climatic factor (Annual average temperature and rainfall).** Rice variety (local or exotic), fertilizer used and size of land to assess their influence of farmers likelihood of experiencing fungal infection on their stored grains. The binomial logistic regression model indicated statistically significance, $\chi 2(9) = 110.105$, $p < .001$. The model explained 26.4% (Nagelkerke $R^2$) of the variance in farmer experience of rice grain fungal invasion in the year 2020 and correctly classified 70.4% of cases. Farmers who reside in Lofa and Nimba, receiving high amount of rainfall and apply fertilizers are likely to experience fungal infestations on their stored grains as shown by Table 2. The likelihood was also found to improve with the farmers having had training in agriculture with a chance of 88.5%.

**Table 2. Contribution of selected predictor factors on the likelihood of a farmer experiencing fungal invasion on their stored rice grains**

| Predictors | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Training in Agriculture | -2.037 | .435 | 21.929 | 1 | .000 | .130 |
| Annual average rainfall (mm) | .079 | .023 | 11.377 | 1 | .001 | 1.082 |
| Annual average temp (ºC) | -.221 | .473 | .217 | 1 | .641 | .802 |
| Land size allocated to rice | .002 | .002 | 1.588 | 1 | .208 | 1.002 |
| Application of fertilizer | .703 | .334 | 4.440 | 1 | .035 | 2.020 |
| Age of the farmer | -.291 | .210 | 1.929 | 1 | .165 | .747 |
| Rice variety | .271 | .347 | .609 | 1 | .435 | 1.311 |
| County of resident | .867 | .228 | 14.481 | 1 | .000 | 2.380 |
| Source of seed | -.672 | .663 | 1.027 | 1 | .311 | .511 |
| Constant | -6.792 | 8.962 | .574 | 1 | .448 | .001 |

Average rainfall and temperature data were all for the year 2020, Significance is measured at 0.05.

The study also revealed that 19.6% of farmers in Liberia rice sector understands the health concerns related with consumption of fungal contaminated grains but this was significantly low and linearly correlated with the percentage of farmers who experienced the fungal infection on their stored grains. The latter indicates that majority of farmers lacked knowledge in evaluating the quality of their grains.

The results showed that Liberia rice sector is dominated by small scale farmers who have limited knowledge and resources. The latter is clearly manifested by small sized lands and obsolete management techniques allocated to rice farming despite the crop being regarded as staple. The low formal literacy level among the farmers and inadequacy of agricultural training makes farmers experience a key driver in rice farming, and the same observation have been made across the rice producing countries of West Africa (Zossou *et al*., 2020). From a different perspective a large population engaged in subsistence farming of rice while intensively cultivating high value crops like rubber, cocoa and palm. Such scenarios are prevalent in Africa, and Dowswell *et al*. (2019) puts it into context where they reported that East African households grow maize despite clearly not embedding commercial value to it. Such practice gives an impression of high number of farmers in a certain cropping value chain but with low productivity. Low literacy levels observed

is a problem cutting across several sectors in Liberia and it has its roots in the shaky development of the nation's development. A United Nations Children's Fund reports also indicates that Liberia lags behind other African countries in literacy level (UNICEF, 2016).

Informal seed system is the main channel through which the farmers acquire their planting materials. The results were anticipated given the poor policies and lack of institutions and technical requirements in Liberia to advance the formal seed system particularly for rice. Farmers therefore, use their own saved seeds from previous harvest, farmer-farmer exchange or buy from local markets. The finding corroborates with Bèye and Wopereis, (2014) who indicated that informal tradition systems of seed supply among rice farmers in sub-Saharan Africa is the primary framework through which farmers acquire seeds. This directly affects yield and quality of the grains. Munyi and De Jonge (2015) stated that planting materials acquired from such channels are of poor quality and prone to spreading diseases.

Fungal infections on the stored grains have been found to largely affect the grains stored using different methods besides the kitchen attic storage. The grains stored in the latter are usually under drying heat and smoke coating which comes from the household cooking activities. Storing rice grains at a high temperature has been observed to reduce the fungal infections (Kamara *et al*., 2019). The smoke coating as observed by Hell *et al.* (2000) deprives fungi capacity to grow, while the heat constantly destroys any growing fungi which explains low infections. Knowledgeable farmers seem to experience less fungal infections than their less knowledgeable counterparts which indicates that the knowledgeable farmers are keen at identifying the infections compared to farmers with no education. Having knowledge implies that farmers awareness on the infection makes them cautious to utilize infected grains unlike the farmers without knowledge.

## Conclusion

Rice farming in Liberia is dominated by resource poor small scale rice farmers with limited knowledge and resources to enhance productivity. The farmers' rice production is primarily for subsistence purpose and the informal seed systems forms the main channel of farmers acquiring seeds for agricultural activities. Fungal infections were reportedly less prevalent in seeds stored in kitchen attic compared to other storage methods used in Liberia.

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