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RESEARCH ARTICLE

ANALYSES OF THE LOGISTICS CHAINS OF SEED COTTON MANAGEMENT BY COTTON GROWERS FROM THE FIELD TO THE GINNING PLANT IN BENIN

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ABSTRACT

Despite its economic importance, seed cotton management in Benin remains the sole responsibility of cotton growers. The objective of this study is to analyze the logistics chains involved in seed cotton management from the field to the ginning plant. The study was conducted in 2018 in the municipalities of Kandi and Kérou in the north and Djidja in the south. Yamane's random sampling method was used to collect data from 394 cotton growers. SPSS 18 software was used for univariate and bivariate descriptive analyses. Discourse and content analysis were the main qualitative tools used. To ensure consistency in the rankings given by cotton farmers to each factor, the nonparametric Friedman test was used. The results revealed that baskets and bags are the main harvesting materials used. Feet, motorcycles, bicycles, and tricycles are the main means used to transport seed cotton to primary markets. Trucks and vans are the main means of transport to the factory. The cotton farmers surveyed do not have warehouses to pre-store seed cotton. From the field to the factory, there is a noticeable decline in the quality of seed cotton. The use of financial resources, equipment, and technical support for cotton farmers remains essential to guarantee the quality of seed cotton.

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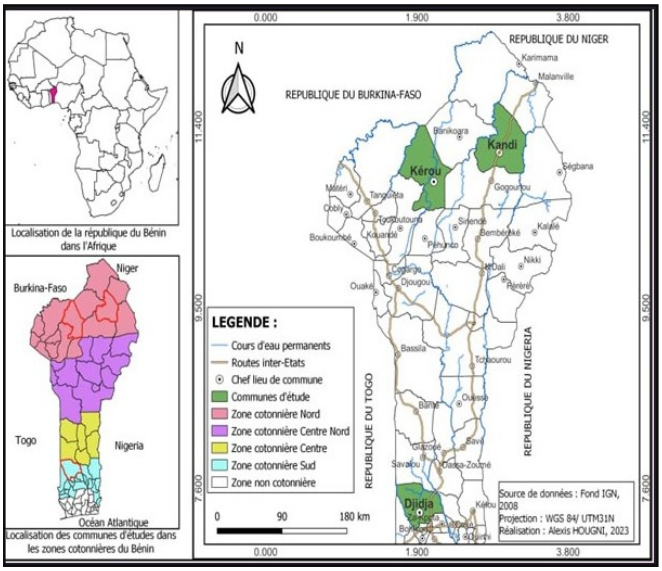
INTRODUCTION

The cotton sector plays a major socio-economic role in Benin. Directly or indirectly, cotton accounts for between 5 and 7% of GDP and around 27% of exports (World Bank, 2017). Cotton is one of the cash crops that brings in the most foreign exchange to Benin. Annually, the cotton sector provides 60 to 70 billion CFA francs to approximately 2 million people, generates 80% of export earnings, and contributes 3.8% to GDP (INSAE, 2008; Degla, 2012) . This sector generates 40% of jobs in rural areas and it is estimated that 50% of the population depends on it (Diakité, 2018) . Estimated at 45% of tax revenues, the cotton sector remains the best organized in the country. It is therefore one of the priority sectors of Benin's economy and provides it with financial and technical support(Batamoussi *et al.*, 2015) . The sector contributes significantly to the financing of the national budget and is the country's leading economy in rural areas(Adjinda, 2016) . Cotton remains the leading export product and has the greatest influence on Benin's economy. In addition to exports, cotton seed is used in a wide variety of cropping systems. Depending on the area, it is grown alongside tubers (yams, cassava), cereals (maize, millet, sorghum) or food and fodder legumes (Diakité, 2018) . As a result, it guarantees food security for rural populations. In addition, Benin produces cottonseed oil through the companies Fludor-Bénin S.A. and SHB-Bohicon. Outside these factories, cotton fiber is also used by local artisans and certain factories, notably SITEX-Bénin, the SOBETEX, and the cotton wool production factory. The cottonseed ginning campaigns last about six (6) months and provide more than three thousand five hundred (3,500) jobs nationwide (PASCIB, 2013). Cottonseed quality control and the introduction of several marketing options are therefore a necessity in all cotton-producing countries. As with any agricultural product, changes in fiber quality depend as much on cultivation techniques as on processing techniques. Controlling seed cotton quality allows cotton growers to share this aspect economically (Marmignon *et al.,* 2007). In Benin, the Plant Production Directorate (PPD), through its Product Quality and Packaging Promotion Service (PQPPS), is responsible for classifying seed cotton into two categories (choice) in ginning factories. However, there are warehouse and logistics problems that negatively impact not only the quality of seed cotton from the field to the ginning factory, but also the economy of cotton farmers. It is therefore natural to question the functioning of the logistics system put in place for the management of seed cotton from the field to the ginning factory via the primary market. It also seems legitimate to question the factors determining the deterioration in the quality of this same seed cotton. The situation could also be problematized in terms of the quality of the logistics chains used by cotton farmers. This study therefore aims to analyze the logistics chains used by actors in the cotton sector in Benin to manage seed cotton from the field to the ginning factory.

MATERIALS AND METHODS

Study area: The study was conducted in the municipalities of Kandi and Kérou (Northern Cotton Zone) and Djidja (Southern Cotton

Zone) (Figure 1). The municipality of Kérou is located in the department of Atacora, between 10°30' 11° 15' north latitude and 1°45'; 2°30' longitude(*et* al., 2020) . Kandi is located in northern Benin in the department of Alibori. It is bordered by the municipalities of Malanville (north), Gogounou (south), Ségbana (east), and Banikoara (west). The municipality of Djidjais located in central Benin, in the department of Zou, at 7°20' north latitude and 1°56' east longitude. In addition to being the leading cotton producer in the south, it is also the breadbasket of the Zou department. As such, it ensures food security for the entire south of the country, which it supplies thanks to its high agricultural production(Salami *et* al., 2022) (Cal Fig. 1)



Sampling and data analysis: The choice of municipalities for the study took into account the historical importance of recorded production and the reasons for the downgrading of seed cotton upon its arrival at the ginning mills. To ensure that all stakeholders (cotton farmers, grading agents, transporters, and ginners) were represented and to better understand the logistics process step by step, five (05) cotton-growing villages were selected per municipality. The observation and reporting unit consisted of cotton farmers selected through theVCPC, primary market managers, packaging agents, loaders, transporters, factory receptionists, and ginners. The sampling method used was that of Yamane (1967) for random sampling, calculated using the following formula:

$$n = \frac{N}{1 + N\,(e)^{2}}$$

n= sample size, N= total population of interest, and e=margin of error set at 5%. Thus, for the purposes of the study, three hundred and ninety-four (394) cotton farmers were surveyed, including one hundred and eighty-five (185) cotton farmers in the commune of Kandi, 103 cotton farmers in the commune of Kérou, and 106 in the commune of Djidja.

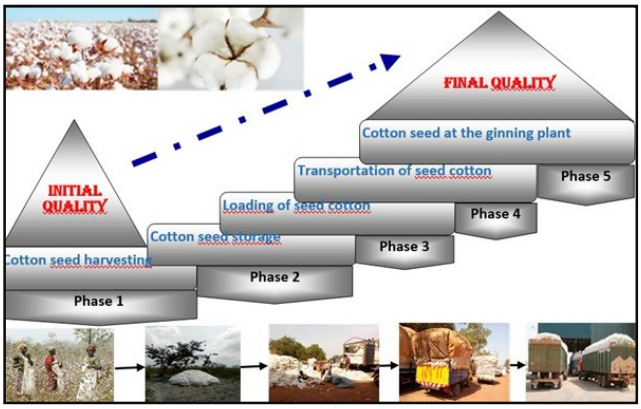
Methods

To fully understand the subject and perform socio-economic analyses, a literature review was conducted to describe the organizational and institutional framework established for assessing cotton seed bales in primary markets and factories, as well as the standards for preserving cotton seed quality. Data (primary and secondary) were collected due to the originality of the research. The primary data is mainly sourced from the field. It was obtained from surveys of subjects, guided interviews (for packaging agents, transporters, and factory receptionists), and structured questionnaires administered with a few contingent valuation questions (for cotton farmers). This method of investigation fits well with the hypothetical-deductive and falsificationist scientific approach adopted in this study. The survey forms were analyzed and the data entered using CS PRO software, followed by univariate and bivariate descriptive analysis using SPSS 18 software. Microsoft Excel Office 2010 software was used to produce graphs and figures. Discourse and content analysis were the main qualitative tools used to transcribe the verbatim statements, enabling the determinants of the deterioration in cottonseed quality to be identified. Discourse analysis makes it possible to identify a number of theoretical and methodological elements that are essential to the work (Courtine, 1982). Content analysis is a disparate set of techniques used to process linguistic material (Moscovici and Henry, 1968). Friedman's nonparametric test was used to ensure consistency in the rankings given by cotton farmers to each factor. This test allows for analysis of the hierarchy established by respondents.

RESULTS

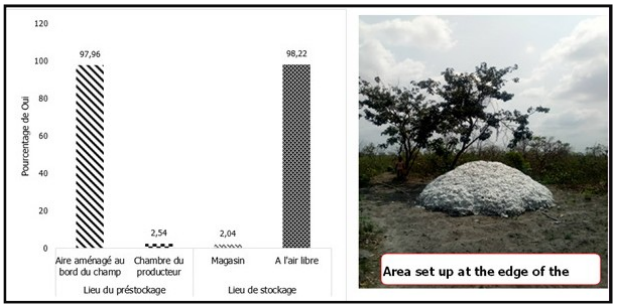
Socio-economic and demographic characteristics of cotton farmers: The socioeconomic and demographic characteristics of all cotton farmers surveyed are presented in Table 2. The average age of the farm managers surveyed was 38 (±12) for all the municipalities visited. This average concealed significant disparities between respondents. The breakdown of respondents (farm managers) by gender and municipality was irrelevant. In fact, almost all of them were men (97.20%) for all observations. This situation seemed normal in the sense that women only attained this status if there was no man in the household of an age to occupy this position, or if they were widowed. The average number of years of experience of respondents in agricultural production was 20 years (±12) for all the municipalities visited, and specifically in cotton production it was 17 years (±10). This demonstrated the quality of the sample selected for the phenomenon under study, which required a minimum number of years of experience in agricultural production in general and in cotton production in particular. The level of education of the cotton farmers surveyed in all the municipalities visited remained relatively low, with an average of 7 years (±3). Nearly 78% of the sample were completely illiterate, with varying proportions depending on the municipalities visited. However, 80.46% of those surveyed who were literate could read and write. This demonstrated the important role played by adult education projects and programs in this regard. Across all municipalities, almost all of the farm managers surveyed belonged to an association other than the cotton association (98.47% on average), with disparities from one municipality to another. The average number of years of experience in an association/group was 15 years for all the municipalities visited. Similarly, the contact between the cotton farmers surveyed and a supervisor showed the same trend as their membership of an association, with an average of 13 visits during the 2018-2019 season.

Logistics chains for managing seed cotton to the ginning factory: The seed cotton management supply chain comprises the following five stages: harvesting, storage, loading, transport, and delivery to the factory (Figure 2).



Types and equipment used for seed cotton harvesting: The majority of cotton farms visited harvested their seed cotton in stages (64.12%) across all the municipalities visited. This type of harvesting

was more common in the municipality of Djidja than in the other two municipalities. Other types of harvesting were marginal in the municipalities visited (Figure 3).

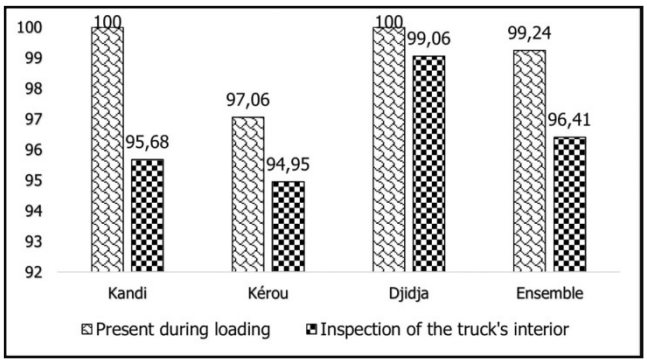


In fact, in documents relating to the preservation of seed cotton quality, staggered harvesting was found to be the most appropriate method in terms of quality control. As a result, in the case of this study, the standards relating to seed cotton harvesting in terms of harvesting type were respected by the majority of cotton farmers surveyed. For all the municipalities visited, baskets and bags were the main tools used for seed cotton harvesting, with disparities from one municipality to another. Cotton bags were recognized as the recommended equipment for preserving seed cotton quality (Table 3). As a result, in the case of this study, standards relating to seed cotton harvesting in terms of the use of appropriate equipment were mixed because the basket, which is not suitable for harvesting, was nevertheless used by the majority of cotton farmers surveyed, as evidenced by its ranking (Table 3).

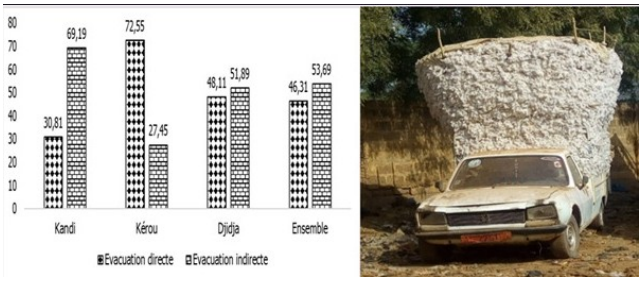
Table 1. Socio-economic and demographic characteristics of cotton-growing

Characteristics	Modalities	Cotton farmers
Averageage (years)	-	38.38 (11.57)
Gender (%)	Male	382 (97.20)
	Female	11 (2.80)
Formaleducation	Number of years	7.53 (3.65)
Literacylevel (%)	Read	14 (16.09)
	Writing	3 (3.45)
	Reading and writing	70 (80.46)
Membership in an association	Yes	98.47
Number of years of experience in an association/group		15.51 (10.74)
Contact with an agricultural advisor	Yes	97
Number of years of experience with mentors		12.92 (9.57)
Number of visits during the 2018-2019 season		13.43 (13.02)
Socio-cultural group (%)	Bariba	77.8
	Peulh	6.0
	Others	16.20
Experience in agricultural production	Number s of years	20.39 (11.64)
Experience in cotton production	Number of years	16.62 (9.94)
Non-agricultural activities (%)	Trade	38
	Crafts	29
	Motorcycle taxi	2
	Other	31

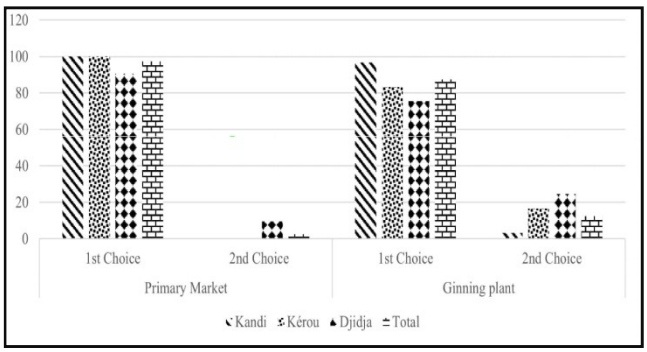
Cotton seed storage: Almost all (98%) of the cotton farmers surveyed pre-stored their cottonseed in areas set up at the edges of their fields without any protection, and only 2.54% of cotton farmers used their bedrooms as pre-storage areas. Furthermore, these results showed that almost all of the cotton farmers surveyed (98.22%) stored their seed cotton in the open air at primary markets before transporting it to the factory, compared to only 2.04% who took care to store their seed cotton in a warehouse (Figure 4). Referring to the standards in force for the pre-storage and storage of cottonseed, which stipulate that proper storage requires the construction of individual or shared warehouses or silos by all farms, in the case of our study, the standards relating to storage and pre-storage conditions were not respected by almost all of the cotton farmers surveyed.



Cotton seed removal: The results showed that 53.69% of the cotton farmers surveyed sold their seed cotton through primary markets in all of the municipalities visited, compared to 46.31% of cotton farmers who preferred direct transport to ginning factories (Figure 5). This trend is found in the municipalities of Kandi and Djidja. However, in the municipality of Kérou, a reversal of the trend was noted, with a very high rate of direct transport (72.55%). This situation can be explained by the use of small-capacity, less expensive means of transport such as covered pickup trucks (Figure 5).



Loading and inspection of the interior of vehicles by cotton farmers: Almost all of the cotton farmers surveyed, across all municipalities, were present during the loading of their cottonseed and actually checked the interior of the vehicles before loading to avoid any contamination (Figure 6).



For all the municipalities visited, tarpaulins, baskets, and hands were the main means used for loading cottonseed, with disparities from one municipality to another (Table 4). Polypropylene bags, which were previously recommended, ranked only fourth in all three municipalities. For all the municipalities visited, walking, motorcycles, and tricycles were the main means used to transport cottonseed from the field to the storage site, with no disparities between municipalities. For both direct transport, which is the most commonly used type of transport, and indirect transport, the most commonly used means are walking, motorcycles, and tricycles, respectively (Table 5).

Table 2 . Ranking of means of transporting seed cotton from the field to the storage facility by municipality and type of transport

Means of transport from the field to the storage location	Direct transport								Indirect transport							
	Municipalities						Total		Municipalities						Overall	
	Kandi		Kérou		Djidja				Kandi		Kérou		Djidja			
	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C
Feet	2.42	1	1.58	1	2.01	1	2.09	1	1.41	1	2.09	1	1.74	1	1.70	1
Motorcycle	3.04	2	3.25	2	3.16	2	3.13	2	2.73	2	2.62	2	2.74	2	2.70	2
Tricycle	3.16	3	3.37	3	3.25	3	3.24	3	2.90	3	2.65	4	2.75	3	2.79	3
4-wheel vehicle	3.19	5	3.39	4	3.29	4	3.27	4	2.91	4	2.65	3	2.77	4	2.80	4
Animal back/cart	3.18	4	3.41	5	3.29	5	3.27	5								
Kendall's concordance test	0.241		0.651		0.456		0.403		0.632		0.266***		0.485***		0.496***	

*MR=Mean Rank; C=Ranking; ***: Significant at the 1% level;* Springs: 2018 field survey

Table 3 . Ranking of the level of use of means of transport for cottonseed from the storage location to primary markets by municipality

Means of transport from storage location to primary markets	Indirect transport							
	Municipalities						Total	
	Kandi		Kérou		Djidja			
	RM	C	RM	C	RM	C	RM	C
Feet	2.97	1	3.21	1	2.45	1	2.89	1
Motorcycle	3.25	2	3.38	2	3.39	2	3.32	2
4-wheel vehicle	3.58	3	3.63	5	3.83	6	3.66	4
Bicycle	3.97	6	3.60	3	3.83	5	3.84	6
Tricycle	3.55	4	3.51	4	3.71	3	3.58	3
Animal/cart back	3.68	5	3.66	6	3.79	4	3.70	5
Kendall's concordance test	0.086		0.066		0.319		0.115	

*RM=Mean Rank; C=Ranking; ***: Significance at the 1% threshold;* Springs: Field survey, 2018

Table 4. Ranking of equipment used for cottonseed harvesting by municipality

Equipment	Municipalities						Overall	
	Kandi		Djidja		Kérou			
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Basket	2.97	2	1.57	1	2.88	2	2.57	2
Lap skirt tied at the hip	2.98	3	2.60	3	3.01	3	2.89	3
Polypropylene bag	1.03	1	2.49	2	1.09	1	1.44	1
Tarpaulins	3.02	4	3.34	4	3.01	4	3.11	4
Kendall's concordance test	0.946		0.387		0.877		0.496	

****: Significance at the 1% threshold Clas.: ranking*
Springs: 2018 field survey

Table 5. Ranking of equipment used for loading cottonseed by community

Equipment	Municipalities						Overall	
	Kandi		Djidja		Kérou			
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Tarpaulins	1.36	1	1.44	1	3.07	2	1.84	1
Household containers	3.61	5	3.59	5	3.58	5	3.59	5
Shopping cart	3.59	4	3.54	4	1.23	1	2.94	2
Polypropylene bag	3.38	3	3.01	2	3.56	3	3.33	4
Hands	3.06	2	3.41	3	3.57	4	3.29	3
Kendall's concordance test	**0.626**		**0.576**		**0.737**		**0.336**	

****: Significance at the 1% threshold Clas.: ranking Springs: 2018 field survey*

Table 6. Ranking of the level of use of means of transport for cottonseed from the storage location to the factories and by municipality

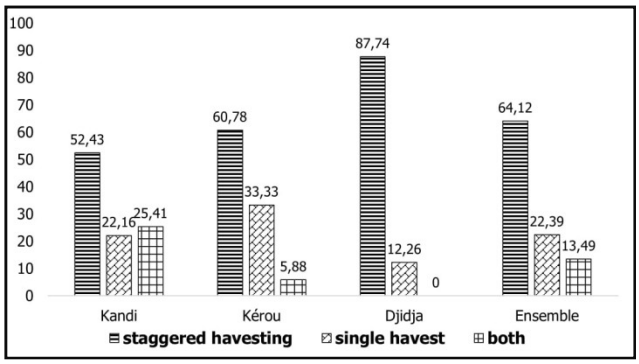
Means of transport from storage to factory	Direct transport								Indirect transport							
	Municipalities						Total		Municipalities						Overall	
	Kandi		Kérou		Djidja				Kandi		Kérou		Djidja			
	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C	RM	C
Truck	1.68	1	1.27	1	1.54	1	1.54	1	1.31	1	1.74	1	1.51	1	1.47	1
Covered truck	2.16	2	2.36	2	2.19	2	2.22	2	2.34	2	2.12	2	2.20	2	2.25	2
Tricycle	2.16	3	2.36	3	2.27	3	2.24	3	2.35	3	2.14	3	2.29	3	2.28	3
Kendall's concordance test	0.315		0.725		0.413		0.446		0.690		0.246		0.450		0.508	

*MR=Mean Rank; C=Ranking; ***: Significant at the 1% level;* Sources: Field survey, 2018

Means of transport from storage locations to primary markets: For all municipalities, walking, motorcycles, and tricycles were the main means of transport used from the storage location to the primary markets (Table 6). While this trend was consistent in the municipality of Djidja, in Kérou and Kandi, bicycles and four-wheeled vehicles ranked third in importance.

Means of transport from storage locations/primary markets to the factory: The results showed that, regardless of the type of transport used by cotton farmers and regardless of the municipality, trucks and covered vans were the main means used to transport seed cotton from the storage location to the ginning factories. On the other hand, tricycles were used only marginally (Table 6).

Seed cotton quality: Across all municipalities, the assessment of seed cotton quality was similar, and the quantity of downgraded seed cotton was marginal compared to the quantity of top-quality seed cotton (Figure 7). However, as it moved from primary markets to ginning factories, there was a noticeable decrease in the quantity of premium-quality seed cotton ( ) in favor of second-quality seed cotton. This situation was much more pronounced in the municipalities of Kérou and Djidja than in the municipality of Kandi.



DISCUSSION

The production of cottonseed, in terms of both quantity and quality, contributes enormously to improving the living conditions of cotton farmers and to the Beninese state's revenues. This idea, implied by the results of our work, is also supported by Bagayoko (2013) in his thesis on the importance and future of cotton production in West Africa, which concludes that the cotton sector also contributes to food self-sufficiency by promoting food crops.

Cotton seed harvest: With regard to seed cotton harvesting in the study area, our results revealed that baskets and bags are the main tools used in the logistical management of seed cotton. These results are similar to those obtained by Bakayoko (2013) in his thesis, who had already noted that cotton farmers in Mali used makeshift tools,
such as empty fertilizer bags recycled into polypropylene, which also contaminate the cotton fiber, during the seed cotton harvest due to their limited financial resources. Adjinda (2016) emphasized the standards for cottonseed harvesting, pointing out that the use of polypropylene is prohibited in cottonseed harvesting and asserting that, from this point of view, Beninese cotton farmers do not comply with the recommendations of extension services. Other previous studies, including those by*et al.*, (2018) , have examined the socio-economic and cultural conditions of Beninese cotton farmers, which are not conducive to the adoption of technological equipment for seed cotton harvesting and which still use rudimentary post-harvest equipment.

Pre-storage and storage: With regard to the storage and pre-storage of seed cotton, our studies revealed that cotton farmers do not have specific infrastructure for storing their harvest. These results are consistent with those obtained by Kadekoy-Tigague*et al.* (2010), who described how cotton producers in Cameroon temporarily store their cottonseed on the ground near their fields before transporting it to collection markets for primary marketing. However, referring to current standards for seed cotton storage, Bagayoko (2013) posits that proper pre-storage and storage would require the construction of individual or shared warehouses or silos on farms, which contradicts the practices of the Beninese cotton growers s interviewed in this study. In the case of this study, the standards relating to storage and pre-storage conditions are not respected by almost all of the cotton farmers surveyed, without this necessarily reducing the quality of the seed cotton. Degla (2012) explains this result by the insufficient financial resources of cotton farmers to meet the additional labor costs for the construction of the warehouses and silos necessary for better storage of harvested cottonseed.

Transport to primary markets: With regard to transport, the results of our work suggest that the transport of seed cotton to primary marketing markets is a major constraint for cotton farmers in our study area. The poor condition of access roads to production and marketing areas forces cotton farmers with limited financial resources to sometimes use whatever means they have available to transport cottonseed, resulting in significant post-harvest losses. Cotton seed is therefore transported to storage facilities mainly on foot, by bicycle, motorcycle, or tricycle. These findings are consistent with those reported by Agbangba*et al.* (2018), who explained that producers in agricultural development hubs had a significant need for equipment and material resources to ensure the profitability of their systems.

Loading and securing: In terms of the quality and securing of seed cotton, our studies revealed that for all the municipalities surveyed, tarpaulins, baskets, bags, and hands are the main means used to load seed cotton, with disparities from one municipality to another. These results, which highlight a failure to follow agricultural advice, are consistent with those of Adjinda (2016) on the effect of not following recommendations to ensure good seed cotton quality during loading and transport. Our studies also revealed that from the cotton grower's field to the ginning factory, there is a noticeable decline in seed cotton quality in favor of lower quality seed cotton. This situation can be explained by the quality of logistics, in particular the dilapidated state of the protective equipment used (tarpaulins), the quality of the equipment used to load trucks, and unorthodox behavior such as deliberate wetting or deliberate adulteration practices, and even the poor condition of the roads. These results are consistent with those of several previous studies on the determinants of seed cotton quality (Bagayoko, 2013; Kadekoy-Tigague*et al.,*Hougni, 2004).

Transport to the ginning factory: Our study revealed that trucks and covered pickup trucks are the main means of transport used to transport seed cotton from storage facilities to ginning mills. These results are similar to those ofand Gaudard, (2018) , who found that the main means of transport used for seed cotton in Benin are walking, bicycles, motorcycles, canoes, and carts (horse-drawn) for intermediate transport, and tractors, vans, trucks, and heavy-duty trucks for transport to the ginning factory. However, the work of Bagayoko (2013) has shown that in Mali, transport infrastructure remains very weak in view of the immense need for trade relations both within and outside the country. Our findings also revealed that failure to comply with traffic regulations and the overloading of vehicles transporting seed cotton cause accidents that have a very negative impact on the quality of the seed cotton. These findings are consistent with those of Kadekoy-Tigague*et al.* (2010), who report that in the Central African Republic, vehicles in poor condition are used to transport cottonseed, causing delays in the collection and delivery of cottonseed to the ginning factory. Our studies have also revealed ( ) that although the transport of seed cotton from primary markets to ginning factories is carried out using the most suitable means of transport, there are sometimes cases of truck accidents and fires that cause enormous damage to the quality and even the quantity of seed cotton before it arrives at the factory. For this final stage of logistics, Kadekoy-Tigague*et al.* (2010) believe that the means of transport must meet certain standards to guarantee the reliability and speed of the transport service.

CONCLUSION

Analysis of the cottonseed management supply chain, from the field to the ginning factory via the primary market, reveals that cotton growers use a wide variety of logistics means and equipment.

Although the use of these various means does not in itself always pose a risk to the preservation of seed cotton quality, it does not always enable cotton growers to adequately protect seed cotton from contamination and weather conditions that can affect its quality during storage and transport. This study calls on cotton growers to be aware of the standards in force for the pre-storage and storage of seed cotton and on the cotton industry authorities to provide cotton growers with adequate equipment in order to minimize the loss of seed cotton quality in Benin. Although it would be imperative to review the various stages of the cottonseed logistics chain from harvest to ginning factory, it is nevertheless essential that awareness-raising campaigns be conducted among the various actors involved in the process.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Abbreviations

CFA	Communauté Financière Africaine
PPD	Plant Production Directorate
PQPPS	Product Quality and Packaging Promotion Service
SHB	Benin Oil Mills Company
SOBETEX	Beninese Textile Company
VCPC	Village Cotton Producers' Cooperatives
SITEX- Benin	Benin Textile Industries company
INSAE	National Institute of Statistics and Economic Analysis
VCPC	Village Cotton Producers' Cooperatives

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