Influence of Storage Conditions on the Quality of Cotton Seeds in Benin Republic

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Abstract

Background The availability of good quality seeds is synonymous with improved farming, especially cash crops such as cotton. However, serious problems with seed germination have been reported recently by cotton farmers in Benin Republic. The assumptions formulated at the base with regard to this situation remain to be verified technically. Thus, this study aims to evaluate the influence of storage conditions on the quality of cotton seeds in Northern Benin. Temperature and relative humidity were assessed followed by a seed sampling sequence in seven (07) cotton seeds stores according to three main periods, ranging from the establishment in conservation to the following seasonal production. Germination tests were then carried out on each sample followed by data analysis using R and Minitab17 software.

Results There is a large variation in the germination rate of cotton seed during their storage period. The probabilities values (Pvalue1 = 0.023, Pvalue2 = 0.001 and Pvalue3 = 0.038) respectively associated with the three samples and the various coefficient of variation (CV) between stores (CV1 = 2.42%, CV2 = 7.1% and CV3 = 8.88%) explain a significant difference not only between the stores but also from one sample to another with regard to sampling periods. There is a strong progressive decrease in seed germination (Germination rate 1 > Germination rate2 > Germination rate3), which is responsible for the failure observed by the growers during sowing. Thus, seeds lose an average of 15% of their initial germination capacity already at one month of storage. This is generally negative due to all the storage conditions and system in the stores.

Conclusions The excessive increase in temperature and the considerable decrease in relative humidity in stores are the main factors of significant loss of germination capacity of cotton seeds. In view of this situation, it is desirable that technical measures be taken in this direction in order to better preserve the quality of the seeds made available to producers for an optimization of the cotton sector in Benin.

Background

The farmer's success depends on the quality and quantity of seeds for intensive production [1]. For a long time, several studies have particularly aimed at improving the quality of seeds of the main food crops in Africa and worldwide [2]. Nowadays, the economic importance attached to the cash crops among which the cotton plant is made, makes think of possible programs of selection or improvement of their respective sectors. Varieties with high agronomic performance have therefore been created and popularized [2, 3]. In most African Franc Zone (AZF) countries including Benin, Burkina Faso, Mali, Chad and Togo, cotton is at the root of development and contributes significantly to the employment and income of the population in rural areas [4]. Its production is exported to more than 95% and the group of AZF countries account for nearly 14% of world exports [5].

In Benin, cotton plays a very important role in economic growth, with a contribution of more than 32% to gross domestic product, representing 90% of export earnings, 45% of tax revenue excluding customs

duties and 60% of the industrial fabric [6; 7]. The revenue from the cultivation of cotton contributes to the creation of numerous socio-community infrastructures [7] and the sector therefore benefits from significant support [4]. Since it was considered to be the most important economical crop in Benin, several breeding programs were devoted to cotton seeds quality improvement [8]. Despite of efforts supplied, farmers are still reporting serious germination issues with unknown sources. Therefore, seeds are very well tested with high germination rate before their distribution to the producers' districts for storage [9; 10]. This problem, becoming more and more alarming in recent growing seasons, it is therefore necessary for the scientific community to intervene in order to identify the main reasons for the considerable loss of germination power of the seeds distributed to producers. Regarding its importance in agriculture, seed sector must be an area under high public control [1; 11]. An improvement in seed management is necessary so as to limit the production costs of cotton seeds and increase the national production [1]. To particularly solve this problem related to the quality of seeds, the diagnosis of the devices involved in the production of seed cotton is essential.

This study aims to evaluate the seed germination rate during the storage period in the different villages of Cotton Producers' Cooperatives (CVPC) stores until the start of seedlings. This will allow us to appreciate the influence of storage infrastructures on the quality of cotton seeds in order to make proposals that will allow a rational use of seeds. Specifically we will have to analyze the storage infrastructures of cotton seeds in the N'dali and Sinendé districts (i); to evaluate the germination capacity of cotton seeds during storage period in central stores (ii) and to propose approaches of solutions to the likely constraints of storing cotton seeds (iii).

Results

Variability of thermal and water conditions inside storage structures.

The highlighting of the thermal and hydrous variants of the seeds during the conservation period, allowed us to realize the graph below. It emerges that there is a thermal variability in the stores which would act significantly on the moisture content of seeds in storage. The thermal gradient and that of moisture of the seeds evolve in opposite directions. So the hotter the store is, the lower is the moisture content of the seeds. This thermal variation would be due to the alternation of diversified periods of sunshine of the environment during the period of storage. This is all the more true since this conservation period generally coincides with the dry season during which high temperaturees are often recorded. The second sampling, which coincides with the sowing period, is characterized by a higher temperature (31.59 ° C) with a relative humidity of 20.16%. This analysis shows that the temperatures and moisture levels of cottonseed stored vary from one store to another and between districts (Fig. 1).

Figure 1: Evolution of temperature and aridity index (Source: field data, 2019)

Variation in germination rate of seeds at the beginning of conservation.

Table 1 below summarizes the probabilities derived from analysis of variance (ANOVA) on seed germination rates from different storage locations. Indeed, it appears that there is a significant difference at the 5% threshold between the seed germination rate (Pvalue = 0.02). Moreover, the Student-Newman-Keuls comparison test reveals a homogeneity of seed germination rate at the threshold of 5%. The average seed germination rate of Fo_Boure, the Municipal Agricultural Development Sectors (SCDA) of N'dali, Sonnoumon and Soka stores are virtually identical. The slight difference is therefore observed only at the level of seeds taken from SCDA Sinendé, Sekere and Yarra stores with a low coefficient of variation (2.42%). Thus, the highest rates are those of Sonnoumon seeds (73.25%) while the lowest are recorded in SEKERE (69.75%). This translates that at the beginning of conservation, the seeds always keep their initial germination rates and know no disturbance of the environment.

Table 1
Variance analysis of seed germination rate at the beginning of storage (Sample1)

Shops	Germination rate(%)
Fo_Boure	73 a
SCDA_N'dali	73.25 a
SCDA_Sinendé	71 a
Sekere	69.75 a
Sokka	72.5 a
Sonnoumon	73.25 a
Yarra	70 a
Moyenne	71.82
Pr	0.023*
F	3.146
CV (%)	2.42

*F: F of Fisher Pr: probability *: significant at 5%; CV (%): Coefficient of variation. On each line, the averages followed by the same alphabetical letter are not different at the 5% threshold according to the Student-Newman-Keuls test.*

Temporal evolution of seed germination rate

Analysis of the variance showed a significant difference at the 5% threshold for the tests (Pr (F) = 0.001), this confirms that the average seed germination rate varies according to the stores. So, seed storage conditions usually vary from one store to another and over time. The seeds are preserved for this purpose

in a diversified way. This reflects a likely and specific influence at each store according to the conditions imposed on the seeds. The associated comparison test stipulates a strong heterogeneity within the stores. The lowest germination rates are recorded in the third sample. The influence of storage conditions varies from one store to another and becomes more and more critical as time increases.

Table 2
Variance analysis of seed germination rate at one month of storage

Stores	Sample 2	Sample 3 (1 month later)
Fo_Boure	61 a	50.25 a
SCDA_N'dali	67.75 a	60.25 a
SCDA_Sinendé	67.25 a	52.50 a
Sèkèrè	51.75 b	51 a
Sokka	62 a	58 a
Sonnoumon	62 a	51 a
Yarra	64.25 a	51.50 a
Moyenne	62.29	53.5
Pr	0.001**	0.038*
F	5.831	2.78
CV (%)	7.1	8.88

*F: F of Fisher Pr: probability *: significant at 5%; **: significant at 1% CV (%): Coefficient of variation. On each line, the averages followed by the same alphabetical letter are not different at the 5% threshold according to the Student-Newman-Keuls test.*

Figure 2: Boxplot of seed germination rate (Source: field data, 2019)

Comparative analysis of the three samplings with regard to estimated germination rate

Table 3 shows the variation of germination rates of the seeds according to the samples and the stores of origin. It appears in a global way that the seed germination rate varies very significantly with time and according to the different stores of origin (overall probability = 0). A variation ranging from 69.82 ± 2.33% to 52.7550 ± 5.11% is generally observed during the first two months of conservation, ie a loss of 17.07 ± 2.78% of germination power. A sharp decrease in the germination rate is observed at the third harvest, especially for seeds from the SCDA Sinendé and Yarra store, SCDA N'Dali and Sonnoumon. The stores are classified in two categories according to the Student Newman Keuls comparison test carried out after the third sampling. This is the category of stores with an average germination rate (Sonnoumon 50.75%,

Sekere 50% and Fo_Boure 50.5%) and the category of stores with a good germination rate which consists of the four remaining stores. (SCDA_N'dali, SCDA_Sinendé, Yarra and Soka.

Table 3
Evolution of seed germination rate by time in different stores

Sources	Sample 1	Sample 2	Sample 3	Probability
Overall mean	69.82 ± 2.33 a	61.04 ± 5.65 b	52.75 ± 5.11 c	≈ 0***
Fo-Boure	70.5 ± 1.29 a	58.5 ± 2.08 b	50 ± 5.60 c	6.31.10-05***
SCDA N'Dali	71.25 ± 0.96 a	67.25 ± 2.50 b	59.75 ± 0.50 b	8.89.10-06***
SCDA Sinende	69 ± 2.16 a	65.5 ± 4.43 a	51.5 ± 3.10 b	1.01.10-04***
Sekere	66.50 ± 1.73 a	53 ± 4.24 b	50 ± 2.16 c	5.02.10-05***
Soka	70.50 ± 1.29 a	58.25 ± 3.59 b	56.75 ± 2.06 b	4.94.10-05***
Sonnoumon	71.75 ± 0.96 a	62.50 ± 2.38 b	50.75 ± 1.50 c	1.21.10-07***
Yarra	69.25 ± 3.30 a	62.25 ± 5.74 a	50.50 ± 7.85 b	4.84.10-03***

On each line, the averages followed by the same alphabetical letter are not different at the 5% threshold according to the Student-Newman-Keuls test.

Discussion

The linking of the information collected as well by the direct observations made in each targeted store and the germination tests carried out, enables us to confirm or invalidate the results of several research projects carried out on organic seeds. Thus, the high variability of the temperature and aridity index observed in all the stores is only a standard phenomenon confirmed by the work of several authors [7, 8, 11]. The increase in temperature is not only related to storage structure but also to the faculty of seed cotyledons to prolong the evapotranspiration of the fresh material usually sip [12, 13]. This naturally creates a gradual increase in temperature that tends to warm the environment, thus contributing to a significant drop in the aridity index [8]. In addition, the influence of storage conditions, in particular the quality of the roof of the storage device and the importance of spacing created between seed lots, must be noted. According to several scientific studies, direct disposal of bags containing seed cotton on a plastered floor is a practice to avoid to ensure good conservation of seeds [7, 14]. It is therefore very essential to find an alternative, usually that involving strong and resistant supports on which the bags of seeds will be placed in order to facilitate a good ventilation through. These same approaches have already been proposed to seed producers of several other speculations such as rice, maize and cowpea (15).

Admittedly, at the beginning of storage, the non-significance of the variation in the germination capacity of the seeds taken from each store is all the more justified, because the time remains too limited to notice

any influence of the storage device. The seeds then behave as treated under the same conditions and until now have not undergone any unusual pressure that may impair their germination [16, 17]. These notions remain standard to most agricultural speculations. In 2004, during their research work on the contribution to the analysis of quality problems in the cotton sector in Benin, especially the seed subsystem, Sekloka *et al.* (2008) deduced that the dormancy of seed cotton is positively correlated with their shelf life [8]. The gradual fall in germination capacity of seeds is then justified after a month or more. The variations observed between the stores can be justified on the one hand because of the diversified sources of seed and on the other hand the quality of the storage device. Thus, in Benin, the quality of seed cotton varies according to the localities, especially the four agroecological zones [18]. The seeds being of a certain exigency and of a thermal sensitivity, the variabilities of the ambient temperatures of the stores would thus be the main cause of the variations observed on their germination rate.

Seed management requires some care at the store during the storage period. Taking responsibility for proper store maintenance was not effective in all structures visited in this study. Thus, the more the global humidity temperature conditions of the stores become critical the more the seeds are negatively affected.

Conclusion

The general objective of this study was to determine the influence of storage conditions on the quality of cotton seeds. The methodological approach adopted really allowed us to highlight the effect of conservation conditions on the germination of seeds. The results obtained made it possible to draw a certain number of conclusions thus answering this scientific curiosity. In sum, it has been found that conservation conditions affect the quality (germination capacity) of seeds. The main factors are thermal fluctuations, which have a significant effect on the humidity of seeds in storage, thus affecting their germination capacity. In addition, it has been reported that the longer the storage time, the lower the germination capacity of seeds becomes.

Given the results of this study, we recommend that the likely measures to correct this weakness be strongly oriented towards development of a general technical sheet on the standards required for seed conservation, the constant watch of the managers of the cotton sector in the storage structures in order to correct the failures over time before they are too critical.

Methods

Presentation of the study environment.

The studies were conducted in the Department of Borgou and more precisely in the communes of N'Dali and Sinendé. The commune of N'Dali is limited to the North by the communes of Bembèrèkè and Sinendé, to the South by the communes of Parakou and Tchaourou, to the East by the municipalities of

Nikki and Pèrèrè and to the West by the communes of Djougou and Péhunco. It covers an area of 3748 km2 representing 14.50% of the area of the department and 3.27% of the total area of Benin. By contrast, Sinendé commune is located in the north-west of the Borgou department and covers an area of 2,289 km2. It is bounded on the north by the commune of Gogounou, on the south by that of N'Dali, on the east by Bembèrèkè and on the west by the communes of Ouassa-Péhunco and Djougou. It is 623 km from Cotonou (economic capital of Benin) and about 150 km from Parakou, capital of the department.

Plant material, choice and brief description of identified stores

The cotton seeds constituting the plant material used within the framework of this study are those of the variety OKP 768 cultivated in the department of Borgou, more precisely in the districts of Sinendé and N'dali. The samples were taken free of charge from seven (7) conservation stores under the authorization and supervision of municipal officials and those of the seed cotton sector of the two target municipalities. It should also be noted that these stores are public, where several scientific researches are currently taking place helping to resolve the germination problems reported by producers. So any particular authorization is needed. In N'dali, two stores are visited (the Municipal Agricultural Development Sectors "SCDA" of N'dali stores and the Sonnoumou village store) while five (5) stores are sampled in Sinendé (SCDA of Sinendé, villages of Fo Bouré, Sekere, Soka and Yarra). A general inspection of the stores was carried out at the beginning of the seed storage for the description of storage tools and system used (Table 4).

Table 4
Overall description of the stores visited

Districts	Stores	Construction Architecture	Environmental Conditions	Storage Mode and Stacking Height of Bags
N'dali	SCDA	Construction made of permanent materials, normal height	Equipped with a ventilation system	Respect storage mode and bagging height
	Sonnoumon	Construction made of permanent materials, height similar to dwellings,	Insufficient ventilation, low lighting	Non respect of the storage mode and stacking height of the bags
Sinendé	SCDA	Construction made of permanent materials, normal height, new roof	Good ventilation	Respect of the storage mode and the filling height of the bags
	Sèkèrè	Construction made of permanent materials, normal height, perforated roof	Store well ventilated	Respect of the storage mode and the filling height of the bags
	Yarra	Construction made of permanent materials, normal height	Presence of small ensuring aeration, normal temperature	Respect of storage mode and bagging height
	Sokka	Construction made of permanent materials, height similar to dwellings	Store with little air with high temperatures	Non respect of the storage mode and the stacking height of the bags
	Fô Bourré	Construction made of permanent materials, normal height	Good aeration	Respect of the storage mode and the filling height of the bags

µSampling and germination tests

Three (03) samples of cotton seeds were taken from the stores:

– 1st sample: make the day of storage (16/03/19),

– 2nd sampling: performed 30 (one month) day after storage,

– 3rd sample: one month after the second.

At each sampling and 15 days later, the temperature and relative humidity were respectively taken according to the official method described by Pierrot Michaël (2016) in each of the stores concerned and more precisely in the seed bags randomly selected and marked throughout the study period.

The germination tests were carried out in germination tanks at the Municipal Agricultural Development Sectors (SCDA) of each commune. A sample of 100 g of seed was made in ten (10) different bags of 40 kg randomly selected by visited store. These final samples collected were then subjected to germination tests in order to evaluate their germination capacity. This operation was repeated over three (3) major periods in order to highlight the spatio-temporal interactions influencing seed germination. The first test carried out just at the beginning of the storage period was followed by the two others, which intervened respectively within 30 days. Stripping ten (10) days after sowing allowed the data to be collected and analyzed using appropriated statistical software.

Data analysis.

The collected data has been entered into the Excel spreadsheet, figures and tables are also done. R software [19] was used for analysis of the variance (ANOVA) was done in order to highlight the significance of the variation of the germination rate between the storage magazines on the one hand and the other between the different samples. The Student-Newman-Keuls comparison test and boxplots were also performed using R software to compare the average germination rates of the seeds collected in each of the targeted stores for categorization.

Abbreviations

SCDA
Municipal Agricultural Development Sectors
ANOVA
Analysis of variance
GRIGADEB
Agricultural Innovation Research Group for Biodiversity management and Action for sustainable and equitable Development at the Base
BIORAVE
Laboratory of Biotechnology, Genetic Resources and Plant and Animal Breeding

Declarations

Ethics approval and consent to participate:

Not applicable

Consent for publication:

Not applicable

Availability of data and materials:

The dataset generated and analyzed during the current study are available from corresponding author on reasonable request.

Competing interest:

No conflict of interest.

Funding:

Any external funding had been allocated to this research

Authors’ contribution

RI and IDA conceived and designed the research. PB, RA and EAD managed the sampling and germination test. RI and PB performed the analysis and wrote the manuscript under the supervision of IDA. All the authors read and approved the final manuscript.

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Figures

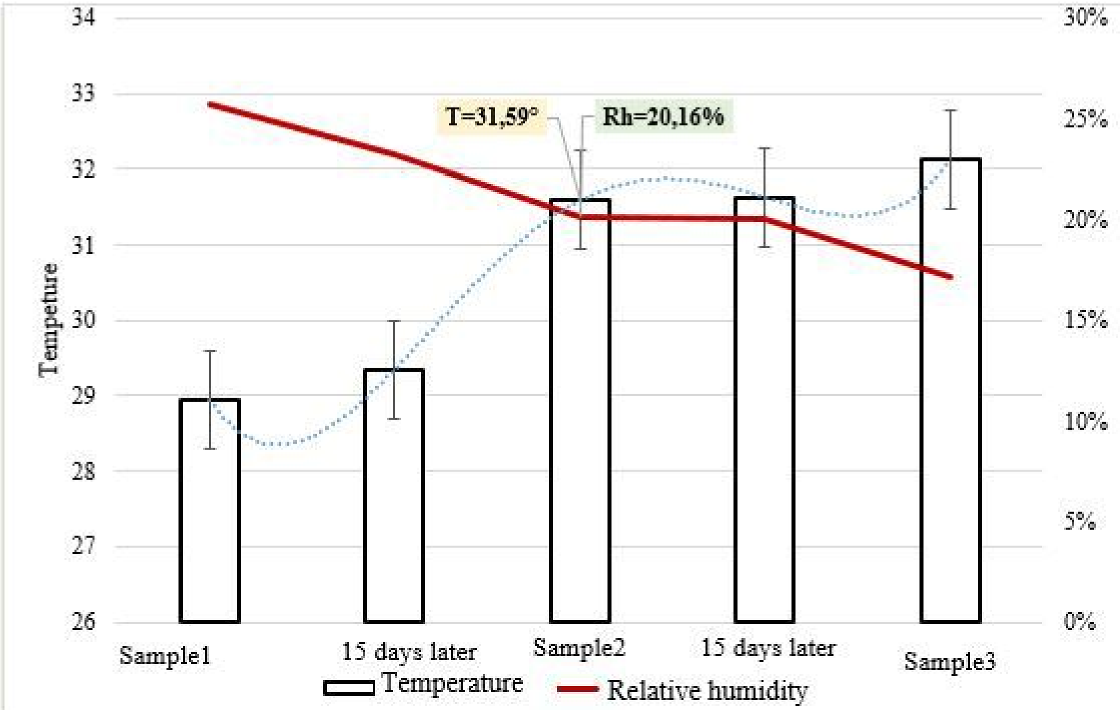

Figure 1

Evolution of temperature and aridity index (Source: field data, 2019)

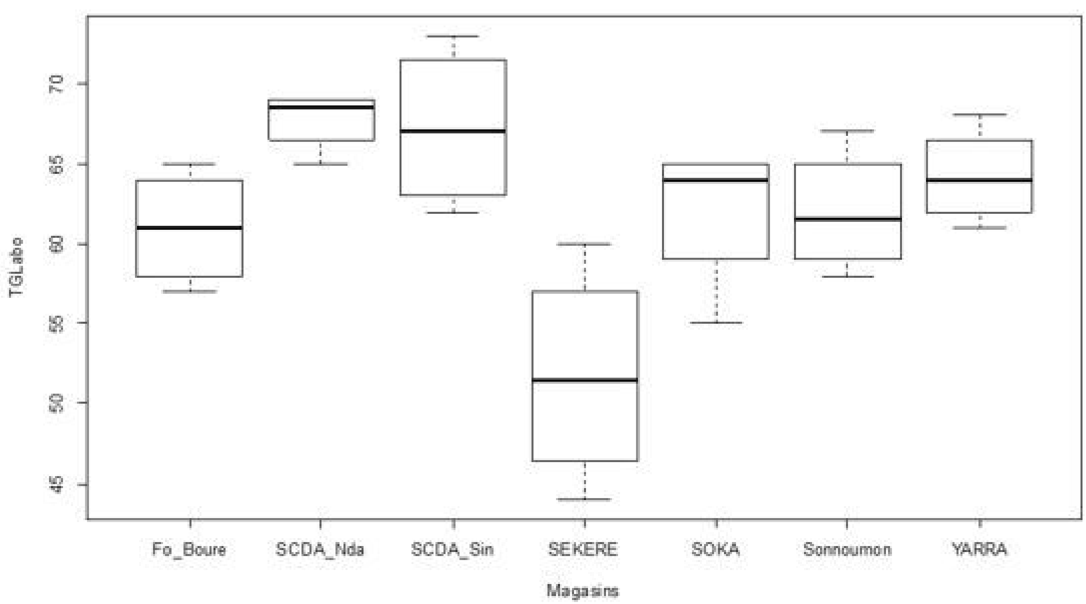

Figure 2

Boxplot of seed germination rate (Source: field data, 2019)