

# Harvest Splitting as a Good Agricultural Practice to Ensure the Quality of Cotton Fiber (*Gossypium hirsutum* L.) in Côte d'Ivoire

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## ABSTRACT

**Context:** The major challenges of cotton cultivation in Côte d'Ivoire are the improvement of field yields and fiber quality. One of the methods proposed to ensure the quality of cotton fiber is split cotton harvesting. In order to study the influence of this practice on the technological characteristics of cotton fiber, a study was undertaken in three production zones in Côte d'Ivoire. In the present study, seed cotton was harvested at 50%, 75% and 100% boll opening. After ginning, the fibers were analyzed on an HVI chain and their main technological characteristics were evaluated. **Results:** The results obtained show that regardless of the area, the crop splitting influences the parameters studied, such as the length, short fiber rate, tenacity, brightness and yellowness index of the fiber. Thus, harvesting at 50% capsule opening improves the fiber length by 1.5 mm, tenacity by 1.04 g/tex and brightness by 1.23, while reducing the short fiber rate by 0.84% and the yellowness index by 0.47. As for harvesting at 75% capsule opening, it increases the length by 0.72 mm, tenacity by 0.79 g/tex and brightness by 1.13, while decreasing the short fiber rate by 0.69% and the yellowness index by 0.45. **Conclusion:** Splitting the cotton harvest improves the quality of the fiber. It is therefore a practice to be recommended to producers in order to preserve the quality of the fiber, especially that carried out at 50% opening of the cotton bolls.

## 1. INTRODUCTION

The marketing and exploitation of cotton fiber, the world's leading source of textile yarns, are the main goals of cotton cultivation (Berti *et al.*, 2006), although the seed remains an important by-product for crushing and sowing. In Côte d'Ivoire, cotton-related activities are very important economically [1, 2] because

they have contributed to the industrial development of cotton-growing areas [3, 4] and ensured food security and sovereignty in the central and northern regions of the country [5], thanks to the food crops associated with cotton cultivation [6]. Given this importance, ensuring the quality of the fiber, the main marketed by-product, is a major concern for traders and spinners as well as for scientific research [7]. This quality depends on various factors, including agricultural practices and harvest and post-harvest conditions [8]. In Côte d'Ivoire, as in most African countries, cotton harvesting is a manual activity that requires a lot of labor [9]. When labor is scarce, harvests are delayed. Delays are also caused by rainfall during cotton harvesting periods. However, in late harvest conditions, there is a deterioration in the quality of seed cotton and its by-products [10], including fiber [11]. To remedy this, splitting harvest is often proposed by the agricultural management of cotton companies and research as a means of preserving cotton quality [10, 12]. However, scientific data are not available to define the advantages of fractional harvesting for producers and cotton companies. Hence, this study is of great importance, which provides information on the impact of this practice on the technological characteristics of cotton fiber. The present study is therefore a contribution to the determination of the technological parameters of the fiber that are improved by the fractioning of the cotton harvest.

## 2. MATERIAL AND METHODS

### 2.1. Plant Material

The plant material used in this study is cotton seed of the cotton variety W766C, popularized in Côte d'Ivoire. This variety was the most widely grown in Côte d'Ivoire when the study was conducted.

### 2.2. Technical Materials

Various technical materials were used in this study. These include a 10-saw gin of the Eagle Continental type for ginning cotton seed (Figure 1(a)) and an integrated measuring chain of the HVI 1000/1000 type for the technological characterization of the fiber (Figure 1(b)).



**Figure 1.** 10-saw gin (a) and integrated measuring chain (b) used for ginning seed cotton and analyzing the technological characteristics of the cotton fiber.

### 2.3. Methods

#### 2.3.1. Trial Setup and Maintenance

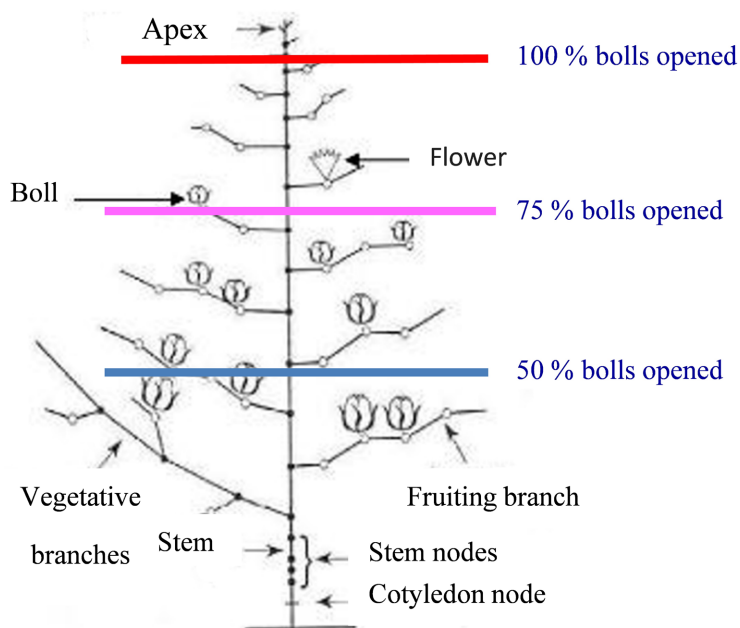
The trials were set up in the three (3) main cotton production areas of the cotton basin of Côte d'Ivoire. These areas cover the southern, central and northern parts of the cotton growing area respectively. Each is represented by a locality housing an observation post (OP). Thus, the trials were set up on the OPs of Séguéla

(Southern zone), Korhogo and Nambingué (Northern zone) with the W766C variety in a Fisher block design with three treatments and three repetitions. Sowing was carried out on a plot of 20 lines of 10 m where the spacing between plants was 80 m between lines and 30 cm between each line.

The plot maintenance work was carried out according to the cotton technical itinerary proposed by Ochou and collaborators in 2007 and popularized in Ivory Coast. Thus, the NPK fertilizer was applied between the 15th and 20th Day After Emergence (DAL), at a rate of 200 kg/ha and urea between the 30th and 45th DAL. During the experiment, six (06) insecticide treatments were carried out at a rate of one treatment every 15 days, from the 45th to the 115th DAL.

### 2.3.2. Seed Cotton Harvest and Sampling

On each elementary plot, 3 types of 5 kg seed cotton samples were taken. They correspond to harvests carried out respectively at 50, 75 and 100% opening of the bolls (**Figure 2**).



**Figure 2.** Schematic diagram of split harvesting in cotton plant.

### 2.3.3. Post-Harvest Analyses

#### 1) Ginning

The seed cotton samples were ginned on a 10-saw Eagle Continental gin at a speed of approximately 7 kg/saw/hour. The seed cotton from each elementary plot was split into 4 samples before being ginned.

#### 2) Technological characterization of the fiber

The determination of technological characteristics allows to classify the cotton fiber. It was done on an Integrated Measuring Chain (CMI) of type HVI 1000/1000 which is a fully automated device. The ASTM 5867 method (Standard Test for Measurement of Physical Properties of Cotton Fiber by High Volume Instruments), cited by [13], was used. For each sample, four analysis repetitions were performed.

The essential parameters of the fiber are:

- Micronaire index (Mic),
- Maturity (Mat),
- Length (UHML),
- Length uniformity (UI),
- Short fiber rate (SFI),
- Tenacity (Str),

Elongation (Elg),  
 Reflectance (Rd),  
 Yellowness index (+b).

### 3) Calculation of the improvement of technological characterization of the fiber due to the fractionation of the harvest

The improvement of the technological parameters of the fiber by the method of fractionation of the cotton harvest was calculated according to the formulas below:

$$\text{Improvement of fiber with harvesting at 50\% opening} = Pf_{50} - Pf_{100} \quad (1)$$

$$\text{Improvement of fiber with harvesting at 75\% opening} = Pf_{75} - Pf_{100} \quad (2)$$

$Pf_{50}$ : Fiber parameters of cotton harvested at 50% boll opening.

$Pf_{75}$ : Fiber parameters of cotton harvested at 75% boll opening.

$Pf_{100}$ : Fiber parameters of cotton harvested at full.

### 4) Data analysis

The collected data were processed using Excel 2016 software. Statistical analyses were performed using SPSS 22.0 software. After carrying out a homogeneity test on the data collected, an analysis of variance (ANOVA) was also carried out on each quality parameter studied. In case of a significant difference between treatments, the Newman-Keuls test was used to compare the means at the 5% threshold (Means are statistically different when  $p$  is less than 0.05).

## 3. RESULTS

### 3.1. Study of the Effects of Splitting the Cotton Seed Harvest on the Technological Parameters of the Fiber According to the Localities

- **Effects of splitting the harvest on the technological parameters of the fiber in Korhogo**

The values relating to the characteristics of cotton fiber according to the type of harvest in the locality of Korhogo are presented in **Table 1**. The analysis of variance revealed significant effects of the partitioning of the harvest on the micronaire index ( $p = 0.00$ ), maturity ( $p = 0.01$ ), length ( $p = 0.04$ ), short fiber rate ( $p = 0.03$ ), elongation ( $p = 0.00$ ), brightness ( $p = 0.4$ ) and yellow index ( $p = 0.01$ ) of cotton fiber, at the threshold of 5%. Thus, the parameters mentioned above are better in the case of harvests carried out at 50 and 75% opening of the capsules. However, no difference was observed between the three types of harvest concerning tenacity ( $p = 0.12$ ) and uniformity index ( $p = 0.25$ ).

**Table 1.** Effects of crop fractionation on technological parameters of fiber from Korhogo.

| Types of harvest  | Technological parameters |                   |                    |                    |                   |                    |                   |                    |                    |
|-------------------|--------------------------|-------------------|--------------------|--------------------|-------------------|--------------------|-------------------|--------------------|--------------------|
|                   | Mic                      | Mat               | UHML (mm)          | UI (%)             | SF (%)            | Str (g/tex)        | Elg (%)           | Rd                 | b+                 |
| R50               | 3.59 <sup>a</sup>        | 0.85 <sup>a</sup> | 28.73 <sup>a</sup> | 82.61 <sup>a</sup> | 7.56 <sup>a</sup> | 29.74 <sup>a</sup> | 5.00 <sup>a</sup> | 80.03 <sup>a</sup> | 10.30 <sup>a</sup> |
| R75               | 3.47 <sup>a</sup>        | 0.85 <sup>a</sup> | 28.15 <sup>a</sup> | 82.18 <sup>a</sup> | 7.52 <sup>a</sup> | 29.45 <sup>a</sup> | 4.35 <sup>a</sup> | 78.78 <sup>b</sup> | 11.05 <sup>a</sup> |
| R100              | 3.21 <sup>b</sup>        | 0.84 <sup>b</sup> | 27.66 <sup>b</sup> | 81.78 <sup>a</sup> | 8.37 <sup>b</sup> | 28.00 <sup>a</sup> | 4.28 <sup>b</sup> | 78.28 <sup>b</sup> | 11.26 <sup>b</sup> |
| Signification (p) | 0.00                     | 0.01              | 0.04               | 0.25               | 0.03              | 0.12               | 0.00              | 0.52               | 0.01               |

In the same column, the mean values assigned to the same alphabetical letter are not significantly different at the  $\alpha = 5\%$  threshold according to the Duncan Test. Mic: Micronaire, Mat: Maturity, UHML: Length, UI: Length Uniformity, SF: Short fiber content, Str: Tenacity, Elg: Elongation, Rd: Gloss, b+: Yellow index.

- **Effects of splitting the harvest on the technological parameters of the fiber in Nambingué**

In the locality of Nambingué, the results of the analysis of variance, presented in **Table 2**, do not indicate significant effects of the harvest splitting on all the technological parameters of the cotton fiber with the exception of the rate of short fibers rate which was significantly lower ( $p = 0.03$ ) for the harvest at 50% boll opening, compared with harvests with 75% and 100% boll opening. The same is true for the yellowness index, which was lower in harvests with 50% and 75% boll opening.

**Table 2.** Effects of crop fractionation on technological parameters of fiber from Nambingué.

| Types of harvest  | Technological parameters |                   |                    |                    |                   |                    |                   |                    |                    |
|-------------------|--------------------------|-------------------|--------------------|--------------------|-------------------|--------------------|-------------------|--------------------|--------------------|
|                   | Mic                      | Mat               | UHML (mm)          | UI (%)             | SF (%)            | Str (g/tex)        | Elg (%)           | Rd                 | b+                 |
| R50               | 3.83 <sup>a</sup>        | 0.85 <sup>a</sup> | 28.22 <sup>a</sup> | 80.95 <sup>a</sup> | 7.18 <sup>a</sup> | 30.23 <sup>a</sup> | 4.56 <sup>a</sup> | 78.31 <sup>a</sup> | 7.93 <sup>a</sup>  |
| R75               | 3.79 <sup>a</sup>        | 0.86 <sup>a</sup> | 27.85 <sup>a</sup> | 81.21 <sup>a</sup> | 8.38 <sup>b</sup> | 30.01 <sup>a</sup> | 4.84 <sup>a</sup> | 79.06 <sup>a</sup> | 8.31 <sup>a</sup>  |
| R100              | 3.70 <sup>a</sup>        | 0.86 <sup>a</sup> | 27.56 <sup>a</sup> | 81.43 <sup>a</sup> | 9.03 <sup>b</sup> | 29.15 <sup>a</sup> | 4.71 <sup>a</sup> | 79.10 <sup>a</sup> | 10.43 <sup>b</sup> |
| Signification (p) | 0.53                     | 0.47              | 0.12               | 0.40               | 0.03              | 0.12               | 0.35              | 0.29               | 0.40               |

In the same column, the mean values assigned to the same alphabetical letter are not significantly different at the  $\alpha = 5\%$  threshold according to the Duncan Test. Mic: Micronaire, Mat: Maturity, UHML: Length, UI: Length Uniformity, SF: Short fiber content, Str: Tenacity, Elg: Elongation, Rd: Gloss, b+: Yellow index.

• **Effects of splitting the harvest on the technological parameters of the fiber in Séguéla**

In Séguéla, a significant effect of harvest splitting was observed on micronaire ( $p = 0.03$ ), short fiber rate ( $p = 0.01$ ), elongation ( $p = 0.04$ ) and yellow index ( $p = 0.02$ ). For these parameters, the values range from good to worse when moving from harvesting at 50% to that carried out at 100% boll opening (**Table 3**). Thus, for the harvest carried out at 50% opening, the micronaire was the highest (3.92). The lowest micronaires were obtained with harvests at 75 and 100% boll opening (3.86 and 3.85 respectively). Furthermore, the analysis of variance revealed a variation of the short fiber rate, depending on the type of harvest. ( $p = 0.01$ ). The lowest values (6.95% and 7.40%) were respectively at the harvests at 50% and 75% boll opening. A significant difference was also observed ( $p = 0.02$ ) on the yellow index which was low at the harvests at 50% and 75% boll opening, with respective values of 7.41 and 7.56. On the other hand, the splitting of the harvest had no significant effect on maturity, length, uniformity index, tenacity, elongation and brightness. The values of these parameters are statistically identical ( $p > 0.05$  in all cases).

**Table 3.** Effects of crop fractionation on technological parameters of fiber from Séguéla.

| Types of harvest  | Technological parameters |                   |                    |                    |                   |                    |                   |                    |                    |
|-------------------|--------------------------|-------------------|--------------------|--------------------|-------------------|--------------------|-------------------|--------------------|--------------------|
|                   | Mic                      | Mat               | UHML (mm)          | UI (%)             | SF (%)            | Str (g/tex)        | Elg (%)           | Rd                 | b+                 |
| R50               | 3.92 <sup>a</sup>        | 0.86 <sup>a</sup> | 29.57 <sup>a</sup> | 83.12 <sup>a</sup> | 6.95 <sup>a</sup> | 30.13 <sup>a</sup> | 4.96 <sup>a</sup> | 80.90 <sup>a</sup> | 7.41 <sup>a</sup>  |
| R75               | 3.86 <sup>b</sup>        | 0.86 <sup>a</sup> | 29.19 <sup>a</sup> | 82.95 <sup>a</sup> | 7.40 <sup>a</sup> | 30.15 <sup>a</sup> | 4.86 <sup>a</sup> | 80.60 <sup>a</sup> | 7.56 <sup>a</sup>  |
| R100              | 3.85 <sup>b</sup>        | 0.86 <sup>a</sup> | 28.68 <sup>a</sup> | 82.20 <sup>a</sup> | 7.63 <sup>b</sup> | 29.91 <sup>a</sup> | 4.84 <sup>a</sup> | 79.43 <sup>a</sup> | 10.51 <sup>b</sup> |
| Signification (p) | 0.03                     | 0.85              | 0.06               | 0.25               | 0.01              | 0.92               | 0.62              | 0.76               | 0.02               |

In the same column, the mean values assigned to the same alphabetical letter are not significantly different at the  $\alpha = 5\%$  threshold according to the Duncan Test. Mic: Micronaire, Mat: Maturity, UHML: Length, UI: Length Uniformity, SF: Short fiber content, Str: Tenacity, Elg: Elongation, Rd: Gloss, b+: Yellow index.

### 3.2. Study of the Improvement of Fiber Characteristics by Fractional Harvesting

- **Improvement of the micronaire index**

Figure 3 shows the evolution of the micronaire index when using the split method during the harvest of seed cotton. This parameter is not really improved in view of the values obtained (0.07 with the harvest at 50% boll opening and 0.05 with the harvest at 75% boll opening).

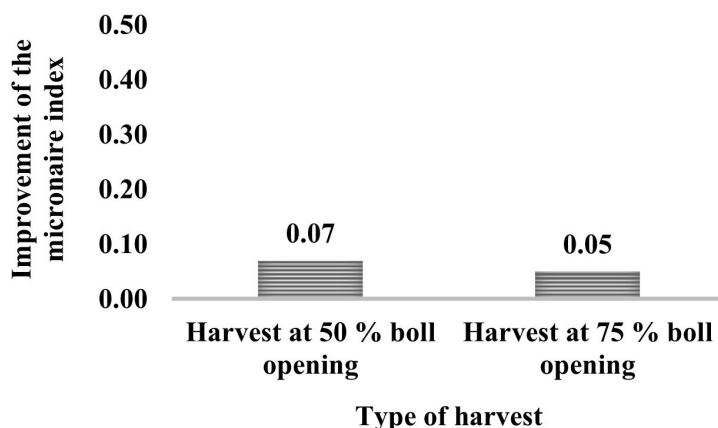


Figure 3. Improvement of the micronaire index by splitting the harvest of seed cotton.

- **Improvement of the length**

Figure 4 shows an increase in fiber length when using harvest splitting method. The length is improved by 1.05 mm when harvesting at 50% boll opening and by 0.72 mm when harvesting at 75% boll opening.

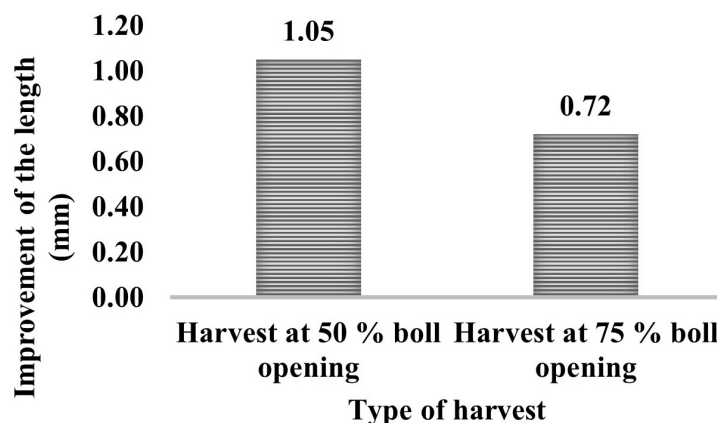


Figure 4. Improvement of the length by splitting the harvest of seed cotton.

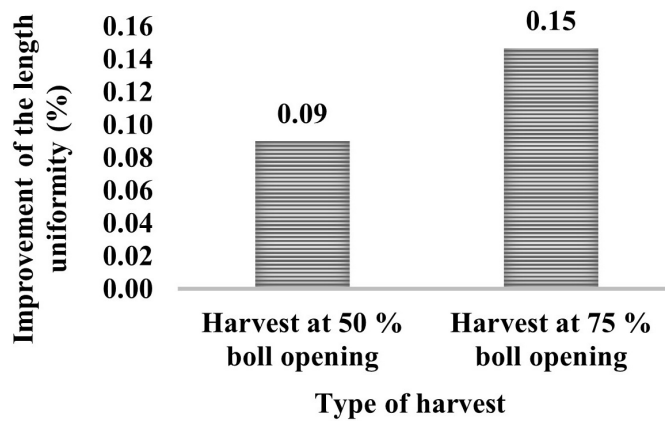
- **Improvement of the length uniformity**

Figure 5 shows the improvement in fiber length uniformity due to splitting during seed cotton harvest. The increases of 0.09% with harvesting at 50% boll opening and 0.15% with harvesting at 75% boll opening show that splitting the harvest does not significantly improve this fiber parameter.

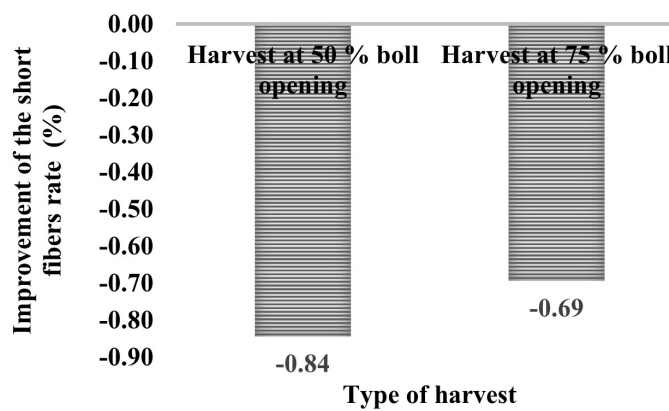
- **Improvement of the short fibers rate**

The level of improvement of the short fibers rate is given in Figure 6. The results show that splitting

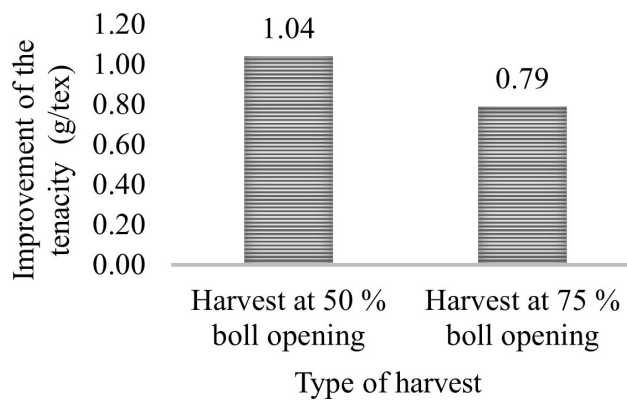
harvest reduces the short fibers rate. It drops by 0.84% when harvesting is done at 50% boll opening and by 0.69% when harvesting is carried out at 75% boll opening.



**Figure 5.** Improvement of the length uniformity by splitting the harvest of seed cotton.



**Figure 6.** Improvement of the short fibers rate by splitting the harvest of seed cotton.



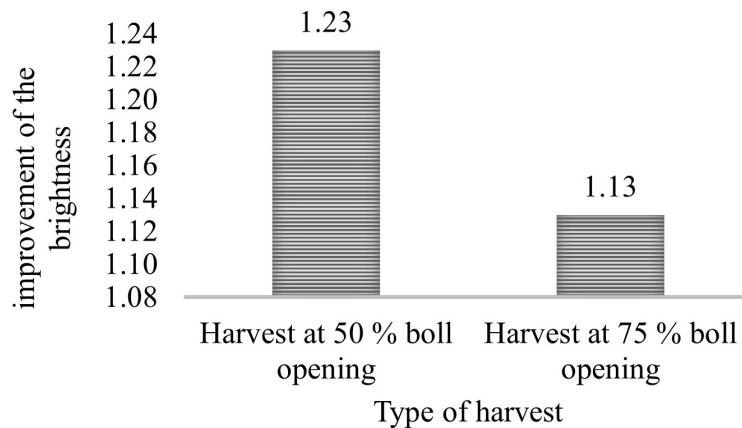
**Figure 7.** Improvement of the tenacity by splitting the harvest of seed cotton.

- **Improvement of the tenacity**

**Figure 7** shows an increase in tenacity, reflecting an improvement in this parameter when the fractionated seed cotton harvesting method is used. In fact, fiber strength as expressed by tenacity is improved by 1.04 g/tex and 0.79 g/tex when seed cotton is harvested at 50% and 75% boll opening, respectively.

- **Improvement of the brightness**

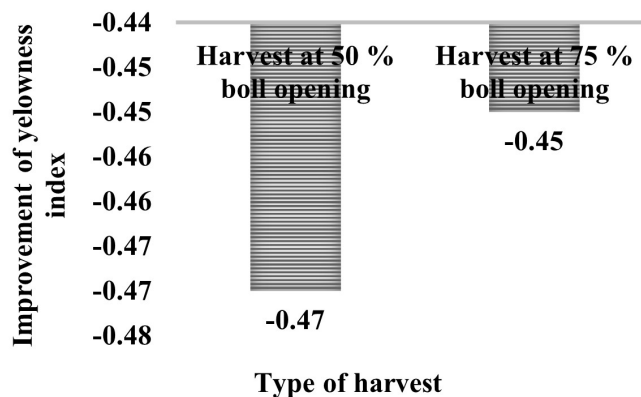
**Figure 8** shows the brightness improvement depending on the type of harvest. In fact, the values obtained show an increase in brightness of 1.23 and 1.13 with the harvest at 50% capsule opening and of 0.13 with the harvest at 75% capsule opening.



**Figure 8.** Improvement of the brightness of the fiber by the fractionation of the harvest of the seed cotton.

- **Improvement of the yellowness index**

**Figure 9** shows a reduction of the yellowness index of the fiber, reflecting an improvement in this parameter when the split-harvest method is used. In fact, the yellowness index decreases by 0.4 with both types of split harvest.



**Figure 9.** Improvement of the yellowness index of the fiber by the fractionation of the harvest of the seed cotton.

#### 4. DISCUSSION

The values of technological parameters such as length, micronaire index, tenacity and fiber elongation generally decrease when moving from early harvests (50% to 75% boll opening) to late harvests (100% boll

opening). This variation is due to the phenomenon of fiber maturation during the cotton cycle. Indeed, the first harvested cotton seeds were obtained from the first capsules opened on the cotton plant. However, as [2], argued, the early production of cotton seeds corresponds to a period of growth and maturation of the capsules presenting less risk of water stress and therefore likely to ensure more favorable conditions for fiber maturation. These bolls mature better than the other bolls, so the fiber they contain is of much better quality. These results are in line with those obtained in studies on the characteristics of cotton fiber and seed in relation to the distribution of bolls on the plant [14]. Brightness and yellowness index reflect the brightness and whiteness of the cotton fiber. The results obtained for the three types of harvest (50%, 75% and 100% boll opening) show that when cotton is harvested quickly, the above-mentioned technological characteristics are good [11]. Indeed, the delay in harvest exposes cotton to various bad weather and to the negative action of certain insects. This is how dust, late rains [15] or certain sucking biters such as whiteflies (*Bemisia tabaci*) and aphids (*Aphis gossypii*) dirty late-harvested cotton [2]. Split harvesting has been proposed to producers as a practice in Benin in order to guarantee the quality of cotton of local varieties [16] and in Côte d'Ivoire where its effect on grain cotton has been demonstrated [10] including the fiber [11].

## 5. CONCLUSION

The results show that crop splitting can have an influence on most of the technological parameters of cotton. The parameters on which this operation has an impact are of two types. On the one hand, there are parameters whose variation is linked to the position of the bolls on the cotton plant. These are parameters such as micronaire, length, length uniformity, short fiber rate, tenacity and elongation. For these parameters, it is the fact that early harvests concern the best capsules that fractionation improves fiber quality. On the other hand, parameters such as brightness and yellowness index are likely to change according to environmental conditions. For these parameters, early harvesting preserves the intrinsic quality of the fiber when the bolls open. In addition, cotton harvested at 50% and 75% open can be grouped together and marketed as a whole, as they have more or less the same characteristics.

As the fiber quality parameters are better when moving from early to late harvests, splitting the harvest is therefore a good practice that should be proposed to growers with a view to preserving fiber quality and guaranteeing a good market value for cotton fiber in Côte d'Ivoire.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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