Influence Of Cultivation Densities On The Technological Characteristics Of The Fibre And Seed Of Cotton (*Gossypium Hirsutum* L.) In Côte d'Ivoire

Abstract

Background: In Côte d'Ivoire, cotton growing is crucial to the economy of the savannah region, accounting for 1.7% of national GDP and 7% of exports. However, yields remain insufficient due to various factors such as climate change and non-compliance with good agricultural practices. **Objectives:** The general objective of this study was to evaluate the effects of sowing densities on the technological characteristics of cotton fibre. **Methodology**: The experiment was conducted at the Station de Recherche sur le Coton in Bouaké and at the observation posts (OP) of the cotton companies (Ivoire Coton and SECO). Nine levels were studied in this factor, numbered T1 to T9. The agronomic observations covered the estimation of seed cotton yield, determination of the Seed Index, seed health, seed germination level and fat extraction and determination of oil content. The data collected from the quality tests on cotton fibre and seed were subjected to an analysis of variance (ANOVA) using R.4.0.1 software. **Results:** The density applied at T6 (111,111 plants per hectare) improved yield compared with the other densities. In terms of seed germinability, seeds from the T6 treatment had the best germination rate (78.67%). The highest oil content was found in treatments T3 (16.17%) and T6 (16.28%), with good Seed Index and healthy seed rates. The final oleic acid content ranged from 6.3 to 11.29%.

Keywords : Cotton; Economic development; Sowing densities; Yield; Germination

1. INTRODUCTION

Cotton plays an essential role in the economic development of many countries in West and Central Africa. In the WAEMU region, cotton accounts for around 6% of global exports and nearly 3.5% of the world's cultivated area **(CIRAD, 2016).** The crop is the main source of income for 15% of the population, contributing 33% of GDP and employing almost 70% of the workforce in the sub-region **(FAOSTAT, 2020)**. The cotton sector has stimulated economic development in rural areas by financing education, healthcare and food for families, while improving living conditions for the inhabitants of the central and northern regions of Côte d'Ivoire. In Côte d'Ivoire, cotton growing is crucial to the economy of the savannah region, accounting for 1.7% of national GDP and 7% of exports (**Markus and Francis, 2010**). However, yields remain insufficient due to various factors such as climate change and failure to follow good agricultural practices **(Amonmidé *et al.*, 2020).** The work of **Jalilian *et al* (2023)** has shown that sowing density is a key factor in improving cotton productivity, also influencing fibre quality. Given the relevance of this work, it is worth asking whether the densities used in Côte d'Ivoire over the past three decades are still appropriate ? Aware of these difficulties, a team of researchers assessed the influence of crop densities on the technological characteristics of cotton fibre and seed. The overall aim of this study is to improve cotton productivity by updating sowing densities in cotton growing in Côte d'Ivoire. More specifically, the aim was to: (i) Assess the effects of sowing densities on the technological characteristics of cotton fibre and (ii) determine the effects of sowing densities on the technological parameters of cotton seed.

2. MATERIALS AND METHODS

2.1. Study area

The experiments were conducted at the Station de Recherche sur le Coton in Bouaké and at the observation posts of the cotton companies (Ivoire Coton and SECO).

2.2Plant material

The plant material consisted of seed cotton of the species Gossypim hirsutum.

2.3. Methodology

2.3.1. Experimental set-up

The experimental design was a Fisher block with three blocks (replicates). A single factor corresponding to sowing density was evaluated. Nine levels were studied in this factor, numbered T1 to T9. For each level, the surface area of the elementary plot was 48 m², i.e. 10 m long by 4.8 m wide. A distance of 2 m separated two blocks (**Table 1**).

Table 1: Treatments (sowing densities) in comparison

Treatments	Géométrie de semis	Number of plants/packet	Density (plants/ha)
T1	1,0 × 0,40	2	50 000
T2	1,0 × 0,30	2	66 666
T3	1,0 × 0,20	2	100 000
T4	0,9 × 0,40	2	55 555
T5	0,9 × 0,30	2	74 074
T6	0,9 × 0,20	2	111 111
T7	0,8 × 0,40	2	62 500
T8	0,8 × 0,30	2	83 300
T9	0,8 × 0,20	2	**2** 0

2.3.2. Conducting the trial

The plots were ploughed with a tractor, followed by harrowing for the trials. Seeding was carried out flat, with 3-5 seeds per pack at distances corresponding to the seeding geometry. Replanting was carried out 10 days after sowing (DAS). Weeding was carried out between 10 and 15 days after plant emergence (JAL). The first weeding was carried out 15 days after sowing, at the same time as weeding. The second weeding was done on demand. The cotton plants were fertilised with the base fertiliser NPKSB (15-15- 15 +6S+1B) and a cover fertiliser, urea (46% N). The base fertiliser was applied by side-dressing between 15 and 20 days before harvest at a rate of 200 kg/ha. Cover fertiliser was applied at a rate of 50 kg/ha between the cotton rows and buried by sarclo-butting between 40 and 45 days before planting. Phytosanitary treatments were carried out using products popularised in each zone according to the phytosanitary protection programme recommended by the research. In order to carry out post-harvest analyses, samples of 3 kg of seed cotton were taken per treatment (sowing densities).

2.3.2. Observations and measures

2.3.2.1. ***Estimated yield of seed cotton***

The actual yield is calculated after the seed cotton has been harvested, dried and weighed for each individual plot. The formula for calculating the yield per hectare is as follows : $RDT\ CG\ (kg/ha) = \frac{PCGp\ (kg)}{SUPp\ (\text{ha})}$

Où : ***RDT CG*** *: seed cotton yield (in kg/ha) ;* ***PCGp*** *: weight of cotton harvested per elementary plot (kg);* ***SUPp*** *: harvested area (in ha) of the elementary plot.*

2.3.2.2. ***Seed yield***

The seed yield was determined by the following formula **(Goreux, 2003)** :

$$\text{Percentage of seeds (\%)} = \frac{\text{Weight (g) of seed}}{\text{Weight (g) of cottonseed}} \times 100$$

2.3.2.3. ***Determining the Seed Index***

The Seed Index is the weight of 100 cotton seeds. It was determined by taking 100 cotton seeds at random and weighing them on a precision balance (Explorer Pro Model EP114C, made in Switzerland).

2.3.2.4. ***Seed health***

The knife test was used to determine the health of the seeds. The test consisted of cutting cotton seeds transversely and examining the inside under a white light in the laboratory. The seeds were then classified according to whether they were healthy, rotten or aborted. Their rates were calculated according to formulae (1), (2), (3) below :

$$\text{Rate of healthy seeds (\%)} = \frac{\text{Number of healthy seeds}}{\text{Number of seeds tested}} \times 100 \qquad (1)$$

$$\text{Rate of rotten seeds (\%)} = \frac{\text{Number of rotten seeds}}{\text{Number of seeds tested}} \times 100 \qquad (2)$$

$$\text{Rate of aborted seeds (\%)} = \frac{\text{Number of aborted seeds}}{\text{Number of seeds tested}} \times 100 \qquad (3)$$

2.3.2.5. ***Germination test***

The seed germination test was determined. The percentages of germinated (4) and non-germinated (5) seeds were calculated according to the following formulae :

$$\text{TRate of germinated seeds (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds tested}} \times 100 \qquad (4)$$

2.3.2.6. ***Extraction of fat and determination of oil content***

The fat content or oil content is assessed by mass difference using the formula :

$$\text{Oil content (\%)} = \frac{\text{P2} - \text{P1}}{\text{Pe}} \times 100 \ (5)$$

Pe : mass (g) of crushed material before extraction ; P1 : mass (g) of empty extraction flask (250 ml) ; P2 : mass (g) (flask + oil); P: mass (g) of oil.

2.3.2.7. ***Determination of oleic acidity***

Oleic acidity was determined by titration in an alcoholic medium in the presence of phenol phthalein with a sodium hydroxide solution (0.1 N). The oleic acidity of the oil expressed as a percentage is given by the following formula:

$$\text{Oleic acidity (\%)} = \frac{\text{V}.n.282}{\text{P}.1000} \times 100 \qquad (6)$$

V : volume (ml) of NaOH (0.1 N) added to equilibrium ; n : normality of the soda solution: 0.1; P : Mass (g) of fat (oil) extracted from each seed sample 282 : molecular weight of oleic acid.

2.4. Statistical analysis

The data collected from the quality tests on cotton fibre and seed were subjected to an analysis of variance (ANOVA) using R.4.0.1 software after verification of the normality of the distribution. When a significant difference was observed ($p < 0.05$) between sowing densities (treatments) for a given parameter, multiple comparisons were carried out using Duncan's test at the 5% probability of error threshold.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Effect of density on seed cotton yield

The seed cotton yields of the different treatments tested gave statistically different values. The highest yields were obtained in treatments T6 and T4 with values of 741.39 kg/ha and 723.84 kg/ha respectively. On the other hand, the lowest yield was obtained in treatment T1 with a value of 287.67 kg/ha (Fig 1).

3.1.2. Effect of treatments on Seed Index

The Seed Index (SI) of the treatments evaluated were statistically identical (Fig 2). The analysis did not reveal any significant differences between treatments. However, the Seed Index was higher for treatments T3 and T6, with values of 8.15 g and 8.08 g respectively. Seed Index values for the other treatments were as follows: T7 (7.96g), T4 (7.85g), T5 (7.84g), T2 (7.79g), T8 (7.77g), T9 (7.61g) and T1 (7.60g).

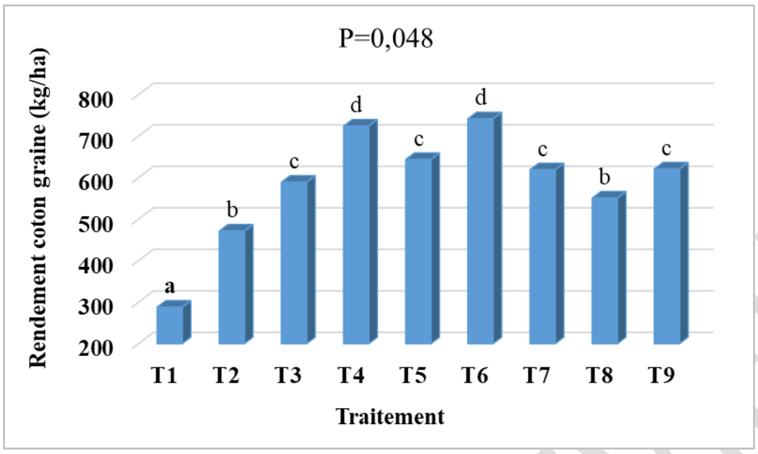

Fig 1 : Field yield of seed cotton as a function of treatments

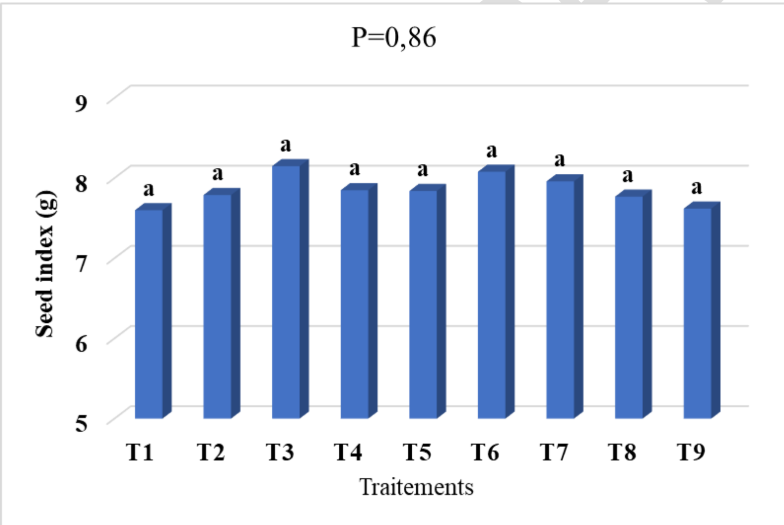

Fig 2: Seed index as a function of treatment

3.1.3. Seed health status

The results of the statistical analyses showed that there was no significant difference between the treatments in terms of seed health (Table 2). In addition, analysis of the cotton seeds harvested revealed that healthy seeds were the most numerous of all the seeds, with rates of between 70% and 85%. However, a significant proportion of the seeds were rotten, with rates of between 10% and 16%. Finally, a small proportion of the seeds were aborted, with rates varying between 4% and 10%.

3.1.4. Germination capacity of seeds

The results of the germination test showed a significant difference at the 5% threshold between treatments with a p-value of 0.0361. The highest germination rate was recorded in treatment T6 with a germination rate of 78.67%. This was followed by treatments T1 (72%), T3 (76.05%), T5 (72.61%), T7 (75.78%) and T8 (72.61%). The lowest germination rate was observed in treatment T9 (63.11%) (Table 3).

Table 2: Proportion of sanitary condition of cotton seeds

Treatments	Healthy (%)	Rotten (%)	Aborted (%)
T1	80,84 ± 8,84 a	11,17 ± 5,73 a	8 ± 3,11 a
T2	78,03 ± 6,88 a	12,29 ± 6,52 a	9,69 ± 0,37 a
T3	84,33 ± 5,23 a	10,84 ± 4,95 a	4,83 ± 0,28 a
T4	82,11 ± 5,67 a	11,34 ± 3,78 a	6,56 ± 1,9 a
T5	75,73 ± 16,17 a	15,34 ± 10,45 a	8,94 ± 5,72 a
T6	84,78 ± 6,56 a	10,26 ± 3,96 a	4,97 ± 2,6 a
T7	83,05 ± 3,84 a	11,44 ± 3,73 a	5,52 ± 0,12 a
T8	76,28 ± 9,06 a	16,1 ± 8,43 a	7,63 ± 0,63 a
T9	73,39 ± 7,61 a	17,67 ± 5 a	8,94 ± 2,61 a
Pr > F	**0,680**	**0,795**	**0,222**

Table 3: Germination rate of seeds according to treatments

Treatments	Estimated averages	Standard deviation	Groups
T1	72,000	7,110	a
T2	68,170	6,390	b
T3	76,055	4,945	a
T4	68,945	2,725	b
T5	72,615	13,945	a
T6	78,670	3,110	a
T7	75,780	3,780	a
T8	72,610	8,610	a
T9	63,110	13,330	b

3.1.5. Oil content

Statistical analysis of the fat content (oil percentage) of the seed revealed no difference (P=0.98) between treatments (Fig 3). Also, the oil content of the seeds varied between 14% and 16%. The highest oil contents were obtained in treatments T6 (16.28%) and T3 (16.17%), while the lowest contents were obtained in treatments T (14.82%) and T9 (14.39%).

3.1.6. Oleic acidity level

Descriptive analysis of seed oleic acidity showed a variation in levels between treatments. However, statistical analysis using Duncan's test at the 5% threshold revealed no significant difference (P=0.99) between treatments (Fig 4). The highest average rates were obtained in treatments T1 (11.29%), T9 (10.50%) and T4 (10.21%). The lowest rates were obtained in treatments T6 (7.98%) and T5 (6.3%).

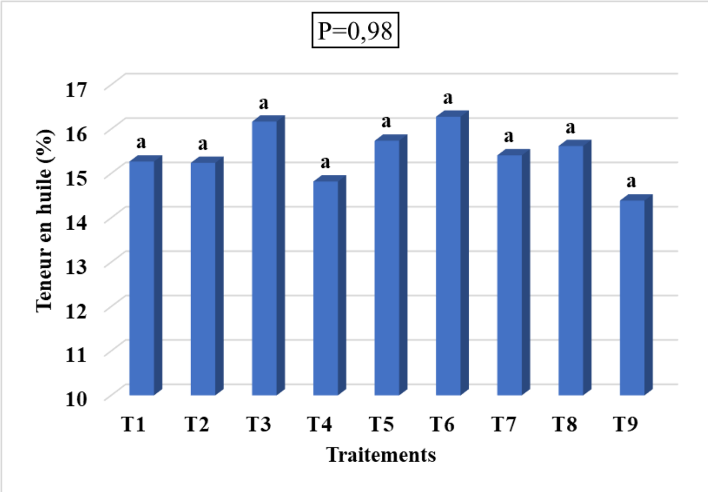

Fig 3: Oil rate depending on treatments

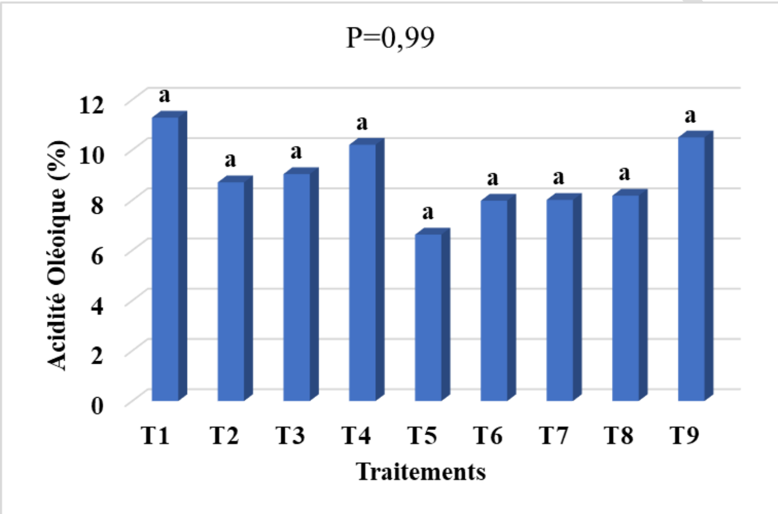

Fig 4: Oleic acidity levels as a function of treatments

3.2. DISCUSSION

The results of this study showed that sowing density had little influence on the technological parameters measured. In fact, of the six parameters measured, only cotton seed yield and germination capacity were influenced. In terms of yield, the density applied at T6 improved yield compared with the other densities. This result could be justified by the number of plants in this treatment. In fact, the plant density in this treatment was the highest at 111,111 plants/ha. Ces résultats sont contraires à celui de **Sekloka *et al.* (2015)**. The author observed that increasing density led to a reduction in the number of fruiting sites per plant and in the capsular retention rate. There were fewer capsules and they were concentrated in the lower parts of the plant. These contradictory observations could be explained by the level of soil fertility. According to Galanopoulou-**Sendouka *et al* (1980)**, high densities lead to increased competition for water and nutrient resources and even for light interception. This means that sowing density must be adjusted according to soil fertility, crop species and variety, and climatic conditions.

In terms of germination capacity, seeds from treatment T6 obtained the best germination rate (78.67%). This result could be explained by the quality of the seeds. Indeed, the descriptive analysis of the health status of the seeds showed that those from treatment T6 were healthier than those from the other treatments. **According to Crétenet (2015)**, parasite pressure and pre-harvest conditions can degrade the quality of cotton seeds, thus affecting their germination capacity. However, statistical analysis of seed health revealed no significant difference between treatments.

The highest oil content was obtained in treatments T3 (16.17%) and T6 (16.28%), which were characterised by good Seed Index and healthy seed rates. This means that the oil content of cotton seeds depends on seed size. The larger the kernel, the more oil it contains. However, there was no significant difference ($P < 0.05$) between high planting density (16.28%) and low planting density (14.39%). The results obtained are in line with those of **Sepideh *et al*, (2023)** who mentioned that the different spacings applied during their work did not have a significant effect on seed oil content, while cotton genotypes or their interaction had a non-significant effect on seed oil content in both years. These statements are in agreement with those reported by **Gotmare *et al*, (2004).** These authors reported that cottonseed oil content varied between 17.61% and 19.54% in six races of G. arboreum. This is supported by the results of **Sharma *et al*, (2009)** which indicate that genotypes and regional variations affect cottonseed oil content. Seed oils containing high levels of oleic acid, also known as high oleic acid (HO) oils, are attracting increasing interest due to their desirable fatty acid composition which offers improved oxidative and thermal stability and a healthier nutritional profile. Thus, the determination of oleic acidity in the seeds revealed non-significant variations between the different treatments studied. The oleic acid content ranged from 6.3 to 11.29%. These values are significantly lower than those obtained by **Sharma *et al* (2009)**. These authors determined that the oleic acid content varies between 14.06 and 17.00% in cottonseed oil. This difference in oleic acid content was explained by **O'Brien (1998) and Baydar and Turgut (1999)** who indicated that the fatty acid composition of seeds varies according to genotype, environmental factors and seed health, depending on whether the seed is healthy or damaged.

4. CONCLUSION

This study focused on the influence of crop density on the technological characteristics of cottonseed. The results showed that sowing densities had little influence on the technological parameters of the seed. Thus, only yields and germination rates were influenced. Furthermore, the highest values for the parameters measured were observed at the density of 111,111 plants/ha. However, there was no significant difference between the different densities studied. This means that density has little influence on the technological characteristics of the seed.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that no generative artificial intelligence technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-image generators were used during the writing of the manuscript. He also declares that he did not use these tools during the writing or editing of this manuscript.

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