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Planting Date Effect on Yield and Fiber Properties in Some Cultivars and Promising Crosses of Cotton (*Gossypium Hirsutum L*.) in Mali

Keywords: Cotton; Fiber; Planting date; Decade; Sowing; Early; Delaying; Late

Abstract

Cotton is the most important cash crops in Mali. It is a major catalyst of economic development in rural areas.

Cotton is produced under rainfall conditions and is subjected to fluctuating rainfall variability, drought, high temperature, moisture, soil poverty in nutrients combined with the lack of innovative technologies, and seed cotton yield price volatility. In Mali cotton is planted during growing season so planting date depends on the beginning of rainfall. In this study, the data from thirty four trials conducted in two vast cotton-producing zones (Southern and central northern) of Mali during two rainy seasons. Data were collected and analyzed to determine the effect of planting date on yield, yield components and particular fiber properties of four promising cotton genotypes. Five planting decades were identified (planting occurred in 1st, 2nd, 3rd decade of June and 1st, 2nd decade of July) in each year. Results indicated that only seed cotton yield, lint percentage, fiber length, fiber fineness and fiber whiteness were significantly affected by planting dates. On the other hand, planting date did not affect significantly the seed index and fiber quality traits such as yellowness. All four genotypes: BRS 293, NTA L65, NTA B149 and NTA E154 used in the experiment produced suitable seed cotton yield and yield attributes and acceptable lint propriety for early sowing. For delaying sowing, the variety BRS 293 was better and is suitable in Malian cotton producing area regardless of the planting date.

Introduction

Cotton is the world's most important fiber crop and the second most important oil seed crop [1]. In West and Central Africa (WCA), cotton represents the main source of income for 20 million people and amounts to up to 60 percent of national export earnings. The WCA region produces about 16% of the world's cotton and is the 5th largest world exporter after the United States, China, India and Uzbekistan [2].

Malian economy is based on agriculture, which occupies more than 70% of its population. Mali's population sustains itself on smallscale, rainfall subsistence agriculture. Cotton, a rainfall and main cash crop, allows around 40% of the rural population to dependent on its production [3]. While rice and coarse grains (maize, millet and sorghum) constitute the main food crops. Cereals represent more than two-thirds of the country's dietary energy supply. Mali is a net

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exporter of cotton and livestock and a net importer of rice [4].

Most smallholders in Mali's cotton zones grow cotton. They earn higher incomes and invest more in agriculture than smallholders in other zones. These additional resources allow cotton farmers to produce up to 70 percent more cereals per capita than non-cotton farmers [5].

Cotton quality has different significances for farmers and industry. For farmers, high cotton quality means more revenue and for the industry, it means fewer losses. So it is important for farmers to manage cotton fields for the best possible attainable quality.

It is important for the industry to acknowledge that there are many uncontrollable factors affecting fiber quality. Fiber quality differs among cotton fields, plants and bolls. Even in one seed different fiber quality may be found. Fiber quality is under genetic control, and cotton fields can be managed for best quality. However, the weather has an important unpredictable effect on quality [2]. Fiber length is largely influenced by variety, but the cotton plant's exposure to extreme temperatures, water stress, or nutrient deficiencies may result in shorter fibers [6].

Mali is today the largest producer of cotton in Sub-Saharan Africa. Mali's cotton production for 2017/2018 is estimated at a record 725,000 tones, up or 12% from last year's (2016 - 2017) record crop. Harvested area was estimated at a record 0.73 million hectares, up 750,000 hectares or 11% from last year's record area. Mali's cotton is planted from May to July and harvest is done from late October to December [7].

Cotton production occurs in a vast zone of southern and central northern of country, where each zone has its own characteristics. All production is managed by a cotton ginning Mill Company belonging to the "Compagnie Malienne de Developpement de Textile -CMDT)".

The Sikasso region in southern Mali produces approximately 60%

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of Mali's total cotton. Cropping conditions in Sikasso are average to above-average from May through October.

Mali's cotton production record is attributed to increased planted area resulting from strong prices and above-average yields due to favorable weather.

Main constraints in cotton production in Mali are the lack of innovative technologies, irrigation, and infrastructure of storage; that combined with price volatility in addition to a very volatile rainfall uncertainty during planting and harvest times [4].

The main objective of this study was to identify effects of planting date on cotton seed yield and fiber quality.

Materials and Methods

Experimental site

The study has covered two vast cotton-producing zones of Mali during the 2017/2018 and 2018/2019 rainy seasons (Figure 1).

The southern zone is located in the Sudanian zone. The average annual rainfall is between 1000 mm and 1200 mm. The length of the rainy season varies 5 to 6 month from May through October. Cotton is planted from May to July and harvested from late October to December [4]. The study was conducted in fourteen villages.

The central northern zone is located in the Sahelo-Sudanian zone. Average annual rainfall ranges between 600 to 1000mm per year. The length of the rainy season varies between 4 to 5 month form June/July to September/October. Cotton planted from June to July and harvest is done from October to December [4]. In the central northern zone, twenty selected villages conducted the experiments.

In all production area (southern and central northern) the cotton production is carried out under rain-fed conditions.

The samples harvested seed cotton was collected from different sites and sample seed cotton was ginned at ginning factories 20 sheets of saw tooth of Agronomic Research Station of N'Tarla, IER Mali, to separate the lint from the seed.

Genetic material was composed of four varieties. One variety is from Brazil and other three are from Mali (Table 1). All these four genotypes are in their last on farm test before going for Value of Cultivation Use

(VCU) and release.

Methodologies

Experimental design

Randomized Complete Block Design (RCBD) with two replications (blocks) was used. Each genotype was planted in five rows of 30 m length. Plant to plant and row to row distances were 30 and 80 cm, respectively. The center three rows of each five-row plot were harvested by hand after cotton boll opened.

The experimental design was implanted inside the farmer field and was planted the same date with farmer field, receive the same crop management (weed control, insect control and fertilizer apply) as in the farmer own field.

Data recorded

Data were collected on two main components: Agronomical and cotton fiber technological characteristics.

Agronomical characteristics

They were composed of:

• **Planting dates:** The planting dates of each site in 2017/2018 and 2018/2019 were recorded.

• Seed cotton yield (kg/ha): Seed cotton harvested from the individual plots (three central rows) was weighted to determine yield in kilogram per hectare (kg/ha).

• Lint yield (percent): Samples of seed cotton harvested from individual plots were ginned using ginning machine of 20 sheets of saw tooth without lint cleaning at the N'Tarla research station facility to determine lint percentage (%) by using the following formula:

$$\%Lint = \frac{\text{Weight of lint cotton (g)}}{\text{Seed cotton weight (g)}} \times 100$$

• Seed Index (g): Seed index was determined as weight of 100 seeds in grams.

Fiber properties

Four major fiber properties were analyzed in this study. They were fiber length, fineness, reflectance degree and yellowness. These properties depends on maturity which determines yarn tensility, evenness, imperfections and hairiness [8]. For fiber properties



Figure 2a: Average decadal and monthly rainfall (mm) over central northern zone from 2017 - 2018 to 2018 - 2019.

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Figure 2b: Average decadal and monthly rainfall (mm) over southern zone from 2017 - 2018 to 2018 - 2019.

characterization, the HVI techniques were used. A sample of 50 g of lint was taken from the individual cotton plots for the analysis of: upper half mean length (UHML); micronaire (Mic), reflectance (+Rd), and yellowness (+b).

• Upper Half Mean Length (mm)

The HVI upper half mean length (UHML) is the average length of the longest 50% of fibers in a sample or bale [9]. This measurement is used to place cotton into the five upland staple classes which are short (<21.0 mm), medium (22.0 mm - 25.0 mm), medium-long (26.0 mm - 28.0 mm), long (29.0 mm. - 34.0 mm), and Extra-Long Staple (ELS) (>34.0 mm) [10].

The importance of fiber length to textile processing is significant. Longer fibers produce stronger yarns that allow for more valuable end products. Longer fibers also enable higher spinning speeds.

• Micronaire (units)

Fiber micronaire (Mic) or fiber fineness is the indicator of fiber maturity and fineness that depends on both fiber diameter and secondary wall thickness. The rating of fineness of given fiber for spinning are: very fine fiber (below 2.9); fine (2.9 - 3.7); medium (3.8 - 4.6); coarse fiber (4.7 - 5.5) and very coarse (5.6 and above) [11]. A low micronaire fiber (<3.5) results in knots of broken fiber whereas high micronaire (>4.9) will not convert into a bean shape that facilitates spinning process cited by [12,13]. It is generally considered that both too-low and too-high micronaire cottons should be avoided, the ideal range being around 3.8 and 4.2 for American Upland type cotton

Table 1: List of cotton plant material used in the experiment during year 2017-2018 and 2018-2019 cropping season in Mali.

Genotype	Pedigree	Origin	Year of 1 st experimentation
BRS 293	Stoneville 132/Delta Opal	Brazil	2014
NTA L65	NTA 88-6*3/STAM 279A	Mali	2012
NTA B149	NTA 93-15/B 163	Mali	2006
NTA E154	ID742/ STAM 279 A	Mali	2009

Table 2: Number and percentages of planting decades per zone: 2017/2018 and 2018/2019 growing seasons.

Decada	Southern		Central northern		Total				
Decade	Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)			
1 st Decade of June (D1)	4	15	2	5	6	9			
2 nd Decade of June (D2)	4	15	7	18	11	17			
3 rd Decade of June (D3)	11	41	19	50	30	46			
1 st Decade of July (D4)	7	26	7	18	14	22			
2 nd Decade of July (D5)	1	4	3	8	4	6			
Total	27	100	38	100	65	100			

Table 3: Correlation matrix among the traits, Average annual rainfall (AAR), Number day of rainfall (NDR), Seed cotton yield (Yield) Seed index (SI), Upper Half Mean Length (UHML), Micronaire (Mic), Reflectance degree (Rd) and Yellowness (b+).

	AAR	NDR	Yield	%Fib	SI	UHML	Mic	Rd	b+
Average annual rainfall (AAR)	1								
Number day of rainfall (NDR)	0.374*	1							
Seed cotton yield (Yield kg/ha)	0.241 ^{ns}	0.086 ^{ns}	1						
Lint yield (%Fib)	-0.069 ^{ns}	0.199 ^{ns}	-0.212 ^{ns}	1					
Seed index (SI)	-0.017 ^{ns}	-0.293 ns	-0.118 ^{ns}	-0.396*	1				
Upper Half Mean Length (UHML)	-0.196 ^{ns}	-0.085 ^{ns}	-0.142 ^{ns}	0.441*	-0.308 ^{ns}	1			
Micronaire (Mic)	0.048 ^{ns}	-0.083 ^{ns}	-0.247 ^{ns}	0.711**	-0.074 ^{ns}	0.374*	1		
Reflectance degree (Rd)	-0.14 ^{ns}	-0.117 ^{ns}	0.149 ^{ns}	-0.314 ^{ns}	-0.114 ^{ns}	0.006 ^{ns}	-0.424*	1	
Yellowness (b+)	0.151 ^{ns}	-0.05 ^{ns}	0.117 ^{ns}	-0.518**	0.248 ^{ns}	-0.266 ^{ns}	-0.162 ^{ns}	0.085 ^{ns}	1

* Significant at the 0.05 probability level;

** Significant at the 0.01 probability level.

ns: not significant

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Figure 3a: Results Agronomics traits per planting date (decade) and per variety. Seed cotton yield (kg:ha).





[14].

• Fiber Color

Color is the basic criterion of cotton classification into cotton grade according to the Universal Cotton Standards (UCS). The color grade of cotton is determined by two parameters: the degree of Reflectance (Rd) and the yellowness (+b), which are measured instrumentally using a High Volume Instrument (HVI) [15]. These two parameters are important standards for determining cotton price. Degree of reflectance shows the brightness of the sample and yellowness depicts the degree of cotton pigmentation. As the color of cotton deteriorates, so does the fibers' ability to absorb and hold dyes and finishes, which is likely to reduce processing efficiency [6].

0 Reflectance degree (%): The degree of reflectance (Rd) indicates how bright or dull a sample is. Its value must be equal to or greater than 75%.

o Yellowness (unit): The yellowness indicates the degree of color pigmentation. Its value must be less than 10.

Statistical analysis

Analysis of variance (ANOVA) was performed on plot means for a gronomic characters and fiber proprieties for across environments using GENSTAT 15^{th} edition.

Means were separated using TUKEY (HSD) tests. The value of the significance level (α) was at P = 0.05.

Results and Discussions

Experimental conditions

The total amount of rainfall per decade and per month during the two years period are presented (Figures 2a and 2b).

The average amount of rainfall recorded in Central northern zone, from 2017 - 2018 to 2018 - 2019 growing seasons was 794 mm. Except October, July, August and September were wet with 233 mm, 247 mm and 152 mm respectively (Figure 2a).

The Figure 2b showed that significant rainfall deficit was recorded only in the first decade of May and the third decade of October, where less than 30 mm of rain was obtained in the last two decades.

Except the month of October, every month was wet during the growing seasons of 2017-2018 to 2018-2019 in southern zone. The average amount of rainfall recorded during the two years 918 mm.

Agronomical characteristics

Planting decades

Data in Table 2 show the number and percentage of planting decades in each zone (Southern and Central northern) during the two growing seasons Dates of planting extended from the first decade of June to the second decade of July in all sites. In the southern zone, the majority of plantings occurred in the third decade of June (41%) while that of Central Northern zone occurred in July (50%).

Planting occurred mostly on average in the two zones during the third decade of June (46%) and the first decade of July (22%). Few experiments were planted in the first decade of June (9%) and the second decade of July (6%) (Table 2).

Seed cotton yield and yield attributes

Results of the analysis of variance revealed highly statistically significant difference between planting dates (decade) for seed cotton yield and lint yield (lint %); for seed cotton yield, lint yield and seed index indicated there were no significant differences among varieties. The variety by planting date interaction was not significant at P = 0.05 for all three parameters (Appendix 1).

Mean performance for different agronomic traits: seed cotton yield, lint yield and seed index in all cotton production zones during



Figure 3c: Results Agronomics traits per planting date (decade) and per variety. Seed Index (g).

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Figure 4a: Fiber properties per planting date (decade) and per variety. Upper Half Mean Length (UHML) (mm).



Figure 4b: Fiber properties per planting date (decade) and per variety. Micronaire value.



Reflectance degree (%).

2017/2018 and 2018/2019 growing seasons are presented in Figures 3a, 3b and 3c respectively. The best seed cotton yields were obtained for planting occurring during the 1st, 2nd, and 3rd decade June for all varieties (Figure 3a), with a decadal average seed cotton yield respectively of 1523 kg/ha, 1500 kg/ha and 1420 kg/ha (Appendix 1). Yields were low for Malian varieties planted in the first and second decades of July, except for Brasilian in the second decade of July.

Fiber lint (Figure 3b) percentage firstly increased, and then decreased with the delaying planting dates. The best fiber yields were obtained for June third planting for all genotypes. While the percentages of the lint fell for all varieties during first and second July planting decades. The maximal decadal mean was 43.55% (1st decade June) and minimal was 41.56% (2nd July) planting decade (Appendix 1).

For the Seed index (Figure 3c), there was no planting date effect on genotypes. Seed cotton yield and Lint Percentage decreased with delayed planting, however this phenomenon was not observed with seed index trait.

Findings revealed that early planting significant and positive advantages on seed cotton yield and lint yield. However, seed index was not significantly affected by planting dates. Researchers reported that late planting usually resulted in reducing seed cotton yield with low lint percentage and boll weight relative to normal planting [16,17]. Lint percentage and seed index were not significantly affected by planting date, however, early planting increased seed cotton yield by 13 to 14% as compared with the late sowing date [18]. The cotton yield and yield attributes can be influenced during the growing period by environmental conditions such as moisture, drought, temperature, sunlight, plant nutrients, mainly continuous rain or severe drought during flowering times.

Technological characteristics (Fiber properties)

The planting dates were significant effects on Upper Half Mean Length (UHML), micronaire and fiber reflectance degree, while the fiber yellowness trait was not significantly affected by sowing date. The genotypes sowed significant effects on UHML. However, there was no significant difference in the interaction effect of genotypes \times planting dates for the four major traits of fiber quality studded (Appendix 2).

Data pertaining to fiber length (mm) of the four genotypes planting at five different planting (June and July) in the two seasons at Southern and central northern cotton production zones in Mali are given in Figure 4a. The first and third sowing decades of June and the latest sowing date (2nd decade July) produced the highest fiber length with decadal averages respectively: 28.66, 28.50 and 28.91 mm in the two growing seasons at all zones. In contrast, the lowest decadal averages 28.18 and 28.36 mm were obtained by the 2nd decade of June and 1st decade of July (Appendix 2). This may be due to climate conditions or genotypic differences Regarding the effect of the genotypes on fiber length, the variety NTA B149 surpassed the



Figure 4d: Fiber properties per planting date (decade) and per variety (con't) (d) Yellowness.

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rest of genotypes by the first sowing decade of June and the second sowing decade (latest sowing decade) of July with a fiber length averages respectively 28.99 and 29.28 mm. According the fiber length of genotypes, all four varieties used in this study, can be placed into upland staple classes of long fiber (29.0 mm - 34.0 mm) (Bradow and Davidonis, 2000).

Micronaire Value (Fiber Fineness) obtained in different sowing times for different varieties in Southern and central northern cotton production zones can be seen in Figure 4b. The result indicated that, planting dates on second decade of June and first decade of July gave the low micronaire value with respectively a decadal average 4.1 and 4.0 (Appendix 2). However micronaire values were significantly greater for early and late plantings. The study noted that there was not a significant difference between genotypes and the interaction between planting dates and genotypes had no significant effect on micronaire value. All cotton varieties used in this study were suitable for use in the textile industry because the finest of all varieties are in the class of the ideal (Medium) range of fineness value: 3.8 and 4.2 (Appendix 2).

Results from our study showed that the decadal average fiber length and micronaire values were significantly greater for early and late plantings than the averages of middle planting decade. Seed cotton yields from this study were very low for delaying planting opposed to early plantings ones. Longer fiber lengths were linked to delayed planting. These results did not agree with those obtained by who noted that the seed cotton yield reduction and fiber length deterioration were significantly associated with delayed planting [19].

The Figure 4c shows the effect of planting dates and genotypes on fiber reflectance values. The average fiber reflectance varied between 78.26% (first decade June) and 80.11% (second decade July) by sowing decade in two growing season (Appendix 2). On the other hand, it was seen that the sowing time affected fiber reflectance, and the fiber reflectance increased with the delay in sowing time. The low value of the fiber reflectance for early sowing date may be due continuous rain and heavy relative humidity (excessive moisture) during August month, period that coincides with boll opening. To these hypotheses on must add prolonged periods of time exposure to sunlight and length of periods of the harvest; these may thus reduce fiber whiteness. Average all fiber reflectance degree for each genotype used in study were greater than 75%, we can conclude that all genotypes are suitable for use in the textile industry.

The results in Figure 4d indicated that the planting dates did not exhibit any significant effect on fiber yellowness. But the height mean value of yellowness by planting decade was obtained in second decade of July (9.84). This may be due to the increase in pests at the end of season period that coincides with boll opening for delaying sowing dates. The lowest fiber yellowness value was obtained for genotype BRS 293 (9.37), whereas the highest fiber yellowness value was obtained for genotypes NTA E154, NTA B149 and NTA L65 (9.6). However, although the delay in planting time did not affect the fiber yellowness significantly, it caused a slight increase and difference between cotton varieties in terms of fiber yellowness values obtained in the study: 9.6 (Appendix 2), all varieties can be ranked in slightly yellow" group of fiber [20]. From the results of our study that the fiber reflectance values obtained in delayed planting for different genotypes were higher than those from early planting. However the lint yellowness values were significantly greater for late than for early plantings. These results agree with those obtained by in similar study on three Egyptian cotton cultivars [21]. Planting time is a factor that affects environmental conditions, and it is reported in numerous studies that planting time practices affect fiber reflectance and fiber yellowness particularly in case of late planting [22]. Other studies indicated that the color of cotton fibers can be affected by rainfall, freezes, insects, fungi, and staining through contact with soil, grass, or cotton-plant leaf and can also be affected by excessive moisture and temperature levels during storage, both before and after ginning [6].

Correlation analysis for yield and fiber quality

The correlation matrix is given in Table 3 showed that Average annual rainfall and Number day of rainfall were not strongly correlated with agronomic and fiber traits. Yield and fiber quality are most important and complex trait as they depend on interaction of genetic architecture of plant and environment [23]. Cotton lint yield showed positive association with fiber Micronaire (fineness), fiber length (UHML) and negative association with yellowness and Seed index. It was observed that fiber fineness had positive association with fiber length and negative association with reflectance degree. The negative correlation between fiber length and the fineness (micronaire) was observed [24].

Conclusion

Cotton producers in Mali must focus on early planting as for higher seed cotton yield and yield components and for optimum fiber quality.

All four cotton varieties: BRS 293, NTA L65, NTA B149 and NTA E154 used in the experiment produced suitable seed cotton yield and yield attributes and adequate lint propriety for early sowing. For delaying planting, only variety BRS 293 exhibited greater to optimum value for all traits analyzed except for fiber length. The variety BRS 293 is suitable for late planting in Malian cotton producing area in addition to its yield advantage.

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