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RESEARCH ARTICLE

EVALUATION OF GENETIC DIVERSITY OF EIGHT COTTON VARIETIES (*GOSSYPIUM HIRSUTUM* L.) TURKS INTRODUCED IN BENIN

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ABSTRACT

The present study was carried out to select the varieties with high yield potential and better technological characteristics adapted to the international market to improve the competitiveness and sustainability of cotton production in Benin.12 cotton varieties of which eight (8) varieties introduced in Benin by Nazilli Cotton Research Institute (ICRC) of Turkey Republic in 2013 and four (4) beninese varieties was evaluated. The field experiment was carried out under three main CRA-CF Permanent Experimental Centers (CPEs), representing the predominant area of cotton growing with 90% of national production during the cropping season 2014-2015. The results revealed very highly significant differences between varieties for yields in kg per hectare of seed cotton (Rdt), ginning yield (ER) and weight of 100 seeds or Seed index (SI) ($P < 0.001$) with the exception of early seed cotton production (R1/RT).The analysis on the technological characters revealed six significantly different groups ($p < 0.000$) with an average percentage of mature fibers of 84.5%. Three Beninese varieties E 956-2 (+ 2.3%), H 782-3 (+ 1.5%) and K 768-3 (+ 1.1%) showed a good percentage of mature fibers. On the other hand, the varieties of Turkey NAZILLI 143 (-1%), AYHAN 107 (-1%) and NAZILLI M-503 (-1, 3%) have very low fiber maturities. The technological characteristics of the fiber are determined on the one hand by the variety and on the other hand influenced by the environment, the cultural conditions and the quality of the ginning. A highly positive significant relationship was found between fiber tenacity (Str) with Upper High Mean Length (UHML), fiber uniformity (UI), Micronaire index (IM), fiber brilliance (Rd) and fiber yield (Rdt). During future breeding program the varieties of Turkey may be kept in mind during making selection to improve cotton yield in Benin.

INTRODUCTION

The cotton sector is the basis of the rural and agro-industrial economy in Benin; 35% of the cultivated area is devoted to cotton growing, which is concentrated between 250 and 450 mmin Benin. The agronomical and technological characteristics of Beninese cotton in the face of the effects of pests, climatic constraints and applied cultural techniques remain poor. With a growing world market and competition from synthetic textiles, there is a need to continuously improve the quality of cotton. This is mainly achieved through the improvement of certain agronomic characteristics, such as seed cotton yield, early maturity, ginning yield, weight of 100 seeds, and technological factors such as fiber length, uniformity, Tenacity, elongation, gloss and yellow index. Fiber alone accounts for more than 95% of the value of the cotton crop (Braden, 2005). The purchase price of fiber depends on its quality (Nacoulima, *et al.,* 2014). It is in this sense that the collaboration between the National Institute of Agricultural Research of Benin (INRAB) and the program of Turkey International Technical Cooperation Agency (TIKA) introduced eight varieties of Turkey cotton in Benin. It aims to select varieties with high yield potential and better technological characteristics adapted to the international market to improve the competitiveness and sustainability of cotton production in Benin.

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MATERIALS AND METHODS

Plant material: Genetic materials consisted of 12 cotton varieties of whicheight (8) varieties introduced in Benin by Nazilli Cotton Research Institute (ICRC) of Turkey Republic

in 2013 (AYHAN 107, GSN-12, GÛRELBEY, NAZILLI 84-S, NAZILLI 143, NAZILLI 663, NAZILLI M-503 and OZBEK 105) and four (4) Beninese varieties (H 279-1, E 956-2, H 782-3 and K 768-3) from the research program of the Center for Agricultural Research Cotton and Fibers (CRA-CF).

Experimental sites

The field experiment was carried out under three main CRA-CF Permanent Experimental Centers (CPEs), representing the predominant area of cotton growing with 90% of national production during the cropping season 2014-2015.It is the CPE ofAngaradébou (4°93 East, 12°30), located in the extreme north of Benin in the commune of Kandi, a region characterized by heavy precipitation (between 700 and 900 mm annually) distributed in a unimodal model with a tropical ferruginous soil on a crystalline base, a Sudano-Sahelian climate; Okpara CPE (2°41 East, 9°18 North, altitude 320 m above sea level) in northern Benin, an area characterized by tropical ferruginous soil with a Sudanian-type climate or Tropical humid with a unimodal regime varying between 1100-1200 mm per year; CPE of Savalou (7°60 East, 2°50 North), located in the center of Benin with a rainfall of 1000 to 1200 mm per year and with a tropical ferruginous soil.

experiments were implemented using a 4-repeat full Random Block (BAC) experimental setup. Each elementary plot comprises 4 lines of 11 m, with planting spacing of 0.80 m between the lines and 0.20 m between the piles, ie a density of 62,500 plants/ha. The planting was carried out at one plant per pole. The fractional plots were injected with cotton fertilizer (N14P23K14S5B1) at a rate of 250 kg/ha on the 15th day after sowing (jas) and supplemented with urea (46%) at the dose of 50 kg / ha on the 40th day after sowing (jas). Weeding was carried out on request. Insecticide protection, reinforced by systematic weekly treatments, was put in place at the 50th jas and until the harvest.

Measurements of agronomic and technological characters

Twelve (12) quantitative characteristics of the International Union for the Protection of New Varieties of Plants (Harem *et al.,* 2012) have been used to characterize varieties. These characters are of two kinds. First, the seed cotton yield (Rdt), the seed cotton (R1/RT), the ginning yield (ER), the weight of 100 seeds or the Seed index (SI); And second of the fiber characteristics: the length of the longest fibers or Upper High Mean Length (UHML), uniformity (UI), toughness (S), elongation (Elg) Micronaire index (IM), brightness (Rd) and yellow index (+ b).

Table 1. Formulas and parameters

Parameters	Formula	Meaning of terms
Genotypic Variance (GV)	GV = (MSG – MSE)/r	MSG : Mean square of genotypes
PhenotypicVariance (PV)	PV= VG + (MSE/r) = MSG/r	MSE : Mean square of the error
Heritability in broad sense(H^2)	H^2(%) = (VG/VP)*100	R: number of repetitions
Coefficient of Genotypic variation (CGV)	CGV (%) = (XVG/X)*100	XVG : Standard deviation of genotypic variance
Coefficient of PhenotypicVariance (CPV)	CPV (%) = (XVP/X)*100	XVP : Standard deviation of phenotypic variance
Genetic Advance (GA)	GA = H^2*XVP*I	I : constant with a selection coefficient of 5%, I is 2.06
Genetic Advance as Percent of Mean (GAM)	GAM = (GA/X)*100	X: Mean

Table 2. Agronomic performance of the 12 varieties

Varieties	Origindescendants	Rdt		R1/RT	RE		SI	
		kg/ha		*%*	*%*		*g*	
H 279-1	Control (Benin)	3510	a	87	47	abc	8,0	cde
E 956-2	Benin	2242	b	85	46	bcd	8,1	abcde
H 782-3	Benin	3441	a	84	48	ab	8,8	abcd
K 768-3	Benin	3577	a	88	48	a	8,3	bcde
AYHAN 107	Turkey	2280	b	87	47	ab	7,4	e
GSN-12	Turkey	2163	b	87	45	cde	8,8	abcd
GÛRELBEY	Turkey	2127	bc	87	44	de	9,3	a
NAZILLI 84-S	Turkey	1214	d	89	46	abcd	7,7	de
NAZILLI 143	Turkey	2225	b	87	46	abc	7,8	cde
NAZILLI 663	Turkey	2436	b	85	48	ab	9,2	ab
NAZILLI M-503	Turkey	1437	cd	86	45	cde	8,4	abcde
OZBEK 105	Turkey	2541	b	90	43	e	8,9	abc
Numberof rep.		4		4	4		4	
Mean		2433		87	46		8,4	
Standard deviation		215,1		4,7	0,7		0,6	
CV (%)		21,7		13,1	3,7		6,1	
Pr.		***		ns	***		***	
F Varieties		9,4		0,4	11,0		8,6	
Nberof sites		3		3	3		3	
Interaction Trait x environ		***		ns	***		ns	
F interaction		4,9		1,6	5,6		1,9	

*uniformity (UI); elongation (Elg); fiber tenacity (Str); Upper High Mean Length (UHML); fiber uniformity (UI); Micronaire index (IM); fiber brilliance (Rd); fiber yield (Rdt); yellow index (+ b); precocity of cotton seed yield (R1/RT); ns, *, **, *** shows respectively non-significant, significant and highly significant differences.*

MATERIALS AND METHODS

Experimental design: On the three Permanent Experimental Centers (CPE) and for the first year of experimentation, the

Statistical analysis

The mean of the measured traits were compared by an analysis of the variance (ANOVA). For all the characteristics, the genetic parameters were estimated from the components of the

Table 3. Genotypic Variance, phenotypic variance, Heritability in broad sense, Coefficient of Genotypic variation, Coefficient of Phenotypic Variance, Genetic Advance and Genetic Advance as Percent of Mean expressed in real values for some yield parameters

	Rdt (kg/ha)	R1/RT (%)	RE(%¨)	SI(g)
Mean	2 433	87	46	8
VG	507 170	-5,2	2,4	0,1
VP	144 398	9,7	0,9	0,1
CVP(%)	29,3	0,0	3,3	6,8
CVG(%)	15,6	3,6	2,0	3,0
H^2	89	-168	87	88
GA	1,9	0,0	1,8	1,1
GAM(%)	0,1	0,0	3,9	13,3

Genotypic Variance (GV); Phenotypic Variance (PV) ; Heritability in broad sense (H^2); Coefficient of Genotypic variation (CGV); Coefficient of Phenotypic Variance (CPV); Genetic Advance (GA) ; Genetic Advance as Percent of Mean (GAM)

Table 4. Technological performance of the 12 varieties

Varieties	Origin of descendants	UHML		UI		Str		Elg		IM		PM		Rd	+ b	
		mm		%		g/tex		%				%		%		
H 279-1	control (Benin)	29	cd	84	bc	30	b	7,5	b	4,0	abcd	84,6	cde	78	9	bc
E 956-2	Benin	31	a	86	a	34	a	6,0	e	4,4	a	86,8	a	78	10	ab
H 782-3	Benin	30	bc	85	ab	31	b	6,6	de	4,3	a	86,0	ab	77	10	ab
K 768-3	Benin	30	ab	83	bcd	31	b	7,0	bcd	4,2	ab	85,6	abc	78	10	ab
AYHAN 107	Turkey	28	def	82	cde	27	c	6,9	bcd	3,4	e	83,4	ef	79	9	c
GSN-12	Turkey	28	def	82	de	27	cd	6,9	bcd	3,8	bcde	84,3	cdef	76	10	ab
GÛRELBEY	Turkey	29	bc	83	cde	27	c	6,2	e	3,4	e	84,0	def	77	10	abc
NAZILLI 84-S	Turkey	27	fg	81	e	25	cd	7,4	bc	3,6	cde	83,6	def	77	10	ab
NAZILLI 143	Turkey	28	de	82	cde	25	d	7,1	bcd	3,5	de	83,4	ef	77	10	a
NAZILLI 663	Turkey	28	def	82	de	26	cd	7,3	bc	4,1	abc	84,8	bcd	76	10	ab
NAZILLI M-503	Turkey	27	efg	81	e	25	d	8,4	a	3,8	bcde	83,2	f	76	10	ab
OZBEK 105	Turkey	26	g	82	de	25	cd	6,8	cd	3,6	cde	84,0	def	76	10	abc
Numberof rep.		3		3		3		3		3		3		3	3	
Mean		28,5		82,7		27,7		7,0		3,8		84,5		77,0	9,8	
Standard deviation		0,2		0,4		0,5		0,3		0,2		0,3		0,2	0,2	
CV (%)		2,4		1,3		5,4		5,3		8,5		1,0		3,1	7,1	
Pr		***		***		***		***		***		***		ns	**	
F Varieties		39,6		14,0		35,3		24,7		10,8		17,1		1,4	3,7	

*(UI); elongation (Elg); fiber tenacity (Str); Upper High Mean Length (UHML); fiber uniformity (UI); Micronaire index (IM); fiber brilliance (Rd); fiber yield (Rdt); yellow index (+ b); precocity of cotton seed yield (R1/RT); ns, *, **, *** shows respectively non-significant, significant and highly significant differences*

Table 5. Pearson's correlation coefficients among agronomic and technological characters calculated from 12cotton varieties

	Rdt	R1/RT	RE	SI	UHML	UI	Str	Elg	IM	PM	Rd
R1/RT	-0,19ns										
RE	0,51ns	-0,52ns									
SI	0,14ns	-0,19ns	-0,27ns								
UHML	0,51ns	-0,53ns	0,43ns	0,01ns							
UI	0,55ns	-0,50ns	0,37ns	-0,11ns	0,87***						
Str	0,61*	-0,44ns	0,45ns	-0,06ns	0,89***	0,94***					
Elg	-0,26ns	0,11ns	0,10ns	-0,22ns	-0,57ns	-0,62*	-0,55ns				
IM	0,51ns	-0,58ns	0,55ns	0,14ns	0,63*	0,69*	0,76**	-0,14ns			
PM	0,57ns	-0,51ns	0,43ns	0,21ns	0,81**	0,86***	0,90***	-0,56ns	0,89***		
Rd	0,43ns	-0,16ns	0,52ns	-0,64*	0,61*	0,64*	0,68*	-0,26ns	0,27ns	0,37ns	
+ b	-0,31ns	-0,13ns	-0,16ns	0,35ns	0,002ns	-0,08ns	-0,18ns	0,04ns	0,24ns	0,16ns	-0,62ns

*uniformity (UI); elongation (Elg); fiber tenacity (Str); Upper High Mean Length (UHML); fiber uniformity (UI); Micronaire index (IM); fiber brilliance (Rd); fiber yield (Rdt); yellow index (+ b); precocity of cotton seed yield (R1/RT); ns, *, **, *** shows respectively non-significant, significant and highly significant differences.*

analysis of variance. Genotypic and phenotypic variances (GV and VP), genotypic and phenotypic (GCV and PCV) coefficients of variation, broad heritability (H^2), and expected Genetic Advance(GA) were calculated according to the formulas used by Johnson *et al.* (1955), presented in Table 1. Statistix 8.1 and Statistica version 10 were used to analyze the collected data.

RESULTS AND DISCUSSION

Agronomic characteristics

The analyzes of variances (Table 2) revealed very highly significant differences between varieties for yields in kg per hectare of seed cotton (Rdt), ginning yield (ER) and weight of 100 seeds or Seed index (SI) ($P < 0.001$) with the exception of early seed cotton production (R1/RT). These highly significant differences indicate the presence of significant genetic variability for these variables. Seed cotton yield data (Table 2) showed very significant differences ($p \leq 0.01$) among cotton varieties. The seed cotton yield of the twelve varieties varied between 1214 and 3577 kg/ha (Table 2). The lowest yield of seed cotton was observed in the NAZILLI 84-S and NAZILLI M-503 varieties, which were the least productive (-1093 and -893 kg/ha). The maximum and statistically equal yield of seed cotton was revealed by two beninese varieties, H 279-1 and K 768-3, which had the best performance (+966 and +1026 kg/ha). In terms of ginning yields, almost all varieties of Turkey have slightly lower values (-1.2 points) and produce fewer medium-sized fibers and seeds than those in Benin. The

varieties NAZILLI 663 and GRELBEY have large seeds (+ 0.8g). The same genetic variability for seed cotton yield was reported by Arshad *et al.,* (1993), Cook and El-Zik (1993) and Kahn (2003). Many quantitative traits show interactions between genetic (G) and environmental (E) effects. The GXE interaction is significant for field yield and ginning yield with the exception of seed cotton (R1/RT) and 100 seed index (SI). The presence of GxE interactions means that the environment has variably influenced the expression of characters by activating or deactivating genes controlling these characters and modifying their level of expression. So all varieties were productivity and yield to ginning variable from one permanent center to another. According to Table 2, the mean values of the traits indicate that the varieties have an average seed cotton yield of 2433 kg/ha with an average harvest time of (87%), a ginning yield of (46%) and an average weight of 100 seeds of 8.4 g.

The genetic and environmental variations were 29.3 and 15.6 and the genetic variance was 4 times greater than the environmental variance (Table 3); therefore, the H^2 estimate for seed cotton yield and the expected selection response were respectively 89% and 1.9% for the seed cotton yield. These results revealed that seed cotton yield was mainly controlled by genetic variance due to its higher values and high heritability, and that there is a potential for improvement. Genetic variability for seed cotton yield was also reported by Terziev *et al*., (1996), Abouzaid *et al.,* (1997) and Khan (2010). Copur (2006) and Khan *et al.,* 2009. Similarly, statistically significant differences in seed cotton yield were also reported by Soomro *et al.* (2005) and Khan (2003) and Khan *et al.* (2007a, 2007b) for cotton varieties. The phenotypic coefficients of variation are lower than the genotypic coefficients of variation for almost all the traits analyzed, but the high extent of the difference between the two shows that these traits are highly influenced by the environment as reported by Djaboutou *et al.* (2017). These phenotypic coefficients of variation are low for seed cotton yield (Rdt), ginning yield (ER) and 100 seeds or seed index (SI); And high for early seed cotton production (R1/RT). However, compared to the deterministic study, heritability is very high for seed cotton yield, ginning yield and 100 seed weight (Table 3). Because of the high values of genetic variance and high heritability, this study shows that these three traits are highly transmissible and other improvements are needed to obtain good productivity in some genotypes because the majority of the quantitative charactersare not independent of one another. Similar conclusions were made by Aktar*et al.* (2008) to the surface of the fiber.

Technological characters

Results on fiber quality revealed statistically significant differences ($p < 0.0000$) between varieties for fiber length (UHML), uniform fiber length (IU), Elongation (Elg), micronaire index (IM), maturity or percentage of mature fibers (PM) and yellow index (+ b). Only the brightness (Rd) does not differ according to the varieties. For the length of silk, the analysis reveals 5 distinct groups. The best fiber lengths are for E 956-2 (+ 2.7 mm) and K 768-3 (+ 1.9 mm) compared to the average (28.5 mm). The other varieties possess fibers, statistically, shorter. This group is followed by H 782-3 (+1.3 mm) and GURELBEY (+0.9 mm). The shortest fibers come from NAZILLI 84-S (-1.5 mm) and OZBEK 105 (- 2.1 mm). The average of the fiber uniformity variable was 82.7%, and three of the four varieties exhibiting the best fiber lengths also showed the best fiber uniformities (+ 3%) for E 956-2; (+ 1.9%) for H 782-3 and (+ 0.6%) for K 768-3. The variables "short fiber index" and "tenacity" clearly distinguish varieties of Turkey from those of Benin. The average of short fibers is 8 and that of toughness is 27.7 g/tex. Almost all beninese varieties have fewer short fibers than those of Turkey. The beninese varieties E 956-2 (+5.9 g/tex), H 782-3 (+3.2 g/tex), K 768-3 (+2.9 g /tex) and H 279-1 +2.5 g/tex) are statistically the most stubborn while Turk varieties NAZILLI M-503 (-3.2 g/tex), NAZILLI 143 (-3 g/tex), OZBEK 105 g/tex), NAZILLI 84-S (-2.3 g/tex) are statistically the weakest for this characteristic ($p < 0.000$).

Concerning elongation, the analysis shows that it is on average 7% and presents 4 distinct groups ($p < 0.000$). NAZILLI M-503, with 8.4%, recorded the best elongation (a) followed by H 279-1 with 7.5% (b); (-0.4%), GURELBEY (-0.8%) and E 956-2 (-1%) constitute the group with the lowest fiber elongation (Elg). The mean micronaire index of the varieties studied is 3.8. The low micronaire indicates the presence of both fine and ripe fibers. Large micronaries were obtained from Benin's H 956-2 (+0.6), H 782-3 (+0.5) and K768-3 (+0.3) varieties. These 3 varieties are statistically similar but superior to other varieties for this characteristic ($p < 0.000$). The NAZILLI 143 (-0.4), AYHAN 107 (-0.4) and GURELBEY (-0.5) varieties have the lowest micronaire indices. The fibers of the finest varieties produce the sons and cloths more flexible and more pleasant to the touch (Lawrence, 2003).More the fibers are fine, more their number is important in the section of the thread and, therefore, more the thread is resistant. According to Aktar*et al.* (2008), the effect of the environment on the heritability of fineness and the effect of selection on this trait would be insignificant. In addition, Frelichowski *et al*. (2006) and An (2010) showed that the micronaire index is positively correlated with yield and toughness and negatively correlated with fiber length. Campbell *et al.* (2005) reported that the influence of environmental factors on the measurement of fineness in terms micronaire is more important than the one of genetic factors. As regards the fiber maturity, it was the least dispersive (CV = 0.4%). The analysis revealed six significantly different groups ($p < 0.000$) with an average percentage of mature fibers of 84.5%. Three beninese varieties E 956-2 (+ 2.3%), H 782-3 (+ 1.5%) and K 768-3 (+ 1.1%) showed a good percentage of mature fibers. On the other hand, the varieties of Turkey NAZILLI 143 (-1%), AYHAN 107 (-1%) and NAZILLI M-503 (-1,3%) have very low fiber maturities. The varieties have a good level of colorimetry. The varieties AYHAN 107, H 279-1 and K 768-3 combine brightness and yellowness. These varieties have a good brightness (78.6, 78.1 and 77.9% respectively) and a less colored fiber (8.7, 9.0 and 9.8 respectively). Three Turks varieties combine low gloss and high yellowness (NAZILLI 84-S, NAZILLI M 503 and NAZILLI 143). The technological characteristics of the fiber are determined on the one hand by the variety and on the other hand influenced by the environment, the cultural conditions and the quality of the ginning.

Relationships among agronomic and technological characters: The table 5 shows the correlation coefficients among agronomic and technological characters calculated from 12 cotton varieties based on the twelve quantitative

characters studied. The most prominent associations are those enters Str, Rdt, UHML and UI; Elg and UI; IM, UHML, UI and Str; UHML, UI, Str and IM; Rd, SI, UHML, UI, Strand IM. The association between fiber uniformity (UI)and the elongation (Elg)was revealed to be positive and highly significant. A highly positive significant relationship was found between fiber tenacity (Str) with Upper High Mean Length (UHML), fiber uniformity (UI), Micronaire index (IM), fiber brilliance (Rd) and fiber yield (Rdt). High negative and significant relationship was also found between fiber brilliance and Seed index (SI). According to Aghace *et al.* (2010), the characters with high positive relationship are moving in similar fashions, while those with negative associations move in opposite direction. Therefore, those results indicated that the fiber tenacity, brilliance and uniformity depend on fiber length and on the fiber yield. Such results had been reported by Gomma (1995).However, more seed index increases; more the fiber loses her brilliance.

Conclusion

The study revealed that the maximum and statistically equal yield of seed cotton was obtained by two Beninese varieties, H 279-1 and K 768-3, which had the best performance. In terms of ginning yields, all varieties of Turkey have slightly lower values and produce fewer medium-sized fibers and seeds than those in Benin. In addition, all Beninese varieties have fewer short fibers than those of Turkey. Three Beninese varieties E 956-2, 782-3 and K 768-3 showed a good percentage of mature fibers. However, these results supported that based on both agronomic and technological traits, turk and Beninese varieties show many similarities, but they provide a better insight into the twelve cotton genotyps compared.

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