1152 Assesing the Stability of early generation mutants of cotton derived from irradiation of cotton seed

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Abstract

Cotton breeders use various approaches to develop improved cultivars. Mutation breeding through irradiation of seed is one method used either in isolation or in combination with other breeding tools to improve the genetic potential of cotton for agronomic and fibre quality characteristics. Multi environment trials assist breeders in selecting stable cultivars. Objectives of this study were to assess the possibility of obtaining stable mutants within the first three generations following irradiation and to compare the performance of mutants to conventionally bred commercial cultivars. Six mutants selected for their favourable agronomic traits were evaluated in a Randomized Complete Block trial Design during three seasons at Cotton Development Trust Research Station. Two commercial cultivars were used as controls in the study. Analysis of variance was performed using Genstat. Stability was assessed by comparing the linear regression coefficients of the mean performance of genotypes over the seasonal (environmental) mean. Some mutant lines performed better than controls in a number of traits. The stability of mutants was comparable to controls in most characteristics studied. Results of this study demonstrate that mutation through irradiation has potential in effecting genetic improvements in cotton. Early selection of lines for advances testing is possible in cotton mutation breeding as shown by stability of some mutants in the study.

Introduction

Cotton in Zambia is grown over an area of more than 150,000 ha. However, the average yield per unit area (600 kg ha^{-1}) is much lower than that obtained in some of the leading cotton producing

areas in the world. Improvement in seed cotton yield is a top priority of the cotton-breeding programme in Zambia. Evolution of cotton varieties with improved yield potential can be realized if the there is sufficient genetic variability for the trait. Genetic variability through cross breeding depends on the genetic diversity of the parents involved. Mutagenesis of cotton cultivars or in combination with hybridization has been shown to be a suitable technique for creating genetic variability in cotton (Al-Didi, 1965 and Kuliev, 1983). Direct development of varieties has been considered as one of the most useful roles of induced mutation in plant breeding (Allard, 1960). Induced mutation has resulted in some cotton varieties of earlier maturity. Rault et al 1971 reported cotton cultivars developed through mutation breeding requiring 60-75 less days to reach maturity.

A number of cultivars obtained from irradiation of cottonseed have been shown to perform well in a diverse range of environments (Muhammad et al, 2002). Growing genotypes in a wide range of environments enables breeders to detect lines that show specific or general adaptation. Environments can be defined as locations or seasons (years) or a combination of locations and seasons. Bucio (1966) used sixteen seasons on one location to compare the stability of *nicotiana rustica* progenies with their parents. Most studies on stability of cotton genotypes have focused on strains obtained through conventional hybridization techniques.

However, detection of stable mutants in early generations could lead to more rapid development of improved cultivars by facilitating early generation selection of promising lines. The objectives of the present study were;

i. To assess the possibility of obtaining a stable mutant of cotton in the early generations following irradiation i.e. the M_2 or M_3 generation.
ii. To compare the performance of mutants with conventional commercial cultivars

Materials and Methods

Nomenclature of Genotypes

In the Zambian cotton mutation-breeding programme, the genotypes are allotted a prefix 'M' to denote the process of derivation of the line-as mutation. The prefix is then followed by the original initials for the genotype and a numeric indication of the dosage of gamma radiation used to derive the genotype e.g. MF-20 means this mutant was derived from cultivar F135 irradiated at 20 Kr.

Field and Laboratory Methodology

In early 2002, six cotton genotypes (FKF, CF, CKF, Chureza, F 135 and G319-16) were subjected to gamma irradiation. Dry Seeds, 300g per treatment of each genotype were irradiated at different doses i.e. 15Kr, 20Kr, 30Kr and 40kr. After irradiation, the seed were planted in non-randomized blocks during the 2002/03 season as M_1. Selection was done on the genotype by treatment populations based on earliness, hairiness and productivity. Selected lines were grown in a randomized complete block trial design during the seasons of 2003/04(M_2), 2004/05(M_3) and 2005/06(M_4). Four replications were used with inter row spacing of 90 cm and intra row spacing of 30 cm. Each plot consisted of three rows 9 m long and the centre row was harvested as net plot. Data collected included, boll weight, plant height, days to flowering, days to boll opening, lint percent and yield. Boll weight was determined by measuring the seed cotton weight of twenty hand-harvested bolls and dividing the weight by 20 to estimate the weight of one boll. Plant height was obtained by measuring the distance from the base of the stem to the tip of five arbitrarily chosen plants in each plot. Days to flowering and boll opening were estimated by counting days to the time when 50% of the plants in the net plots had flowered or open bolls respectively. Data were pooled to assess the stability of mutants in comparison to commercial cultivars as checks. Fibre quality data was not included in the analysis because it was available in only one season. In the analysis, years were considered as environments. Genstat statistical software was used for analysis of variance. Microsoft excel was used to generate the slopes for stability determination. The principle developed by Eberhard and Russel (1966) was used to assess the stability of genotypes. Stability was determined by the degree of deviation of the slope from 1.00 in a given character. Results

Analysis of Variance

Differences were detected among entries in average boll weight, lint percent and plant height. Table 1 shows the analysis of variance for the studied traits over the three seasons.

There was significant variation due to Genotype and Year main effects for average boll weight trait in the study. Genotype, Year and Genotype by Year accounted for 24.6%, 67.0% and 8.5% of the total variation in sums of squares respectively. Blanche et al (2006)

found that boll weight was influenced more by Genotype than Environment or Genotype by Environment interaction effects. Averaged across years, MCZA-20Kr had significantly ($p=0.05$) less average boll weight than all the genotypes used in the study including its parent Chureza (Table 2). This result indicates a potential negative effect of irradiation on some cotton genotypes.

Only the Genotype component of variation was significant for lint percent. Genotype, Year and Genotype by Year accounted for 63.8%, 3.8% and 32.4% of the total variation in sum of squares (Table1). Kerby et al (2000) found that variation in sums of squares for lint percent was influenced more by Genotype and Genotype by Environment than by Environment. The overall mean for lint percent of MG-15Kr was significantly higher ($p=0.05$) than one of the check cultivars, Chureza (Table 3).

All sources of variation were significant for the plant height character. Genotype, Year and Genotype by Year accounted for 4.2%, 87.3% and 8.5% of the total variation in sums of squares for plant height (Table 1). Stability Analysis

The linear regression coefficient of the mean performance of the genotypes over the environmental (seasonal) mean was used as a measure of response of genotype to varying environments. Based on our stability criteria of degree of deviation of slope of regression line from 1.00, MCKF-40Kr and MG-15Kr were more stable than both commercial checks for boll weight trait. MG-25Kr was the most stable genotype for this trait with a slope of 1.00 (Table2).

All mutants had slopes significantly different from the 1.00 standard for slope of regression line. They were therefore more unstable than commercial cultivar checks for this character (Table 3).

Plant height was the only character with significant genotype by year interaction in the study. The stability of mutants in this trait was comparable to that of commercial checks (Table 4). Similar stability trends were observed for yield with slopes of mutants comparable to commercial cultivar checks (Table 7).

Discussion

Stability data in tables 2 through 7 suggest that early-generation mutants of cotton can be as stable as the established conventional cultivars in most characteristics. Lines MFKF-20Kr and MG-15Kr were the most stable mutants with instability in only one character, lint percent. The lines were even more stable than one of the check varieties, F 135. Overall, Chureza was the most stable entry in the study with stability in all the characteristics studied. Some mutants performed better than the commercial check Chureza in lint percent (MG-15Kr and MCKF-40Kr). Mohammed et al (2002) found similar results in their study of cotton mutants obtained through irradiation. The significantly shorter plants ($p=0.05$) obtained among some m0pmutant lines could indicate the potential of this breeding method in breeding for shorter but high yielding genotypes. There is need for further research on the effectiveness of this breeding tool or in combination with other methods such as interspecific hybridization in improving the fibre properties of cotton and the quality of products obtained from cottonseed such as seed proteins and gossypol.

Conclusion

Results of the analysis of variance demonstrate that mutation breeding through irradiation has potential in effecting genetic improvements of cotton in essential agronomic traits without excessive deleterious effects. One potential advantage of this method is that the genetic gains can be made in a shorter period than using conventional methods of hybridization followed by pedigree selection.

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Trait	Source	D.f	SS	F-Value	Prob	% Total variation
Days to Flowering	Genotype	7	47.88	0.5	0.833	**2.8**
	Year	2	1425.86	51.63	<0.001**	**84.6**
	Genotype x Year	14	211.22	1.09	0.389	**12.6.**
Days to Boll Opening	Genotype	7	94.83	0.92	0.501	**0.98**
	Year	2	9336.33	316.29	<0.001**	**96.9**
	Genotype x Year	14	208.33	1.01	0.462	**2.2**
Average Boll Weight	Genotype	7	4.19	4.83	<0.001**	**24.6**
	Year	2	11.41	45.98	<0.001**	**67.0**
	Genotype x Year	14	1.44	0.83	0.633	**8.4**
Lint Percent	Genotype	7	38.9	4.67	<0.001**	**63.8**
	Year	2	2.33	0.98	0.384	**3.8**
	Genotype x Year	14	19.75	1.18	0.320	**32.4**
Plant Height	Genotype	7	2683.9	3.12	0.009*	**4.2**
	Year	2	55666.4	226.62	<0.001**	**87.3**
	Genotype x Year	14	5407	3.14	0.002*	**8.5**
Yield	Genotype	7	780340	1.13	0.359	**3.3**
	Year	2	21167576	107.59	<0.001**	**90.4**
	Genotype x Year	14	1460650	1.06	0.416	**6.2**

Table 1- Degrees of freedom, sums of squares, and significance levels by trait

Traits marked with asterisks * and ** are significantly different (p=0.05 and p=0.01 respectively)

Genotype	**2003/04**	**2004/05**	**2005/06**	Mean	**Slope for Regression**
MFKF- 20Kr	4.6	5.5	5.7	**5.3**	**1.22**
MCF-30Kr	5.0	5.1	5.5	**5.2**	**0.44**
MCF-20Kr	4.5	5.6	5.6	**5.2**	**1.33**
MCKF-40Kr	4.5	5.3	5.5	**5.1**	**1.13**
MCZA-20Kr	3.7	4.8	4.9	**4.5**	**1.32**
MG-15Kr	4.6	5.4	5.5	**5.1**	**1.00**
Chureza ©	4.8	5.3	5.6	**5.2**	**0.85**
F 135 ©	4.8	5.2	5.5	**5.2**	**0.70**
Mean	**4.6**	**5.3**	**5.5**		
CV %	**3.5**	**8.5**	**2.5**	**6.9**	
LSD (5%)	**ns**	**ns**	**0.2**	**0.3**	

Table 2-mean boll weight in each year, across years and stability statistics for each genotype

Genotype	**2003/04**	**2004/05**	**2005/06**	Mean	Slope for Regression
MFKF- 20Kr	40.7	42.5	42.1	**41.8**	***3.8***
MCF-30Kr	40.2	41.9	41.9	**41.3**	***4.3***
MCF-20Kr	42.4	41.8	41.8	**42.1**	***-1.2***
MCKF-40Kr	43.5	42.5	42.6	**42.9**	***-2.3***
MCZA-20Kr	40.1	41.4	40.8	**40.8**	***2.2***
MG-15Kr	43.5	42.1	43.8	**43.2**	***-0.1***
Chureza ©	41.7	41.7	42.1	**41.8**	***0.8***
F 135 ©	42.2	42.7	42.3	**42.4**	***0.5***
Mean	**41.8**	**42.1**	**42.2**		
CV %	**2.8**	**2.5**	**2.1**	**2.6**	
LSD (5%)	**2.0**	**ns**	**1.5**	**1.0**	

Table 3-mean Lint Percent (%) in each year, across years and slope of regression for each genotype

Genotype	**2003/04**	**2004/05**	**2005/06**	**Mean**	Slope for Regression
MFKF- 20Kr	72.3	121	156	**116.4**	**1.23**
MCF-30Kr	99.3	120	153.3	**124.2**	**0.77**
MCF-20Kr	80.7	121.7	132	**111.4**	**0.78**
MCKF-40Kr	76	130.7	148	**118.2**	**1.09**
MCZA-20Kr	69.3	132	124	**108.4**	**0.87**
MG-15Kr	73.3	121.7	158	**117.7**	**1.25**
Chureza ©	95	116.7	167.3	**126.3**	**1.02**
F 135 ©	93	122	161.3	**125.4**	**0.99**
Mean	**82.4**	**123.2**	**150.0**		
CV %	**10.8**	**12.4**	**0.5**	**9.3**	
LSD (5%)	**15.6**	**26.7**	**1.26**	**10.5**	

Table 4-mean Plant Height (cm) in each year, across years and slope of regression for each Genotype

Genotype	**2003/04**	**2004/05**	**2005/06**	Mean	**Slope for Regression**
MFKF- 20Kr	129.3	108	131.0	**122.8**	**0.92**
MCF-30Kr	131.3	110.3	135.0	**125.6**	**0.96**
MCF-20Kr	134.6	105.	132.0	**123.9**	**1.17**
MCKF-40Kr	134.3	107	134.3	**125.2**	**1.13**
MCZA-20Kr	132.3	107.3	133.3	**124.3**	**1.05**
MG-15Kr	129.7	106.3	134.3	**123.4**	**1.07**
Chureza ©	130	107	130.3	**122.4**	**0.96**
F 135 ©	127	110.3	129.7	**122.3**	**0.75**
Mean	**131.1**	**107.6**	**132.5**		
CV %	**3.5**	**3.7**	**1.8**	**3.1**	
LSD (5%)	**ns**	**ns**	**ns**	**ns**	

Table 5-mean Days to Boll Opening in each year, across years and slope of regression for each genotype

Genotype	**2003/04**	**2004/05**	**2005/06**	Mean	**Slope for Regression**
MFKF- 20Kr	78.7	77.3	68.7	**74.9**	**0.94**
MCF-30Kr	81.3	73.3	70.3	**75**	**0.99**
MCF-20Kr	83.7	70.3	70.7	**74.9**	**1.14**
MCKF-40Kr	82.0	76.7	69.7	**76.1**	**1.13**
MCZA-20Kr	78.3	76.7	68.3	**74.4**	**0.94**
MG-15Kr	79.7	75.3	68.7	**74.6**	**1.02**
Chureza ©	80.0	79.3	69.7	**76.3**	**0.98**
F 135 ©	78.0	74.3	68.7	**73.7**	**0.86**
Mean	**80.2**	**75.4**	**69.3**		
CV %	**3.4**	**7.0**	**1.5**	**5.0**	
LSD (5%)	**ns**	**ns**	**ns**	**ns**	

Table 6-mean Days to flowering in each year, across years and slope of regression for each genotypeX

Genotype	**2003/04**	**2004/05**	**2005/06**	**Mean**	Slope for Regression
MFKF- 20Kr	1333	1430	2639	**1801**	**1.09**
MCF-30Kr	1377	1219	2323	**1639**	**0.87**
MCF-20Kr	953	1358	2244	**1518**	**0.98**
MCKF-40Kr	1150	1488	2304	**1649**	**0.88**
MCZA-20Kr	799	1226	2374	**1466**	**1.21**
MG-15Kr	1036	1690	2546	**1758**	**1.08**
Chureza ©	1400	1194	2434	**1676**	**0.96**
F 135 ©	1387	1115	2342	**1614**	**0.92**
Mean	**1179.4**	**1340.0**	**2400.8**		
CV %	**35.9**	**17.9**	**8.6**	**19.1**	
LSD (5%)	**ns**	**ns**	**ns**	**ns**	

Table 7-mean Seed cotton Yield (Kg/ha) in each year, across years and slope of regression for each genotype