The Effect of Mutagenesis on Egyptian Cotton

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ABSTRACT

The present study was initiated to evaluate the effectiveness of Gamma irradiation (10 k.r.) and Dimethylsulphate (0.02%) on some characters of Egyptian cotton. Gamma ray treatment showed decreased numbers of fruiting branches except in the M_2 of Giza 81 while Dimethylsulphate treatment showed decreases the M_1. The days to the first flower (earliness) were greater with both mutagens. With both treatments the number of bolls per plant increased in the M_2 generation in the two varieties. The boll weight values were mainly decreased in both varieties with Gamma rays and with Dimethylsulphate. Seed cotton yields were higher than those of the untreated in the M_2 generation in the two varieties with both mutagen treatments. All treatments decreased lint percentage in both varieties while increasing seed index. The micronaire reading (fiber fineness) was increased only with Dimethylsulphate whereas, it was Gamma rays in Giza 81. Mirconaire readings did not show consistent changes. Gamma rays did not effect Pressley index values (strength) while Dimethylsulphate reduced values. Estimates of heritability recorded moderate to high values for number of fruiting branches, number of days to the first flower and lint percentage and moderate to low values for number of bolls per plant, boll weight, seed cotton yield, seed index, fiber fineness and fiber strength of the two mutant generations with both treatments.

Introduction

This investigation was initiated to study the effect of the a physical mutagen, Gamma irradiation, and a chemical mutagen, Dimethylsulphate, on inducing mutation in Egyptian cotton as a source of genetic variance that could be used to help the plant breeder. The success of a breeding program depends on sufficient genetic variability among the genotypes to permit effective selection in economic characters such as number of fruiting branches per plant, number of days from planting to the first flower, number of bolls per plant, boll weight, seedcotton yield per plant, lint percentage, seed index, fiber fineness and strength. The study was carried out on two varieties, Giza 85 and Giza 81.

Many investigators have studied the effect of physical and chemical mutagens on cotton. Nazir and Saeed Iqbal (1974) treated seeds with Gamma rays and obtained significant genetic variability and high heritability estimates for seed cotton yield. Kadambaranusundaram and Madhava Menon (1975) treated two varieties with 10 k.r. of Gamma rays. Seedcotton yield, number of bolls and seed index Plants were reduced with increased variability for those characters. Zhalilov (1980) obtained high yielding, early forms and good fiber quality by treating three varieties with ionising radiation. Kurepin, Pak and Nigmatov (1981) irradiated dry seeds with Gamma rays, increasing the variations in boll weight, fiber yield, length and seed index were. Some favourable mutants were found including mutant families with yield of 91-100 grams per plant. Basu (1981) treated dry seeds with Gamma rays and found increased variability in the M_2 generation for number of bolls, seed cotton yield, boll weight, ginning-out-turn and halo length. Kim (1989) treated seeds of two varieties, 108F and S6524, with Gamma rays at 10, 15 and 20 k.r. The treatment reduced the yield of 108F but increased it in S62524. Conversely, the doses of radiation used altered the variation in morphological and biological characters. Bazhanaova, Mamedov and Rustamova (1990) treated a cotton variety with various mutagens (chemicals or physical) and selected three mutants that were superior in fiber outturn and earliness, but inferior in yield resulting from reduced boll number and weight and reduced fiber length. Gorshkova (1990) investigated the effect of some chemical mutagens on *Gossypium hirsutum*. The most useful altered forms were obtained with combined treatment and individual high-yielding mutants were selected. Sinnongulyan and Kim (1990), stated that phenotypically normal *G. hirsutum* plants generally ignored by mutation breeders following irradiation, may carry many small mutations that increase variation and heritability for yield and improve the effectiveness of selection. Raafat (1994) found that Gamma irradiation of three Egyptian cotton varieties of *G. barbadense* (Giza 77, Giza 80 and Giza 8l) increased boll weight and variability of seed cotton yield and boll weight in Giza 77 but decreased lint percentage in the same variety. Raafat (1995) found that treatment of cultivars with 10 k.r. Gamma rays significantly increased means for number of fruiting branches, number of bolls, seed cotton yield and lint percentage in the M_2 generation. Conversely, Gamma irradiation was found to increase the variance for number of fruiting branches, number of bolls, boll weight and seed cotton yield significantly.

Material and Methods

Air dried selfed cotton seed of two Egyptian cotton cultivars (Giza 85 and Giza 81), *Gossypium barbadense*, was exposed to Gamma rays (10 k.r.) from cobalt 60 at the middle East Regional Radio-Isotopes Centre for the Arab Countries. In the other treatment, air-dried selfed cottonseeds of the two varieties were treated by soaking in a solution of Dimethylsulphate (0.02%). Untreated and differently treated seeds of both varieties were sown for two season. In the first season, seeds of both varieties were sown without any treatment to produce an untreated population. Treated seeds were planted in the same season to produce the first mutant generation (M_1). In the second season, selfed seeds from both varieties were divided into two portions. The first portion was treated in the same way as previously described to give M_1 plants. The second portion was planted as a control. The selfed seeds from M_1 were sown to give the second mutant generation M_2 plants. Seeds of each treatment (control, M_1 and M_2) of both varieties were sown as individual plants in five rows in four complete randomized replicated plots. Data were recorded on the untreated, M_1 and M_2 plants in both cultivars for the traits number of fruiting branches, number of days from planting to first flower, number of bolls per plant, boll weight, seedcotton yield per plant, seed index, lint percent and fiber fineness strength.

Statistical Procedure

- The means (X), and the variance (S^2) were calculated for untreated, M_1 and M_2 generations for each variety.
- Test of significance: The t-test was used to test the significance of the shifts of the treatment populations from their corresponding untreated population means.
- Broad sense heritability (h^2), was estimated as:

$$\frac{\text{Vs of treated pop.} - \text{Vs of untreated pop.}}{\text{Vs of the same population}} \times 100$$

Results and Discussion

Number of fruiting branches. In both varieties the number of fruiting branches was decreased highly significantly in the M_1 by both the Gamma rays and Dimethylsulphate treatments. In the M_2 generation a highly significant increased mean was obtained with Gamma rays for Giza 81, while highly significant decreased value was observed for Giza 85. A highly significant difference was obtained in Giza 85 after Dimethylsulphate treatment with a higher mean than untreated population.

The Gamma rays and Dimethylsulphate increased the variability in both mutant generations (M_1 and M_2) for the two varieties, except in the M_2 of Gamma rays treated Giza 85 (Table 2). These increases were highly significant except that of that M_1 generation with Ga/DMS in Giza 85 was insignificant. The conclusion was that this trait was altered by the two types of mutagens in both mutant generations of the two varieties. These results are in agreement with those obtained by Raafat (1995).

Estimates of heritability were high and for Giza 81 (53.85%) and Giza 85 (48.80%) in the M_1 for Gamma ray treatment. An intermediate heritability estimate (30.77%) was found for Giza 81 in the M_2 generation for the same treatment. Conversely, with Dimethylsulphate treatment high estimates of heritability (47.92%) for the M_1 generation and low estimates of heritability for the M_2 generation were obtained in Giza 81. Heritability values were intermediate and ranged from 19.96% to 32.39% for M_1 and M_2 generations, respectively in Giza 85.

Number of the days to the first flower: The results for this trait in the two cultivars treated with either Gamma or Demithylsulphate in M_1 and M_2 generations showed that Giza 81 mean values were increased with all treatments except the gamma ray treatment in the M_2 generation (earliness) (Table 1). Results of Giza 85 revealed that all treatments increased the mean values (Zhalilov, 1980).

For Giza 81, all treatments decreased the variance (Table 2) except the Dimethylsulphate in the M_1 generation, which was highly significantly higher than that of the untreated. Conversely, for Giza 85, all treatments in the M_1 and M_2 generations increased variance highly significantly being higher in the M_1 than the M_2.

The heritability estimates (Table 3) were zero in the two mutant generations with Gamma rays and the M_2 generation with Dimethylsulphate treatment for Giza 81, because the values of the heritability estimates were negative, and therefore estimated as zero. In Giza 85, estimates of heritability were high at 62.13% and 50.00% for the M_1 generation in Gamma ray and Dimethylsulphate treatments, respectively but they were low, 8.24% and 10.34% for the M_2 generation of the same treatments, respectively.

Number of bolls per plant. The number of bolls was highly significantly increased in the M_2 generation with Gamma ray treatment for both varieties and with Dimethylsulphate treatment for Giza 85 only (Table 1). These results are in harmony with the findings of Kadambaranusundaram and Madhava Menon (1975), Ergabulov and Bekbanov, (1979) and Sinnongulyan and Kim (1990).

The variance of number of bolls (Table 2) was higher in treated than in the untreated population with highly significant differences in all treatments in the two mutant generations, supporting the findings of Basu (1981) and Raafat (1995).

Heritability estimates (Table 3) were high (42.1 1 %) and intermediate (35.82%) for M_2 and M1 generations, respectively with Gamma rays and intermediate (29.30% and 21.96%) for M_1 and M_2 generations, respectively with Dimethylsulphate in Giza 81. Conversely, heritability estimates in Giza 85 were intermediate (24.50% and 35.78%) for M_1 and M_2 generations, respectively with Gamma ray treatment and low heritability estimates (2.66% and 8.35%) were obtained for M_1 and M_2 generations with Dimethylsulphate.

Boll weight. Table 1 shows that the decrease in means was highly significant in the M_1 generation with Gamma rays and Dimethylsulphate for Giza 81 and Giza 85 but means were decreased insignificantly in the other populations under study, except the M_1 generation with Dimethylsulphate that showed an insignificantly increased value.

The variance of boll weight (Table 2) was highly significantly increased for all mutant generations in both cultivars with the two treatments. This result indicated that boll weight was sensitive for both treatments. These results are in complete agreement with Kurepin, Pak and Nigmatov (1981), Basu (1981), Raafat (1993 and 1994).

The heritability estimates were intermediate for the M_1 and M_2 generations with Gamma rays (25.00%, 40.00%, 30.77% and 40.00%) for Giza 81 and Giza 85, respectively (Table 3). Heritability estimates with Dimethylsulphate treatment were low for the M_1 and M_2 generations (14.39% and 7.69%), respectively in Giza 81 and the M_1 generation (18.18 %) in Giza 85 but this value was intermediate (40.00%) in the M_2 generation for the same treatment.

Seed cotton yield per plant. It is apparent from data of Giza 81 that the mean of plants treated with Gamma rays decreased significantly in the M_1 generation and was highly significantly increased in the M_2 generation (Table 1). The means were increased with Dimethylsulphate treatment but not significantly. With Giza 85 both treatments had highly significantly decreased seed cotton yield in the M_1 generation, while it was increased highly significantly in the M_2 generation.

The variance of seed cotton yield was highly significantly increased with the two treatments in Giza 81 and Giza 85 except in the two mutant generations with Dimethylsulphate treatment in Giza 85 (Table 2). This supports the findings of Kadambaranusundaram and Madhava Menon (1975), Kurepin, Pak and Nigmatov (1981), Basu (1981), Raafat (1993 and 1994).

Estimates of heritability were low and intermediate for the M_1 and M_2 generations in Giza 81 and Giza 85 (29.3%, 42.72, 15.46% and 40.26%, respectively) with Gamma ray treatment (Table 3). Heritability values showed the same trend with Dimethylsulphate except the M_1 generation of Giza 85 was zero, because the value of the heritability estimate was negative. High heritability after treatment was obtained by Nazir and Saeed Eqbal (1974) and Sinnongulyan and Kim (1990).

Lint percentage. Lint percentage was highly significantly decreased with Gamma rays for the M_1 and M_2 generations in Giza 81, for the M_1 generation in Giza 85 and significantly decreased for the M_2 generation in the latter (Table 1). It was found that the lint percentage with Dimethylsulphate treatments was highly significantly less for the M_2 generation in Giza 81 and for the M_1 generation in Giza 85 and significantly less for the M_1 generation in Giza 85.

The variance of lint percentage (Table 2) was highly significantly higher in the treated plots in all cases. Other workers found the same trend (Sinnongulyan and Kim, 1990, Raafat, 1995).

Intermediate heritability values were observed with Gamma rays for M_1 and M_2 (28.41% and 34.25%, respectively) in Giza 81 and high values for the two mutant generation (65.74% and 52.14%, respectively) in Giza 85 (Table 3). Low heritability was obtained with Dimethylsulphate for the M_1 and M_2 generations (19.79% and 6.75%, respectively) in Giza 81 and high heritability estimates for both mutant generations (51.09% and 59.07%, respectively) in Giza 85.

Seed Index. The mean of seed index increased with all treatments significant or highly significant in both varieties except the M_1 generation with Gamma rays and Dimethylsulphate in Giza 81 and Giza 85, respectively (Table 1).

The variance was increased highly significantly with Gamma rays for M_1 and M_2 generations in both varieties. Conversely, the variance values with Dimethylsulphate were highly significantly higher than that of the untreated for the M_1 and M_2 generations in Giza 85 and the M_2 generation only in Giza 81. These results are in agreement with those obtained by Kadambaranusundaram and Madhava Menon (1975), Zhalilov (1980) and Kurepin, Pak and Igmatov (1981).

Heritability estimates were low for the M_1 generations with the two treatments in both cultivars. Intermediate heritability estimates were found for the M_2 generations with both treatments in Giza 81 and Giza 85.

Fiber fineness. The fiber fineness means in Giza 81 were highly significantly decreased for the M_2 generation with Gamma rays and Dimethylsulphate while it was highly significant increased for the M_1 with Dimethylsulphate (Table 1). The mean values of this trait in Giza 85 were found to be insignificantly different except the M_1 generation with Gamma rays which was highly significantly increased. High mean values after treatment were observed by Kuliev and Kulieva (1975), Zhalilov (1980) and Bazhanova, Mamedov and Yu Rutamova (1990).

The variance of the micronaire reading was decreased, but not significantly, for the two mutant generations with both treatments in Giza 81 and was highly significantly increased in all treatments for Giza 85.

The heritability estimates were zero in both generations and both mutagens for Giza 81, because the heritability values were negative, and therefore estimated as zero (Table 3). Conversely, an intermediate to low degree of heritability for the M_1 and M_2 generations was found in the two treatments in Giza 85.

Fiber strength. No effect for irradiation was apparent on the means of fiber strength for the two generations (M_1 and M_2) for both varieties (Table 1). With the chemical mutagen significant and highly significant reductions occurred for the M_1 and M_2 generations respectively in Giza 81, and highly significant and nonsignificant reductions for the M_1 and M_2 generations respectively in Giza 85.

The variance was highly significantly increased for the M_2 and M_1 generations for Gamma rays and Dimethylsulphate respectively in Giza 81. For Giza 85 the variances were highly significantly increased for the two mutant generations with both treatments. These results are in harmony with the finding of Kuliev and Kulieva (1975), Zhalilov (1980), Bazhanova, Mamedov and Yu Rustamova (1990) and Sinnongulyan and Kim (1990).

Heritability estimates were low (17.60%) to zero for the various treatments in Giza 81. In Giza 85 an intermediate heritability value (30.77%) was obtained for the M_1 generation with Gamma rays. The heritability estimate was zero in the M_2 generation for the same treatment. Dimethylsulphate treatment showed low values of heritability (25.0% and 15.6%) for M_1 and M_2 generations, respectively.

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Table 1. Tests of significance of differences between means of the studied characters.

Characters	Cultivars	Untreated Populations	γ-rays treatment M1	γ-rays treatment M2	DMS treatment M1	DMS treatment M2
Number of fruiting branches	Giza 81	13.01	12.25**	13.82**	11.39**	13.13
	Giza 85	12.28	11.15**	3.08**	11.25**	13.49**
Number of days to the first flower						
	Giza 85	88.56	89.24**	88.70	88.92**	88.69**
Number of bolls per plant	Giza 81	36.39	34.33	43.27**	36.63	39.05
	Giza 85	35.93	32.57	42.63**	33.23	41.64**
Boll weight	Giza 81	2.35	2.23**	52.33	2.40	2.31
	Giza 85	2.26	2.06	2.25	2.12**	2.24
Seed cotton yield per plant	Giza 81	83.9	75.54*	99.32**	89.91	88.78
	Giza 85	79.84	65.50**	95.34**	68.59**	93.51**
Lint percentage	Giza 81	35.55	34.89**	35.16**	35.24	35.05**
	Giza 85	35.4	34.34**	35.00*	34.84**	35.08*
Seed index	Giza 81	8.08	8.20	8.5**	8.25*	8.35**
	Giza 85	7.72	8.17**	8.26**	7.87	8.09**
Fiber fineness	Giza 81	3.61	3.63	3.48**	3.81**	3.51*
	Giza 85	3.09	3.22**	3.14	3.10	3.06
Fiber strength	Giza 81	10.04	9.99	10.00	9.93*	9.86**
	Giza 85	9.84	9.83	9.91	9.69**	9.81

*, ** significant at 0.05 and 0.01 levels, respectively.
M1, M2; First and second mutant generations, respectively.
γ, gamma rays
DMS; Dimethylsulphate

Table 2. Tests of significance of differences between variances of the studied characters.

Characters	Cultivars	Untreated Populations	γ-rays treatment M1	γ-rays treatment M2	DMS treatment M1	DMS treatment M2
Number of fruiting branches	Giza 81	4.14	8.97--	5.99--	7.95--	4.19--
	Giza 85	5.05	9.80--	4.76	6.10	7.41--
Number of days to the first flower	Giza 81	1.22	1.11	0.49	1.51--	0.87
	Giza 85	0.78	2.06--	0.85--	1.56--	0.87--
Number of bolls per plant	Giza 81	215.9	336.1--	372.6--	304.9--	276.4--
	Giza 85	322.7	427.3--	502.3--	331.5--	352.0--
Boll weight	Giza 81	0.1214	0.1545--	0.1971--	0.1362--	0.1331--
	Giza 85	0.0806	0.1344--	0.1481--	0.1146--	0.1511--
Seed cotton yield per plant	Giza 81	1218.1	1723.9--	2126.7--	1838.4--	1336.4--
	Giza 85	1489.9	1762.4--	2494.0--	1334.5	2020.4
Lint percentage	Giza 81	3.04	4.23--	4.62--	3.79--	3.26--
	Giza 85	2.46	7.18--	5.16--	5.03--	6.01--
Seed Index	Giza 81	0.6104	0.6126--=	0.7666--	0.5531	0.9711--
	Giza 85	0.6576	0.9930--	0.9380--	0.8092--	1.0908--
Fiber fineness	Giza 81	0.2132	0.1877	0.2050	0.1761	0.2129
	Giza 85	0.1005	0.1500--	0.1264--	0.1080--	0.420--
Fiber Strength	Giza 81	0.2753	0.2656	0.3434--	0.3430--	0.2685
	Giza 85	0.2664	0.3910--	0.2698--	0.3643--	0.3223--

*, ** significant at 0.05 and 0.01 levels, respectively.
M1, M2; First and second mutant generations, respectively.
γ, gamma rays
DMS; Dimethylsulphate

Table 3. Heritability percentage of populations under study.

Characters	Cultivars	γ-rays treatment		DMS treatment	
		M1	M2	M1	M2
Number of fruiting	Giza 81	53.85	30.77	47.92	1.20
branches	Giza 85	48.80	0.00	19.96	32.39
Number of days	Giza 81	0.00	0.00	19.21	0.00
To the first flower	Giza 85	62.13	8.24	50.00	10.34
Number of bolls	Giza 81	35.82	42.11	29.30	21.96
per plant	Giza 85	24.50	35.75	2.66	8.35
Boll weight	Giza 81	25.00	40.00	14.29	7.69
	Giza 85	30.77	40.00	18.18	40.40
Seed cotton yield	Giza 81	29.34	42.72	33.70	8.79
per plant	Giza 85	15.46	40.26	0.00	26.26
Lint percentage	Giza 81	28.41	34.20	19.79	6.75
	Giza 85	65.74	52.14	51.09	59.07
Seed index	Giza 81	0.36	20.78	0.00	37.11
	Giza 85	20.20	29.78	18.51	39.45
Fiber fineness	Giza 81	0.00	0.00	0.00	0.00
	Giza 85	33.00	23.70	9.10	9.10
Fiber strength	Giza 81	0.00	17.60	17.60	0.00
	Giza 85	30.77	0.00	25.0	15.6