

## EFFECT OF INJECTING COLCHICINE IN THE GREEN BOLLS ON COTTON FIBER PHYSICAL PROPERTIES AND STRUCTURAL DEFORMITIES

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### Abstract

Seeds of the two Egyptian cotton cultivars; Giza 77 (extra-long staple) and Giza 75 (long-staple), *Gossypium barbadense* L., and Upland cotton cultivar McNaire 220, *G. hirsutum* L., were sown in the two successive growing seasons of 1990 and 1991. The first season was assigned to determine the suitable colchicine concentration and the tolerance of loculus to colchicine injection. On the basis of study of 1990, colchicine concentrations of 0.00% (distilled water as a control) and 0.01% were used for injecting green bolls of 25, 30 and 35 days post anthesis (DPA), to study the direct effect of colchicine on the cotton fiber physical and structural properties, and the possibility of inducing fiber structural deformities.

It was found that colchicine caused an increase in maturity ratio and degree of wall thickening of Giza 75, but reduced fiber sugar content of Giza 77 and McNaire 220 in all boll ages. It also decreased fiber strength, elongation percentage and reduced sugar content of Giza 75 in all boll ages, fiber strength of Giza 77 of bolls aged 25 and 30 DPA, degree of wall thickening of Giza 77 and McNaire 220 in all boll ages. However, it did not affect fiber strength of Giza 77 of boll aged 35 DPA and (T1) of McNaire 220 of bolls at all ages and strength uniformity percent of the three cultivars and elongation percent of Giza 77 and McNaire 220. Whereas, the older fiber-aged, water or colchicine treated bolls, had the higher values of strength, maturity and degree of wall thickening of the higher values of strength, maturity and degree of wall thickening of the three cultivars, but they had the lower values of reducing sugar content in the three cultivars. With respect to fiber deformities structures, their total major and minor attained their maximum at 30

DPA age either for water or colchicine injection in the three cultivars. Giza 77 and Giza 75 cultivars had lower total fiber percentage deformities than McNaire 220. Colchicine or water injection showed five major deformities, i.e., extreme tapering, knee, knot and small and large enlargement and one minor deformity of emergence form. The more frequent was knot, while the fiber deformities spectrum varied with changing the injection age and cotton cultivar.

## INTRODUCTION

Colchicine treatments are recently used to induce useful mutations to impart the increase in yield and higher fiber quality. It is felt important to study the unuseful side effect of colchicine on fiber deformities and its direct effects on the cotton fiber structural and physical properties. Lord (1961) concluded that both fiber maturity ratio and degree of wall thickening increased with increasing fiber age for all cotton cultivars but, with different degrees according to cotton cultivar and growing conditions. Liu *et al.* (1983), by using gas chromatography, found that the natural sugar contents increased markedly during the elongation of the primary wall of the fiber. Ramey *et al.* (1982) concluded that fiber degree of wall thickness tended to increase with boll age. Askalany (1986) showed that there were no differences between the Egyptian cotton Dendera and the American cottons; Tamcot CAMDE and McNaire 220 grown in Egypt, concerning reducing sugars. Farr (1934) concluded that counts of fiber deformities showed a large number in Acala, a smaller number in Super Seven and very few in Pima, Soliman (1979) and EL-Sahar *et al.* (1981) found that the cotton fiber deformities were classified into major and minor according to their number and frequency in 13 cultivars of Egyptian cotton. They added that differences in number of fiber deformities among the cultivars, different types of fiber deformities, and the interaction between cultivars and types were highly significant. Yatsu and Jaks (1981) and Yatsu (1983), by using the injection of aqueous colchicine solutions into developing cotton bolls, found that the injection succeeded to abolish cytoplasmic microtubules, that line the periphery of the protoplasm, in the hair cells (fibers). Yatsu (1983) suggested that microtubules are responsible for the orientation of cell wall microfibrils. He added that the tenacity of colchicine-treated fibers was significantly lower than the untreated ones. No previous study had known any conclusion between colchicine injection and formation of fiber deformities, therefore, this work was carried out to study the effect of colchicine on fiber deformities, beside other physical and chemical properties of the colchicine treated fibers in the green bolls.

## MATERIALS AND METHODS

The experimental work field was conducted at the Agricultural Experimental Station, Agricultural Research Center, Giza, ARE, during 1990 and 1991. The first year (1990) was assigned to determine the suitable colchicine concentrations and the tolerant degree of loculus to colchicine injection. The seeds of the three varieties under investigation; Giza 77, Giza 75, and McNaire 220 were sown in the 15<sup>th</sup> of April in complete Randomized Block Design with three replicates. Land preparation, fertilizer applications and natural operations followed the normal practices of cotton cultivation. Flowers on different cotton plants growing in the experiment were tagged as they blossomed. Aqueous colchicine solutions were injected into ends of loculus of bolls, ranging in age from 15 days DPA to 40 DPA. Excess solution was allowed to flood through a hole pierced in the other end of the loculus with a sterile needle. The solution was injected with a 5 ml plastipak disposable syringe. Colchicine at concentrations of 0.00, 0.01, 0.05, 0.10, and 0.50% in distilled water were used. It was realized from this experiment that injection of colchicine proved lethal or deleterious of loculus younger than 20 DPA. The older loculus were more tolerant to colchicine injection (The older the loculus, the more tolerant). From the results of the first season, it was suggested that 0.01 % colchicine solution in addition to distilled water as control could be used. In addition, the recommended ages of injected bolls were 25.30 and 35 DPA to be used in the second year of study 1991. The experimental work was as follows:

Two Egyptian cotton cultivars namely Giza 77 and Giza 75 and one American cotton cultivar namely McNaire 220 were used. Aqueous colchicine solutions were injected into the ends of loculus of bolls of age of 15,20,25,30 ,35 and 40 DPA. The solutions injected were distilled water, as control and colchicine 0.01. All tests of cotton fiber properties were carried out at the Cotton Technology Laboratories, Cotton Research Institute, Agricultural Research Center, Giza ARE under controlled conditions of 65% relative humidity and  $70 \pm 2^{\circ}\text{F}$ . The following fiber technological properties were estimated: Fiber flat-bundle strength at 1/8 inch (T1) and Zero inch gauge length (To) in g / tex and fiber elongation (%) by the Stelometer tester according to ASTM (D-1445. 1969). Fiber strength uniformity ratio was calculated as follows:  $T1 / To \times 100$  (%). Fiber maturity (M) was determined according to the swelling method by 18% caustic soda solution as described by Lord (1961). The degree of wall thickening has been obtained from the relation given by Peirce and Lord (1939). Fiber reducing sugars content was determined in mg/g (%) according to Smith (1979). Deformities structures of cotton fibers as described by Soliman



(1979) and El-Sahar *et al.* (1981). They classified them as follows: 1) The major deformities; fiber extreme tapering, fiber knee, fiber knot, and fiber enlargement. 2) The minor deformities; fiber emergence. The data of colchicine effect on fiber physical properties, were statistically analyzed as Factorial Experiment in Complete Randomized Block Design according to Snedecor (1961). The significance between different means were determined by New L.S.D. test, Waller and Duncan (1969).

## RESULTS AND DISCUSSION

### A. Fiber physical properties :

1- Fiber flat - bundle strength (To): It is clear from Table (1) that the injection of bolls at 25 DPA with colchicine caused highly significant decrease in (To) of Giza 75 and Giza 77 as compared to those injected with water, while it was insignificant in upland cultivar McNaire 220 at 30 DPA age. This negative effect was significant in the three cultivars. Whereas, the injection of bolls at 35 DPA either with colchicine or water were statistically similar. However, these results indicate that the young aged-fibers were more sensitive to colchicine treatment than the older fibers. In general, the decrease in fiber strength could be explained that colchicine abolishes cell wall microfibrils to lose their orientation and so cause weakness of their breaking strength (Yatsu and Jaks, 1981).

2- Fiber flat-bundle strength (T1): From Table (1), it is obvious that values of fiber strength at 1/8 inch (T1) were lower than those measured at zero gauge length (T0). This might be due to the effect of weak places occurred along the fiber (Lord 1961). The comparisons between colchicine and water treatments at each age revealed intervarietal response. For Giza 77 cultivar, the injection of colchicine of bolls at 25 DPA age caused a significant decrease in values of (T1) than those injected with water (the control), while the two treatments were statistically similar at 30 DPA age. On the other hand, the colchicine injection exhibited highly significant decreases in Giza 75 cultivar at all DPA ages and the highest decrease percent was at 35 DPA age; being 5.96%. In the case of McNaire 220 cultivar, the colchicine and water (control) treatments were statistically similar in their effects at different injection ages. The effect of injection age was also obvious on fiber strength at 1/8 inch gauge length (T1) and with higher values for older fibers and vice versa in the three cotton cultivars. These results could be explained on the same assumptions of Yatsu and Jack (1981) and Yatsu (1983), previously discussed for fiber strength at (To).

Table 1. Fiber physical properties of three cotton cultivars as affected by colchicine injection.

Cultivar	Injection age/ days DPA	Fiber strength at Zero gauge To (g/tex)		Fiber strength at 1/8 gauge T1 (g/tex)		Fiber strength uniformity %		Fiber elongation %	
		Water	Colchicine	Water	Colchicine	Water	Colchicine	Water	Colchicine
		$\bar{x}$	Arc Sign	$\bar{x}$	Arc Sign	$\bar{x}$	Arc Sign	$\bar{x}$	Arc Sign
Giza 77	25	36.15	33.49	25.70	24.30	71.10	57.52	12.11	4.22
	30	39.35	37.17	29.55	30.40	77.25	61.52	12.11	4.34
	35	42.96	44.60	30.60	41.15	72.66	58.54	12.37	5.11
	Average	39.49	38.42	28.05	29.08	73.67	59.19	12.20	4.56
	P-value	<0.01	<0.01	<0.01	<0.01	>0.05	>0.05	>0.05	>0.05
Giza 75	25	34.91	32.65	24.65	23.75	70.32	56.67	12.86	4.45
	30	37.02	34.98	28.20	27.25	75.69	60.48	13.05	4.93
	35	20.24	38.21	31.90	30.00	79.34	63.00	13.44	5.32
	Average	37.39	35.28	28.15	27.00	73.86	59.38	13.12	4.93
	P-value	<0.01	<0.01	<0.01	<0.01	>0.05	>0.05	<0.01	<0.01
McNaire 220	25	28.91	29.41	22.44	21.53	77.75	61.95	12.59	4.53
	30	31.61	29.75	23.55	22.75	74.51	59.73	12.92	5.05
	35	33.25	33.44	24.00	23.50	72.19	58.18	12.99	5.08
	Average	31.26	30.87	23.33	22.59	74.82	59.95	12.83	4.86
	P-value	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05
P-value	New LSD (0.05)	1.68	1.35	1.35	1.35	4.36	4.36	0.86	0.86
	New LSD (0.01)	2.31	1.94	1.94	1.94	6.97	6.97	1.31	1.31
	New LSD (0.01)	2.26	2.04	2.04	2.04	9.24	9.24	0.18	0.18
P-value	New LSD (0.05)	1.61	1.04	1.04	1.04	5.73	5.73	0.32	0.32
	New LSD (0.01)	2.41	2.41	2.41	2.41	9.20	9.20	0.47	0.47
	New LSD (0.01)	2.41	2.41	2.41	2.41	9.20	9.20	0.47	0.47

3- Fiber strength uniformity ratio: Table (1) shows significant difference between 25 and 35 DPA ages of Giza 75 bolls injected with water. On the other hand, the bolls aged 30 DPA injected with colchicine gave higher fiber strength uniformity percent than both 25 and 35 DPA of Giza 77 only. It is interesting to note that the values of strength uniformity percent are very close for the three cotton cultivars in spite of the differences between (To and T1). These results could be explained by the parallel trends of decreasing in values of both (To) and (T1) with each cultivar and between control and colchicine treated fibers.

4- Fiber flat-bundle elongation: The variance ratio showed intervarietal effects of colchicine injection on fiber flat-bundle elongation in both Giza 75 and McNaire 220, Table (1). Therefore, colchicine and water treatments at all ages of Giza 77 and McNaire 220 did not exhibit any significant differences. With respect to Giza 75, the bolls with injected colchicine gave significant lower percent of fiber elongation than those injected with water at all DPA ages, Table(1). Injecting either with water or colchicine revealed that the older the treated fiber the increasing in fiber elongation percent (Joham ,1969). These findings could be interpreted on the base of the effect of colchicine on fibrils orientation within the fiber cell which might differ from cultivar to another.

5- Fiber maturity ratio: It is evident from Table (2) that the bolls of Giza 75 injected with colchicine gave higher maturity ratios than those injected with water at different DPA ages. On the other hand, the reverse effects were obvious in the two other cultivars. The effect of injection age was clear within each cultivar with an increase in maturity ratio for the older ages of injection either with water or with colchicine ( Lord -1961). Therefore, it could be concluded that colchicine had no clear effect on cotton fiber maturity under the studied cultivars and conditions. This may be due to that colchicine effects were mainly on the fiber orientation more than on the amount of cellulose deposition (Yatsu and Jacks,1981; Yatsu , 1983).

6- Degree of wall thickening: It is obvious from Table (2) that the values of degree of wall thickening were in complete parallel with those of maturity ratio, since they were calculated from them. Therefore, it could lead to the same conclusions. Generally, it is clear that the wall thickening increases with the increase of fiber age either for water or colchicine injections (Ramey et al. - 1982).

#### **B- Fiber reducing sugar content:**

The mean values of fiber reducing sugar content presented in table (2) indicat-



ed that the differences between colchicine and water treatments at all DPA ages of the three cultivars were of low magnitude. In addition, the colchicine injection gave higher content of reducing sugar than water injection treatment at all DPA ages of Giza 77 and McNaire 220. Contradicting results were obtained with respect to Giza 75 cultivar, where water injected in bolls had more sugar content as compared with colchicine treatment at all DPA ages. Within each cultivar, it is obvious that the young aged-fibers had higher reducing sugar content than older ones. These results agreed with those of Huterer *et al.* (1981), Liu *et al.* (1983) and Askalany (1986).

### C- Fiber deformities :

(1) Fiber deformities frequency : It is clear from Table (3) and Figure (1) that the total major and minor deformities started with lower percentages for the 25 DPA injection, then increased obviously to 30 DPA injection, and then decreased to 35 DPA injection, either for water or colchicine treatments in the three cotton cultivars. The highest general totals at 30 DPA were; 10.4 %, 8.1 % and 5.7 % for McNaire 220, Giza 75 and Giza 77, respectively. These results indicated that the fibers at 30 DPA were more sensitive to the injection of colchicine or water. This might be due to that injection might interrupt the deposition of cellulose molecules in the fiber wall, resulting in abnormal growth and more fiber deformities in general, Jack (1981) and Yatsu (1983). Regarding the cotton cultivars, it is evident that Giza 77 had the lower total percentage (13.5%) than Giza 75 (18.9 %), while the higher total percentage was for McNaire 220 (25.9 %). The preceding finding indicated that the Egyptian cotton cultivars were superior than the Upland one in cotton quality. This result confirmed that the cotton cultivar is an important factor in determining the presence of fiber deformities (Farr - 1934), Pearson, (1944), Soliman, (1979), and El-Sahar *et al.* (1982).

The effect of colchicine treatment, behaved a greater general total percentages than the water injection treatment in Giza 77 and McNaire 220. The reverse situation was clear for Giza 75, Table (3) and Figure (1). These results indicate that there were intervarietal responses to colchicine treatment with respect to fiber deformities.

### 2- Fiber deformities spectrum :

Data presented in Table (3) and illustrated in Fig. (2) clearly demonstrate that colchicine or water treatment induced five major types and one minor type of deformities in the three cultivars. The major deformities included the forms of ; extreme

Table 2. Effect of colchicine injection on fiber maturity ratio, degree of wall thickening and reducing sugar content for three cotton cultivars.

Cultivar	Injection age/ days DPA	Fiber maturity ratio		Degree of wall thickening		Reducing sugar content (mg/g.)	
		Water	Colchicine	Water	Colchicine	Water	Colchicine
Giza 77	25	1.018	1.017	0.600	0.599	0.52	0.53
	30	1.068	1.066	0.633	0.631	0.45	0.50
	35	1.120	1.095	0.663	0.647	0.43	0.49
	Average	1.069	1.059	0.632	0.626	0.47	0.51
Giza 75	25	1.005	1.019	0.591	0.600	0.55	0.51
	30	1.005	1.062	0.622	0.627	0.49	0.46
	35	1.164	1.170	0.690	0.693	0.39	0.37
	Average	1.075	1.084	0.634	0.840	0.48	0.45
MaNaire 220	25	1.31	1.012	0.608	0.596	0.45	0.48
	30	1.040	1.035	0.409	0.405	0.44	0.47
	35	1.142	1.140	0.685	0.676	0.32	0.38
	Average	1.071	1.062	0.567	0.559	0.44	0.44



Table 3. Frequency and spectrum of fiber deformities in three cotton cultivars as a result of colchicine injection in the growing season of 1991 (data obtained from 1000 fibers for each treatment).

Cultivar	Injection age/ days DPA	Major fiber deformities										Total		Minor fiber deformities		General total				
		Extreme tapering					Knee					Small enlargement					Total		Total	
		W. (1)	C. (2)	W.	C.	W.	W.	C.	W.	C.	W.	W.	C.	W.	C.	W.	C.	W.	C.	
Giza 77	25	-	0.10	0.30	1.60	0.20	-	0.10	0.10	-	-	0.6	1.8	2.40	0.10	0.40	0.50	0.70	2.90	
	30	0.60	-	1.00	2.50	-	0.10	-	0.10	0.10	0.10	1.7	2.8	4.50	0.60	0.60	1.20	2.30	5.70	
	35	-	-	1.50	1.00	-	-	0.80	0.20	0.20	0.10	2.5	1.3	3.80	0.30	0.80	1.10	2.80	4.90	
Total		0.60	0.10	2.80	5.10	0.20	0.10	0.90	0.40	0.30	0.20	4.80	5.90	10.70	1.00	1.80	2.80	5.80	13.50	
W+C		0.70		7.9		0.30		1.30		0.50						2.80				
Giza 75	25	-	0.10	1.30	1.20	-	-	0.20	0.20	0.20	0.50	1.70	2.00	3.70	1.70	2.40	3.40	5.10	6.10	
	30	0.20	-	2.90	1.80	1.00	-	0.70	0.40	0.20	0.10	5.00	2.30	7.30	0.10	0.70	0.80	5.10	8.10	
	35	0.10	0.10	1.40	1.30	-	-	0.40	0.20	0.10	0.10	2.00	1.70	3.70	0.40	0.60	1.00	2.40	4.70	
Total		0.30	0.20	5.60	4.30	1.00	-	1.30	0.80	0.50	0.70	-	-	14.70	2.20	2.00	4.20	10.90	18.90	
W+C		0.50		9.90		1.0		2.10		1.20					4.20					
MaNaire	25	0.20	-	1.10	3.60	-	-	0.30	0.20	-	0.60	1.60	-	6.00	0.10	0.80	0.90	1.70	6.90	
	30	0.10	0.10	3.80	3.00	-	-	0.20	0.10	0.20	0.20	4.30	4.40	7.70	1.80	0.90	2.70	6.10	10.40	
	35	0.10	-	2.00	4.50	0.20	0.20	0.10	0.10	0.20	-	2.60	3.40	7.40	0.50	0.70	1.20	3.10	8.60	
Total		0.40	0.10	6.90	11.10	0.20	0.20	0.60	0.40	0.40	0.80	8.50	4.8	21.60	2.40	2.40	4.80	10.90	25.90	
W+C		0.50		18.00		0.40		1.00		1.20		21.10			4.80					

(1) Water injection

(2) Colchicine injection

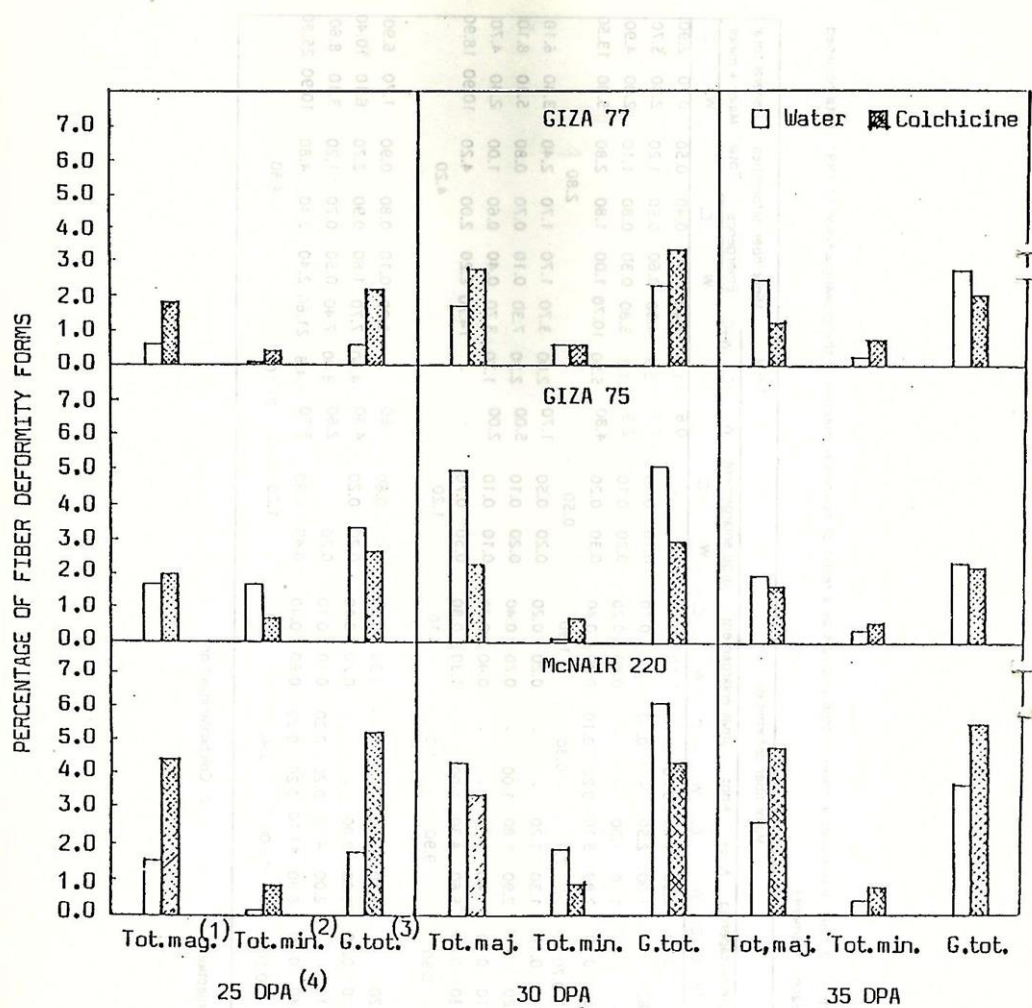
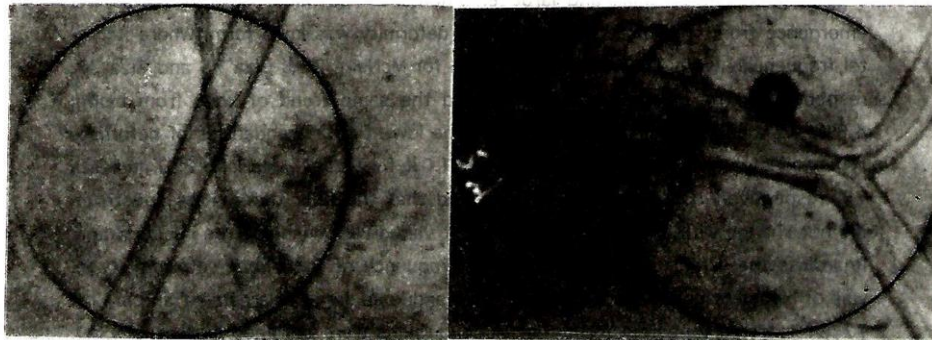
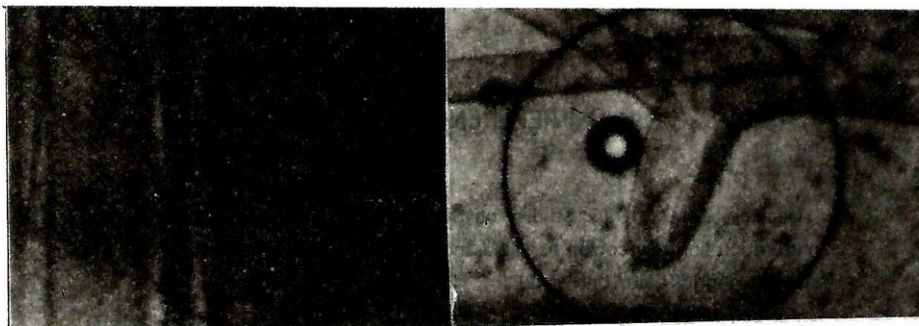


Fig. (1) : Effect of colchicine injection at various ages of cotton bolls on the percentages of fiber deformities of the three cotton cultivars.



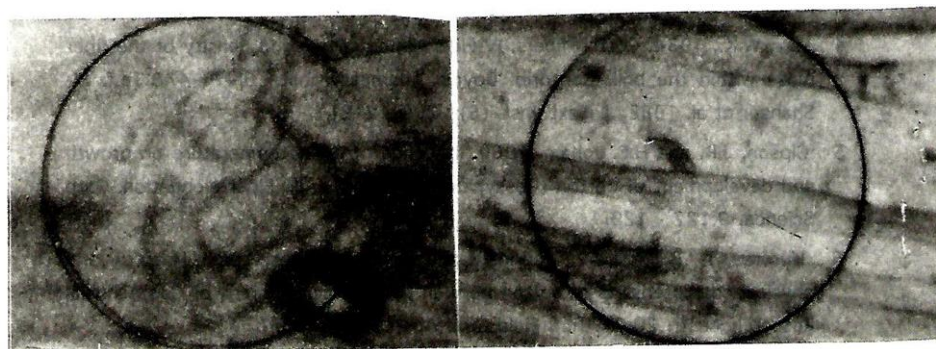
Extreme tapering

Large enlargement



Knee

Small enlargement



Knot

Emergence

Fig. (2) : 111 ustratin types of fiber deformities in the three cotton cultivars injected with water or colchicine ( X 500).



tapering, knot and small and large enlargement. The minor deformity was the emergence from. The more frequent major deformity was knee form; where its total frequencies were 18.0% 9.9% and 7.9% for McNaire 220, Giza 75 and Giza 77, respectively. The emergence form behaved the same trend of knee form being; 4.8%, 4.2% and 2.8% in the same order. The lowest total frequencies of deformity type was knot form being; 0.3%, 0.4% and 1.0% for Giza 77, McNaire 220 and Giza 75, respectively. Data in Table (3) revealed that the fiber deformities spectrum did not change with different cultivars, but it varied with changing the injection age. Regardless the effect of injection age, the frequency of each fiber deformity type, was of higher magnitude in McNaire 220 for and knee, large enlargement and in Giza 77 for extreme tapering form. Similar conclusions were obtained by Farr (1934), Pearson (1944), Soliman (1979) and El-Sahar *et al.* (1982). They concluded that the cotton fiber deformities were affected by the fiber density conditions in the boll, the cotton cultivar and the growing conditions of cotton plant.

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## تأثير حقن الكولشيسين في اللوز الأخضر على الصفات الفيزيائية والتراكيب الشاذة لشعيرات القطن

على أحمد الاشوط ، أحمد حنفى احمد عفيفى

فوقية قدرى الخطيب

معهد بحوث القطن - مركز البحوث الزراعية - الجيزة .

تم زراعة بذور صنفين من القطن المصرى (جيزة ٧٧ فائق الطول وجيزة ٧٥ طويل *Gossypium barbadense*) وصنف القطن الأمريكى (ماكثير ٢٢٠ *G. hirsutum*) فى موسمى ١٩٩٠ و ١٩٩١. وقد خصص الموسم الأول لتقدير التركيزات المناسبة للكولشيسين ومدى تحمل الفص للحقن بالكولشيسين، وعلى أساس الدراسة لموسم ١٩٩٠ استخدمت تركيزات الكولشيسين الممكنة صفر ٪ (ماء مقطر كمعاملة مقارنة) ٠.٠٠١ ٪ لحقن اللوز الأخضر فى أعمار ٢٥ ، ٣٠ ، ٣٥ يوما بعد التزهير لدراسة التأثير المباشر للكولشيسين على الصفات الفيزيائية والتركيبية ودرجة احتمال استحداث تركيبات شاذة للتيلة. وقد وجد أن الكولشيسين تسبب فى زيادة نسبة النضج ودرجة تغليظ جدار الشعرة لصنف جيزة ٧٥ وقد نقص محتوى الشعرة من السكريات المختزلة فى جميع اعمار اللوز المدروسة . بينما أدى الى خفض متانة الشعرة ( عند مسافتى ٨/١ وصفر بوصة) والنسبة المئوية للاستطالة ومحتوى السكريات المختزلة فى جميع أعمار اللوز لصنف جيزة ٧٥ وكذا متانة الشعرة للوز عمرى ٢٥ ، ٣٥ يوما بعد التزهير لصنف جيزة ٧٧ ودرجة تغليظ الجدار فى جميع الأعمار للوز الصنفين جيزة ٧٧ و ماكثير ٢٢٠. بينما لم يؤثر الحقن فى متانة الشعيرات للوز عمر ٣٥ يوما بعد التزهير لصنف جيزة ٧٧ و المتانة عند ٨/١ بوصة لشعيرات اللوز فى جميع الأعمار للصنف ماكثير ٢٢٠. بينما كانت القيم الأعلى للمتانة ونسبة النضج ودرجة تغليظ الجدار للوز الأصناف الثلاثة سواء المحقون منها بالكولشيسين أو بالماء ، فى حين أعطت أقل القيم لمحتوى السكريات المختزلة للأصناف الثلاثة. وقد وصل اجمالى التراكيب الشاذة الكبرى والصغرى للشعيرات الى اقصاه للوز عمر ٣٥ يوما بعد التزهير سواء كان محقونا بالماء أو بالكولشيسين.

وكانت النسب المئوية لاجمالى التراكيب الشاذة للصنفين جيزة ٧٧ وجيزة ٧٥ أقل منها فى الصنف ماكثير ٢٢٠. وقد اظهر الحقن بالكولشيسين أو بالماء خمسة تركيبات شاذة كبرى وهى الاستدقاق المتناهى والعقدة والركبة والتضخم الصغير والكبير بالإضافة إلى تركيب واحد شاذ وصغير وهو النتوء، وكان تركيب الركبة أكثر التراكيب الشاذة تكرارا بينما كان تركيب العقدة هو أقلها تكرارا، فى حين اختلف توزيع التراكيب الشاذة باختلاف عمر الحقن وصنف القطن.