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Effect of Selected γ-Irradiated Cotton Varieties on Fiber Quality During M2 Generation under Rainfed Condition

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Abstract: Several studies have been conducted on radiation effects on organisms. Although most of the interest has been on humans, yet during the last few years increasing attention has been directed to other organisms, focusing on an ecosystem perspective with the intention of defining safe levels of radiation. In this study, we looked at low dose effects of gamma radiation on cotton at the Co-60 source at as, analyzing parameters such as fiber quality and yield parameters including lint percentage, staple length, fiber fineness (Micro-naire), fiber strength, seed yield and cotton yield. Improved varieties of cotton were selected from Cotton Research Institute, Multan and were treated with cobalt source at the rate of 0, 10, 15, 20 and 25 Krades. Three potential cotton varieties i.e Gomal-93, Bt-131 and Bt-CIM-602 previously irradiated @ 15, 20 and 25 KR respectively were selected from among the six varieties. Seeds of these three commercial varieties of cotton (G. *hirsutum)* were sown in May, 2013 at well prepared plots by dibbling method in the experimental fields of the University of Science & Technology, Bannu. Seeds were sown in a Randomized Complete Block Design (RCBD) with three replications. Varieties significantly affected lint percentage, staple length and fiber fineness. Bt-131 recorded maximum lint perentage (37.7%), lengthy staple (30.9) and highest cotton yield (340.4 kg ha^{-1}) as compared to other varieties. While Bt-CIM-602 observed maximum fiber strength (31.2 G/Tex) and highest seed yield (451.8 kg ha^{-1}). Gomal-93 produced finest fiber as compared to other varieties. It is concluded that Bt-131 showed best fiber quality and is recommended for general cultivation in Bannu region.

Key words: Lint % · Staple length · Fiber fineness · Fiber strength · Seed · Cotton · Yield

INTRODUCTION

Cotton is one of the major fibre crop of global significance. It is cultivated in tropical and sub-tropical regions, the world occupying nearly 33 m ha with an annual production of 19 to 20 million tones of bales. China, U.S.A. India, Pakistan, Uzbekistan, Australia, Brazil, Greece, Argentina and Egypt are major cotton producing countries in the present world. These countries contribute nearly 85%, of the global cotton production [1,2]. Pakistan is the fifth largest producer of cotton in the world, the third largest exporter of raw cotton, the fourth largest consumer of cotton and the largest exporter of cotton yarn. About 1.3 million farmers (out of a total of 5 million) cultivate cotton over 3 million hectares, covering 15 per cent of the cultivable area in the country. Cotton and cotton products contribute about 10 percent to GDP and 55 per cent to the foreign exchange earnings of the country. As a whole, between 30 to 40 percent of the cotton ends up as domestic consumption of final products. The remaining is exported as raw cotton, yarn, cloth and garments.

Cotton fiber represents about fifty percent of the cost of yarn and there is a direct correlation between specific quality characteristics of the fiber and those of the yarn. Traditionally, the price of cotton was largely determined

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by factors such as staple length, grade, color and micronaire. Those factors are still the major determinants of price but spinners today are also interested in other fiber properties that affect the quality of their yarns and the efficiency at which they produce those yarns. As the textile industry has been striving to improve quality and efficiency through automatic high-speed machinery, new technologies place increasingly severe technical demands on textile fibers, raising the importance of other properties of cotton: strength, uniformity, maturity, fineness, elongation, short fiber content, spinning performance, dyeing ability and cleanliness. All else being equal, spinners pay a higher price for longer, finer and stronger cotton lint that is white, bright and fully mature [3]. The extra long staple cultivar, Giza 88 surpassed the long staple cultivar, Giza 86 in gin stand capacity (kg/inch/hr), short ginning time (hr/cantar), UHML, (mm), mean length (mm), uniformity index, fiber bundle strength (g/tex) and fiber elongation (%). Meanwhile, the long staple cotton cultivar, Giza 86 recorded the highest mean values concerning ginning out-turn (%), lint grade, micronaire value, maturity (%) and reflectance degree (Rd %), [4]. Fiber maturity parameters, bundle strength and elongation % were highly significantly affected by the cotton cultivar, [5]. Staple length, reflectance degree (Rd %), yellowness (+b), proportion of maturity (PM), hair weight bundle strength and elongation % were significantly affected by the cotton cultivar,[6]. Cotton quality is affected by cotton cultivar and growing conditions [7]. The objective of this research was to investigate the effectiveness of irradiated cotton varieties on fiber properties.

MATERIALS AND METHODS

Experimental Site and Plant Material: This study was carried out at Department of Botany, Faculty of Biological Sciences, K.P.K, Pakistan. Improved varieties of cotton were selected from Multan Cotton Research Station and were treated with cobalt source at the rate of 0, 10, 15, 20 and 25 Krades. Three potential cotton varieties i.e Gomal-93, Bt-131 and Bt-CIM-602 previously irradiated @ 15, 20 and 25 KR respectively were selected from among the six varieties. Seeds of these three commercial varieties of cotton (G. *hirsutum)* were sown in May 2013 at well prepared plots by dibbling method in the experimental fields of the University of Science & Technology, Bannu. Seeds were sown in a randomized complete block design (RCBD) with three replications. Each replication comprised of twenty plants in two rows by keeping a distance of 60 cm and 75 cm between plant to plant and row to row distance respectively. All usual agronomic and cultural practices including plant protection were under taken according to the schedule. Fiber quality analysis were completed in Central Cotton Research Institute, Multan. The metrological data for the cotton growing season was collected from Metrological Station of University of Science & Technology, Bannu (Fig. 1). Soil sample was taken at depth from 0- 30 cm for physical and chemical analyses as described by [8] (Table 1).

The following parameters were studied during experiment.

Lint Percentage (GOT %): Weight of clean and dry samples of seed cotton were taken and ginned separately with a single roller electric gin. The lint obtained from each sample was taken and lint percentage was computed by the following formula.

Lint percentage (GOT) = Weight of lint in a sample/Weight of seed Cotton in a sample*100

Staple Length (mm): Staple length was measured from the representative sample of each plant tuft method. The lint sample was turned into sliver and passed it through a draw box for several times till it was drafted into a uniform band of parallel fibers. The fibers were then mounted on a set of metallic comb, fixed parallel to each other on a stand. One of the processed samples was aligned with the help of a pair of tweezers and the two tufts were carefully drawn from each sample on a velvet cover tuft board. Two lines were drawn, one on the even end of the tuft just beneath grip mark of the tweezers and second on the opposite of the tuft, where the rate of change of visual density of the fiber was maximum. The distance between the two lines was measured with a scale with mm. The average staple length was calculated by taking mean of two readings for the individual plant.

Fiber fineness (Micronaire): It was measured through the Micronaire instrument in which the rate of air flow through a standard volume of cotton is utilized.

Fiber Strength (G/Tex): The strength of fiber was measured by the Pressley strength tester in which two sets of jaws holding a cotton fiber sample are placed in the machine, which measures the force required to break the cotton fibers.

Table 1: Soil analysis result for physical and chemical characteristics of sandy loam soil.

Characteristic	Soil depth	Soil texture	EC	pH	N	P	K
Value	0-30 cm	Sandy loam	1.84 ds m $^{-1}$	7.3	0.034 %	0.023 %	0.52 %

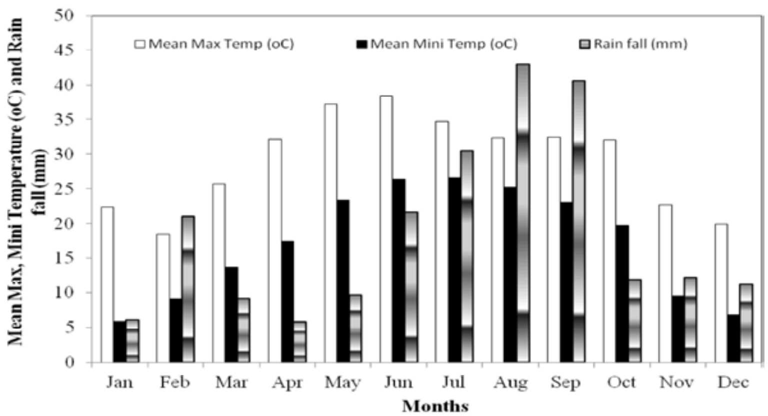

Fig. 1: Monthly Mean Maximum, Minimum Temperature (°C) and rain fall (mm) of the growing season (2013).

Seed yield (Kg ha^{-1}): Seeds of two central rows in each subplot was harvested, sun dried, cleaned and converted into seed yield per hectare.

Cotton yield (Kg ha^{-1}): Cotton of two central rows in each subplot was harvested and converted into cotton yield per hectare.

Statistical Procedures: This investigation was conducted I n a randomized complete block randomized design with three replicates. The data was computed using the M-Statc program. To test differences among studied mean of treatments, the least significant difference (L.S.D.) was used at 0.05 level of probability.

RESULTS AND DISCUSSION

Lint percentage (G. O. T %): Lint percentage was significantly affected by cotton varieties (Table 1). Maximum lint percentage (37.7%) were recoreded in Bt-131 vareity as radiated at the rate of 20 KRade, while minimum lint percentage (34.7 %) was recorded in Gomal-93 when their parents were radiated at the rate of 15 KRade. Bt-CIM-602 is the second highest lint observed after the Bt-131 when their parents seed were radiated at the rate of 25 KRade (Fig. 1). Studied proved that gamma irradiation has helped us in production of high yielding CLCUV superior fiber quality traits [9]. Radiation applies were created variation on lint percentage, two lines (ACH22 and ACH36) were found higher from control Acalpi and the other standard cultivars [10]. Similar results were obtained by some investigators [11].

Staple length (mm): Fiber length plays leading role in textile industry. Quality thread is made only from longer fibers. Fibrous materials must have sufficient length so that they can be made into twisted yarns. In addition, the width of the fiber (the diameter of the cross section) must be much less than the overall length of the fiber and usually the fiber diameter should be 1/100 of the length of the fiber. The fiber may be "infinitely" long, as found with continuous filament fibers, or as short as 0.5 inches (1.3 mm), as found in staple fibers. The analysis of variance for staple length of cotton varieties showed significant variation (Table 2). Bt-131 and Bt-CIM-602 showed highest (30mm) staple length as their parents seeds were radiated at the rate of 20 and 25 Krade respectively. while Gomal-93 recorded minimum staple length (29 mm) as their parent seed radiated at the rate of 15 krade. The most length fibers were obtained form ACH26 line that created from 300 Gray radiation applied, while the shortest was from ACH6 line. The similar results were reported by [11, 12].

Fiber Fineness (Micronaire): Fiber fineness is play important role in textile industry and it is desired quiet thin. Fiber finenesse was significantly affected by cotton varieties (Table 5). Although micronaire is known to measure fiber surface area and to be affected by both fiber fineness and wall thickness, this airflow resistance method is the standard instrumental measure of fiber maturity [13, 14, 15]. All the cotton varieties have very mature fiber finess. However, finest fiber (4.8) were recorded in Gomal-93 while less finest fiber (4.4) were observed in Bt-131. Bt-CIM-602 showed second fininest

Table 1: Means of lint percentage, staple length, fiber fineness, fiber strength, seed yield Kg ha^{-1} and cotton yield Kg ha^{-1} as affected by selected irradiated cotton verities.

Varieties	Lint %	Staple length (mm)	Fiber Fineness	Fiber Strength (g/tex)	Seed yield Kg ha^{-1}	Cotton yield Kg ha^{-1}
Gomal-93	34.700 b	29.9 b	4.800 a	30.867	185.133	118.400
Bt-131	37.733 a	30.9 a	4.400 ab	29.733	155.513	340.400
Bt-CIM-602	36.100 ab	30.3 ab	3.967 b	31.233	451.800	259.000
Lsd at 0.05	1.63	0.6801	0.6125	ns	ns	Ns

Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test

Table 2: Analysis of variance for lint percentage, staple length (mm), fiber fineness, fiber strength (g/tex), seed yield Kg ha^{-1} and cotton yield Kg ha^{-1} as affected by selected irradiated cotton verities.

Sources of variance	D.F	lint %	Staple length (mm)	Fiber Fineness	Fiber Strength	Seed yield Kg ha^{-1}	Cotton yield Kg ha^{-1}
Replications	2	0.120	0.014	0.058	0.351	154077.193	51967.243
Cotton Varieties	2	0.760*	6.914*	0.521*	1.834ns	79887.127ns	37839.163ns
Error	4	0.090	0.519	0.073	0.439	48775.422	107083.189
Total	8						
CV (%)		1.99%	0.99%	6.15%	2.17%	83.61%	136.77%

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, ns = Non significant, CV= Co-efficient of variation

fiber after Gomal-93. Direct measurements of biological fiber fineness are quite costly in time required for each assessment and are strongly biased by sampling errors and the natural, highly convoluted, noncircular shape of cotton fibers. During cotton classing, fiber fineness is measured indirectly as micronaire, an air-permeability parameter that estimates fiber surface area [13, 16]. However, micronaire is significantly affected by fiber physical maturity, that is, the relative cell wall thickness of the fibers [14]. According to [10] the thinnest fibers were found from ACH1, ACH14, ACH30 and ACH34 lines nevertheless the thickest fibers were found ACH24 line. The similar results were reported by [11, 12, 17-22].

Fiber Strength (g tex^{-1}): Fiber strength is an important character in terms of textile industry. The strength of a single fiber is called the tenacity, defined as the force per unit linear density necessary to break a known unit of that fiber. The breaking tenacity of a fiber may be expressed in grams per denier (g/d) or grams per tex (g tex^{-1}). Both denier and tex are units of 1inear density (mass per unit of fiber length) and are defined as the number of grams of fiber measuring 9000 meters and 1000 meters, respectively. Fiber strength was non-significantly affected by cotton varieties (Table. 2). However, strongest fiber strength (31.2 g tex^{-1}) was recorded in Bt-CIM-602. Bt-131 showed lowest fiber strength (29.7 g tex^{-1}). Gomal-93 showed second strongest fiber strength (30.8 g tex^{-1}) after Bt-CIM-602. The best mean values of the most importance fiber properties i.e. fiber length (35.9 mm), uniformity index (89.10 %), lowest short fiber content (3.2 %) and lowest yellowness degree (+b) 8.6 % were obtained from the highest lint cotton grade, good to fully good (G/FG) of extra long staple variety Giza 45 [23]. The highest fiber strength was obtained from ACH6 line while the lowest was from ACH22 line [11]. The result in this study confirms the similar results obtained by [17, 18, 21]. NIAB-92 recorded maximum fiber strength during 1990-91 (90.4 000Psi) and 1991-92 (91.7 000Psi) as compared to all other varieties.

Seed Yield Kg Ha^{-1}: Seed yield was not significantly affected by cotton varieties Table. 9. Bt-CIM-602 produced maximum (451.8 kg ha^{-1}) seed yield, when their parents seeds were treated at the rate of 25 KRade. Gomal-93 produced minimum seed yield (185.5 Kg ha^{-1}) as their parent seed was radiated at the rate of 15 krade. The highest total seed cotton yield were indicated ACH22 and ACH36 lines, while the lowest were indicated ACH6 line [10]. Similar results were obtained by [11,18]. Four cotton cultivars produced 28 % more fruiting and 44 % seed cotton yield when sown in narrow rows [24]. Yield of cotton cultivars found that yield of early maturing varieties was maximum because they developed canopy earlier and harvested more light [25]. Cultivar CIM-506 produced more seed cotton yield of 3333 kg ha^{-1} and increase in yield was 19% and 26% higher over cv CIM-496 and NIAB-111, respectively [26].

Cotton Yield Kg Ha^{-1}: Cotton yield showed no significant difference (Table). Bt-131 produced highest cotton yield (340.4 kg ha^{-1}) as compared to Gomal-93 (118.4 kg ha^{-1}), while Bt-131 and Gomal-93 parents seeds were radiated at the rate of 20 and 15 kRade respectively. Bt-CIM-602 was the second highest cotton (259 kg ha^{-1}) producer after Bt-131. The results of the mutant NIAB-92 obtained in farmers fields during 1991-92 illustrated higher yield potential and gave significantly higher mean yield [27]. In check pea the highest yield was obtained through the plants treated with 100 Gy and the lowest yield was at 900 Gy [28]. The lines C15-1, C15-3 and C15-4 possess earliness, high yield and a proper length of lint [29].

CONCLUSION AND RECOMMENDATIONS

Among the three cotton cultivars studied, Bt-131 gave the highest cotton yield of 340.4 Kg ha^{-1} with the highest lint percentage (G.O.T) and staple length (30.9). This cultivar had medium fiber fineness of 4.4 and minimum seed yield of 155.5 kg ha^{-1}. As Bt-131 demonstrated highest values of desired characters, therefore is recommended for general cultivation in Bannu region

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