Induced Genetic Variability in Selected γ-Radiated Cotton Varieties during Second Year Ratooning Under Rain Fed Environment

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ABSTRACT

The cotton is one of the most raw materials of the textile industry. At the same time, Pakistan is one of the most important cotton producing countries. Cotton has a wide variety of uses, especially in the textile industry. Cotton cultivars response to different doses of gamma radiation for branches plant^{-1}, leaves plant^{-1},bolls plant^{-1}, flowers plant^{-1}, seed weight (g), cotton weight plant^{-1}, intermodal length (cm), hundred seed weight (g) and plant height (cm) were studied in 2013. Three newly developed cotton varieties i.e Gomal-93, Bt-131 and Bt-CIM-602 previously (2012) irradiated @ 0, 10, 15, and 20 kR in Nuclear Institute for Food and Agriculture, Tarnab, Peshawar, Pakistan. The cotton varieties were sown in May, 2012 University of Science & Technology, Bannu. After harvesting cotton varieties were left in the field for 2013 production as ratoon crop. The experiment was laid out in randomized complete block design with split arrangement i.e. radiation treatment were kept in main plots and varieties in subplots. Radiation treatments significantly affected branches plant^{-1}, Leaves plant^{-1}, flowers plant^{-1}, cotton weight plant^{-1}, intermodal length (cm) and hundred seed weight (g) except bolls plant^{-1} and plant height (cm). Maximum branches plant^{-1} (24.3), flowers plant^{-1} (234.5), and heavy seed weight (7.98 g) were recorded in cotton varieties when irradiated at the rate of 15 Krad. While highest cotton weight plant^{-1} (34.4 g) were recorded at 10 Krad treated seeds. Highest flowers plant^{-1} (241.3), seed weight plant^{-1} (8.2 g), lengthy plants (4.81 ft) and maximum cotton weight plant^{-1} (33.9 g) were observed in Bt-131 variety. Bt-131 is recommended for general cultivation and production in Bannu.

Keywords: Gamma, Radiation, Cotton, Ratoon

INTRODUCTION

Cottons (*Gossypium hirsutum*) is a member of the genus *Gossypium* and the family Malvaceae. Gossypium has 45–50 species. Majority of the species are diploids (2n = 26). The word "cotton" is a modified form of "al qatan" (an Arabic word). In Pakistan two of these (Gossypium arboreum and G. herbaceum) are diploids,and two (G. hirsutum and G. barbadense) are tetraploids. More than 80% of the world's cotton area is covered by tetraploids. The cotton is one of the most raw materials of the textile industry. At the same time, Pakistan is one of the most important cotton producing countries.

Cotton has a wide variety of uses, especially in the textile industry. Cotton is spun into thread that is used in many clothing products such as underwear, socks and T-shirts. Bed sheets are usually made of cotton because of its soft feel. Cotton yarn is also used for knitting and crochet.

This is used to make towels, and robes. Cotton is also used to create denim for jeans and many other clothing materials. Cotton is also used to create fishing nets, tents and cotton paper. Cotton paper is used to create banknotes and high quality art paper. It is also used in coffee filters, gunpowder and bookbinding.

The seed of the cotton plant also has some important uses. Firstly, it can be used to produce cottonseed oil, which is a popular vegetable oil for cooking. The remains can be used as feed for cattle and other animals. This product is used for many medical and cosmetic purposes.

From the lint (the fibre separated from the seed) come the major products, chiefly textile and yarn goods, cordage, automobile-tire cord, and plastic reinforcing. The linters (short, cut ends removed from the seed after ginning) are a valuable source of cellulose. Cotton hulls are used for fertilizer, fuel, and packing; fibre from the stalk is used for pressed paper and cardboard.

Cotton fibre is a unique raw material for the textile industry. Increase in world population and, rise of living standard, textile products have to be increased. For that reasons, textile industry prefers quality cotton in terms of fibre length, high lint percentage, fibre strength, fibre fineness, fibre uniformity etc. Some researchers had reported that, mutagen applications had caused variations on fibre characters and by selecting the superior progenies, the new superior cultivars can be developed [1,2]. On the other hand, mutagen applications that had made artificial mutation, caused to earliness, 100 seed weight, cold and dry tolerance and verticillium and the genetic structure has been changed and could be improved were reported [2-5]. The objective of this study was to investigate the effect of gamma radiation on growth and yield of cotton varieties.

MATERIALS AND METHODS

Experimental Treatment and Plant Material

Seeds of three commercial varieties of *Cotton* via V1-(Gomal-93) and V2-(Bt-CIM-602), V3-(Bt-131) were obtained from Central Cotton Research Institute Multan. Pure seed of the three varieties of cotton were treated with Cobalt-60 source at the rate of 0, 10, 15, 20 KR. Seeds were shown in May 2012 at well-prepared plots in the experimental fields of the Department of Botany, University of Science and Technology Bannu after harvesting plant were left for 2013 as ratoon crop. Seeds were sown in a randomized complete block design (RCBD) with three replications. Each replication comprised of 10 plants in one row by keeping a distance of 60 cm and 75 cm between plant to plant and row to row distance respectively with six meter row length. The metrological data for the cotton growing season was collected from Metrological Station of University of Science & Technology, Bannu (Figure 1). The following parameters were studied during the experiments branches plant^{-1}, leaves plant^{-1},bolls plant^{-1}, flowers plant^{-1}, seed weight (g), cotton weight plant^{-1}, intermodal length (cm), hundred seed weight (g) and plant height (cm) were recorded as.

Data Collection Procedure

Branches plant-1; Four random cotton plants were selected for number of branches at maturity and averaged the data. Leaves plant-1; Four random cotton plants were selected for number of Leaves plant-1 at maturity and averaged the data. Bolls plant-1; Four random cotton plants were selected for number of Bolls plant-1 at maturity and averaged the data. Flowers plant-1; Four random cotton plants were selected for number of Flowers plant-1 at maturity and averaged the data. Seed weight (g); Four random cotton plants were selected for number of Seed weight (g) at maturity and averaged the data. Cotton weight (g); Four random cotton plants were selected for number of cotton weight (g) at maturity and averaged the data.

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Internodal length (cm); Four random cotton plants were selected for number of intermodal length (cm) at maturity and averaged the data. 100 seed weight (g); Four random cotton plants were selected for number of 100seed weight (g) at maturity and averaged the data. Plant height (cm); Four random cotton plants were selected for number of plant height (cm) at maturity and averaged the data.

Statistical Analysis

MSTAT-C statistical analysis packed program was used in the statistical analysis and least significant test was used to classify significant difference between treatment means.

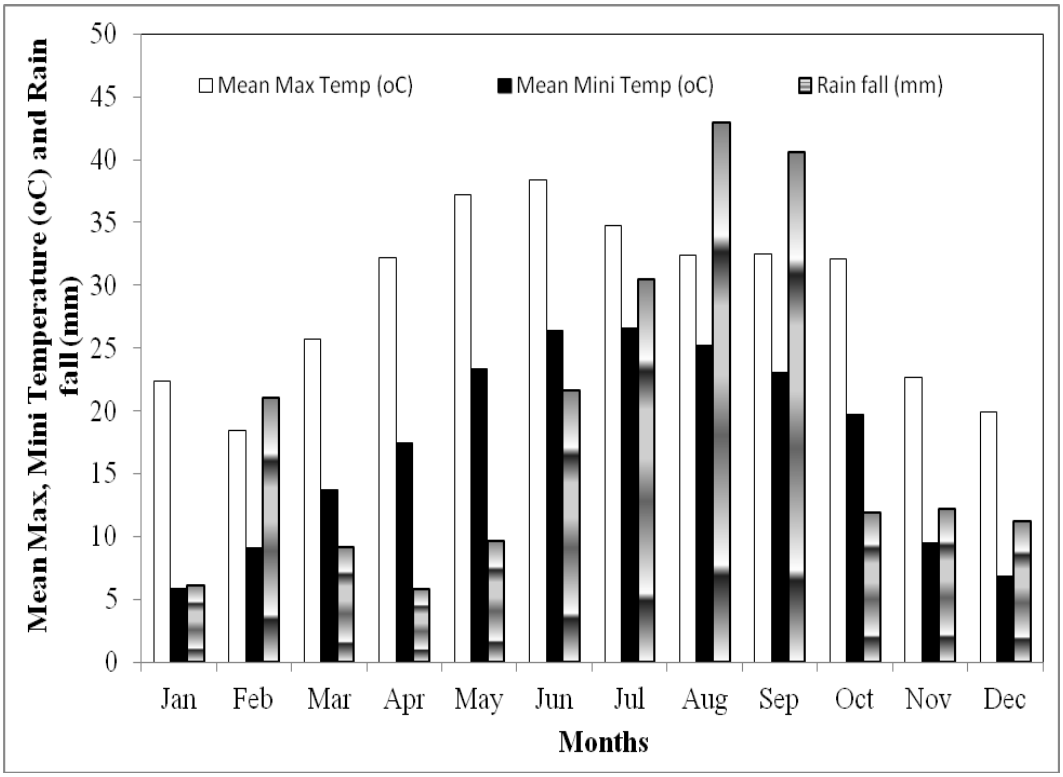

Figure 1. Monthly Mean Maximum, Minimum Temperature (^{o}C), and rain fall (mm) of the growing season (2013)

RESULTS AND DISCUSSION

Branches Plant^{-1}

Branches plant^{-1} was significantly affected by radiation treatments (Table.1). Maximum branches plant^{-1} (24.3) were recorded, when cotton seed were irradiated at the rate of (15 krad), while minimum branches plant^{-1} (16.2) were observed in varieties, when seeds radiated at the rate of (10 krad). All radiation doses have negative and positive effects on number of sympodial branches in different cotton varieties[3]. Gomal-93 has highest branches plant^{-1}(22.9) as compared to Bt-131 (16.5). Balady Okra variety have highest (7.20) number of braches as compared to Sabahia (6.25), when there seeed radiated from 300 to 500 Gy[6]. R×V interaction showed significant effect on branches plant^{-1}, more branches plant^{-1} (28.9) were counted in Gomal-93 when a cotton seed were radiated at the rate of (15 krad), less branches plant^{-1} (2.15) were seen in a same variety, where the seed were kept control. Highest number of sympodia braches per plant was obtained from ACH_{31}, ACH_3 and lines while the lowest was found from Acalpi cultivar[2]. The number of branches was significantly affected in lentil at increased dose of gamma rays[6].

Leaves Plant^{-1}

Leaves plant^{-1} was significantly affected by radiation treatments (Table.1). Maximum (1062.2) leaves plant^{-1} recorded when cotton seed were not irradiated and were kept as control. While minimum leaves plant^{-1}(624) were observed in varieties, when seeds radiated at the rate of 20 krad. Higher dosages of gamma rays show reduced number of branches and number of leaves[7]. It can be inferred that the biomass of *Centella asiatica* leaves was significantly inhibited by γ-radiation as compared with the control ($p < 0.01$)[8]. BT-CIM-602 showed highest leaves plant^{-1} (1006.4) as compared to Bt-131 (805.5). R×V interaction showed significant effect on leaves plant^{-1}. More leaves plant^{-1} (1736.0) were counted in Gomal -93 when a cotton seed were kept control, while less leaves plant^{-1} (16.8) were seen in a same variety, where the seed were radiated at 20 krad. Reduction in emergence of treated leaves as function of dose compared with that of dose compared with that of control might be due to increase inhibition of activity and oxidative phosphorylation of ADP-ATP[5]. A decline in Chrysanthemum height and numbers of branches and leaves when it was irradiated with low doses of gamma rays (1.5, 2, and 2.5 k-rad)[9]. Likewise, showed that higher doses of gamma irradiation (40-120 k-rad) decreased plant height, number of leaves and the branching capacity of safflower[10].

Bolls Plant^{-1}

Bolls plant^{-1} was significantly affected by radiation treatments (Table 1). Maximum bolls plant^{-1}(302.1) recorded, when cotton seed were irradiated at the rate of 20 krad, while minimum bolls plant^{-1} (164.6) were observed in those varieties, as seed is radiated at 10 krad. The effects of radiation applications on cotton seeds were obtained positive and negative on boll weight[1]. The bolls cultivars and lines were changed from 3.89 to 6.95 (g), as the highest boll was observed from ACH_{36}, while the lowest was obtained from ACH_2 line. The radiation application was created genetic variation on bolls weight. Bt-CIM-602 accounted highest bolls plant^{-1} (273.1) as compared to Gomal-93 (162.2). R×V interaction showed significant effect on bolls plant^{-1}, more bolls plant^{-1} (328.0) was counted in Gomal-93 when a cotton seed were not radiated. While, less bolls plant^{-1} (42.8) were seen in a same variety, where the seed were radiated at the rate of 20 Krad. Number of umbels per plant in fennel plant decreasing by increasing gamma radiation doses from 2-20 Kard [11].

Flowers Plant^{-1}

Flowers plant^{-1} was significantly affected by radiation treatments (Table.2). Maximum (234.5) flowers plant^{-1} were recorded, when cotton seed were irradiated at the rate of 15 krad. While lowest flowers plant^{-1}(108.1) were observed in those cotton varieties, when there seeds irradiated at the rate of 20 krad. Low dose of gamma radiation (2.5 kR) of dry and wet seeds increased number of flowers per branches in both seasons, on contrast with increasing the doses caused negatively effect on flower number per branches [12]. Bt-131have highest (241.3) flowers plant^{-1} as compared to Gomal-93 (159.1) and Bt-CIM-602 (130.6). R×V interaction showed significant effect on flowers plant^{-1}. More flowers plant $^{-1}$(494.9) were counted in Bt-131 when a cotton seed were not radiated. Less (48.2) flowers plant^{-1} were seen in Gomal-93. The flowering was progressively delayed in lentil at higher doses of radiation [13].

Seed Weight (g)

Seed weight (g) was significantly affected by radiation treatments (Table 2). Maximum (40.7 g) seed weight was recorded, when cotton seed were kept control. While minimum (31.5 g) seed weight was observed in cotton varieties, when seeds radiated at the (13.0) rate of 20 Krad. Gamma radiation doses from 20-80 Gy induced seed weight in *Digitaria exilis*, while seed weight decrease from 80-100 Gy[14]. Heaviest (45.9 g) seed weight was showed by Bt-

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131, while lightest (25g) seed weight was noted in Gomal-93. R×V interaction showed significant effect on seed weight (g). More seed weight (56.0 g) were counted in Bt-CIM-602, when a cotton seed were radiated at the rate of 10 krad, less (13 g) seed weight was seen in Gomal-93, where the seed were irradiated at 20 krad. The highest seed weight (g) were obtained from ACH36 and ACH22 lines, while lowest was obtained from ACH5 line[1]. These lines were created from 100, 200, 300 and 400 Gray radiation doses application.

Cotton Weight (G)

Cotton weight (g) was significantly affected by radiation treatments (Table.6). Maximum (34.4) Cotton weight (g) recorded, when cotton seed were irradiated at the rate of 10 krad, while minimum cotton weight (25.1 g) were observed, when seed irradiated at the rate of 20 krad. The highest seed weight was obtained from 300 Gy treated plants and the lowest was in control[15].

Bt-131 showed heaviest (33.9 g) cotton weight as compared to both Gomal-93 (17.5 g) and Bt-CIM-602 (32.9 g). R×V interaction showed significant effect on cotton weight plant^{-1}. Highest (38.6 g) cotton weight was counted in Bt-CIM-602, while lowest (10 g) cotton weight was recorded in Gomal-93 when a cotton seed were radiated at the rate of 10 krad. It is reported that the significant increase in cotton yield achieved with the mutant NIAB 78 in Czechoslovakia and mutant barley Diamant exceeded 12% return on the original variety[16]. The highest seed cotton weight was obtained from ACH36 lines that created from 400 gray confirms the similar results found by [1].

Internodal Length (cm)

Internodal length (cm) was significantly affected by radiation treatments (Table.7). Lenthy (1.47 cm) internodes was recorded, when cotton seed were irradiated at the rate of 20 krad. Shortest internodes (1.40cm) were observed in cotton varieties, those seeds were irradiated at the rate of 15 krad. M5 mulberry variety, saplings recovered from gamma irradiated cuttings showed reduced internodal distances at 4kR, 6kR and 7kR and at lower doses (1kR to 3kR) the internodal distance was not affected [17]. Bt-CIM-602 showed lengthy internodes (1.46cm) as compared to Gomal-93 (1.44cm) and Bt-131 (1.42cm). R×V interaction showed significant effect on internodal length (cm), lengthy internodal length (1.70 cm) were counted in Gomal-93, when seed were irradiated at the rate of 10 krad, shortest internodal length plant $^{-1}$ (1.36 cm) were seen in Bt-131 at 15 kR gamma radiation application. Dwarf forms with shortened internodes in M2 of the buckwheat seeds treated with gamma ray doses of 1, 5, 10 and 15 kR[18].

Plant Height (cm)

Plant height (cm) was significantly affected by radiation treatments (Table.3). Tallest (4.78 cm) plants were recorded, when cotton seed were irradiated at the rate of 20 krad. Shortest (4.63 cm) plants were observed in cotton varieties when radiation applied at the rate of 15 krad. Plant height significantly reduced by all doses of radiation[19]. Maximum (4.81 cm) plant height was observed in Bt-131. While minimum plant height (4.60 cm) was observed in Gomal-93. Radiation and varieties showed significance difference. Bt-131 showed tallest (6 cm) plants at 10 kR gamma radiation, while shortest (3.76 ft) plants were collected in highest dose of radiation (20 kR). Tallest (93.36cm) Okra plants as compared to Balady (90.53 cm), their seeds were radiated from 300 to 500 Gy[6]. Plant height was decreasing by increasing the dose of gamma-rays and in-significant differences in plant height were found between control and all treatments except the highest dose; 50 kR[20]. Similar results were obtained by[21]. Who found a gradual decrease of plant height and days to heading with increase of radiation dose.

Hundred Seed Weight (g)

Hundred seed weight was not significantly affected by radiation doses (Table. 3). Heaviest (7.98 g) seed weight was recorded, when radiated at the rate of 15 krad, while lightest (6.69 g) seed weight was observed in control plots. The effect of the radiation application on 100 seed weight of cultivars and lines were changed (8.85 to 12.48 g), while the highest 100 seed weight was obtained from ACH_{29} line that applied 400 gray radiations, the lowest was obtained from ACH_{34} line[22]. Cotton varieties have no significant effect on hundred seed weight. However, heaviest 8.2 seed weight was recorded in Bt-131 as compared with all other varieties. R×V interaction showed significant effect on hundred seed weight. Heaviest seeds (9.5) were counted in Gomal-93, when a cotton seeds were radiated at the rate of 15 krad. Lightest (6.77 g) seeds were seen in same variety, when the seed were kept control. Thousand seed weight for all treatments of gamma radiation were non-significant but the combination treatments such as 300Gy + 0.4%EMS and 300Gy + 0.5%EMS (30.50g and 29.80g) had shown considerable increase in 1000 seed weight over control[23].

CONCLUSION AND RECOMMENDATION

Maximum branches plant (24.3), flowers $plant^{-1}$(234.5) and heavy seed weight (7.98 g) were recorded in cotton varieties when seeds were irradiated at the rate of 15 Krad. While highest cotton weight $plant^{-1}$ (34.4 g) were observed at 10 Krad treated seeds. Highest flowers $plant^{-1}$ (241.3), seed weight $plant^{-1}$(8.2 g), tallest plants (4.81ft) and short intermodal length (1.42 cm) were observed in Bt-131 variety. However, more branches $plant^{-1}$ (29.9) and leaves $plant^{-1}$ (149.3) observed in Gomal-93 variety.

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APPENDIX

Table 1. Means of branches plant^{-1}, leaves plant^{-1} and bolls plant^{-1} as affected by selected irradiated cotton verities during second year rationing

Treatment	*Branches Plant $^{-1}$*			*Mean*	*Leaves Plant $^{-1}$*			*Mean*	*Bolls Plant $^{-1}$*			*Mean*
	Gomal-93	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*	
T0 Control	2.15 e	21.5e	16.7 g	19.9	1736.0 a	829.2 cd	1589.7 f	1062.2	328.0 bc	226 cd	487.6 cd	184.0
T1 (10 kR)	13.0 h	16.9 g	18.9 f	16.2	1126.8 g	1063.5 e	373 d	686.9	79.1 d	225 cd	126.0 cd	164.6
T2 (15 kR)	28.9 a	21.5 e	22.5 d	24.3	323.8 f	378.5 e	1255.1b	927.5	144.8 cd	152.2 cd	711.0 ab	238.6
T3 (20 kR)	28.2 b	23.5 c	8.2 i	19.9	16.8 f	814 c	245.2 fg	624	42.8 cd	76.2 a	69.3 cd	302.1
Mean	22.9	20.8	16.5	-	664.0	1006.4	805.5		162.2	273.1	231.7	-
Lsd at 0.05	Irradiation	Varieties	RxV	-	Irradiation	Varieties	RxV		Irradiation	Varieties	RxV	-
Values	0.6289	o.6289	0.6289	-	149.3	139.0	139.0	-	253.9	261.4	261.4	-

Table 2. Means of flowers plant^{-1}, seed weight (g) and cotton weight plant^{-1} as affected by selected irradiated cotton verities during second year ratooning

Treatment	*Flowers Plant $^{-1}$*			*Mean*	*Seed Weight (g)*			*Mean*	*Cotton Weight (g)*			*Mean*
	Gomal-93	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*	
T0 Control	332.3 b	234.0 i	494.9 e	194.1	35.6 d	45.0 c	53.0 b	40.7	28.0 de	54.6 e	34.3 cd	28.4
T1 (10 kR)	87.3 l	232.0 c	129.7 d	171.4	41.6 g	56.0 b	29.0 a	38.0	26.3 g	38.6 a	18.6 b	34.4
T2 (15 kR)	162.6 g	126.3 j	118.6 a	234.5	45.0 f	22.3 e	36.0 a	34.7	31.0 g	13.3 e	25.0 c	24.4
T3 (20 kR)	48.2 f	82.3 h	76.0 k	108.1	13.0 e	29.0 d	29.0 e	31.5	10.0 f	25.6 e	31.6 cd	25.1
Mean	159.1	130.6	241.3		25.0	37.9	45.9		17.5	32.9	33.9	-
Lsd at 0.05	Irradiation	Varieties	RxV	-	Irradiation	Varieties	RxV		Irradiation	Varieties	RxV	-
Values	0.6591	0.8944	0.8944	-	0.979	3.080	3.080		4.308	3.767	3.767	-

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Table 3. Means of intermodal length (cm), plant height (cm) and hundred seed weight (g) as affected by selected irradiated cotton verities during second year ratooning

Treatment	*Internodal length (cm)*			*Mean*	*Plant Height (ft)*			*Mean*	*100 Seed Weight (g)*			*Mean*
	Gomal-93	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*		*Gomal-93*	*Bt-cim-602*	*Bt-131*	
T0 Control	1.42 (b)	1.42 (a)	1.37 (b)	1.49	4.36 (def)	4.80 (bcd)	5.30 (bcd)	4.68	6.77 (c)	6.00 (c)	7.3 (bc)	6.69
T1 (10 kR)	1.70 (b)	1.50 (b)	1.42 (b)	1.46	4.90 (ef)	5.40 (bcd)	6.00 (ab)	4.71	7.24 (c)	6.40 (c)	9.48 (c)	7.71
T2 (15 kR)	1.37 (b)	1.46 (b)	1.36 (b)	1.40	4.80 (def)	4.46 (def)	4.60 (abc)	4.63	9.5 (a)	6.66 (c)	7.77 (c)	7.98
T3 (20 kR)	1.46 (b)	1.37 (b)	1.47 (b)	1.42	3.93 (a)	4.13 (cde)	3.76 (f)	4.78	7.84 (c)	7.74 (c)	8.23 (b)	7.94
Mean	1.44	1.46	1.42	-	4.69	4.60	4.81	-	7.8	6.70	8.2	-
Lsd at 0.05	Irradiation	Varieties	γxv	-	Irradiation	Varieties	γxv		Irradiation	Varieties	γxv	-
Values	0.09481	0.1448	0.1448	-	1.420	0.7856	o.7856	-	6.112	6.112	6.112	-

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Table. 4. Analysis of variance for branches plant^{-1}, leaves plant^{-1},bolls plant^{-1}, flowers plant^{-1}, seed weight (g), cotton weight plant^{-1}, intermodal length (cm), hundred seed weight (g) and plant height (cm) as affected by selected irradiated cotton verities during second year ratooning

Source of Variance	D.F	Branches Plant^{-1}	Leaves Plant^{-1}	Bolls Plant^{-1}	Flower Plant^{-1}	Seed Weight Plant^{-1}	Cotton Weight Plant^{-1}	Internodal Length (cm)	Plant Height (cm)
Replication	2	40.104	14304.35	28402.15	33.60	35.11	37.19	0.03	0.152
Radiation(R)	3	97.716**	378017.43**	34315.84 ns	25137.40**	143.29**	188.00**	0.016**	0.037ns
Error-I	6		0.132	7444.497	21517.936	0.145	2.963	6.194	0.003
Varieties (V)	2	125.1**	355153.0**	37650.90 ns	39707.17**	1336.69**	1016.36**	0.004ns	0.132ns
(R×V)	6	100.3**	1277511.965**	189353.66 **	66028.5**	350.88**	332.58**	0.038ns	2.215**
Error-II	16	0.132	6446.786	22801.040	0.267	3.167	4.736	0.007	0.206
Total	35	-	-	-	-	-	-	-	-

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