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Original Research Article

EVALUATION OF COTTON MUTANTS FOR WATER DEFICIT CONDITION

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Abstract: *Cotton (Gossypium hirsutum ssp.) belongs to the genus Gossypium from the family Malvaceae. About 100 genera are in the family Malvaceae and about 1500 species. It is grown worldwide for oil, seed, and fiber. A major problem in cotton cultivation is a drought that's why this experiment was planned to evaluate the cotton mutants for drought tolerance. A variety of cotton Cyto-155 was mutated with gamma rays at different intensities such that 20kR, 25kR, 30kR, and 35kR, to obtain some genetic variation. Mutated seed along with non-mutated of that cotton variety was sown in split plot layout under randomized complete block design with three replications, under the normal irrigated condition with six irrigations and water stress condition with two irrigations at maturity data was collected for plant height, number of monopodial branches, number of sympodial branches, bolls per plant, boll weight, seed index, GOT%, lint index, seed cotton yield, relative water content and excised leaf water loss. Results showed a highly significant effect of genotype and water regime on all observed traits. Water regime × genotype interaction was also highly significant for plant height, number of sympodial branches, seed index, boll weight, lint index, and excised leaf water loss. Water regime × genotype interaction was non-significant for number of monopodial branches, bolls per plant, GOT%, seed cotton yield, and relative water content. Mean comparison indicated that seed mutated at 30kR and 35kR performed well for all yield-related traits in both irrigated conditions.*

Keywords: Rice, submergence, drought, Sub1, stress tolerance indices

Introduction

The cotton word was derived from "Quotn" a word from Arabic language (Zafar, 2018). In India subcontinent, cotton is termed as "Kapas", which is derived from a word "Karpasa" a Sanskrit word (Blaise and Kranthi, 2019). Cotton is considered as one of the earliest grown crops. The initial reference to farming of cotton crop was founded in an Indian holy book Rig-Vida, which was written in 1500 BC (Zafar, 2018). Gossypium fibre has been discovered in the East found from 6000 BC from Mehargarh, (Baluchistan) Pakistan (NaSeer and JaN, 2018). Residues of cotton fibre were found in the West dating from 5800 BC in Mexico. The first cultivation of cotton was by the Indus valley civilization in 3500 BC (Singh and Nigam, 2017). The main purpose of growing cotton is the production of fibre. To isolate lint from its seed, seed cotton harvested from the crop is ginned. The separated lint is a spinnable raw material that is knitted or woven into fabrics for yarn production. The textile industry relies on cotton fabrics to make clothes, towels and other household items (Munir et al., 2020). Cotton seed composition is 45% meal, 28% hull, 17% crude oil and 10% short fibers after removing lint from the seed called linters. Cotton meal is high in protein (up to 41 %) and used in animal feed. The linters are used as a major source of cellulose in mattresses, mops, upholstery. To make oil, the seed is crushed. Seed oil from cotton is used in a variety of ways, including edible vegetable oil, plastics and soaps (Shuli et al., 2018).

Drought is a very complex phenomenon that involves many environmental factors that interact and define

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the severity and duration of drought (Farooq et al., 2009). As soil moisture levels decrease, plant water content decreases (Salehi-Lisar and Bakhshayeshan-Agdam, 2016). In plant biochemical processes, tissue water plays an important role. Under drought stress, normal plant functioning is highly disturbed (Ostmeyer et al., 2020; Tekle and Alemu, 2016). Due to lower stomatal behaviour, CO_2 absorption is reduced under conditions of drought stress. The decrease in the concentration of intercellular CO_2 results in impaired photosynthesis. Photosystem activity is affected by severe water shortage (Sharma et al., 2020). Electron sinks are reduced, and low photosynthetic rate combines with photorespiration because energy transduction is over-energized. Excess energy or electrons produce reactive oxygen species that damage ATP synthase, resulting in a decrease in ATP content as drought increases (Salehi-Lisar and Bakhshayeshan-Agdam, 2016; Tekle and Alemu, 2016).

Global climate change has posed a major challenge to sustained crop production (Bodner et al., 2015). Development of drought-tolerant crop plants to meet food and fiber demand has become a necessity in view of the ongoing process of water deficit for agricultural production (Saeed et al., 2012, Chen et al., 2011). Drought affects all crop production aspects from germination to final harvest. Increasing aridity of semi-arid regions and limited water resources have resulted in a crucial need to improve resistance to crop drought (Zia et al., 2021). Gamma rays emitted by physical mutagens during the decay of radioisotopes such as cobalt-60 (60Co), cesium-137 (137Cs) to a lesser extent plutonium-239 (239Pu) and these mutants are useful as a crop improvement raw material (Percy et al., 2015). These mutants create mutation on the plant's reproductive and somatic cells or any other surface of the living object that is exposed. The mutation is the only subject that contributes to the evolution, if it is a mutation of the germ line, it can be passed from one generation to another(Fang et al., 2018).Mutations mostly have negative effects, if the active amino acid site is altered, the protein function may be diminished or destroyed. But a small percentage of mutation improves the gene and gene product function that provides the evolutionary mill with the "grist". Evolution depends entirely on mutations as mutation is the only way to create new alleles and regulatory regions(Fang et al., 2018; Percy et al., 2015).

The following objectives were included in this study

1. Creation of genetic variability in a cotton variety through induced mutation.
2. Evaluation of cotton mutants for Drought Stress tolerance.
3. Evaluation of cotton mutants for yield components.

Materials and Methods

The current research work was conducted in the 2017 – 2018 in normal cotton growing seasons in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Below are the details of the various steps taken to carry out the research work. Seed of a cotton variety was mutated at different intensities of gamma rays such that 20kR, 25kR, 30kR and 35kR from Nuclear Institute for Agriculture and Biology. Mutated seed along with non-mutated of that cotton variety was grown under normal irrigated condition with six irrigations and water stress condition with two irrigations, in randomized complete block design followed by triplicate split plot design. Each mutated population was sown in two rows, maintaining 75 cm distance from one row to another and maintaining 30 cm distance from one plant to another plant. At maturity data was collected for the plant height, number of monopodial branches, number of sympodial branches, bolls per plant, boll weight, seed index, GOT%, lint index, relative water content, excised leaf water loss and seed cotton yield.

Statistical analysis

Mean data collected from mutants under two water regimes on all characters in each replication were used to analyze the variance (Steel and Torrie, 1980) to see the meaning of the genotypical and treatment methods. According to Split Plot Design, genetic data analysis was carried out. Tukey's HSD test was used for mean comparison.

Results

Plant Height

Analysis of variance for plant height revealed highly significant effect of genotype and water regime on plant height (Table 1). Water regime x genotype interaction was also highly significant for plant height (PH) indicating a differential response of genotypes across irrigation regimes. Mean values of plant height of genotypes in the normal and stressed condition are summarized in figure 1. Showing that the seed without mutation having a good performance for the height of plant in both conditions drought as well as in normal, whereas, mutant seeds which were radiated at 35kR, 30kR and 25kR have medium height and radiation at 20kR results in a lower plant height.

Number of Monopodial Branches

Analysis of variance for number of monopodial branches revealed highly significant effect of genotype and a significant effect of water regime on number of monopodial branches (Table 1). Water regime x genotype interaction was not significant for number of monopodial branches indicating a non-differential response of genotypes across irrigation regimes Mean values of number of monopodial branches of genotypes in the normal and stressed

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condition are summarized in figure 2. Showing that the seed without mutation having a good performance for the number of monopodial branches in both conditions drought as well as in normal, whereas, mutant seeds which were radiated at 20kR have medium range for the number of monopodial branches and radiation at 35kR, 30kR and 25kR results in a lower number of monopodial branches.

Number of Sympodial Branches

Analysis of variance for Number of Sympodial Branches revealed highly significant effect of genotype and water regime on Number of Sympodial Branches (Table 1). Water regime x genotype interaction was also highly significant for Number of Sympodial Branches indicating a differential response of genotypes across irrigation regimes. Mean values of Number of Sympodial Branches of genotypes in the normal and stressed condition are summarized in figure 3.Showing that the mutant seeds which were radiated at 25kR having a good performance for the number of sympodial branches in both conditions drought as well as in normal, whereas, seed without mutation and mutant seeds which were radiated at 30kR have medium range for the number of sympodial branches and radiation at 20kR and 35kR results in a lower number of sympodial branches.

Number of Bolls per Plant

Analysis of variance for Number of Bolls per Plant revealed highly significant effect of genotype and water regime on Number of Bolls per Plant (Table 1). Water regime x genotype interaction was non-significant for Number of Bolls per Plant indicating a non-differential response of genotypes across irrigation regimes. Mean values of Number of Bolls per Plant of genotypes in the normal and stressed condition are summarized in figure 4. Showing that the mutant seeds which were radiated at 30kR produces maximum number of bolls per plant and seed without mutation and mutant seeds which were radiated at 35kR having a good performance for the number of bolls per plant in both conditions drought as well as in normal, whereas, mutant seeds which were radiated at 20kR and 25kR have lower number of bolls per plant.

Boll Weight

Analysis of variance for boll weight revealed highly significant effect of genotype and water regime on boll weight (Table 1). Water regime x genotype interaction was also significant for boll weight indicating a differential response of genotypes across irrigation regimes. Mean values of boll weight of genotypes in the normal and stressed condition are summarized in figure 5. Showing that the mutant seeds which were radiated at 35kR having a good performance for the boll weight in both conditions drought as well as in normal, whereas, seed without mutation and mutated seeds at 30kR have medium boll weight and radiation at 20kR and 25kR results in a poor boll weight.

Lint Index

Analysis of variance for lint index revealed highly significant effect of genotype and water regime on lint index (Table 1). Water regime x genotype interaction was also significant for lint index indicating a differential response of genotypes across irrigation regimes. Mean values of lint index of genotypes in the normal and stressed condition are summarized in figure 6. Showing that the mutant seeds which were radiated at 30kR have maximum lint index in both conditions drought as well as in normal, whereas, seed without mutation and mutant seeds which were radiated at 35kR have good performance for lint index and radiation at 20kR and 25kR results in a lower value for lint index.

Seed Index

Analysis of variance for seed index revealed highly significant effect of genotype and water regime on seed index (Table 1). Water regime x genotype interaction was also highly significant for seed index indicating a differential response of genotypes across irrigation regimes. Mean values of seed index of genotypes in the normal and stressed condition are summarized in figure 7. Showing that the seed without mutation and mutant seeds which were radiated at 35kR gives a good value for seed index in both conditions drought as well as in normal, whereas, mutated seeds which were radiated at 20kR, 25kR and 30kR have a medium value for seed index.

GOT%

Analysis of variance for GOT% revealed highly significant effect of genotype and water regime on GOT% (Table 1). Water regime x genotype interaction was non-significant for GOT% indicating a non-differential response of genotypes across irrigation regimes. Mean values of GOT% of genotypes in the normal and stressed condition are summarized in Graph figure 8. Showing that the mutant seeds which were radiated at 30kR having a good performance for GOT% in both conditions drought as well as in normal, whereas, seed without mutation and mutated seeds which were radiated at 35kR have medium value for GOT% and radiation at 20kR and 25kR results in a poor value for GOT%.

Excised Leaf Water Loss

Analysis of variance for excised leaf water loss revealed highly significant effect of genotype and significant effect of water regime on excised leaf water loss (Table 1). Water regime x genotype interaction was also highly significant for excised leaf water loss indicating a differential response of genotypes across irrigation regimes. Mean values of excised leaf water loss of genotypes in the normal and stressed condition are summarized in figure 9.

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Showing that the mutant seeds which were radiated at 25kR having a maximum value for excised leaf water loss in both conditions drought as well as in normal, whereas, seed without mutation and mutated seeds which were radiated at 20kR have medium value for excised leaf water loss and radiation at 30kR and 35kR results in a lower value for excised leaf water loss.

Relative Water Content

Analysis of variance for relative water content revealed highly significant effect of genotype and significant effect of water regime on relative water content (Table 1). Water regime x genotype interaction was non-significant for relative water content indicating a non-differential response of genotypes across irrigation regimes. Mean values of relative water content of genotypes in the normal and stressed condition are summarized in figure 10. Showing that the seed without mutation have the maximum value of relative water content in both conditions drought as well as in normal and mutant seeds which were radiated at 25 and 30kR having a normal value for relative water content in both conditions drought as well as in normal, whereas, mutated seeds which were radiated at 20kR and 35kR have lower value of relative water content.

Seed Cotton Yield

Analysis of variance for seed cotton yield revealed highly significant effect of genotype and water regime on seed cotton yield (Table 1). Water regime x genotype interaction was non-significant for seed cotton yield indicating a non-differential response of genotypes across irrigation regimes. Mean values of seed cotton yield of genotypes in the normal and stressed condition are summarized in figure 11. Showing that the mutant seeds which were radiated at 30kR have the maximum amount of seed cotton yield in both conditions drought as well as in normal, whereas, seed without mutation and mutated seeds which were radiated at 35kR have medium amount of seed cotton yield and radiation at 20kR and 25kR results in a poor amount of seed cotton yield.

Table 1 Analysis of Variance for yield and yield related traits in cotton

Source	**DF**	**PH**	**NMB**	**NSB**	**NBP**	**BW**	**LI**	**SI**	**GOT%**	**ELWL**	**RWC**	**SCY**
Rep (A)	2	2.65	0.049	0.274	0.342	0.002	0.003	0.002	0.352	0.001	2.977	1.475
Treatment (B)	1	1181.9*	1.323*	122.412*	310.408*	1.262*	6.100*	2.253*	118.441*	0.104*	74.813*	71.787*
Error A*B	2	0.49	0.028	0.441	0.494	0.004	0	0.002	0.64	0.002	1.906	0.194
Genotype (C)	4	96.38*	0.537*	14.027*	46.021*	0.584*	5.987*	1.280*	286.222*	0.224*	89.692*	328.451*
B*C	4	42.39*	0.007	3.362*	6.883	0.017*	0.024*	0.037*	0.102	0.016*	0.851	0.04
Error A*B*C	16	1.24	0.009	0.439	3.617	0.004	0.006	0.008	1.69	0.001	2.199	0.681

* = Significant at 5% probability level, PH = Plant height, NMB = Number of monopodial branches, NSB = Number of sympodial branches, NBP = bolls per plant, BW = boll weight, SI = Seed index, GOT%, LI = Lint index, RWC = Relative water content, ELWL = Excised leaf water loss, SCY = Seed cotton yield

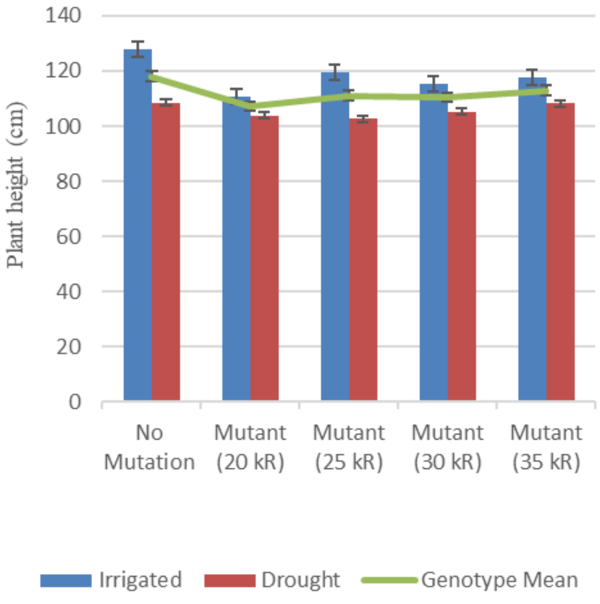

Figure 1 Tukey HSD All-Pairwise Comparisons Test of Plant Height

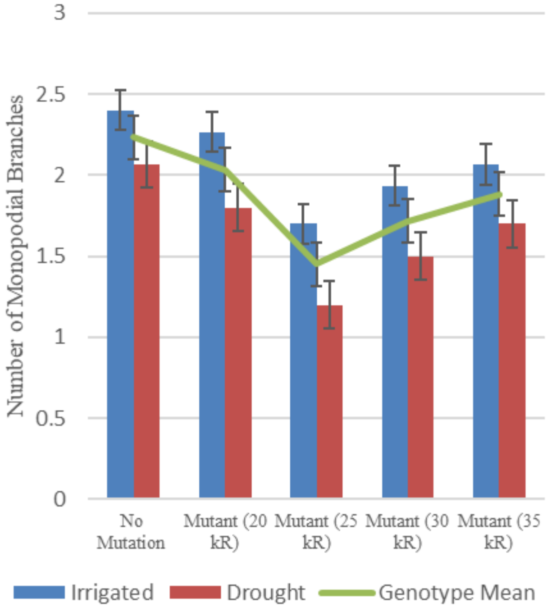

Figure 2 Tukey HSD All-Pairwise Comparisons Test of Number of Monopodial Branches

[Citation: Munir, M.A., Bashir, H., Zaghum, M.J., Aziz, S., Akhter, S., Ahmad, N.H., Kanwal, S., Kiran, S., Tipu, A.L.K., Liaqat, S., Ahmad, M.I., Latif, A., Latif, A., Nadeem, M., Shaukat, S. (2022). Evaluation of cotton mutants for water deficit condition. *Biol. Clin. Sci. Res. J.*, **2022***: 107*. doi: https://doi.org/10.54112/bcsrj.v2022i1.107]

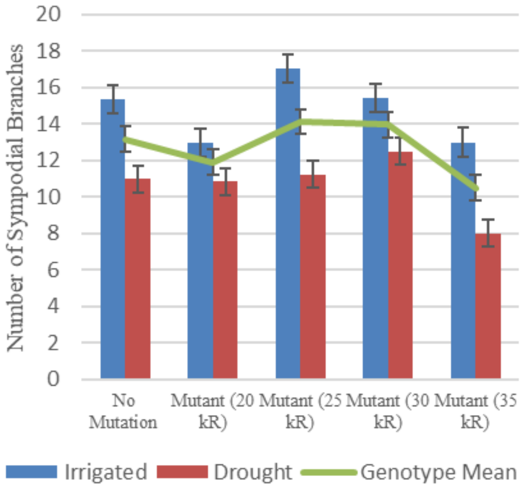

Figure 3 Tukey HSD All-Pairwise Comparisons Test of Number of Sympodial Branches

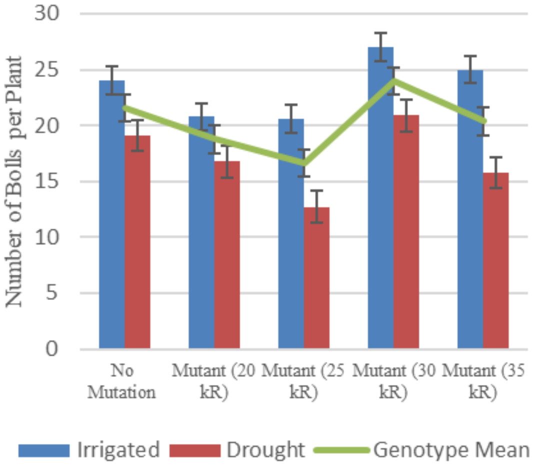

Figure 4 Tukey HSD All-Pairwise Comparisons Test of Number of Bolls per Plant

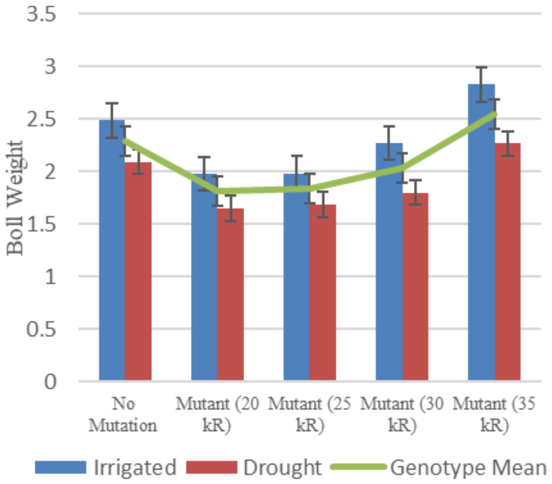

Figure 5 Tukey HSD All-Pairwise Comparisons Test of Boll Weight

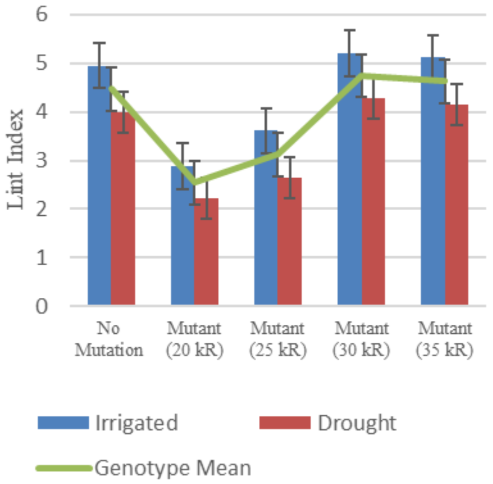

Figure 6 Tukey HSD All-Pairwise Comparisons Test of Lint Index

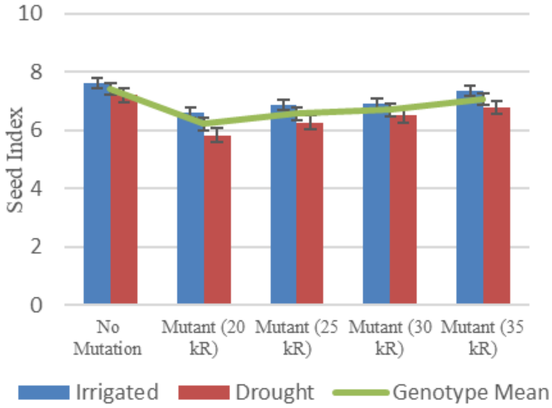

Figure 7 Tukey HSD All-Pairwise Comparisons Test of Seed Index

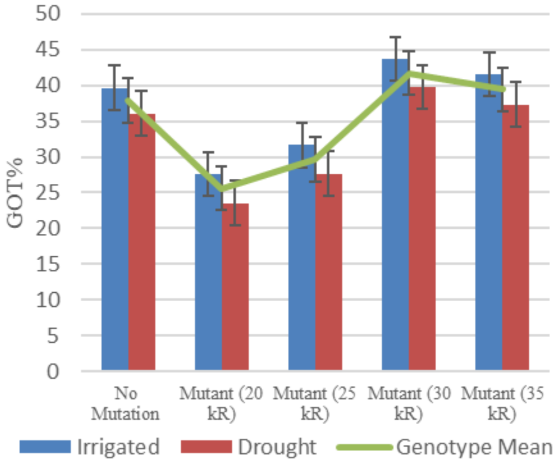

Figure 8 Tukey HSD All-Pairwise Comparisons Test of GOT%

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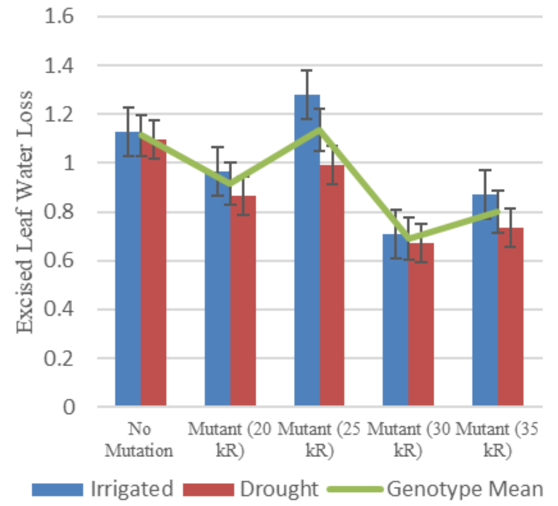

Figure 9 Tukey HSD All-Pairwise Comparisons Test of Excised Leaf Water Loss

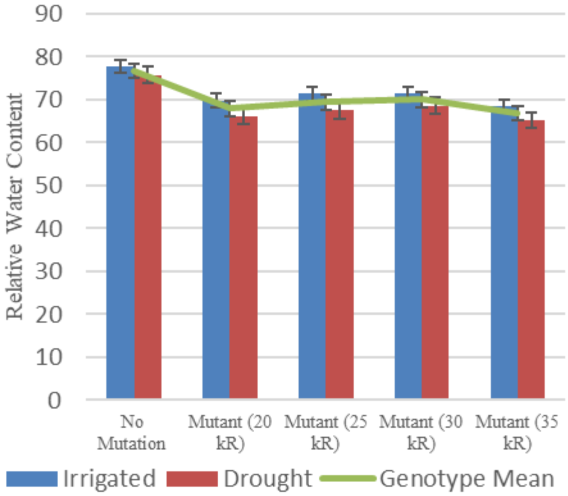

Figure 10 Tukey HSD All-Pairwise Comparisons Test of Relative Water Content

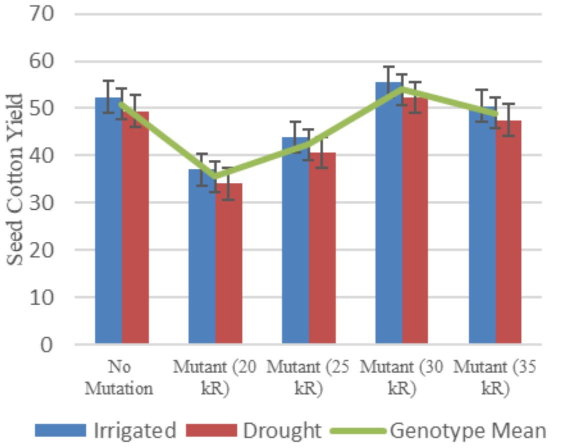

Figure 11 Tukey HSD All-Pairwise Comparisons Test of Seed Cotton Yield

Discussion

Current study has been done to measure the effect of genotype and water pattern on yield related traits. Seed of cotton was mutated by using gamma rays at different intensities 20kR, 25kR, 30kR and 35kR. Mutated and non-mutated seed was examined under normal and water stress conditions with three replications. Plant height is very important character in cotton crop and it can be influenced by the genetics of parent material as well as inputs provided. Genotype and irrigation have a significant effect on plant height. Similar observations were also done by A. (Sahito et al., 2015). He observed the considerable increase in plant height ($P < 0.01$) in response to varieties and irrigation frequency considerably affected the plant height while this was non-significant ($P > 0.05$) when irrigation frequency and input interacted. In current study it was observed that the plants without mutation and the plants which were mutated at 25kR performed well for plant height in both irrigated and drought condition. Above results are also confirmed by (Witt et al., 2018).For number of monopodial branches, it was observed that the plants without mutation and the plants which were mutated at 20kR performed well for the number of monopodial branches per plant in both irrigated and drought condition. Sympodial branches are the fruiting bodies that results in bolls ultimately for producing seed cotton and it is the scientific fact that number of sympodial branches develop simultaneously with number of bolls(Kaul et al., 2017). In current study it was observed that the plants which were mutated at 25kR and 30kR performed well for the number of sympodial branches per plant in both irrigated and drought condition.Number of bolls per plant contributes in increasing quantity of seed cotton per plant which eventually accumulates the seed cotton yield per hectare(Khan et al., 2019).It was observed that the plants which were mutated at 30kR and 35kR performed well for the number of bolls per plant in both irrigated and drought condition.The ginning out-turn (GOT) plays important role in the quality of cotton crop(Yaqoob et al., 2016). Analysis of variance showed that the differences in the G.O.T. percent were highly significant due to irrigation and different varieties, as well as interaction between them.

Under water deficit conditions, efficient use of resources (irrigation) is the first step for better crop production(Singh et al., 2010). Assessing the water requirement for cotton is one of the most crucial steps in this regard(Hussain et al., 2020).According to these observations it was found that the mutation of cotton seed with gamma rays at 30kR and 35kR can be helpful for the improvement of cotton plant for increasing its yield as well as for the better

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performance of cotton plant under water deficit condition.

Conflict of interest

The authors declared absence of conflict of interest.

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