INT. J. BIOL. BIOTECH., 16 (1): 129-135, 2019.

IMPACT OF GAMMA RAYS ON PHENOLOGICAL, GROWTH AND YIELD ASSOCIATED CHARACTERS IN BREAD WHEAT GENOTYPES

Tanweer Fatah Abro[1], Abdul Wahid Baloch[1], Zahoor Ahmed Soomro[1], Mehboob Ali Sial[2], Wahid Dino Sipio[1], Muhammad Naveed Tareen[4], Ayaz Ahmed Lashari[3], Muhammad Sharif Kakar[4],Gul Muhammad Panezai[4] and Ghulam Asghar Baloch[4]

[1]Department of Plant Breeding & Genetics, Sindh Agriculture University, Tandojam,
[2]Nuclear Institute of Agriculture, Tandojam, Pakistan, [3]Agriculture Extension, Dera Murad Jamali, Balochistan, [4]Agriculture Research Institute Quetta

ABSTRACT

The effect of gamma rays on morphological and yield associated traits of bread wheat irradiated with 150, 200, 250 and 300Gy was observed on newly developed mutant population (M1). The population was developed from four commercial wheat varieties viz., Khirman, TD-1, NIA-Sarang and ESW-9525. The mutation populations originating from four different doses of gamma rays were evaluated along with their mother varieties (non-irradiated) under the field conditions for growth, phenological and yield associated traits in a split plot design with three replications. The present research revealed that means were significantly different ($P \leq 0.05$) among the genotypes for most of the traits, whereas treatments also created significant variations for some of the traits. Thus, these genotypes and treatments (Gamma rays) can be utilized for further breeding programs to improve bread wheat for various traits. Among the doses, the lowest dose (150 Gy) exhibited desirable results for most of the traits, referring that low dose of radiation may be useful in order to achieve better results for various quantitative traits. Considering the mean performance among the mutants, the TD-1-mutant showed outstanding performance for majority of the traits, followed by NIA-Sarang-mutant. Of special note, the mutants of TD-1and NIA-Sarang were found to be promising for variety of traits, suggesting that TD-1 and NIA-Sarang mutant can extensively be used in breeding programs, so that bread wheat can be improved with respect to growth, phenological and yield associated traits.

Keywords: Mutation, gamma irradiations, wheat varieties, yield associated traits

INTRODUCTION

Wheat, *Triticum aestivum* L., belongs to the family *Poaceae* is considered as staple cereal crop in the World. Due to main consumption of wheat in human diet and wide adaption makes it one of the most important crops in the world (Farzi and Bigloo, 2010). There is limited genetic variability among the existing wheat genotypes; however, to enhance the genetic variability Muller (1927) and Stadler (1928) initiated the mechanism of induced mutation which became an important tool in plant breeding. Mutation breeding has very significant contributions in various crops for improving agronomical traits (Maluszynski *et al.,* 1995). Induced mutation can improve the existing genotypes for certain specific traits. Induced mutations have been successfully used in major crops such as wheat, rice, cotton and barley (Ahloowalia and Maluszynski, 2001). Different kinds of radiation such as alpha, beta and gamma rays are being used for inducing mutation among the existing wheat genotypes. The utilization of radiation enables the plant breeder for selecting the highly diverse mutant genotype. Gamma rays are highly penetrating radiation with high level of energy in comparison to alpha and beta (Kovacs and Keresztes, 2002). Agronomical, physiological and other yield contributing characters of wheat can be improved by treating the wheat genotypes with gamma rays (Kiong *et al.,* 2006). Although advance molecular techniques such as embryo culture, tissue culture and pollen culture have also been developed for improvement of crops, but still induced mutation remained of prime importance due to existence of rare type of beneficial mutants. Till to date, more than 3088 varieties of different crop species have been produced through mutagens (FAO, 2014). Different researchers have studied the effect of gamma rays. Rao (1975) reported that there will be drastic effect on quality of wheat if dose is above 5 kGy. Similarly, Ghafoor and Siddiqui (1976) found significant difference for number of tillers and plant height in wheat varieties after exposing to gamma irradiation. Choudhry (1983) applied 10-14 kr gamma rays to dry grain of wheat varieties for evaluating germination percentage, and found that germination increase, on applying lower dose in lines having poor germination. Thus, mutation plays an important role to produce highly diverse and promising genotypes. Keeping in view the above facts, the current study was carried out with the aim to determine the effect of gamma irradiations on growth, phenological and yield associated characters in bread wheat genotypes.

MATERIALS AND METHODS

The experiment was conducted at Nuclear Institute of Agriculture (NIA), TandoJam during rabi season, 2013-14. The experiment was laid out in split plot design (SPD) having three replications. Each variety was sown with five rows of 4m length at 30 cm distances. Four wheat varieties/advance lines viz; Khirman, TD-1, NIA-Saarang, ESW-9525 along with control (non-irradiated) material was studied under field conditions. The seeds were got irradiated with four (150Gy, 200Gy, 250Gy and 300Gy) different doses of gamma rays from Nuclear Institute of Medicine and Radiotherapy (NIMRA), Jamshoro. The following observations, like, early growth vigor, plant height, days to heading, days to maturity, spikelets spike^{-1} and 1000-grain weight were recorded. Early growth vigour was recorded after twenty and thirty days of sowing. The plant height was measured at the time of crop maturity. Days to heading was recorded when more than 75% spikes came out from the flag leaf. Days to maturity was recorded when crop was fully matured. Numbers of spikelets spike-1 were counted visually at time of maturity, whereas 1000-grain weight was recorded from each variety and weight was recorded in grams. The sowing was done by dibbling, keeping 20 cm space between plants and 30 cm between rows. Five plants were randomly selected and tagged from each replication. After collecting necessary data under field conditions, further observations were recorded at the laboratory. All the required cultural operations were adopted uniformly throughout the growing period as and when required. The analysis of variance for all the traits was carried out separately as described by Gomez and Gomez (1984) to established the level of significance among the varieties and the means were compared through Duncan's Multiple Range test (DMRT) by statistix-10.0 version computer package.

RESULTS AND DISCUSSION

The analysis of variance was carried out to investigate the differences among mutants and non-irradiated parental varieties for various traits (Table-1). The results indicated that the mean squares obtained from ANOVA for genotypes were significantly ($P \leq 0.05$) different with one another for all the measured traits except days to maturity. The mean squares of treatments significantly differed with one another for three traits, such as, early growth vigour, plant height and number of days to heading. The mean squares for genotype x treatment (GxT) interaction were non-significant for all the studied traits. Thus, it indicates that genetic variation existed in all bread wheat genotypes, referring that genetic resources used in the current study may be used for further breeding programs.

Table 1. Mean squares of different quantitative traits of bread wheat genotypes.

Sources of variation	D.F.	Mean squares					
		Early growth vigour (cm)	**Plant height (cm)**	**Days to heading**	**Days to maturity**	**Spikelets spike^{-1}**	**1000-grain weight (grams)**
Replications	2	55.86	2.02	1.093	38.53	2.27	0.26
Genotypes	7	956.72**	1590.19**	107.62**	16.36$^{N.S}$	72.37**	238.64**
Error A	14	16.95	16.52	11.36	13.0	1.41	0.66
Treatments	3	320.60**	136.54**	58.46**	24.04$^{N.S}$	2.12$^{N.S}$	0.49$^{N.S}$
Genotypes x Treatments	21	27.10$^{N.S}$	12.99$^{N.S}$	5.83$^{N.S}$	13.89$^{N.S}$	1.08$^{N.S}$	0.83$^{N.S}$
Error B	42	21.39	13.23	8.01	12.82	1.14	0.65
Total	89						

Note: ** = Significant at 0.01 level of probability; NS= Non-significant

Early growth vigour (cm)

Overall mean for early growth vigour depicted that TD-1-mutant showed significant increase in early growth vigour (54.16 cm) as compared to the other mutants (Table-2). The decreased early growth vigour (40.24cm) was observed in the Khirman-mutant than rest of the mutants. Considering the dose effects, the dose of 150 Gy produced better results for the mutants of TD-1 (61.85cm) and NIA-Sarang (60.70cm).The results suggested that mutants of TD-1 variety are more vigorous than all the other mutants; therefore, the variety TD-1 could be utilized in various mutation breeding programs in order to improve bread wheat genotypes. With regard to dose effects, all mutants demonstrated more vigour at low dose (150 Gy) as compared to higher dose i.e. Khirman-mutant (45.41 cm), TD-1-mutant (61.85 cm), NIA-Sarang-mutant (60.70 cm) and ESW-9525-mutant (47.91 cm). It is further confirmed that low dose of radiation is more desirable in turn to achieve desirable results for agro-morphological traits.

Table 2. Mean performance of mutants and their parents for early growth vigour in bread wheat genotypes.

Genotypes	Early growth vigour (cm)				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	45.41	42.85	35.66	37.02	40.24 E
TD-1-mutant	61.85	56.67	46.69	51.45	54.16 C
NIA-Saarang-mutant	60.70	52.89	45.55	47.71	51.71 C
ESW-9525-mutant	47.91	45.91	36.44	36.05	41.58 E
Khirman-control	61.10	56.70	59.21	57.37	58.60 B
TD-1-control	63.67	63.97	63.78	62.70	63.53 A
NIA-Saarang-control	67.49	64.07	58.76	60.10	62.61 A
ESW-9525-control	49.20	45.95	47.66	47.55	47.59 D
Mean	57.2A	53.6B	49.2C	50.0C	

Plant height (cm)

The mean performance showing plant height is depicted in Table -3. The maximum plant height was observed in Khirman-mutant (95.73 cm) while minimum plant height (70.23cm) was observed in the TD-1-mutant (70.23 cm). On an average, mutants took more days to heading comparing to parental lines. Thus, applying irradiation for improving plant height could not be effective, so conventional breeding should be carried out in order to improve plant height trait.

Table 3. Mean performance of mutants and their parents for plant height in bread wheat genotypes.

Genotypes	Plant height (cm)				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	97.1	98.2	92.7	94.9	95.73 B
TD-1-mutant	73.3	71.0	69.7	66.9	70.23 F
NIA-Saarang-mutant	97.3	92.5	87.5	85.7	90.75 C
ESW-9525-mutant	86.5	83.8	78.7	78.5	81.88 E
Khirman-control	102.4	102.9	100.9	100.7	101.75 A
TD-1-control	75.9	74.5	69.7	72.1	73.05 F
NIA-Saarang-control	99.4	96.6	97.6	97.4	97.75 B
ESW-9525-control	88.7	83.5	87.5	82.2	85.48 D
Mean	90.1A	87.9B	85.5C	84.8C	

Days to heading

Genotypes showed different response for days to heading. Number of days taken to ear emergence in the wheat mutant population was significantly increased as compared to non-irradiated (control)/parental lines. The result showed that the highest number of days to heading (88.40 days) was recorded in Khirman-mutant as compared to other mutant lines and its mother variety Khirman (84.52 days). The second ranked genotype was mutant of ESW-9525, which also took the significantly highest number of days to heading (88.07 days) than its mother variety ESW-9525 (86.68 days). Taking overall mean number of days to heading in consideration at different gamma irradiation doses, it was observed that significantly minimum number of days to heading (78.9 days) were recorded in T1(150 Gy), whereas days to heading were increased in other treatments viz. T2: 200 Gy, T3: 250 Gy and T4: 300 Gy (Table 4).On an average, the mutants took more days to heading while comparing parental lines, indicating that applying radiations to evolve early maturing verities is still in question, hence conventional breeding may be preferred. The results suggested that low dose of gamma rays could be more beneficiary for achieving desirable results in bread wheat genotypes.

Table 4. Mean performance of mutants and their parents for days to heading in bread wheat genotypes.

Genotypes	**Days to heading**				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	86.1	87.7	89.3	90.5	88.40A
TD-1-mutant	78.9	81.9	85.9	82.4	82.28CD
NIA-Saarang-mutant	82.5	83.4	86.3	86.0	84.55BC
ESW-9525-mutant	86.7	87.1	90.1	88.5	88.07 A
Khirman-control	83.7	85.1	84.4	84.9	84.52 BC
TD-1-control	78.9	80.1	82.7	79.6	80.33 D
NIA-Saarang-control	80.3	81.1	83.4	82.0	81.70 CD
ESW-9525-control	87.2	82.1	89.3	88.1	86.68 AB
Mean	83.03B	83.56B	86.43A	85.24A	

Days to maturity

Days taken to maturity period by wheat genotypes showed significant difference ($P \leq 0.05$) for irradiated as well as non-irradiated (control) population (Table-5). Results depicted that the significantly highest number of days (124.68 days) were taken to maturity as it was observed in ESW-9525-mutant as compared to its control (non-rradiated) mother variety ESW-9525 (122.43 days). The second ranked genotype which took more days to maturity was Khirman-mutant which matured in 124.62 days. The minimum days to maturity (122.3 days) were found in T1 (150 Gy) as compared to other treatments. The difference between other 3 treatments was non-significant T2 (122.3 days), T3 (123.9 days) and T4 (123.5 days). The maturity period of wheat genotypes decreased at T1 (150 Gy) as compared to other treatments. The lower doses/concentrations of the mutagenic treatments could enhance the biochemical components, which are used for the improvement of economic traits (Muthusamy *et al.*, 2003) Gamma radiations are dose dependent, where a low dose has less effect comparing to high dose. Therefore, suitable dose must be identified for improvement of specific traits of crop plants (Jamil and Khan, 2002).

Days taken to maturity period by wheat genotypes showed significant differences for irradiated as well as non-irradiated populations suggesting that both (conventional and non-conventional) approaches can be used to get early maturing cultivars. Our results are in agreement with those obtained by Singh and Balyan (2009).

Spikelets spike^{-1}

The Khirman-mutant produced the highest number of spikelets spike^{-1} (23.80) compared to other mutant varieties. Khirman parent showed an increase in number of spikelet spike^{-1} (25.63). However, the lowest (18.0) number of spikelets spike^{-1} were observed in TD-1-mutant as compared to control parent (19.62). More number of spikelets spike-^{1} (24.2) were recorded in T1 (150 Gy, whereas T3 and T4 showed decrease in this trait (Table-6). Thus, it can be suggested from the present findings that lower doses of radiations are more suitable than higher doses.

Table 5. Mean performance of mutants and their parents for days to maturity in bread wheat genotypes.

Genotypes	**Days to maturity**				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	124.2	123.4	125.6	125.3	124.62 A
TD-1-mutant	122.3	122.9	124.2	123.9	123.33 AB
NIA-Saarang-mutant	122.4	122.3	123.9	123.5	123.00 AB
ESW-9525-mutant	123.9	123.9	125.7	125.3	124.68 A
Khirman-control	124.1	122.7	123.8	123.5	123.52 AB
TD-1-control	122.9	122.7	123.6	122.2	122.87 AB
NIA-Saarang-control	122.3	122.9	123.3	115.9	121.08 B
ESW-9525-control	124.6	115.1	125.3	124.8	122.43 AB
Mean	123.3AB	122.0B	124.4A	123.0AB	

Table 6. Mean performance of mutants and their parents for spikelets spike^{-1} in bread wheat genotypes.

Genotypes	**Spikelets spike^{-1}**				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	24.2	24.1	23.3	23.7	23.80 B
TD-1-mutant	18.3	18.1	17.4	18.2	18.00 F
NIA-Saarang-mutant	22.9	22.5	21.5	21.3	22.03 CD
ESW-9525-mutant	22.1	21.7	20.2	20.6	21.13 D
Khirman-control	25.5	26.5	25.0	25.5	25.63 A
TD-1-control	20.1	19.7	19.4	19.3	19.62 E
NIA-Saarang-control	24.2	23.3	24.6	23.1	23.80 B
ESW-9525-control	22.1	21.5	23.0	22.9	22.35 C
Mean	22.4	22.1	21.8	21.8	

1000-grain weight (g)

The highest (48.44g) 1000-grain weight was recorded in NIA-Sarang-control, followed by mutant of NIA-Sarang (47.30g). The significantly lowest (36.48) 1000-grain weight was shown by ESW-9525-mutant, followed by control of ESW-9525 (37.03). The results obtained from overall treatment wise mean at different gamma irradiation doses showed non-significant difference between the treatments (Table-7).In view of the previous studies, many scientists including Jamil and Khan (2002) and Albokari (2014)also advocated that low dose of radiations could give desirable 1000-grain weight. In consonance with our results, Singh and Balyan (2009) also reported that some promising mutants produced higher 1000-grain weight, number of tillers plant^{-1} and spikelets spike^{-1} in M_3 generation as compared to control.

Table 7. Mean performance of mutants and their parents for 1000-grain weight (g) in bread wheat genotypes.

Genotypes	**1000 grain weight (g)**				
	T1(150Gy)	**T2(200Gy)**	**T3(250GY)**	**T4(300Gy)**	**Mean**
Khirman-mutant	45.3	45.2	45.0	44.7	45.06 D
TD-1-mutant	43.4	44.2	43.2	42.9	43.43 E
NIA-Saarang-mutant	47.2	47.7	47.3	47.0	47.30 B
ESW-9525-mutant	36.7	36.5	36.6	36.1	36.48 F
Khirman-control	46.0	45.7	45.9	45.7	45.84 C
TD-1-control	44.8	44.7	44.6	44.7	44.69 D
NIA-Saarang-control	48.4	48.4	48.6	48.4	48.44 A
ESW-9525-control	37.5	35.2	38.0	37.4	37.03 F
Mean	43.7A	43.5A	43.6A	43.4A	

Conclusions

The present research revealed that means were significantly different ($P \leq 0.05$) among the genotypes for most of the traits whereas treatments also created significant variations for some of the traits thus these genotypes and treatments (Gamma rays) can be utilized for further breeding programs to improve bread wheat for various traits. Among the doses, the lowest dose (150 Gy) demonstrated desirable results for variety of traits, suggesting that low dose of radiation can be useful in order to obtain better results for quantitative traits. Concluding that the, mutants of TD-1 and NIA-Sarang were found to be promising for a range of characters, suggesting that these both mutants can extensively be used in breeding programs.

Acknowledgements

The authors wish to acknowledge to the Director, Nuclear Institute of Agriculture, Tandojam for providing facilities in the experimental field and laboratory to carry out the present research work.

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(*Accepted for publication December 2018*)