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EFFECT OF GAMMA RAYS AND FAST NEUTRONS TREATMENTS ON TILLER NUMBER AND PLANT HEIGHT IN WHEAT*

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Abstract

Six cultivars (Pak-70, Barani-70, Mexipak, Nayab, 6134 X C-271 and *H*-68) of bread wheat, *Triticum aestivum* (2n = 6x = 42 = AABBDD) with diverse stability of yield were selected for treatment with gamma rays (^{60}Co. 10, 15 and 20 kR) and fast neutrons (Nf. 300, 450 and 600 RADS). The irradiated seeds alongwith respective non-irradiated controls were grown during 1972-73. Studies on tiller number per unit area and plant height at maturity were undertaken.

Analysis of results showed that these cultivars varied significantly for both the characters. Significant treatment effects were observed only for tiller number. However, cultivars X treatments effects were non-significant for tiller number as well as for plant height, indicating a stability of performance across different irradiation treatments. The treatment Nf. 450 RADS showed significantly reduced tiller number as compared with the control whereas other treatments were similar to control in performances of both these characters.

Introduction

Plant height and tiller number have evolutionary significance (Siddiqui, 1971) and are important for plant breeders because of their respective influences on crop yield (Romero & Frey, 1973; Joppa, 1973; Shukla, 1974). At present, many plant breeding programmes are concentrating on development of semi-dwarf selection with one gene only (Allan & Pritchett, 1973). Semi-dwarf trait, for instance, is doubly beneficial in wheat production because short plants are lodging resistant and have high grain-straw ratios (Vogal *et al.*, 1956). Semi-dwarf lines also produce more tillers than the tall lines, and as expected, environments have large effect on the number of tillers. Environments that induce the highest number of tillers also produce the highest yields (Joppa, 1973).

Considerable work has been done on the effects of ionizing radiations on seeds, seedlings and plant tissue cultures among different agricultural crops (Sparrow, 1966; Bajaj *et al.*, 1970 and Walther & Haug, 1973). These studies have suggested that radiosensitivity varies considerably among cultivars, although there are no significant differences in nuclear size and DNA content of the interphase chromosomes. The information on the effects of radiation on the productive traits, such as tiller number and plant height is however very scanty (Bhatia & Swaminathan, 1962).

In the present work, cultivars were selected on the basis of their stability performance to study the effects of gamma rays and fast neutrons on plant height and tiller number. Such studies can be instrumental in producing genotypes and population with high genetic homeostatis (Lerner, 1954) and ultimately in enhancing the yield of varieties of bread wheat.

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Materials and Methods

The following six cultivars of bread wheat, *Triticum aestivum* ($2n = 6x = 42$), were selected for treatment with gamma rays and fast neutrons.

(1) Pak-70	:	A variety evolved in Pakistan from a cross between C-271 X (Wt. (E)—Sonora 64). Bred at ARI, Tandojam, Sind.
(2) Barani-70	:	A variety evolved in Pakistan from a cross between (Pitic 62-Gabo) X C-271. Bred at ARI. Lyallpur, Punjab.
(3) Mexi-pak	:	A variety derived from a cross between Penjamo "S" X Gabo 55 made at CIMMYT, Mexico. The segregating material (F2 generation) was introduced into Pakistan. A progeny was selected and tested in Pakistan. Released as variety in 1965.
(4) Nayab	:	A variety derived from a cross between (Pj. 62-Gb. 55 X Gb. 56) X (Tzpp. X Nai. 60) in Pakistan. Bred and evolved at ARI. Tandojam, Sind, in 1968.
(5) 6134 X C-271	:	A line derived from a progeny of a cross between 6134X C-271 in Pakistan. Bred at ARI, Tarnab, NWFP. Extensively used in breeding programme of Wheat Section at ARI, Tandojam, Sind, for specific characters.
(6) H-68	:	A local variety derived from a cross between HSW-III X I.P. 120 made at Sakrand in 1947. Selected and released during late fiftees at ARI, Tandojam, Sind.

The basis of selection of the cultivars for irradiation treatments in terms of stability parameters is presented in Table 1.

TABLE 1. Stability parameters of cultivars selected for irradiation treatments. (Based on yield data of 12 cultivars tested over 9 sites in Sind, Pakistan).

Cultivar	Mean yield over all sites (gm/plot)	Relative Yield	Stability indices	
			Regression coefficient(b)	S.E. (b)
(1) Pak—70	550.8	100	1.08	.193
(2) Barani—70	511.4	92.8	1.41	.264
(3) Mexi-pak	526.1	95.5	1.08	.412
(4) Nayab	474.2	86.1	1.09	.314
(5) 6134 X C-271	493.5	89.6	0.94	.374
(6) H-68	497.6	90.3	1.08	.403

Seeds of each of these cultivars were sent to IAEA, Vienna, Austria for treatment with different doses of gamma-rays (^{60}Co. 10, 15 and 20 kR) and fast neutrons (Nf. 300, 450 and 600 RADS). The treated seeds and the respective controls were sown in the field plots at this Centre in a split-plot design with 4 replications during year 1972-73. Wheat cultivars made up the main plots and irradiation treatments the sub-plots. Each plot consisted of 5 rows 1.5m long spaced at 30 cm apart. Seventy five seeds were planted in each plot with 15 seeds per row while the plant to plant distance within a row was kept 10 cm.

At maturity, 6 samples of 30 cm long portions from the three central rows of each plot were selected randomly. Observations for productive tiller number and plant height (cm) were recorded for each sample. Data on tiller number per unit area and plant height were recorded as the mean obtained from the six randomly selected samples used for measurement in each plot.

The data for each character were analysed statistically by a split plot technique. The cultivars effects, treatments effects and cultivars X treatments interaction effects were studied.

TABLE 2. Analysis of variance for *tiller number per unit area* in M_1 generation (1972-73).

Source of variation	df	MS	VR
Replicates	1	31.3	
Cultivars (Factor A)	5	47.9	18.42**
Error (a)	5	2.6	
Treatments (Factor B)	6	8.1	2.53*
A X B interaction	30	4.2	1.31ns
Error (b)	36	3.2	
TOTAL:	83		

ns — Non-significant, * — Significant at 5% level.
** — Significant at 1% level.

(1) Coefficient of variability (c.v): c.v (a) = 5.63%
c.v (b) = 6.26%

(2) Difference between two cultivar means (factor A): LSD (.05) = 1.57

Difference between two treatment means (factor B): (LSD (.05) = 1.48

Difference between two treatment means in the same cultivar: LSD (.05) = 3.63

Results and Discussion

The analyses of variance for tiller number per unit area and plant height are presented in Tables 2 & 3, whereas the data of mean values of these characters in each of the irradiated populations are recorded in Tables 4 & 5. The cultivar mean squares were significant at 1% and 0.1% levels of probability for tiller number and plant height respectively. This indicates that the cultivars under study varied significantly for both the characters. The analyses of variance results (Tables 2 & 3) showed that significant treatments effects (P >.05) were observed only for tiller number. In comparison between non-irradiated controls and irradiated populations, tiller number was significantly increased and decreased for the γ—15 kR and Nf. 450 RADS treatments respectively in case of Pak-70 cultivar. It is interesting to note that the mean values for this character were decreased with the fast neutron treatments whereas the means were increased in the gamma-rays irradiated populations of

TABLE 3. Analysis of variance for *Plant height* (*cm*) in M_1 generation (1972-73).

Source of variation	df	MS	VR
Replicates	1	169.2	
Cultivars (Factor A)	5	1,689.2	72.81***
Error (a)	5	23.2	
Treatments (Factors B)	6	3.1	0.62ns
A X B interaction	30	7.4	1.48ns
Error (b)	36	5.0	
TOTAL:	83		

ns — Non-significant, *** = Significant at 0.1% level.

(1) Coefficient of variability (c.v): c.v (a) = 5.39%
c.v (b) = 2.51%

(2) Difference between two cultivar means:
(Factor A): LSD (.05) 4.68
LSD (.01) = 7.33

Pak-70. Further more, a significant decrease in tiller number of 613⁴X C-271 cultivar was observed for the γ—20 kR irradiated population (Table 4). While studying the effect of EMS (0.04m) treatment on floret sterility of barley cultivars (having different yields and adaptation patterns) Ghafoor Arain (1974) concluded that considerable M_1 sterility was induced in the treated material compared to respective control in each cultivar but the magnitude of induced floret sterility of different cultivars varied widely.

TABLE 4. Mean tiller number of wheat cultivars.

Cultivar	Irradiation treatments (doses)							Mean for Cultivars
	Control	Nf. 300 RADS	Nf. 450 RADS	Nf. 600 RADS	^{60}Co. 10 kR	^{60}Co. 15 kR	^{60}Co. 20 kR	
Pak-70	30.3	26.9	26.5*	27.9	30.8	34.6*	30.6	29.6
Barani-70	30.3	28.9	27.7	27.5	29.2	30.4	29.2	29.0
Maxi-pak	28.9	28.7	26.7	26.9	28.5	27.9	27.9	27.9
Nayab	26.9	28.6	30.1	28.9	28.8	29.8	28.6	28.8
6134XC-271	27.0	25.7	25.0	25.8	26.1	26.4	21.6*	25.3
H-68	31.1	31.8	29.7	30.1	30.7	30.8	31.4	30.8
Mean for Treatments	29.1	28.4	27.6*	27.8	29.0	30.0	28.2	

*Treatment means significantly different from respective controls at P>0.05

For the average of all the six cultivars, the mean tiller number was decreased in all the doses of fast neutrons compared with control. However, the maximum reduction was observed at both the higher doses (Nf. 450 RADS and Nf. 600 RADS) compared with the lower dose (Nf. 300 RADS). There was hardly any meaningful difference in the overall mean values between Nf. 450 RADS (27.6) and Nf. 600 RADS (27.8) treatments but the significance of the former treatment became statistically pronounced (P>.05) compared with the control. This reduction was contributed mainly by one cultivar *viz.* Pak-70 in the case of Nf. 450 RADS (Table 4). Moreover, mean tiller number over all cultivars was increased for γ—15 kR treatment but this change in mean was statistically non-significant. The analyses of variance results (Tables 2 & 3) show that cultivars X treatments interaction mean squares were non-significant for both the characters, indicating a consistency of performance over different irradiation treatments.

The prime object of this study was to initiate genetic variability for different quantitative traits in bread wheat cultivars with diverse yield and stability characteristics, so as to utilize the desirable changes in our breeding programmes. The mutagenic treatments essentially provide a threshold of heterozygosity and subsequently a basis of segregation in the M_2 or even in M_3 generation. Our studies on M_2 generation (unpublished data) have shown that the doses of irradiation reported in the present paper were quite effective in producing segregants with desirable plant breeding attributes such as increased number of productive tillers, stiff and short straw, earliness, lateness, and bold kernels. It therefore seems necessary to concentrate on characters of agronomic significance, which manifest themselves at maturity rather than at the earlier stages of growth and development.

TABLE 5. Mean plant height (cm) of wheat cultivars.

Cultivar	Irradiation treatments (doses)							Mean for Cultivars
	Control	Nf. 300 RADS	Nf. 450 RADS	Nf. 600 RADS	^{60}Co. 10 kR	^{60}Co. 15 kR	^{60}Co. 20 kR	
Pak-70	84.5	85.0	86.1	87.2	87.1	85.6	85.2	85.8
Barani-70	82.9	87.0	88.1	87.8	89.2	88.9	88.1	87.4
Mexi-pak	89.3	85.7	84.3	85.2	84.2	86.4	87.3	86.7
Nayab	86.1	87.9	91.5	88.1	88.6	91.0	87.6	88.7
6134XC-271	79.2	78.7	77.1	75.9	77.5	77.4	77.2	77.5*
H-68	108.8	111.2	109.6	110.8	111.9	107.5	112.6	110.3**
Mean for Treatments	88.4	90.0	89.4	89.2	89.7	89.4	89.6	

*, ** denote cultivar means significantly different from other cultivars at $P > .05$ and $P > .01$ respectively.

As breeders we are interested in positive changes and not in undesirable changes which usually accompany the acute irradiation treatments. The choice of doses of gamma rays as well as fast neutrons seems to be quite appropriate as the irradiated material was devoid of drastic changes in the mean values of plant height and of tiller number. This may also be due to the compensation provided by the homeologous alleles. Although, bread wheat can tolerate the loss of one or more chromosomes, the deficient forms in normal breeding material would result in significant reduction of mean performances for productive characters usually mediated through a constellation of pleiotropic effects (Siddiqui, 1972).

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