Phenotypic Structure of Grain Size and Shape Variation in M5 mutant lines of spring wheat

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Cereal crops of importance in the Kazakhstan

- **Kazakhstan is one of the major wheat producers and exporters in Central Asia.**
- **Wheat area is about 13 million ha.**
- **The bread wheat (*Triticum aestivum* L.) accounts 91% and durum wheat is 9% of total area. Spring wheat occupies 95 percent of the total wheat area in Kazakhstan.**
- **Kazakhstan producted 13,5-20,1 million tons of grain. Average grain yield is (9 centner/ha), it is not stable.**
- **Nine major wheat agroecological zones have been recognized in Kazakhstan on the basis of different wheat types, growing season, hydrothermic and soil conditions.**

Kazakhstan Wheat Regions

Introduction

- Availability of genetic variability is the prerequisite for any breeding program.
- Besides conventional methods, induced mutation has been extensively used for creating new genetic variation in crop plants.
- To date, 264 mutant cultivars of bred wheat

have been released (FAO/IAEA, 2012). Mutation induction with radiation was the most commonly used method to develop direct mutant cultivars.

- Mutation breeding is one of an important tool in crop improvement with increased agronomic values.

- **Grain size and shape are two of the main targets for wheat breeding.**
- They affects many milling characteristics and end-use qualities in wheat. Wheat seed size also influences the seedling vigour and establishment in field.
- **Grain size is characterized by grain size variables (i.e., TGW, area, width and factor form density (FFD).**
- **Grain shape means a relative proportion of the grain main growth axes.**
- **Grain shape is generally estimated by the grain shape**
- **variables (i.e., ratio of L/W and length), vertical perimeter, sphericity and horizontal axes proportion.**

Material and methods

- Based on radiation sensitivity studies, dose of 100 and 200 Gy was chosen to irradiate of cv. Zhenis of spring wheat to obtain M_3 mutant lines. Initially, irradiation of dried seeds was performed in an ionizing device (PXM -γ 20, ^{60}Co gamma rays) at the Kazakh Nuclear Center. The plants were grown in field experimental plots.

- The selection of individual high-yielding potential mutant lines was done every generation from M_3 taking into account the following yield parameters:

- Grain weight per plant,
- greater number of grain per main spike,
- greater weight of grains per main spike compared to the parental variety.
- The best genotypes were chosen according to their elements of yield.

Material and methods

- M5 seeds of the selected M3 lines were used in this study to assess *grain morphometric* variations in mutant germplasm developed through gamma radiation by 100 and 200 Gy doses .

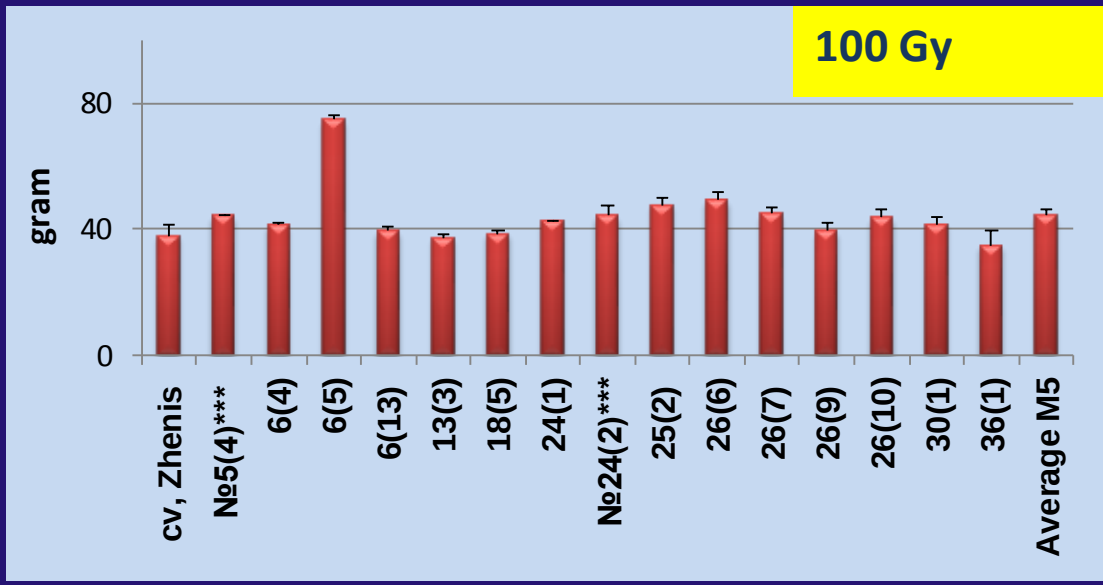
Grain morphometric analysis

- Morphometric measurements were performed on 50 to 60 grains/line using Image system for grain analysis (the analyzer regent Instrument 2007,USA).
- Grain area (GA), Grain length (GL), TGW and grain width (GW), were measured. The ratio of average GL/GW was calculated.
- Factor form density (FFD) describes the differences in grain density and the deviation of a shape from a cylindrical form and is given by: grain weight/(grain length*grain width) (Giura and Saulescu, 1996).

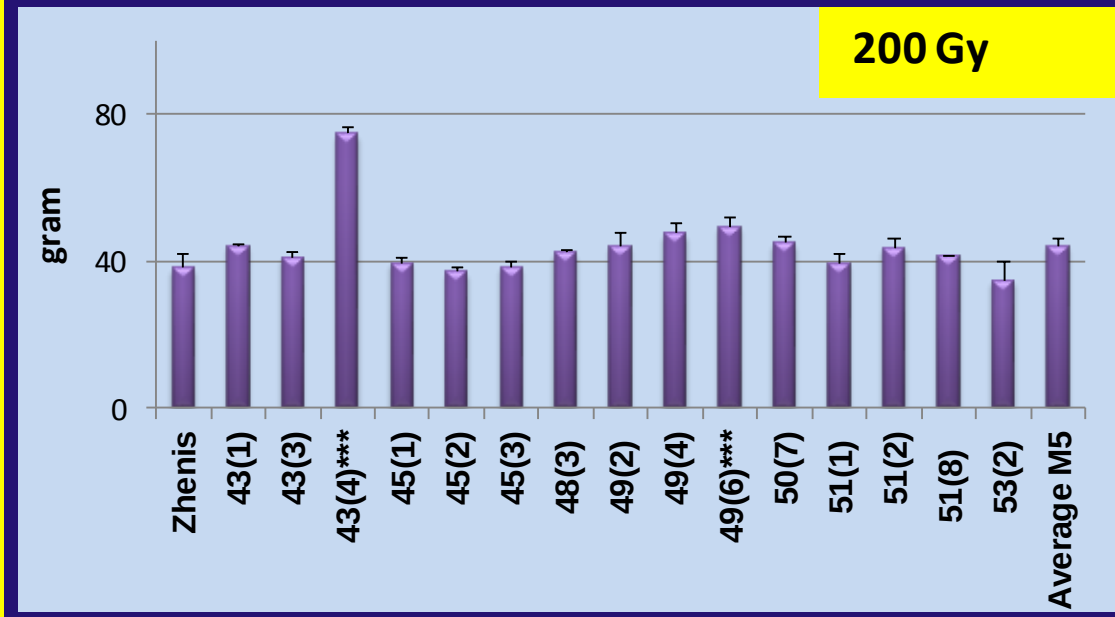
Phenotypic variations in thousand grain weight, g, in M5 mutant lines of spring wheat developed using 100 and 200 Gy doses and background cv. Zhenis

TGW 38.93 g to 51.69 g in 100 Gy germplasm, with a mean value of 41,54 g (SD ± 1.77, n=15).

2 lines (№5(4) and №24(2) differed significantly from cv. Zhenis being characterized by higher values than the parental variety (1.31 and 1.36 times).

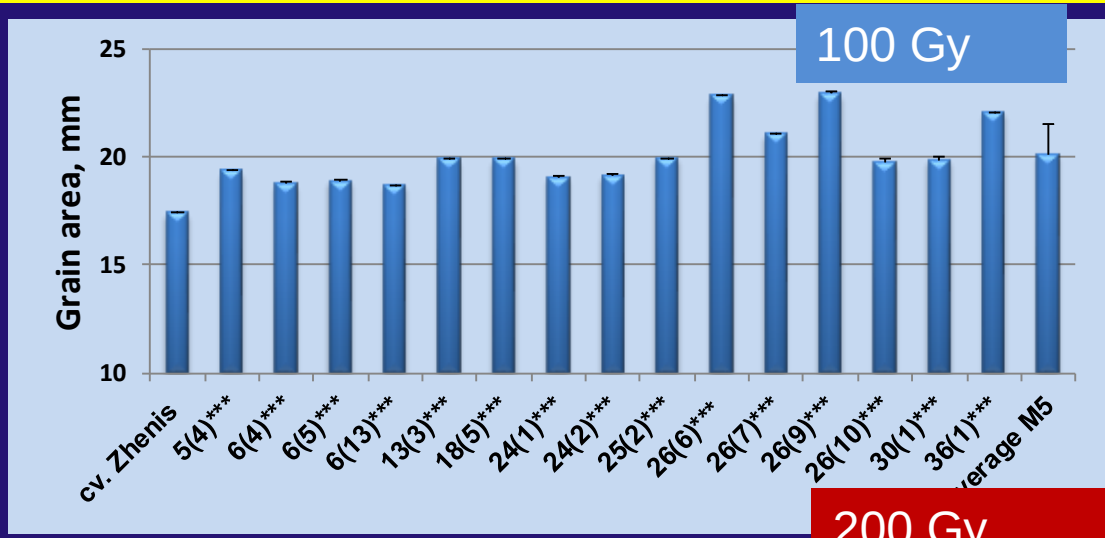


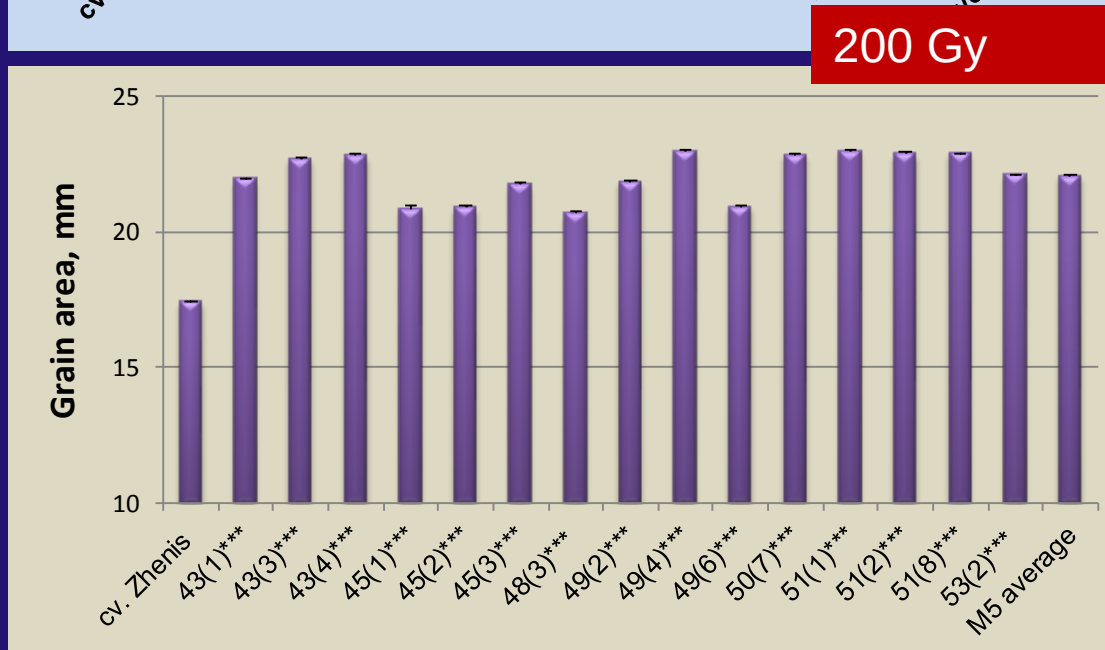
TGW showed greater degree of variation compared to 100 Gy germplasm. The mean value ranged from 34.92 to 74.65 g with a mean value of 44,23 g (SD ± 1.96, n=15). **3 lines (№43(4), (№49(4) and №49(6)** differed significantly from cv. Zhenis being characterized by higher values than cv. Zhenis (on 1.96, 1.25 and 1.30 times, respectively).



Phenotypic variations in grain area in M5 mutant lines of spring wheat developed using 100 and 200 Gy doses and background cv. Zhenis

GA in wheat 100 Gy mutant germplasm were from 18.88 mm to 22.97 mm (mean=20.15 mm; SD=1.88 mm; n=15) the range of 7.5%-31.9% higher than the mean value of cv. Zhenis . There were highly significant differences between the parental cv. Zhenis and all mutant lines for **GA**. The GA was the highest in **three lines (№26(6), №26(9) and №36(1)** characterizing value greater than 22 mm which was higher by 1.26 and 1.32 times than that of cv. Zhenis.





The mean value of in (**GA**) in 200y G mutant germplasm ranged from 20.83 to 22.96 mm (mean=22.14 mm; SD=0.88 mm; n=15). The highest GA was the in seven M5 mutant lines **(№43(4), №45(1), №49(6), №51(1), №51(2), №51(8) and №53(2).**

Correlation coefficient between grain area and TGW in M5 mutant lines of spring wheat developed using 100 and 200 Gy doses and genetic background cv. Zhenis

100 Gy

- **№24(1) №26(6) №36(1)**

0.25	**-0,54**	**-0,98**	**-0,96**	**-0,12**	**-0,85**	**0,30**	**0,98**	**-0,75**	**-0,13**	**0,98**	**0,48**	**0,16**	**0,12**	**0,94**

cv. Zhenis №5(4) №6(4) №6(5) №6(13) №13(3) №18(5) №24(1) №24(2) №25(2) №26(6) №26(7) №26(9) №26(10) №30(1), №36(1)

200 Gy

- **№45(2) №49(6) №53(2)**

0.25	**-0,56**	**-1.00**	**-0,50**	**-0,01**	**0,98**	**-0,52**	**-0,43**	**-0,93**	**0,30**	**0,80**	**0.82**	**-1.00**	**-0,14**	**-0,62**	**0.79**

Zhenis №43(1) №43(3) №43(4) №45(1) №45(2) №45(3) №48(3) №49(2) №49(4) №49(6) №50(7) №51(1) №51(2) №51(8) №53(2)

Phenotypic Variation in Grain Size and Shape in mutant germplasm.

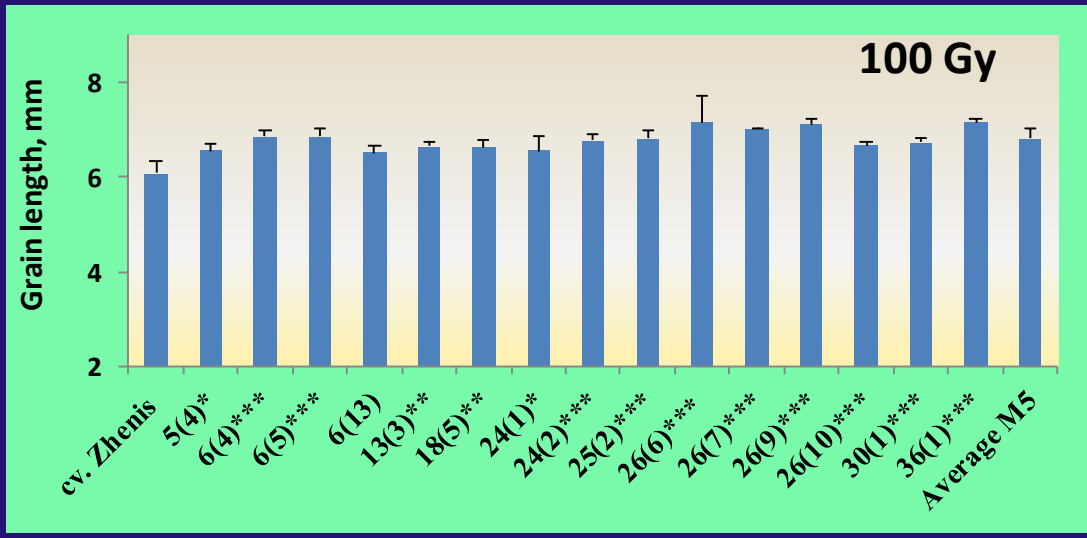
100 Gy

200 Gy

Phenotypic variations in GRAIN LENGTH in M5 mutant lines developed using 100 Gy and 200 Gy doses and genetic background of cv. Zhenis

The average of GL which largely describe grain shape ranged from 6.51 mm to 7.15 mm (mean = 6.80 mm, SD=0.22, n=15). This trait that was higher in the range of 6.9% -17.4% than the mean value of cv. Zhenis. GL was the highest in **four M5 mutant lines (№26(6), №26(7), №26(9) and №36(1)** having value higher by 1.16 and 1.17 times than cv. Zhenis.

GL ranged from 7.48 to 8.22 mm (mean = 7.83 mm, SD=0.49, n=15) . The GL was the highest in **four M5 mutant lines (№51(1), (№51(8), №53(2) and №51(2)** with a value of greater than 8 mm that is higher compared with cv. Zhenis in the range of 22.8%-35.0%.



Correlation coefficient between grain length and TGW

in M5 100 Gy germpasm

							№18(5)	№24(1)		№25(2)			№26(10)	
0.69	-0,76	-0,29	-1.00	0,56	-0,07	0,77	1.00	-0,93	0,84	-0,30	-0.82	0.95	0.54	-1.00

cv. Zhenis №5(4) №6(4) №6(5) №6(13) №13(3) №18(5) №24(1) №24(2) №25(2) №26(6) №26(7) №26(9) №26(10) №30(1) №36(1)

M5 200 Gy germpasm

		№43(1)	№43(3)										№51(8)	№53(2)
0.69	0,80	0,96	0,62	0,07	-0,97	-0,46	-0,43	-0,24	0,12	0,29	-0,99	-0.69	-0.99	0.75	1.00

Zhenis №43(1) №43(3) №43(4) №45(1) №45(2) №45(3) №48(3) №49(2) №49(4) №49(6) №50(7) №51(1) №51(2) №51(8) №53(2)

Phenotypic variations in grain width in M5 mutant lines developed using 100 Gy and 200 Gy doses and genetic background of cv. Zhenis

The range of GW was 3.22 to 3.88 mm (mean = 3.60 mm, SD=0.18, n=15). The GW was the highest in three M5 lines (№24(2), №26(7) and №26(9) with means compared with cv. Zhenis that is higher in the range of 21.7% - 24.0%.

The range of GW was 3.64 mm to 3.91 mm in M5 germplasm developed using 200 Gy (mean = 3.75 mm, SD=0.08, n=15). Four M5 lines (№51(1), №51(2), (№51(8) and №53(2) showed the highest GW in the range of 21.4 up to 24.9%.

Correlation coefficient between grain width and TGW

in M5 100 Gy germpasm

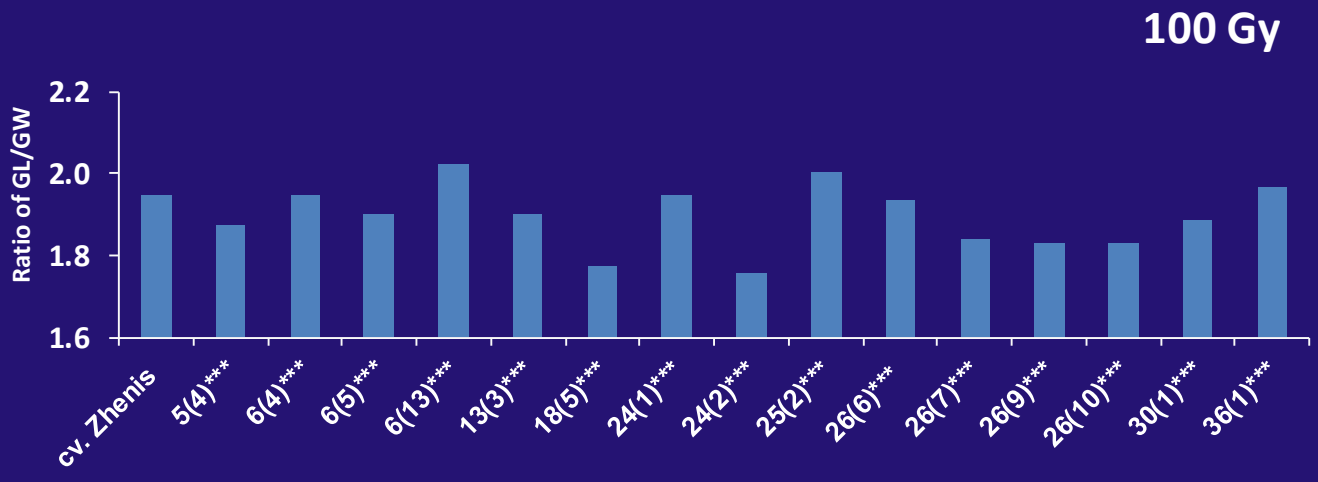
1.00	0,78	0,30	1.00	0,66	0,40	-0,22	-0,75	-0,52	0,13	0,03	-0,80	-0.08	-0.93	-0.95	0.17

M5 200 Gy germpasm

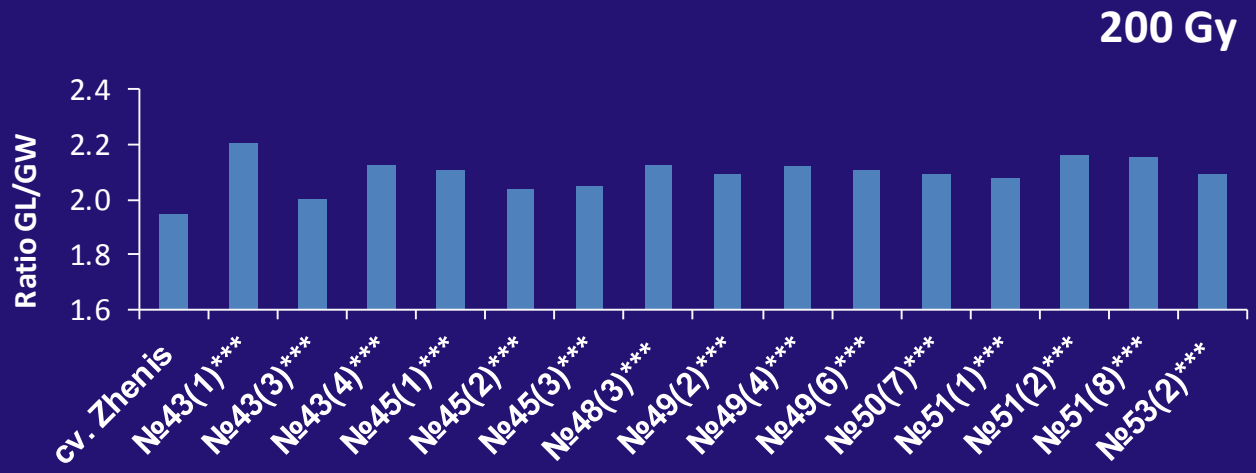
1.00	0,51	0,84	-0.26	-0,46	-0,47	0,51	0,42	0,03	-1.00	0,93	-0,26	0.41	-0.16	0.89	-0.08

Phenotypic variations in ratio of GL and GW in M5 mutant lines developed using 100 Gy and 200 Gy doses and genetic background of cv. Zhenis

The range of ratio of GL and GW was 1.77 to 2.02. The ratio was the highest in three M5 lines (№6(13), №25(2) and №36(1). cv. Zhenis - 1.95.

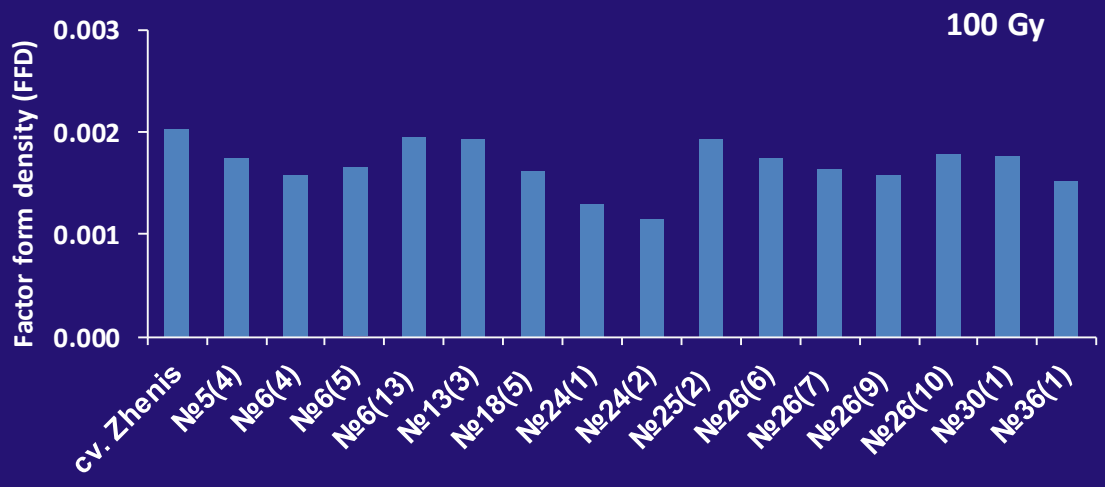


The range of ratio of GL and GW was 2.03 to 2.21. The ratio was the highest in three M5 lines (№43(1), №43(4), №48(3), №51(2), and №51(8). cv. Zhenis - 1.95.

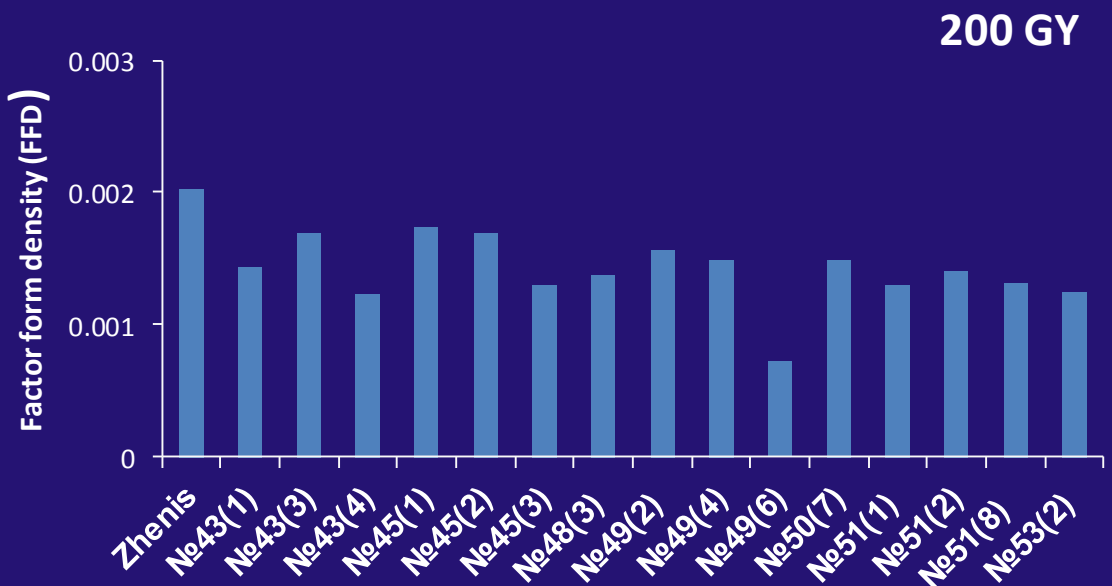


Phenotypic variations in Factor form density (FFD) in M5 mutant lines developed using 100 Gy and 200 Gy doses and genetic background of cv. Zhenis

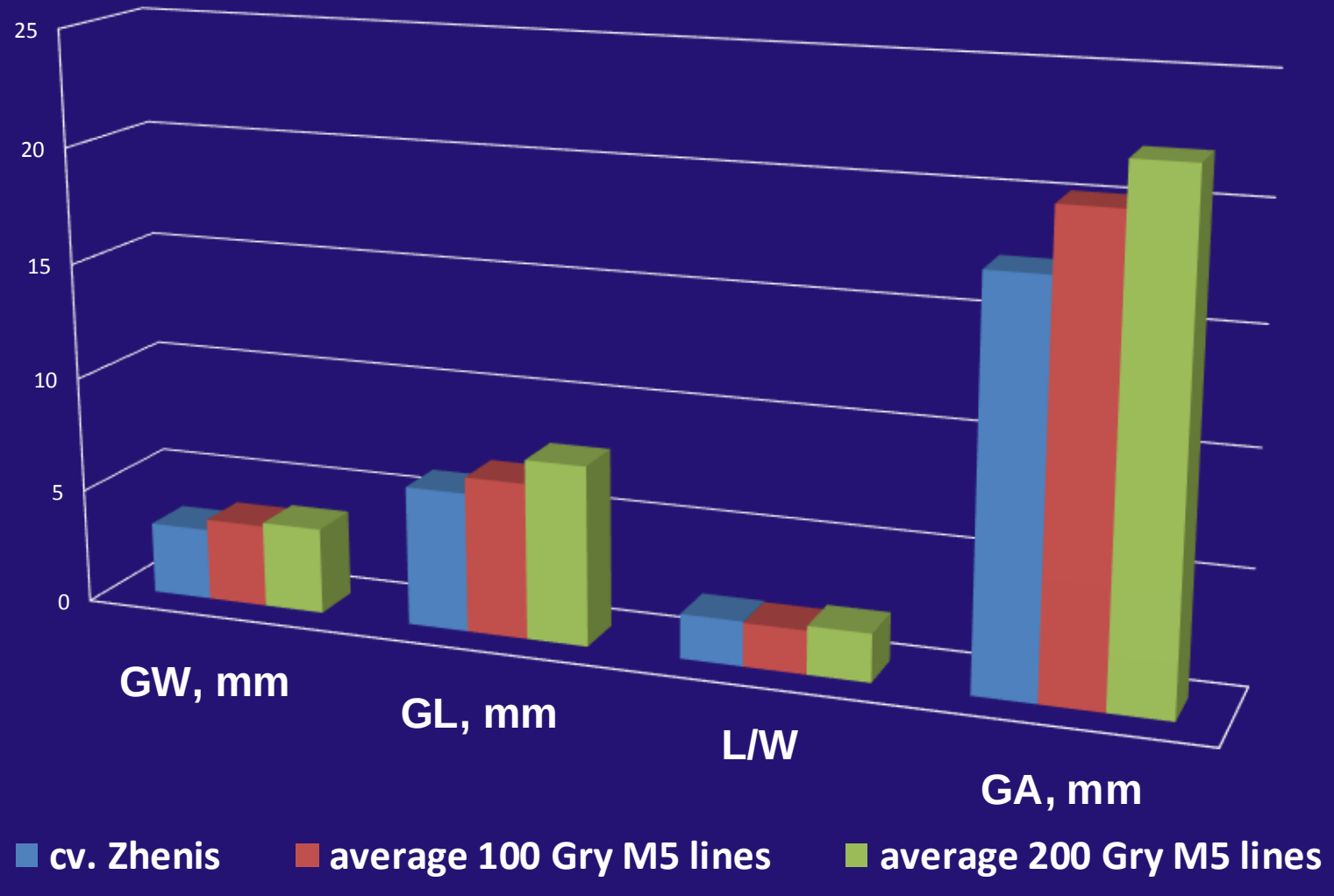
FFD 0.0011 to 0.0020



FFD from 0.0007 to 0.0017

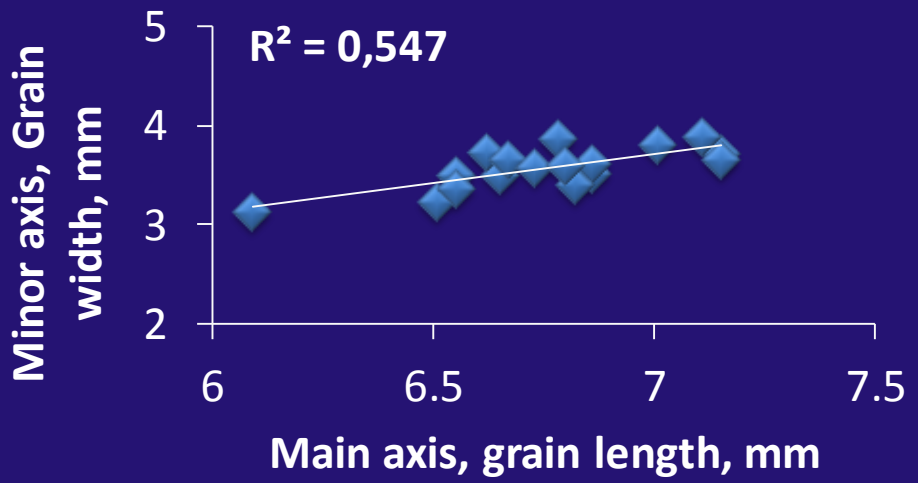


Effect of 100 Gy and 200 Gy on the mean value of grain length, width, length/width ratio and area in M5 mutant germpalsm developed on background cv. Zhenis (n=15 for each).

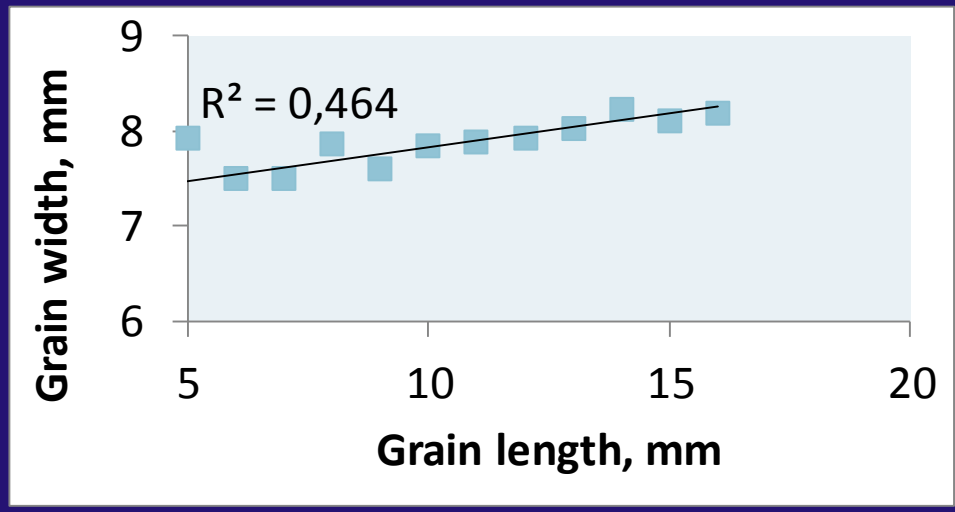


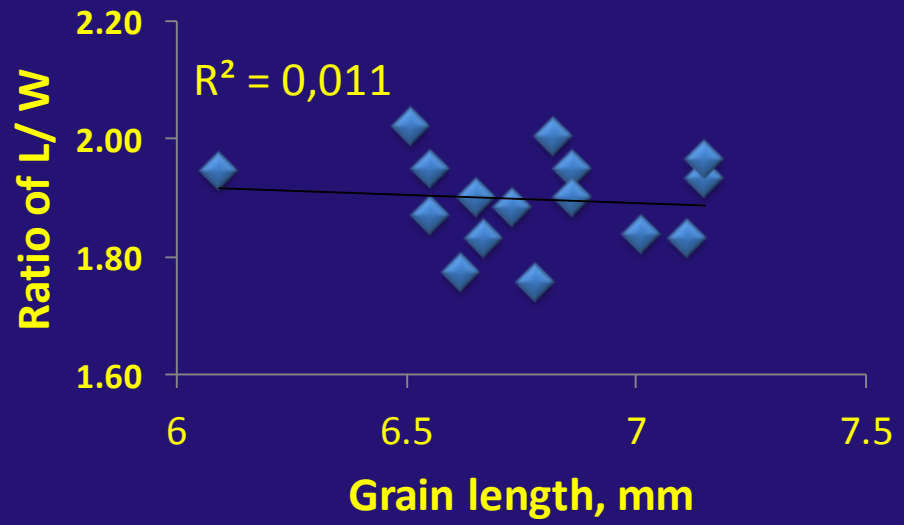
Relation between grain length and width, relation between L/W and length Simple linear correlation coefficients (Spearman's rho)

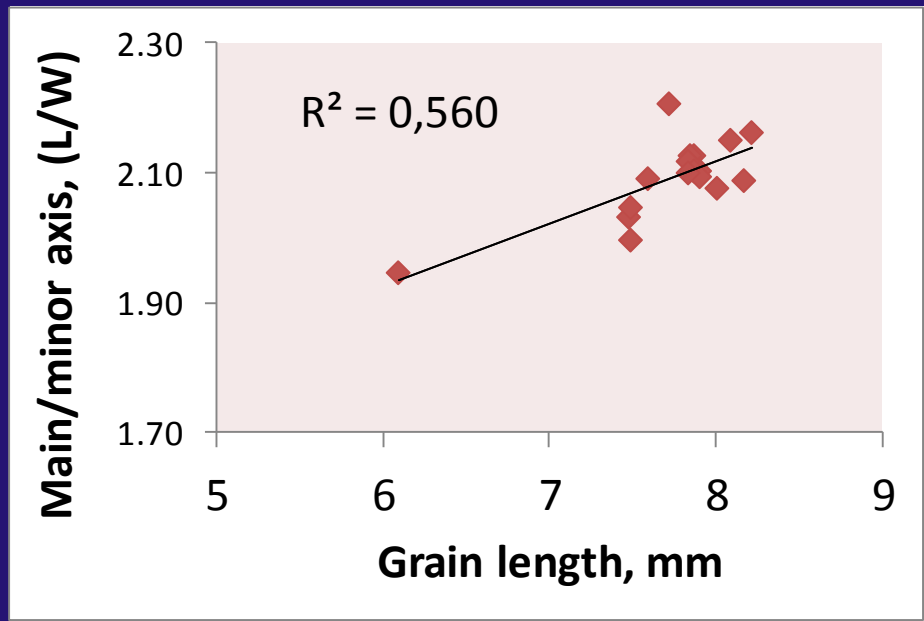
In M5 100 Gy germpasm



In M5 200 Gy germpasm







Conclusions

1. 100 and 200 Gy gamma radiation can induce significant **Phenotypic variations in grain size and grain shape.** The mutants developed by means of 100 and 200 Gy had significantly higher, particularly GA, GL, and GW than the parental cv. Zhenis.
2. **GL and GA** are the most phenotypic variable traits and their variations are also significantly gamma dose dependent, variations in GW and L/W ratio are moderately and the least variable, respectively. 200 Gy gamma is more effective dose to induce positive g
3. **TGW** is highly positively correlated with two morphological traits, **GA and GW** in lines №6(5), №53(2), and №49(6) in germplasm developed using 100 and 200 Gy, respectively.
4. There was a more positive association between **GL and GW, GL and ratio L/W in mutant germpasm developed by 200 Gy** (r=0.90 and r=0.56) than gempasm developed by 100 Gy (r=0.55 and r=0.01)
5. **The L/W ratio** shows very weak and middle correlation with GL and GW (r =0.011 and r =0.559, $P < 0.001$), respectively in M5 population obtained with the 100 Gy treatment. The L/W ratio very weakly and weakly correlated with either of the two main grain size variables (TGW and grain area, r =0.021 and r=0.258, $P < 0.001$) suggesting that the relative proportions of the main growth axes of the grain, which largely describe grain shape, is independent of grain size.

Acknowledgements

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