RADIOSENSITIVITY OF RICE TO FAST NEUTRONS

Y. V. Aleksiayenak, A.I. Kruglyak

Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics

ISINN-31, 2025

OBJECTIVES

- BACKGROUND
- AIM
- EXPERIMENT DESIGN
- RESULTS
- CONCLUSSION

BACKGROUND

FAST-NEUTRON MUTAGENESIS

- Heritable
- Complete knockout
- Can delete more than one gene if linked
- Observed mutations are different from the gamma irradiation
- Required doses are lower in comparison with gamma

BACKGROUND

Fast neutrons sources:

- Californium-252 (Cf-252)

Half-Life (T1/2) - 2.645 Years

Emean ~ 2 MeV

- Neutron Source Facilities

En ~ 14 MeV

Osaka, Vienna, China Institute of Atomic Energy (CIAE), California

Problems:

- Sources are not monoenergetic
- Neutron energy varies from 2 to 20 MeV
- No specification on flux
- No information about irradiation time

BACKGROUND

- Mean lethal dose (LD50) where 50 percent of the total irradiated individuals die are those with the best likelihood of producing sustainable mutations for genetic improvement. In addition to the LD50, some studies indicate that the dose at which the 50% growth reduction (GR50) appears has a solid chance of causing successful mutants.

- Studies showed that two metrics (LD50 and GR50) are predicated on the fact that low doses of irradiation produce minimum impacts on the genome, which rarely generate phenotypic changes; whereas high doses may produce multiple impacts on the genome which consistently produce aberrations or negative changes. Therefore, identifying the LD50 and GR50 is the preliminary stage in a mutation breeding method as well as for molecular and genetic studies

Doses specified in literature for rice: 10, 20, 33 Gy

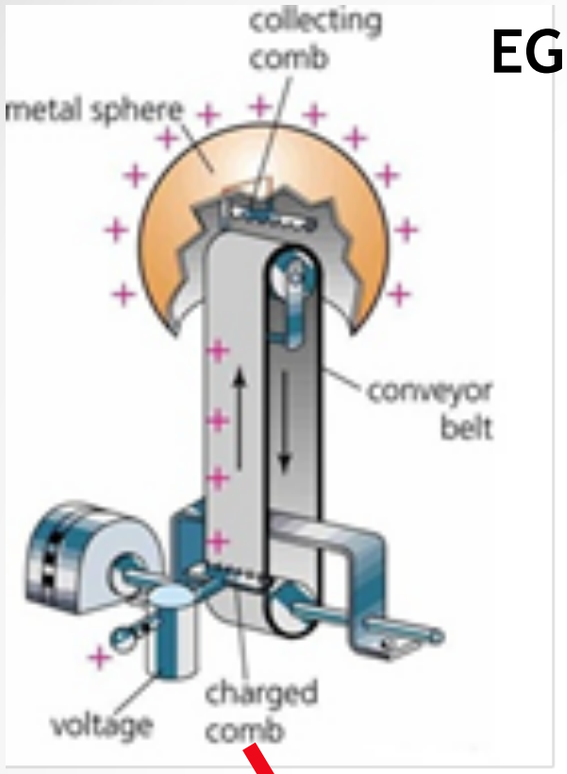
AIM

- The objectives of this study were to

- (1) investigate the effects of fast neutron on the survival rate, shoots, and root morphometric traits after irradiation on the EG-5 accelerator for the specific rice variety Syr Suluyu;

- (2) measure 30, 50% lethal dose and 30, 50% growth reduction dose based on shoots and root morphometric characteristics to estimate rice radiosensitivity for the further applied research in plant radiobiology and mutagenesis

EG-5 in the global accelerator infrastructure

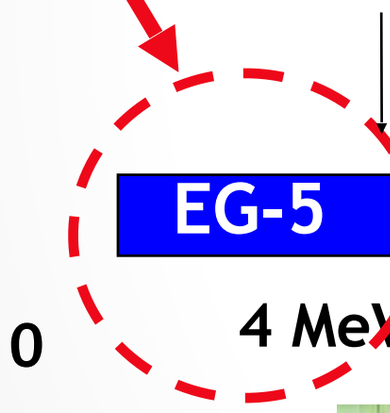


EG-5

The colliders of protons and heavy ions

NICA (*Nuclotron-based Ion Collider Acility*)

LHC Collider



EG-5 provides a relatively low level of particle energies

Isochronous cyclotron 80 MeV/n

The synchrophasotron - a 10 GeV/n (JINR)

The range of tasks for EG-5 is no less extensive than for the Hadron collider

EXPERIMENT DESIGN

Seed samples

Neutron–producing gas target

Output of the accelerator ion conductor

Irradiation characteristics:

- En= 4.1 MeV
- deuteron beam current (reaction D (d,n) ^{3}He)
- neutron monitor of the PIXE-4 type
- neutron flux intensity - 3×10^{7} particles/cm^{2}

EXPERIMENT DESIGN

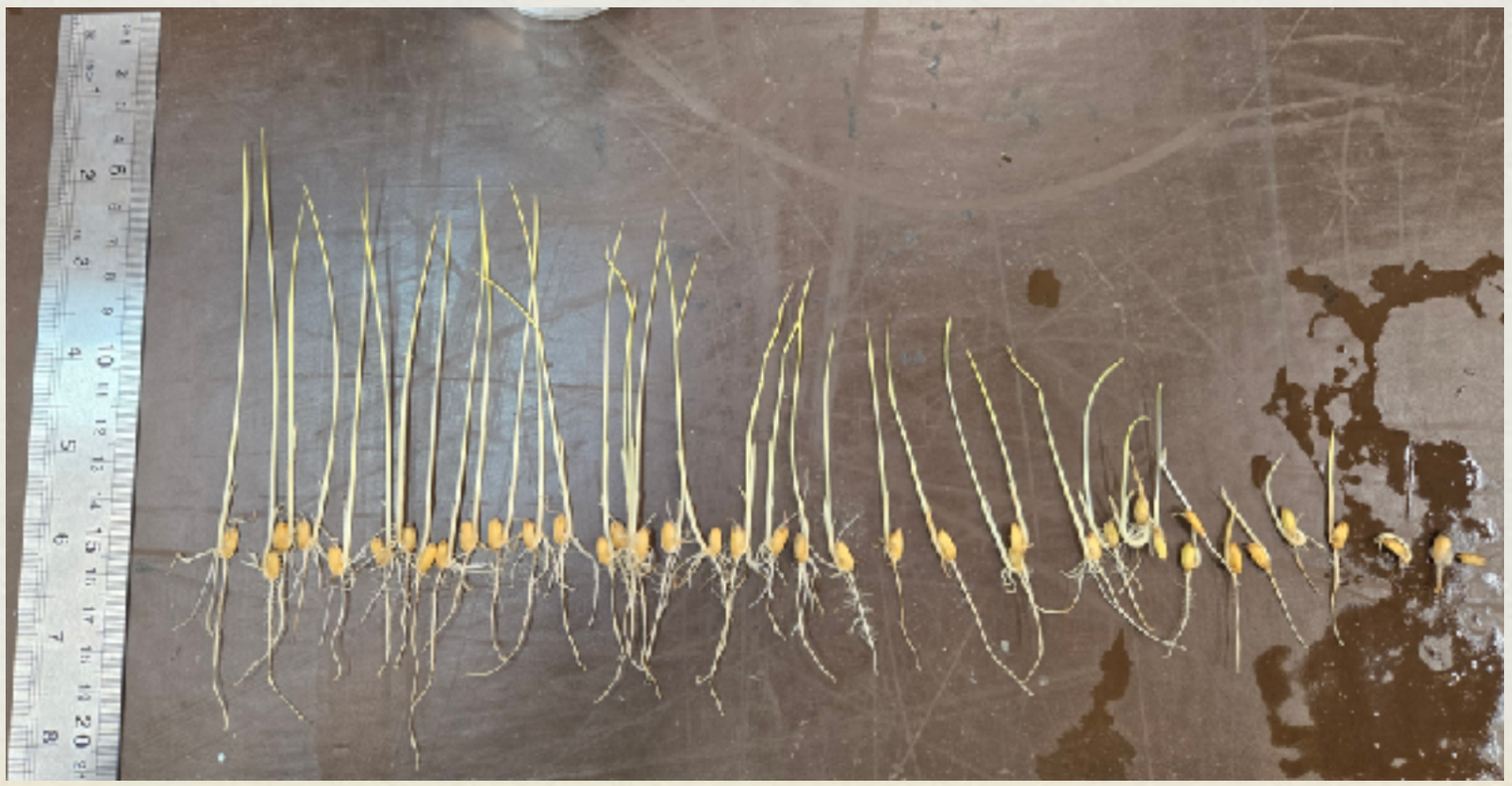
- Seeds of the Syr Suluyu variety were subjected to the FN irradiation with doses: 10, 25, 40, 50, and 75 Gy (100 seeds per dose)

- Seeds were grown for 10 days in a dark chamber

RESULTS

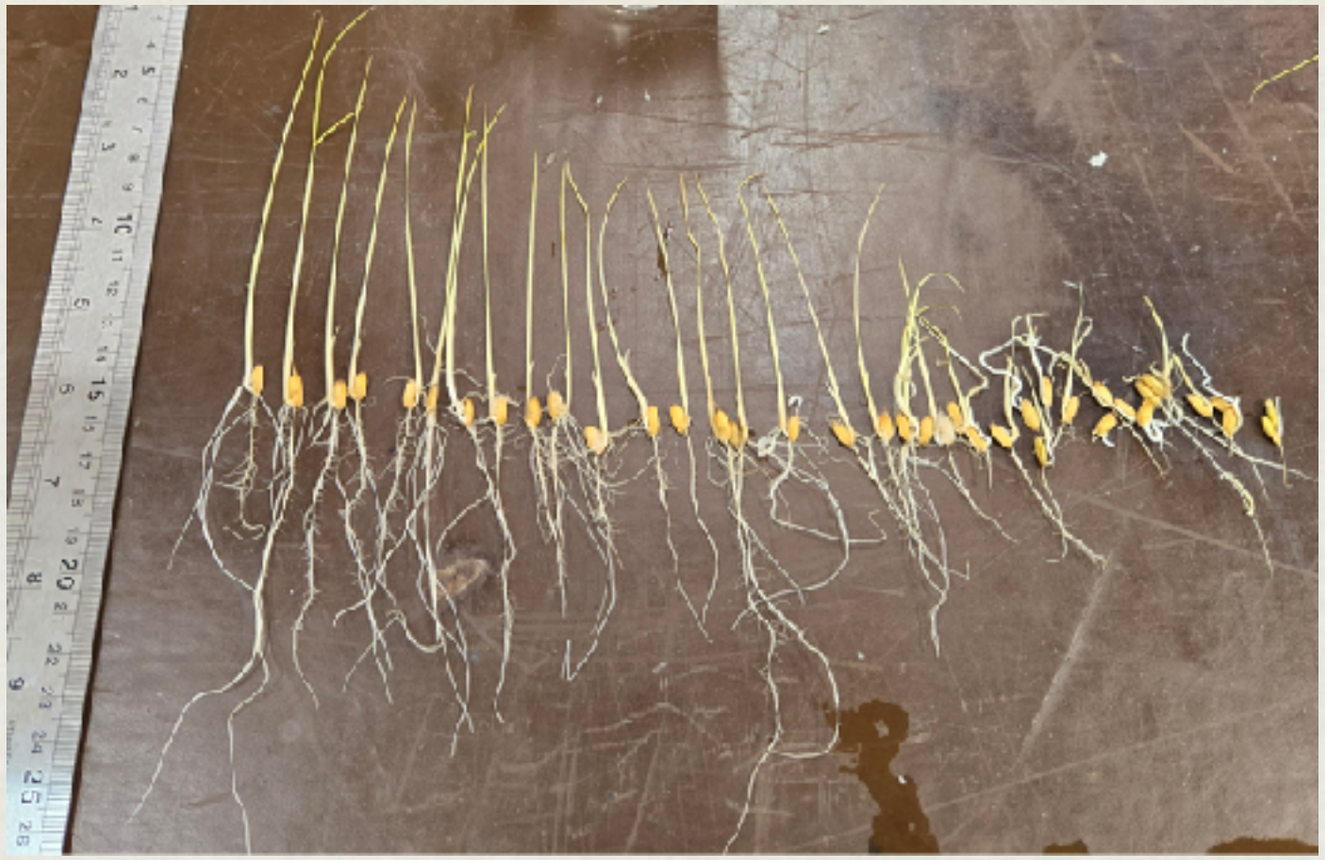
- Control

- 10 Gy



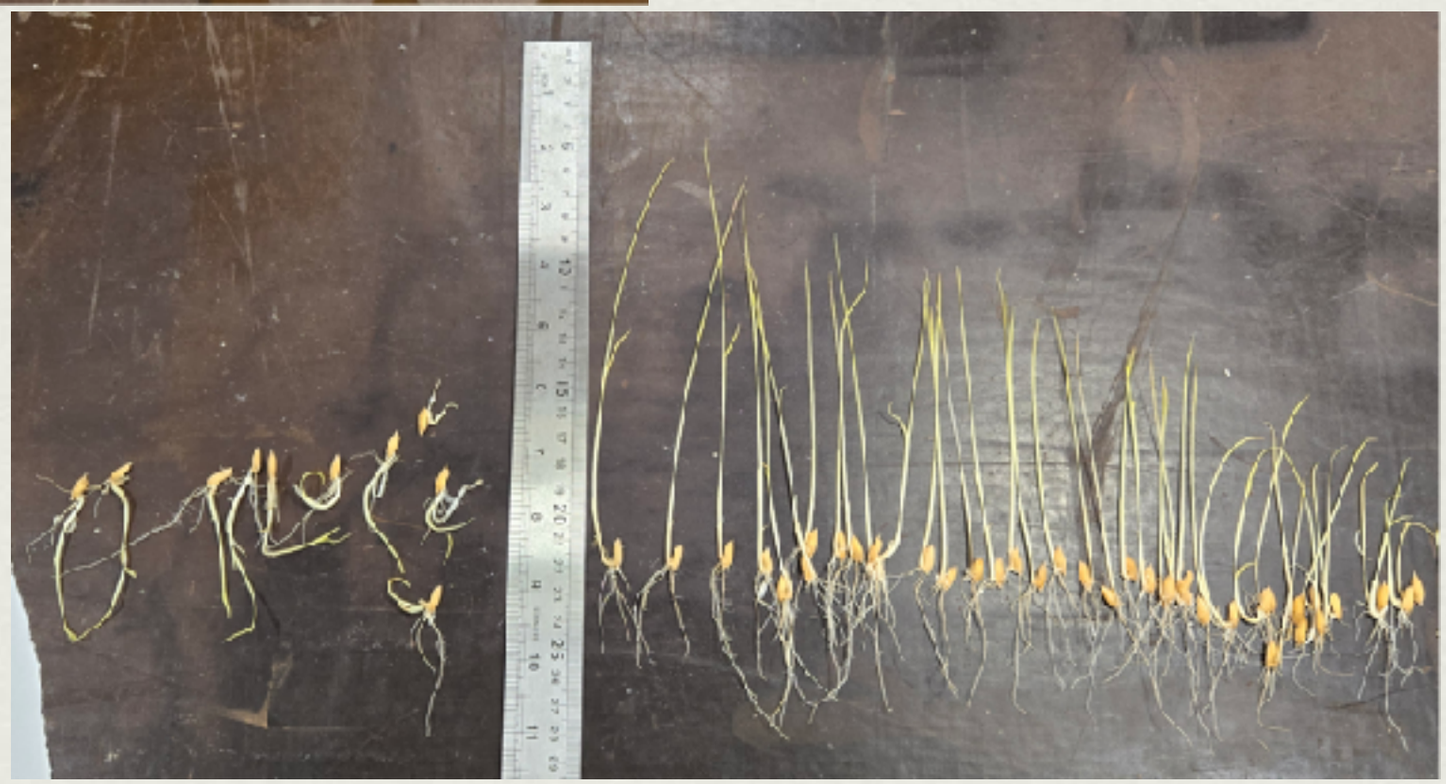
- 25 Gy

- 40 Gy



50 Gy

75 Gy



RESULTS

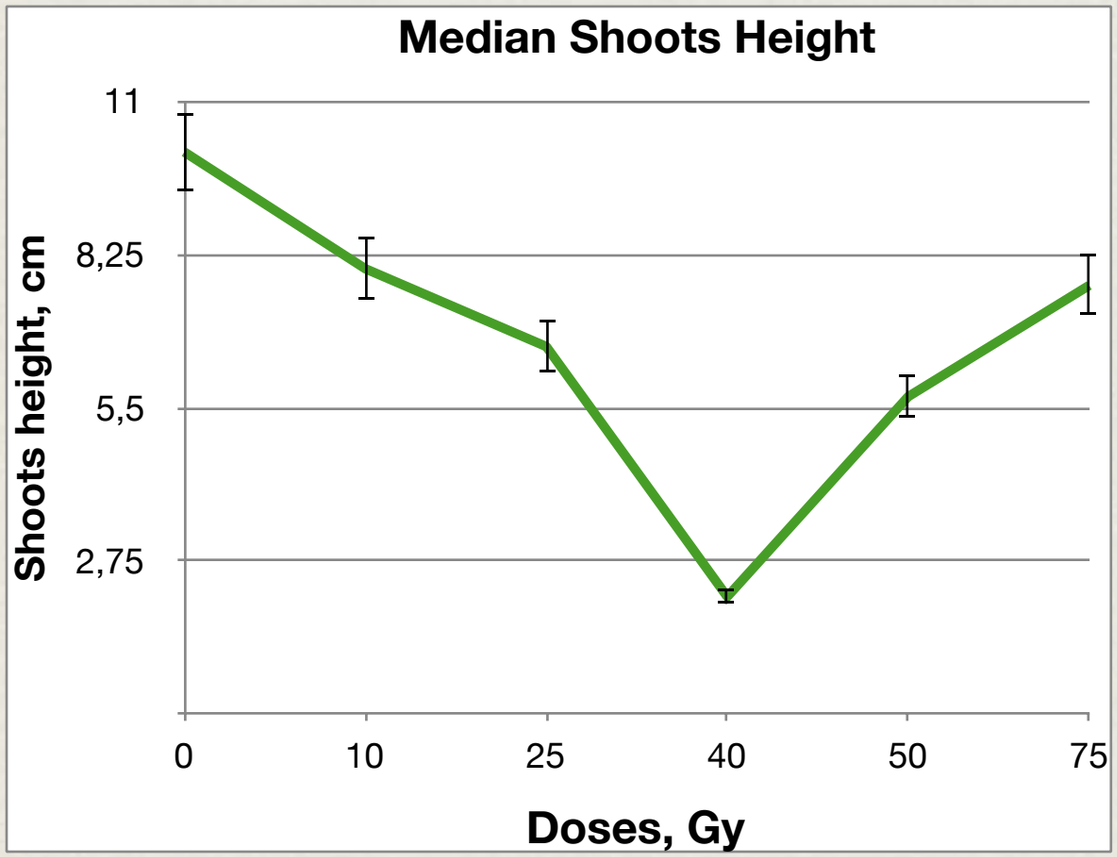
- Mutations on morphological levels are observed from the dose of 25 Gy. 32 % of the plants are crooked and twisted
- At the 40 Gy maximum growth reduction is detected
- For 14% of the plants at the dose of 75 Gy negative geotropism is observed

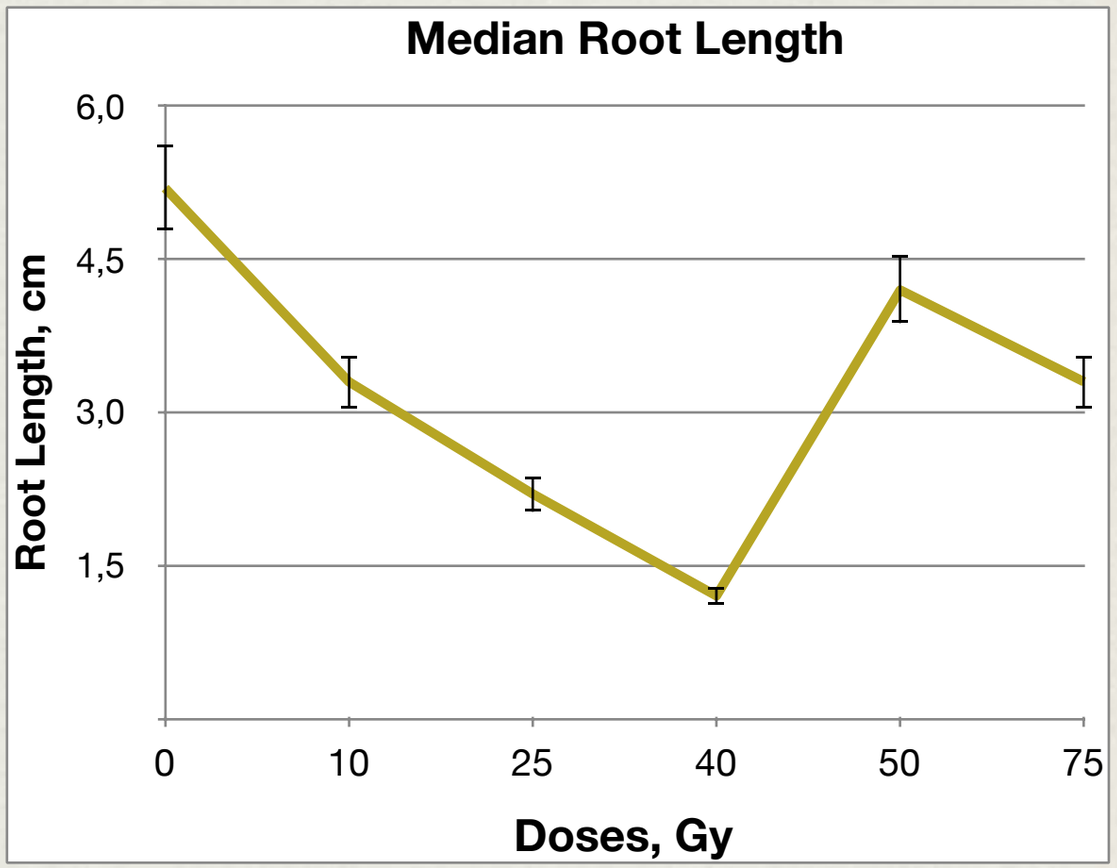
ANALYSIS

Shoots	Control	10	25	40	50	75
Max	15,5	12,7	11,9	7,7	13,9	12,5
Min	1,0	1,3	0,1	0,2	1,4	0,8
MEDIAN	10,1	8,0	6,6	2,1	5,7	8,2
MEAN VALUE	9,1	7,5	6,0	2,2	6,1	7,7
DISPERSION	10,4	8,9	13,0	1,4	10,6	5,9
ST. DEV.	3,2	3,0	3,6	1,2	3,3	2,4
MEAN ERROR	0,34	0,48	0,58	0,20	0,53	0,42

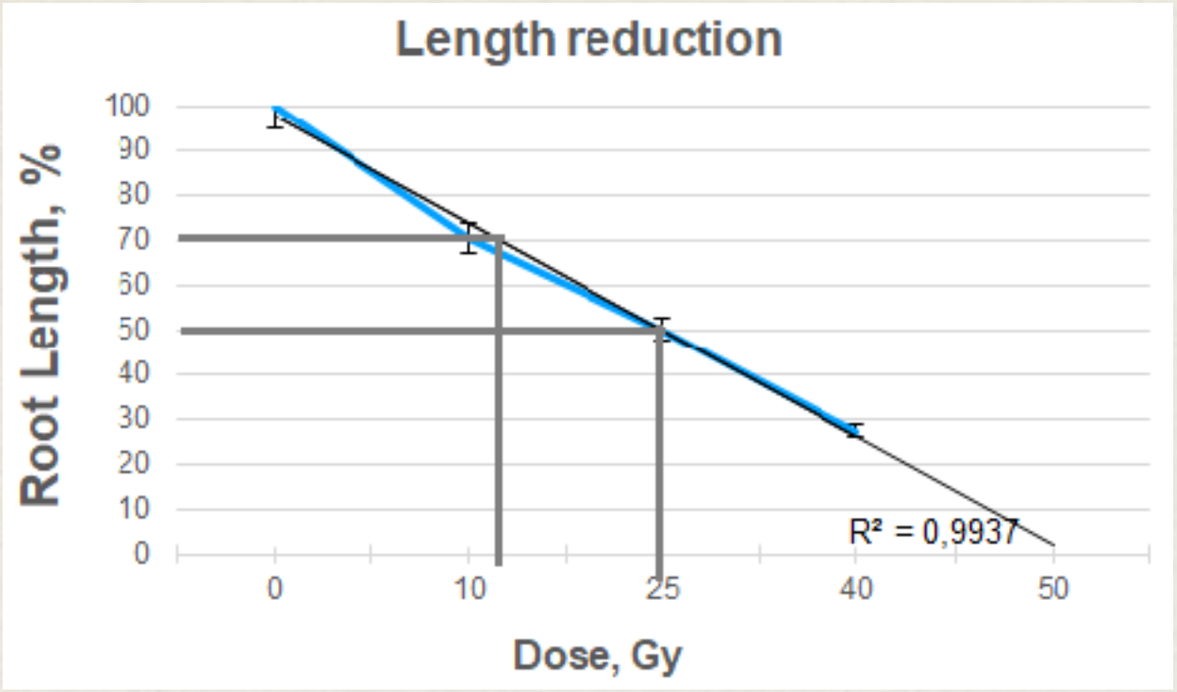
Roots	Control	10	25	40	50	75
Max	20,5	5,8	8,7	2,9	12,7	5,5
Min	0,5	0,3	0,1	0,1	0,1	0,3
MEDIAN	5,0	3,3	2,2	1,2	4,2	3,3
MEAN VALUE	5,2	3,3	2,2	1,2	4,7	3,3
DISPERSION	1,3	0,7	1,9	0,3	11,2	1,0
ST. DEV.	1,1	0,9	1,4	0,6	3,3	1,0
MEAN ERROR	0,1	0,1	0,2	0,1	0,6	0,2

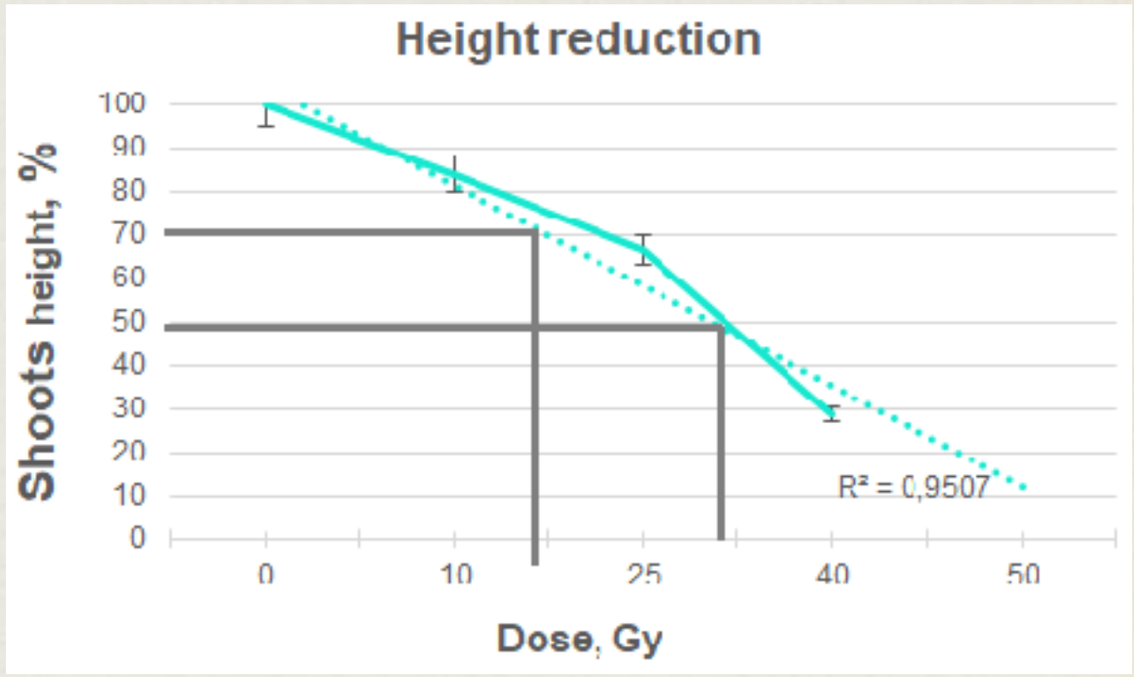
GROWTH REDUCTION





GROWTH REDUCTION



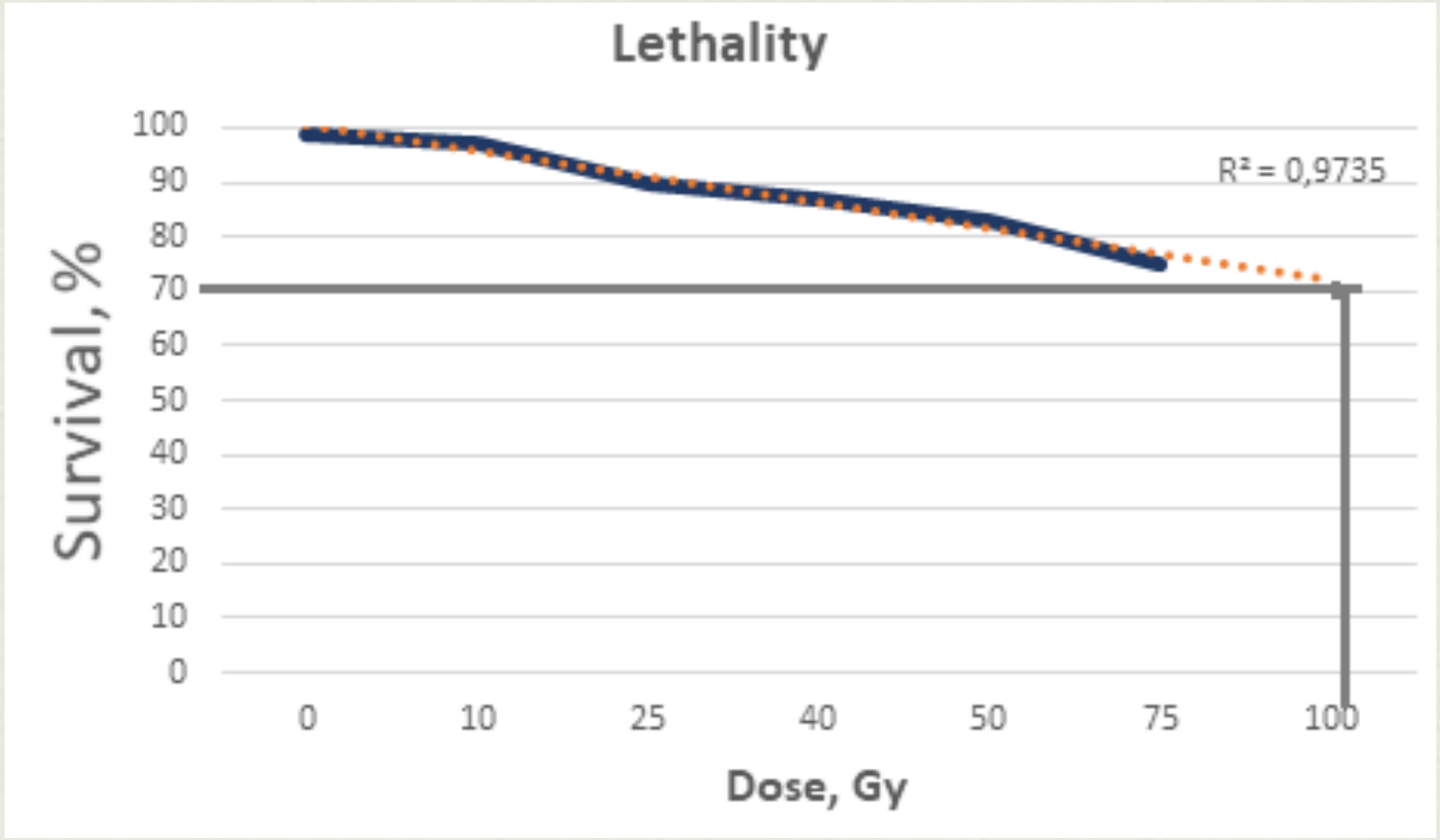


- GR_{30} - 12,7 Gy for Roots
- GR_{50} - 25 Gy for Roots
- $GR_{30\ mean}$ - 14,8 Gy
- $GR_{50\ mean}$- 28,5 Gy

16,9 Gy - for Shoots

32 Gy - for Shoots

SURVIVAL RATE



- Expected LD_{30} -100 Gy
- Further experiments with higher doses are required

CONCLUSION

- Fast neutron irradiation significantly ($p<0.05$) induced variabilities on the evaluated traits
- Mean growth reduction rates were established: $GR_{30\ mean}$ - 14,8 Gy, $GR_{50\ mean}$ - 28,5 Gy
- At the doses of 50 and 75 Gy hormesis effect is observed
- Dose of 40 Gy showed the maximum inhibition rate for plants (4-5 times lower in comparison with the control)
- For the mean Lethal Dose determination higher doses are required
- Further studies will be conducted

Thank you
for your attention!

感谢您的关注!