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Research Article

# The Growth Kinetics of RhizoctoniasolaniAfter 1 MeV Electron Irradiation

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**Abstract.** Crops, especially potatoes, are prone to a wide range of fungal, viral and bacterial diseases, including black scurf caused by *Rhizoctoniasolani*. This study focused on the radiation treatment of the phytopathogenic fungus *Rhizoctoniasolani*Kuhn, grown from sclerotium irradiated with 1 MeV electrons in the dose range from 20 to 4500 Gy. The doses absorbed by the sclerotia were determined using computer simulation. The growth of the fungus samples was monitored after 24, 48, 72, and 96 hours from the time of seeding. It was found that the dependence of the radial growth velocity of *R. solani* on the time after irradiation with doses ranging from 20to 1800 Gywas nonlinear. Irradiation at a dose over 4500 Gyled to complete suppression of the germination of *R. solani* sclerotia.

**Keywords:** radiation treatment, electron radiation, radiation dose, sclerotia of *Rhizoctoniasolani,* Kuhn, radial velocity of growth

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Considering the current priorities of the global community for sustainable development of the natural environment, it has become common to abolish harmful practices involving toxic substances inthe treatment of foodstuff.

A modern-day alternative to chemical treatment methods is radiation technology, which is widely used in agriculture as well as medicine and various other industries [1].

There are a lot of projects around the world whichfocus on the effect of irradiation on microbiological, biochemicaland organoleptic properties of foodstuff to increase their shelf life without a negative impact on the quality [2-7].

Grain crops are of aparticular interest for researchers these days. It's been found that irradiation processing can acceleratesprouting of seeds and reduce the risk of fungal diseases [8].

Crops, especially potatoes, are prone to a wide range of fungal, viral and bacterial diseases, including black scurf caused by *Rhizoctoniasolani* [9-12].

Irradiation processing can both reduce and stimulatethe virulence of phytopathogens; however, it is highly important to determine the exact physical parameters of irradiation in order to inhibit the growth of phytopathogens.

This project studies the influence of 1 MeV electrons on *Rhizoctoniasolani* grown from sclerotia which were treated with different doses of irradiation.

Sclerotia samples (3 ± 1) mm in diameter placed in 2 ml Eppendorf tubes were irradiated with 1 MeV electrons using UELR-1-25-T-001 industrial accelerator with the average beam power 25 kW.

Tubes with the samples were placed onduralumin plate located 12 cm from the beam output. All the experiments were carried out at 18°C to ensure the uniform conditions for both treated and control samples. The charge absorbed by theduralumin plate was monitored during the exposure to estimate the dose absorbed by the samples using computer simulation. The source code allowsto calculate the dose distribution in irradiated volume using theMonte-Carlo method.

The tubes were simulated by 39 mm long polypropylene cylinders 7 mm in diameter while sclerotia samples were represented by water phantoms 3 mm in diameter. Beam current used in simulation for better precision was $Q_{model}$= $10^8$. The resulting dose absorbed by the samples during the experiment was adjusted taking into account the charge measured during the exposure.

To estimate the dose uniformity in sclerotia samples, the water phantom was broken down into 0.1 mm cross-sections to calculate the dose distribution across the radius in theplane perpendicular to the beam direction. The ratio of the maximum dose value $D_{max}$to the minimum $D_{min}$ varied from 1.2 to 1.6 throughout the sphere.

Experimental samples were placed in Petri dishes filled with potato dextrose agar. Next step involved cultivating sclerotia samples under 24°C. Then the diameter of fungi was monitored 24, 48, 72 and 96 hours after seeding.

The radial velocity of fungus growth was determined using the following formula[13, 14]:

$$K_r = \frac{r - r_0}{t - t_0} ,$$

where $K_r$– radial velocity of fungi [mm/hour], $r_0$– radius of fungus colony at the time of previous monitoring $t_0$, *r*– radius of fungus colony at the time of monitoring *t*.

It's been found that the dependence of theradial velocity of fungus grown from irradiated sclerotia samples on the monitoring time is nonlinear.

Figure 1 (a,b) shows the experimental results of fungus growth ratio. 24 hours after seeding, the radial velocity of fungus colonies grown from the samples irradiated with the doses ranging from 20 Gy to 900 Gy was similar to that of control values and varied from 0.29 to 0.40 mm/24 hours.

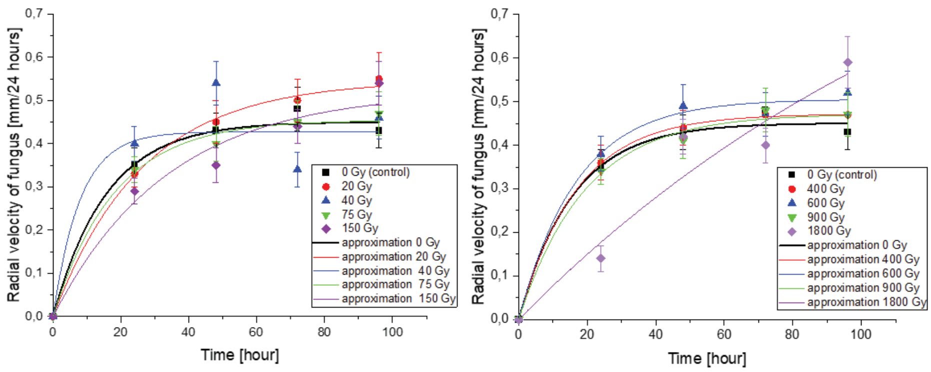


**Figure** 1: The dependence of radial velocity of fungus grown from irradiated sclerotia samples on the monitoring time.

48 hours after seeding, the radial velocity of the given samples increased and varied from 0.35 to 0.49 mm/24 hours. Two days following irradiation the sample irradiated with 40 Gy showed the maximum radial velocity0.54 mm/24 hours exceeding the velocity of other samples 1.1-1.2 times.

72 hours after seeding the velocity of irradiated samples varied from 0.34 to 0.5 mm/24 hours while the control sample velocity was 0.48 mm/24 hours. On the 96th hour of monitoring the velocity of irradiated samples exceeded the control sample velocity by 0.03 – 0.12 mm/24 hours while the control sample velocity was 0.43mm/24 hours.

The irradiation treatment of sclerotia samples with the dose 1800 Gysignificantly decreased the growth of fungus during the first two days of monitoring while reducing $\square_r$ values 2.1-2.5 times compared to the control values. However, 48 hours after seeding, the radial velocity of given samples rocketed to the level of 0.59 mm/24 hours exceeding the control sample velocity by 0.16mm/24 hours.

Irradiation treatment with 4500 Gy completely inhibited the sprouting of sclerotia *R. solani* samples.

To estimate the impact of electron treatment on the phytopathogen *R. Solani* grown from irradiated sclerotia samples the experimental data were approximated using the function $f(t) = a(1 - e^{-bt})$, where **t**is the monitoring time after seeding, **a**stands for the limited value of radial velocity; *b=1/*□, where□ is the time reaching the plateau. Table 1 shows the values of $f(t)$ calculated using the least-squares method. The correlation coefficient$R_{corr}$varies from 0.96 to 0.99 which confirms the adequacy of the suggested approximation.

The results of approximation show that the limited value of radial velocity (a) for the samples irradiated with the doses from 20 Gy to 900 Gy differ from the control values

TABLE 1: The values of $f(t)$ function.

| Dose [Gy] | *a*[mm/24 hours] | *b*[hour]$^{-1}$ | $R_{corr}$ |
|---|---|---|---|
| 0 | 0.45 ± 0.02 | 0.06 ± 0.02 | 0.99 |
| 20 | 0.55 ± 0.03 | 0.04 ± 0.01 | 0.99 |
| 40 | 0.43 ± 0.05 | 0.13 ± 0.19 | 0.96 |
| 75 | 0.46 ± 0.03 | 0.06 ± 0.01 | 0.99 |
| 150 | 0.52 ± 0.07 | 0.03 ± 0.01 | 0.99 |
| 400 | 0.47 ± 0.02 | 0.06 ± 0.01 | 0.99 |
| 600 | 0.51 ± 0.03 | 0.06 ± 0.01 | 0.99 |
| 900 | 0.47 ± 0.03 | 0.05 ± 0.01 | 0.99 |
| 1800 | 1.18 ± 1.42 | 0.01 ± 0.01 | 0.96 |

and vary within 10 %. The samples irradiated with 1800 Gy exceeded the control values 2.5 times which is determined by the effect of the dose on *R. solani* growth inhibition. The value *b*for the sample irradiated with40 Gy exceeded the control values 2 times which serves as a proof of the short-term stimulating effect of this dose on the growth of phytopathogen.

It has been found that the 1 MeV electron treatment on sclerotia *R. solani*at the doses ranging from 20 Gy to 1800 Gy has both inhibiting and stimulating effects at the different periods of the monitoring time. The nonlinear dependence ofthe radiobiological effect on the dose may be related to the nonuniformity of sclerotia cells' sensitivity to the irradiation treatment as well as the probability of the impact of irradiation on biological structures.

It seems interesting to investigate the influence of irradiation treatment on *R. solani*pathogen located on the surface of seed potatoes because the inhibition of *R. solani*growth may significantly increase the potato yield.

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