Nuclear technologies to improve the resilience of native forest and plantations in the face of climate change

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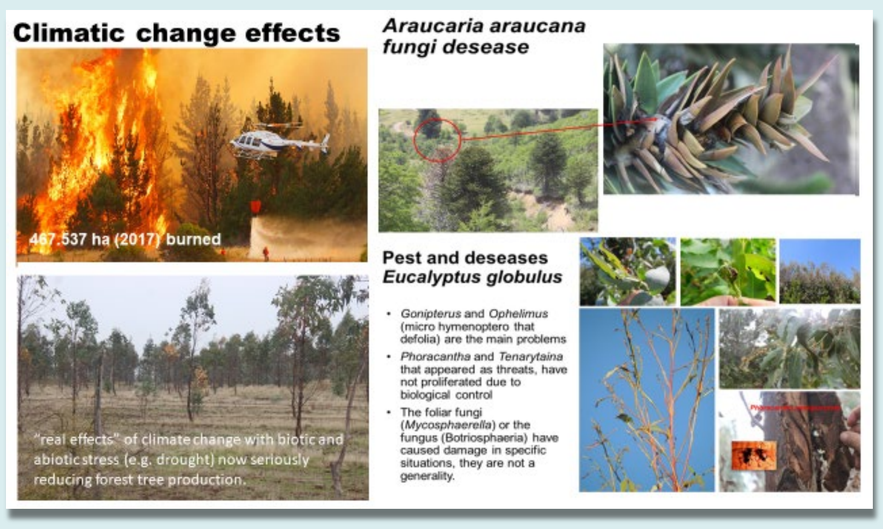


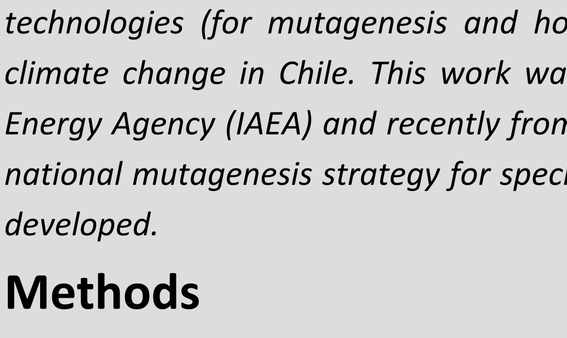
Introduction

Nuclear technologies have multiple applications in medicine, industry, agriculture and energy and great potential in combatting adverse effects of climate change that affect native forest ecosystems and tree plantations. In 2020, INFOR and CCHEN initiated CHI5052 project to exploit nuclear technologies (for mutagenesis and hormesis) in forest species affected by climate change in Chile. This work was funded by the International Atomic Energy Agency (IAEA) and recently from Government of Biobio-Chile, FIC-R. A national mutagenesis strategy for species of forestry interest in Chile is being developed.

Methods

Seeds of Eucalyptus globulus, E. nitens were irradiated in a self-shielded Gamma Cell 220R irradiator equipped with CO60, an irradiation rate of 8.9 Gy/min was established by Fricke dosimetric system for LD_{30} from radio-sensitivity testing. For hormesis studies in Eucalyptus nitens a range of gamma irradiation seed treatments were used (0, 10, 20, 30, 40, 50 Gy) and the effects on germination and seedling growth measured and the best treatment was 10 Gy.

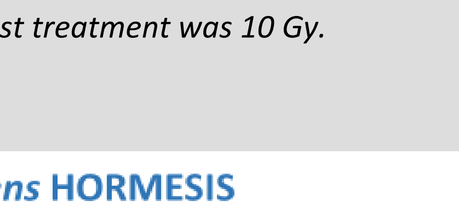
DOSIMETRY FOR *Eucalyptus nitens* HORMESIS



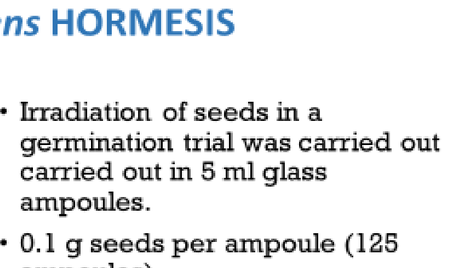
- Irradiation of seeds in a germination trial was carried out carried out in 5 ml glass ampoules.
- 0.1 g seeds per ampoule (125 ampoules).
- Ampoules with seeds irradiated: 10, 20, 30, 40 and 50 Gy.

DOSIMETRY FOR M_1 *E. globulus* MUTAGENESIS

- *E. globulus* capsules were collected at the Maintencillo Clonal Seed Orchard from open pollination of an elite clone (281) ranked in the top 10 of the INFOR genetic ranking for timber volume production.
- Seed capsules were sent to INFOR laboratory where they were dried for 24 hours at 40°C.
- Seeds were removed from the capsules and cleaned (paraphysis removed). The number of seeds/g was evaluated (normal standard practices).
- Dried and clean seeds (M_0) were stored at the germoplasm bank of INFOR. After pre-treatment and storage, the seed irradiation treatments were carried out in a self-shielded Gamma Cell 220R equipped with Co^{60} with an irradiation rate of 8.9 Gy/min. After treatment the seed is classed as M_1.



Regression of LD30 and LD50 for E. globulus open pollinated 281. Based on seed germination and not survival



PRELIMINARY RESULTS

a)Gamma irradiation of seed at 10 Gy and lower (hormesis) has a positive improvement on germination and initial growth of E. nitens.

b)The preliminary results on hormesis provide guidance regarding the magnitude of gamma irradiation to be used and confirm that relatively low doses would be the most effective to improve germination and initial seedling growth for plantation. The effective dose is specific and must be determined for each species.

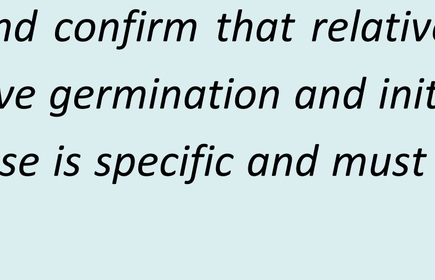
c)The preliminary semiletal dose LD_{30} on E. globulus seeds generated seedlings with typical physiological disorders, though knock-out mutations and dominant mutations cannot be ruled out. To be confirmed by molecular markers and physiological disorders will disappear in the M2 generation.

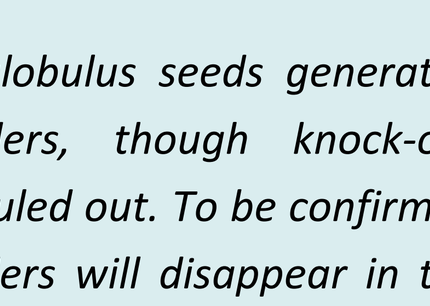
Results

EFFECT OF HORMESIS ON THE GERMINATION OF *EUCALYPTUS NITENS* SEEDS

- 10 Gy of gamma radiation has a positive effect in improving germination of *E. nitens* seeds;
- Doses of 20 to 50 Gy do not exhibit differences.
- *E. nitens* produced 90% germination in the control, but this was enhanced buy irradiation at 10 Gy.
- The preliminary results provide guidance regarding the magnitude of gamma radiation to be used and confirm that low doses are effective in improving germination.

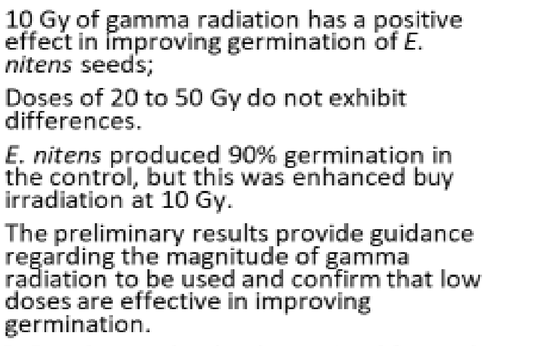
NB: Results need to be determined for each species





EFFECT OF HORMESIS ON THE INITIAL GROWTH OF *E. nitens* SEEDLINGS → 6 months

- The effects of: 0, 10, 20 and 30 Gy on the initial growth: height, collar diameter (DAC) and DAC^2H of seedlings of *E. nitens* during the first year of field planting.
- A dose treatment of 10 Gy provided the most beneficial results with faster growth rates, taller seedlings and greater girth at 6 month.



EFFECT OF MUTAGENESIS ON THE EARLY GROWTH OF *E. globulus* SEEDLINGS AT THE NURSERY

- E. *globulus* seeds capsules were collected in the Maintencillo Clonal Seed Orchard corresponding to family 281. This is an elite clone ranked in the top 10 of the INFOR genetic ranking for timber volume production
- After pre-treatment and storage, the seed irradiation treatments were carried out in a self-shielded Gamma Cell 220R (JL Shepherd & Associates) irradiator equipped with CO60 and an irradiation rate of 8.9 Gy/min established by the Fricke dosimetric system
- The preliminary LD30 radiations dosimetry of E. globulus have generated M1 seedlings with leaf aberration, pleiocotyly. No strong conclusion can be made from this as the phenotypes observed may be due to physiological perturbations cause by the irradiation treatment.
- Other possibilities are genetic, e.g., knock-out mutations of a dominant allele at a heterozygous locus or a dominant mutation. Our work aims to analyses the M1 individual seedlings for sequence mutations in genes of interest. This can be done at the nursery stage and M1 seedlings of interest grown on to produce M2 populations.

Future research aims to develop an hormesis protocol to improve germination rate on seeds and initial growth of seedlings specially native species and also to continue nutagenesis breeding program for Chilean forest species affected by climate change.

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