Multiple stressor effects of ionising (gamma) radiation and non-ionising (UV) radiation in duckweed (*Lemna minor*)

Li Xie[1,2,3], You Song[1,3], Knut Asbjørn Solhaug[2,3], Ole Christian Lind[2,3], Brit Salbu[2,3], Bjørn Johnsen[4], Knut Erik Tollefsen[1,2,3]

[1] Norwegian Institute for Water Research (NIVA)

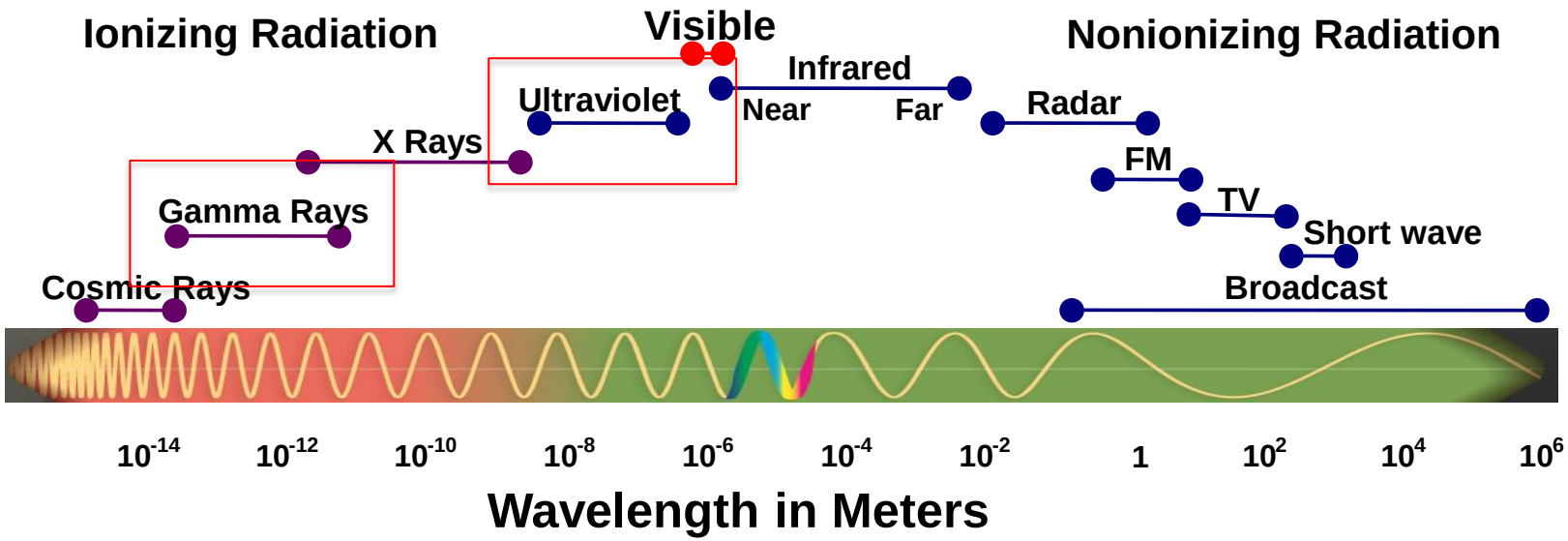
[2] Faculty of Environmental Sciences and Natural Resource Management (MINA), Norway Norwegian University of Life Sciences (NMBU)

[3]Centre for Environmental Radioactivity (CERAD), Norwegian University of Life Sciences (NMBU)

[4]Norwegian Radiation protection Authorty (NRPA)

Contact : Li.Xie@niva.no

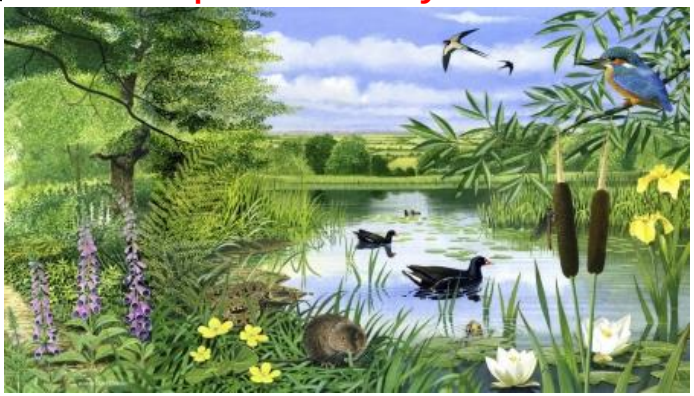
Ionizing and Non-Ionizing radiation



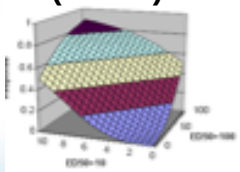
The challenge



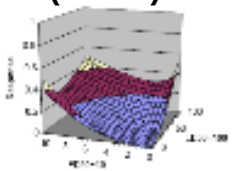

What will happen in the aquatic ecosystem?



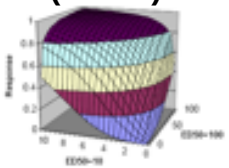
Additivity (1+1=2)



Antagonism (1+1<2)



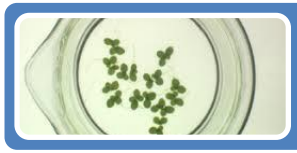
Synergy (1+1>2)



Duckweeds (*Lemna minor*)

Central function in aquatic ecosystems

Easily cultured in controlled laboratory conditions



✧Standardised protocols available for regulatory testing

Rapid reproduction capacity

✧Highly sensitive to contaminants

✧Genome partly sequenced, molecular tools partly available

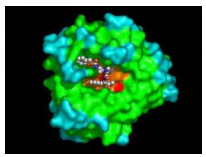
Objective

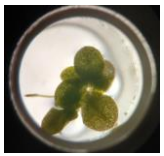
Study — Clarify the individual and combine effect of γ-radiation and UVR in the duckweed

Modeling — Develop adverse outcome pathway (AOP) framework

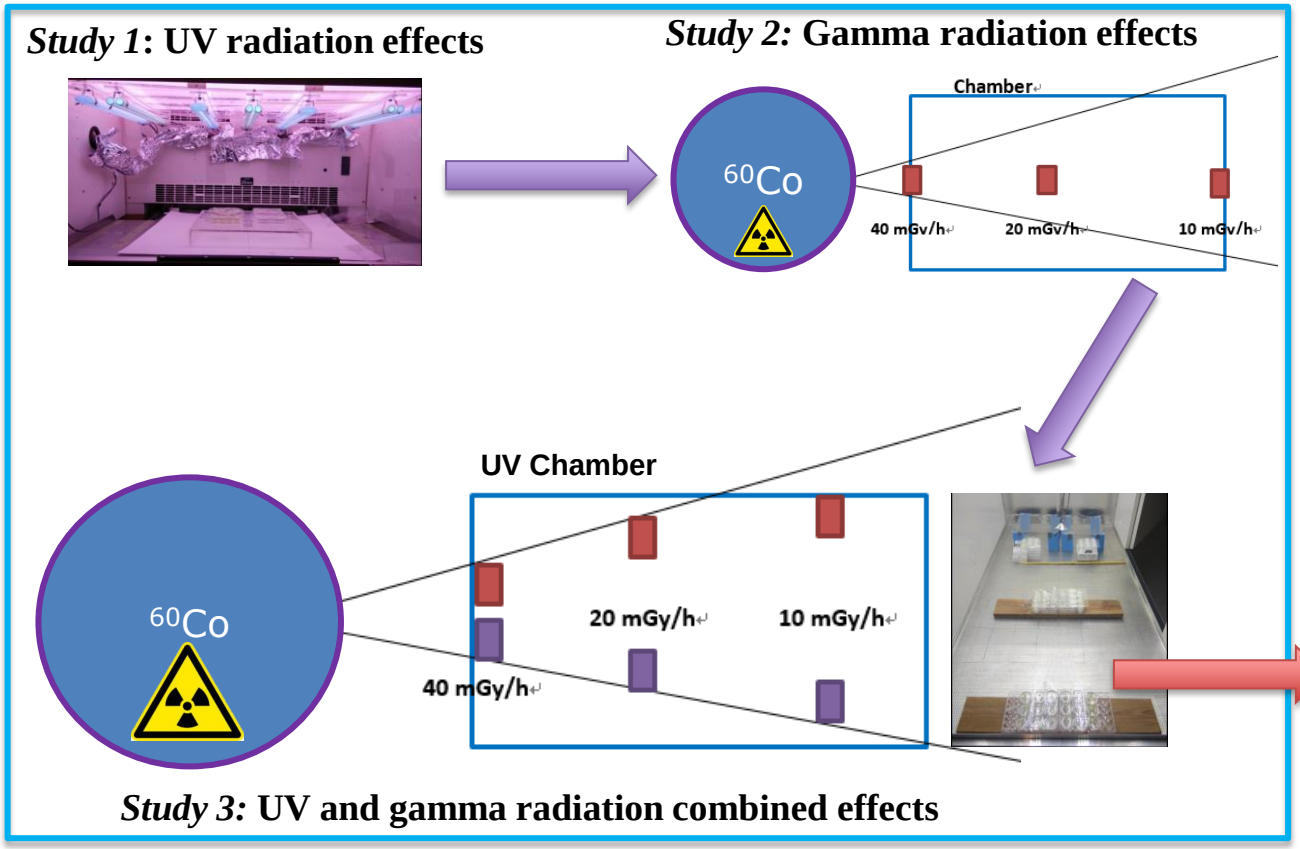
Application — Hazard Assessment

Stressor → Molecular Initiating Event → Key Events → Adverse Outcome → Population effect






Approach

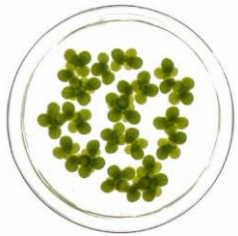


Endpoints:
Growth
ROS formation
Lipid peroxidation
OXPHOS
PSII efficiency
Pigments
DNA damage
Gene expression

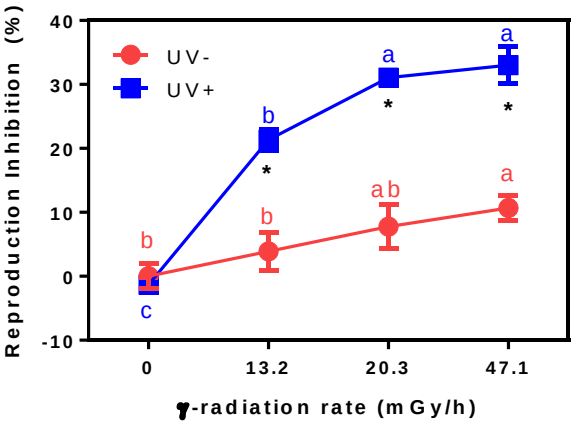
Gamma dose rate D_{Water} (mGy/h)*	Gamma total dose D_{Water} (mGy)	UV Dose rate (W/m²)
13.2	2195	0.5±0.03
20.3	3375	
47.1	7831	

Statistics
Two-way ANOVA

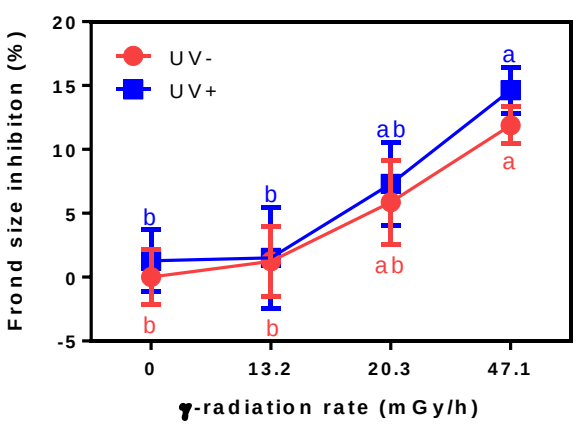
Growth



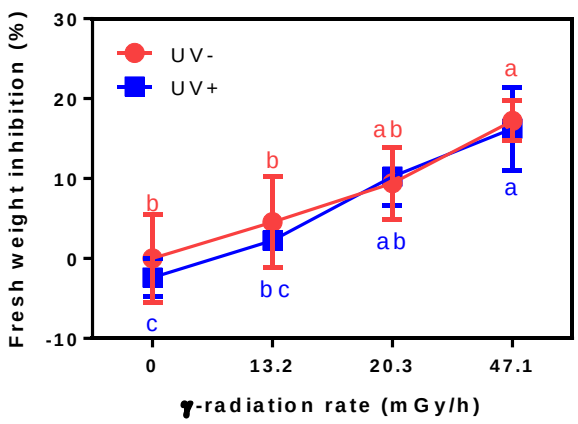
Reproduction



Frond size

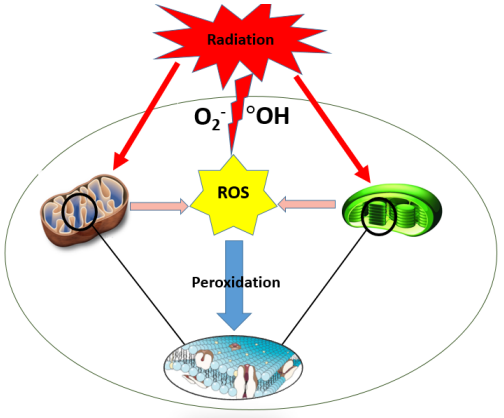


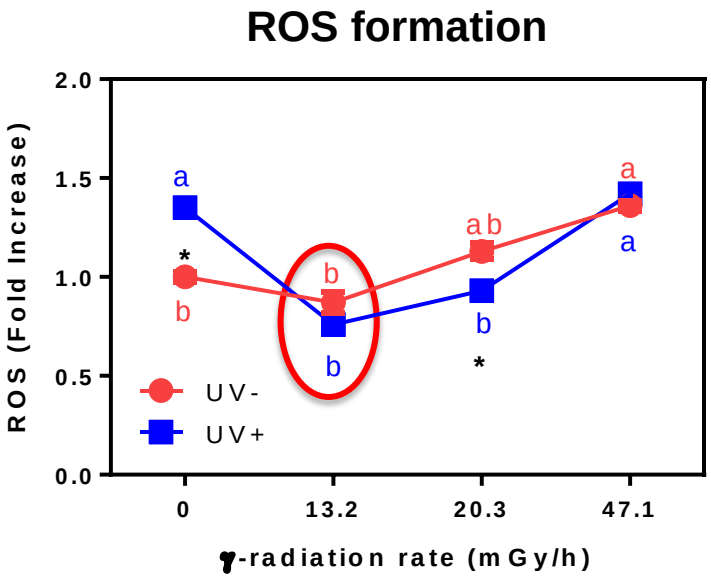
Frond weight

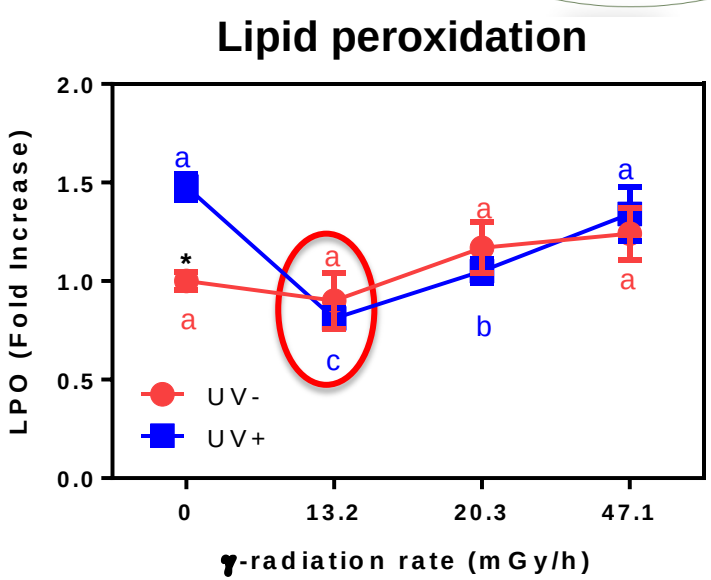


UV did not interrupt gamma radiation effects on frond size and weight but reproduction rate.

Oxidative stress

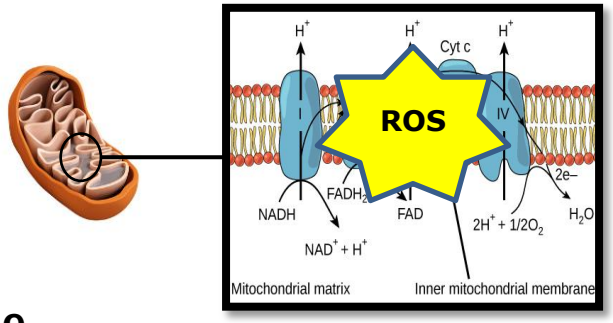


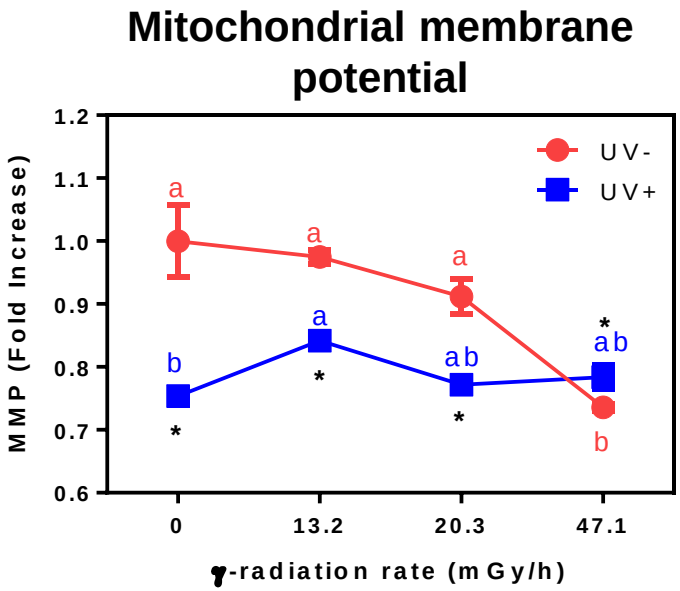




Activation antioxidant defense system

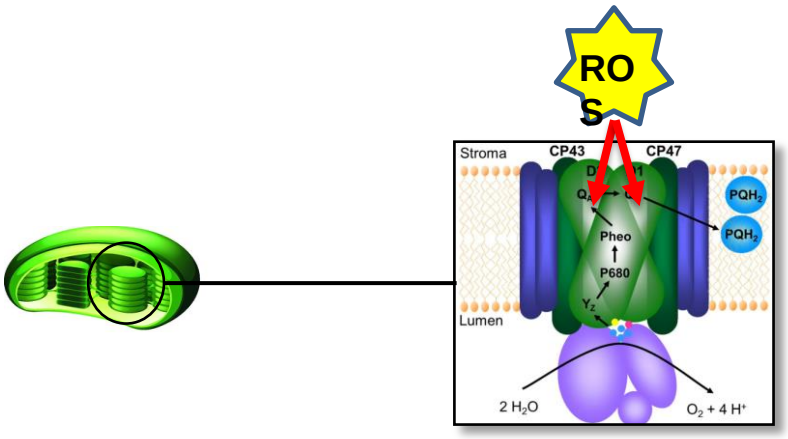
Oxidative phosphorylation



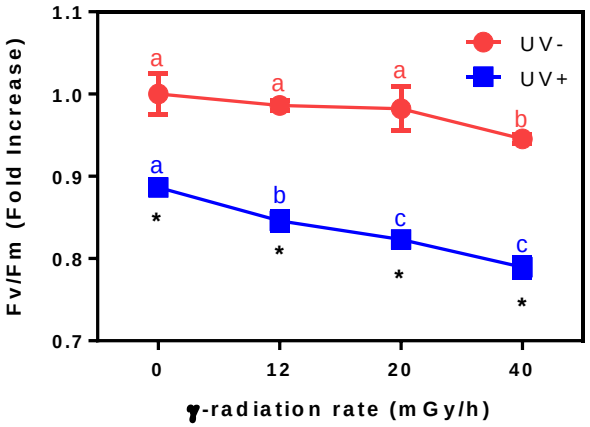


UVR reduced MMP and interfere gamma radiation effect

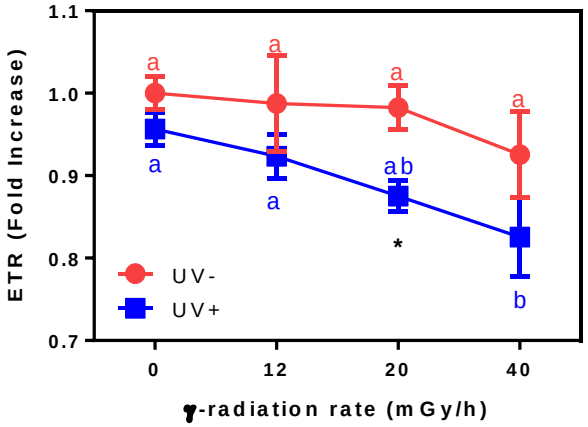
PS II inhibition



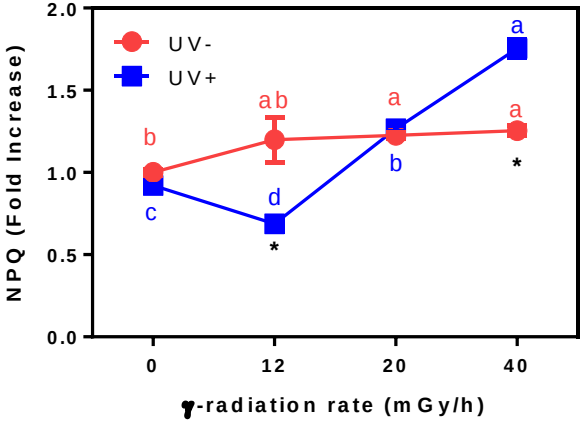
Maximal PS II efficiency



Electron transport rate

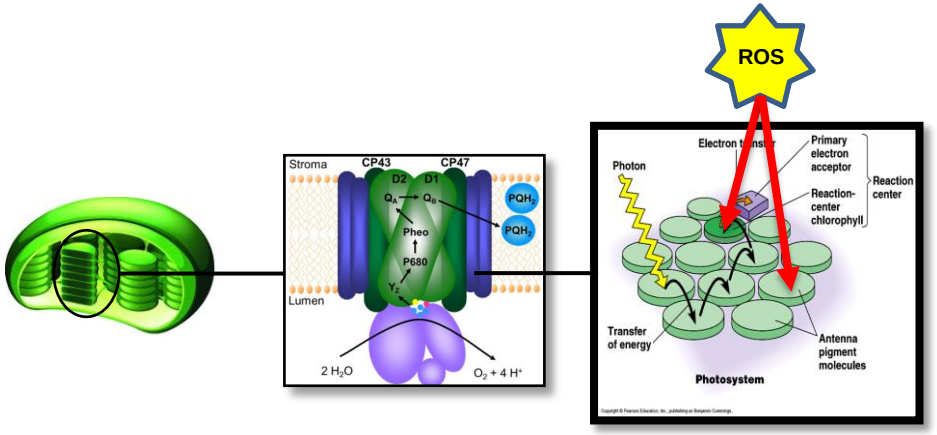


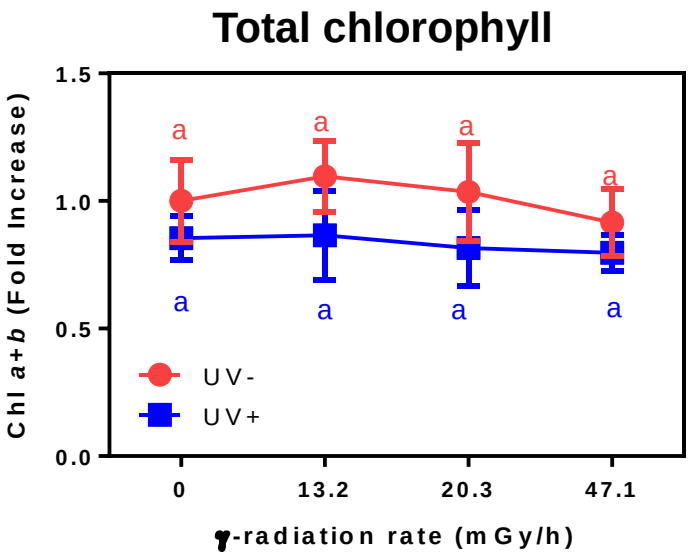
Non-photochemical quenching

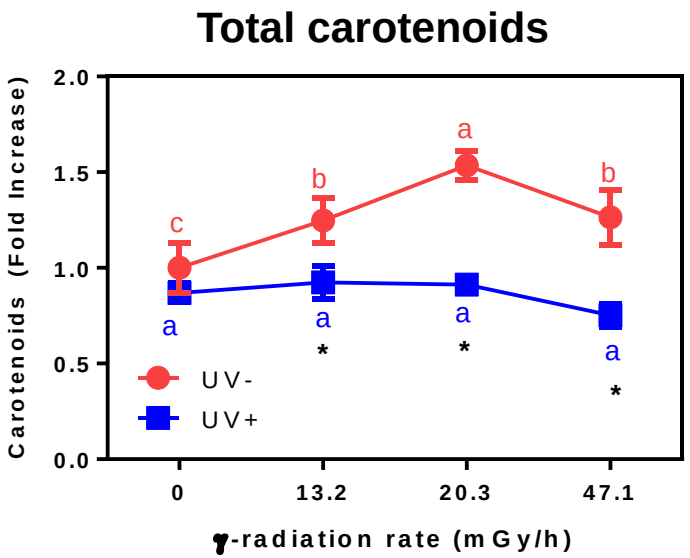


In combined exposure, γ-radiation and UV had additive effects on Fv/Fm

Pigment content







Carotenoids are also antioxidants to quenching ROS in plant

ROS

Pigment destruction

NPQ increase

ETR blocking

PSII efficiency

Growth

PSII efficiency

Growth

Population trajectories

OXPHOS

Stressor → **M**olecular **i**nitiating **E**vent → **K**ey **E**vent**s** → Individual effect → Population effect

Norwegian Institute for Water Research

Tânia Gomes
You Song

Dag Brede
Dag Wenner
Hans Christian Teien
Yetneberk Ayalew Kassaye

Statens strålevern
Norwegian Radiation Protection Authority

Terje Christensen

QUESTIONS ?

THANK YOU!

Li.Xie@niva.no

CERAD
CENTRE FOR ENVIRONMENTAL RADIOACTIVITY