



**THE INFLUENCE OF WATER WITH A LOW
CONTENT OF DEUTERIUM ON GROWTH AND
STATE OF LEAF CABBAGE**

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Ordinary natural water contains 9 types of molecules, not equal in isotope composition:

- **hydrogen in water molecules is an extremely light isotope – protium**
 $H_2^{16}O, H_2^{17}O, H_2^{18}O;$
- **hydrogen in water molecules is an extremely heavy isotope—deuterium**
 $D_2^{16}O, D_2^{17}O, D_2^{18}O;$
- **hydrogen in water molecules is as a light, and as a heavy isotope**
 $H^{16}OD, H^{17}OD, H^{18}OD$

The international standard of water isotope composition is a middle oceanic water, SMOW, where the content of water heavy in hydrogen is
140 ppm, or 0,015 ‰

The influence of heightened content of deuterium on living organisms

Taken out of a work: Lobishev V.I., Kalinichenko L.P. //Isotope effects D2O in biological systems// M. Science 1978, p. 215

Animals

- 1. Disorder of circadian rhythms**
- 2. Reduction of survival potential protozoa**
- 3. Repression of syntheses DNA and mitosis in liver cell of a rat**
- 4. Death of animals (rats) when rising D₂O in tissue water till 30% and more**

Plants

- 1. Disorder of circadian rhythms**
- 2. Decrease of dimensions**
- 3. Undeveloped root system**
- 4. Poor differentiation and structure of chloroplasts**
- 5. Dimension increase of epidermis and parenchyma cells when decreasing dimensions of through cells**

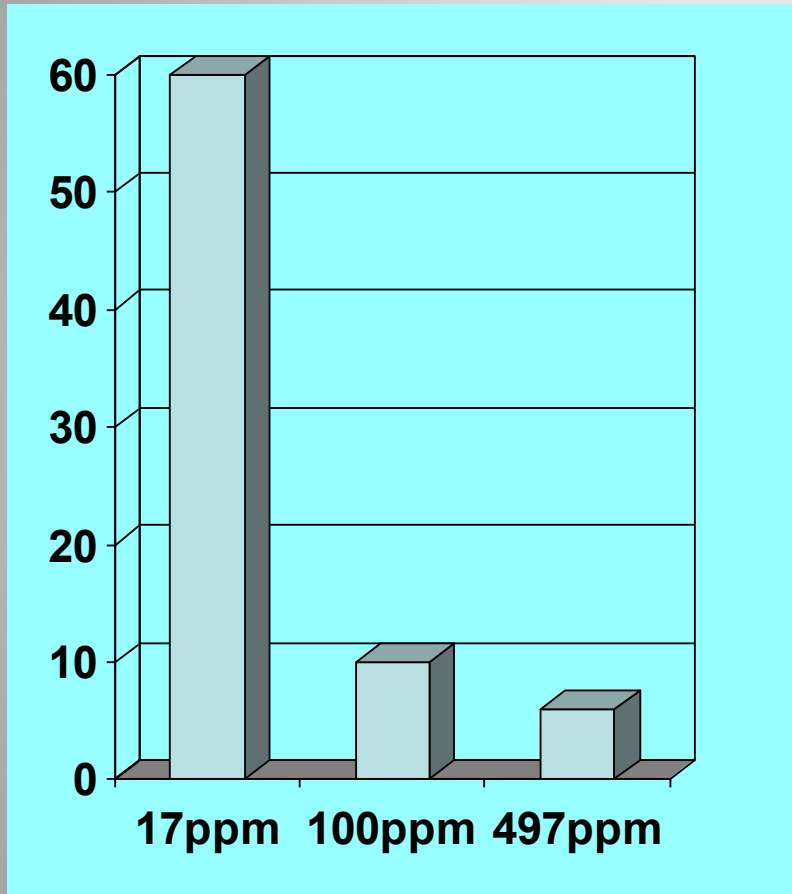
Water with heightened content of heavy oxygen isotope provokes similar effects, as those detected for water with heightened content of deuterium

Object of this research:

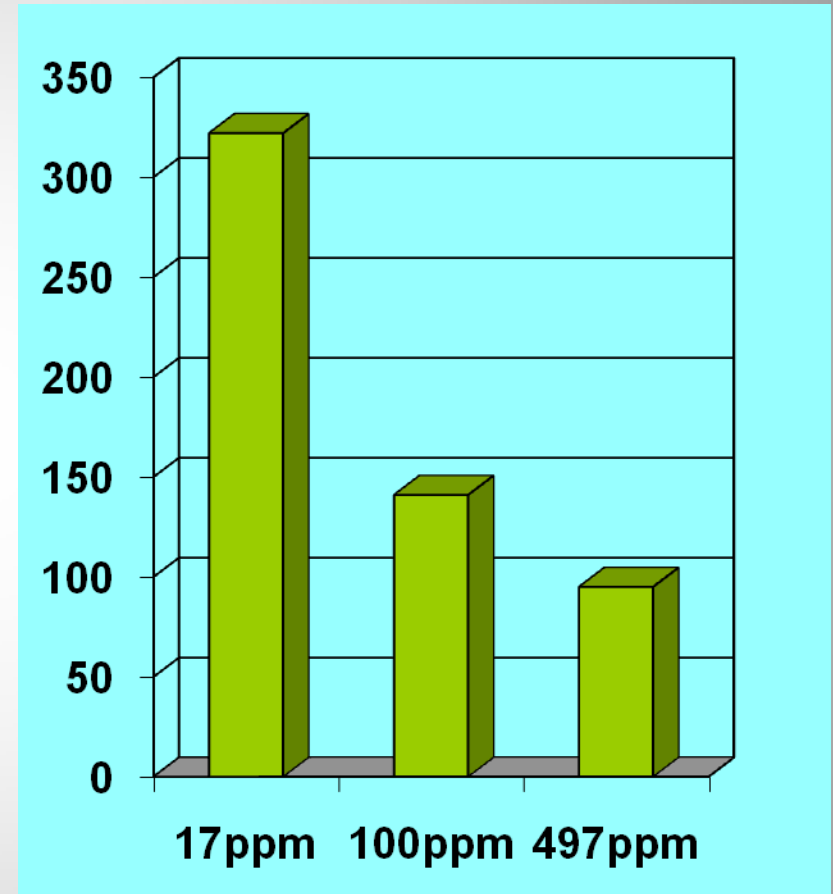
To estimate the expected experimental effects of using light isotope water for water supply of the crew and the plants cultivated in space plant growth facility.

Growth and seed production of the *Arabidopsis thaliana* L. plants depending on content of the deuterium in water

Shoot dry weight, g



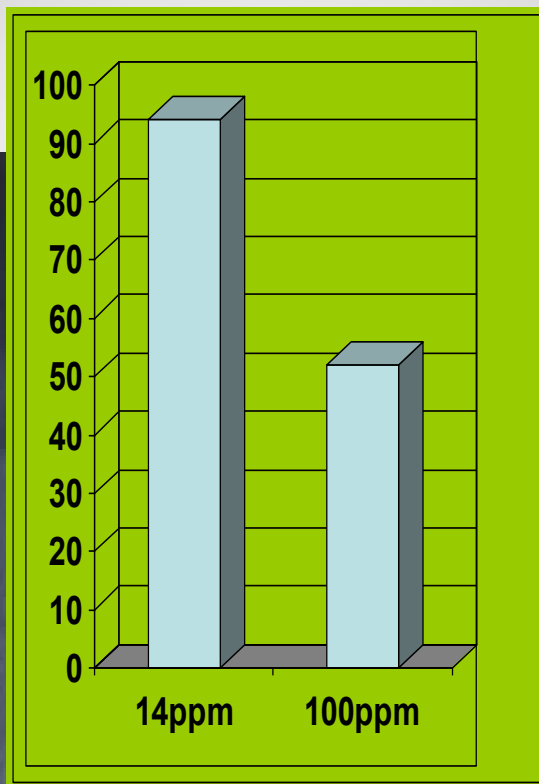
Quantity of seeds, piece/plant



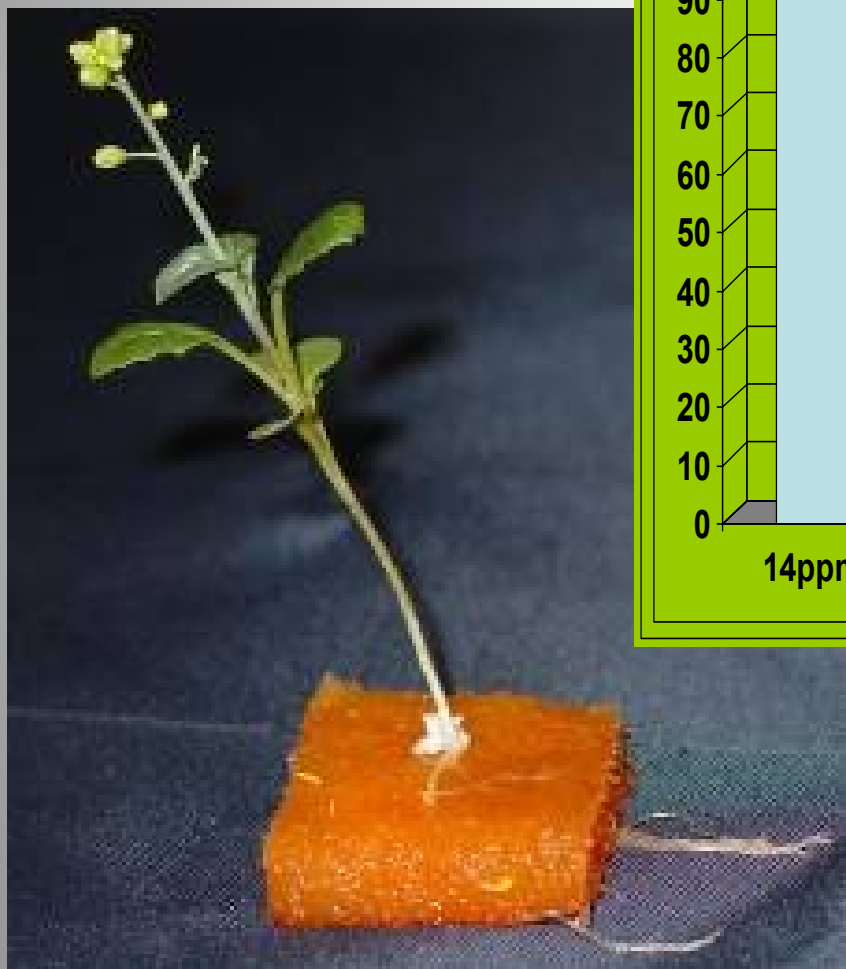
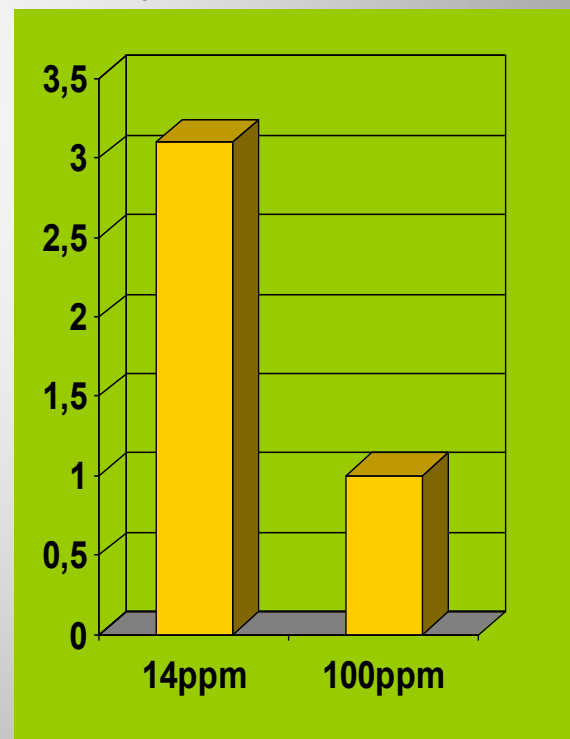
Taken from a research: Sinyak Y., Grigoriev A., Gaydadimov V., Gurieva T., Levinskih M., Pokrovskii B. Deuterium-free water ($^1\text{H}_2\text{O}$) in complex life-support systems of long-term space missions. // *Acta Astronautica*, 2003, v.52, p.575-580

Growth and seed producing plant capacity of type *Brassica rapa* L. depending on content of the deuterium in water

- Shoot dry weight, g



Quantity of seeds, piece/plant



Object of the experiment

Chinese cabbage *Brassica chinensis*
L., sort Vesnyanka

Chosen as a source of vitamin biomass,
shoots are characterized by rapid
growth with high content of an ascorbic
acid



Japanese cabbage *Brassica japonica*
L., line 927

chosen as a spicy-gustatory culture,
shoots have special nice taste

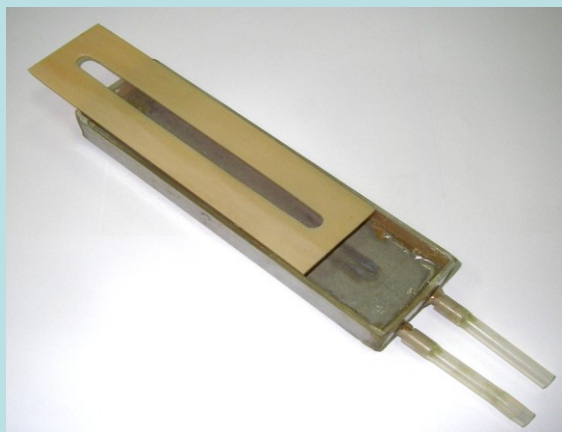
Place of seed selection and production –

All-Russian Research Institute of Vegetable Breeding and Seed Production of Russian Academy of Agricultural Sciences

Root modules

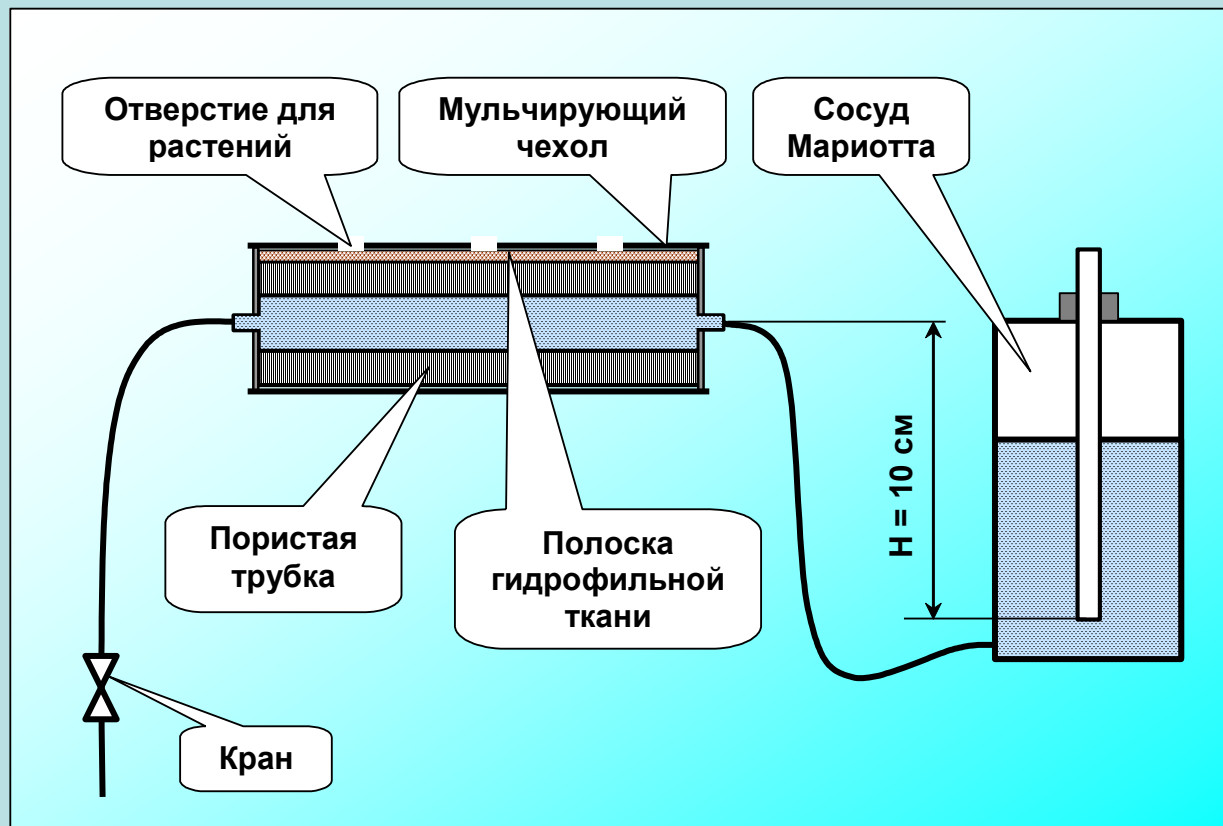


Metal-ceramic porous tube



Vegetative cuvette with small porous and titanic membrane

Scheme of test-bed with root module with porous tube



Conditions of experiment

Content of deuterium in water

110 - 125 ppm (control); 10 - 20 ppm (test)

Mineral nutrition

0,5 of a norm of a nutritious solution of Chesnokov with an addition of microelements according to Hoglund

Source of light

Luminescent lamp of white light;

Light unit based on warm white light-emitting diodes;

Light unit based on red and blue light-emitting diodes

Mode of lightening

uninterrupted

Water potential on membrane surface or on axis of tube

(-1,0) kPa

PPF levels:

- Japanese cabbage - $125 \pm 15 \mu\text{M}/(\text{m}^2 \cdot \text{s})$
- Chinese cabbage - $85 \pm 15 \mu\text{M}/(\text{m}^2 \cdot \text{s})$; $250 \pm 20 \mu\text{M}/(\text{m}^2 \cdot \text{s})$

Air temperature

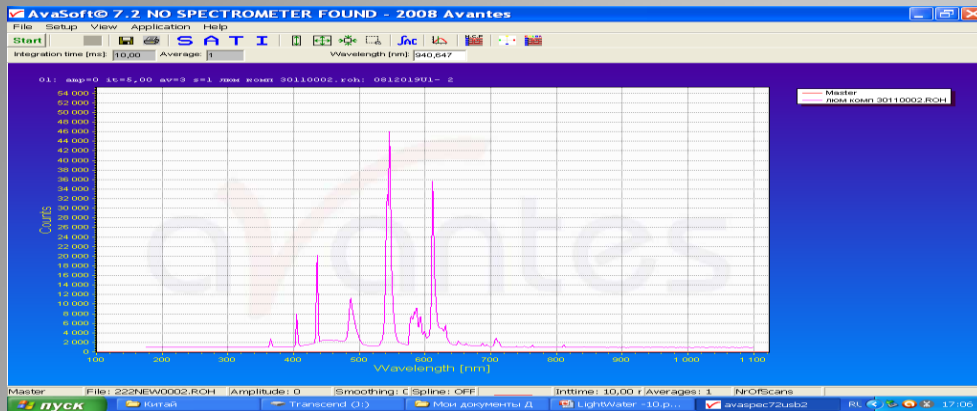
Japanese cabbage - $33 \pm 1 \text{ }^\circ\text{C}$ (optimal); $26 \pm 2 \text{ }^\circ\text{C}$ (suboptimal)

Chinese cabbage - $31 \pm 2 \text{ }^\circ\text{C}$ (optimal); $27 \pm 1 \text{ }^\circ\text{C}$ (suboptimal);

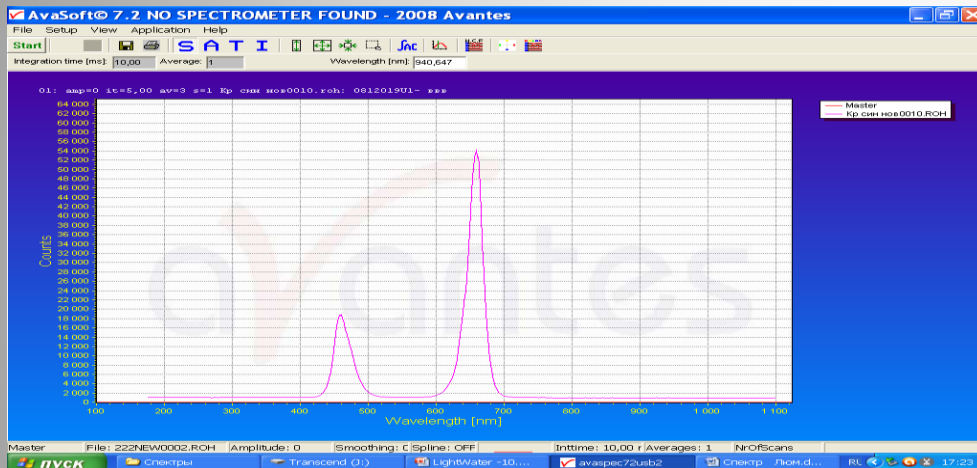
$22 \pm 1 \text{ }^\circ\text{C}$ (not optimal)

SPECTRUMS OF THE TESTED LIGHT UNITS

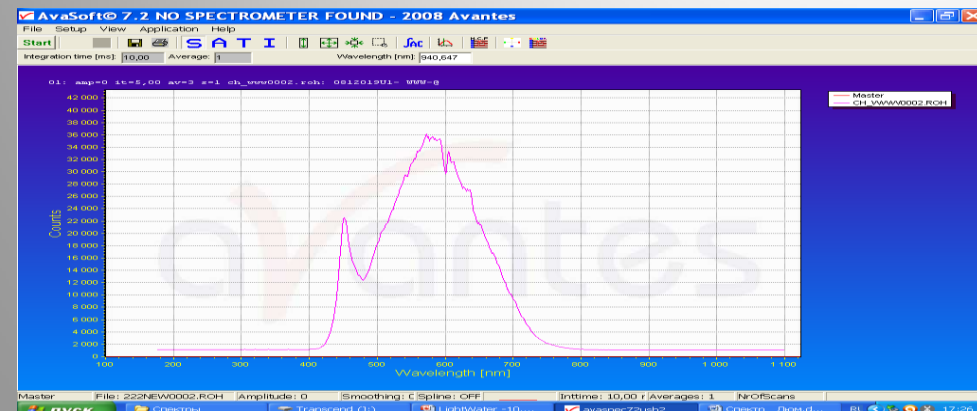
White luminescence lamp



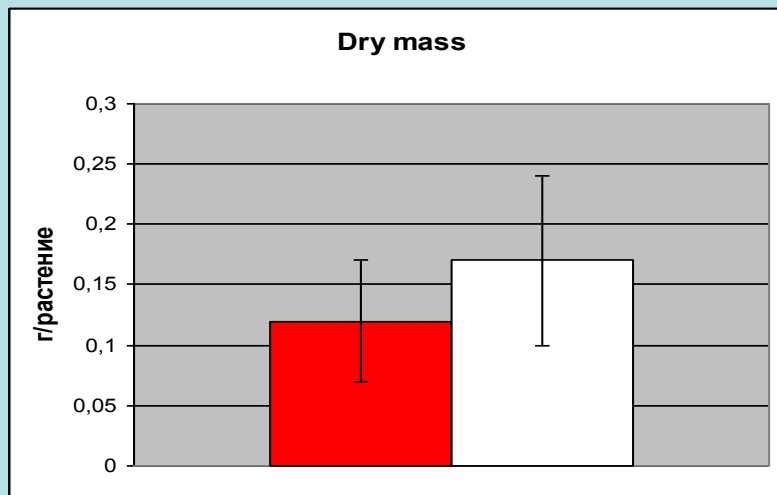
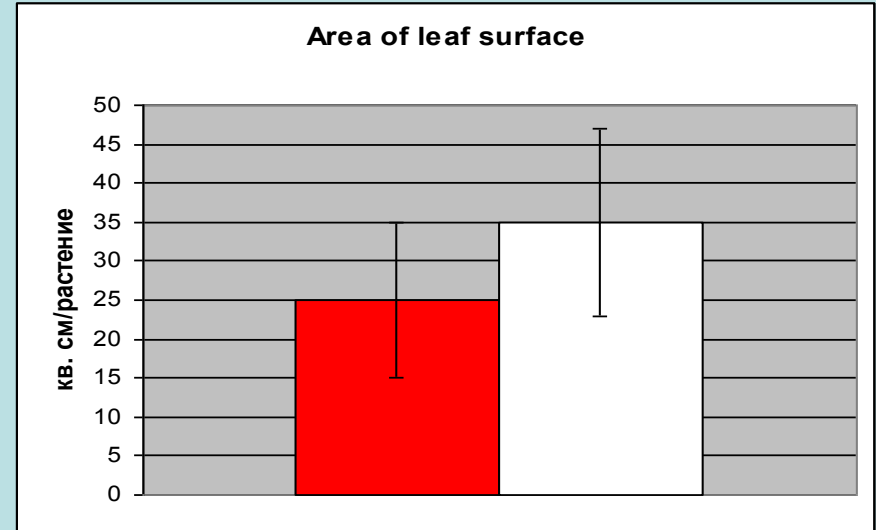
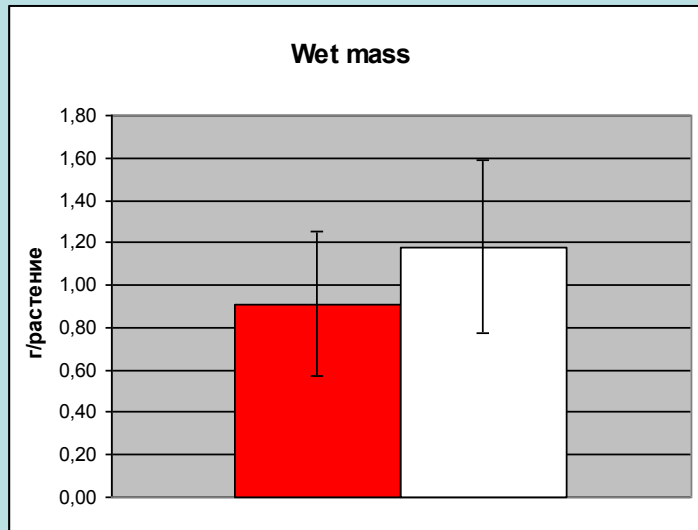
Light unit on the base red and blue LED



Light unit on the base white LED



Morphometrical parameters of 30-day's Japanese cabbage *Brassica japonica* L., line 927, under an optimal temperature regime depending on content of deuterium in water.

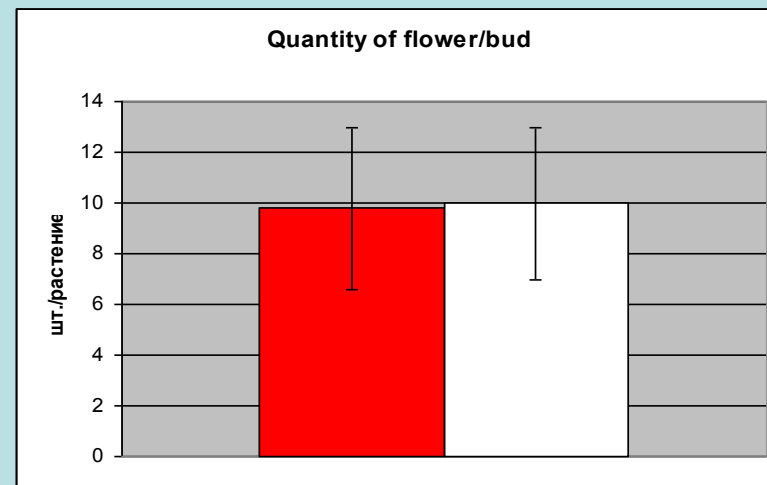
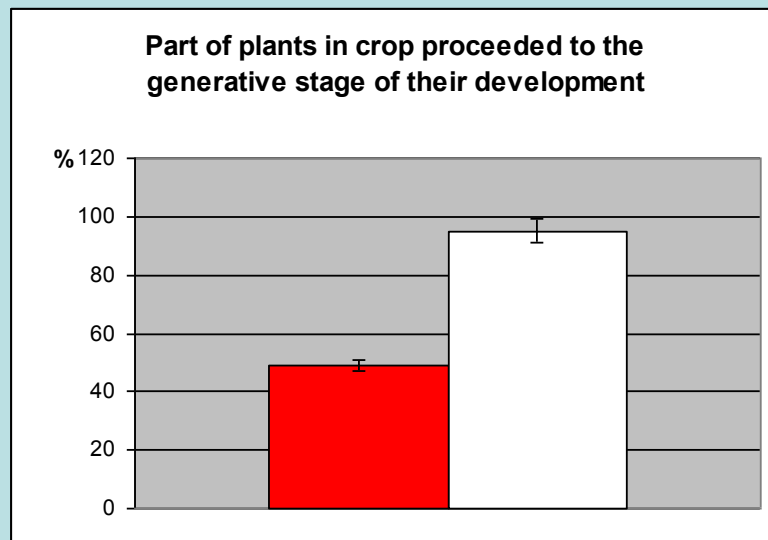
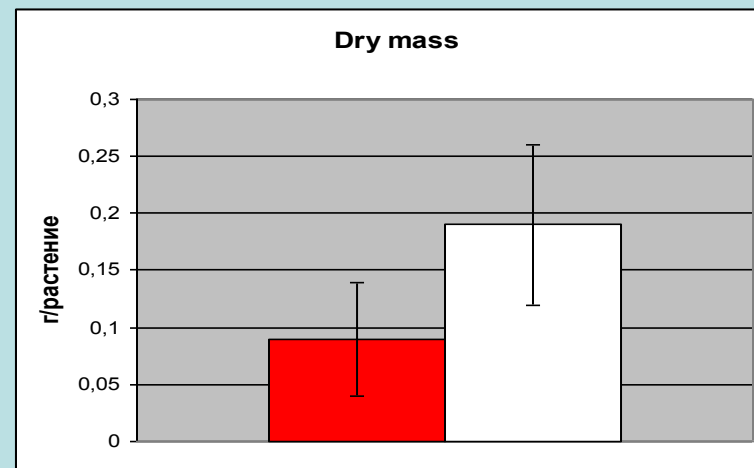
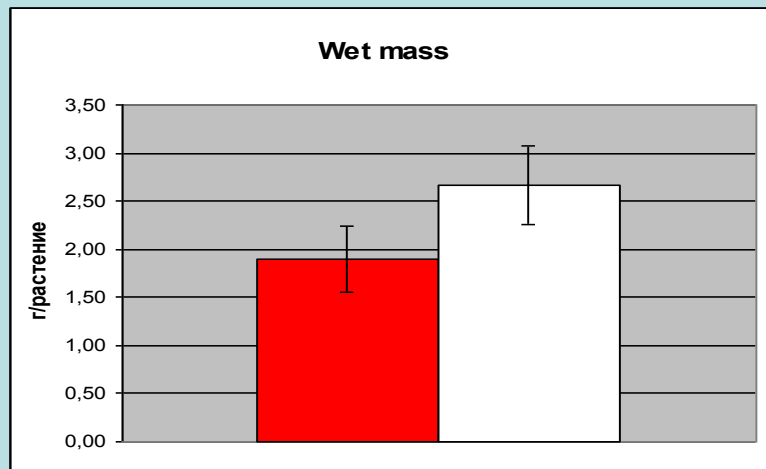


Content of deuterium in water 125 ppm



Content of deuterium in water 10 ppm

Parameters of growth and seed potential capacity of 30-day's plants of Japanese cabbage *Brassica japonica* L., line 927, under a suboptimal temperature regime depending on content of deuterium in water.



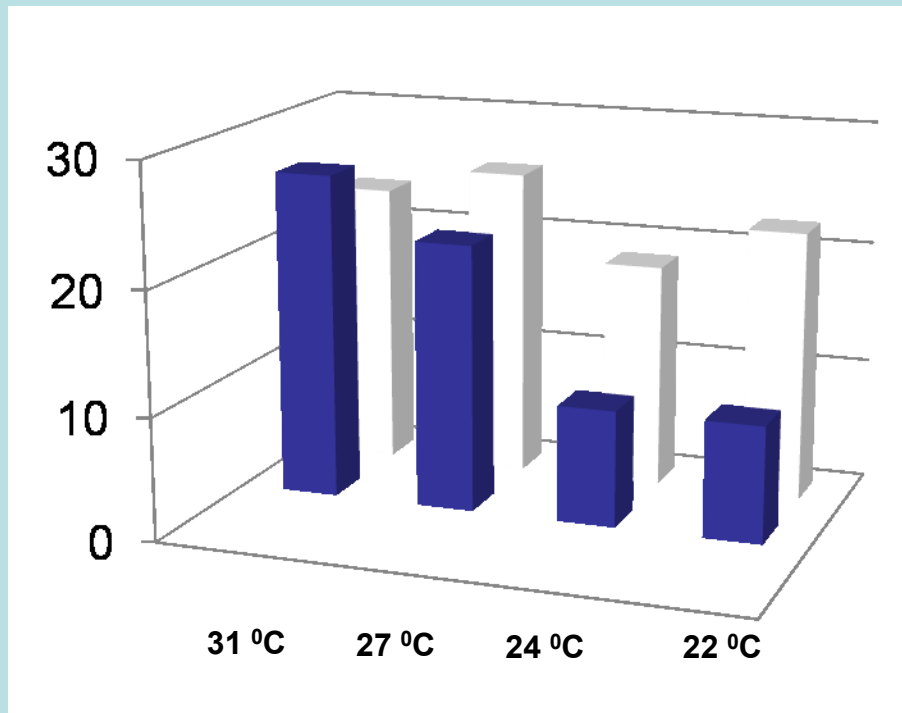
Content of deuterium in water 125 ppm



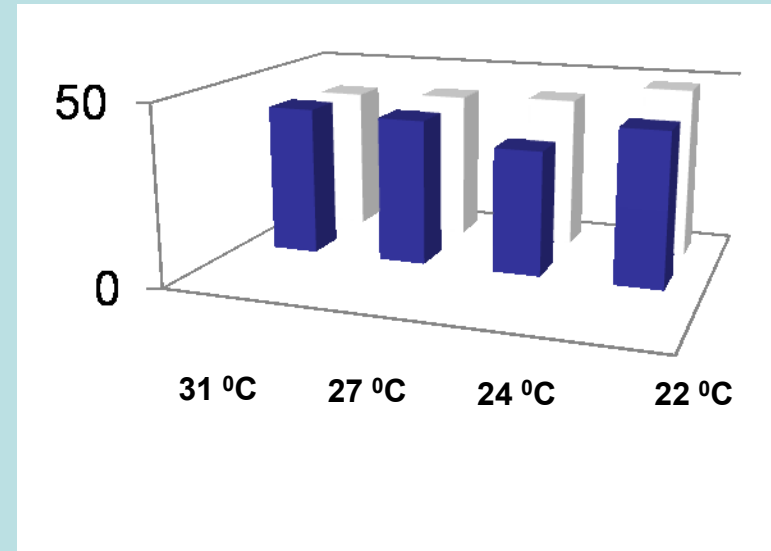
Content of deuterium in water 10 ppm

The deuterium's content in water influence on morphometrical parameters of 28-day plants of Chinese cabbage *Brassica chinensis* L., cv. Vesnyanka, under different temperature regimes.

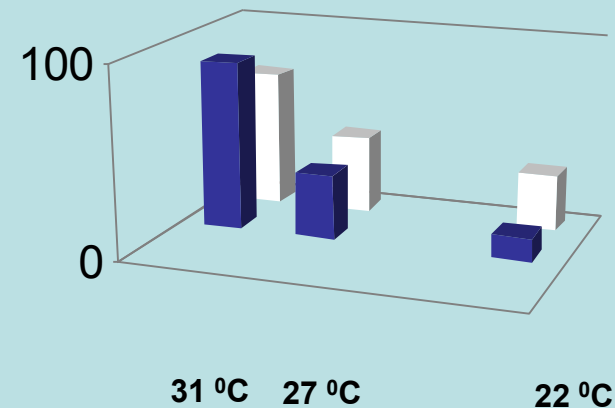
Shoot fresh weight, g



Specific surface density of a leaf, mg/cm²



The ratio of fresh weight of shoots and roots

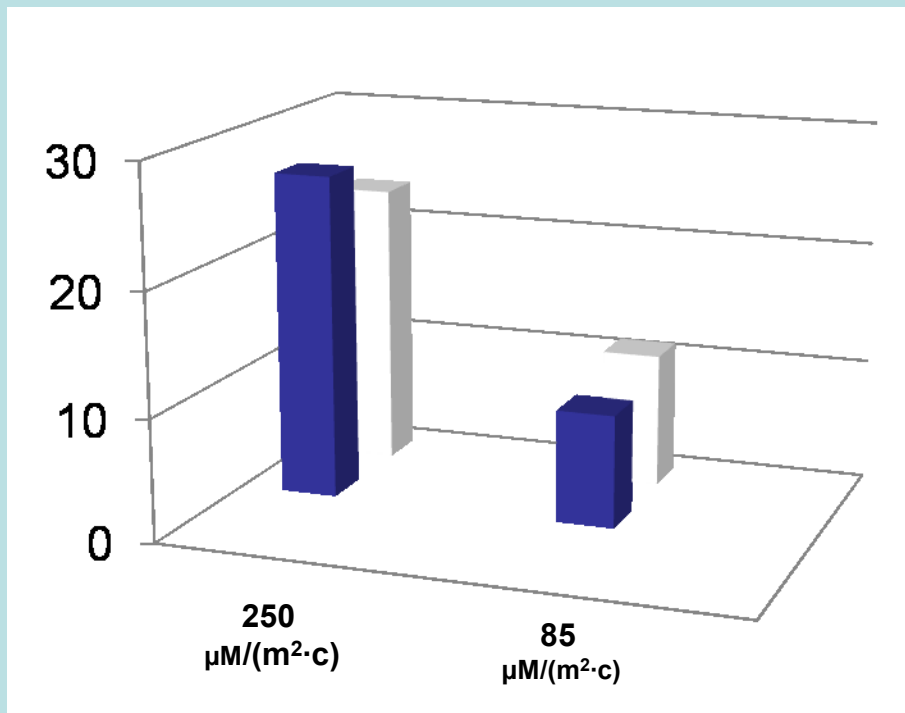



Content of deuterium in water 110 ppm




Content of deuterium in water 17 ppm

Shoot fresh weight, g

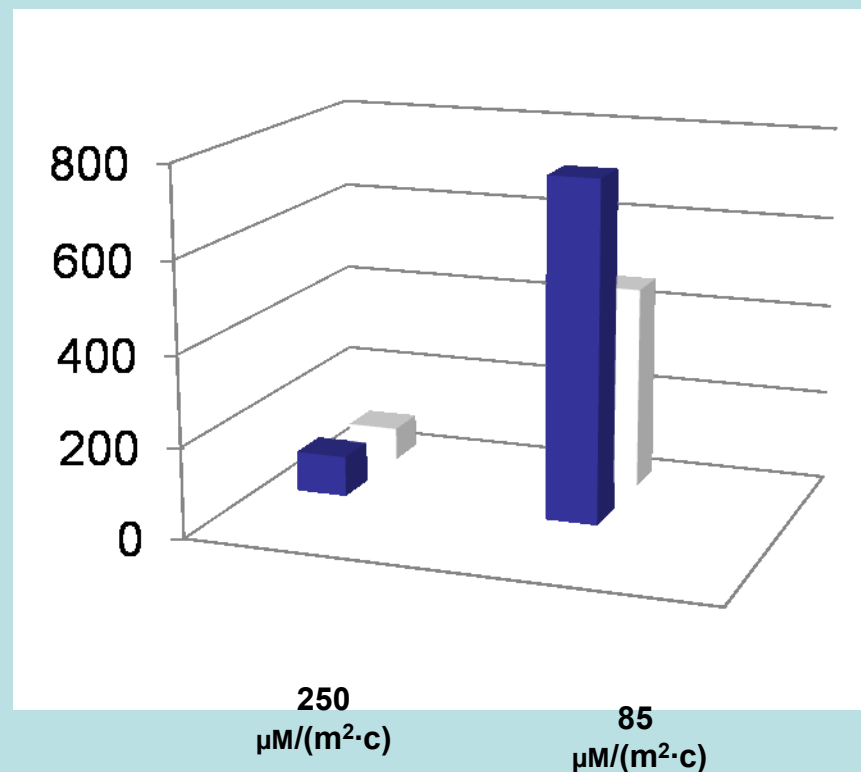


 Content of deuterium in water 110 ppm

 Content of deuterium in water 17 ppm

The deuterium's content in water influence on morphometrical parameters of 28-day plants of Chinese cabbage *Brassica chinensis* L., cv. Vesnyanka depending on PPF level

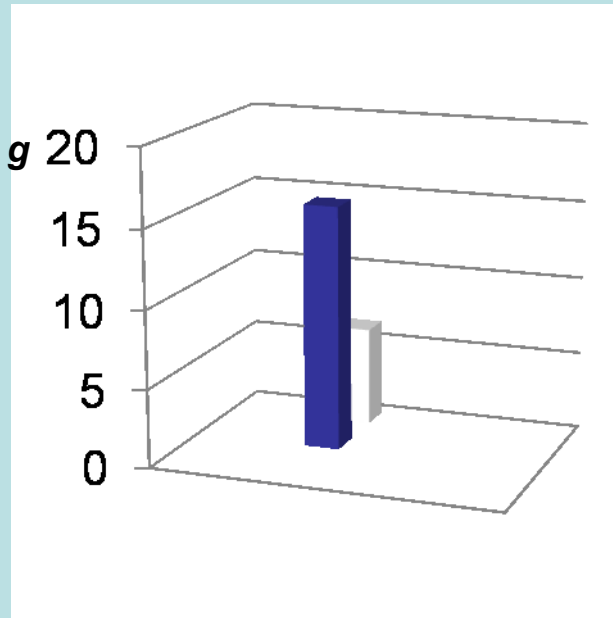
The ratio of fresh weight of shoots and roots



The deuterium's content in water influence on morphometrical parameters of 28-day plants of Chinese cabbage *Brassica chinensis* L., cv. Vesnyanka, depending on a source of light.

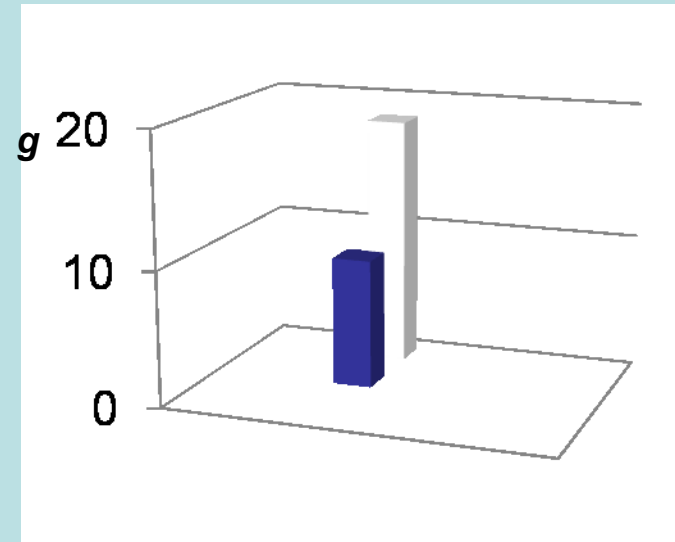
Air temperature: 24 °C,
PPF=250 $\mu\text{M}/(\text{m}^2 \cdot \text{s})$

Light unit based on warm white light-emitting diodes

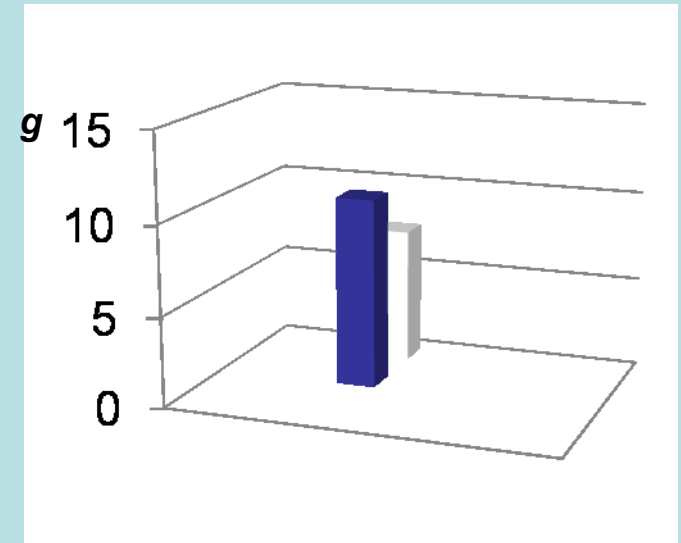


 Content of deuterium in water 110 ppm

Luminescent lamp of white light

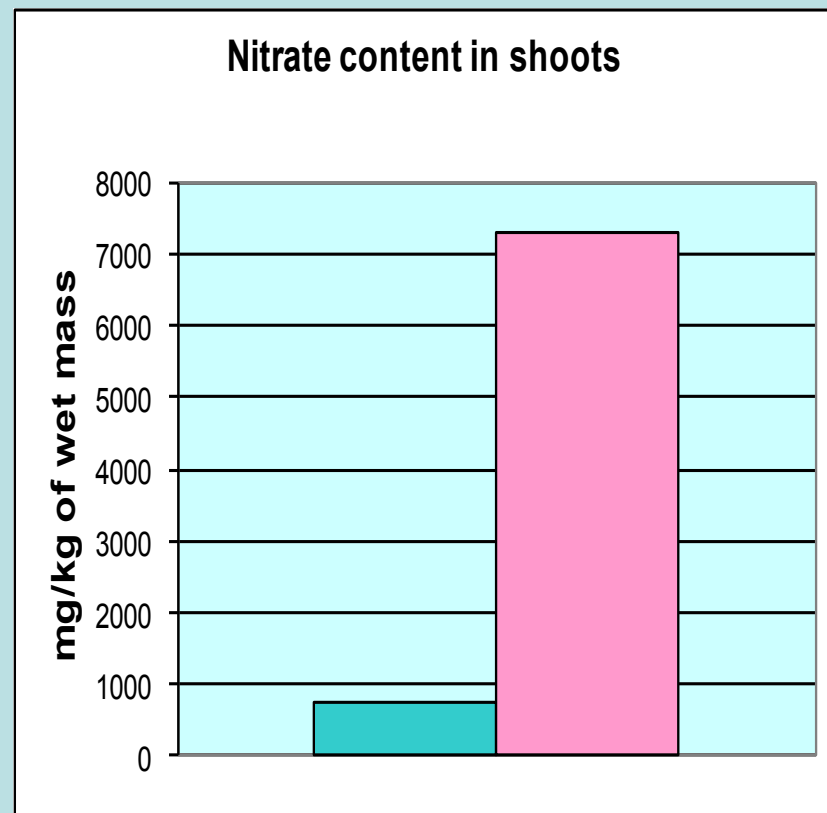
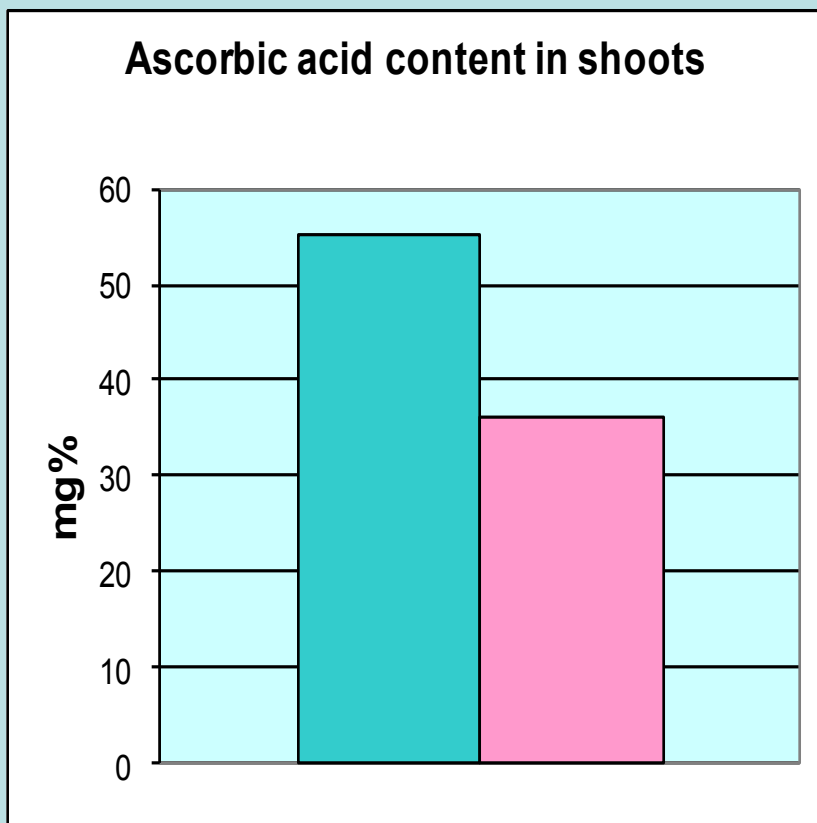


Light unit based on red and blue light-emitting diodes



 Content of deuterium in water 17 ppm

The deuterium's content in water influence on biochemical parameters of 28-day plants of Chinese cabbage *Brassica chinensis* L., cv.Vesnyanka under an air temperature of 22 °C



 Content of deuterium in water 110 ppm

 Content of deuterium in water 17 ppm

CONCLUSIONS:

- Water with a low content of deuterium under some conditions can have a good biological activity regarding leaf cultures having an important influence on photosynthesis and nitrogen exchange.***
- A stabilize influence of a light isotope water on growth and structure of plants under fall of an air temperature was detected.***
- There was detected the considerable accumulation of nitrates in shoots under a fall of deuterium content in water, it marks the miscoordination of nitrate nitrogen absorption and assimilation by plants processes.***
- The was detected tendency to the growth fall of plants cultivated with light isotope water under an influence of a LED light unit radiation.***
- A complex examination of the water isotope content influence on plants is necessary for elaboration of advices about light- deuterium - water utilization in crop production.***