The growth of Chinese cabbage plant *Brassica chinensis L.* under LED light units with various spectrum of radiation

Avercheva O.V.[1], Berkovich Yu.A.[2]., Zhigalova T.V.[1],

Smolyanina S.O.[2], Bassarskaya E.M.[1], Erokhin A.N.[2]

[1] Federal State Educational Institution of Higher Professional Education M.V.Lomonosov Moscow State University

[2] State Scientific Centre of the Russian Federation – Institute of Bio-Medical Problems, Russian Academy of Sciences

The problem is to elaborate scientific advices on plants cultivation under LED including space vitamin plant growth facilities to supply the astronauts with fresh vitamin biomass in long-term space expeditions.

The aim of this work was the experimental evaluation of Chinese cabbage growth and conditions under LED light units with various spectrum of radiation.

Experiment object:

Chinese cabbage *Brassica chinensis L.*,

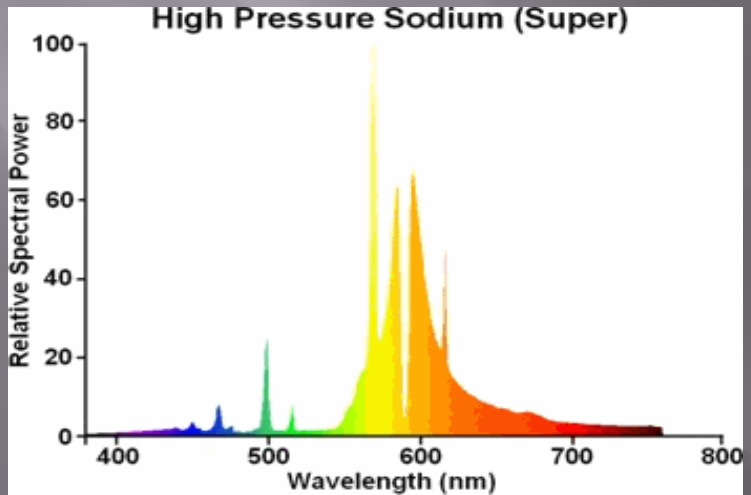
cultivar Vesnyanka,

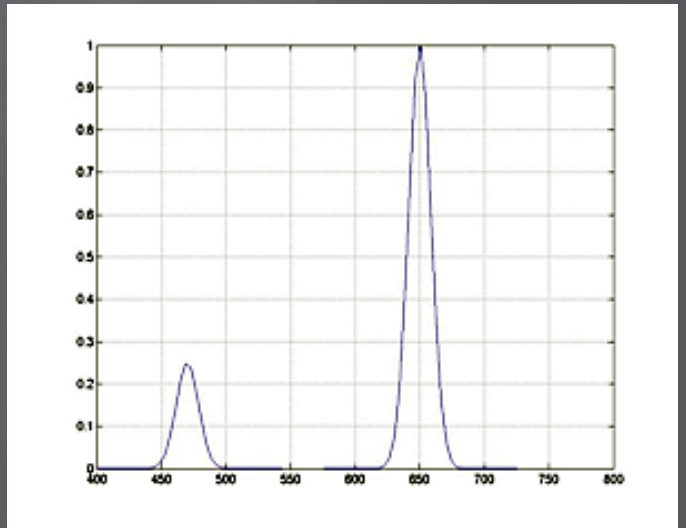
selected in All-Russian Research Institute of Vegetable Breeding and Seed Production of Russian Academy of Agricultural Sciences

First experiment series

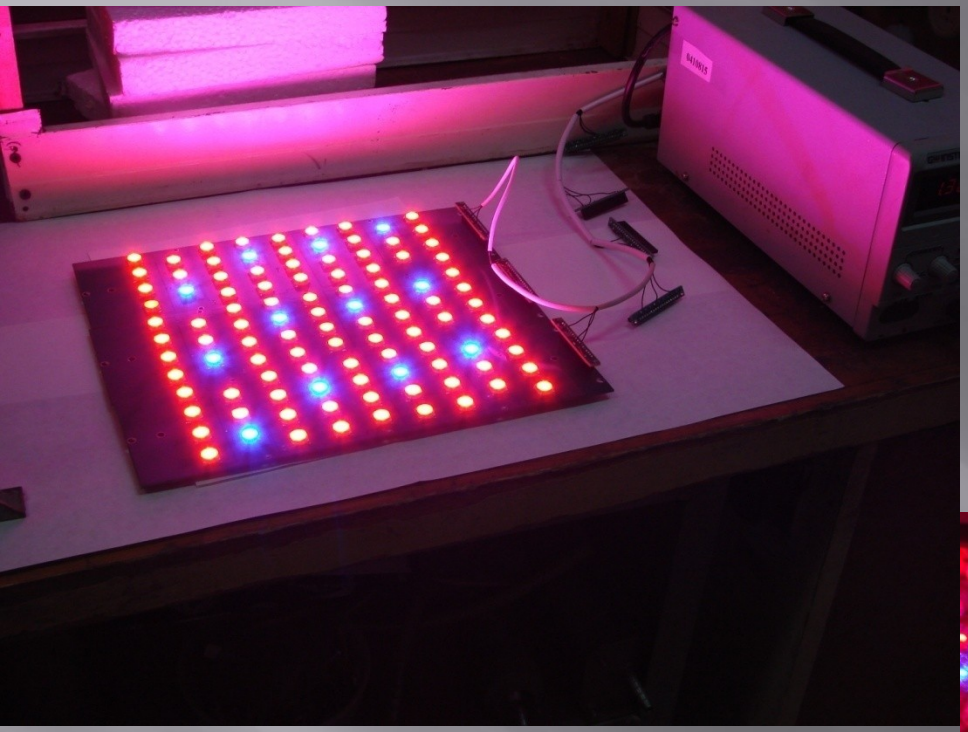
Control sowing under high pressure sodium lamp ДНаТ- 400W

Experimental sowing under red (650nm) and blue (470nm) diodes lamp





Red and blue LED lamps

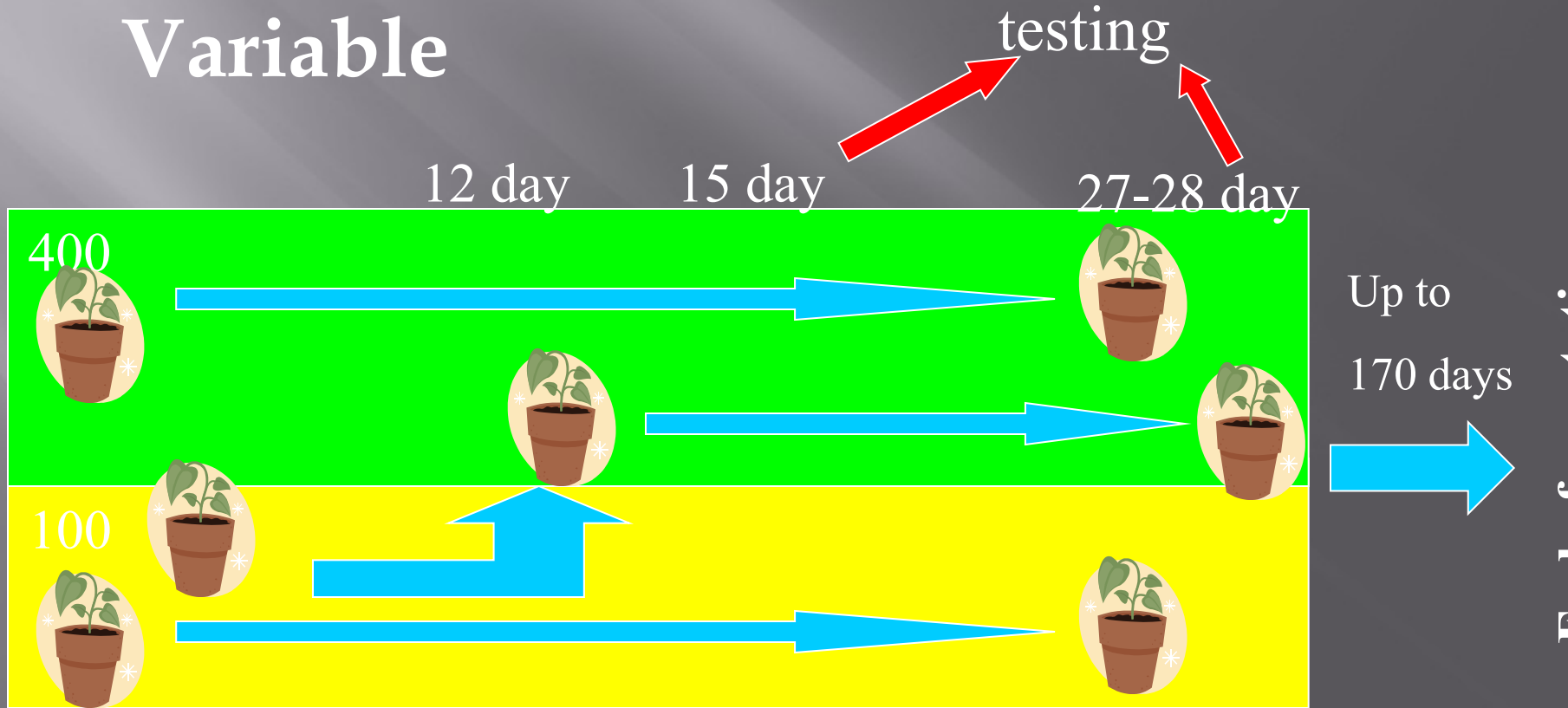


Root module for plants growth:

porous ceramic-metal tube with fibrous ion-exchange soil substitute, joining Mariotte vessel

Lighting modes

1. About 400 micromol$^{-2\cdot}$ s^{-1} - **Normal**
2. About 100 micromol$^{-2\cdot}$ s^{-1} - **Low**
3. 100 (to 12 d)--400(after 12 d) - **Variable**



Experiment conditions

- Growth method: **hydroponics**
- Mineral nutrition: **standard Chesnokov solution in 0,5 strength with microelements according to Hoglund**
- Water potential in a root zone:

  (-1,0) ± 0,1 kPa
- Air temperature: **25 ± 1 °C**
- Relative air humidity: **15 ± 5 %**

Under PPF density about 100 µM/(m²·s) in a phase of technical ripeness (27 days old plants), plants in control and test variants did not differ significantly in:

- **Structure of photosynthesis apparatus;**
- **Fresh weight of shoots;**
- **Photochemical activity of chloroplasts membrane;**
- **Intensity of oxygen active forms generation in chloroplasts.**

Under such PPF density plants didn't start blossom neither in control nor in experimental variant.

Under PPF density about 100 μM/(m²·s) in a phase of technical ripeness (27 days old plants), plants in control and test variants differed significantly in:

- **smaller part of root in a weight of a whole plant;**
- **low concentration of dry matter in shoots;**
- **low concentration of sugar in leaves;**
- **high photophosphorylation activity and in changed functional properties of chloroplasts proteins;**
- **considerable prolongation of a vegetation period;**
- **greater dry mass of shoots in the end of ontogenesis**

Under PPF density about 400 μM/(m²·s) in a phase of technical ripeness (27 days old plants), plants in control and test variants did not differ significantly in:

- **structure of photosynthesis apparatus;**
- **photochemical activity of chloroplasts membranes;**
- **intensity of oxygen active forms formation in chloroplasts**

Under PPF density about 100 μM/(m²·s) in a phase of technical ripeness (27 days old plants), plants in control and test variants differed significantly in:

- **smaller fresh weight (by 25-30%) of shoots**
- **smaller part of root in a mass of a whole plant**
- **high concentration of dry matter in shoots**
- **low concentration of sugar in leaves**
- **low photophosphorylation activity and in changed functional properties of chloroplasts proteins**
- **smaller dry mass of shoots in the end of ontogenesis**
- **absence of flowering**

Under PPF density change during plant growing (in first twelve days - about 100 μM/(m²·s) then about 400 μM/(m²·s)) in a phase of technical ripeness considerable distinctions between control and experimental variants were marked.

Sodium lamp lighting:

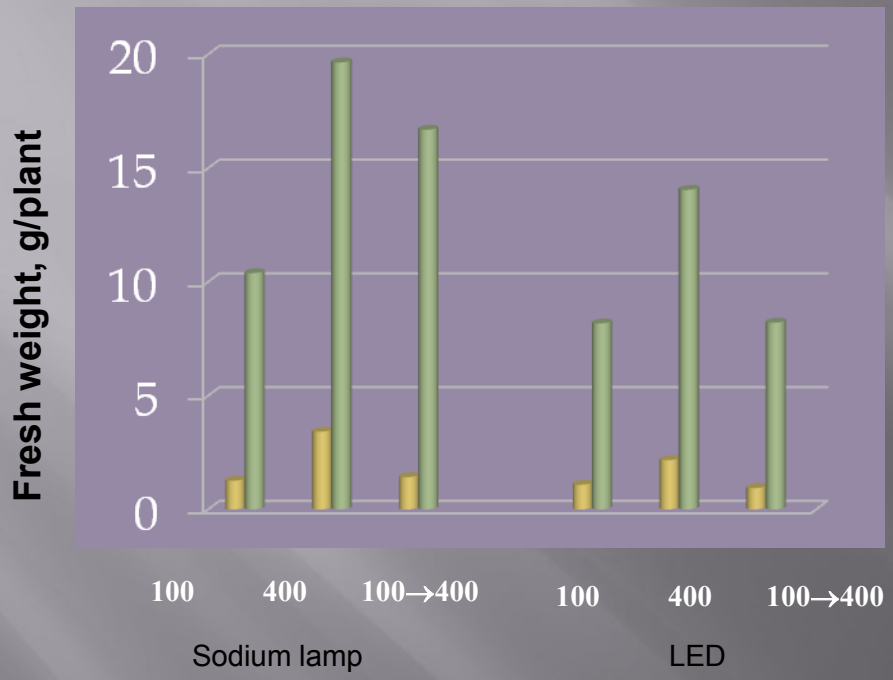
- The photosynthesis apparatus rapid adaptation to the increasing of PPF level;
- Chloroplast photophosphorylation activity growth;
- Shoot growth increasing and root growth decreasing in comparison with constantly growthing plants under 400 μM/(m²·s);
- Formation of flowers

LED lighting:

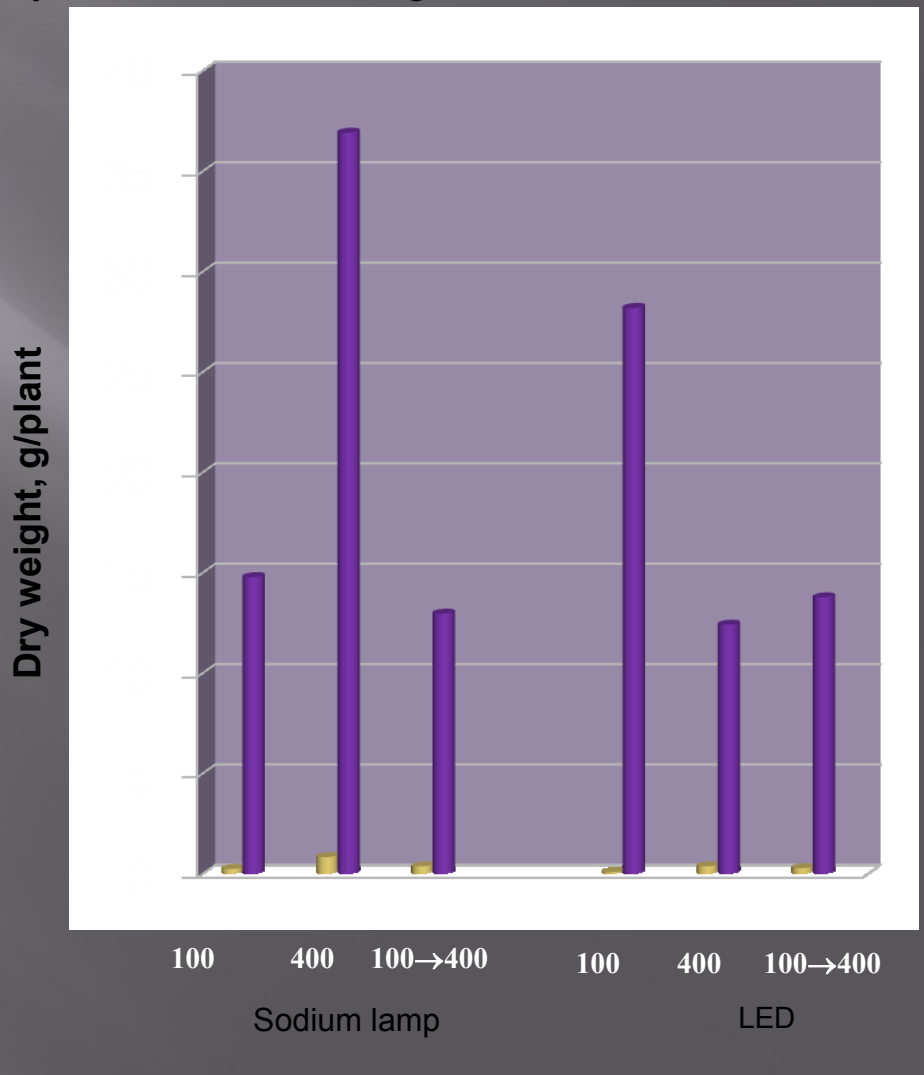
- The photosynthesis apparatus slow and incomplete adaptation to the increasing of PPF level;
- Chloroplast photophosphorylation activity slowdown;
- Shoot growth decreasing and root growth increasing in comparison with constantly growing plants under 400 μM/(m²·s);
- Blossom absence.

Biomass dynamics (according to the light regime) of plants shoots of Chinese cabbage grown under sodium lamp and red and blue LED light unit

Wet mass dynamics of shoots between 15th and 27th days



Dry mass dynamics of shoots between 27th day and the end of vegetation



Chinese cabbage plants crops, grown under a constant level of PPF 400 μM/m^2·s in the end of vegetation

Sodium lamp

Red and blue LED

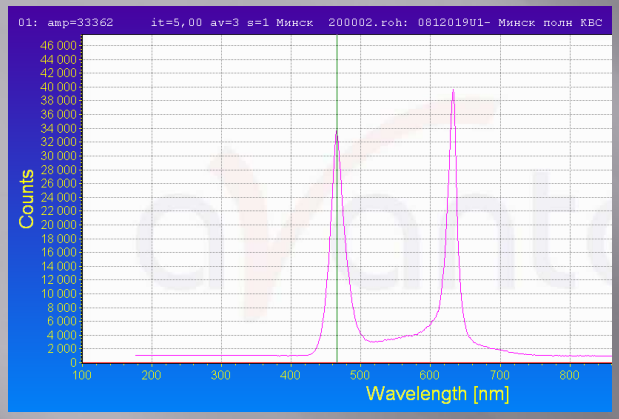
The first series of experiments showed that:

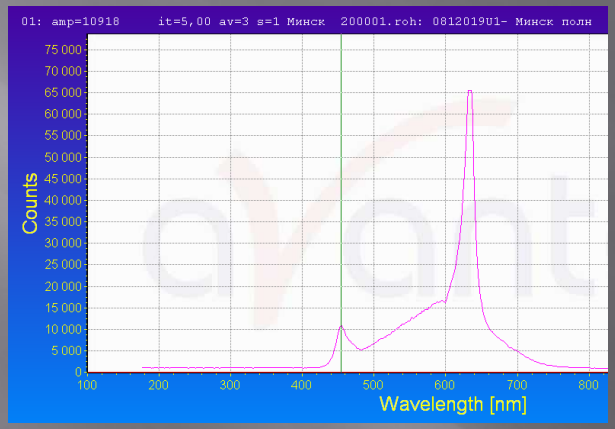
- **The lighting of plants by red-and-blue radiation assured the plants growth comparable with the same under sodium lamp lighting but under low density of luminous flux.**
- **Productivity and gustatory qualities of the produced biomass became worse when PPF density increased to 400 μM/(m²·s);**
- **Red-and-blue LED light units cannot be recommend for plants lighting in the intensive lighting conditions**

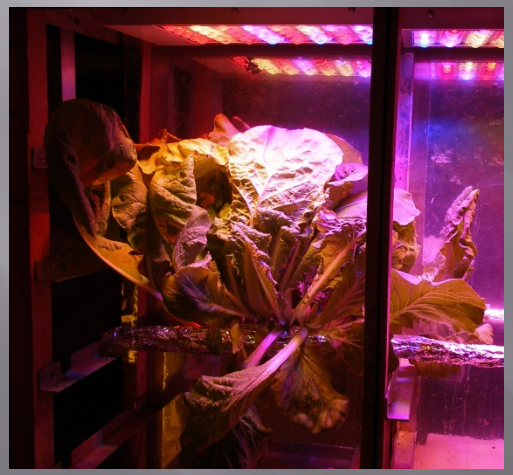
The second series of experiments

Each LED light unit includes 40 1-Watt LED.
Under consumed power of about 32 V, photons flux density averaged 1000 μM/(m^2·s) at 100 mm distance.

Experimental crops under LED light units with various spectrum of radiation.







White, red and blue LED

White and red LED

White LED

Levels and regimes of lighting

Photons flux density:

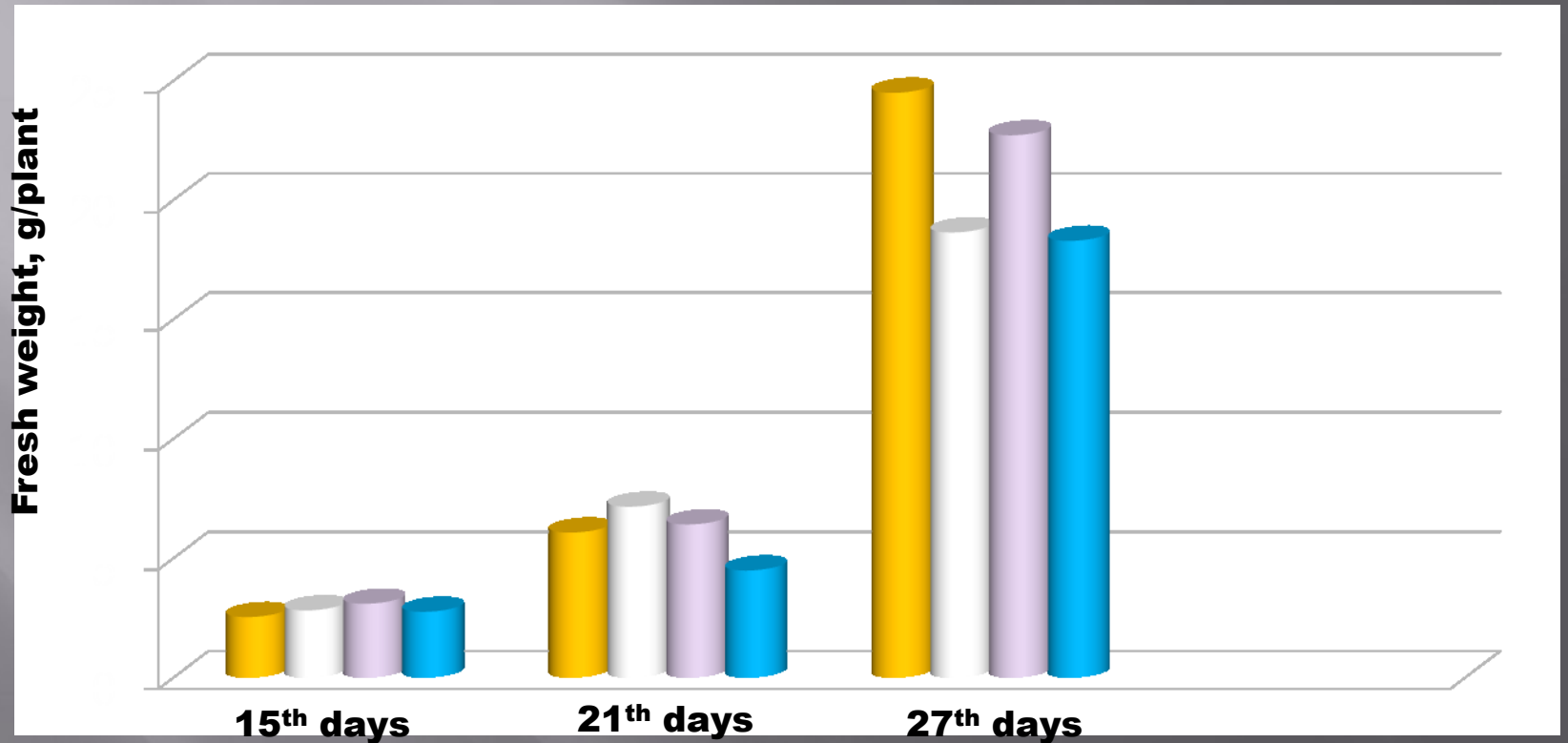
about 400 μM/(m²·s) (normal)

Photoperiod: 24 hours

Lighting regime:

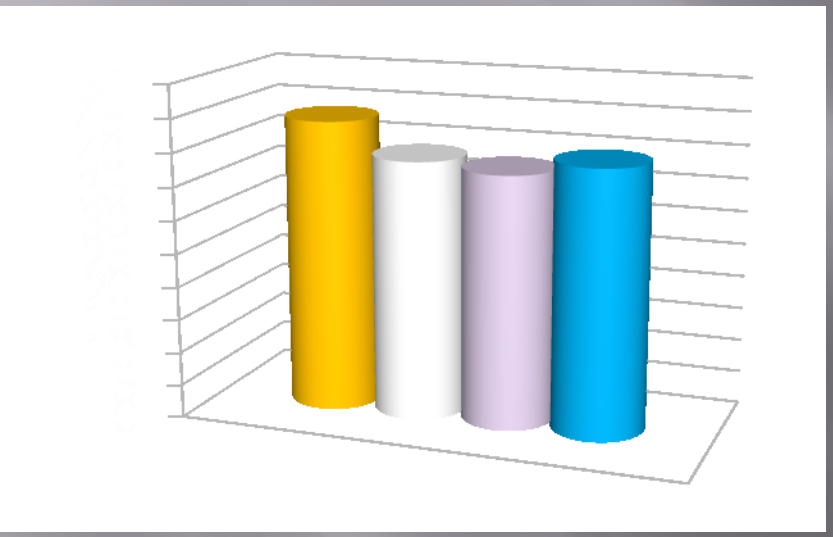
constant lighting during all vegetation

Biomass dynamics of plants shoots of Chinese cabbage grown under sodium lamp and different LED light units under a constant level of PPF of 400 μM/(m^2·s)

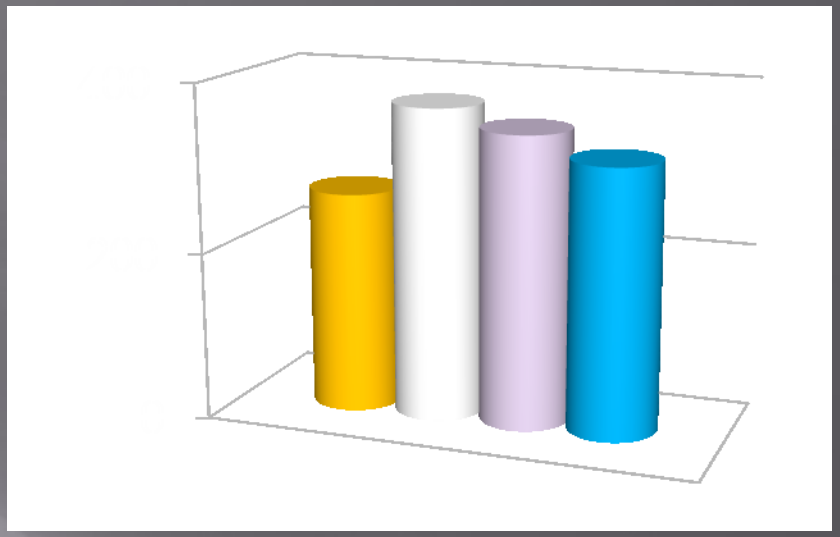


Indices of Chinese cabbage plants at the age of 27 days old, grown under a sodium lamp and a different LED light units at constant level of PPF of 400 μM/(m²·s)

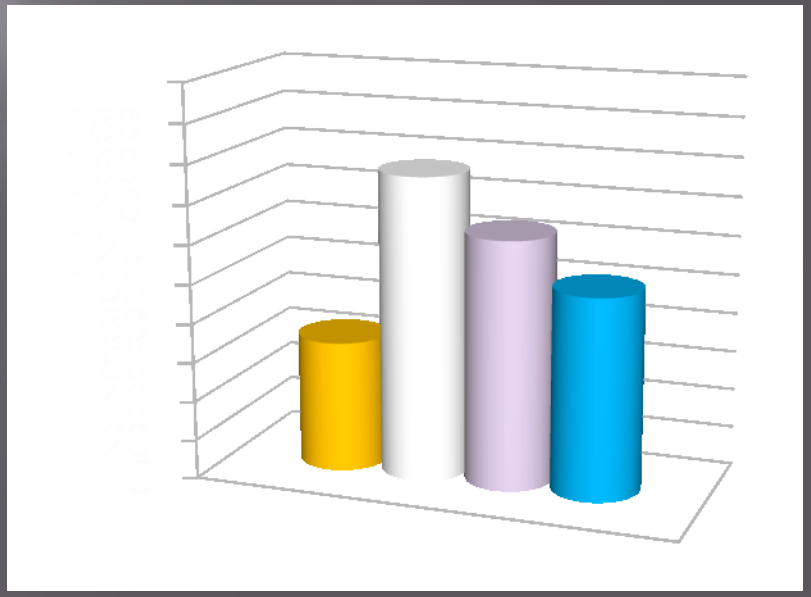
Specific density of leaf surface, (mg of fresh weight) /cm²



Transpiration coefficient, (g of water)/(1 g of dry weight)



Ratio of shoot and root fresh weight



Sodium lamp

White LED

White and red LED

White, red and blue LED

Chinese cabbage plants crops, grown under a constant PPF level about 400 μM/(m²·s) at 50-th day of growing

Sodium lamp

White LED

White and red LED

White, red and blue LED

CONCLUSIONS

- **Under a constant PPF level between 350 - 400 μM/(m^2·s), red-and-white LED light units assured a plants productivity comparable with the same under sodium lamp and it makes possible to recommend this LED unit for greens cultivation in artificial lighting conditions under such light regime including developing space plant growth facilities.**

- **White-and-red LED light unit made changes in physiological indices and provoked ontogenesis breaches and it can adversely affect plants growth under other parameters of light regime.**