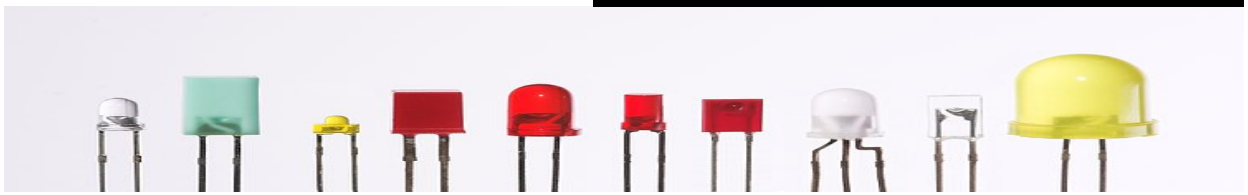
Demonstration and integration of energy saving LED luminaires for greenhouses

by Theoharis Ouzounis

Introduction

- Semiconductor light source with very high brightness
- The last decade LEDs have attracted interest as supplemental light
- Commercial production in latitudes where natural light limits plant production
- ADVANTAGES compared to e.g HPS:
- control light spectrum
- have small size
- low cost
- long lifetime
- cool emitting temperature
- suitable for plants



Introduction

- Roses
- Chrysanthemums
- Campanulas

- Important ornamental crops for the floriculture industry in Denmark

- Need a year-round supply

Necessary to add artificial light even when sunlight is optimized

Secondary metabolites

- Compounds that are not directly involved in the normal growth, development, or reproduction of a plant

  # Primary

- Role of SMs: In the beginning they thought to be functionless end products of metabolism, but: plant defence against pathogens, and herbivores, and abiotic stress, serve as attractants (smell, color, taste) for pollinators and seed-dispersing animals, function as agents of plant-plant competition and plant-microbe symbioses

Hypotheses

- Plants grown under LEDs are of similar or higher quality
- Selective spectral composition of LED lighting will increase the amount of protective secondary metabolites
- Red and blue light affect the photosynthetic apparatus
- Benefits from LEDs will vary from crop to crop

Objectives

- To characterize the effect of LED lighting in horticultural products grown under greenhouse facilities
- To characterize the effect of LED lighting on the photosynthetic characteristics and the physiological mechanisms of selected plant species
- To determine the optimum light spectra and environment for different plant species grown under artificial light
- To characterize the effect of LED lighting and spectra on secondary metabolites which play a crucial role in the biochemical defense of the plant

Materials and Methods

- Roses (*Rosa hybrida* 'Scarlet'), Chrysanthemums (*Chrysanthemum morifolium* 'Coral Charm'), and Campanulas (*Campanula portenschlagiana* 'BluOne')
- LED array yielding approximately 200 µmol $m^{-2}s^{-1}$ for 16 hours per day
- The temperature in the greenhouse compartments was set to 24° C and 18° C during the day and night, respectively
- The plants were grown to flowering (except chrysanthemums) and plant growth was recorded at the end of the experiment

Greenhouse compartment 1

(1) 40% Blue 60% Red (2) 20% Blue 80% Red (3) 100% Red (4) 100% White

Photosynthetic measurements

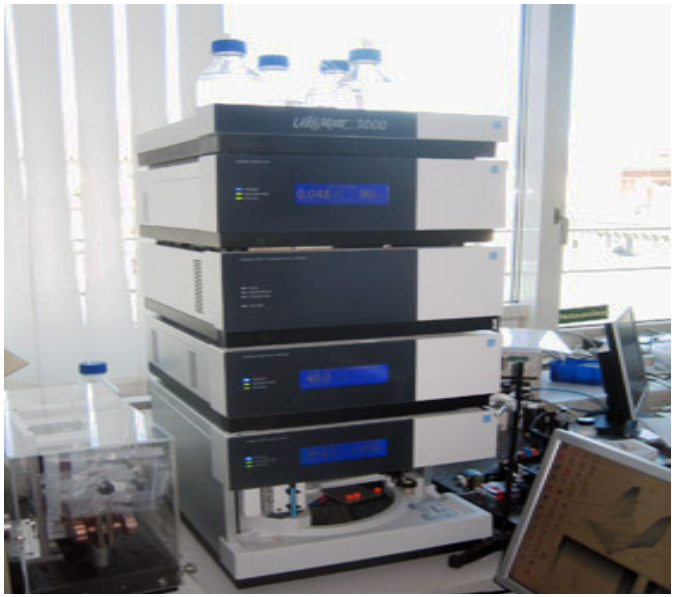
- Open gas exchange systems CIRAS-II. Real-time measurements of CO_2 uptake, transpiration, stomatal conductance (g_s), and intercellular CO_2

- DUALEX (an optical absorbance meter for epidermal polyphenolics) as an indication to measure chlorophyll and flavonol content

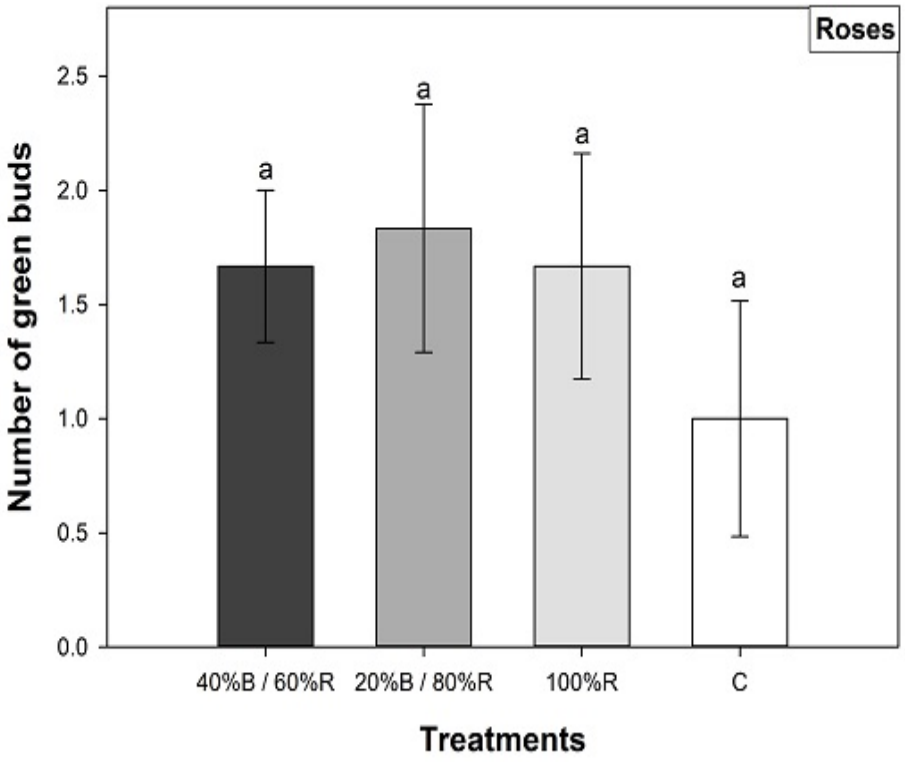
- Fresh and dry weight of the stems and leaves, leaf area, and plant height

Chemical measurements and identification

- Leaf samples are taken randomly for later analysis by HPLC/LCMS
- Samples were ground with liquid nitrogen and 80% (MeOH) was used for extraction
- Separations with a Zorbax Eclipse XDB-C18 column (5µm, 150 X 4.6 mm; Agilent)
- Phenolic acid and flavonoids will be quantified in extracts by HPLC and LCMS at 320 nm and 360 nm, respectively



Roses – Number of buds



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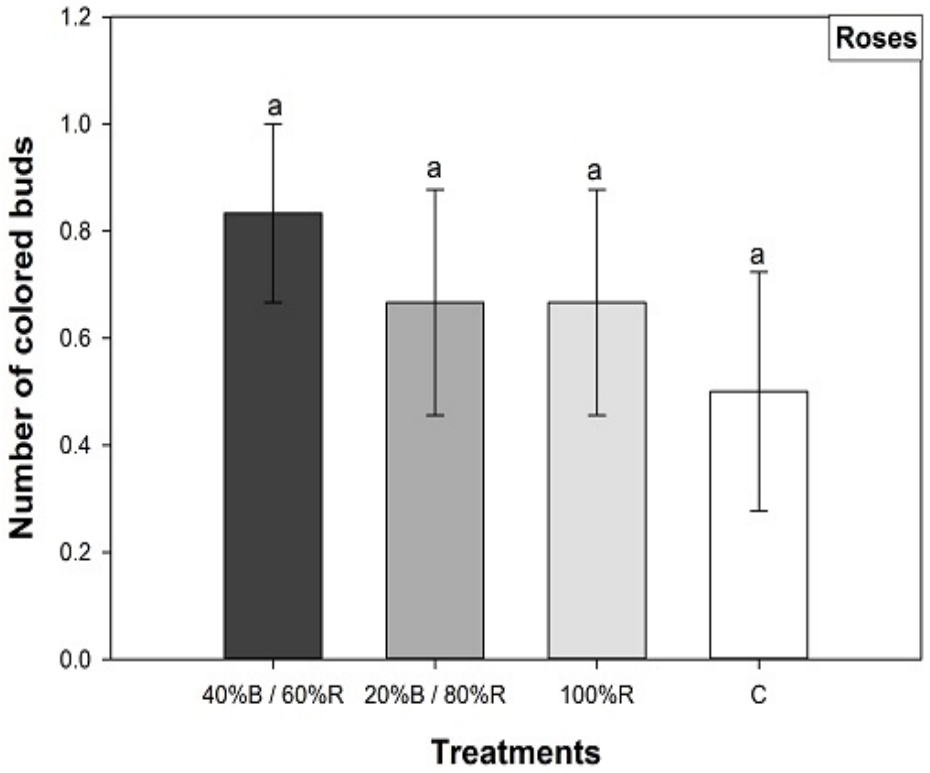

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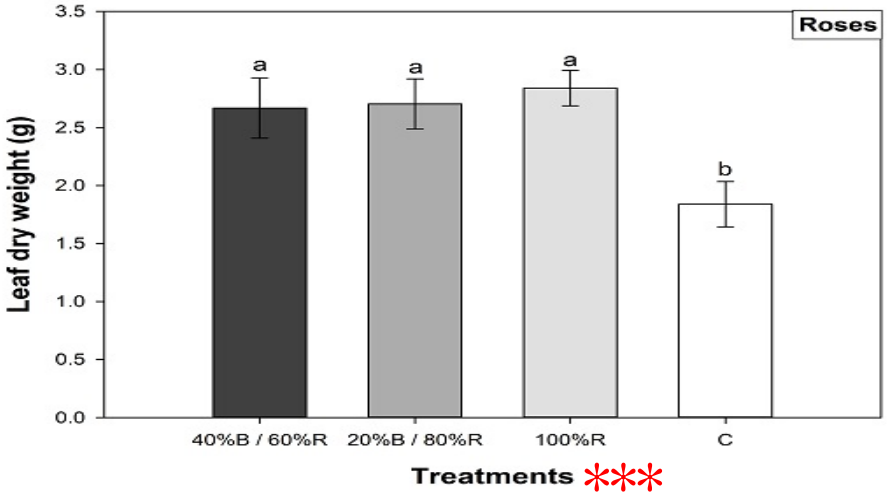
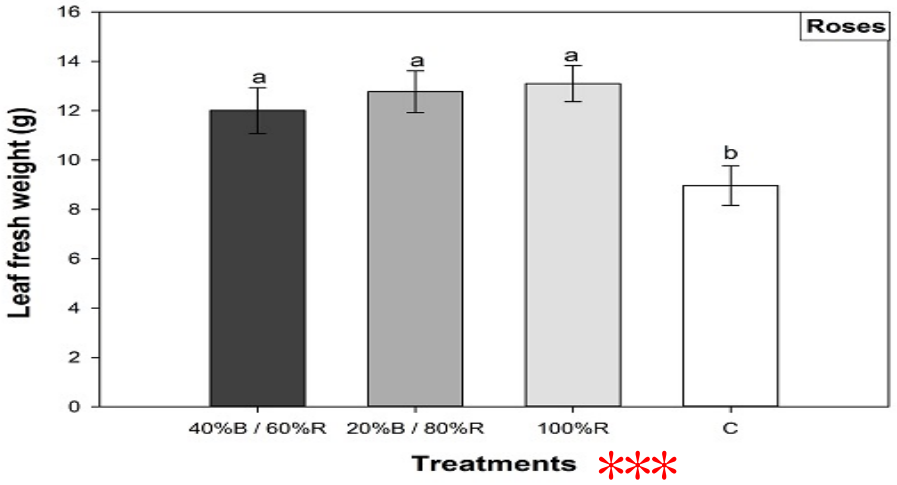
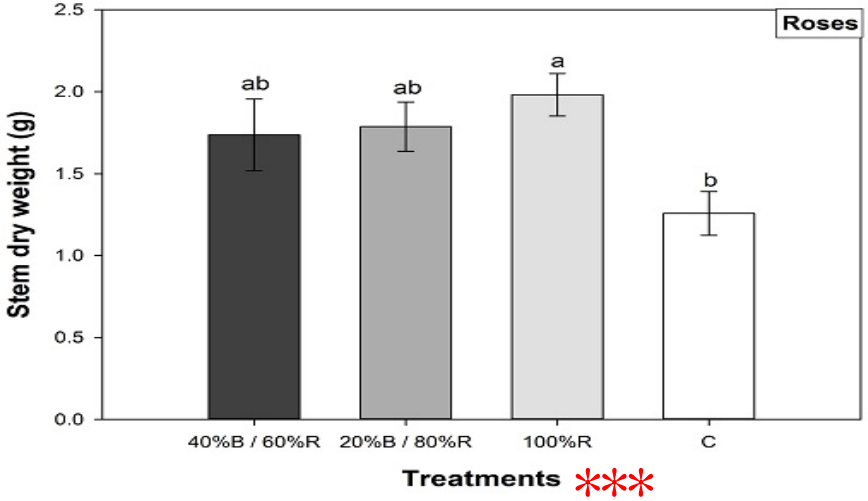
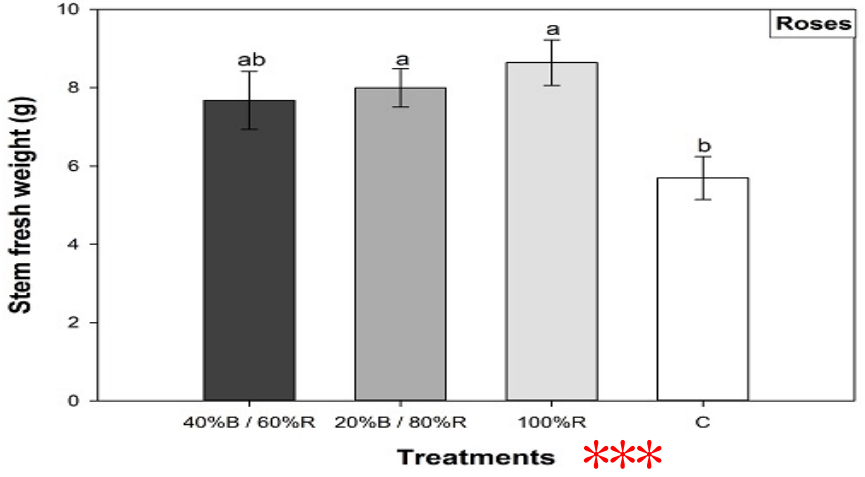
Roses – Fresh and dry weight

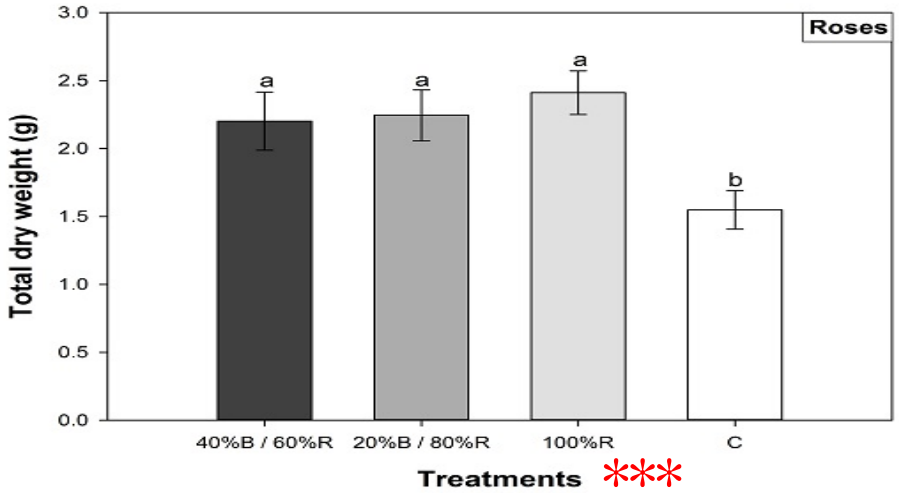


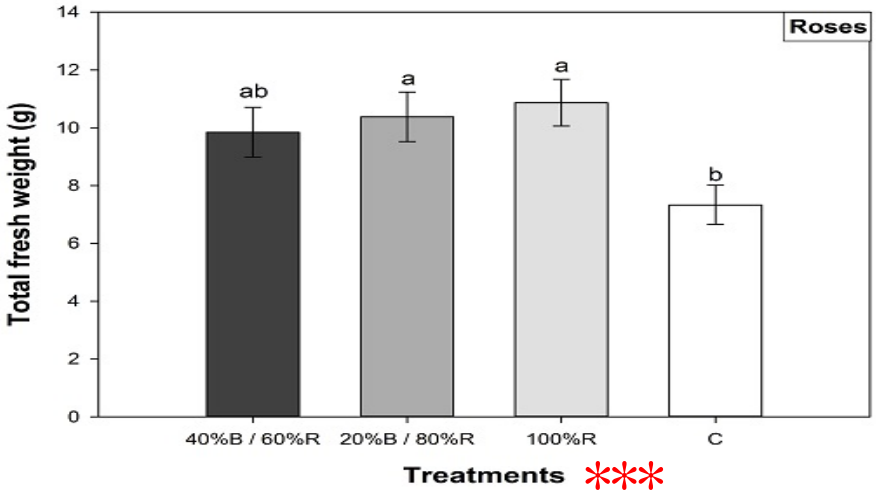


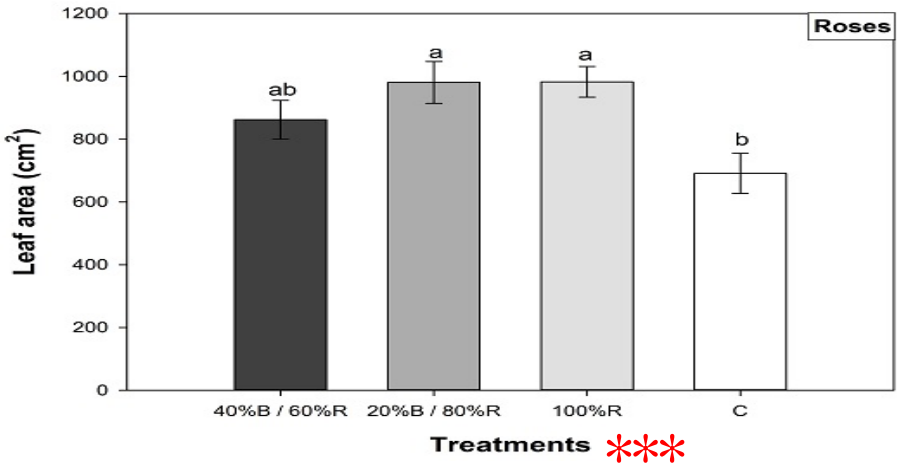


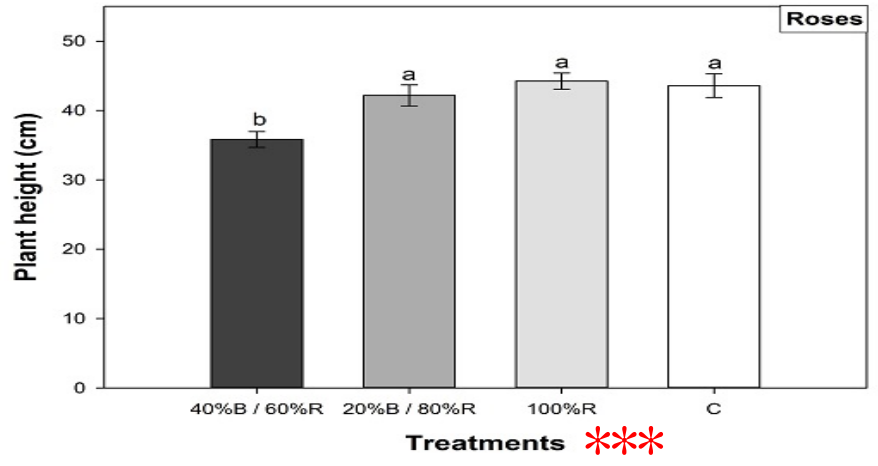


Roses – Plant growth measurements

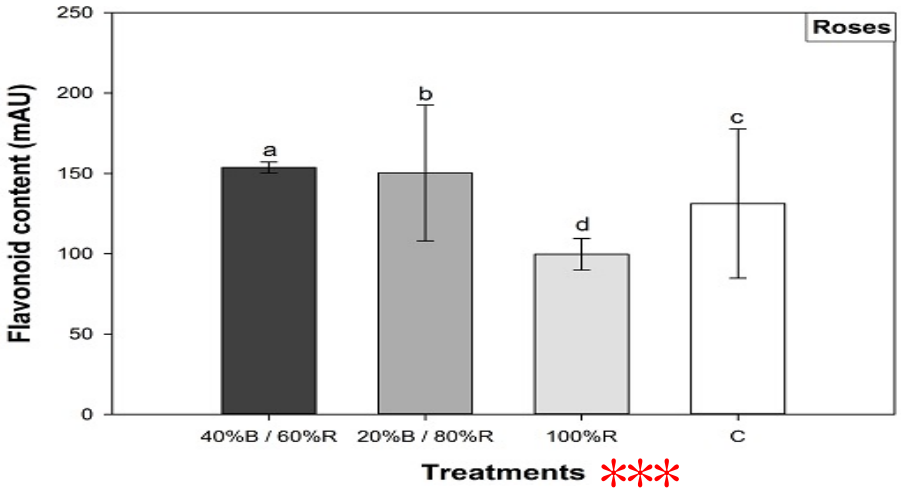


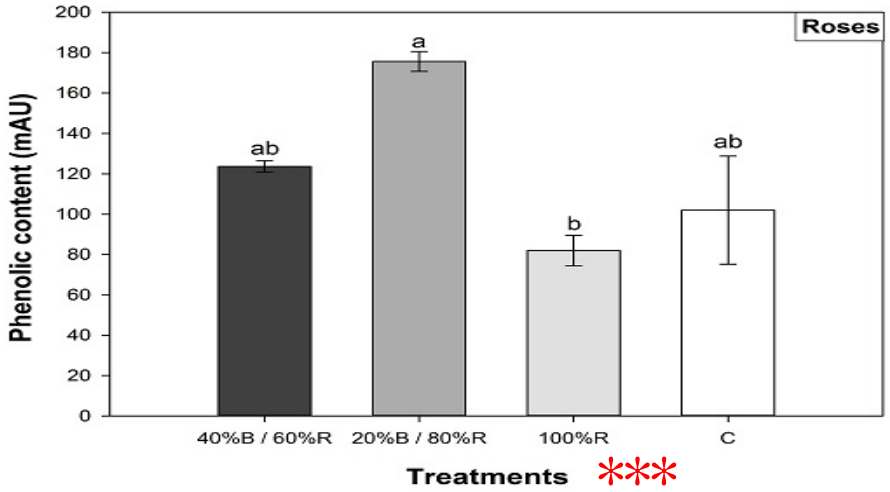


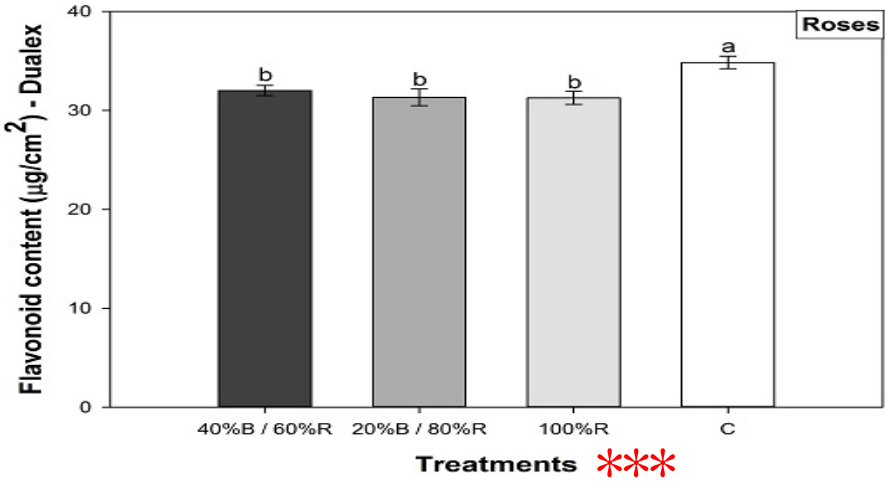


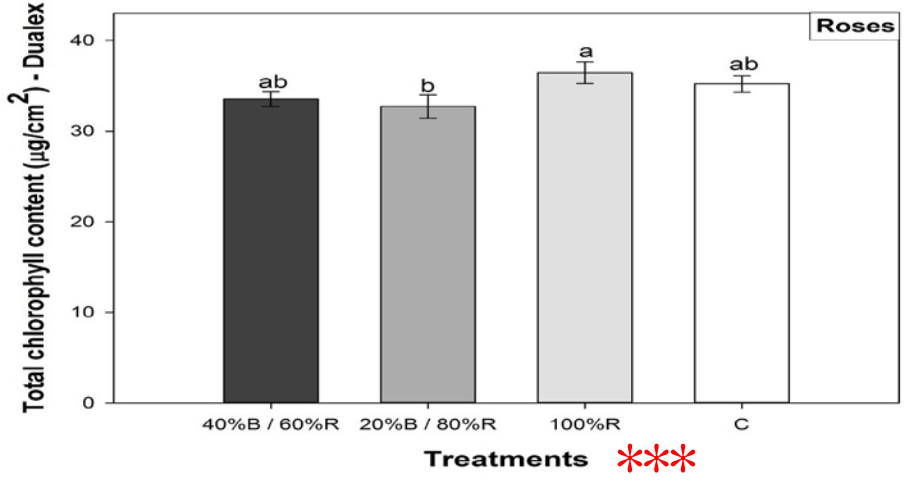


Roses – Flavonoids and phenolics

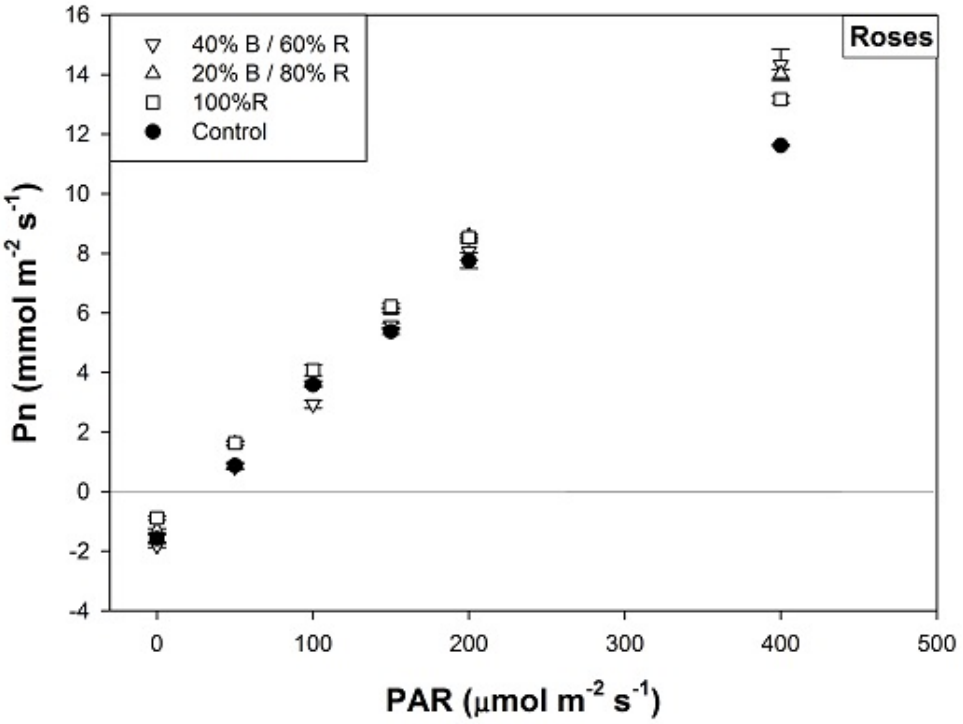








Roses – Net photosynthesis and stomatal conductance



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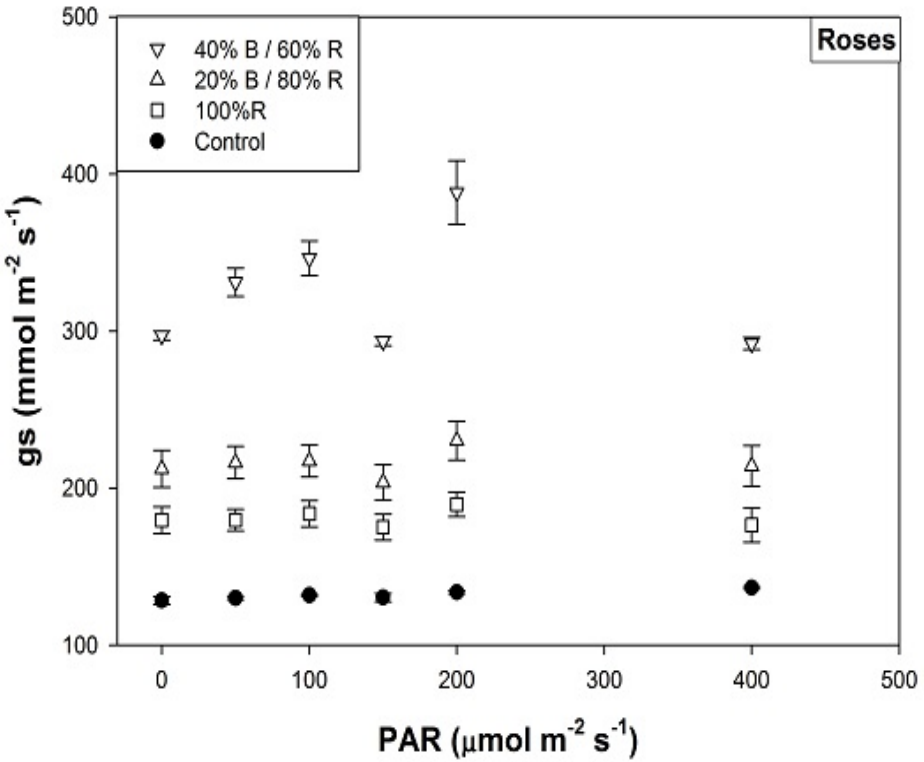


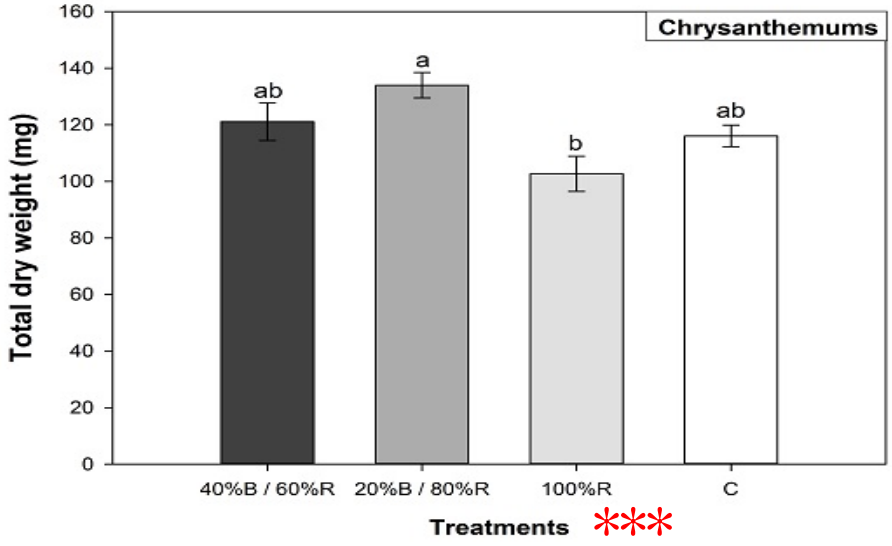
40% B/60% R a

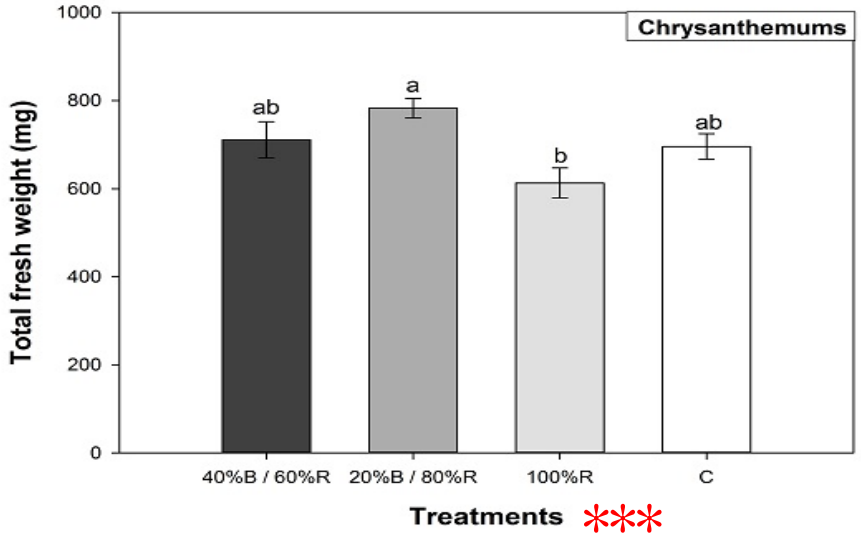
20% B 60% R b

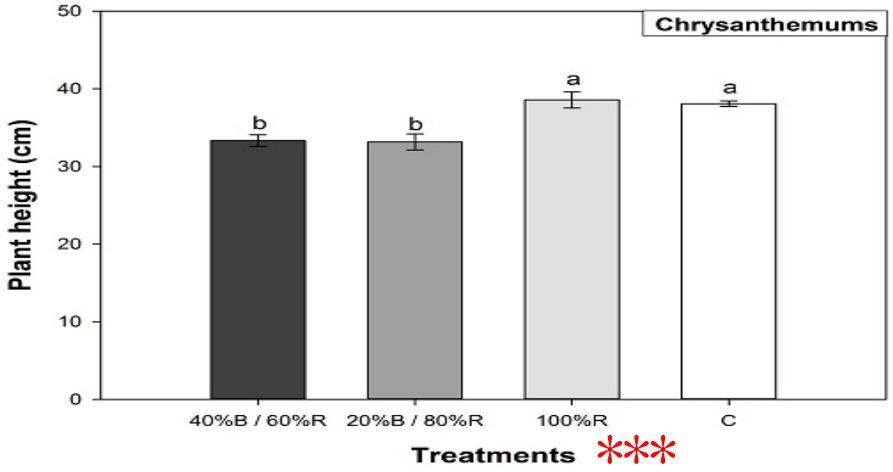
100 R c

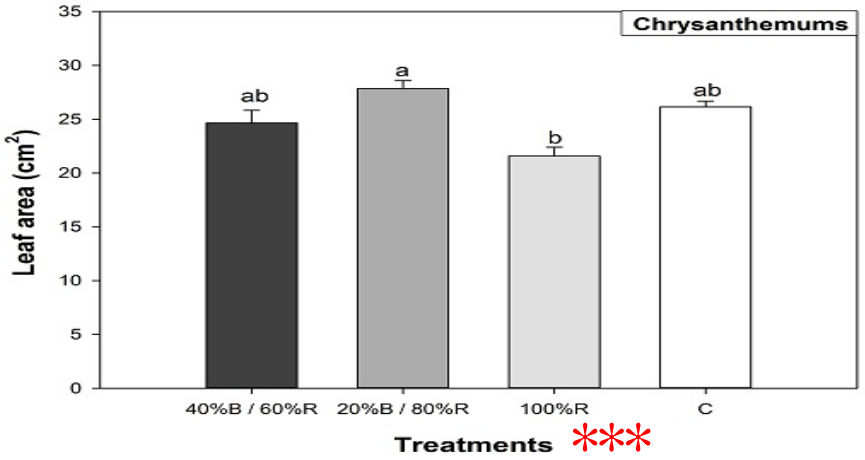
Control d

Chrysanthemums – Plant growth measurements

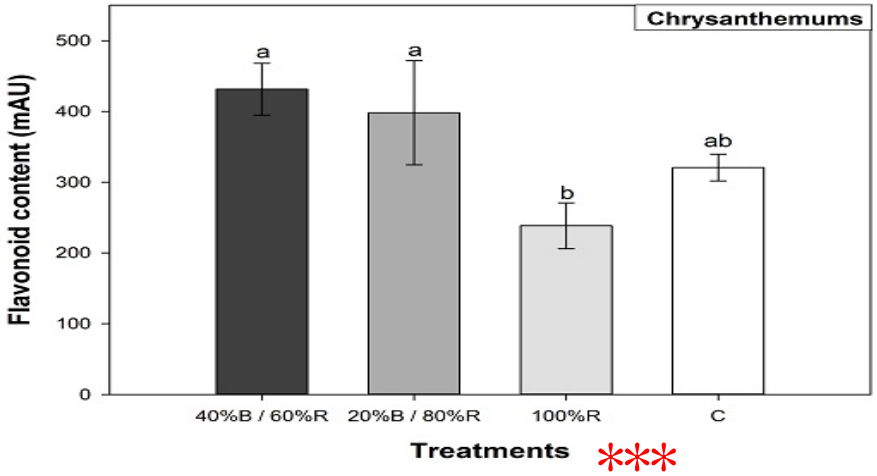


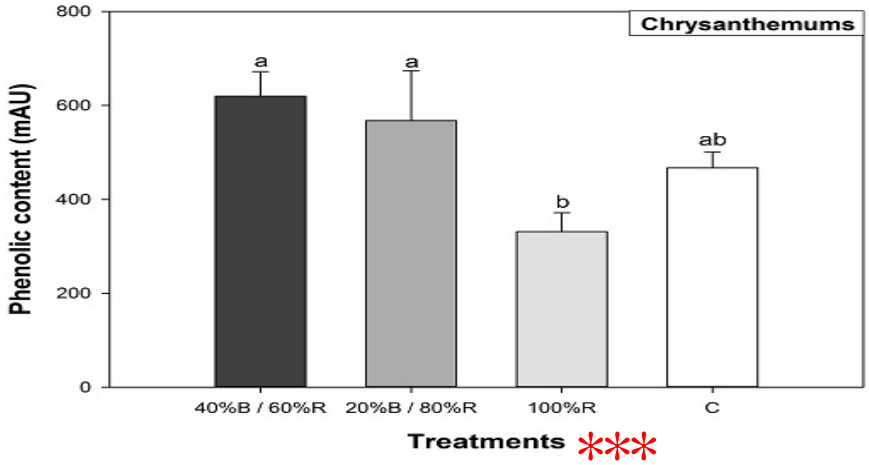


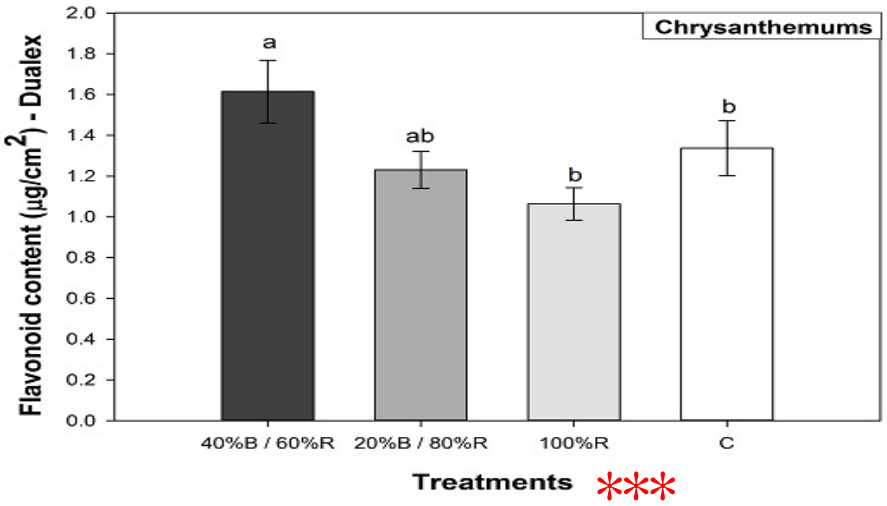


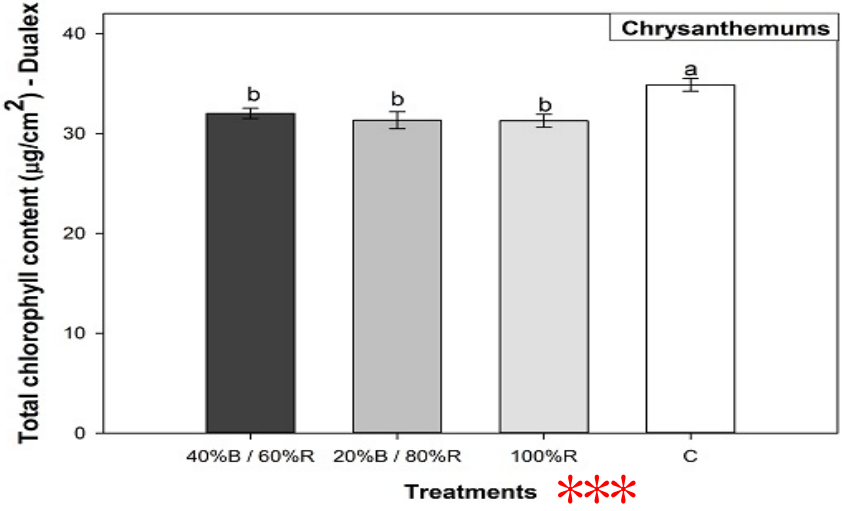


Chrysanthemums – Flavonoids and phenolics

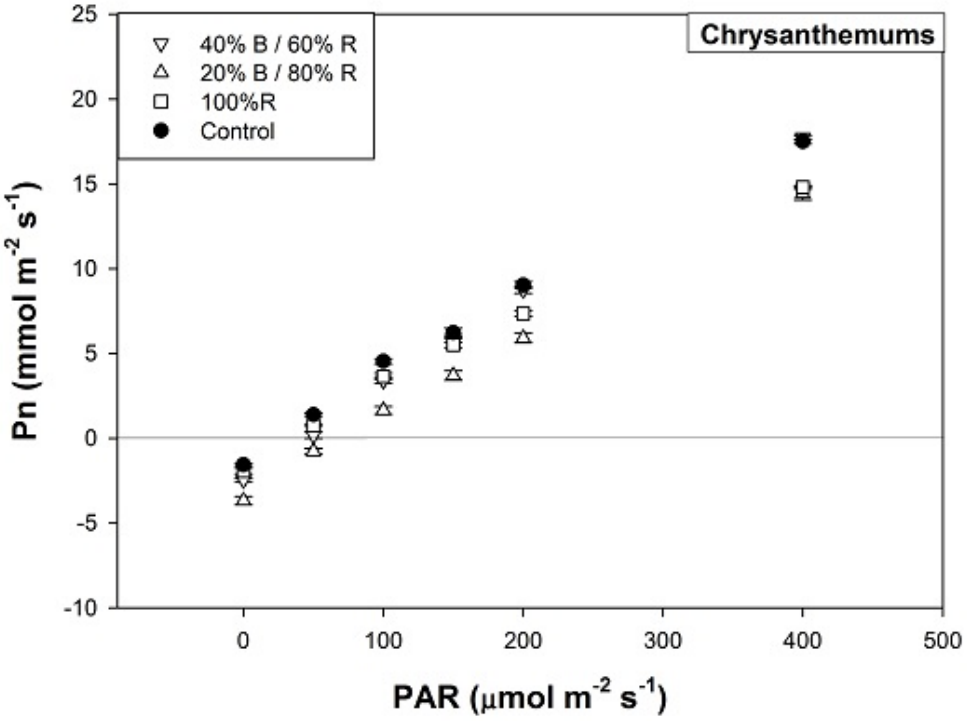








Chrysanthemums – Net photosynthesis and stomatal conductance



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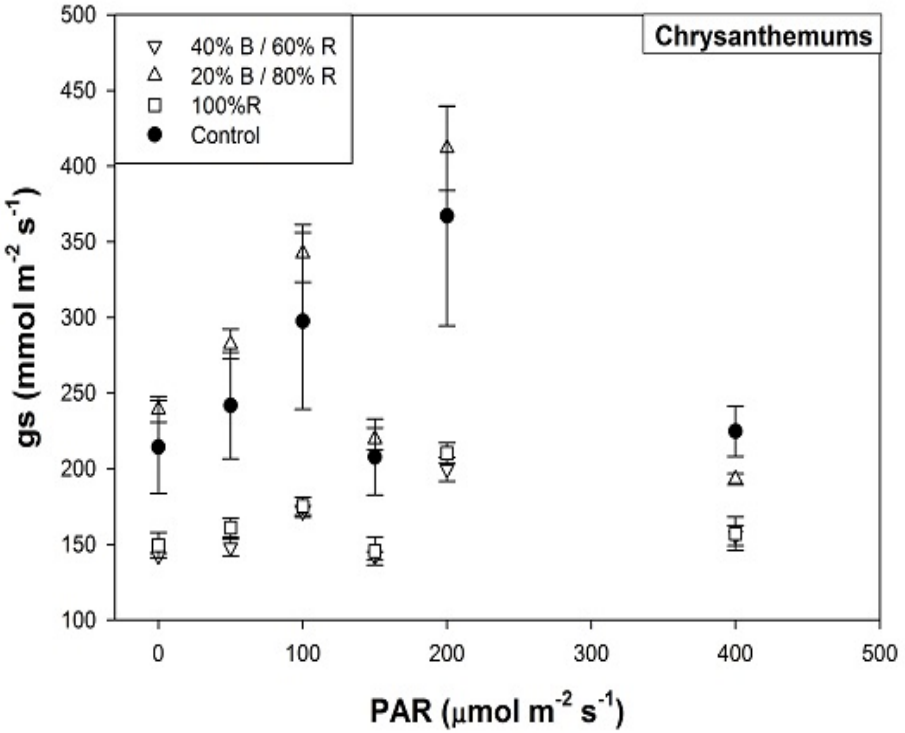
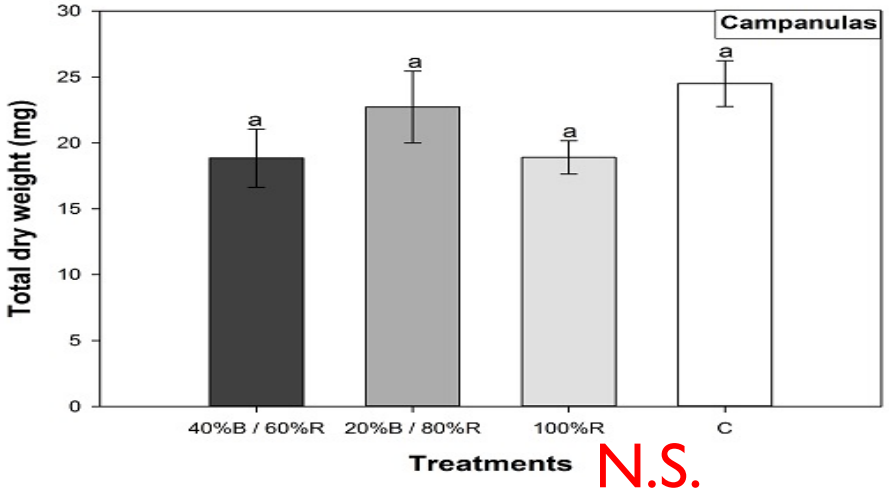


40% B / 60% R b
20% B / 60% R a
100 R b
Control a

Campanulas – Plant growth measurements



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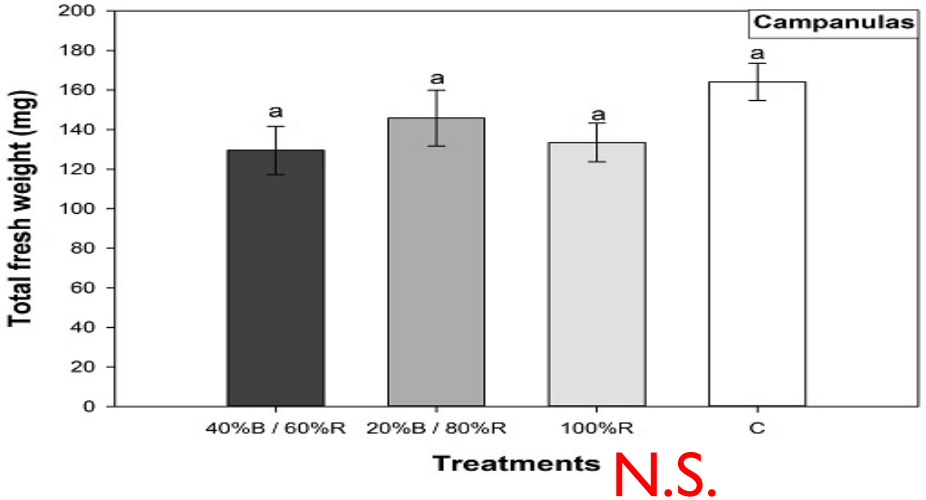

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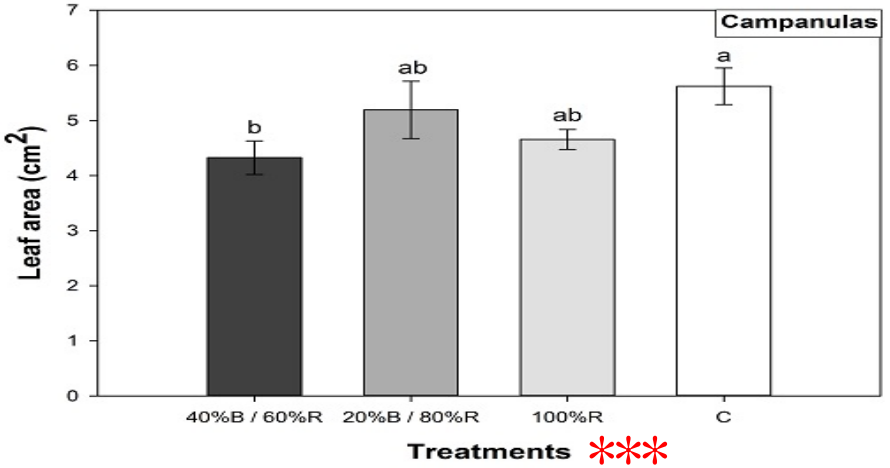

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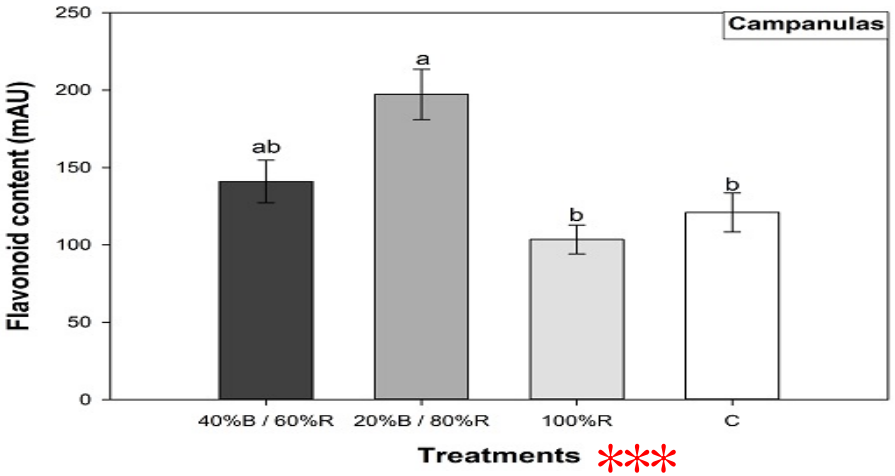
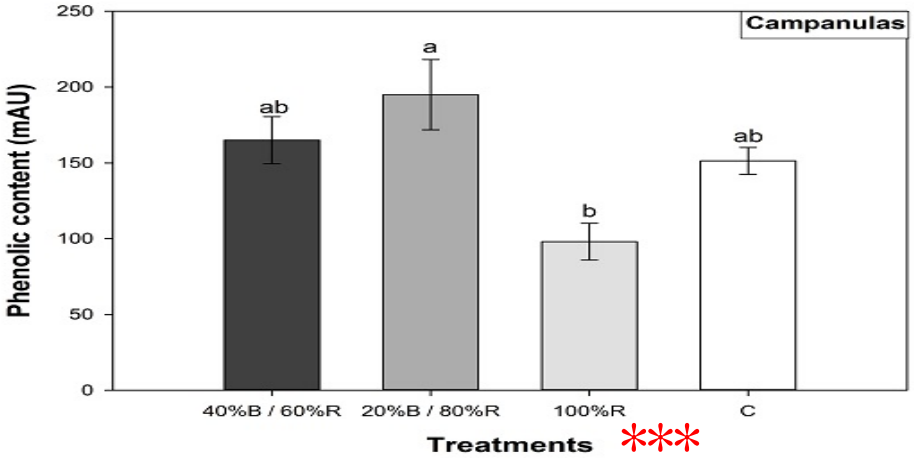
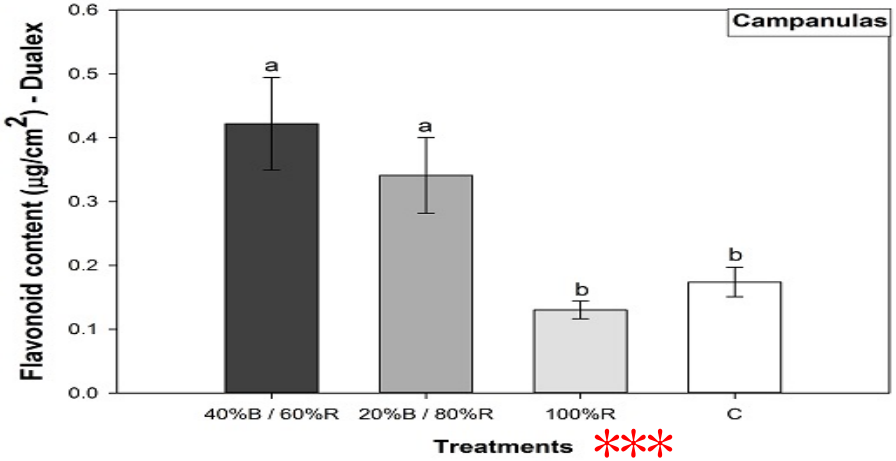
Campanulas – Flavonoids and phenolics







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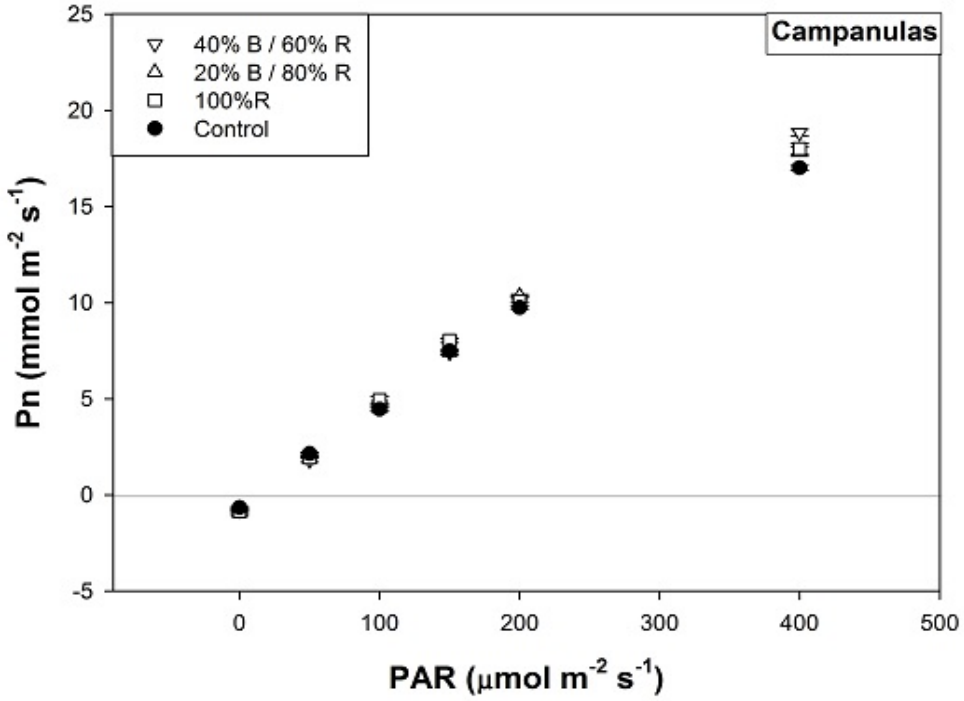

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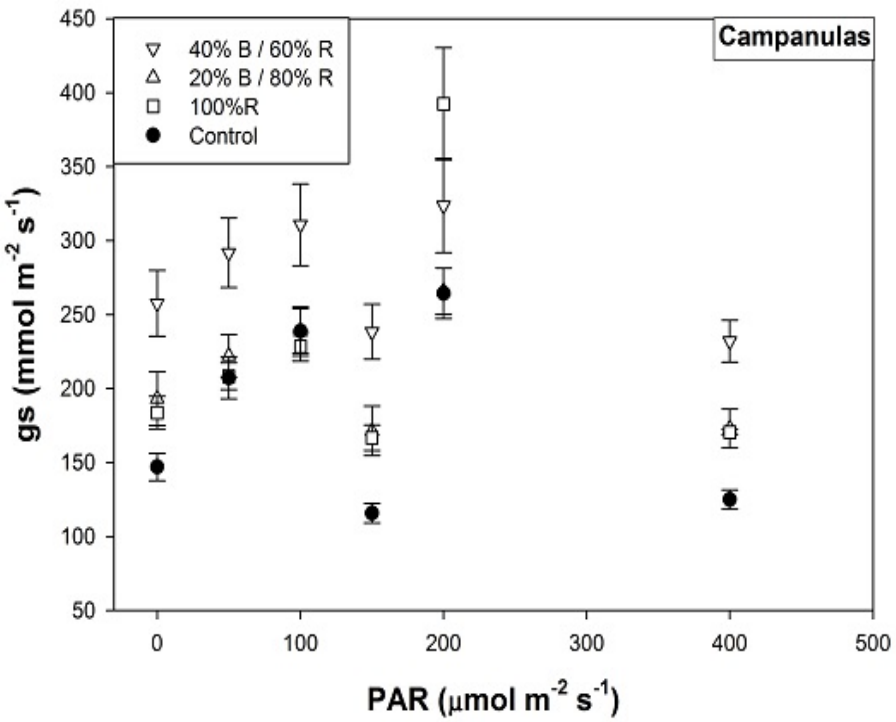

40% B / 60% R a
20% B / 60% R b
100 R ab
Control b

Conclusions

- The combination of red and blue LED lighting has a positive effect on plant growth and development of roses, chrysanthemums, and campanulas.
- The physiological and photosynthetic parameters increase with increase of BLUE light.
- Secondary metabolites, which are important for the biochemical defence of the plants, also increase with additional BLUE light.
- The mechanisms used under different supplemental light quality are not yet well known and more investigation should be carried out.

Feedback-Suggestions