Response of Rice to Changes in the Green and Far-Red Light Ratio

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Background

Light Emitting Diodes (LEDs) have become the standard for plant lighting in the last years. Research has shown that white LEDs have certain benefits for plant growth compared to grow light that is composed from narrow bandwidth single color LEDs. White LEDs cover the whole photosynthetic active spectrum (400 to 700 nm) including high levels of green light, but have a sharp cut-off beyond 700 nm. Thus, far red light is almost not present in their spectrum.

Far Red Light is one of the important photomorphological triggers for higher plants. compared to red light, its absorbance by leaves is low and thus far red light ratios in lower canopy layers are high. Plants are able to sense far red light levels via the phytochrome photosensory system. Numerous morphological responses, particularly such that are associated with shade avoidance are modulated via this signaling network. Grasses have been shown to increase leaf area and to decrease tillering under conditions of a low red to far red light ratio.

Table: Some light quality aspects of white LEDs compared to sunlight. R/FR is the ratio of Red to Far Red Light. YPS is the *Yield Photon Flux*, a measure of the photosynthetic efficiency of the incident light in terms of absorbance and quantum efficiency.

	Red %	Green %	Blue %	FR %	R/FR Ratio	YPF Rel.
Sun	37	36	27	33	1	0.71
White LED	23	50	27	3	9	0.76

Green light has a slightly higher transmittance than other wavebands in the photosynthetic active spectrum and was thus long time considered as being less effective in terms of driving plant growth. However, research has shown beneficial effects of an increased level of green light on growth performance of several plants species.

Objectives

Manufacturers of **Commercially available LED Panels** for plant growth often advertise their products as having improved or optimized light spectra. These optimizations often include additional far red light or additional green light, even if green light ratios of white LEDs alone are around 50 per cent. We were interested if these alterations yield any benefit for plant growth or if they result in any morphological or photosynthetic changes.

Results

We cultivated plants of 3 different rice genotypes (a semi-dwarf, a full-dwarf and a super-dwarf genotype) under far-red-enriched (+FR) and green-enriched (+Gr) light spectra of white LEDs. A control treatment with only light from a white LED was also included.

Under +Gr, dry matter production was significantly reduced for the semi-dwarf genotype but not for the other genotypes. +FR did not affect dry matter production for all genotypes compared to the control treatment.

We assessed 6 morphological parameters (total and specific leaf area, number of tillers and leaves, average leaf width and length). There were only 3 significant differences among the whole experiment (higher no. of leaves under +Gr for the semi-dwarf, decreased leaf width under the control treatment for the full-dwarf, decreased leaf length for the superdwarf under +FR).

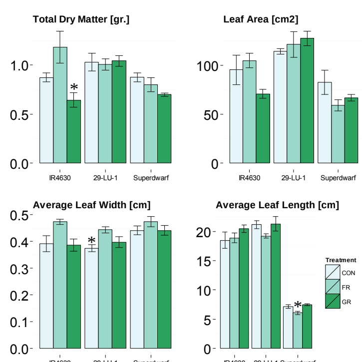

Figure: Total dry matter, leaf area and average leaf width and length of 3 different rice genotypes grown under light from either white LEDs (CON) or light from white LEDs enriched with far red (FR) or green (GR) LEDs. Error bars indicate standard errors. A star indicates significant differences (Tukey's HSD with alpha= 0.05).

We extracted over 20 photosynthetic status parameters from the Light and A/ci-Response curves (CO_2 and Light compensation, internal conductance to CO_2, quantum yield, dark respiration in light and dark, etc.) and found no statistically significant differences at all.

Conclusion

In our treatments, green light ratio was increased by more than 10 per cent and R/FR ratio was decreased for 9 to 1. However, our results indicate no clear effect of the manipulated light qualities on plants and differences in biomass production and morphology found in one variety did not establish in the other ones. Therefore, we doubt that enriching the light of white LEDs with green or far red light results in a significant benefit for plant growth.

Materials and Methods

We equipped 12 ventilated tubes (15 cm diameter, 48 cm height) with a white LED (8 Watt, 4500 K). The R/FR-ratio and the level of green radiation in the spectrum were increased by adding a far red (λ_{peak}: 735 nm) respectively green (λ_{peak}: 520 nm) LED to each 4 of the tubes. In each tube, 3 plants of 3 different rice genotypes (IR 4630, Lu 29-1 and a superdwarf rice genotype) were cultivated. Plants were harvested after 4 to 6 weeks and biomass production and allocation and morphological features were accessed. Additionally, intensive gas exchange measurements were performed, including measurements of chlorophyll fluorescence, light response and A/ci curves.

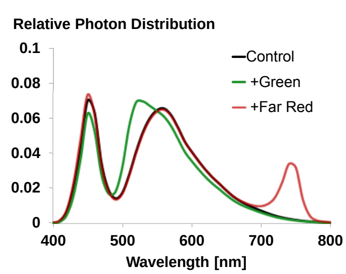

Figure: Light spectra used in the experiment. Control is a cool white LED, +Green and +Far Red are white LEDs enriched with green and far red LEDs respectively.