ARTIFICIAL LIGHT SPECTRA AND PLANT GROWTH.

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SUMMARY

This study was undertaken to investigate the suitability of various commercially available high-pressure discharge lamp systems for controlled environment use. Two main experiments were carried out. The Spectral Balance experiment consisted of three treatments each at a similar total visible irradiance (160 W m^{-2}) based on high-pressure discharge lamps (HPLR, HPI and "Metal-arc" types) supplemented with blue-fluorescent and tungsten lamps, and three subsequent treatments based on the "Metal-arc" lamp with varying supplemtation and different irradiance levels (105, 200, 250 W m^{-2}). The Spectral Bias experiment consisted of blue-biased, balanced and red-biased spectral treatments obtained by varying the proportions of different artificial lamp types (viz. "Metal-arc", Blue HPI and Quartz Halogen). Each spectral bias treatment was studied at two irradiance levels (130 and 200 W m^{-2}). Four species (Sorghum bicolor L., Glycine max L., Lolium perenne L., Trifolium repens L.) were used as test plants at day and night regimes of 22.5/17.5°C and 60/90% R.H. with a 12 h photoperiod for all treatments. The two experiments were carried out in Climate Rooms and Growth Cabinets of the Plant Physiology Division, D.S.I.R., Palmerston North.

Results from the Spectral Balance experiment showed that either of the three lamp types with adequate blue and red wavelength supplementation could be used for plant studies in controlled environments, but on an efficiency basis the order of selection was "Metal-arc", HPI, HPLR. Results from the Spectral Bias experiment showed marked changes in shoot dry-weight increases, leaf area formation, dry-weight per unit area of leaf, stem length, tiller number, main stem angle, root/shoot ratio, proportions of plant parts, relative growth rates, relative rates of leaf area expansion, net assimilation rates and leaf area ratios in response to the biased spectral treatments. Biochemical changes were also recorded which showed short-wave enhancement of total amino-acids, proteins, aspartic and glutamic and other amino acids, and a long-wave enhancement of soluble sugars, starch and total carbohydrates. A scheme is presented incorporating the observed responses with those recorded in the literature. Total leaf chlorophyll was

increased under short-wave conditions but chloroplast structure was found to be unaffected by the spectral treatments.

Calculations were made of the relationships between leaf area, the number of absorbed quanta and the total dry-matter accumulation for each Spectral Bias treatment and results indicated that the spectral influence on the distribution of the assimilated carbon within the plant (i.e. to leaf or to non-leaf tissue) primarily influenced the subsequent plant dry-weight increase.

The implications of the present studies are discussed in relation to providing a standardized artificial light spectrum for controlled environment work. This consideration includes a study of natural sunlight spectra under various environmental conditions and a discussion of the technical difficulties encountered when using these particular lamp systems.

TABLE OF CONTENTS

FIGURES

TABLES

PLATES

DIAGRAMS

SCHEME

"If at any time I speak of Light and Rays as coloured or endued with colours, I would be understood to speak not philosophically and properly, but grossly, and according to such Conceptions as vulgar People in seeing all these experiments would be apt to frame. For the Rays to speak properly are not coloured. In them there is nothing else than a certain Power and Disposition to stir up a Sensation of this or that Colour".

"OPTICKS"
NEWTON.