Polarotropism and Phototropism in the Chloronemas of Dryopteris filix mas (L.) Schott

Summary

Previous results had shown that vertically directed polarized red light orients the growth of horizontally growing chloronemas of Dryopteris filix mas (L.) Schott in either direction perpendicular to the plane of vibration, i.e. the electric vector. This polarotropic response has been investigated more closely.

1. The effect was measured in terms of angle formed during bending of preoriented chloronemas in response to a turn of the vibration plane by 50°.

2. The orientation perpendicular to the vibration plane occurs throughout the visible spectrum. The action spectrum in the visible region has two peaks: one around 665 nm and another one, about hundred times higher, in the blue.

3. From the action spectrum and other results it must be assumed that polarotropism in the blue and the red far-red region is mediated by two different pigment systems.

4. As had been previously shown, far-red reduces the width of the chloronemas as compared to red and dark. This effect is clearly visible in the region between 707 and 747 nm. Its intensity dependence parallels that of polarotropism by the same wavelengths, and on the basis of this observation and other data it may be assumed that both effects are mediated by the same pigment.

5. The morphogenetic response, that is the development of a prothallium from the chloronema in blue light, requires much higher doses than the blue light polarotropic response and starts at intensities at which saturation of polarotropism has almost been reached. From this it is assumed that these effects are mediated by two different pigment systems.

6. Partially illuminated chloronema tips react by bending toward the side of the illuminated flank. This is the case in both red and blue light.

7. From the results with polarized light and partial illumination it is inferred that both blue and red light absorbing pigment molecules are dichroic and located close to or in the cell wall with their axes of maximum absorption parallel to the cell surface.

8. These results allow a detailed description of the optics which are responsible for the absorption gradient in phototropism by unpolarized red and blue light. The gradient is caused by the screening effect, the lens effect creating a by-passed subequatorial zone, and possibly by the orientation of the dichroic pigment molecules, all of them leading to a gradient with more absorption on the side facing the light.
9. By dropping rice starch grains on chloronema tips and following their position during positive phototropic bending it was determined that the tip curvature is caused by bulging of the inner rather than by increased growth of the outer side. Thus in polarotropism and positive phototropism the side that absorbs more light has the higher growth rate.

10. The effect of polarized red light is not reversed by subsequent polarized far-red but is instead slightly increased.

11. Adaptation by red light reduces the sensitivity to polarized red, but enhances the effect of polarized far red light as compared to dark adaptation.

12. Adaptation by red light also reduces the sensitivity to polarized blue light.

13. Unpolarized far-red partially reverses the effect of red light adaptation on red light sensitivity.

14. Unpolarized far-red given after polarized red light reduces the effect of the latter.

15. Assuming that phytochrome controls the effect in the red and far-red, all results can be satisfactorily interpreted only if one assumes that the axis of maximum absorption of phytochrome turns by 90° during the transition of the red absorbing form (Pr) to the far red absorbing form (Pfr), leading to an orientation of the Pfr molecules perpendicular to the cell surface.

16. From the interaction between red and far-red and red and blue it is assumed that adaptation by red light consists of a saturation with Pfr as well as with intermediate products formed subsequently to Pfr. Only saturation with the latter would interfere with the blue light response.

17. Growth measurements together with other results indicate that although the average growth rate of the chloronemas does not change over several days, the growth rate of individual chloronemas shows considerable fluctuations, perhaps representing regular oscillations with periods of several hours duration.

Einleitung