AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 04 Issue: 06 June 2023 Article No: 08

How Does A Plant Sense Shade?

Nalishma Raghu, Viji M.M. and Ammu Alphonsa John
Department of Plant Physiology, College of Agriculture, Vellayani

SUMMARY

Light is the major limiting factor that regulates the productivity under agricultural system. One of the situations in which light might become limited is under canopy shade, such as such as in forests, prairies where a mixture of different species growing in dense conditions and might eventually result in shading. Other situation is under agricultural ecosystem especially for intercrops. The ratio of red light to far red light received by the plants act like a signal for shade responses. Plants when grown under low or no vegetation density, the red light to far red ratio received by the plant is constant (R: FR) and is about 1.2–1.5. Whereas in environments of high vegetation density, two related but different situations may occur with lower the R: FR: plant proximity (without direct shading by neighboring plants) and direct plant canopy shade. The change in R: FR, total PAR and certain regions of photosynthetic radiation is taken as the signal for elucidating shade responses.

INTRODUCTION

In the current scenario of rapid population growth and limited amount of arable land on earth, efficient agricultural practices might require even higher planting densities and intercropping together with changes in plant architecture to maximize crop yield. As sessile photoautotrophs, plants must continuously adjust their development and growth to optimize photosynthetic activity under different conditions. Among the environmental factors, light is the major limiting factor that regulates the productivity under agricultural system. Under natural conditions, one of the situations in which light might become limited is under the shade of canopy, such as in forests, prairies where a mixture of different species growing in dense conditions and might eventually result in shading and there experience a shortage of solar energy both by quality and quantity for photosynthesis. Another situation is under agricultural ecosystem, where plants are grown as a community which leads to the reduction of light quality by proximity shade. The parameter commonly used to describe the quality of light under natural environments is the ratio of photon irradiance in the red region of the spectrum to that in the FR region (termed R: FR ratio). This R: FR ratio is the most exploited and well studied parameter of light related to plant growth and development.

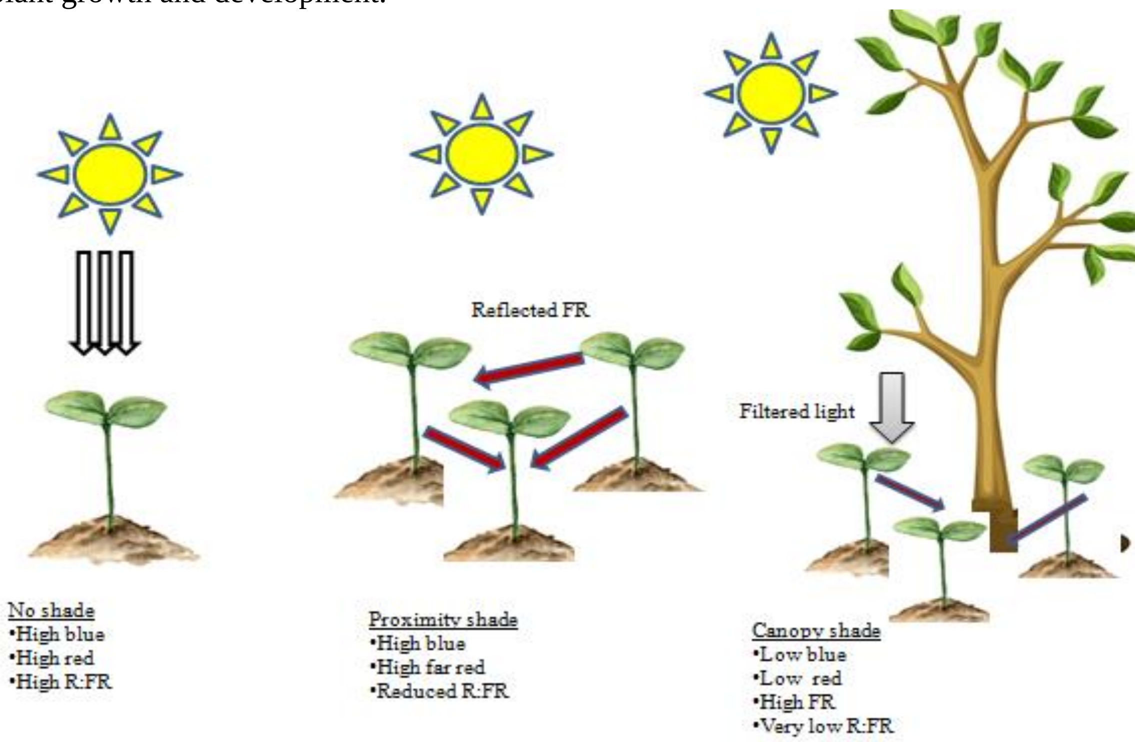

Fig 1: Comparison between neighbor detection and canopy shade

When plants are grown under low or no vegetation density, the sunlight received by plant is relatively constant in quality and the red light to far red light ratio received by the plant (R:FR) is about 1.2–1.5. Whereas in environments of high vegetation density, two related but different situations may occur with lower the R: FR: *plant proximity* (without direct shading by neighboring plants) and *direct plant canopy shade*. Under plant proximity the significant alteration occurs in R: FR when daylight is reflected from living vegetation (Gommers et al 2013). Preferential absorption of red and blue wavebands by chlorophyll and carotenoid pigments results in the selective enrichment of lesser absorbed regions in transmitted light (Vilanova and Martinez-Garcia, 2016). The latter include green and FR region, making plants appear green to the human eye. Although not detectable by human vision, the greatest enrichment occurs in FR wavelengths and thus reducing the R: FR ratio. The low R: FR ratio of reflected light can provide an early warning of the presence and proximity of neighboring vegetation, enabling the initiation of adaptive developmental strategies to either avoid or tolerate the shade by neighboring vegetation.

In contrast, under direct canopy shade, both the amount of PAR and R: FR are strongly reduced (low and very low red light is perceived). The latter effect is mainly due to the selective absorption of red region of light by the leaves (Smith, 1982) (Fig 1). The integration of multiple environmental signals, therefore enables plants to distinguish between the threat of vegetation shading (proximity perception) and actual shading (shade perception).

The R: FR ratio is a reliable and strong indicator of plant proximity as very few objects other than green plants absorb R light so efficiently and FR barely at all. Plants can differentiate the shade of an inanimate object (e.g. a rock) and the shade of another plant and also the presence of nearby vegetation that may *shade* it in the future. The change in R: FR, total PAR and certain regions of photosynthetic radiation is taken as the signal for elucidating shade responses. Different classes of photoreceptors perceive different ranges of the light spectrum: cryptochromes, absorb blue/UV-A light, phytochromes maximally absorb red and far-red and small portion of blue light and UVR8 (UV-B resistance 8) absorbs UV-B radiation(280–315 nm). The most widely studied signal is R: FR ratio which is perceived by phytochrome in shade signaling (Ballare et al., 1985).

CONCLUSION

Light is one of the inevitable resources for plants, which compete for it particularly under dense communities. Plants have different receptors that perceive the ratio of red to far red light that help in identifying the presence of nearby competitors so that to adjust their growth and development accordingly.

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