Potential Application of High-Intensity Red Light for Weed Seedbank Management

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Introduction

Most annual weeds produce many small light-sensitive seeds. These seeds accumulate in the seedbank where they will not germinate until they are exposed to light with a high ratio of red to far-red (high light quality). Sunlight penetrates only a thin layer of the topsoil (Figure 1) and thus, light-sensitive weed seeds need to be close to the soil surface for optimal germination (Ciani et al., 2005; Hopkins and Huner 2008). We quantified seed germination of six weed species in response to end-of-day exposure to red and far-red (FR) light.

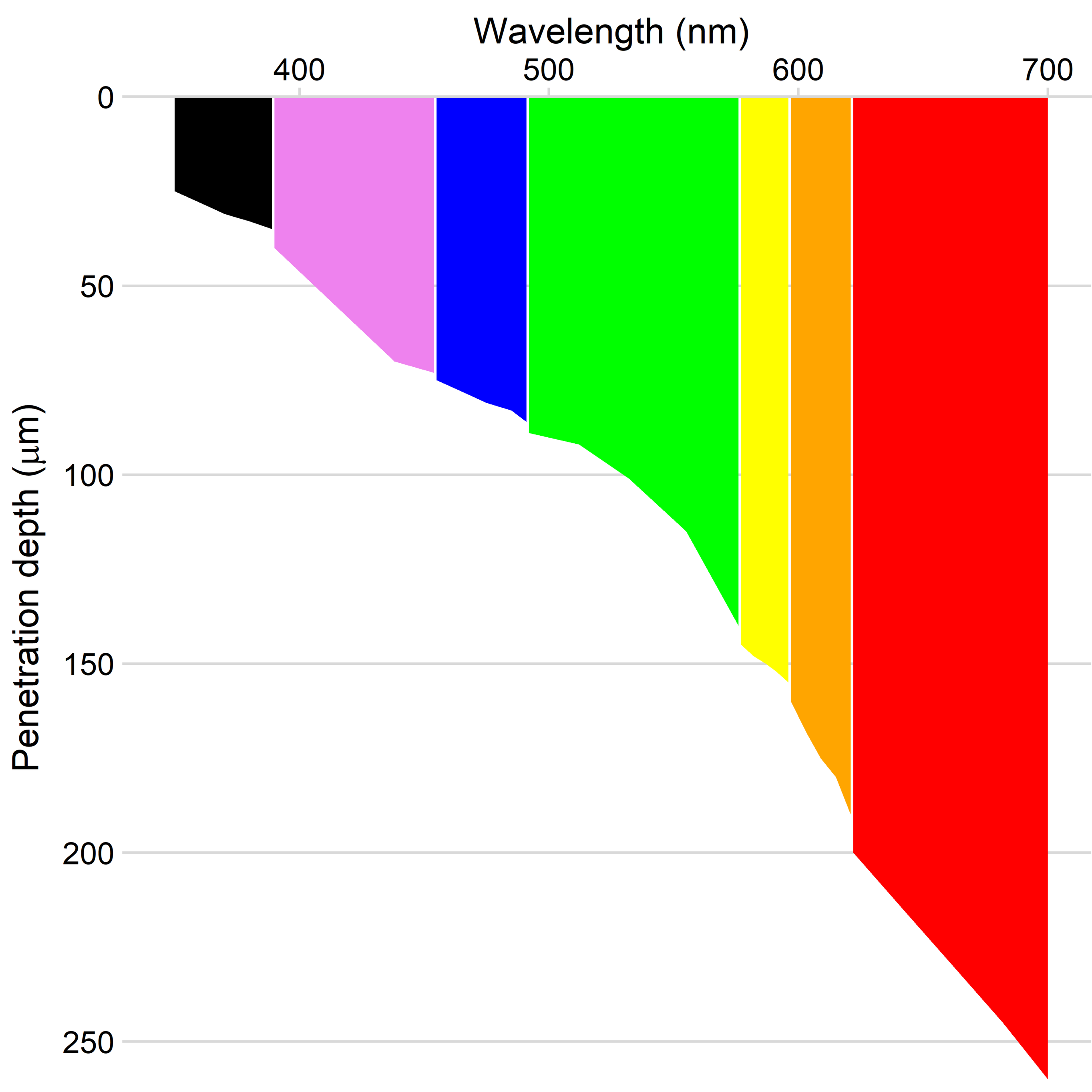

Figure 1. Light penetration depth of a soil. Data from Ciani et al. (2005)

Table 1. Parameter estimates weed seed emergence following the three-parameter log-logistic model

Species	*d* parameter estimate[a] ----- % -----		
	Dark	Far-red	Red
Amaranthus retroflexus	43	29	43
Bassia scoparia	45	42	57
Chenopodium album	43	35	87
Avena fatua	36	38	55
Echinochloa crus-galli	22	23	46
Lolium multiflorum	63	56	92

[a]Y = d *-exp (b * (log(x) - e)), parameters are described in Eq. [1]

References

Ciani et al. (2005) Light penetration in soil and particulate minerals. European J Soil Sci 56: 561–574.

Hopkins WG, Huner N (2008) Introduction to Plant Physiology, 4th ed. The University of Western Ontario, London.

Ritz et al. (2015) Dose-Response Analysis Using R PLOS ONE, 10(12), e0146021

Seefeldt et al. (1995) Log-logistic analysis of herbicide dose-response relationships. Weed Technol. 9: 218-227.

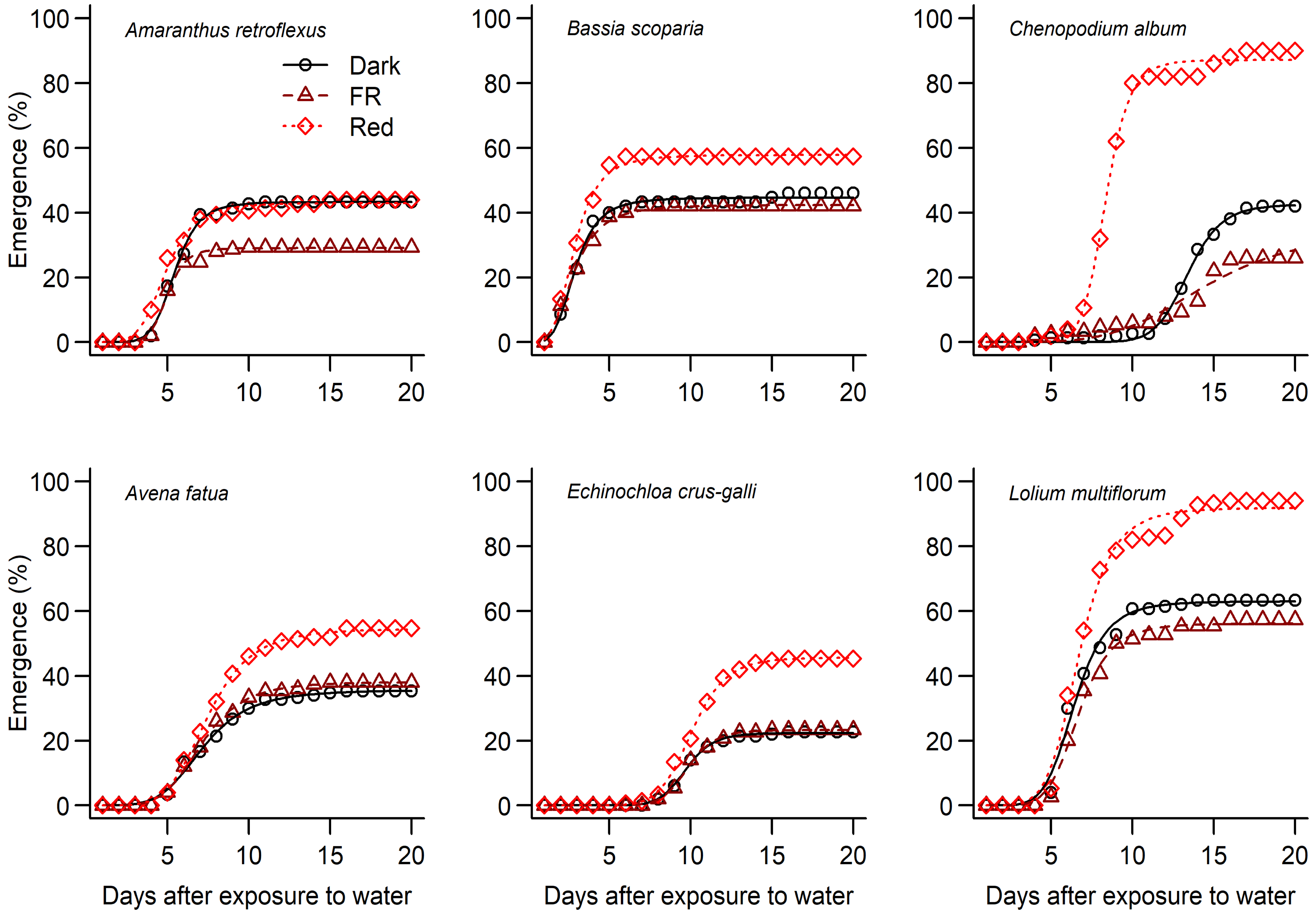

Figure 2. Emergence of six weed species in response to daily exposure to 8 minutes (6:00 to 6:08 pm) of either red (660 nm) or far-red (FR) light (730 nm) compared to the untreated check (dark)

Methods

- Experiment conducted in January 2021 in the greenhouse [temperature (24 °C) and humidity (40%)] at Kimberly, ID
- Six weed species: common lambsquarters (*Chenopodium album*), kochia (*Bassia scoparia*), redroot pigweed (*Amaranthus retroflexus*), barnyardgrass (*Echinochloa crus-galli*), Italian ryegrass (*Lolium multiflorum*), and wild oat (*Avena fatua*), each replicated three times
- 50 seeds per pot filled with potting soil
- Seeds grown in darkness (cardboard boxes)
- Daily exposure to 8 minutes (6:00 to 6:08 pm) of either red (660 nm) or FR (730 nm) light
- Untreated check (darkness) included
- Three-parameter log-logistic model (Eq. [1]) using the drc package in R (Ritz et al. 2015)

$$Y = d / (1 + (X / e)^b) \qquad [1]$$

where Y = germination (%), d = upper limit (maximum germination), X = days after exposure to water, e = the value of X at the inflection point of the curve, and b = slope of the curve at e (Seefeldt et al., 1995)

Results and Discussion

- Weed species responded similarly to the light conditions (Figure 2, Table 1)
- End-of-day exposure to red light increased emergence in all weed species except redroot pigweed
- End-of-day exposure to FR light decreased emergence in all weed species
- Potential for field application of end-of-day red or FR light for weed seed bank management by attaching high-intensity red and FR light to wheel-line or center pivot irrigation systems (Figure 3)

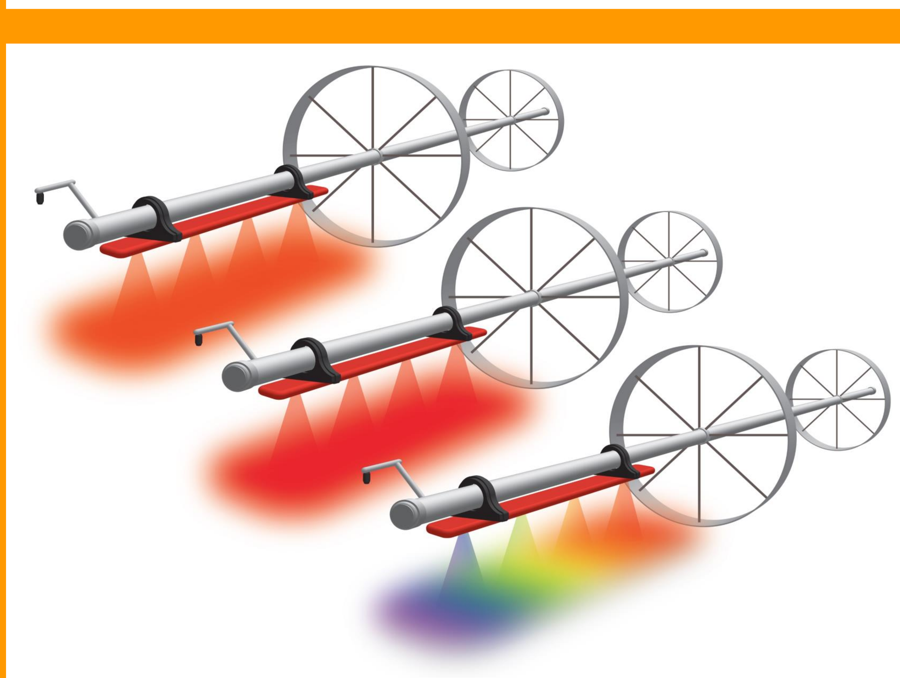

Figure 3. Potential field application of end-of-day red or FR light. Drawing by Scott Riener

Future research

- Effect of duration of red and FR light exposure on weed seed emergence in the field
- Effect of end-of-day red and FR exposure on crop seed emergence