LIGHT QUALITY EFFECTS ON GRASS SEEDLING GROWTH AND DEVELOPMENT

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ABSTRACT

The poor establishment success of Russian wildrye (*Psathyrostachys juncea* Fisch. Nevski) limits its use. Our hypothesis was that Russian wildrye (RWR) was more sensitive to light competition than crested wheatgrass (*Agropyron desertorum* Fischer ex Link) or Dahurian wildrye (*Elymus dahuricus* Turcz. Ex Grieseb.). Seedlings were grown under plastic filters that altered both quantity and quality of light. Tiller counts, leaf counts, leaf area, light intensity and red:far-red light ratio (above and beside each seedling) were recorded each week for four weeks after planting. Seedling dry weights were determined at four weeks. Low light intensity significantly reduced tiller number and seedling dry weight for all three species. Within similar light intensity treatments, there was a tendency for larger seedling dry weight at higher r:fr ratio treatments. Site filling at week three was correlated to r:fr light ratio (side) for all three species. Site filling of RWR was lowest but responsive to increased r:fr light ratio. New RWR pastures should be seeded without companion crops.

KEYWORDS

Seedling vigour, light quality, red:far-red light ratio, phytochrome

Acronyms: CWG- crested wheatgrass, DWR - Dahurian wildrye, RWR- Russian wildrye, SF- site filling

INTRODUCTION

The poor seedling vigour of Russian wildrye (*Psathyrostachys juncea* Fisch. Nevski) is well known and limits its use as a cool-season forage species on the Northern Great Plains of North America. Plant breeding to improve Russian wildrye (RWR) seedling vigour has used non-competitive test environments. Our observations suggest that seedling growth and subsequent RWR forage productivity is enhanced by reducing competition during the seeding year. Russian wildrye seedlings may be more sensitive to light competition than other grasses and this response is mediated by phytochrome which senses altered red:far-red light ratio.

Vertically oriented green tissues such as emerging leaves and leaf sheaths may be sensitive to red:far-red light ratio received from a field of view which is perpendicular to the growth axis (Casal and Smith, 1989). Grass seedlings may be able to 'sense' impending competition from adjacent plants through perturbation in the lateral red:far-red environment before direct shading occurs. This 'early warning' system would provide an adaptive advantage to seedlings in competitive environments. Phytochrome mediated responses indicate that plants can detect neighbouring competitors up to a distance of 30 cm (Smith et al., 1990).

Low red:far-red light reduced tillering and shoot dry weight in Italian ryegrass and increased leaf blade and leaf sheath length (Casal et al., 1985; 1987; 1990). In one report, tiller number was reduced but shoot biomass was not affected by lower red:far-red ratio (Casal et al., 1985). This result also suggests that tiller size was altered. Site filling (number of tillers per leaf axil) of Italian ryegrass was reduced by low red:far-red light ratio (Casal et al. 1985).

Our objective was to compare the seedling development of RWR, crested wheatgrass (*Agropyron desertorum* Fischer ex Link), and Dahurian wildrye (*Elymus dahuricus* Turcz. Ex Grieseb.) as affected by light quality in the growth room.

MATERIALS AND METHODS

Seed of RWR, crested wheatgrass (CWG) and Dahurian wildrye (DWR) were germinated on moistened silica sand at 21 C until the radicle had emerged. Germinated seedlings were transplanted to pots containing one l of greenhouse potting soil.

Two growth rooms were set to run at 21/15 C for 16/8 h photo period. Light intensity in the growth room was approx. 550 μeinsteins $m^{-2} s^{-1}$ and was provided by cool-white flourescent and incandescent lights. Light quality was altered by plastic theatrical colour filters (Roscolux, 1271 Denison St. #66, Markham, ON L3R 4B5) that were selected for contrasting light absorption and transmission properties to provide a range of light quality and intensity. The filters were mounted in aluminum frames of 120 x 60 cm dimension and suspended just above the growing plants. Prior to the initiation of the experiment, light intensity and red:far-red (r:fr) (670:730 nm) ratios were determined beneath the filters with a LiCor quantum sensor and LI-1800 scanning spectroradiometer (LiCor P.O. Box 4425 Lincoln, NE 63504 USA), respectively. In growth room I, the treatments were: control-1, 100% incident intensity, 1.4 red:far-red ratio; #61 mist blue, 66% , 1.14; #26 light red, 12%, 1.1; #68 sky blue, 14%, 0.41. In growth room II , the treatments were control-2, 100% intensity, 1.4 red:far-red ratio; #63 pale blue, 56%, 1.09; #66 cool blue, 62%, 0.45; #129 sky blue silk, 14%, 0.34.

The pots were arranged in groups of four rows and eleven columns below each filter. The outside plants were used as border plants. The experiment units consisted of two adjacent pots of each species. There were three replicates of experimental units below each filter. Pots were watered daily during the experiment.

The following variables were measured on each seedling at weekly intervals after the initiation of the experiment: tiller number, leaf number, leaf area, light intensity at the top of the plants, r:fr ratio horizontally just above the plants (top) and at a 90^{o} angle beside the plant (side). Site filling (proportion of visible tillers:potential tiller sites) was calculated. After the fourth week, the plants were destructively harvested at soil level and dry weights determined. For the analysis of variance, the eight treatments and three grasses were treated as main effects in a factorial design. The error term was the sampling error from the plants within treatment and species combination.

RESULTS AND DISCUSSION

The low light intensity treatments had reduced tiller numbers and seedling dry weight for all three species at four weeks (Table 1). Among the three low light treatments the high r:fr ratio treatment had numerically higher seedling dry weights than the low ratio treatments but these differences were not significant. Among the three moderate light treatments, filter #61 had numerically higher DWR and RWR seedling dry weights than the other two treatments which had lower r:fr ratios. Higher ratio treatments also tended to have more tillers than the low ratio treatment although this effect was not statistically significant.

At three weeks, there were significant linear relationships between side r:fr ratio and site filling of all three grasses (Fig. 1). At high ratio, DWR had the greatest site filling while RWR had nearly the tillering rate of CWG. As r:fr ratio declined however, the decline in RWR site filling was steeper than the decline for CWG. The slope for RWR and DWR were similar but since the DWR site filling rate had been much higher at high r:fr ratio, the lowest site filling for DWR was twice that for RWR.

These results suggest that light competitive conditions will reduce tillering and seedling biomass of RWR to a greater extent than for CWG and DWR through reduced light intensity (shading) and reduced r:fr ratio effects. Phytochrome is the likely environmental sensor that reduces the seedling vigour of Russian wildrye under low r:fr light ratio conditions. The recommendations for seeding RWR pastures should encourage producers to avoid any companion or 'nurse' crop for establishment and the use of herbicides to control weedy competitors.

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Table 1

Light intensity, red:far-red ratio, tiller number, and plant dry weight for crested wheatgrass (CWG), Dahurian wildrye (DWR), and Russian wildrye (RWR) grown for four weeks in the growthroom under six light filters.

Filter	Light	r:f ratio		tillers plant^{-1}			dry weight g plant^{-1}		
	µmoles m^{-2} s^{-1}	top	side	CWG	DWR	RWR	CWG	DWR	RWR
#129	70	0.47	0.40	3.3	4.2	2.8	0.23	0.23	0.10
#68	90	0.46	0.36	4.7	5.5	3.2	0.28	0.31	0.14
#26	110	1.22	0.70	4.5	5.0	3.0	0.34	0.48	0.18
#63	330	1.21	0.66	5.8	10.7	3.8	0.66	0.62	0.25
#66	360	0.96	0.68	5.2	8.0	2.8	0.75	0.60	0.28
#61	420	1.32	0.79	6.2	8.2	3.7	0.69	0.83	0.42
control-1	570	1.38	0.84	10.2	8.8	7.2	1.43	1.24	0.76
control-2	570	1.44	0.90	8.7	11.5	7.8	1.14	0.90	0.61
					s.e. = 2.1			s.e. = 0.18	

Figure 1

Site filling (SF) of crested wheatgrass (CWG), Dahurian wildrye (DWR), and Russian wildrye (RWR) seedlings at three weeks as affected by r:fr light ratio (side). Linear regression lines are shown; equations are: CWG SF=0.153r:fr + 0.127, R^2=0.73*; DWR SF=0.266r:fr +0.110, R^2=0.74*; RWR SF=0.262r:fr + 0.005, R^2=0.86**.