Seed biology of *Chloris truncata* (windmill grass) and *Chloris virgata* (feathertop Rhodes grass)

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Summary Loss of dormancy over time (aging or after-ripening), light effect on seed germination and seed persistence of *Chloris truncata* R.Br. and *Chloris virgata* Swartz were investigated. Fresh *C. virgata* seed had greater dormancy than fresh *C. truncata* seed. *Chloris truncata* achieved 50% germination at one month after maturity, while *C. virgata* reached 50% germination at four months after maturity. Maximum germinability of *C. truncata* and *C. virgata* were reached at seven to eight months after maturity. Light had significant effects on the germination of both *C. truncata* and *C. virgata*; however a small amount of germination occurred in the dark. Under field conditions, the viability of both *C. truncata* and *C. virgata* seeds decreased rapidly with time; but the decline was faster in *C. virgata*. Viability of seeds buried in soil at 5 cm depth was greater than those left on the soil surface.

Keywords *Chloris truncata*, *Chloris virgata* germination, dormancy, seed bank persistence.

INTRODUCTION

Chloris truncata and *C. virgata* are warm season, C4, annual grasses found throughout the Australian mainland. They have become significant weeds in agricultural systems in northern Australia (Osten 2012). These weed species have spread to southern Australia where they could threaten agriculture. In a field survey of summer fallow weed species of the Western Australian grain belt, *C. truncata* was found at 12% of the sites (Michael *et al.* 2010a). It is projected that *C. truncata* could become one of the five most threatening weed species to agriculture in the Northern Agricultural Region in the southwest of Western Australia (Michael *et al.* 2010b). As a summer-active grass, *C. truncata* will reduce the potential yield of winter crops by utilising moisture and nutrients that would otherwise be available to the following crop, and delay sowing due to the time taken for weed control in the autumn (Osten *et al.* 2006, Borger *et al.* 2011a). Similarly, *C. virgata* has become a weed problem in the vineyards and orchards in South Australia and in parts of the Western Australian grain region (Osten 2012). *Chloris virgata* is also a host for aphids (Holman 2009) and diseases such as barley yellow dwarf virus and cereal yellow dwarf virus in the grain-belt of south-western Australia (Hawkes and Jones 2005). Most Australian studies on *C. truncata* so far have been undertaken from a pasture perspective, and there is little information on *C. virgata*.

Studies on weed biology such as seed bank dynamics for annuals and root reserves, dormancy and longevity of vegetative propagules for perennials can be employed to predict weed infestations and to evaluate sustainable management strategies (Bhowmik 1997). For example, integrated approaches that deplete seed banks by interfering with dormancy or germination requirements have great potential to enhance weed management strategies. In this study, loss of dormancy over time (aging or after-ripening), light effect on seed germination and seed persistence were examined to understand seed biology of *C. truncata* and *C. virgata.*

MATERIALS AND METHODS

Effect of seed age on germination On a monthly basis after initial seed production, germination tests were conducted on seeds from two populations each of *C. truncata* (CT2 and CT3) and *C. virgata* (CV1 and CV4). Four replicates of 25 seeds each were placed on moist filter paper in glass Petri dishes (150 mm diameter by 15 mm deep) and randomly placed in an incubator set at 12 h alternating fluorescent light/dark temperatures of 30/20°C. To avoid evaporation, parafilm was used to seal the dishes. Germinated seeds (emerged coleoptile) were counted every two days for 14 days. Germination counts were expressed as a percentage of the 25 seeds per replicate.

Effect of light on germination The effect of two light regimes (12 h alternating light/dark and 24 h dark, 30/20°C) was examined on the germination of *C. truncata* (CT2 and CT3) and *C. virgata* (CV4 and CV5) seeds at 7 months after maturity. The 24 h 'dark' treatment was achieved by wrapping each petri dish in aluminium foil. The petri dishes of both treatments were opened after 14 days and germinated seeds counted. Other methodology was similar to that described in the previous section.

Seed bank persistence under field conditions The experimental design was factorial with two *Chloris* spp. populations (CT2 and CV5) and two burial depths (0 and 5 cm) with four replicates in randomized complete blocks. Twenty five seeds of CT2 and CV5 were mixed with soil, put in 10 cm by 5 cm permeable nylon bags and then placed at two depths (0 and 5 cm) in the field at Roseworthy, SA in July 2013. Sixteen plots/bags consisting of two populations and two burial depths in four replicates were randomly selected and removed at zero, two, four and eight months for CT2 and zero, two, four, six and eight months for CV5 following burial. The extracted seeds were checked for germination in an incubator with 12 h alternating light/dark temperature of 30/20°C for 14 days. In addition, 25 seeds of CT2 and CV5 stored in room conditions with four replicates were tested for germination at zero, two, four, six and eight months. Seed viability (%) was expressed as the number of germinated seed buried at 0 or 5 cm in the field relative to the number of germinated seed stored in room conditions at the same time.

GenStat 15th edition was used to analyse the data. Standard error of the mean was calculated for all experiments. Duncans multiple range tests were used to identify significant differences between treatment means at P = 0.05 in the light effect experiment.

RESULTS

Effect of seed age and light on germination At seed maturity, germinability of *C. truncata* was 31%, while no seed germination occurred for *C. virgata*. It required one and four months after maturity for *C. truncata* and *C. virgata* respectively to achieve more than 50% germination. Seed germination of *C. truncata* and *C. virgata* reached a maximum of 77% and 80% at seven and eight months respectively after maturity (Figure 1).

Light had a significant effect on the germination of both *C. truncata* and *C. virgata*, but the effect was variable across populations. Seed germination in *C. truncata* CT3 population increased from 2% in the dark to 77% in the light. Similarly, seed germination in *C. virgata* CV5 population increased from 17% in the dark to 72% when exposed to light. However, higher germination occurred in the dark for *C. truncata* CT2 population at 15% and for *C. virgata* CV4 population at 35% (Table 1).

Seedbank persistence under field conditions Under field conditions, the viability of both *C. truncata* and *C. virgata* seeds decreased with time; but the decline was faster for *C. virgata* seeds. Seed viability decreased by about 50% following two and four month burial for *C. virgata* and *C. truncata* respectively (Figure 2). Viability of seeds buried in soil at 5 cm depth was longer than those left on the surface (Figure 2).

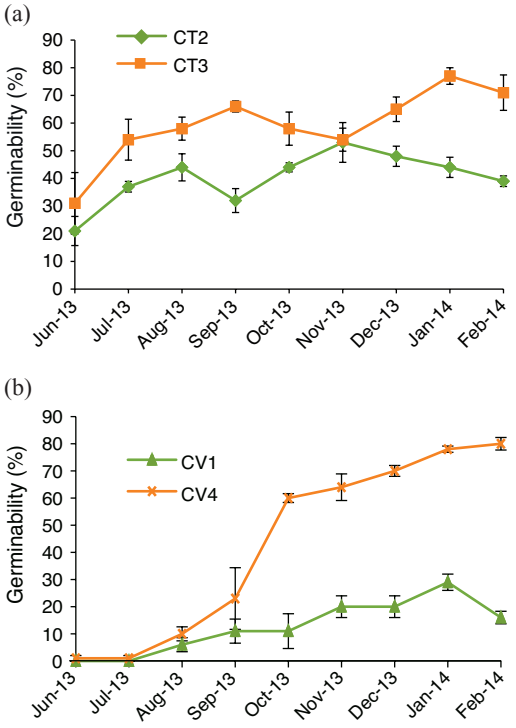

Figure 1. Germinability of *C. truncata* (a) and *C. virgata* (b) seed collected in June 2013, and tested monthly from Jun 2013 to Feb 2014. Vertical bars indicate standard error of the mean.

Table 1. Effect of light on germination of *C. truncata* and *C. virgata* seed collected in Jun 2013 and tested in Jan 2014. Different letters after the means indicate significant differences at P = 0.05.

Population	Germinability (%)			
	24 h dark		12 h light/dark	
	Mean	SE*	Mean	SE
CT2	15.0b	5.0	44.0c	3.7
CT3	2.0a	1.2	77.0d	3.0
CV4	35.0c	3.4	78.0d	1.2
CV5	17.0b	5.3	72.0d	6.5

*SE: standard error of mean.

DISCUSSION

Chloris virgata seeds on the soil surface lost their viability completely after eight months. Osten (2012) also found that seeds of *C. virgata* in Central Queensland were short-lived (7–12 months). Our results mean if no further seeds are added to the seed bank, the population of *C. virgata* could be reduced quickly. However, *C. virgata* seeds can be readily dispersed by wind and fields could be re-colonised by seeds from nearby populations.

Germination of both *C. truncata* and *C. virgata* seeds was stimulated by light. This is similar to that found by Maze *et al.* (1993) for *C. truncata* and Osten (2012) for *C. virgata*. However, a small proportion of seeds germinated in the dark (*C. truncata*: 2–15%; *C. virgata*: 17–35%), which could have contributed to a decline of the viable seeds buried at 5 cm (Figure 2). For this to occur there must be suitable temperature and moisture conditions, as occurred, in this experiment at Roseworthy in February 2014 (Figure 3).

The dormancy period of *C. truncata* seeds in this study (one to two months) was shorter than three to four months reported by Borger *et al.* (2011a). *Chloris virgata* seeds in our study were dormant for three to four months, which is slightly longer than that reported earlier by Osten (2012).

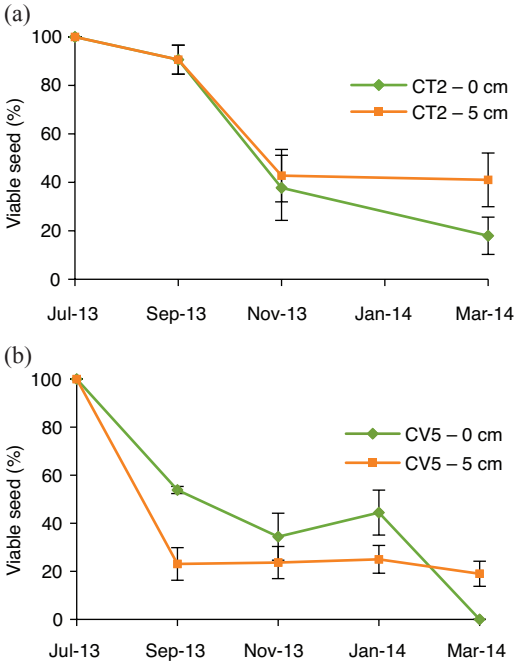

Figure 2. Changes in viable seed *C. truncata* (a) and *C. virgata* (b) seed following burial at two depths in July 2013.

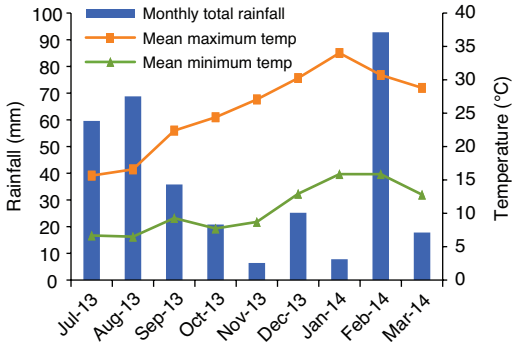

Figure 3. Monthly total rainfall, mean maximum and minimum temperatures at Roseworthy (http://www.bom.gov.au).

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