Germination biology of *Portulaca oleracea* L.

Bhagirath S. Chauhan and David E. Johnson
Crop and Environmental Sciences Division, International Rice Research Institute, Los Baños, Philippines
Email: b.chauhan2@cgiar.org

Summary Experiments were conducted to determine the effect of various environmental factors on seed germination and seedling emergence of *Portulaca oleracea* L. Seeds of *P. oleracea* were able to germinate over a broad range of temperatures (25/15, 30/20, and 35/25°C day/night temperatures). Germination was stimulated by light although some seed germinated in the dark. Germination decreased from 71% to 10% as osmotic potential decreased from 0 to −0.6 MPa, and was completely inhibited at osmotic potentials lower than −0.6 MPa. Germination was greater than 70% over a pH range of 5 to 9, but declined to 57% at pH 4. Seedling emergence was the greatest (63%) for seed at the soil surface, but decreased progressively as sowing depth increased. No seedlings emerged from seed buried at a soil depth of 2 cm. The requirement for light and the inability of this species to emerge from depths of greater than 2 cm suggest that reduced tillage systems may favour its recruitment.

Keywords Germination, light, emergence, burial depth.

INTRODUCTION

Portulaca oleracea L. utilises the C_4 photosynthetic pathway and is considered a serious weed of 45 crops in 81 countries (Holm *et al.* 1977). Recently, the species was reported to occur in 17 countries in dry seeded rice and three countries in wet seeded rice (Rao *et al.* 2007). The lifecycle of *P. oleracea* is completed in 2–4 months (Miyanishi and Cavers 1980). The seeds of this plant are very small and spread by wind and water. A single plant can produce as much as 10,000 seeds. The succulent leaves and stems accumulate toxic levels of oxalates and may cause sickness and death in animals (Miyanishi and Cavers 1980). In addition, the species is an alternate host of nematodes, insects and fungi.

Despite the importance of this weed, there is limited information available on its seed germination biology, making it difficult to develop components of integrated weed management strategies. The objective of the research reported here therefore was to determine the influence of various environmental factors on germination and seedling emergence of *P. oleracea*.

MATERIALS AND METHODS

Seed collection and germination protocol Seeds of *P. oleracea* were collected in February 2007 from the fallow rice fields in Los Baños, Philippines. Seeds were cleaned manually and stored at room temperature until used in the experiments. Seed germination was evaluated by placing 25 seeds in a 9 cm diameter Petri dish containing two layers of Whatman No. 1 filter paper and 5 mL of distilled water or a test solution. Dishes were placed in an incubator at fluctuating day/night temperatures of 30/20°C in light/dark (12 h/12 h), unless otherwise specified. For germination in complete darkness, the dishes were wrapped in a double layer of aluminium foil. Germination was determined after 14 days, at which time seeds with an emerged radicle were considered to have germinated.

Germination response to temperature and light To determine the effect of temperature and light on germination of *P. oleracea*, freshly harvested seeds were incubated in germination chambers at different day/night temperatures (35/25, 30/20, and 25/15°C) and light conditions (light/dark and continuous dark).

Germination response to osmotic stress To determine the effect of osmotic stress, solutions with osmotic potentials of 0, −0.1, −0.2, −0.4, −0.6, −0.8, and −1.0 MPa were prepared by dissolving polyethylene glycol 8000 in 1 L of distilled water as described by Michel (1983).

Germination response to pH of buffered solution The influence of pH on the germination of *P. oleracea* seed was studied by using buffer solutions of pH 4 to 9 prepared as described by Chauhan *et al.* (2006). Unbuffered distilled water (pH 6.2) was used as a control.

Seedling emergence response to seed burial depth The effect of seed burial depth on seedling emergence was studied in a screen house. Fifty seeds of *P. oleracea* were placed on the soil surface in 15 cm diameter pots and then covered with soil to achieve burial depths of 0, 0.2, 0.5, 1, 2, and 3 cm. Autoclaved soil, having a pH of 6.2 and organic carbon 1.3%, was used for this experiment. Pots were watered as needed to maintain adequate soil moisture. Seedlings were considered emerged when a cotyledon was visible.

Statistical analyses All experiments were conducted in a randomised complete block design with three replications. All experiments were conducted twice and the data were combined. Regression analysis was used where appropriate, otherwise means were separated using LSD at P = 0.05. Data variance was visually inspected by plotting residuals to confirm homogeneity of variance before statistical analysis.

RESULTS

Germination response to temperature and light Germination of freshly harvested seed of *P. oleracea* was influenced by temperature and light, and the interaction (P <0.05) of these (Figure 1). In the dark, germination (1.1 to 2.2%) was not influenced by the temperatures tested. However, in the light/dark regime, germination was significantly lower at 25/15°C (58.9%) and 35/25°C (60.6%) than at 30/20°C (69.4%).

Germination response to osmotic stress Germination decreased linearly with decreasing osmotic potential ($G = 66.7 + 88.9x$, $r^2 = 0.98$) (Figure 2). Germination decreased from 71% to 10% as osmotic potential decreased from 0 to −0.6 MPa; germination was completely inhibited at osmotic potential of −0.8 MPa.

Germination response to pH of buffered solution The influence of pH on germination of *P. oleracea* was tested using buffered pH solutions. Germination was greater than 70% over a pH range of 5 to 9, but declined to 57% at pH 4 (data not shown).

Seedling emergence response to seed burial depth The data on seedling emergence of *P. oleracea* were fitted to an exponential decay curve (E (%) = 63.2 x $e^{-4.8x}$, $r^2 = 0.99$) Seedling emergence decreased sharply with increased seed burial depth (Figure 3). Seedling emergence was greatest (63%) for seed present on the soil surface, but decreased progressively as depth increased. No seedlings emerged from seed buried at a depth of 2 cm.

DISCUSSION

Seed of *P. oleracea* germinated over the range of temperatures (25/15, 30/20, and 35/25°C) tested. The ability to germinate over this range is probably one of the reasons why this species emerges throughout the year at low altitudes in tropical countries. Such broad adaptation to temperature provides many opportunities for seed production and weed proliferation. Germination was stimulated by light, suggesting the seeds of this species are positively photoblastic. Species showing greater germination in light may become more prevalent in no-till systems, as these systems tend to concentrate weed seed on or close to the soil surface. Further, seedling emergence of *P. oleracea* was greatest for the seed present on the soil surface (63%) and emergence decreased rapidly with increased burial depth from 0 to 2 cm (Figure 3). These results are consistent with the stimulation of germination in the presence of light, as seeds present on the soil surface

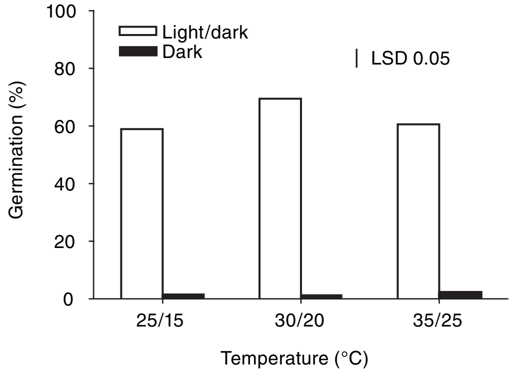

Figure 1. Effect of temperature (25/15, 30/20, and 35/25°C alternating day/night temperatures) and light (light/dark and dark) on germination of freshly harvested seed of *Portulaca oleracea*.

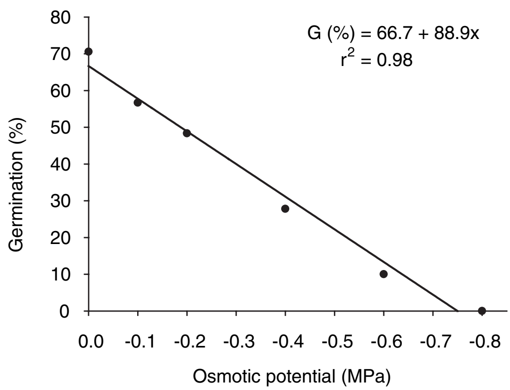

Figure 2. Effect of osmotic potential (MPa) on germination of *Portulaca oleracea* seed incubated at 30/20°C in a 12 h photoperiod for 14 days. Line represents a linear model fitted to the data.

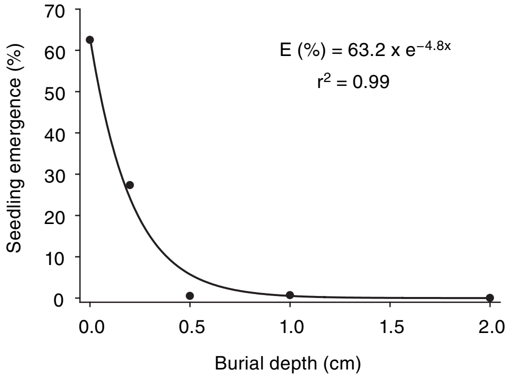

Figure 3. Effect of seed burial depth on seedling emergence of *Portulaca oleracea*. Line represents an exponential decay model fitted to the data.

receive a considerable amount of light. Seed buried too deep may also be enforced into dormancy due to an unfavourable environment. Decreased seedling emergence due to increased seed burial depth could also be related to seed size (Benvenuti *et al.* 2001), as seed buried too deep may not have sufficient energy reserves to support seedling emergence. The results suggest that this weed species could be favoured in reduced tillage systems. A possible management option may therefore be a deep inversion tillage that will bury the seed below its maximum depth of emergence. Subsequent tillage operations may, however, bring the seed back to the soil surface and lead to a re-infestation of the area with *P. oleracea*. This may be prevented if subsequent tillage operations are shallow to avoid bringing back the seed on the surface.

The steep decline in germination with decreasing osmotic potential suggests that *P. oleracea* would favour a moist environment for germination. In times of drought therefore, *P. oleracea* may remain ungerminated until moisture levels are adequate for germination. Water stress conditions during the dry season may therefore delay *P. oleracea* germination until the beginning of the rains. In rainfed systems such a response is a valuable strategy for *P. oleracea*.

Different weed populations often vary in germination requirements; therefore, conclusions drawn from the results of this study should be limited to the weed population tested. Further field research is needed to understand the emergence pattern of this weed species under different tillage systems, especially no-till systems in which its emergence is expected to be greater. Research is also required to determine the impact of variable burial depth caused by different tillage systems on the persistence of *P. oleracea* seed.

REFERENCES

Benvenuti, S., Macchia, M. and Miele, S. (2001). Quantitative analysis of emergence of seedlings from buried weed seeds with increasing soil depth. *Weed Science* 49, 528-35.

Chauhan, B.S., Gill, G. and Preston, C. (2006). Influence of environmental factors on seed germination and seedling emergence of Oriental mustard (*Sisymbrium orientale*). *Weed Science* 54, 1025-31.

Holm, L.G., Plucknett, D.L., Pancho, J.V. and Herberger, J.P. (1977). ‘The world’s worst weeds: distribution and biology’. (University of Hawaii Press, Honolulu, Hawaii USA).

Michel, B.E. (1983). Evaluation of the water potentials of solutions of polyethylene glycol 8000 both in the absence and presence of other solutes. *Plant Physiology* 72, 66-70.

Miyanishi, K. and Cavers, P.B. (1980). The biology of Canadian weeds. 40. *Portulaca oleracea* L. *Canadian Journal of Plant Science* 60, 953-63.

Rao, A.N., Mortimer, A.M., Johnson, D.E., Sivaprasad, B. and Ladha, J.K. (2007). Weed management in direct-seeded rice. *Advances in Agronomy* 93, 155-257.