

Influence of Temperature, Light and Burial Depth on Germination and Emergence of *Phalaris minor* Seeds

GURVINDER KAUR, AXAY BHUKER*, MS HARISH AND VS MOR

Department of Seed Science and Technology
CCS Haryana Agricultural University, Hisar, Haryana-125 004, India
*bhuker.axay@gmail.com

(Received January 2025; Revised February 2025; Accepted March 2025)

ABSTRACT: Weed infestation, particularly by objectionable species like *Phalaris minor*, poses a significant challenge in seed production due to its morphological similarity to wheat and persistence in agricultural fields. Effective management of such weeds requires a clear understanding of their germination ecology. This study was conducted in the Department of Seed Science and Technology, CCS HAU Hisar to assess the effects of temperature, light/darkness, and burial depth on the germination behaviour of freshly collected *Phalaris minor* seeds. The findings indicated that alternating temperature and light conditions significantly influenced seed germination and emergence. Seeds showed no dormancy and germinated optimally at an alternating temperature of 15/20°C under a 16-hour light and 8-hour dark cycle. Field emergence was highest at a burial depth of 4 cm, with seeds capable of emerging from depths up to 8 cm. The results underscore the importance of environmental factors in managing *P. minor* and provide valuable insights for developing targeted weed control strategies.

Keywords: Objectionable weeds, germination, burial depth, hard seed, *Phalaris minor*

INTRODUCTION

Numerous annual and perennial weeds compete with crops for essential resources, often resulting in significant yield reductions. However, in seed production, objectionable weeds are of particular concern due to their resemblance to the seed crop either in plant morphology or seed appearance. Once these weed seeds contaminate the crop seed, they are difficult and often uneconomical to remove.

Various crops have specific objectionable weeds. For example, *Phalaris minor* and *Convolvulus arvensis* are problematic in wheat; wild oat (*Avena fatua*) in oats; wild rice (*Oryza sativa* L. var. *fatua* Prain) in paddy; *Argemone mexicana* in mustard; wild sunflower (*Helianthus* spp.) in sunflower; *Cichorium intybus* in berseem; wild safflower (*Carthamus oxyacantha* M. Bieb.) in safflower; and *Cuscuta* spp. in lucerne. According to the Indian Minimum Seed Certification Standards [1], specific thresholds are set for objectionable weed seeds—e.g., *P. minor* seeds should not exceed 2 per kilogram in foundation seed and 5 per kilogram in certified seed.

Among these, *Phalaris minor* Retz., commonly known as small canarygrass, is a self-pollinated ($2n = 28$) annual grass weed from the Poaceae family and a major problem

in wheat cultivation. It is also referred to as Mediterranean canarygrass or littleseed canarygrass. This weed disperses primarily through the shattering of its caryopsis from glumes, while related species like *P. paradoxa* disarticulate spikelets from the inflorescence upon maturity [2]. *Phalaris minor* exhibits straight or curved stems ranging from 30 to 130 cm and propagates solely through seeds. It is particularly resilient, capable of tolerating various agronomic stresses, and commonly invades fields of vegetables, legumes, cereals, peas, sugar beet, and gardens—especially during the winter season.

Weeds, being integral parts of dynamic agroecosystems, each have unique ecological requirements. Understanding weed ecology is essential for developing sustainable management strategies. Weed seed germination is influenced by environmental factors such as temperature, moisture, light, and pH. Of these, water and temperature are the primary determinants. Most weed seeds germinate optimally between 15°C and 30°C. Gaining insights into the ecological requirements of specific weeds can guide the development of targeted cultural practices that either inhibit their emergence or promote germination at times when control measures are most effective [3].

Weeds compete with crops for sunlight, water, and nutrients, thus compromising both yield quantity and quality. Light, in particular, plays a pivotal role in regulating dormancy and germination. Weed seeds perceive their surroundings through photoreceptors (mainly phytochromes), which detect the spectral composition and intensity of light—signaling whether they are buried deep in soil, under canopy cover, or exposed due to cultivation. These light cues, in conjunction with alternating temperature conditions, are essential for triggering germination in many species [4,5]. Phytochromes within imbibed seeds help assess environmental competition and make germination decisions accordingly [6].

Temperature also affects seed physiology by helping break dormancy and influencing both the rate and success of germination [7]. Moreover, the depth of seed burial significantly impacts emergence; deeper burial requires more energy, often reducing the likelihood of seedling establishment. Larger seeds with greater energy reserves are typically better able to emerge from deeper soil layers than smaller seeds.

Seed dormancy, an inherent trait in many weed species, prevents germination even when environmental conditions are favourable [8,9]. Considering these factors, the present study aims to investigate the effects of temperature, light, and burial depth on the emergence behavior of *Phalaris minor* seeds. This information is crucial for devising effective weed control strategies, particularly in seed production systems where purity is paramount.

MATERIALS AND METHODS

Freshly collected seeds of *Phalaris minor* were exposed to the alternate temperatures of 15/20, 20/25 and 25/30°C with two light regimes i.e. 16 hours light followed by 8 hours darkness and complete exposure to darkness for 24 hours in the laboratories of Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2023-24. Following observations were recorded:

Germination (%): The germination test was conducted through top of paper method (TP) in which three replications of objectionable weeds were placed at alternate temperature of 15/20°C, 20/25°C and 25/30°C in the germinator. Throughout the test 16/8 hrs light/dark cycle (Lower temperature for sixteen hours and higher

temperature for eight hours) was followed. A light source of 20watt cool white fluorescent bulb provided light requirements. Germination test was conducted in transparent petri dishes for treatment under light. After the emergence of both radicle and plumule, the seeds were observed on daily basis until the maximum germination was achieved. The germination was calculated using following formula [10].

Germination (%) =

$$\frac{\text{Number of normal seedlings}}{\text{Total number of seedlings per replicate}} \times 100$$

Radicle emergence (%): The radicle emergence test was conducted by using top of paper method for all the weed species. Weed seeds in three replications were randomly placed on petri dish with sufficiently moistened Whatman No.1 filter paper. Then the petri dishes were placed inside a controlled germinator maintained at different alternate temperatures of 15/20°C, 20/25°C and 25/30°C. The seeds that exhibited at least 2mm radicle emergence were counted and recorded at 24 hour interval, starting from the initiation of radicle emergence till maximum radicle emergence.

Radicle emergence (%) =

$$\frac{\text{No. of seeds with 2mm radicle length}}{\text{Total no. of seeds placed}} \times 100$$

Seedling length (cm): The length of seedlings (including both root and shoot) from 10 randomly chosen normal seedlings from three replicates of the standard germination test, was measured in centimeters using a scale. The average length of the 10 seedlings was then calculated for final analysis. In case, the germination percentage was below 10 percent, average seedlings length was calculated [11].

Seedling dry weight (mg): During germination test, 10 randomly selected normal seedlings were taken and dried in a hot air oven for 24 hours at a temperature of 80 ±1°C. The average weight of 10 dried seedlings was recorded and expressed in milligrams (mg). In some cases where germination percentage was below 10 percent, then average weight of germinated seedlings was calculated [11].

Hard seeds (%): Seeds that remain hard and impermeable to water at the end of test period were considered as hard seeds. The hard seed percentage was calculated by dividing the number of hard seeds by total number of seeds per replicate and expressed as

percentage. The presence of hard seeds was also confirmed by using tetrazolium test (viability test).

Vigour indices: The vigour index-I and vigour index-II were calculated by following methods [12].

Vigour Index-I = Standard germination (%) × Average seedling length (cm)

Vigour Index-II = Standard germination (%) × Average seedling dry weight (mg)

To assess the effect of burial depth, twenty-five seeds in three replications were sown in pots at various depths i.e. 4, 6 and 8 cm in soil and following field parameters were recorded:

Speed of emergence: The number of seedlings emerged were counted on each day up to seedling establishment. The speed of emergence was calculated as described [13].

Speed of emergence =

$$\frac{\text{No. of seedlings emerged}}{\text{Day of first count}} + \dots + \frac{\text{No. of seedlings emerged}}{\text{Day of final count}}$$

Field emergence (%): Field emergence was assessed by counting the total number of seedlings after completion of emergence or when there were no further additions to the total count of seedlings.

Statistical Analysis: Statistical analysis of data collected during the study was done by using the factorial complete randomized (CRD) design [14]. All the values described as mean of the replicates with the evaluation of CD at 5% level of significance using the online statistical tool (OPSTAT) [15].

RESULTS AND DISCUSSIONS

The results revealed that the alternate temperature of 15/20°C recorded the maximum germination (95.33%) followed by 20/25°C (89.33%). The minimum germination (62.00%) was recorded at higher temperature i.e. at 25/30°C. Between the two light regimes i.e. L₁ (16 hours light followed by 8 hours darkness) and L₂ (complete darkness), L₁ recorded more germination (89.77%) over L₂ (74.66%). The germination percentages were generally higher for *Phalaris minor* seeds exposed to light compared to those kept in darkness. Seeds showed a stronger positive response to light, particularly those stored at room temperature. In these conditions, germination rates in light were consistently 20 to 35% higher than in darkness [16]. Optimal germination (95%) was observed at 15/25°C (day/night), while no

germination occurred at 20/35°C (day/night) in *Phalaris minor* [17], in *Phalaris paradoxa* [18], in *Phalaris arundinacea*. [19] Maximum germination (96.00%) was observed at alternate temperature of 15/20°C in L₁ (16 hours light followed by 8 hours darkness). *Phalaris minor* seeds have a higher propensity for high germination, and prefer alternating temperatures (10/20°C or 5/25°C) over constant 15°C and light/dark (16/8 hrs) regimes [20]. It indicates that light stimulates the process of germination and growth in *Phalaris minor* and optimum temperature is 15/20°C. *Phalaris minor* had high dry weight at 10/6°C and 16/10°C regime. The radicle emergence was found high at low alternate temperature (15/20°C) and lowest at high temperature (25/30°C) as the fluctuation between day and night temperatures can mimic natural environmental conditions, and enhance the physiological processes which is necessary for radicle emergence [21]. The similar result is also favoured in *Phalaris minor* [22]. During the study, no hard seeds were found in *Phalaris minor* at any alternate temperatures and under light/darkness conditions indicating the absence of dormancy in these seeds (Table 1). The reason may be that *Phalaris minor* seeds respond positively to light, which suggests that their dormancy can be broken by environmental cues rather than requiring the physical barrier of a hard seed coat. The alternate temperature of 15/20°C recorded the maximum seedling length (12.07cm) followed by 20/25°C (10.21cm). The minimum seedling length (7.81cm) was recorded at higher temperature i.e. 25/30°C. Between the two light regimes, 16 hours light followed by 8 hours darkness recorded more seedling length (10.03cm) over complete darkness (8.29cm). Maximum seedling length (12.07cm) was recorded at alternate temperature of 15/20°C under 16 hours light followed by 8 hours darkness (Table 1).

Maximum seedling dry weight (mg) was observed when seeds were exposed at alternate temperature of 15/20°C (0.87 mg) followed by 20/25°C (0.72 mg). The minimum seedling dry weight (0.65 mg) was recorded at 25/30°C under 16 hours light followed by 8 hours darkness. Between the two light regimes 16 hours light followed by 8 hours darkness recorded more seedling dry weight (0.79 mg) over complete darkness (0.70 mg). Maximum seedling dry weight (0.89 mg) was recorded at alternate temperature of 15/20°C under 16 hours light followed by 8 hours darkness (Table 2).

Maximum vigour index-I (995.03) was observed at 15/20°C followed by 20/25°C (828.19). The temperature that

Table 1. Effect of temperatures and light/darkness on seed germination, hard seeds and seedling length of *Phalaris minor*

Alternate Temperatures (T)	Germination (%)			Hard seeds (%)			Seedling length (cm)		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
15/20°C	96.00	94.66	95.33	00	00	00	12.07	8.79	10.43
20/25°C	90.67	88.00	89.33	00	00	00	10.21	8.29	9.25
25/30°C	82.66	41.33	62.00	00	00	00	7.81	7.78	7.80
Mean	89.77	74.66		00	00		10.03	8.29	
SE±(m)	T=1.61, L=1.32, T x L= 2.27			-			T=0.26, L= 0.21, T x L= 0.37		
C.D. (P=0.05)	T=5.02, L=4.01, T x L=7.09			-			T=0.81, L=0.66, T x L=1.15		

Where L₁ =16 hours light followed by 8 hours darkness and L₂= exposure to complete darkness for 24 hours

Table 2. Effect of alternate temperatures and light/darkness on seedling dry weight and vigour indices of *Phalaris minor*

Alternate Temperatures (T)	Seedling dry weight (mg)			Vigour index I			Vigour index II		
	L ₁	L ₂	Mean	L ₁	L ₂	Mean	L ₁	L ₂	Mean
15/20°C	0.89	0.84	0.87	1158.40	831.67	995.03	85.44	79.58	82.51
20/25°C	0.77	0.67	0.72	925.89	730.48	828.19	69.68	52.57	61.13
25/30°C	0.70	0.60	0.65	644.53	322.38	483.46	57.64	27.92	42.78
Mean	0.79	0.70		909.61	628.18		70.92	53.36	
SE±(m)	T=0.03, L=0.02, T x L= 0.04			T=12.15, L=9.92, TxL=17.18			T=1.30, L=1.06, T x L= 1.83		
C.D. (P=0.05)	T=0.09, L=0.08, T x L=NS			T=37.84, L=30.90, T x L=53.52			T=4.04, L=3.30, TxL=5.71		

Where L₁ =16 hours light followed by 8 hours darkness and L₂= exposure to complete darkness for 24 hours

exhibited the minimum vigour index-I (483.46) was 25/30°C. More vigour index-I (909.61) was recorded under 16 hours light followed by 8 hours darkness over complete darkness (628.18). Maximum vigour index-I (1158.40) was recorded at alternate temperature of 15/20°C under 16 hours light followed by 8 hours darkness. Among the alternate temperatures, maximum vigour index-II (82.51) was observed at 15/20°C followed by 20/25°C (61.13). The temperature that exhibited the minimum vigour index-II (42.78) was 25/30°C. More vigour index-II (70.92) was recorded under 16 hours light followed by 8 hours darkness over complete darkness (53.36). Maximum vigour index-II (85.44) was recorded at alternate temperature of 15/20°C under 16 hours light followed by 8 hours darkness (Table 2).

The radicle emergence was started after 72 hours under 16 hours light followed by 8 hours darkness while it was started after 84 hours under complete darkness under alternate temperature of 15/20°C and 20/25°C. Under higher alternate temperature of 25/30°C, no radicle emergence was started at 72 hrs in any of the light regimes. The alternate temperature of 15/20°C recorded the maximum radicle emergence (65.11%) followed by

20/25°C (62.72%). The minimum radicle emergence (44.55%) was recorded at higher temperature *i.e.* at 25/30°C (62.00%). Between the two light regimes *i.e.* 16 hours light followed by 8 hours darkness recorded more radicle emergence (63.92%) over complete darkness for 24 hrs (51.00%). Maximum radicle emergence (96.00%) was observed at alternate temperature of 15/20°C under 16 hours light followed by 8 hours darkness after 84 hours (Table 3).

Maximum field emergence (32.00%) was recorded at 4cm followed by 6cm (25.33) whereas minimum field emergence was observed at 8cm (6.67%). Among the different depths, the highest speed of emergence was recorded at 4cm (5.98) whereas minimum speed of emergence was observed at 8cm (0.41) (Table 4). It is clear that as the burial depth increases the emergence for *Phalaris minor* decreases. These results are supported in *Phalaris minor* [23]. Generally, the seedling emergence can be influenced by temperature, light and available moisture [24, 25]. As soil depth increases availability of oxygen gradually decreases. The maximum germination and emergence were reached in most seeds at oxygen pressures close to that of air [26]. The influence of

Table 3. Effect of temperature, light/darkness and duration on radicle emergence (%) of *Phalaris minor* seeds

Temperature (T) →	15/20°C		20/25°C		25/30°C		Mean
Light (L) ^a →	L ₁	L ₂	L ₁	L ₂	L ₁	L ₂	
Duration (D)							
72 hrs	32.00	0.00	17.33	0.00	0.00	0.00	8.22
84 hrs	96.00	26.67	49.33	37.33	32.00	36.00	46.22
96 hrs	96.00	74.67	84.00	62.67	62.67	41.33	70.22
108 hrs	96.00	74.67	86.67	68.00	65.33	44.00	72.44
120 hrs	96.00	94.67	86.67	84.00	78.67	44.00	80.67
132 hrs	96.00	94.67	86.67	90.00	85.33	45.33	83.00
Mean	69.33	60.89	68.44	57.00	54.00	35.11	
SE±(m)	T=0.67, L=0.55, D=0.95 T x L=0.95, T x D=1.65, L x D=1.34					T x L x D=2.33	
C.D. (P=0.05)	T=1.89, L=1.55, D=2.68 T x L=2.68, T x D=4.64, L x D=3.79					T x L x D=6.56	
Mean	T(15/20°C) = 65.11, T (20/25°C) =62.72, T(25/30°C) =44.55, L ₁ = 63.92, L ₂ =51.00						

Where L₁ =16 hours light followed by 8 hours darkness and L₂= exposure to complete darkness for 24 hours

Table 4. Effect of burial depth on field emergence and speed of emergence of *Phalaris minor* seeds

Burial depth (cm)	Field emergence (%)	Speed of emergence
4	32.00	5.98
6	25.33	4.28
8	6.67	0.41
SE±(m)	0.86	0.16
C.D. (P=0.05)	3.04	0.64

temperature on seed germination in Senna was evaluated. Germination was lowest at 20°C (19.33%) and peaked at 25°C (32.33%), with moderate germination observed at 30°C (26.66%) and 35°C (25.00%) [27]. Comparable findings were observed in seeds of *Bidens pilosa* L. and *Richardsonia pilosa* H.B.K. when tested at soil depths of 2, 7, and 15 cm. After one year, the viable seed population of *B. pilosa* declined by 66% at a 2 cm depth, whereas *R. pilosa* showed a 22% reduction at the same depth [28]. Satavar (*Asparagus racemosus*) seeds were evaluated for germination test at various temperatures and observed that 20°C temperature was optimum as compared to 25, 30 and 35°C [29].

CONCLUSION

It is concluded from the study that alternate temperature of 15/20°C is found optimum for germination of *Phalaris minor* seeds under 16 hours light followed by 8 hours darkness. Radicle emergence was after 72 hrs and maximum at 15/20°C in the light regime. The field emergence was maximum at burial depth of 4 cm and seeds can emerged from a depth of 8 cm. This information will be useful for the scientists working on weed control.

ACKNOWLEDGMENT

The authors would like to express their gratitude to Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar for providing the necessary facilities to conduct the research and University of Queensland, Gatton, Australia for providing technical guidance.

REFERENCES

1. ANONYMOUS (2013). Indian minimum seed certification standards. The Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. 36-37.
2. MATUS-C'ADIZ M AND P HUCL (2002). Morphological variation within and among five annual *Phalaris* species. *Can. J. Plant Sci.*, **82**:85-88. doi: 10.4141/P01-050
3. OPEÑA JL, BS CHAUHAN AND AM BALTAZAR (2014). Seed Germination Ecology of *Echinochloa glabrescens* and Its Implication for Management in Rice (*Oryza sativa* L.). *PLoS ONE*, **9**(3), e92261. <https://doi.org/10.1371/journal.pone.0092261>
4. BASKIN CC AND JM BASKIN (1998). Seeds-ecology, bio geography, and evolution of dormancy and germination. Academic Press, San Diego. CA: Academic Press; 1998.
5. VANDELOOK F, D VAN DE MOER AND JA VAN ASSCHE (2008). Environmental signals for seed germination reflect habitat adaptations in four temperate Caryophyllaceae. *Functional Ecology*, **22**(3): 470-478.
6. SHINOMURA T (1997). Phytochrome regulation of seed germination. *Journal of Plant Research*, **110**: 151-161.
7. PRESOTTO A, M POVERENE AND M CANTAMUTTO (2014). Seed dormancy and hybridization effect of the invasive species, *Helianthus annuus*. *Annals of Applied Biology*, **164**(3): 373-383.
8. BATLLA D AND RL BENECH-ARNOLD (2007). Predicting changes in dormancy level in weed seed soil banks: implications for weed management. *Crop Protection*, **26**(3): 189-197.

9. FENNOR M AND K THOMPSON (2005). The ecology of seeds. New York, USA: Cambridge University Press; 2005.
10. WIESE AM AND LK BINNING (1987). Calculating the threshold temperature of development for weeds. *Weed Science*, **35**: 177-179.
11. ISTA (2019). Informational rules for seed testing. International Seed Testing Association. Zurich. Switzerland.
12. ABDUL-BAKI AA AND JD ANDERSON (1973). Vigour determination in soybean by multiple criteria. *Crop Science*, **13**: 630-633.
13. MAGUIRE JD (1962). Speed of germination-Aid in selection and evolution for seedling emergence and vigour. *Crop Science and Technology*, **28**: 155-162.
14. PANSE VG AND PV SUKHATME (1985). Statistical methods for agricultural workers, 4th Ed., ICAR, New Delhi.
15. SHEORAN OP (2010). Online statistical analysis (OPSTAT) software developed by Chaudhary Charan Singh Haryana Agricultural University, Hisar, India.
16. OHADI S, HR MASHHADI AND R TAVAKOL-AFSHARI (2009). Seasonal changes in germination responses of seeds of the winter annual weed little seed canarygrass (*Phalaris minor*) to light. *Weed science*, **57**(6): 613-619.
17. AHMADI A, HOSSEINI M AND ZEIDALI E (2013). Study of ecological characteristics of canary grass (*Phalaris minor*). *Technical Journal of Engineering and Applied Sciences*, **3**(16): 1835-1840.
18. TAYLOR IN, NCB PETERS, SW ADKINS AND SR WALKER (2004). Germination response of *Phalaris paradoxa* L. seed to different light qualities. *Weed Research*, **44**(4): 254-264.
19. LANDGRAFF A AND O JUNTILA (1979). Germination and dormancy of reed canary grass seeds (*Phalaris arundinacea*). *Physiologia Plantarum*, **45**(1): 96-102.
20. ALSHALLASH KS (2018). Germination of weed species (*Avena fatua*, *Bromus catharticus*, *Chenopodium album* and *Phalaris minor*) with implications for their dispersal and control. *Annals of Agricultural Sciences*, **63**(1): 91-97.
21. YADURAJU NT AND JC CASELEY (1984). Some studies on germination emergence and growth of *Phalaris minor* Retz. and *P. paradoxa* L. Proceedings EWRS Symposium on Weed Problems in the Mediterranean Area, pp.447-454.
22. REZVANI M, S NADIMI, F ZAEFARIAN AND B CHAUHAN (2021). Environmental factors affecting seed germination and seedling emergence of three *Phalaris* species. *Crop Protection*, **148**: 105743.
23. ZEIDALI E, M HOSSEINI AND A FATHI (2021). Study of ecological factors on characteristics of germination of *Phalaris minor* and *Bromus tectorum*. *Central Asian Journal of Plant Science*, **1**(2):91-101.
24. ZHANG H, Y LI AND J WU (2024). Effect of seed burial depth and environmental conditions on the emergence of *Amaranthus retroflexus* L. *Weed Biology and Management*, **24**(1): 22-30.
25. GN CHATEE, MG PATIL, MP WANKHEDE AND AM MISAL (2022). Efficacy of systemic fungicides on the incidence of *Fusarium oxysporum*, seed germination and seedling vigour index of Mungbean. *Seed Research*, **50** (2):118-121.
26. AL-ANI A, F BRUZAU, P RAYMOND, V SAINT-GES, JM LEBLANC AND A PRADET (1985). Germination, respiration, and adenylate energy charge of seeds at various oxygen partial pressures. *Plant Physiology*, **79**(3):885-890.
27. PATEL JR, PATIL K, DA PATEL AND P KUMARI (2020). Effect of temperature, physical and chemical treatments on seed quality enhancement in Senna (*Senna alexandrina*). *Seed Research*, **48**(1): 55-60.
28. SAHOO UK AND JHALK (1997). Effect of depth and duration of burial on seed viability and dormancy of *Bidens pilosa* L. and *Richardsonia pilosa* H.B.K. *Seed Research*, **25**(1): 5-10.
29. VIJAYLAXMI, RS VERMA AND O VERMA (2014). Substratum and temperature requirement for germination of satavar (*Asparagus racemosus*) seed. *Seed Research*, **42**(1): 69-73.