DOI: 10.29050/harranziraat.1665841
Harran Tarım ve Gıda Bilimleri Derg. 2025, 29(3): 448-457.

Research Article/Araştırma Makalesi

Studies on biology, ecology and control of *Amaranthus retroflexus* populations from Turkiye

Türkiye'deki Amaranthus retroflexus popülasyonlarının biyolojisi, ekolojisi ve mücadelesi üzerine çalışmalar

Khawar JABRAN

Department of Plant Production and Technologies, Nigde Omer Halisdemir University, Nigde, Turkiye
https://orcid.org/0000-0001-8512-3330

To cite this article:
Jabran, K. (2025). Studies on biology, ecology and control of *Amaranthus retroflexus* populations from Türkiye. Harran Tarım ve Gıda Bilimleri Dergisi, 2025, 29(3): 448-457.

DOI: 10.29050/harranziraat.1665841

Address for Correspondence:
Khawar JABRAN
e-mail:
khavar.jabran@ohu.edu.tr

Received Date:
06.04.2025
Accepted Date:
25.07.2025

ABSTRACT

Amaranthus retroflexus (L.) is one among the most common weeds that invade different cropping systems in Turkiye. This study investigated seed germination response of *A. retroflexus* to various environmental factors such as temperature, sodium chloride concentrations, light conditions, pH, osmotic stress and soil burial depth. Additionally, this research also investigated the potential of various post-emergence herbicides to control *A. retroflexus*. The germination test at the start of the experiments showed that seeds were non-dormant and viable, with 98% germination within three days. The highest germination percentage (98%) of *A. retroflexus* was achieved at a temperature of 25°C. Salinity exerted significantly negative effect on the germination and no seed germinated at 200 mM sodium chloride concentration. Similarly, osmotic potential also inhibited germination significantly and germination percentage was 18% or lower at -0.4 MPa or higher osmatic potential. Meanwhile, light had no significant effect on germination, and a soil depth of 0-4 cm was found as the most suitable for emergence of *A. retroflexus*. Among the post-emergence herbicides, clopyralid and 2,4-D proved the most effective to control *A. retroflexus*.

Key Words: *A. retroflexus*, germination, moisture stress, temperature, herbicide

ÖZ

Amaranthus retroflexus (L.), Türkiye'deki çeşitli ekim sistemlerini istila eden en yaygın yabancı otlardan biridir. Bu çalışma *A. retroflexus*'un tohumlarının çimlenmesinin sıcaklık, sodyum klorür konsantrasyonu, ışık koşulları, pH, ozmotik stres ve toprak gömülme derinliği gibi çeşitli çevresel faktörlere verdiği yanıtı araştırmayı amaçlamaktadır. Ayrıca, bu araştırmada *A. retroflexus*'un çeşitli çıkış sonrası herbisitlerle kontrol edilebilme potansiyeli de değerlendirilmiştir. Çalışmanın başlangıcında yapılan çimlenme testi, kullanılan tohumların uyku halinde olmadığını ve canlı olduğunu göstermiş; tohumlar üç gün içinde %98 oranında çimlenme başarısı sağlamıştır. *A. retroflexus* tohumlarının maksimum çimlenme oranına (%98) 25°C sıcaklıkta ulaşıldığı belirlenmiştir. Tuzluluk, çimlenme üzerinde önemli ölçüde olumsuz bir etkisi yaratmış; 200 mM sodyum klorür konsantrasyonunda hiçbir tohum çimlenmemiştir. Benzer şekilde, ozmotik potansiyel de çimlenmeyi önemli ölçüde engellemiş; -0,4 MPa veya daha yüksek ozmatik potansiyellerde çimlenme oranı %18'in altında kalmıştır. Öte yandan, ışık koşullarının çimlenme üzerinde anlamlı bir etkisi olmadığı gözlemlenmiştir ve *A. retroflexus* tohumlarının çıkışı için en uygun toprak derinliği 0-4 cm aralığı olarak tespit edilmiştir. Çıkış sonrası yapılan herbisit uygulamaları arasında en etkili maddeler clopyralid ve 2,4-D olarak belirlenmiştir.

Anahtar Kelimeler: *A. retroflexus*, çimlenme, su stresi, sıcaklık, herbisit

Introduction

The global cropping systems face numerous constraints due to which the productivity and sustainability of these cropping systems is compromised. These constraints can be grouped as biotic and abiotic ones, and weeds are one among the most important biological constraints (Ahmad, 2023). Globally, the number of agriculturally important weeds ranges between 300 to 500, and *Amaranthus retroflexus* L. is one among such agriculturally important weeds, which are extremely obnoxious, problematic and invasive. This weed is known with several common names such as redroot pigweed, common amaranth, careless weed and redroot etc.

Although native to North America, *A. retroflexus* is now distributed across numerous countries in Africa, Asia, Australia, Europe and South America continents (Sauer, 1967; Mandak et al., 2011; Qin et al., 2018; CABI, 2021). *Amaranthus retroflexus* is one among the noxious weeds and is a challenge in several arable crops such as potato (Iamonico, 2010; Siddiqui and Jabran, 2025; Ahmad and Jabran, 2025), soybean (Bensch et al., 2003; Lu et al., 2024), beans (Turker and Coruh, 2023), apple (Ustuner, 2017), maize (Desai et al., 2025), cotton (Suer and Tursun, 2024), tomato (Qasem, 2018) and red kidney bean (Amini et al., 2014). In addition to the arable crops, the weed is also a serious issue in fruit orchards (Dudic et al., 2020). In addition to being a strong competitor against crop plants, *A. retroflexus* is also a stronger competitor against other weeds such as *A. tricolor* L. (Li et al., 2024). Other than the agricultural areas, the weed also infests the non-cropped areas and may damage the infrastructure and recreational areas. The presence and high infestation of this weed in a variety of agricultural landscapes is due to its adaptability to diverse environmental conditions, high genetic variability, phenotypic plasticity and high seed production (Costea et al., 2004; Mandak et al., 2011; Khan et al., 2021). An individual plant can produce 25,000 to 500,000 seeds depending on the weather conditions, resource availability and nature of competition (Costea et al., 2004).

Studies on biology and ecology of a weed are important to better understand the growth behavior of a weed and formulate the management strategies accordingly. Although, *A. retroflexus* is known as one of the most problematic weeds around the globe, the aspects of this weed such as seed viability (Uremis and Uygur, 2005) and control with herbicides (Kahramanoglu, 2014) have been studied in Turkiye but there has been very limited information regarding biology and ecology of this weed in the perspective of Turkish cropping systems. Hence, this study was aimed at determining the effect of different environmental factors on seed germination of *A. retroflexus*. Further, the study also investigated the effect of different herbicides on control of the weed under greenhouse conditions. The information on the response of this weed to different environmental conditions will be helpful in better formulating the management strategies under field conditions.

Materials and methods

This research was conducted at the Department of Plant Production and Technologies, Nigde Omer Halisdemir University, Nigde, Türkiye during the summer season of 2024. Seeds of *A. retroflexus* were collected from a wide variety of environments, including crop fields, non-cropped lands, roadsides and fruit orchards during August to October 2023. A completely randomized design (CRD) with five replications was used to conduct the experiments under laboratory and greenhouse conditions.

Germination assays were conducted by placing 20 seeds in Petri dishes (9 cm diameter) containing two layers of Whatman No. 1 filter paper moistened with 5 ml of distilled water to determine dormancy and germination rate. The dishes were placed in an incubator (WiseCube® SI-ML) at 25°C temperature. The seeds were considered germinated when visible protrusion of the radicle was observed. The experiment continued for 2 weeks, and germination was recorded in each Petri dish.

Germination was observed under different temperature regimes, i.e., 5, 10, 15, 20, 25, 30, 35 and 40°C by placing 20 seeds on filter paper in Petri dishes moistened with 5 ml distilled water. These dishes were kept in the incubator at respective temperature regimes for 14 days, and data of germination was recorded.

The effect of salinity was assessed by placing 20 seeds on filter paper in Petri dishes moistened with 5 ml solutions of 0, 25, 50, 100, 150, 200, 250 and 400 mM of sodium chloride. These dishes were incubated at 25°C temperature for 14 days, and data of germination was recorded.

The impact of different osmotic potentials on germination was assessed by placing 20 seeds on filter paper in Petri dishes with 5 ml polyethylene (PEG 6000) solutions of 0, -0.2, -0.4, -0.6, -0.8, and -1.0 MPa pressure. These dishes were placed in an incubator at 25°C temperature, and data of germination was recorded at the end of experiment.

The effect of different light duration on germination was assessed by placing the seeds in Petri dishes with light treatments of 24 h dark; 12 h light/12 h dark; and 24 h light. These Petri dishes were incubated at 25°C temperature for 14 days, and data of germination was recorded. For light conditions, seeds were placed according to required light conditions while for 24 h dark, Petri dishes were covered with aluminum foil.

The impact of seed sowing depth on seedling emergence was determined in the greenhouse. Thirty seeds were seeded at depths of 0, 2, 4, 6, 8, and 10 cm by using plastic pots (depth × diameter = 22.5 × 16.5) filled with a mixture of compost and perlite (2:1). Pots were irrigated regularly throughout the experiment. The emergence count was done on a regular basis from each pot.

A pot experiment was conducted to determine the impact of herbicide on the suppression of *A. retroflexus*. Fifteen seeds of *A. retroflexus* were seeded at 2 cm depth in plastic pots (depth × diameter = 22.5 × 16.5). A compost and perlite mixture (2:1) was used to fill the pots and seeds were seeded in each pot. At the four-leaf stage, the seedlings were sprayed with six different herbicides as mentioned in Table 1.

Table 1: List of herbicides used for the control of *Amaranthus retroflexus* in this study

Treatment	**Dose (ml/ha)**
Glufosinate ammonium (Phaeton 100)	3000
2,4-D (Kor-ester)	1500
Clopyralid (Phaeton 100)	1000
Glyphosate (Sonround)	3000
2,4-D + picloram (Telson 101)	1000
Pinoxaden + cloquintocet-mexyl (Safener)	900

There was a control treatment in which herbicides were not applied. Seedlings' survival rate was determined at 28 days after herbicide treatment with the criterion of at least one green leaf on the plant indicating survival. The survived/remained portion of the plants was cut from the pot surface and kept in an oven at 70°C for 72 h to measure their dry biomass using a sensitive measuring scale (ATX24, SHIMADZU), and the percent control from each herbicidal treatment was determined by using the formula:

$$Control\ (\%) = \frac{dry\ weight\ of\ weeds\ in\ control - dry\ weight\ of\ weeds\ in\ treated\ pot}{dry\ weight\ of\ weeds\ in\ control} \times 100 \qquad (1)$$

Statistical analysis

The data for the temperature, light, sowing depth and herbicides were analyzed using Analysis of Variance (ANOVA) with Statistix 8.1 software. The mean differences were determined using the least significant difference (LSD) test at a 5% probability level. Germination, osmotic potential and salinity data were modeled by using a three-parameter sigmoid model with the help of SigmaPlot 15.0 software.

$$Y = Y_{\max} / \{1 + \exp[-(x - x0)/b]\} \qquad (2)$$

Here, Y shows germination percentage, Y_{max} is the maximum germination percentage, $x0$ is the treatment value required for achieving 50% germination, and b is the slope of the curve.

Results and Discussion

The germination test conducted at the start of the studies showed that the *A. retroflexus* seeds (being used in this research) were viable and completed germination within three days after seeding. Moreover, the seeds possessed a high germination percentage (98%) (Fig. 1). This confirmed that the weed seeds were viable and non-dormant.

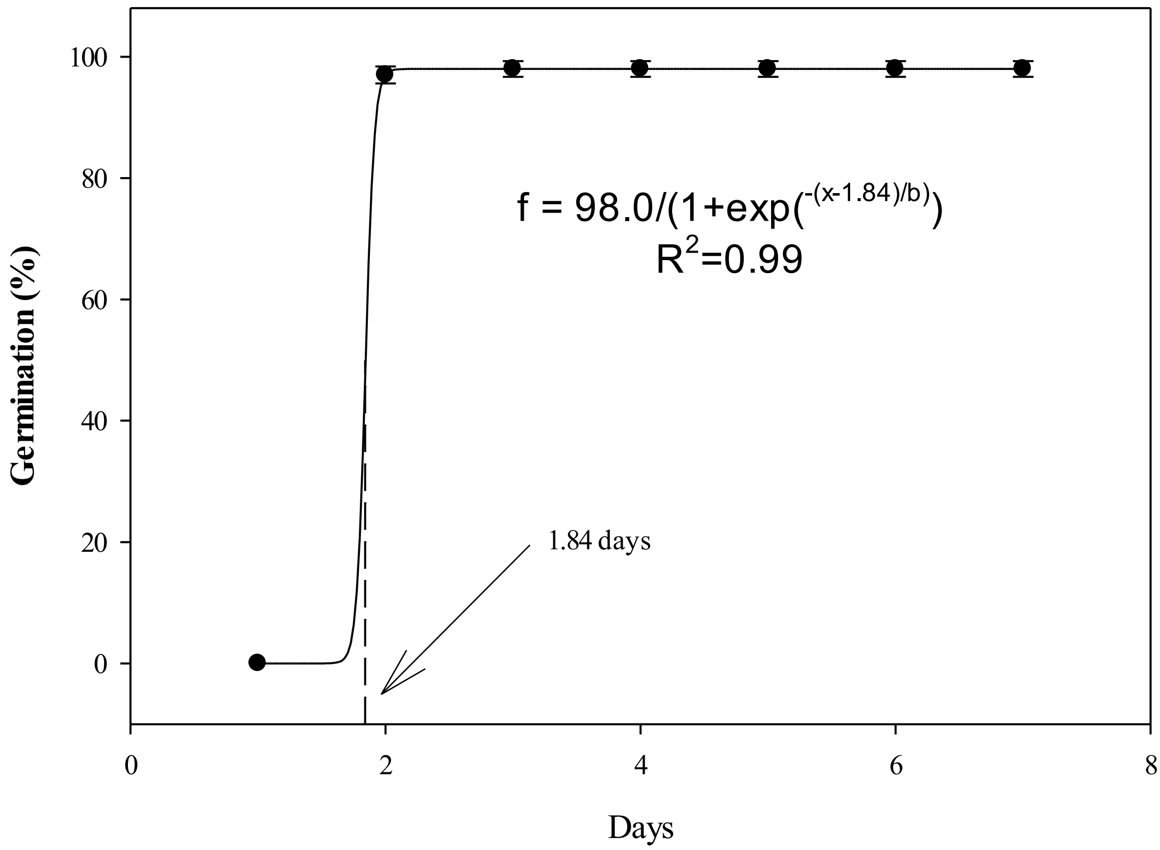

Fig. 1: Germination percentage of *Amaranthus retroflexus* seeds used for different studies in this research.

Different concentrations of sodium chloride had a significant influence on the germination of *A. retroflexus* (Fig. 2). Germination rate decreased with an increase in the sodium chloride concentration and no germination was achieved at 200 mM concentration.

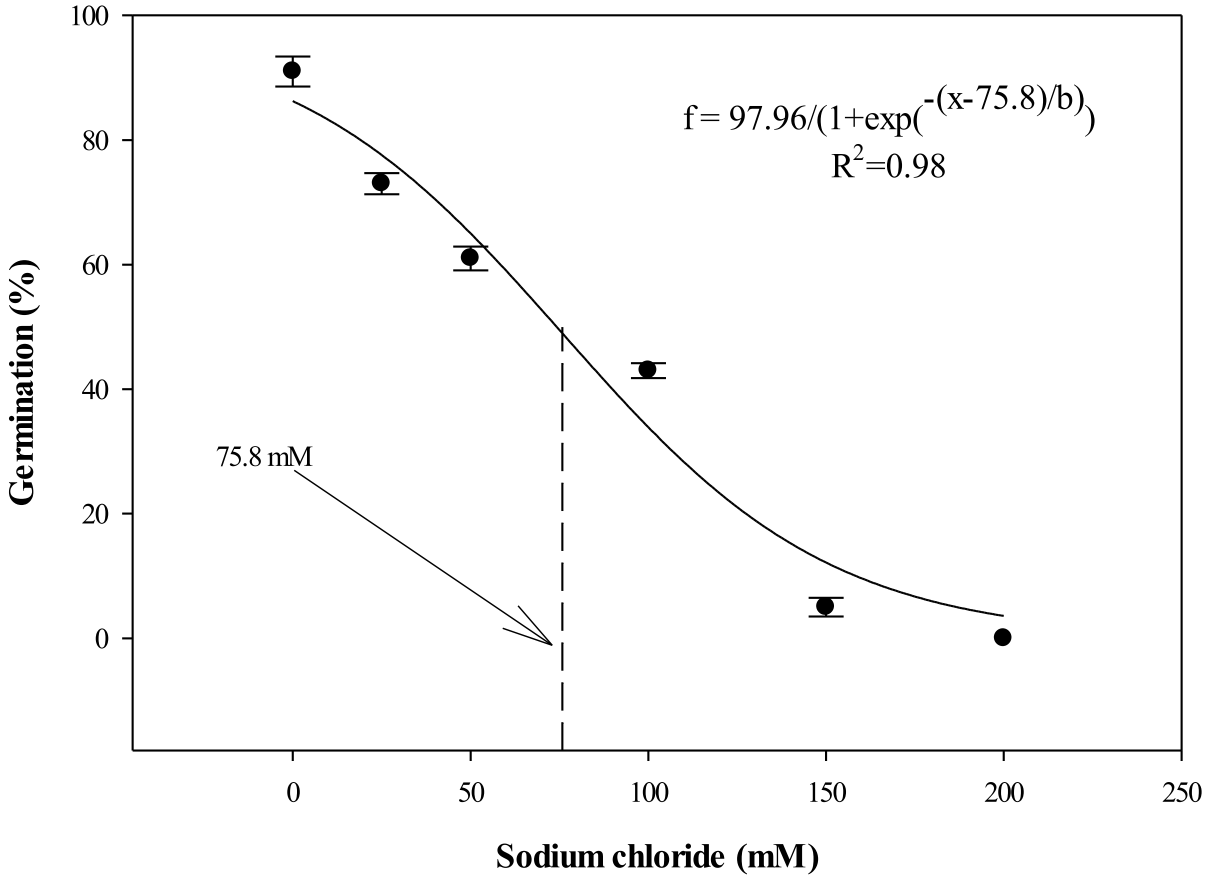

Fig. 2. Effect of different concentrations of sodium chloride on the germination of *Amaranthus retroflexus*.

Application of sodium chloride solution with a concentration of 75.8 mM caused a 50% reduction in the germination. Similarly different levels of osmotic stress also had a significant effect on the germination (Fig. 3). The germination decreased with an increase in osmotic stress. A 50% reduction in germination was recorded at the osmotic potential of -0.25 MPa. At the osmotic potential of -0.4 MPa or higher the germination was close to complete inhibition with a germination percentage between 18 and 0%, respectively.

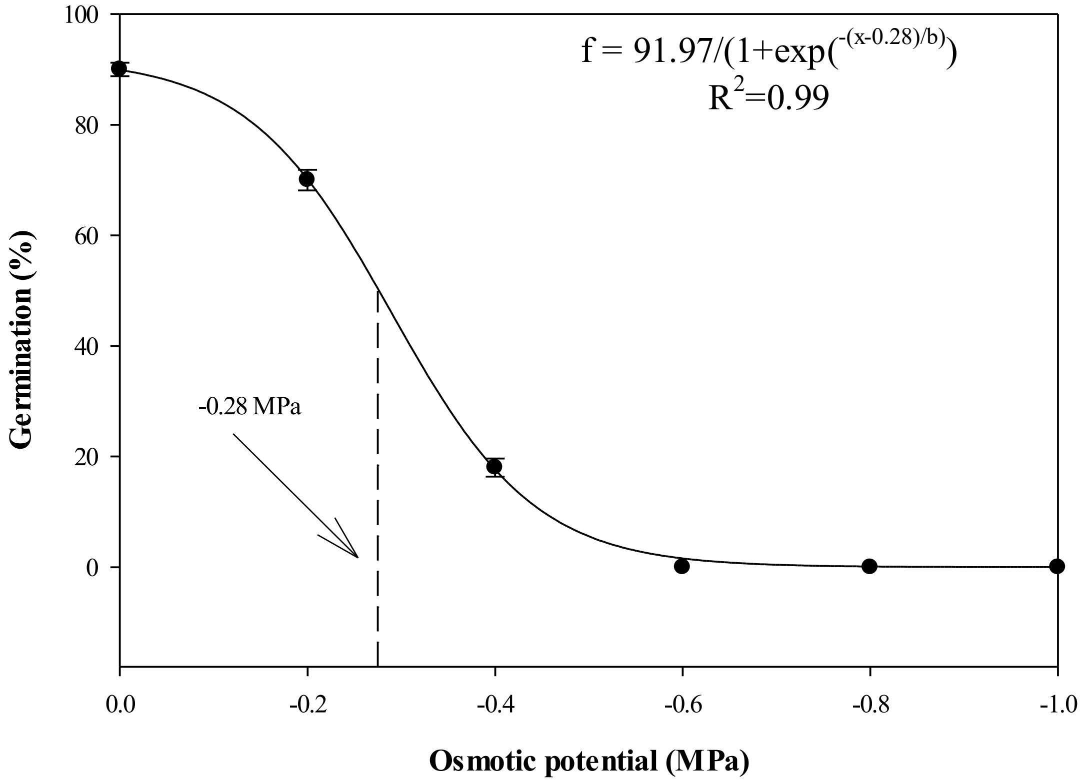

Fig. 3. Effect of different osmotic potential levels on the germination of *Amaranthus retroflexus*.

The temperature regimes were found to have a significant effect on germination (Fig. 4). No seeds were germinated at the temperature levels of 5°C and 10°C while the highest germination (98%) was noted at 25°C followed by 30°C (92%) although both of these levels were statistically similar. At temperature levels of above 30°C, i.e., at 35°C and 40°C, germination of the weed was significantly decreased compared to the germination at 25°C. Hence, this work demonstrated that the optimal temperature range to achieve maximum germination was 25-30°C. Temperature is one among the most important abiotic factors that not only influence the germination but also the growth of any plant species. A previous study from the United Kingdom reported that a temperature range between 25 and 40°C (Ghorbani et al., 1999). The effect of alternating temperatures on *A. retroflexus* germination has also been studied recently (Safavi et al., 2023), which indicated that a day/night temperature of 25/18°C was optimum for germination of the three weed populations in the study. Another study on nine *Amaranth* spp. showed that the optimal temperature for achieving the maximum germination was more than 20°C proving the requirement of specific temperature for its germination (Steckel et al., 2004). A reduced germination of the weed at temperatures of ≤20°C or ≥30°C shows that this weed germinates/achieves maximum germination only when the temperature conditions are favorable (Vidotto et al., 2013; Travlos et al., 2020). Favorable temperature conditions are inevitable for activation of enzymes, which are precursor to the germination process (Guzmán-Ortiz et al., 2019).

Different light conditions, i.e., 24 h dark, 12 h light/12 h dark and 24 h light could not cause a major impact on the germination of *A. retroflexus* and seeds from all the light regimes had more than 90% germination (Fig. 5). Different sowing depths were found to have a significant effect on *A. retroflexus* emergence (Fig. 6). The highest emergence, i.e., 80% was recorded for the *A. retroflexus* seeds which were placed at 2 cm soil depth followed by the ones placed at 4 cm soil depth (62% emergence) and 0 cm (58% emergence). No emergence was noted at the depth of 8 and 10 cm.

The environmental factors other than temperature also influenced the germination of

A. retroflexus except for the light conditions, which had a neutral effect on the weed. As the seeds were able to germinate even under dark conditions, a thin soil layer or a fine mulch cover will not be able to inhibit the germination of this weed species (Chauhan and Johnson, 2010; Batlla and Benech-Arnold, 2014). Moreover, germination of *A. retroflexus* was reduced under saline conditions and it had a moderate level of sensitivity against salinity stress (Nikolic et al., 2023). Similarly, the weed was also sensitive to moisture stress as it is evident from its reduced germination under the osmotic stress (Singh et al., 2022).

Seed burial depth can have implications for cultural control of any weed (Sousa-Ortega et al., 2023). Seed germination of *A. retroflexus* was significantly reduced at 6 cm and it was completely inhibited at 8 cm soil depth. This implies that tillage to a depth of 8 cm or even deeper will help to place seeds of this weed to a level from which these cannot emerge (Ghorbani et al., 1999; Chauhan, 2012). A previous study reported a soil depth of 0.5-3 cm as optimum for germination of *A. retroflexus* (Ghorbani et al., 1999).

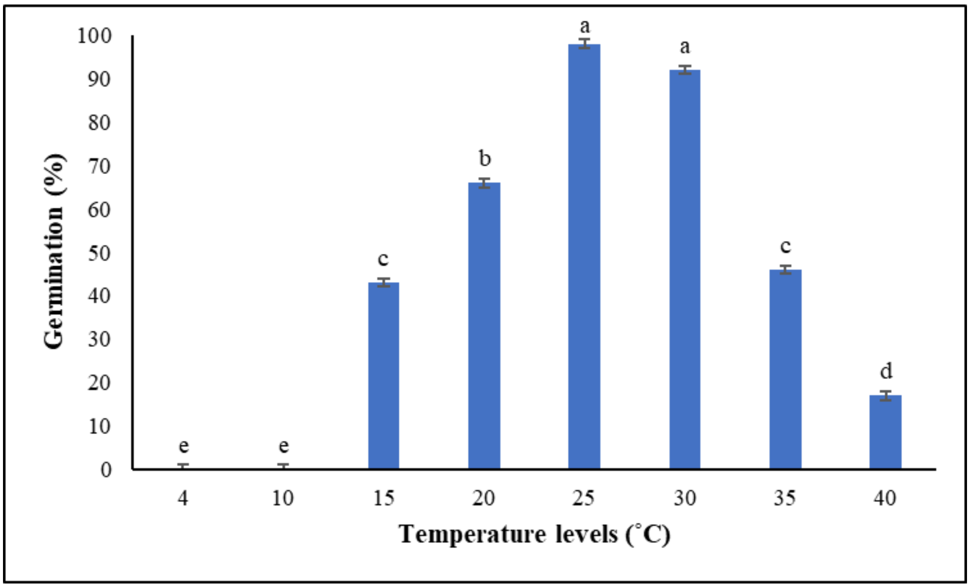

Fig. 4. Effect of different temperature levels on the germination of *Amaranthus retroflexus*.

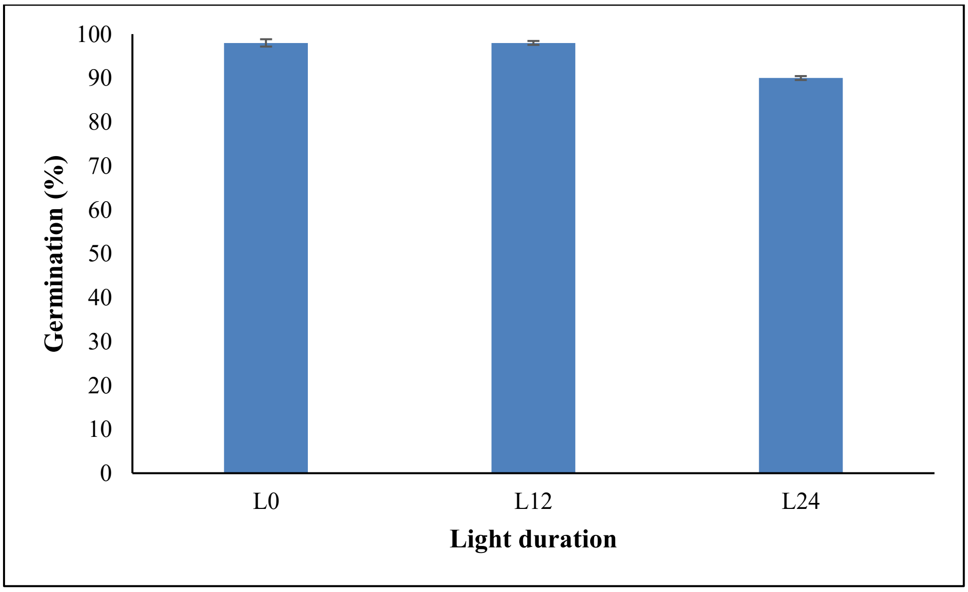

Fig. 5. Effect of different light duration on the germination of *Amaranthus retroflexus*. L0 = 24 h dark; L12 = 12 h light/12 h dark; L24 = 24 h light

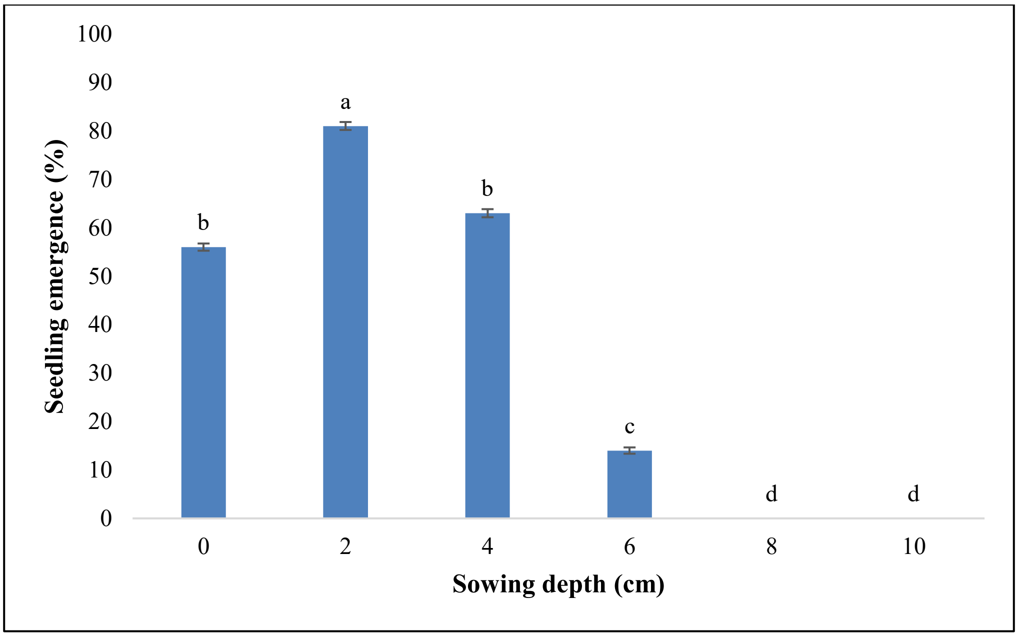

Fig. 6. Effect of different sowing depths on the emergence of *Amaranthus retroflexus*.

The results obtained from the herbicide experiment showed that weed control percentage was statistically varied among the applied herbicides (Table 2). The lowest weed dry weight of 0.43 g and the highest control (90.6%) of *A. retroflexus* was recorded for the herbicide clopyralid and this was followed by the weed control, which was achieved after application of 2,4-D (Table 2). The herbicides evaluated were different for their effect on *A. retroflexus*, and clopyralid and 2,4-D were the most effective herbicides. There has been sufficient evidence in literature that these two herbicides are effective not only to control *A. retroflexus* but also effective to suppress other weeds in the genus *Amaranthus* (Chitband et al., 2020; Kaur et al. 2024). Two recent studies reported that the herbicide clopyralid was effective to control *A. retroflexus* and *A. palmeri* (Chitband et al., 2020; Kaur et al. 2024).

Table 2: Effect of herbicide application on the dry weight and control percentage of Amaranthus retroflexus

Treatments	**Dry weight (g/plant)**	**Control (%)**
Control	4.58 a	0 e
Glufosinate ammonium (Phaeton 100)	2.94 b	35.8 d
2,4-D (Kor-ester)	0.86 d	81.3 b
Clopyralid (Phaeton 100)	0.43 e	90.6 a
Glyphosate (Sonround)	1.81 c	60.4 c
2,4-D + Picloram (Telson 101)	1.02 d	77.6 bc
Pinoxaden + Cloquintocet-mexyl (Safener)	1.89 c	58.7 c
LSD $_{(0.05)}$	0.28	3.5

The means not sharing a letter in common differ significantly at p =0.05 according to the least significant difference (LSD) test.

In this study, six herbicides were tested to manage *A. retroflexus* but only clopyralid was found to control the weed by >90%. Another herbicide 2,4-D was also reasonably effective and provided >80% control of the weed while the level of weed suppression provided by other herbicides in the study was not satisfactory and may not be acceptable by farmers.

Conclusion

The results of this study showed that the seed germination of *A. retroflexus* had a >90% germination and received a significant influence from various environmental factors such as salinity, osmotic potential, temperature, pH and seed burial depth. Environmental factors including salinity, pH and osmatic potential had a negative effect on the germination of this weed. The light conditions had no effect while a temperature of 25°C was found as the most suitable for the weed germination. The most effective post-emergence herbicide to control this weed were clopyralid and 2,4-D.

Acknowledgement

The author extends thanks to Dr. Taseer Ahmad for his help in the study.

Conflict of interest

The author declares that there is no conflict of interest regarding this interest.

Author contribution

KJ conceptualized the idea, conducted the research and wrote the manuscript for this research.

Data availability

All the data related to the study has been provided in this article.

References

Ahmad, T. & Jabran, K., 2025. Inter-and intra-specific competition of potato with four common weed species and their impact on tuber yield. Potato Research, https://doi.org/10.1007/s11540-025-09879-5.

Ahmad, T., Jabran, K., Cheema, Z. A., Bajwa, A. A., & Farooq, M. (2023). A global perspective of education in weed science. Weed Science, 71, 536-548.

Amini, R., Alizadeh, H., & Yousefi, A. (2014). Interference between red kidney bean (*Phaseolus vulgaris* L.) cultivars and redroot pigweed (*Amaranthus retroflexus* L.). European Journal of Agronomy, 60, 13-21.

Batlla, D., & Benech-Arnold, R. L. (2014). Weed seed germination and the light environment: Implications for weed management. Weed Biology and Management, 14, 77-87.

Bensch, C. N., Horak, M. J., & Peterson, D. (2003). Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. Weed Science, 51, 37-43.

CABI. (2021). *Amaranthus retroflexus* (redroot pigweed). CABI Compendium, 4652. CABI Head Office, Wallingford, UK. https://doi.org/10.1079/cabicompendium.4652

Chauhan, B. S. (2012). Weed ecology and weed management strategies for dry-seeded rice in Asia. Weed Technology, 26, 1-13.

Chauhan, B. S., & Johnson, D. E. (2010). The role of seed ecology in improving weed management strategies in the tropics. Advances in Agronomy, 105, 221-262.

Costea, M., Weaver, S. E., & Tardif, F. J. (2004). The biology of Canadian weeds. 130. *Amaranthus retroflexus* L., *A. powellii* S. Watson, and *A. hybridus* L. Canadian Journal of Plant Science, 84, 631-668.

Desai, H. S., Menalled, F., Gaines, T. A., & Shergill, L. S. (2025). Ecological, evolutionary, and management implications of sugarbeet cropping systems with three transgenic herbicide resistance traits. Weed Science, 1-31. https://doi.org/10.1017/wsc.2025.10

Dudic, M., Meseldzija, M., Ljevnaic-Masic, B., Rajkovic, M., Markovic, T., Begovic, R., Jurisic, A., & Ivanovic, I. (2020). Weed composition and control in apple orchards under intensive and extensive floor management. Chilean Journal of Agricultural Research, 80, 546-560.

Ghorbani, R., Seel, W., & Leifert, C. (1999). Effects of environmental factors on germination and emergence of *Amaranthus retroflexus*. Weed Science, 47, 505-510.

Guzmán-Ortiz, F. A., Castro-Rosas, J., Gómez-Aldapa, C. A., Mora-Escobedo, R., Rojas-León, A., Rodríguez-Marín, M. L., Falfán-Cortés, R. N., & Román-Gutiérrez, A. D. (2019). Enzyme activity during germination of different cereals: A review. Food Reviews International, 35, 177-200.

Iamonico, D. (2010). Biology, life-strategy, and invasiveness of *Amaranthus retroflexus* L. (Amaranthaceae) in central Italy: Preliminary remarks. Botanica Serbica, 34, 137-145.

Kahramanoglu, I. (2014). Assessment of pre-planting Pendimethalin's minimum dose on redroot pigweed (*Amaranthus retroflexus* L.). International Journal of Agricultural Sciences, 4, 210-213.

Kaur, R., Rogers, R., Lawrence, N. C., Shi, Y., Chahal, P. S., Knezevic, S. Z. & Jhala, A.J. (2024). Effect of herbicide programs on control and seed production of multiple herbicide–resistant Palmer amaranth (*Amaranthus palmeri*) in corn resistant to 2, 4-D/glufosinate/glyphosate. Weed Technology, 38, e37.

Khan, A. M., Mobli, A., Werth, J. A., & Chauhan, B. S. (2021). Effect of emergence time on growth and fecundity of redroot pigweed (*Amaranthus retroflexus*) and slender amaranth (*Amaranthus viridis*): Emerging problem weeds in Australian summer crops. Weed Science, 69, 333-340.

Li, C., Li, Y., Xu, Z., Zhu, M., Wei, Y., Xu, Z., Zhong, S., Wang, C., & Du, D. (2024). Invasive *Amaranthus retroflexus* obtains a competitive advantage over native *A. tricolor* under the addition of *A. retroflexus* leaf litter. Ecological Research. https://doi.org/10.1111/1440-1703.12539

Lu, P., Pang, Y., Wang, H. J., Zhang, Z. H., Dai, X., Bing, X. W., & Yuan, Q. Y. (2024). Asymmetric effects of planting pattern and density on leaf-height traits of *Glycine max* and *Amaranthus retroflexus*. Journal of Plant Ecology, 17, rtae101.

Mandak, B., Zákravský, P., Dostál, P., & Plačková, I. (2011). Population genetic structure of the noxious weed *Amaranthus retroflexus* in Central Europe. Flora - Morphology, Distribution, Functional Ecology of Plants, 206, 697-703.

Nikolic, N., Ghirardelli, A., Schiavon, M., & Masin, R. (2023). Effects of the salinity-temperature interaction on seed germination and early seedling development: A comparative study of crop and weed species. BMC Plant Biology, 23, 446.

Qasem, J. R. (2018). Competition of redroot pigweed (*Amaranthus retroflexus* L.) and nettle-leaved goosefoot (*Chenopodium murale* L.) with tomato (*Lycopersicon esculentum* Mill.) cultivars. The Journal of Horticultural Science and Biotechnology, 93, 634-643.

Qin, Z., Zhang, J. E., Jiang, Y. P., Wei, H., Wang, F. G., & Lu, X. N. (2018). Invasion process and potential spread of *Amaranthus retroflexus* in China. Weed Research, 58, 57-67.

Safavi, M., Rezvani, M., Zaefarian, F., Golmohammadzadeh, S., & Sindel, B. M. (2023). Seed germination requirements of *Amaranthus retroflexus* L. populations exposed to environmental factors. Botany, 101, 99-111.

Sauer, J. D. (1967). The grain amaranths and their relatives: A revised taxonomic and geographic survey. Annals of the Missouri Botanical Garden, 54, 103-137.

Siddiqui, A. O., & Jabran, K. (2025). Weed tolerance and suppressive ability of potato cultivars to natural weed infestations. Journal of Crop Health, 77, 47.

Singh, M., Thapa, R., Kukal, M. S., Irmak, S., Mirsky, S., & Jhala, A. J. (2022). Effect of water stress on weed germination, growth characteristics, and seed production: A global meta-analysis. Weed Science, 70, 621-640.

Sousa-Ortega, C., Leon, R. G., Lopez-Martinez, N., & Castro-Valdecantos, P. (2023). Influence of burial depth and soil disturbance on the emergence of common weed species in the Iberian Peninsula. Weed Science, 71, 369-377.

Steckel, L. E., Defelice, M. S., & Sims, B. D. (1990). Integrating reduced rates of postemergence herbicides and cultivation for broadleaf weed control in soybeans (*Glycine max*). Weed Science, 38, 541-545.

Suer, I.E., & Tursun, N. (2024). Weeds in the cotton growing areas in the Southeastern Anatolia Region. Harran Tarım ve Gıda Bilimleri Dergisi, 28, 209-221.

Travlos, I., Gazoulis, I., Kanatas, P., Tsekoura, A., Zannopoulos, S., & Papastylianou, P. (2020). Key factors affecting weed seeds' germination, weed emergence, and their possible role for the efficacy of false seedbed technique as a weed management practice. Frontiers in Agronomy, 2, 1.

Turker, O. & Coruh, I. (2023). Determination of the weed species, density and frequency in bean fields in Bayburt Province. Journal of Tekirdag Agricultural Faculty, 20, 542-549.

Uremis, I., & Uygur, F. N. (2005). Seed viability of some weed species after 7 years of burial in the Cukurova Region of Turkey. Asian Journal of Plant Sciences, 4, 1-5.

Ustuner, T. (2017). Determination of the frequency and density of weed species in apple orchards in Kahramanmaras region of Turkey. Bangladesh Journal of Agricultural Research, 42, 87-102.

Vidotto, F., De Palo, F., & Ferrero, A. (2013). Effect of short-duration high temperatures on weed seed germination. Annals of Applied Biology, 163, 454-465.