

Natural resistance of different red lentil varieties to Imazamox herbicide

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Abstract

Weeds are among the most important factors that decrease crop yields in addition to climate and a variety used. Herbicide resistant varieties of different crops have made weed management easier in the recent era; therefore determining natural resistance in the available germplasm is of significant importance. This study was aimed at determining natural resistance of different lentil varieties, i.e., 'Fırat 87', 'Çağıl', and 'Altıntoprak' to imazamox herbicide. Six different imazamox doses, i.e., no application and ¼, ½, 1, 2, and 4-fold of the recommended dose were used in the experiment. The herbicide was applied at 4-6 leaves of plants. Plant samples were collected 28 days after herbicide application by harvesting the above-ground parts. The fresh and dry weight of the collected samples were recorded. The collected data were analyzed with SAS statistical software. Analysis of variance was used to infer the differences among tested varieties and log-logistic regression was used to determine the dose affecting half of the population (I50) and creating dose-response curve. The results revealed that 'Fırat 87' variety was the most tolerant to imazamox, whereas 'Çağıl' was the most sensitive. The I50 values for 'Çağıl', 'Altıntoprak' 'Fırat 87' were 14.05, 23.00 and 38.47 ml/ha, respectively. If it is considered the recommended dose of imazamox 100ml/da, much lower dose of imazamox is quite affective on these lentil varieties.

Keywords: Imazamox; Clearfield; Red lentil; Herbicide Tolerance

1. Introduction

Lentil (*Lens culinaris* Medik.) is an important legume crop extensively cultivated in India, Canada, Turkey, Nepal, Iran, Australia, Bangladesh, Syria, USA, Morocco, and Ethiopia. The lentil production in Turkey was 447.400 tonnes in 2010, 360,000 tonnes in 2015, and 370.815 tonnes in 2020 (1).

According to the 2022 data from the Food and Agriculture Organization (FAO), 6.5 million tons lentils were produced on an area of 5.0 million hectares globally. The highest lentil production areas were recorded during 2017, while a decrease was observed in the production area in 2018 and 2019. According to FAO, Canada, India, and Turkey have been the leading lentil producers between 2010 and 2020 with Turkey ranked at 3rd position (1).

Lentil cultivation suffers from considerable annual variations in yield, and a clear decline has emerged over the last five years in Turkey due to management problems, and susceptibility to various biotic and abiotic stresses (Figure 1). The yield of the available lentil cultivars ranges between 1450 and 1950 kg/ha in Turkey, and the yield can be considerably decreased due to poor weed management (2).

Yield losses due to weed competition considerably vary depending on the level of weed infestation and prevalent weed species. Yield losses in lentils are estimated between 20-80% due to weed infestation (3,4,5,6) and the critical period of

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weed infestation ranges between 30 and 60 days after sowing (7). Therefore, weed management at the early stage is crucial to harvest higher yield and better quality.

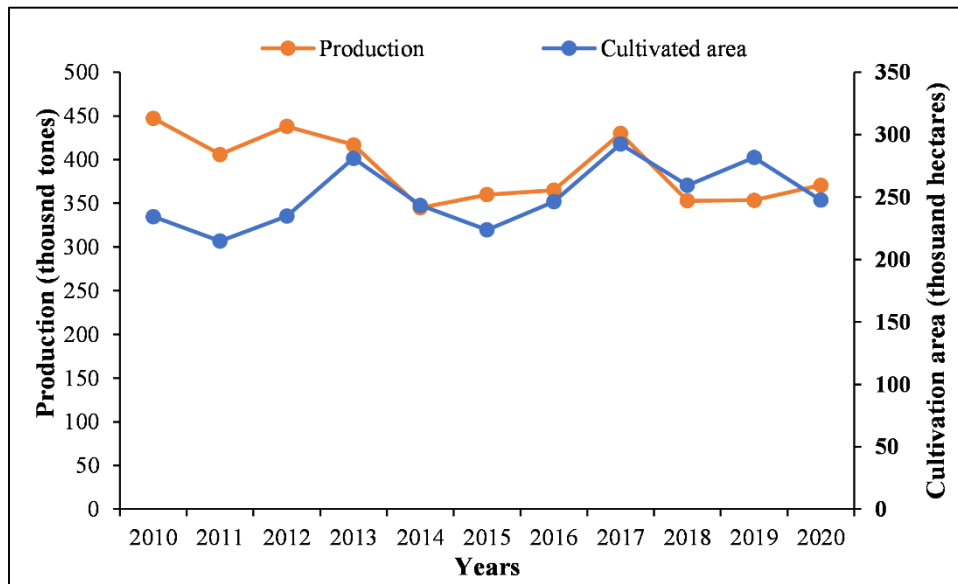


Figure 1 Lentil (*Lens culinaris Medik.*) cultivated area and production in Türkiye

Imidazolinone (IMI) herbicides inhibit the enzymes called acetohydroxyacid synthase (AHAS) or acetolactate synthase (ALS) in weeds and provide control over them (8). These enzymes play an important role in the synthesis of branched amino acids in plants. These herbicides can be used at very low doses to control many narrow and broad-leaved weed species and have very low toxicity to the environment, mammals, aquatic organisms, and fish (Stidham & Singh, 2017).

The IMI herbicides are effective for controlling a broad spectrum of weeds in several food legumes (9). The IMI herbicides are registered for the control of broadleaf weeds in food legumes in Turkey (10). Because of these properties, IMI herbicides are highly preferred from an environmental perspective. These environmentally safe herbicides can be successfully used in many crops. The use of IMI herbicide will gain significant importance in establishing successful weed control program to avoid evolution of herbicide resistance in weeds.

Red lentil is widely grown in Şanlıurfa, Diyarbakır, Mardin, Gaziantep, Adıyaman and Şırnak provinces in southeastern Anatolia region of Turkey. Besides climate and a variety of factors that limit lentil production, weeds are among the most important ones reducing yield (4). It is emphasized that weeds generally cause ~60% yield loss which could reach 100% under high weed infestation. Since lentil plants grow slowly, weeds can suppress them quickly in the first developmental period and limit their development. Since lentils are short statured, they are poor competitors with weeds and suffer from high yield losses due to the competition. Weed control is the biggest problem in lentils due their low tolerance to herbicides, and very few herbicides licensed. (11).

Weeds are among the most important factors negatively affecting crop yield; therefore, weed control is necessary for profitable production. However, weed control is difficult in some crops such as red lentils as there are no licensed herbicides against broad-leaved weeds, which cause high yield losses in lentils. There is a need to discover new herbicides; however, it has become almost impossible to find new selective molecule in the chemical industry (12). Difficulty of discovering a new herbicide, and evolution of herbicide resistance in weeds warrants that growing crops resistant to existing herbicides could play significant role in weed management.

The resistance is genetic phenomenon and occurs naturally. The genetically modified plants could be used to induce herbicide resistance. However, several countries containing genetically modified organisms. Therefore, inducing resistance through classical breeding will make significant contributions to weed control in such countries. Turkey is among the countries where genetically modified organisms or their products are not preferred; therefore, resistance induction relies on classical breeding.

The present study evaluated genetic variation of 3 different lentil varieties for their tolerance to imazomox post-emergence herbicide and determined their degree of tolerance for potential use in the development of herbicide-

tolerant varieties. The variety with high degree of tolerance could be utilized in future mutation breeding studies to induce tolerance to imazamox based on the current study.

2. Material and methods

2.1. Plant material and experimental details

Three different red lentil cultivars, i.e., 'Firat-87', 'Çağıl', and 'Altıntop', were used in the experiment. Seeds of these cultivars were planted in plastic trays (15×20 cm) and grown under controlled greenhouse conditions (Figure 2). The seeds were surface sterilized with 1% of NaOCl (v/v) solution prior to sowing in trays. The trays were irrigated daily until seed germinating. The greenhouse temperature was set to 8 – 13 °C.



Figure 2 Sowing of lentil seeds in plastic trays

The experiment was established in the greenhouse of Plant Protection Department, Faculty of Agriculture, Harran University, Şanlıurfa Turkey. The experiment was laid according to the randomized plot design with 3 replications and repeated 2 times. The amount of seed sown was optimized according to the field conditions (14-15 kg/ha). A total of 15 plants were harvested from each tray to record the fresh and dry weight after the application of herbicide doses.

2.2. Herbicide application



Figure 3 Full automated cabinet sprayer used to apply imazamox to lentil cultivars included in the study

Imazamox (2-(4,5-Dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-5-(methoxymethyl)-3 pyridinecarboxylic acid) herbicide was used in the bioassay (Figure 3). The herbicide has been registered for use in pea, soybean, and beans

with recommended dose of 100 ml/da in Turkey. The imazamox herbicide was applied using a fully automated cabinet sprayer (Figure 3) with a water volume of 50 L ha⁻¹ using a flat fan nozzle at 300 kPa pressure.

When the plants were at the 6-8 node stage, herbicide was applied at control, recommended dose, and ¼, ½, 1, 2, and 4-fold of recommended dose.

2.3. Measurements

2.3.1. Visual scoring



Figure 4 Visual comparison of different imazamox doses applied to 'Altıntoprak' lentil variety

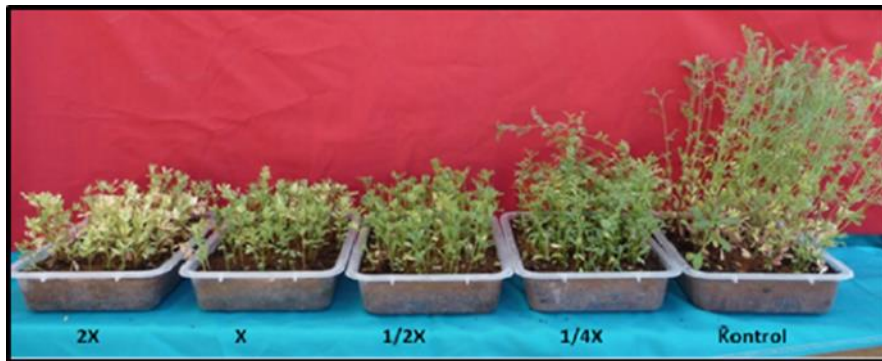


Figure 5 Visual comparison of different imazamox doses applied to 'Çağıl' lentil variety



Figure 6 Visual comparison of different imazamox doses applied to 'Firat 87' lentil variety

The varieties were scored at 14 days after herbicide application on a 1-5 scale for herbicide tolerance as proposed by Gaur et al. (13) where, 1 indicate highly tolerant (excellent plant appearance, no chlorosis / narrowing / burning of leaves), 2 tolerant (good plant appearance with minor chlorosis / narrowing / burning of leaves), 3 moderate tolerant (fair plant appearance with moderate chlorosis / narrowing / burning of leaves), 4 sensitive (poor plant appearance

with severe chlorosis / narrowing / burning of leaves) and 5 highly sensitive (complete burning of leaves leading to mortality of most of the plants), (Figure 4, 5, 6).

2.3.2. Fresh and dry weight

The above-ground parts of 15 plants from each tray were harvested 28 days after herbicide application and their fresh and dry weights were measured.

2.4. Statistical analyses

Analysis of variance (ANOVA) was used to infer the differences among cultivars in SAS statistical analysis program. Dose-response curve was obtained by finding I_{50} value affecting half of the population in the applications using log-logistic regression formula.

$$y = C + \frac{D - C}{1 + \exp\{b \cdot [\log(z) - \log(ED_{50})]\}}$$

Where;

Y = Dependent variable (biomass)

z = Independent variable (dose of herbicide)

D = Upper limit of y

C = Lower limit of y

ED_{50} = Dose giving biomass halfway between D and C

B = relative slope of curve around ED_{50}

3. Results and discussion

The damage response of lentil genotypes against imazamox herbicide based on visual observation revealed that 'Firat 87' was more tolerant than rest of the varieties, i.e., 'Çağıl' and 'Altıntop' (Table 1).

Table 1 Visual scoring of varieties after 14 days of herbicide application

1-5 Scale (14 Days After Herbicide Treatment)	
Firat 87	T
Altıntop	MT
Çağıl	S

The ANOVA indicated that 'Firat 87' was the most tolerant to imazamox from tested lentil cultivars. The variety 'Çağıl', on the other hand, was the most sensitive.

'Firat 87' showed better development and higher fresh weight, compared to other varieties. The lowest fresh weight (7.6 g) was noted for 'Çağıl' variety, whereas 'Firat 87' produced the highest (10.5 g) fresh weight (Figure 7). Similarly, the lowest (1.7g) and the highest (3.5 g) dry weight was recorded for 'Çağıl' and 'Firat 87' varieties, respectively (Figure 8). The results warrant that 'Firat 87' red lentil cultivar could be selected for the development of imazamox-tolerant since it is more tolerant to imazamox than other cultivars.

The I_{50} values of 'Çağıl', 'Altıntoprak' and 'Firat 87' were 14.05, 23.00 and 38.47 ml/ha, respectively. Considering that the recommended dose of imazamox herbicide is 100 ml/ha, the herbicide at doses far below the recommended dose affects these lentil varieties.

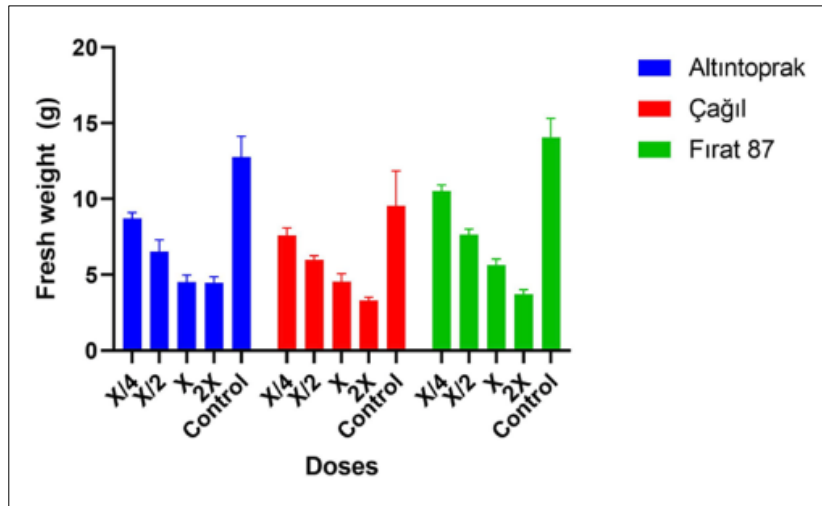


Figure 7 Fresh weight of above ground parts produced by different lentil varieties included in the study

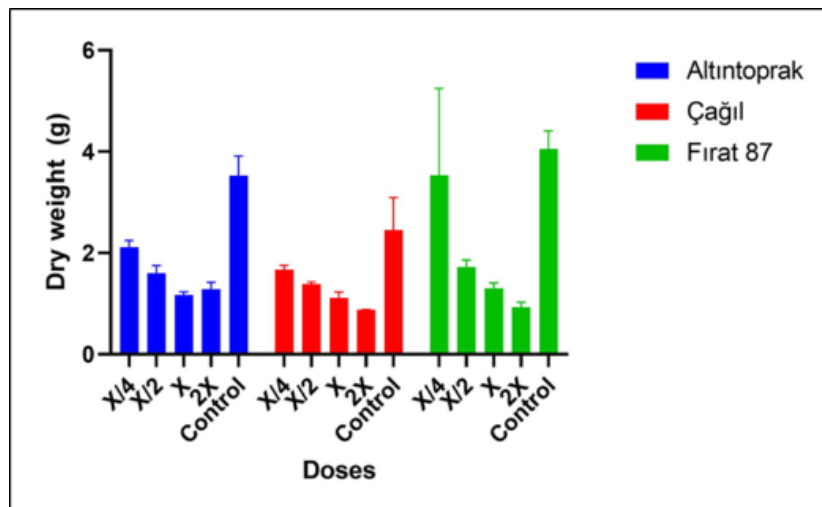


Figure 8 Dry weight of above ground parts produced by different lentil varieties included in the study

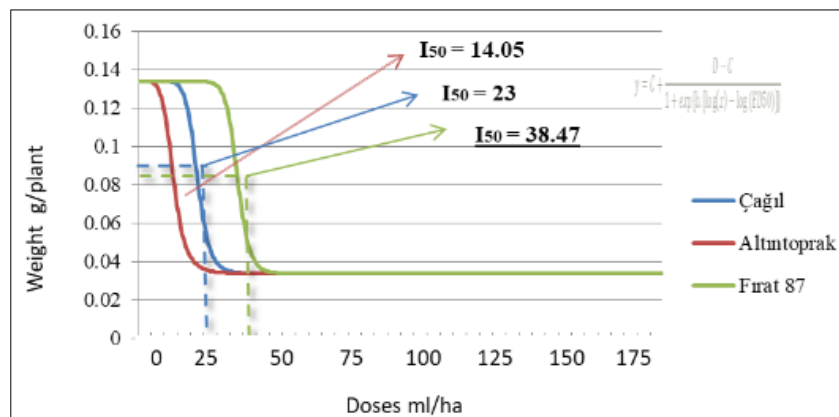


Figure 9 Dose-response curve and I_{50} values of lentil varieties treated with different doses of imazamox

4. Conclusion

Lentil genotypes responded differently to imazamox in greenhouse experiments. Results revealed that 'Firat 87' was found to be the most resistant and could be used as experimental material for the development of IMI-tolerant lentil varieties.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have declared no conflict of interest

References

- [1] FAOSTAT. 2022. The Food and Agriculture Organization Corporate Statistical Database.
- [2] Aktar, S., Hossain, M. A., Siddika, A., Naher, N., & Amin, M.R. Efficacy of herbicides on the yield of lentils (*Lens culinaris Medik*). *The Agriculturists*, 2013. 11(1): 89-94.
- [3] AL-Thahabi, SA, Yasin, J. Z., Abu-Irmaileh, B. E., Haddad, N.I., & Saxena M.C. Effect of weed removal on productivity of chickpea (*Cicer arietinum L.*) and lentil (*Lens culinaris Med.*) in a Mediterranean environment. *J. Agron Crop Sci.*, 1994. 172(5), 333-341.
- [4] Halila MH. 1995. Status and potential of winter-sowing of lentil in Tunisia. In: *Proceedings of the Workshop on Towards Improved Winter-sown Lentil Production for the West Asia and North African Highlands*, December, 1994. 12-13, Antalya, Turkey.
- [5] Tepe I, Erman M, Yazlik A, Levent R, Ipek K. Comparison of some winter lentil cultivars in weed–crop competition. *Crop Prot.*, 2005. 24:585–589.
- [6] Yenish JP, Brand J, Pala M, Haddad A. Weed Management. In: Erskine, W, Muehlbauer, FJ, Sarker, A, Sharma, B, editors. *The lentil: Botany, Production and Uses*. 2009. Wallingford (UK): CAB International,
- [7] Yaduraju NT, Mishra JS. Weed management. In: Singh, G, Sekhon, HS, Kolar, JS, editors. *Pulses*. Udaipur (India): Agrotech Publishing Academy, 2005. p 359-373,
- [8] Stidham MA. Herbicides that inhibit acetohydroxyacid synthase. 1991. *Weed Sci.*, 39:428– 434.
- [9] Taran B, Holm F, Banniza. Response of chickpea cultivars to pre- and post-emergence herbicide applications. *Can J Plant Sci.*, 2013. 93:279–286.
- [10] Kantar F, Elkoca E, Zengin H. Chemical and agronomical weed control in chickpea (*Cicer arietinum L. cv. Aziziye-94*). *Turk J Agric For.*, 1999,23:631–635.
- [11] BALL D. A., A. G. OGG. JR., and P. M. CHEVALIER, The influence of seedling rate on weed control in small-red lentil (*Lens Culinaris*). *Weed Science*, 45, 296-300. , 1997.
- [12] GRESSEL J. *Molecular biology of weed control*, 2002. Taylor & Francis, London. ,
- [13] Gaur, P.M., Jukanti, A.K., Samineni, S., Chaturvedi, S.K., Singh. S., Tripathi, S., Singh, I., Singh, G., Das, T.K., Aski, M., Mishra, N., Nadarajan, N., & Gowda, C.L.L. Large genetic variability in chickpea for tolerance to herbicides imazethapyr and metribuzin. *Agronomy*, 2013.3:524–36.