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# Weeds in the cotton growing areas in the Southeastern Anatolia Region

## *Güneydoğu Anadolu Bölgesi pamuk ekim alanlarında bulunan yabancı otlar*

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**ABSTRACT**

The Southeast Anatolia Region plays an important role, as it accounts for around sixty percent of Türkiye's cotton production. One of the most important factors limiting cotton cultivation is weeds. The aim of this study was to determine the weed species, their frequency and population density in the cotton growing areas of the Southeast Anatolia region. For this purpose, surveys were conducted in 152 cotton growing areas in Diyarbakır, Mardin and Şanlıurfa provinces in 2020 and 2021. The surveys were conducted using the segmented sampling method. As a result of the studies, 43 weed species belonging to 16 families were identified. When the weed species found in cotton are evaluated by family, the Poaceae family ranks first with 7 species, followed by Asteraceae with 6 species, Euphorbiaceae and Amaranthaceae with 5 species. redroot pigweed (*Amaranthus retroflexus* L.), field bindweed (*Convolvulus arvensis* L.), purple nutsedge (*Cyperus rotundus* L.), jungle rice (*Echinochloa colonum* (L.) Link), ground cherry (*Physalis* spp.), common purslane (*Portulaca oleracea* L.), black night shade (Solanum nigrum L.), johnson grass [*Sorghum halepense* (L.). Pers] and common cocklebur (*Xanthium strumarium* L.) were identified as the most common weed species. These weeds are widespread in many summer crops, especially in cotton. The development of effective management methods against these weeds in cotton will contribute to higher yields.

**Key Words:** Cotton, weeds, frequency, Southeast Anatolia Region

**ÖZ**

Güneydoğu Anadolu Bölgesi Türkiye'nin pamuk üretiminin yaklaşık yüzde altmışını karşılaması nedeni ile önemli bir yere sahiptir.Pamuk üretimini sınırlayan önemli faktörlerden biri de yabancı otlardır. Bu çalışmada Güneydoğu Anadolu Bölgesi pamuk ekim alanlarındaki yabancı ot türleri, yaygınlık ve yoğunluklarının belirlenmesi hedeflenmiştir. Bu amaçla 2020 ve 2021 yıllarında Diyarbakır, Mardin ve Şanlıurfa illerinde 152 adet pamuk ekim alanlarında sürveyler gerçekleştirilmiştir. Sürveyler bölümlü örnekleme yöntemine göre yapılmıştır. Çalışmalar sonucunda 16 familyaya ait 43 yabancı ot türü tespit edilmiştir.Pamukta bulunan yabancı ot türleri familyalara göre değerlendirildiğinde Poaceae familyası 7 tür ile ilk sırada yer alıp bu familyayı 6 tür ile Asteraceae, 5 tür ile Euphorbıaceae ve Amaranthaceae familyaları takip etmiştir. Yapılan sürveylerde; kırmızı köklü tilki kuyruğu (Amaranthus retroflexus L.), tarla sarmaşığı (Convolvulus arvensis L.), topalak (Cyperus rotundus L.), benekli darıcan [Echinochloa colonum (L.) Link], fener otu (Physalis spp.), semiz otu (Portulaca oleracea L.), it üzümü (Solanum nigrum L.), kanyaş [Sorghum halepense (L.). Pers] ve domuz pıtrağı (Xanthium strumarium L.) türleri en yaygın yabancı ot türleri olarak belirlenmiştir. Bu yabancı otlar pamuk başta olmak üzere birçok yazlık kültür bitkisinde yaygın olarak görülmektedir. Pamukta bu yabancı otlara karşı etkili mücadele yöntemlerinin geliştirilmesi daha yüksek verim elde edilmesine katkı sağlayacaktır.

**Anahtar Kelimeler:** Pamuk, Yabancı ot, Yaygınlık, Güneydoğu Anadolu Bölgesi

## Introduction

Cotton (*Gossypium hirsutum* L.), native to India, is an industrial plant from the Malvaceae family. In cotton processing, it is the basic raw material for the ginning industry, for the oil and animal feed industry with its seeds, for the textile industry with its fibers and for the paper industry with its linters. With these aspects, cotton has become a strategic product of economic importance in the world. However, with population growth and the rise in living standards, the demand for cotton plants is increasing day by day. In particular, the cotton plant has become an important economic product for some countries as it creates high added value (Keskinkılıç, 2014).

Cotton, the most important natural raw material in the textile industry, was grown on an average of 32.01 million hectares of land in the world in the 2023 production season and around 24.6 million tons of cotton products were obtained. Türkiye ranks seventh in the world in terms of cotton production, and fourth and fifth in terms of import and consumption, respectively. (Anonymous, 2023a). In addition, Türkiye has the most efficient and highest quality cotton production among non-GMO cotton producing countries (Anonymous, 2023b). Cotton cultivation in Türkiye generally takes place in the Mediterranean, Aegean and Southeastern Anatolia regions. Approximately 59% of Türkiye's cotton production takes place in the Southeast Anatolia Region, 24% in the Aegean Region and 17% in the Mediterranean Region (TÜİK, 2023).

There are many factors that limit cotton production, and one of the most important factors is weeds. Weeds compete with crops in terms of light, water and nutrients, and by reducing their effectiveness; they significantly reduce crop yield and quality (Özer et al., 1998). In this context, it has been found that cotton yield losses are 34-61% if weeds are not controlled regularly (Ahmad et al., 2003), and that this percentage can even rise to 90% (Beltrao, 1994). To prevent weed-induced yield losses in cotton, it is important to carry out weed control in the critical period between the first 1-2 weeks and 7-10 weeks after cotton emergence (Vargas et al., 1996; Bükün and Uygur, 1997; Tursun et al., 2016). Furthermore, weeds compete with cotton in the early stages, hindering its development and significantly reducing its yield. In addition to direct yield losses, *Convolvulus arvensis* L., *Datura stramonium* L., *Solanum nigrum* L., *Xanthium strumarium* L. and *Setaria viridis* (L.) P. Beauv. occur especially after irrigation. Weeds such as these adhere to the fibers of the cotton plant, which reduces fiber quality and makes harvesting more difficult (Bükün and Uygur, 1997; Özer et al, 1998; Boz and Doğan, 2004; Güncan and Karaca, 2014). For this reason, weed control is necessary to achieve high-quality and efficient cotton production In order to prevent the damage caused by weeds, their occurrence and density must be determined.

With the expansion of irrigation areas as part of the Southeastern Anatolia Project (GAP), cotton cultivation began in a large agricultural area of the region. Irrigation provides a suitable growing environment not only for the grown cotton but also for water-loving weeds, which compete with cotton (Bükün et al., 2005). In addition, the irrigation of cotton fields enables the transportation of weed seeds and the infection of other areas, which particularly promotes the reproduction and spread of invasive weeds.

It is stated that weed species in cotton growing areas may change due to increasing agricultural irrigation in the GAP region, changing crop patterns, changing weed control methods and global warming (Doğanoğlu, 2010; Arslan, 2018). For this reason, it is important to constantly monitor the spread and density of weeds in cotton fields and to develop strategies against these weeds by developing effective control methods. For this purpose, the frequency and density of weeds in the cotton fields of Diyarbakır, Şanlıurfa and Mardin provinces were determined studied.

## Material and Method

In this study, surveys were conducted in 2020

and 2021 to determine the frequency and density of weeds in the cotton growing areas of Şanlıurfa, Diyarbakır and Mardin provinces in Türkiye (Table 1). The surveys were conducted using the segmented sampling method (Bora and Karaca, 1970). Samples were taken during the surveys to represent the field and to ensure that there was a distance of at least 3 km between the cotton fields. To avoid the edge effect, sampling began 10-15 m inside the edge of the field in a diagonal direction. Counts were made at each sampling point by randomly throwing 10 frames from a 0.25 m² (50 x 50 cm) frame in the fields with ≤10 da., 15 frames in the fields with 11-50 da., 20 frames in the fields with 51-100 da. and 25 frames in the fields with >100 da. (Özkil et al., 2019).

In the surveys conducted in the cotton growing areas of the Southeastern Anatolia Region in June, July and August in 2020 and 2021, sampling was carried out in 48 fields in 5 districts in Diyarbakır, 19 fields in 4 districts in Mardin and 85 fields in 8 districts in Şanlıurfa. Accordingly, counts were conducted in a total of 1 558 173 da. (TÜİK, 2020) and 152 fields in the survey studies (Table 1).

Table 1. Cultivated areas of the provinces where surveys were conducted in the cotton fields in the Southeast Anatolia Region and the number of fields where sampling took place.

| Provinces | Districts | Cultivation areas (da) | Number of fields surveyed |
|---|---|---|---|
| **Şanlıurfa** | Akçakale | 207 000 | 14 |
| | Bozova | 27 959 | 6 |
| | Eyyübiye | 176 670 | 14 |
| | Haliliye | 156 500 | 10 |
| | Harran | 174 600 | 13 |
| | Hilvan | 36 181 | 6 |
| | Siverek | 121 413 | 9 |
| | Viranşehir | 212 150 | 13 |
| **Total** | | **1 112 473** | **85** |
| **Diyarbakır** | Bismil | 200 000 | 18 |
| | Çınar | 115 720 | 12 |
| | Eğil | 30 00 | 4 |
| | Sur | 38 000 | 7 |
| | Yenişehir | 26 368 | 7 |
| **Total** | | **383 088** | **48** |
| **Mardin** | Artuklu | 48 71 | 2 |
| | Derik | 13 360 | 4 |
| | Kızıltepe | 40 000 | 10 |
| | Nusaybin | 650 | 3 |
| **Total** | | **58 881** | **19** |
| **General Total** | | **1 558 173** | **152** |

In the surveys to determine the weed species in the cotton fields, the identification of weed species was carried out according to Davis (1965-1988).

The density of weeds (number/m$^2$), frequency of occurrence (%), special and general weed cover areas (%) were calculated (Odum, 1971; Uygur, 1984). The formulas for determining the frequency of occurrence, density (number/m$^2$), general cover area and specific cover area are given below.

$$\text{Density (weed/m}^2\text{)} = y/n$$

y = Number of weed species included in the frame

n = Total number of frames thrown

Occurrence Frequency (O.F.): It is the value that shows the percentage of a weed species encountered within the surveyed areas.

$$\text{O.F.(\%)} = (n/m) \times 100$$

n = Total number of fields where a species is found

m = Total number of fields measured

General Covering Area (G.C.A.): It is the amount that a species covers in the total area measured as a percentage.

G.C.A.(%) = T.C.A./m

T.C.A.(%)=Coverage of a weed species in surveyed weed species in surveyed fields

m= number of total surveyed fields

Specific Covering Area (S.C.A): It is the amount that a species covers only in the area where it is found, in %.

S.C.A. (%)= T.C.A/n

T.C.A.= Coverage of a weed species where a species ed species where a species occurred

n= number of total surveyed fields

**Results and Discussion**

During the surveys in Diyarbakır, Mardin and Şanlıurfa provinces, where cotton is intensively cultivated in the Southeastern Anatolia Region, 43 weed species belonging to 16 families were identified. It was found that 7 of the identified weed species were monocotyledonous and 36 were dicotyledonous species. Looking at the weed species found in cotton by family, the Poaceae family ranked first with 7 species, followed by the Asteraceae with 6 species, the Euphorbiaceae and the Amaranthaceae family with 5 species (Figure 1). Similar to our study, in studies conducted in cotton growing areas in Türkiye, most of the weed species found in cotton were found to belong to the Poaceae family (Uludağ and Katkat, 1991; Boz et al, 1995; Arslan, 2012; Arslan, 2021; Özaslan and Bükün, 2013; Özkil , 2019; Kaya and Nemli, 2002; Pala and Mennan, 2019; Şahin et al, 2020; Tursun et al, 2004). It was found that most of the species identified during surveys in cotton growing areas in Ethiopia, China, Kenya and Greece in the world belonged to the Poaceae family (Kimunye, 2011; Tena, 2012; WeiHua et al, 2014; Taye, 2019 and Issayev, 2023).

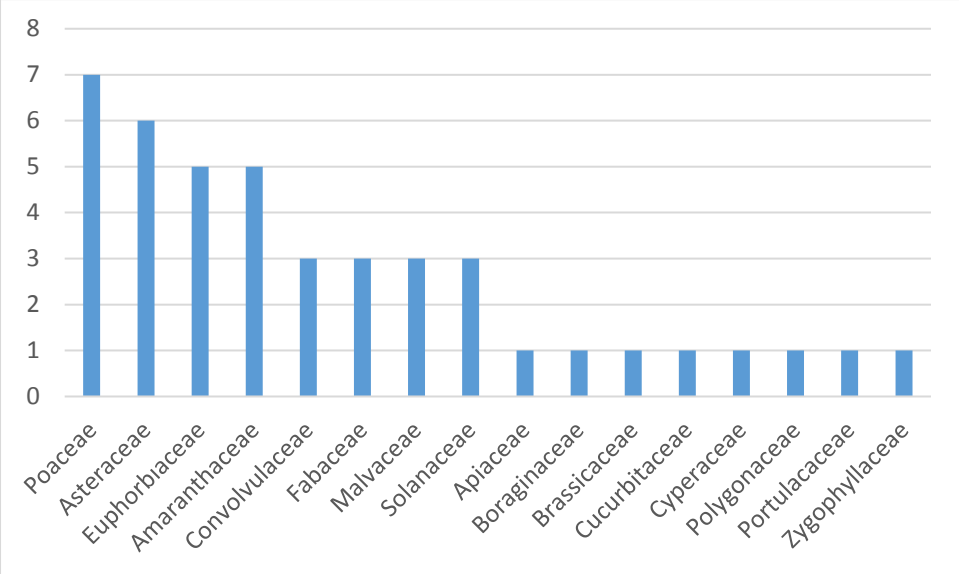


Figure 1: Families and their numbers identified during surveys in cotton fields in the southeast Anatolia Region.

Weed density (number/$m^2$), frequency of occurrence (%), specific and general cover areas (%) were calculated based on the average of the surveys conducted in 2020 and 2021 in the cotton fields of Diyarbakır, Mardin and Şanlıurfa provinces (Table 2).

As a result of the surveys conducted in the provinces with intensive cotton cultivation in the Southeastern Anatolia Region, the top 10 weed species in terms of frequency of occurrence were:

*Sorghum halepense* (L.). Pers, *Physalis* spp., *Xanthium strumarium* L., *Portulaca oleracea* L., *Amaranthus retroflexus* L., *Convolvulus arvensis* L., *Solanum nigrum* L., *Tribulus terrestris* L, *Echinochloa colonum* (L.) Link and *Cyperus rotundus* L. Similar to the species identified in our study, various researchers have conducted studies in different years in Southeastern Anatolia, Aegean and Mediterranean regions where cotton production is intensive in Türkiye: *A. retroflexus, A. albus, C. arvensis, C. dactylon, C. tinctoria, C. rotundus, E. colonum, P. oleracea, Physalis sp, Prosopis farcta, S. halepense, S. nigrum, T. terrestris* and *X. strumarium* weed species were among the most common species (Uludağ and Katkat, 1991; Boz et al, 1995; Uludağ and Üremiş, 2000; Özaslan and Bükün, 2013; Arslan, 2018; Pala and Mennan, 2019, Kadıoğlu et al, 1993; Uygur, 1997; Gönen, 1999; Boz, 2000; Kaya and Nemli, 2002; Gözcü and Uludağ, 2005; Tursun et al, 2004; Basal et al, 2019; Özkil et al, 2019).

In surveys carried out in cotton fields in various countries around the world, *Amaranthus* spp*., C. album, C. rotundus, C. arvensis, C. tinctoria, C. dactylon, D. stramonium, E. crusgalli, H. trionum, P. oleracea, Setaria glauca, S. halepense, S. nigrum, X. strumarium* and *X. spinosum* weed species were detected and were similar to the species detected in our study (Taye et al, 2019; Tena et al, 2012; Issayev, 2023; Economou et al, 2005).

Table 2. Density of weed species (number/m$^2$), frequency of occurrence (%), specific and general cover areas (%) in surveys in cotton growing areas in Diyarbakır, Mardin and Şanlıurfa provinces in 2020 and 2021.

| | | Diyarbakır | | | | Mardin | | | | Şanlıurfa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family** | **Scientific name** | **O.F. (%)** | **Density (weed/m$^2$)** | **G.C.A. (%)** | **S.C.A. (%)** | **O.F. (%)** | **Density (weed/m$^2$)** | **G.C.A. (%)** | **S.C.A.(%)** | **O.F. (%)** | **Density (weed/m$^2$)** | **G.C.A.(%)** | **S.C.A. (%)** |
| **Amaranthaceae** | *Amaranthus albus* L. | 14.58 | 0.08 | 0.79 | 5.43 | 11.76 | 0.09 | 0.99 | 8.43 | 1.20 | 0.04 | 0.32 | 26.67 |
| | *Amaranthus blitoides* S. Watson | 22.92 | 0.14 | 1.78 | 7.78 | 23.53 | 0.10 | 1.69 | 7.19 | 2.41 | 0.02 | 0.29 | 11.94 |
| | *Amaranthus palmeri* S. Watson | - | - | - | - | 11.76 | 0.32 | 1.17 | 9.93 | 8.43 | 0.24 | 1.23 | 14.64 |
| | *Amaranthus retroflexus* L | 60.42 | 1.82 | 10.15 | 16.81 | 82.35 | 5.10 | 23.18 | 28.15 | 45.78 | 0.79 | 4.03 | 8.81 |
| | *Chenopodium album* L. | 14.58 | 0.05 | 0.54 | 3.67 | 5.88 | 0.01 | 0.44 | 7.50 | 2.41 | 0.02 | 0.19 | 7.71 |
| **Asteraceae** | *Centaurea* sp. | 2.08 | 0.01 | 0.23 | 10.91 | - | - | - | - | - | - | - | - |
| | *Conyza canadensis* (L.) Cron. | - | - | - | - | - | - | - | - | 1.20 | 0.00 | 0.05 | 3.75 |
| | *Lactuca serriola* L. | 2.08 | 0.02 | 0.32 | 15.29 | 5.88 | 0.01 | 0.22 | 3.75 | 2.41 | 0.01 | 0.12 | 5.00 |
| | *Sonchus* sp. | 2.10 | 0.02 | 0.47 | 22.35 | - | - | - | - | 2.41 | 0.01 | 0.12 | 5.00 |
| | *Xanthium spinosum* L. | 4.17 | 0.07 | 0.49 | 11.82 | 5.88 | 0.01 | 0.81 | 13.75 | 3.61 | 0.02 | 0.52 | 14.42 |
| | *Xanthium strumarium* L. | 83.33 | 2.25 | 23.66 | 19.71 | 79.00 | 1.93 | 20.33 | 16.05 | 84.70 | 2.21 | 19.96 | 16.91 |
| **Apiaceae** | *Daucus carota* L. | 2.08 | 0.02 | 0.23 | 10.91 | - | - | - | - | - | - | - | - |
| **Boraginaceae** | *Heliotropium europaeum* L. | 6.25 | 0.03 | 0.56 | 8.95 | 5.88 | 0.01 | 0.15 | 2.50 | 1.20 | <0.01 | 0.05 | 3.75 |
| **Brassicaceae** | *Sinapis arvensis* L. | - | - | - | - | - | - | - | - | 1.20 | <0.01 | 0.03 | 2.67 |
| **Convolvulaceae** | *Convolvulus arvensis* L. | 54.17 | 0.78 | 8.94 | 16.50 | 64.71 | 0.83 | 7.86 | 12.14 | 56.63 | 1.80 | 14.19 | 25.05 |
| | *Convolvulus stachydifolius* Choisy | 2.08 | 0.02 | 0.16 | 7.50 | - | - | - | - | - | - | - | - |
| | *Ipomea purpurea* (L.) Roth | 14.58 | 0.09 | 1.17 | 8.00 | - | - | - | - | 21.69 | 0.14 | 1.50 | 6.93 |
| **Cucurbitaceae** | *Cucumis melosub* sp. *agrestis* (Naudin) Pangalo | 35.42 | 0.22 | 2.49 | 7.03 | 11.76 | 0.07 | 1.47 | 12.50 | 24.10 | 0.15 | 1.32 | 5.46 |
| **Cyperaceae** | *Cyperus rotundus* L. | 33.33 | 2.06 | 7.92 | 23.77 | 17.65 | 2.07 | 3.85 | 21.81 | 48.19 | 8.91 | 17.59 | 36.49 |
| **Euphorbıaceae** | *Euphorbia aleppica* L. | - | - | - | - | - | - | - | - | 1.20 | <0.01 | 0.05 | 3.75 |
| | *Euphorbia helioscopia* L. | 4.17 | 0.02 | 0.23 | 5.63 | - | - | - | - | 1.20 | <0.01 | 0.05 | 3.75 |
| | *Euphorbia serpens* Kunth. | 4.17 | 0.02 | 0.23 | 5.63 | - | - | - | - | 1.20 | <0.01 | 0.05 | 3.75 |
| | *Euphorbia* sp | 4.17 | 0.03 | 0.10 | 2.50 | 5.88 | 0.08 | 1.08 | 18.35 | 2.41 | 0.07 | 0.29 | 12.21 |
| | *Chrozophora tinctoria* (L.) Rafin. | 33.33 | 0.25 | 2.60 | 7.80 | 35.29 | 0.30 | 3.61 | 10.22 | 14.46 | 0.11 | 0.69 | 4.79 |
| **Fabaceae** | *Alhagi pseudalhagi* (Bieb) Desv. | 2.08 | 0.06 | 0.57 | 27.50 | 17.65 | 0.19 | 2.58 | 14.60 | 7.23 | 0.08 | 0.87 | 12.07 |
| | *Prosopis farcta* (Banksand Sol.) Macbride | 12.50 | 0.07 | 0.84 | 6.74 | 17.65 | 0.12 | 0.98 | 5.56 | 8.43 | 0.07 | 0.83 | 9.84 |
| | *Glycyrrhiza glabra* L. | 6.25 | 0.03 | 0.42 | 6.75 | - | - | - | - | 2.41 | 0.01 | 0.08 | 3.13 |
| **Malvaceae** | *Hibiscus trionum* L. | - | - | - | - | - | - | - | - | 4.82 | 0.08 | 0.39 | 8.16 |
| | *Malva* sp | 4.17 | 0.17 | 0.66 | 15.84 | 5.88 | 0.02 | 0.21 | 3.64 | 2.41 | 0.01 | 0.12 | 5.00 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Malvella sherardiana* (L.) Jaub. And Spach. | 14.58 | 0.34 | 2.04 | 14.02 | - | - | - | - | 4.82 | 0.01 | 0.15 | 3.13 |
| **Poaceae** | *Cynodon dactylon* (L.) Pers | 41.67 | 0.70 | 4.86 | 11.66 | 23.53 | 0.39 | 2.13 | 9.07 | 31.33 | 0.30 | 2.08 | 6.64 |
| | *Digitaria sanguinalis* (L.) Scop. | 8.33 | 0.06 | 0.62 | 7.47 | 5.88 | 0.02 | 0.09 | 1.54 | 16.87 | 0.20 | 1.02 | 6.08 |
| | *Echinochloa colonum* (L.) Link | 33.33 | 0.78 | 3.71 | 11.12 | 17.65 | 0.95 | 2.52 | 14.31 | 49.40 | 1.30 | 9.04 | 18.31 |
| | *Echinochloa crus-galli* (L.) P.B. | 27.08 | 0.33 | 2.07 | 7.66 | 11.76 | 0.49 | 1.32 | 11.25 | 27.71 | 0.57 | 2.95 | 10.65 |
| | *Elymus repens* (L.) Gould | 4.2 | 0.03 | 0.42 | 10.00 | - | - | - | - | 4.8 | 0.02 | 0.52 | 10.82 |
| | *Setaria verticillata* (L.) P. Beauv. | 2.08 | 0.02 | 0.47 | 22.35 | - | - | - | - | 2.41 | 0.05 | 0.13 | 5.33 |
| | *Sorghum halepense* (L.). Pers | 95.83 | 2.59 | 28.50 | 29.74 | 82.35 | 1.70 | 20.44 | 24.82 | 95.18 | 2.15 | 24.87 | 26.13 |
| **Polygonaceae** | *Polygonum aviculare* L. | 2.08 | 0.01 | 0.10 | 5.00 | - | - | - | - | 2.41 | 0.01 | 0.09 | 3.85 |
| **Portulacaceae** | *Portulaca oleracea* L. | 66.67 | 1.83 | 11.50 | 17.26 | 58.82 | 3.20 | 14.88 | 25.30 | 81.93 | 3.26 | 18.61 | 22.72 |
| **Solanaceae** | *Datura stramonium* L. | 2.08 | 0.01 | 0.17 | 8.00 | 11.76 | 0.06 | 0.71 | 6.06 | 12.05 | 0.12 | 0.78 | 6.48 |
| | *Physalis* spp. | 91.67 | 1.56 | 14.27 | 15.57 | 82.35 | 1.91 | 18.38 | 22.31 | 95.18 | 2.34 | 16.39 | 17.22 |
| | *Solanum nigrum* L. | 52.10 | 0.85 | 5.75 | 11.05 | 64.70 | 0.70 | 6.90 | 10.77 | 45.78 | 0.67 | 3.43 | 7.50 |
| **Zygophyllaceae** | *Tribulus terrestris* L. | 45.83 | 0.46 | 5.32 | 11.60 | 41.18 | 0.55 | 8.69 | 21.11 | 39.76 | 0.51 | 3.94 | 9.92 |

The weed species with a frequency of more than 50 % in the provinces where the survey was conducted were *S. halepense* (95.83 %), *Physalis* spp. (91.67 %), *X. strumarium* (83.33 %), *P. oleracea* (66.67 %) and *A. retroflexus* (60.42 %) in Diyarbakır; *S. halepense* (82.35 %), *Physalis* sp (82.35 %), *A. retroflexus* (82.35 %), *X. strumarium* (79.0 %) and *C. arvensis* (64.71 %) in Mardin and *S. halepense* (95.18 %), *Physalis* sp (95.18 %), *X. strumarium* (84.70 %), *P. oleracea* (81.93 %) and *C. arvensis* (56.63 %) in Şanlıurfa (Table 3).

In the cotton growing areas of Diyarbakır, *X. strumarium* (89.30 %), *Physalis* spp. (61.90 %) and *S. nigrum* (58.60 %) of Özaslan (2011), *S. halepense* (73 %), *X. strumarium* (67 %), *S. nigrum* (60 %) and *Physalis philadelphica* Lam. (53 %) in Şanlıurfa by Arslan (2018), *X. strumarium* (85.99 %), *Physalis* sp (84.07 %) and *S. halepense* in Mardin (85.99 %) and *Physalis* spp. (92.13 %), *X. strumarium* (89.33 %) and *A. retroflexus* (73.3 %) in Şanlıurfa by Özaslan and Bükün (2013) were the most common species and were similar to the species found in our study.

Table 3. Weed species with a frequency of over 50% in surveys of cotton fields in the provinces of Diyarbakır, Mardin and Şanlıurfa

| | Occurrence Frequency (%) | | |
|---|---|---|---|
| **Weeds** | **Diyarbakır** | **Mardin** | **Şanlıurfa** |
| *Amaranthus retroflexus* L. | 60.42 | 82.35 | - |
| *Convolvulus arvensis* L | - | 64.71 | 56.63 |
| *Sorghum halepense* (L.). Pers | 95.83 | 82.35 | 95.18 |
| *Physalis* spp. | 91.67 | 82.35 | 95.18 |
| *Portulaca oleracea* L. | 66.67 | - | 81.93 |
| *Xanthium strumarium* L. | 83.33 | 79.00 | 84.70 |

When analysed according to their density in the studied fields, it was found that the densest species were *S. halepense* with 2.59 weeds/m$^2$ in Diyarbakır, *A. retreflexus* with 5.10 weeds/m$^2$ in Mardin and *C. rotundus* with 8.91 weeds/m$^2$ in Şanlıurfa (Table 4). ). After these species, the weed species with the highest density in the studied fields were: *P. oleracea*, *Physalis* spp., *X. strumarium*, *C. arvensis* and *E. colonum*, and their densities varied between 1 and 4 weeds/m$^2$.

Considering the survey studies in the Southeastern Anatolia region with weed densities ≥ 1 piece/m$^2$; Uludağ and Katkat (1991) reported that the densities of *C. dactylon*, *S. halepense* and P. olerecea species in the GAP region were 2 to 3 weeds/m$^2$, and Özaslan (2011) reported that *A. retreflexus*, *C. rotundus*, *P. olerecea*, *Physalis* sp, *S. halepense*, *S. nigrum* and *X. strumarium* in Diyarbakır had densities between 1 and 3 weeds/m$^2$. Özaslan and Bükün (2013) reported that the most abundant species in Mardin and Şanlıurfa provinces were determined to be *A. retreflexus*, *Physalis* spp. and *X. strumarium* with 1 to 3 weeds/m$^2$. In addition, in the studies conducted by Arslan (2018) in Şanlıurfa, the densities of *A. retreflexus*, *C. arvensis*, *C. rotundus*, *C. dactylon*, *P. olerecea*, *Physalis* sp, *S. halepense*, *S. nigrum* and *X. strumarium* were 1 to 10 in per m$^2$. Pala and Mennan (2019) found that the density of *A. retreflexus*, *C. arvensis*, *Physalis* spp., *S. halepense* and *X. strumarium* in the Karacadağ basin was between 1 and 1.5 weeds/m$^2$.

Similar to our results in the southeastern Anatolia region, the Aegean and the Mediterranean, where cotton production is intensive; Kadıoğlu et al. (1993) *Alhagi pseudalhagi*, *Cyperus* spp*., C. rotundus, E. colonum, H. trionum, P. oleracea, S. verticillata, S. nigrum, S. halepense, X. strumarium, C. arvensis, Prosopis farcta*, Boz (2000) *A. retroflexus, C. rotundus* and *X. strumarium*, Kaya and Nemli (2002) *C. dactylon, C. rotundus, C. album, P. olerecea, S. halepense*, Tursun et al. (2004) *S. halepense, C. arvensis L., S. nigrum, X. strumarium, P. oleracea, Setaria* spp., *Cyperus rotundus* and E. cruss-galli, Özkil et al. (2019) *C. rotundus* and *Ipomoea triloba* species were determined with more than 1 weed/m$^2$.

Table 4. Weed species with a density of more than 1 weed/m$^2$ in surveys of cotton fields in the provinces of Diyarbakır, Mardin and Şanlıurfa

| | Density (weed/m$^2$) | | |
|---|---|---|---|
| **Weeds** | **Diyarbakır** | **Mardin** | **Şanlıurfa** |
| *Amaranthus retroflexus* L. | 1.82 | 5.10 | - |
| *Convolvulus arvensis* L | - | - | 1.80 |
| *Cyperus rotundus* L. | 2.06 | 2.07 | 8.91 |
| *Echinochloa colonum (L.) Link* | - | - | 1.30 |
| *Sorghum halepense* (L.). Pers | 2.59 | 1.70 | 2.15 |
| *Physalis* spp. | 1.56 | 1.91 | 2.34 |
| *Portulaca oleracea* L. | 1.83 | 3.20 | 3.26 |
| *Xanthium strumarium* L. | 2.25 | 1.93 | 2.21 |

When the weeds found in the studied cotton fields were evaluated according to their specific and general cover area, it was found that *S. halepense* in Diyarbakır and *A. retroflexus* in Mardin had the highest specific and general cover area, while the highest specific cover area was found in *C. rotundus* and the highest general cover area was found in *S. halepense* in Şanlıurfa (Table 2). Similar to our study, Boz et al. (1995) found *S. halepense* in the GAP Region, Şahin et al. (2020) determined *C. arvensis, P. oleracea, S. halepense* and *X. strumarium* in Iğdır, Özkil et al. (2019) found *C. rotundus*, *I. tribola* and *S. halepense* species had the highest coverage area in Antalya.

During the surveys in the cotton growing areas in the region where our study was conducted, it was found that the prevalence rates of *S. halepense, X*. *strumarium* and *Physalis* spp., which are the most common species, were of over 80%.

Comparing these species with the surveys conducted in the Southeast Anatolia region in the last 30 years. In the study conducted by Bükün (2005) in 1996 and 2004 to determine the changes in weed flora in the last decade after irrigation in the cotton growing areas of Harran Plain, it was found that the frequency of occurrence of *S. halepense* increased from 23.63% to 60.00% and *X. strumarium* from 56% to 72%. Arslan (2018) stated that the most common species in the changes in weed flora in Şanlıurfa and Southeastern Anatolia Region were *S. halepense*, *X. strumarium* and *Physalis* spp. and found that the prevalence rates of these weeds were over 60, 70 and 80%, respectively, in the last twenty years. Pala and Mennan (2019), in their surveys of cotton fields in the Karacadağ Basin, found that the prevalence of *S. halepense* was 72%, *X. strumarium* 86% and *Physalis* spp. 56%, and the results of the study showed that the prevalence of these weed species is increasing in the region.

During the surveys in the cotton fields of Diyarbakır, Mardin and Şanlıurfa provinces in the Southeast Anatolia region, it was found that weed species and densities vary depending on the province. The reason for this variation is that the dominance level of weed species varies according to location and cultivated product, and some weed species that are heavily infested in some regions may not have the same level in other locations (Tena et al., 2012). In addition, the surveys have shown that the occurrence and density of some important species and other species vary across the region. It is assumed that the main reasons for this variability are irrigation and control methods (Bükün, 2005).

It is predicted that the prevalence of *S. halepense*, *X. strumarium* and *Physalis* spp. will increase when agricultural land is opened to irrigation under the GAP project. Studies have shown that the density of these species increases in agricultural areas due to the effects of irrigation and that these species develop faster in a humid environment (Mennan and Işık, 2003; Bükün and Uygur, 2003; Bükün, 2005). It has been reported that the occurrence and density of Physalis spp. increased compared to before, especially after 1995 and 1996 when the Harran Plain was irrigated, and that the increase of this species may have been contaminated with seed material in the Harran Plain and spread rapidly to

fields that were not contaminated with irrigation water (Bükün and Uygur 2003; Bükün, 2005; Arslan, 2018). Another factor that plays an important role in weed flora is crop rotation. Different crops can be grown in crop rotation and the adaptation of certain species can be prevented by using different herbicide applications and different cultural control methods in the control of weeds in different crops (Bükün and Uygur, 2003; Bükün, 2005; Serim et al., 2023).

When comparing the results of our survey studies with the survey results carried out in the region over the last 30 years, it was found that there were significant changes in weed species and densities. In the cotton field surveys, it was found that the frequency of occurrence of *Amaranthus palmeri* L., one of the invasive weed species, was 11.76% in Mardin and about 10% in Şanlıurfa. *A. palmeri* is a weed species of American origin and was first sighted in Türkiye in 2014 in the east of Adana, Hatay and Osmaniye (Eren et al., 2016). In the Southeastern Anatolia region, it was first sighted in 2017 by Özaslan et al. (2017) in cotton and maize fields in Mardin, and in the surveys conducted by Turan (2019) in cotton and maize fields, it was found that the frequency of occurrence was 16.29%. It has been determined that the prevalence of this invasive species is increasing every year in agricultural and non-agricultural areas and will cause problems in certain regions (Özaslan et al., 2017; Turan, 2019; Sırrı, 2022). In our study, the prevalence of this invasive species was found to have increased in Şanlıurfa cotton fields. It was found that the prevalence of *Ipomoea* spp., one of the other invasive species identified in the region, was over 10% in Diyarbakır and Şanlıurfa, while *C. melo* species was found in all three provinces where the survey was conducted and prevalence rates varied between 11% and 36%. In the surveys conducted by Arslan (2018) in cotton fields in Şanlıurfa, it was found that these two species were identified for the first time in the Southeastern Anatolia Region and their prevalence rate was below 10%. It has been reported that studies should be conducted on the spread, distribution and control of the weed species *Ipomoea triloba* L., *Amaranthus palmeri* L. and *Cucumis melo*, which pose a threat to cotton fields, and measures should be taken to prevent the spread of these species (Yazlık et al, 2014; Yazlık et al. , 2018; Özkil et al, 2019; Serim et al., 2023).

One of the factors causing changes in the weed flora is global climate change. It is said that the basic climate variables, the increase in $CO_2$ levels and the resulting changes in global temperature and precipitation will increase the invasion success of many weed species due to their proliferation, spread and development (Sorte et al, 2013; Manea et al, 2016; Varanasi et al, 2016; Fernandino et al, 2018). In our study, the weed species *C. tintoria* and *P. farcta* were found to have increased in the Southeastern Anatolia region. It is thought that this increase may be influenced by both climate change and other factors. Similar to our results, Serim et al. (2023) found that changes in the weed flora in cotton fields in the eastern Mediterranean region of Türkiye caused an increase in the average temperature of *C. tintoria*, *P. farcta* and *S. halepense* species.

**Conclusion**

Surveys carried out in the cotton growing areas of the Southeast Anatolia Region revealed that the occurrence and density of weed species have increased. With the increase in irrigable agricultural land in the region, cropping patterns and the crop rotation system have changed. Changes in the crop rotation system and changes in cultural, mechanical and chemical weed control can lead to differences in the weed flora. The use of post-emergence herbicides against broadleaf weeds in cotton is limited but not effective. It is therefore predicted that the incidence of broadleaf weeds such as *A. palmeri*, *Physalis* spp. and *X. strumarium* will increase. Effective control methods need to be developed to prevent the damage caused by invasive species that are

spreading rapidly on agricultural land, pastures, dams and biodiversity. During the observations in the cotton fields, it was found that irrigation and planting methods had a significant impact on the weeds and that the weed problem decreased in the areas where drip irrigation and ridge planting were applied. It has been shown that drip irrigation is more successful than flood irrigation method in all weed control applications (Hakoomat et al. 2017). It is believed that the use of sprinkler and drip irrigation systems instead of overhead irrigation, especially in cotton cultivation, can reduce the spread of weed species.

As a result of the study, it is necessary to continuously monitor the occurrence and density of weed species in the cotton growing areas of the region and conduct detailed studies on the biological characteristics of these species, alternative control methods, determination of the economic level threshold and the critical period.

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**Conflict of Interest**

The authors declare that there is no conflict of interest in this study.

**Author Contributions**

N. T. planned to work, İ. E. S. carried out the field studies. N. T. examined the data obtained from the study and the article was written by İ. E. S.

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