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The Frequency and Density of Weeds in Peanut (*Arachis hypogaea* L.) Fields of Adana Province, Türkiye

Adana İli Yer Fıstığı (*Arachis hypogaea* L.) Tarlalarında Yabancı Otların Rastlanma Sıklığı ve Yoğunluğu, Türkiye

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ABSTRACT

Peanut (*Arachis hypogaea* L.) is an important arable crop. However, weeds cause significant yield losses difficulties. This study was conducted to determine the occurrence frequency and density of weed species in peanut fields in Adana province. In the 2021 vegetation period, surveys were conducted in 50 peanut fields in Adana and its districts. As a result of the surveys, 38 weed species belonging to 17 different families were identified. The Poaceae family had the highest number of weed species with 12 species, followed by the Amaranthaceae family with 4 species. Other important families included Euphorbiaceae, Asteraceae, Cyperaceae, Convolvulaceae, Malvaceae, and Solanaceae, each represented by 2 species. The studies showed that most of the weeds in peanut fields were broadleaf and annual species. According to survey results, species such as *Cyperus rotundus* L. (78%), *Sorghum halepense* (L.) Pers (67%), *Xanthium strumarium* L. (52%), *Convolvulus arvensis* L. (49%), and *Portulaca oleracea* L. (46%) were among the most common weeds in the region with the highest occurrence frequencies. In terms of density, *Setaria viridis* (L.) P. Beauv. (1,050 plants/m²) had the highest density. Other dense species included *C. rotundus* (0.715 plants/m²), *Echinochloa colona* L. (0.630 plants/m²), *Echinochloa crus-galli* (L.) P. Beauv. (0.505 plants/m²), and *S. halepense* (0.425 plants/m²). These species are dominant in the weed flora of the region with high occurrence frequencies and density levels.

Keywords: Peanut, Weeds, Adana, Frequency of occurrence, Density

ÖZ

Yerfıstığı (*Arachis hypogaea* L.), ekim alanlarında yabancı otların neden olduğu verim kayıpları nedeniyle önemli bir sorun teşkil etmektedir. Bu çalışma, Adana ilindeki yerfıstığı ekim alanlarında bulunan yabancı ot türlerinin rastlama sıklığı ve yoğunluklarını belirlemek amacıyla gerçekleştirilmiştir. 2021 yılı vejetasyon döneminde, Adana ili ve ilçelerinde toplamda 50 yerfıstığı tarlasında surveyler yapılmıştır. Surveyler sonucunda, 17 farklı familyaya ait 38 yabancı ot türü tespit edilmiştir. Poaceae familyası, 12 türle en fazla yabancı ot barındırırken, Amaranthaceae familyası ise 4 türle ikinci sıradadır. Diğer önemli familyalar arasında Euphorbiaceae, Asteraceae, Cyperaceae, Convolvulaceae, Malvaceae ve Solanaceae yer almakta ve her biri 2 türle temsil edilmektedir. Yapılan incelemeler, yerfıstığı ekim alanlarındaki yabancı otların büyük çoğunluğunun geniş yapraklı ve tek yıllık türlerden oluştuğunu göstermektedir. Survey sonuçlarına göre, *Cyperus rotundus* L. (%78), *Sorghum halepense* (L.) Pers (%67), *Xanthium strumarium* L. (%52), *Convolvulus arvensis* L. (%49) ve *Portulaca oleracea* L. (%46) gibi türler, en yüksek rastlama sıklığına sahip olup bölgedeki en yaygın yabancı otlar arasında yer almaktadır. Yoğunluk açısından, *Setaria viridis* (L.) P. Beauv. (1,050 adet/m²) en yüksek yoğunluğa sahip tür olarak öne çıkmaktadır. Diğer yoğun türler sırasıyla *C. rotundus* (0,715 adet/m²), *Echinochloa colona* L. (0,630 adet/m²), *Echinochloa crus-galli* (L.) P. Beauv (0,505 adet/m²) ve *S. halepense* (0,425 adet/m²) olarak belirlenmiştir. Bu türler, yüksek rastlama sıklığı ve yoğunluk seviyeleriyle bölgedeki yabancı ot florasında baskın durumdadır.

Anahtar Kelimeler: Yer fıstığı, Yabancı otlar, Adana, Rastlama sıklığı, Yoğunluk

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Introduction

Peanut (*Arachis hypogaea* L.) is an annual plant of the legume family that thrives in tropical and subtropical regions characterised by a warm climate. It is found in regions between 40° north and south latitudes (Kadiroğlu, 2018). Peanut is an important oil plant both in Turkey and worldwide (Arslan et al., 2022). This plant, which is a valuable food source for humans and animals, is rich in oil, protein, carbohydrates, vitamins, and minerals (Arıoğlu, 2007). In addition to its use in human consumption and as animal feed, peanut is also significant as an oilseed crop due to its ability to fix nitrogen in the soil (Doğaka, 2020). Peanut seeds contain 42-52% oil and 25-32% protein, and it is particularly used in the production of peanut oil, snack foods, and peanut butter (Chang et al., 2013). Globally, 49% of peanuts are used for oil production, 41% for human consumption, and 10% for animal feed and seed production. In Türkiye, a large portion of the peanut production is consumed as snack foods, while a smaller portion is used in the oil industry (Şahin, 2014). In 2022, a total of 54,238,560.13 tons of peanuts were produced worldwide on 30,536,263 hectares of land. The production came from Asia (58.45%), Africa (32.01%), and America (9.49%). The top three peanut-producing countries in that year were China (18,329,500 tons), India (10,134,990 tons), and Nigeria (4,284,000 tons) (FAO, 2024). In Türkiye, as of 2023, 185,137 tons of peanuts were produced on 460,098 hectares, with Adana province accounting for 48.07% of Türkiye's peanut production, producing 89,011 tons from 208,442 hectares (TÜİK, 2024).

With the increasing global population, the demand for agricultural products is growing. Therefore, enhancing plant production is necessary to meet the nutritional needs of the population. However, various factors negatively affect agricultural productivity, with weeds being one of the most significant (Tepe, 1998; Swinton & Van Deynze, 2017; Gharde et al., 2018). Weeds not only reduce crop yield but also damage the quality of the products (Jabran & Chauhan, 2018). The yield losses caused by weeds vary depending on the type of crop, geographic region, and weed species. Some weed species cause problems in multiple crops, while others affect only specific crops (Güncan, 2025). Weeds compete with crops for resources such as water, light, and nutrients, negatively affecting the physiological processes and growth of the crops, resulting in reduced yield and quality. This leads to economic losses (Anwar et al., 2021; Abdelaal et al., 2022; da Silva et al., 2022; Kumar et al., 2024)

To minimize losses caused by weeds, it is necessary to develop an effective weed management strategy. The foundation of this strategy is to identify weed species and understand their biology (Özer et al., 1998). There are many weed species in peanut cultivation areas in Turkey, and these species cause significant yield and quality losses in peanuts (Uygur, 1997; Arslan & Üremiş 2003; Uludağ et al., 2012; Abacı & Üremiş, 2016; Beycioğlu et al., 2020; Yılmaz et al., 2022). Farmers in the Çukurova region have reported encountering new weed species in peanut fields that are not affected by the currently registered herbicides. This situation necessitates the identification of weeds in peanut fields and a better understanding of their biological/ecological characteristics. Based on the data obtained, it is aimed to develop region-specific weed control methods considering the ecological characteristics of the area (Özaslan & Kendal, 2014). This study aims to determine the occurrence frequencies and densities of weed species found in peanut fields in Adana province, Türkiye.

Methods

Surveys were conducted in the districts of Yüreğir, Karataş, Kozan, Ceyhan, Karaisalı, Yumurtalık, and İmamoğlu in Adana province to identify weed species problematic in peanut production areas. In this study, surveys were conducted in 50 peanut fields during the 2021 vegetation period. The surveyed districts and fields were selected based on the total peanut planting areas (da) in 2020 according to TÜİK data. Table 1 shows the total peanut planting areas (da) in Adana Province and its districts and the number of surveys conducted in these districts.

Table 1.
Peanut planting areas in Adana province and the number of surveys conducted in districts based on 2020 data from TÜİK

Districts	Planting area (da)	Total number of fields surveyed
Yüreğir	46,500	8
Karataş	64,367	9
Kozan	17,300	7
İmamoğlu	12,650	6
Ceyhan	112,400	12
Karaisalı	2,550	3
Yumurtalık	8,250	5

Before the surveys, peanut planting areas were determined, and by going in lines towards these areas, the nearest peanut field, which was randomly selected every 10 km, was entered (Uygur, 1985). In the areas where the study was to be carried out, care was taken to ensure that the land generally consisted of medium-sized parcels. Using Sırma et al., (2001), the plants in the field were counted according to the size of the field (Table 2).

Table 2.
Number of frames thrown according to the size of the field in the surveys

Field Size (da)	Number of Frames Placed
0-5	4
5-10	6
10-20	8
20-50	12
50+	16

In the counts, a 1 m² frame was used to represent the field, starting from 5-10 m inside, away from the edge effect, and the weeds that entered were counted randomly. After the weeds were determined, the % Frequency of Encounter (R.S) of the weeds was calculated according to (Odum, 1983; Uygur, 1985). Frequency of Encounter; It is the ratio showing what percentage of a weed species is encountered in the regions where observations were made. The calculation of these ratios was made with the formula below.

R.S (%) = 100 x N/M

R.S: Frequency of Encounter (%)

N: Number of fields where a species is found

M: Total number of fields where measurements were made

The evaluation was made based on the arithmetic mean to determine the density of weeds. The total number of plants in m^2 of the surveys determined for weed densities (plants/m^2) were divided by the number of surveys made and the density of the species were calculated one by one (Odum, 1971).

Density (plant/m^2) = B/m

B: Total number of individuals in the sample taken

m: Total number of samples

Davis (1965-1988) was used in the identification of plant samples. Scale values developed and adapted by different researchers (Uludağ, 1993) were used to classify the weeds determined in the surveyed planting areas according to their frequency and density values and to emphasize important species. The meanings of the scale values were evaluated according to (Arslan, 2018). The relevant scale values are given in Table 3.

Table 3.
Grading of the density and prevalence of weeds

Frequency			Density		
Ç	≥%50	Very Common	A	≥10 plants/m^2	Very Dense
Y	%25-49	Common	B	5,00 - 9,99 plants/m^2	Dense
O	%13-24	Moderately Common	C	1,00 - 4,99 plants/m^2	Moderately Dense
N	<%12	Rare	D	0,10 - 0,99 plants/m^2	Low Dense
			E	0,01 - 0,09 plants/m^2	Very Low Dense
			F	<0,01 plants/m^2	Rare

Evaluation of data

Sankey diagram was used to visualize the distribution and interactions of weed species according to their families, leaf types and life spans. After transforming and normalizing the data, hierarchical cluster analysis (SRplot) was performed to group weeds according to their similarities in frequency and density. Network graph analysis (PAST software) was applied to determine and visualize the relationships between weeds according to frequency and density. When these two analyses are used together, it is possible to examine and evaluate the relationships of different applications in a much more comprehensive way. In addition, principal component analysis (PAST software) was performed to reduce multivariate data to a lower dimensional space and to determine important variables.

Results and Discussion

As a result of the surveys conducted in peanut cultivation areas of Adana province, a total of 38 weed species belonging to 17 different families were identified. In this study, the number of weed species in each family was determined and these data are presented visually in Figure 1.

The distribution of weed species identified as a result of surveys conducted in peanut cultivation areas by family shows that the Poaceae family has the most species with 12 weed species. This is followed by the Amaranthaceae family with 4 species. Other families include important groups such as Euphorbiaceae, Asteraceae, Cyperaceae, Convolvulaceae, Malvaceae, and Solanaceae, each of which has 2 weed species. The remaining families are represented by only 1 weed species (Figure 1). The identified weed species, their families, whether they are narrow-leaved or broad-leaved, and their life spans are presented in Figure 2 in the form of a Sankey diagram.

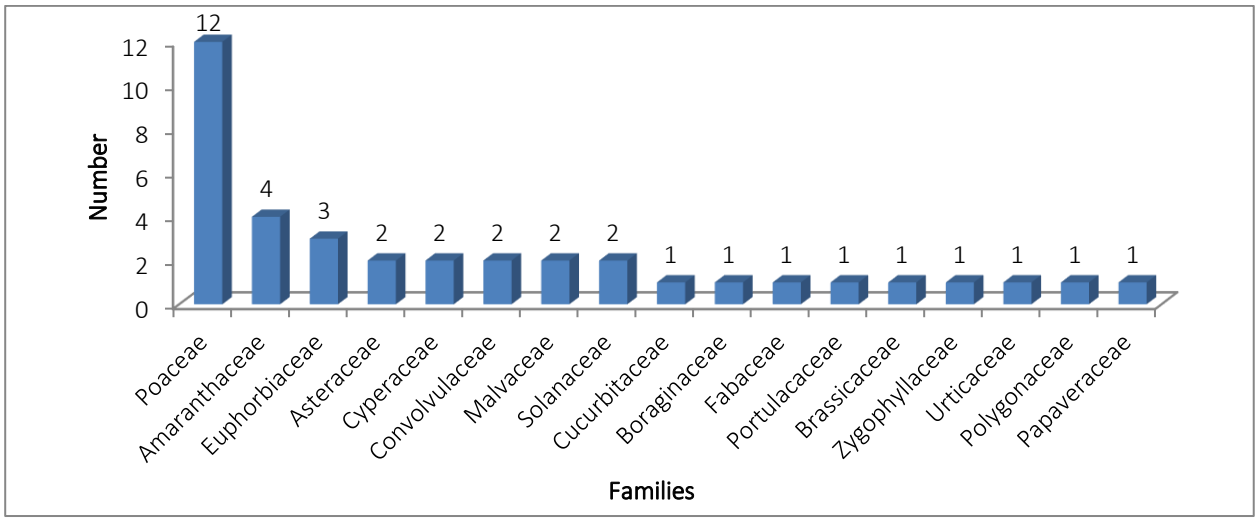

Figure 1.
Number of weed species of the identified weed families

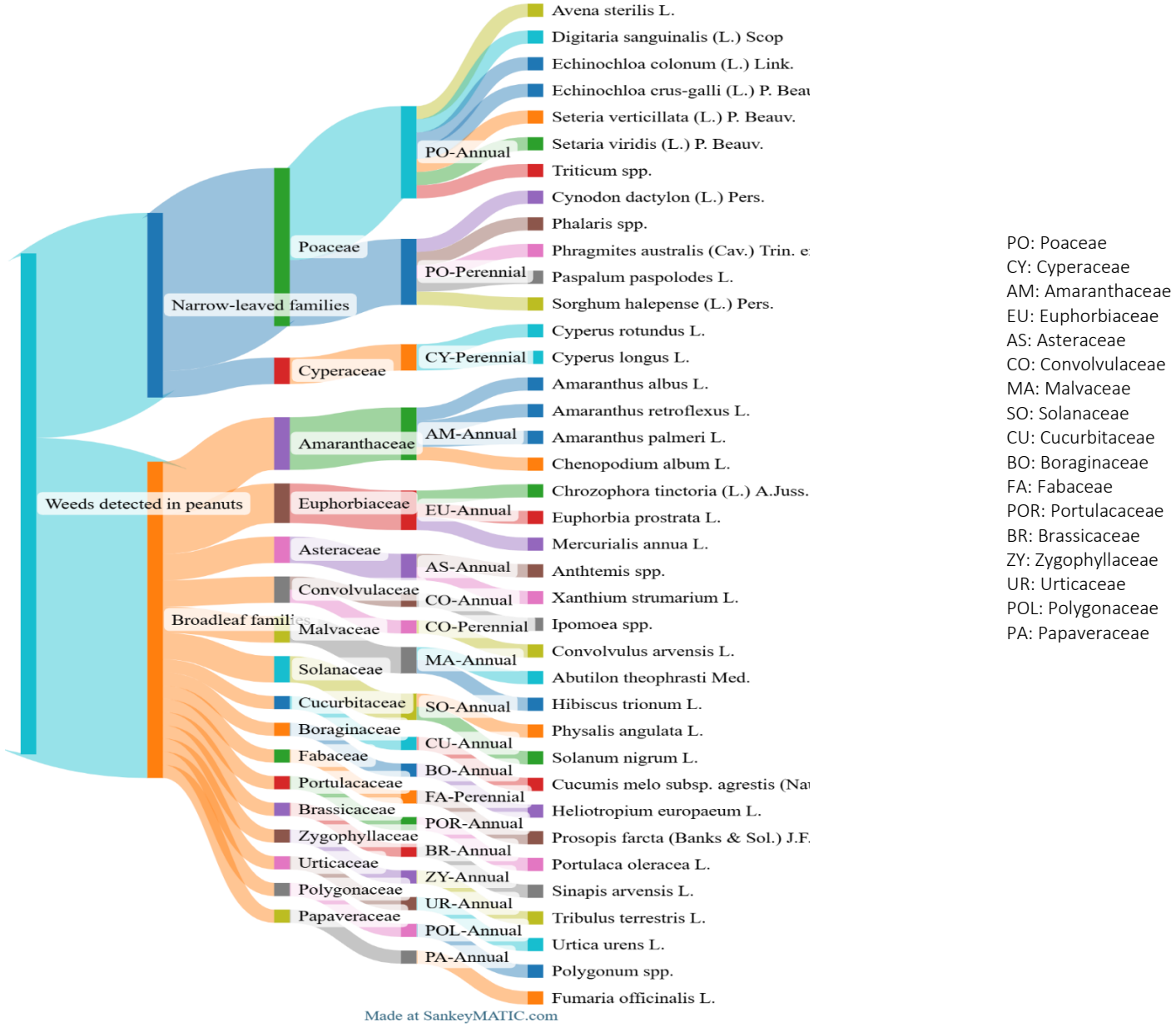

Figure 2.
Sankey diagram of the detected weed species, their families, narrow and broad leaves and their life spans

As a result of the surveys conducted in the peanut cultivation areas of Adana province, a total of 38 weed species belonging to 17 different families were detected. 14 of these species are narrow-leaved and 24 are broad-leaved. Narrow-leaved weeds consist of the Poaceae and Cyperaceae families, 7 of which are annual and 7 are perennial. Among the broad-leaved weeds, 21 species are annual and 3 species are perennial (Figure 2). This distribution shows that the vast majority of weed species in peanut cultivation areas consist of annual broad-leaved, while narrow-leaved weeds have a more balanced mix of annual and perennial species. The percentage frequencies and densities of weed species detected in peanut cultivation areas are given in Table 4.

Table 4.

Percentage frequencies and densities of weed species detected in peanut cultivation areas in Adana.

Scientific Names	Common Names	F (%)	C.	D.(plants/m²)	D.L
Abutilon theophrasti Med.	Velvetleaf	6	O	0.035	F
Amaranthus albus L.	White pigweed	24	O	0.125	D
Amaranthus retroflexus L.	Redroot pigweed	31	O	0.160	D
Amaranthus palmeri L.	Palmer amaranth	16	O	0.095	F
Anthemis spp.	Chamomile	7	O	0.065	F
Avena sterilis L.	Wild oat	8	O	0.130	D
Chenopodium album L.	Lamb's quarters	2	N	0.055	F
Chrozophora tinctoria (L.) A.Juss.	Dyer's croton	3	N	0.040	F
Convolvulus arvensis L.	Field bindweed	49	Ç	0.255	C
Cucumis melo subsp. *agrestis* (Naudin.)	Wild melon	37	Y	0.140	D
Cyperus rotundus L.	Purple nutsedge	78	Ç	0.715	A
Cyperus longus L.	Yellow nutsedge	17	O	0.220	C
Cynodon dactylon (L.) Pers.	Bermuda grass	26	Y	0.325	B
Digitaria sanguinalis (L.) Scop.	Crabgrass	3	N	0.175	D
Echinochloa colonum (L.) Link.	Jungle rice	42	Y	0.630	B
Echinochloa crus-galli (L.) P. Beauv.	Barnyard grass	29	O	0.505	B
Euphorbia prostrata L.	Prostrate spurge	3	N	0.210	C
Fumaria officinalis L.	Fumitory	4	N	0.050	F
Heliotropium europaeum L.	European heliotrope	3	N	0.040	F
Hibiscus trionum L.	Flowering hibiscus	4	N	0.075	F
Ipomoea spp.	Morning glory	21	O	0.090	D
Mercurialis annua L.	Annual mercury	1	N	0.025	F
Prosopis farcta (Banks & Sol.) J.F. Macbride.	Mesquite	7	O	0.175	D
Phalaris spp.	Canary grass	3	N	0.155	D
Phragmites australis (Cav.) Trin. ex Steud.	Common reed	9	O	0.120	D
Physalis angulata L.	Cutleaf groundcherry	4	N	0.045	F
Polygonum spp.	Knotweed	1	N	0.020	F
Portulaca oleracea L.	Purslane	46	Ç	0.235	C
Paspalum paspolodes L.	Nutsedge	5	O	0.040	F
Setaria verticillata (L.) P. Beauv.	Bristly foxtail	16	O	0.385	B
Setaria viridis (L.) P. Beauv.	Green foxtail	14	O	1.050	A
Sinapis arvensis L.	Wild mustard	5	O	0.050	F
Solanum nigrum L.	Black nightshade	4	N	0.060	F
Sorghum halepense (L.) Pers.	Johnsongrass	67	Ç	0.425	B
Tribulus terrestris L.	Puncturevine	4	N	0.060	F
Triticum spp.	Volunteer wheat	17	O	0.275	C
Urtica urens L.	Small nettle	2	N	0.020	F
Xanthium strumarium L.	Common cocklebur	52	Ç	0.260	C

F: Frequency; D: Density; C: Common; D.L: Density level; Ç: F≥%50, Very Common; Y: F= %25-49, Common; O: F=%13-24, Moderately Common; N: F<%12, Rare; A: D≥10 plants/m², Very Dense; B: D= 5.00- 9.99 plants/m², Dense; C: D=1.00-4.99 plants/m², Moderately Dense; D: D= 0.10-0.99 plants/m², Low Dense; E: D= 0.01-0.09 plants/m², Very Low Dense; F: D<0.01 plants/m², Rare.

Among the species identified in the surveys, 16 species had a frequency of occurrence above 10%. The plants with the highest frequency of occurrence were *C. rotundus* (78%), *S. halepense* (67%), *X. strumarium* (52%), *C. arvensis* (49%), and *P. oleracea* (46%). These species are the most common weeds in terms of frequency and generally occur at high density levels. In particular, species like *C. rotundus* and *E. colona* dominate the weed flora in the region. The species with the lowest frequency of occurrence were *M. annua* (1%), *Polygonum spp.* (1%), C*. album* (2%) and *U. urens* (2%). When examining the density (individuals/m²), the species with the highest density in the peanut fields of Adana province was *S. viridis*, with a density value of 1,050 individuals/m². Other species with high density were *C. rotundus* (0.715 individuals/m²), *E. colona* (0.630 individuals/m²), *E. crus-galli* (0.505 individuals/m²), and *S. halepense* (0.425 individuals/m²). Species with lower density values included *A. theophrasti* (0.035 individuals/m²), *C. tinctoria* (0.040 individuals/m²), and *M. annua* (0.025 individuals/m²). In the general evaluation, *C. rotundus* is categorized as "Very Common" with a frequency of occurrence and as "Very Dense" with a density value of 0.715 individuals/m². *S. viridis*, with a density value of 1,050 individuals/m², is also categorized as "Very Dense." Meanwhile, *S. halepense*, with a density value of 0.425 individuals/m², is classified as "Dense." On the other hand, species like *A. albus* and *A. retroflexus* have medium density and are frequently encountered but are not excessively dominant species (Table 4). The weeds identified in peanut fields are an important issue directly affecting production. The species with the highest frequency of occurrence in the Adana study, such as *C. rotundus*, *S. halepense*, *X. strumarium*, *C. arvensis*, and *P. oleracea*, are commonly found in peanut fields. The important weed species observed in peanuts grown in Türkiye, with varying prevalence and density rates, *are S. halepense, X. strumarium, C. arvensis, A. retroflexus* and *P. oleracea* (Uygur, 1997; Arslan & Üremiş 2003; Uludağ et al., 2012; Abacı & Üremiş, 2016; Beycioğlu et al., 2020; Yılmaz et al., 2022). This is similar to findings from studies by Gözüyeşil (2014) and Kadiroğlu (2018), which highlighted common weed species in peanut fields. Furthermore, studies by Grichar (2008) and Burke et al. (2007) also mentioned that weeds like *Amaranthus palmeri* limit peanut growth. As a result, the identified weed species largely align with the existing literature.

Various statistical analyses were conducted to assess and visualize the relationship between weed frequency and density. These analyses included hierarchical clustering analysis, network graph analysis, and Principal Component Analysis (PCA) based on average frequency and density values. The hierarchical clustering analysis was performed in three different ways: by frequency, by density, and by considering both variables together. In the hierarchical clustering analysis based on frequency, the weeds were divided into two main groups. The first group included species with very high frequency, which were widespread in almost all areas, such as *C. rotundus*, *S. halepense*, *C. arvensis*, *X. strumarium*, *P. oleracea*, *C. melo*, and *E. colona*. Within this group, *C. rotundus* and *S. halepense* formed a separate subgroup. The second main group was further split into two subgroups. The first subgroup consisted of species with medium frequency, and the second subgroup included species with low frequency of occurrence. Similarly, the hierarchical clustering analysis based on density revealed two main groups. The species with the highest density, *S. viridis*, formed its own group. In the other main group, species with relatively high density included *S. verticillata*, *S. halepense*, *C. dactylon*, *C. rotundus*, *E. colona*, and *E. crus-galli*. Other species with lower density values were grouped into a separate subgroup.

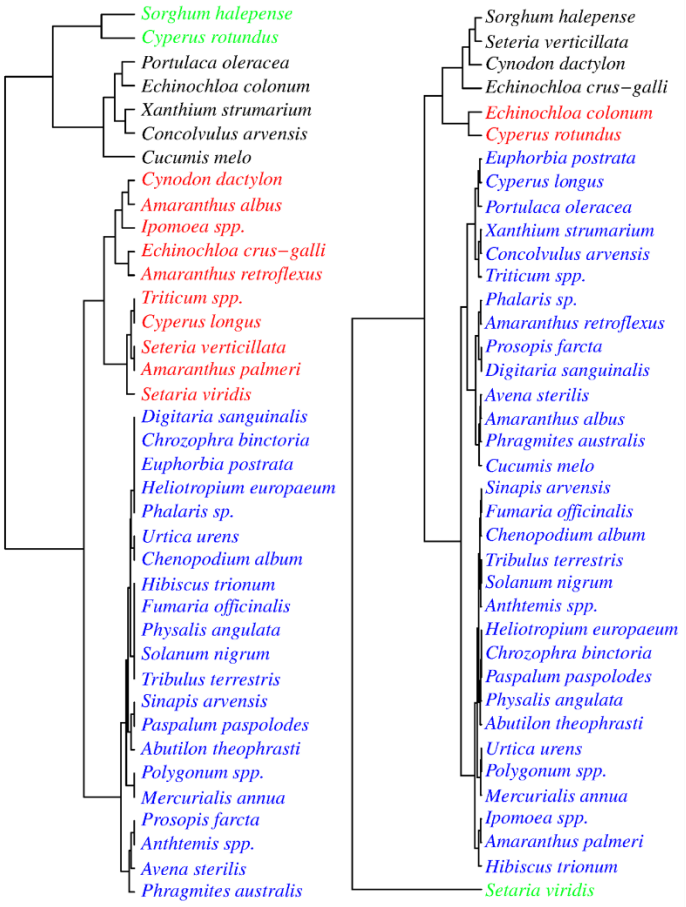

Figure 3.
A; Dendrogram of frequency of occurrence and B; dendrogram of density

In the study, hierarchical clustering analysis was conducted by considering both frequency of occurrence and density values together. As a result, the weed species were divided into two main groups. The first group included *S. viridis*,

which has a density significantly higher than the other species. The other main group was further divided into two subgroups. The first subgroup consisted of seven weed species with both high frequency of occurrence and high density values. Prominent species in this group included *C. rotundus, E. colona, X. strumarium, P. oleracea, C. arvensis, E. crus-galli* and *S. halepense*. These species are dominant in peanut fields due to both their high density and wide occurrence. The second subgroup included rare weed species with low frequency of occurrence and density. These analysis results not only provide an evaluation of the current situation but also highlight which species need more attention (Figure 4).

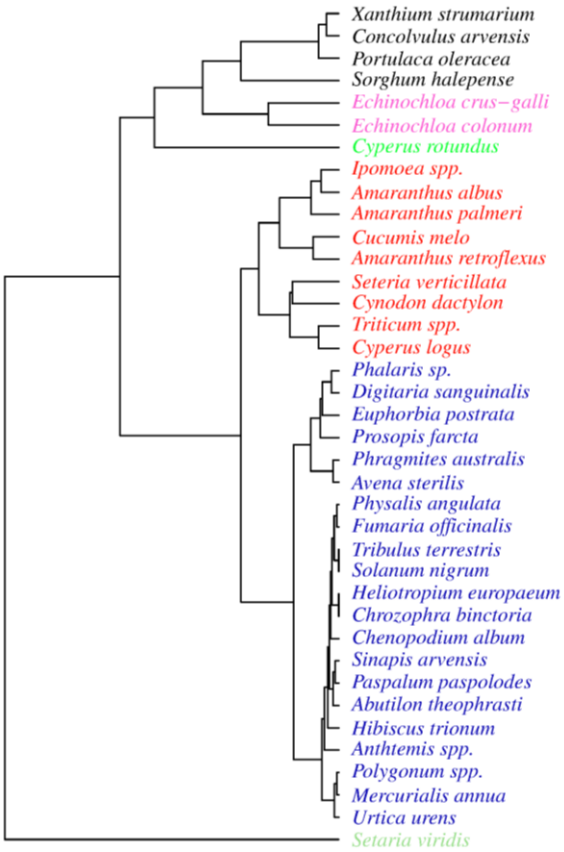

Figure 4.
Dendrogram of frequency and density of occurrence

The network graph analysis performed to determine the relationships between weeds visualized the strength of the connections between species and allowed for a more detailed evaluation of these connections. As a result of the analysis, lines representing the strength of the relationships between species were used. The thickness of the lines indicated the strength of the relationships, while thicker lines indicated strong connections, and thinner or lighter lines indicated weak connections. The results obtained showed that a clear distinction emerged, consistent with the hierarchical clustering analysis. It was determined that weed species with high frequency and density of occurrence in particular were not related to other species. However, a certain degree of relationships were found between other weed species (Figure 5).

In this study, principal component analysis (PCA) was applied to better understand the frequency and density of weed occurrences, to determine the differences between species and to reduce the complexity of the data. PCA is a powerful method that allows multidimensional data to be examined by reducing it to a smaller number of components and stands out as an effective tool especially in evaluating weed profiles in agricultural ecosystems. This analysis determined how species with high frequency and density of occurrence differ from others. Within the scope of the study, the first two components (PC1: 75.45% and PC2: 21.54%) of the data obtained explained 96.99% of the total variance. This rate shows that the parameters related to the distribution and density of weed species can be effectively evaluated with PCA. The high variance explained indicates that the analysis results are reliable. PCA also clearly revealed how dominant species (*S. viridis, C. rotundus, E. colona, X. strumarium, P. oleracea, C. arvensis, E. crus-galli* and *S. halepense*) differed from rare species (Figure 6).

In the study, advanced analyses such as hierarchical clustering, network graph analysis and principal component analysis performed on the average values of the frequency and density of weeds were quite effective in determining the clustering of weed species and their relationships with each other. These analyses were used as a powerful method in reducing the complexity in the data and narrowing down the size of the variables considered. With the applied analyses, the effects and relationships between the parameters such as frequency and density were clearly revealed. In this way, more comprehensive and reliable findings were obtained about the distribution, density and relationships of weed species in our study.

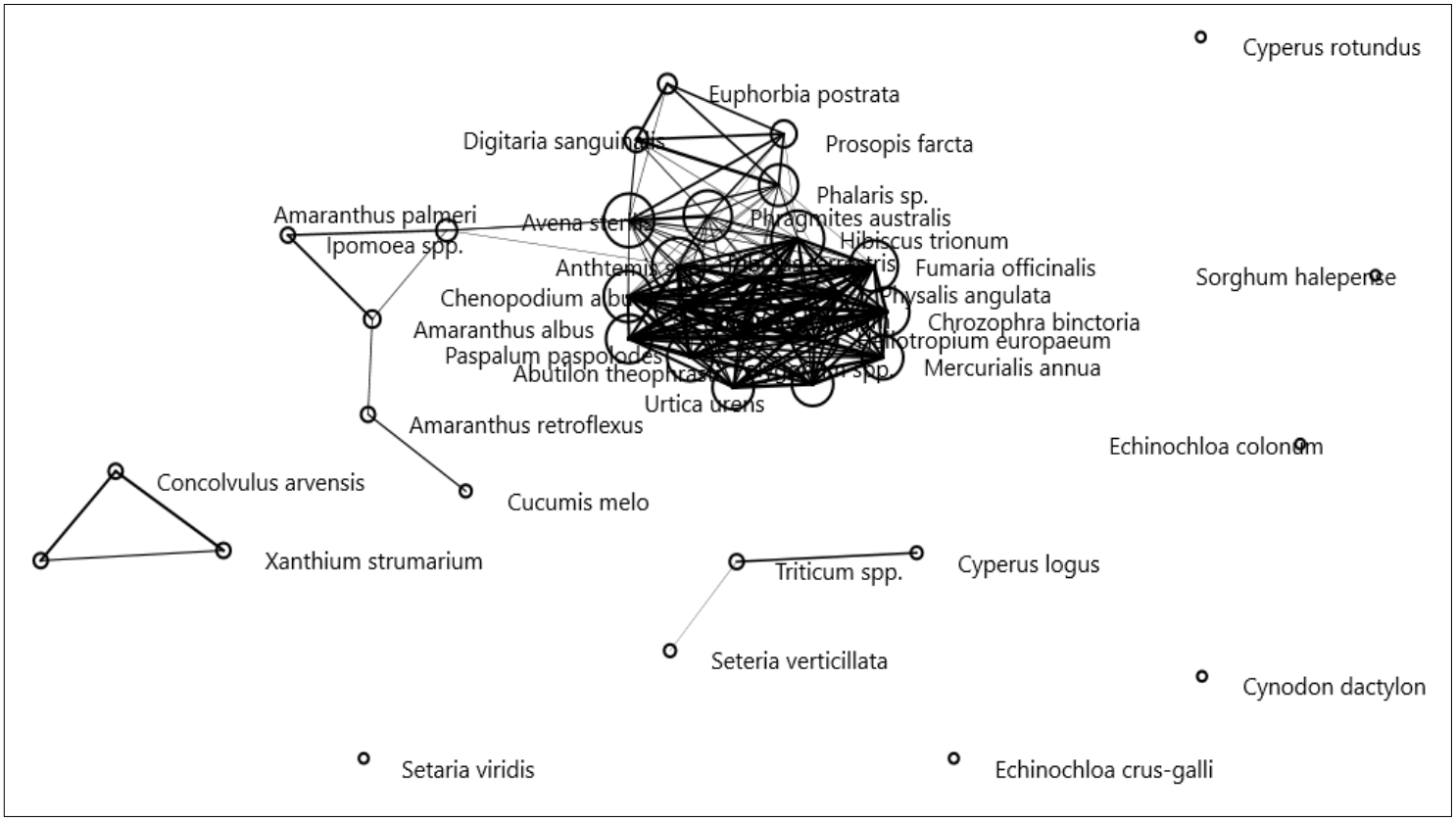

Figure 5.
Network graph analysis of weeds

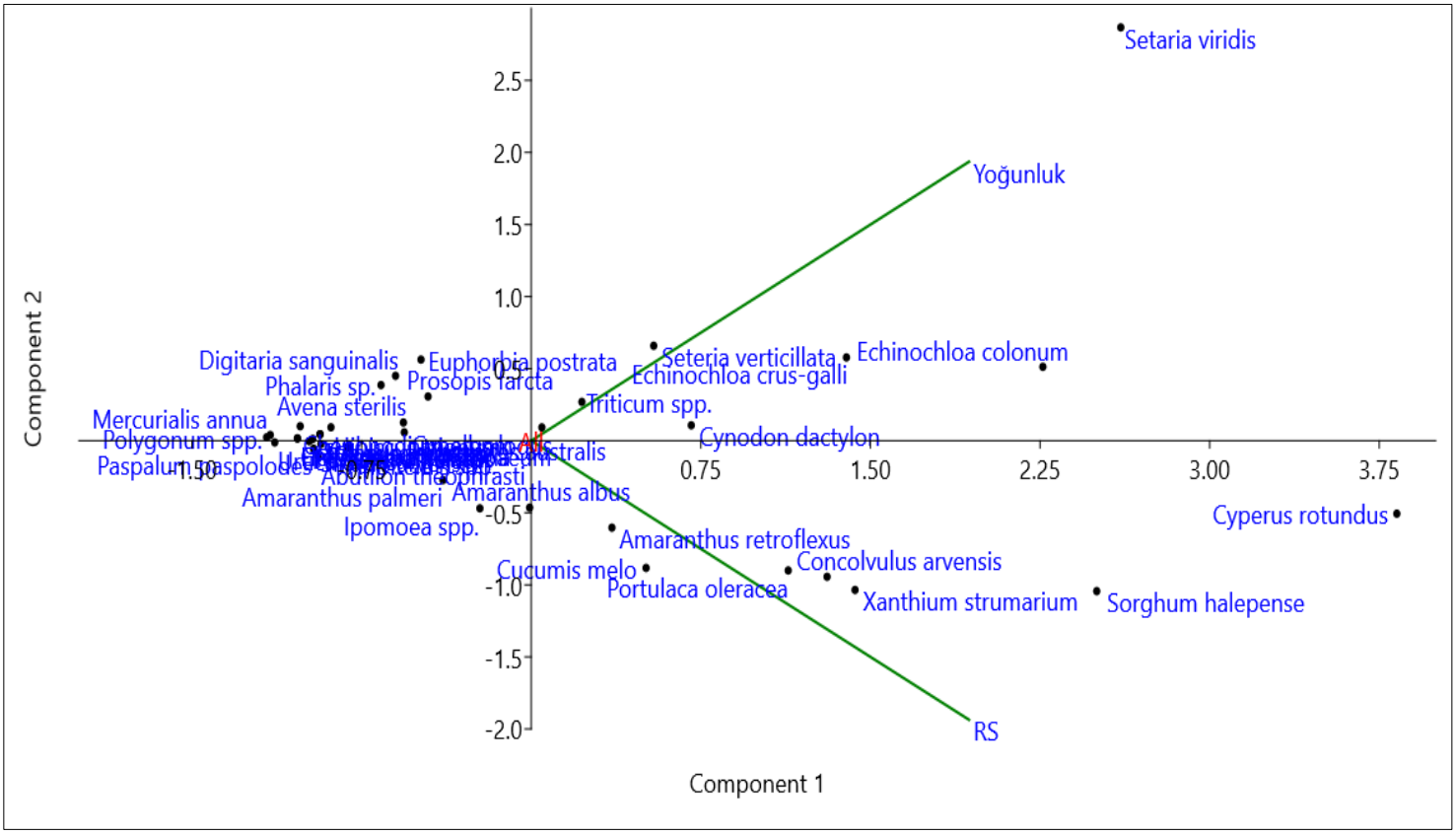

Figure 6.
Principal component analysis of weeds

Conclusion and Recommendations

This study was carried out to determine the frequency and density of weed species found in peanut cultivation areas in Adana province. As a result of the study, a total of 38 weed species belonging to 17 different families were determined, and it was seen that the majority of these species were from the Poaceae and Amaranthaceae families. In addition, the majority of the weeds detected in peanut cultivation areas were annual broad-leaved species. Evaluations based on frequency of occurrence and density data reveal that species such as *C. rotundus*, *S. viridis*, and *S. halepense* are the most common and dense weeds in the region. While *C. rotundus* and *E. colona* are dominant in the weed flora in the region with their very high frequency of occurrence, *S. viridis* draws attention with its high density value. As a result of the study, an integrated weed control method should be applied especially against the weed species detected intensively. The herbicides to be used should be carefully selected to avoid environmental factors and damage to other plant species. In areas where weeds are intensive, rotational farming practices are recommended instead of continuous cultivation of single-type products such as peanuts. These findings provide basic information for the development of effective weed control methods in peanut farming. In order to prevent yield loss, especially in important agricultural products such as peanuts, having information about the types and densities of weeds will help to spread more efficient and sustainable practices in agriculture. In addition, this study can guide local farmers to provide a more efficient production process by using correct and targeted control methods.

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