



Weed Diversity, Phytosociological Structure and Co-occurrence Patterns in Cereal Fields of the Sétif High Plateaus (Algeria)

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Abstract: Weeds constitute a major biotic constraint in rainfed cereal agroecosystems of semi-arid regions, where limited and irregular rainfall intensifies competition for water and nutrients. This study investigated weed diversity, phytosociological structure, and co-occurrence patterns in cereal fields of the Sétif High Plateaus (northeastern Algeria) based on repeated field surveys conducted over three consecutive growing seasons (2021/2022-2023/2024). A total of 353 quadrats (1 × 1 m) were sampled across 118 cereal fields covering 35 cereal-producing areas. Phytosociological parameters, including frequency, density, abundance, and the importance value index (IVI), were calculated for each species, and dominant weeds were identified using Two-Step cluster analysis. Weed assemblage organization was further examined using co-occurrence network analysis. The survey recorded 192 weed species belonging to 29 botanical families, dominated by Asteraceae, Fabaceae, and Poaceae, with annual species largely prevailing, reflecting adaptation to recurrent disturbance and semi-arid conditions. Marked differences in dominance patterns were observed among key weeds. *Sinapis arvensis* was highly frequent and widely distributed but showed moderate local abundance, *Bromus rigidus* exhibited high density and the highest Importance Value Index (IVI), reflecting its strong competitive dominance in the community. In contrast, *Avena sterilis* was less frequent but locally very abundant, forming dense and spatially heterogeneous infestations. Co-occurrence analysis revealed non-random weed assemblages, with *S. arvensis* and *Silybum marianum* displaying strong and recurrent associations. These findings highlight the importance of targeting weed communities rather than individual species and support integrated weed management strategies adapted to dryland cereal systems of northeastern Algeria.

Key words: Rainfed cereals, semi-arid agroecosystems, weed flora, phytosociological indices, co-occurrence network, integrated weed management.

The cultivation of cereals, particularly wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), holds a strategic place in Algerian agriculture, covering between 2.4 and 3.2 mha, which represents approximately 26% to 40% of the useful agricultural area (Meriem and Rafika, 2021; Allilouche and Bouchafaa, 2025). It constitutes an essential activity, particularly in semi-arid and arid zones where rainfall is limited and irregular, and where cereal cultivation represents the main source of food security and subsistence for family farms. In the wilaya of Sétif, the cultivation of cereal crops is particularly important due to the Mediterranean climatic conditions and suitable arable soils, making this region a strategic pillar for local and national food security (Taibi *et al.*, 2013; Bakhtache and Hadjene, 2023).

However, cereal production in Algeria is severely limited by both biotic and abiotic constraints. Among these constraints, weeds represent one of the most important biotic factors, as they directly compete with cereal crops for water, nutrients, light, and space. This competition leads to significant yield losses, which can reach up to 56% in dry areas and 38% in sub-humid areas (Hamadache, 2011; Kellil *et al.*, 2024). At the global scale, yield losses caused by weeds may range from 10% to 56%, depending on agroecological conditions (Matelionienè *et al.*, 2022).

Concept and role of phytosociological studies to understand the composition and dynamics of weed communities, phytosociological studies are a fundamental scientific tool. Phytosociology analyzes the floristic composition, structure, distribution, and dominance of plant species in relation to environmental factors and agricultural practices (Cano-Ortiz *et al.*, 2025). The use of phytosociological surveys allows for the quantification of parameters such as density, frequency, relative dominance, and the Importance Value Index (IVI) of species. Applied to cereal crops, this approach allows for the identification of dominant species and the evaluation of their competitive impact on cereal crops, thus providing a solid scientific basis for developing effective integrated pest management strategies (Chauhan *et al.*, 2015; Hussein *et al.*, 2025).

Although several studies have addressed weed flora in Algeria, comprehensive

phytosociological information at the scale of the Sétif region remains scarce, particularly for cereal fields. Floristic and ecological investigations on weeds have been conducted in various agroecosystems and regions of the country, including the plains of the interior zones under different cultural practices (Karkour, 2012), the Batna region (Hannachi, 2013), and orchard systems in northern Sétif (Benarab Haddouda, 2008). Other studies have focused on the dynamics of weed flora in relation to cropping systems and conservation agriculture, notably under no-till conditions and the effect of previous crops (Fortas *et al.*, 2021). Furthermore, research has also examined the impact of weeds on crop performance, such as their effects on morphological, agronomic, and allelopathic characteristics of durum wheat (*Triticum durum* Desf.) (Melakhessou, 2020).

However, most of these studies were based on punctual or short-term surveys and did not include continuous monitoring of weed communities in cultivated and fallow fields throughout their full growth cycle. In addition, several investigations were limited to specific crops or agroecosystems, which restricts a comprehensive understanding of weed community dynamics in cereal-based systems of the Sétif region.

The present study addresses this gap by providing a regional-scale phytosociological assessment based on repeated field surveys conducted across 35 cereal-growing areas in Sétif over three consecutive agricultural years (2021-2024), from October to June. This extensive spatial and temporal coverage allows for a robust evaluation of weed diversity, spatial distribution, density, frequency, and ecological importance, and provides a solid scientific basis for understanding weed community structure in semi-arid cereal agroecosystems.

The main objective of this study is to examine weed diversity and analyse the phytosociological composition of weed communities associated within cereal fields in Sétif region. Specifically, it aims to identify the dominant and prevalent species, evaluate their distribution patterns, density, frequency, and ecological importance, and generate scientific information to support the development of adapted integrated weed management strategies, thereby contributing to

improved cereal productivity and local food security.

In the dryland context of the Sétif High Plateaus, where rainfall is scarce and highly variable and crop performance is tightly governed by soil-plant-water interactions, weed communities can strongly amplify water stress by pre-empting limited soil moisture early in the season. Under increasing climatic variability, shifts in weed dominance and non-random co-occurrence patterns may further complicate control and reduce the efficiency of single-species or single-herbicide strategies. Therefore, the phytosociological and co-occurrence-based evidence generated in this study provides a dryland-relevant baseline to prioritize dominant weed complexes and to support climate-resilient, integrated weed management aimed at improving water-use efficiency and yield stability in arid and semi-arid cereal systems.

Materials and Methods

Spatial delineation of the study area and geographic stratification

Following the regional agro-ecological framework traditionally adopted for the Setif High Plains (Baldy, 1974; Lahmar, 1993; Djaouti, 2010; Rouabhi *et al.*, 2019), the study area was conceptually subdivided into three broad zones: northern, central and southern Sétif. This subdivision reflects well-established gradients in climate, topography and land use that characterize the province.

For operational purposes, and in order to consistently assign the 353 sampling quadrats to these zones, a coordinate-based geographic stratification was applied using latitude values recorded in the field with GPS. Quadrats located north of latitude 36.2° N were assigned to the northern zone, those between 36.132°N and 36.2°N to the central zone, and those south of 36.132° N to the southern zone. The recorded latitude values ranged from 35.836° N (minimum) to 36.439° N (maximum).

This spatial stratification was used exclusively to guide the sampling design, ensure balanced regional coverage and avoid spatial bias in the selection of cereal fields, rather than as a climatic or environmental explanatory factor. Accordingly, all phytosociological analyses were conducted on the pooled dataset at the

regional scale, without comparative analyses between zones.

Sampling and field surveys

The sampling design was conceived to prioritize regional representativeness of weed communities rather than an exhaustive characterization at the individual field scale. Each cereal field was therefore considered as an integrated sampling unit within a regional network covering a wide range of agro-climatic and topographic conditions across the Setif Province. This approach ensured a robust and comparable assessment of phytosociological parameters at the regional scale.

Field surveys were conducted repeatedly to inventory weed species and assess their phytosociological characteristics using the quadrat method, which is widely applied in vegetation studies (Clements, 1905; Odum, 1971). Each quadrat (1 × 1 m²) was considered an individual sampling unit and is hereafter referred to as a sampling site in the co-occurrence and network analyses. In each field, three to five quadrats were randomly placed at least 10-20 m from field borders to avoid edge effects. Although higher numbers of quadrats may be used for fine-scale vegetation analysis, this sampling intensity was considered appropriate for the objectives and spatial scale of the present regional study.

A total of 118 cereal fields were surveyed across 35 agricultural zones representing northern, central and southern Setif. Fields were selected along transects with a minimum distance of approximately 10 km between consecutive sites to reduce spatial autocorrelation. Surveys were carried out over three consecutive agricultural seasons (2021-2022, 2022-2023 and 2023-2024), covering the full weed life cycle from emergence to seed maturity (October-June). In total, 353 quadrats were inventoried across the study area.

Weed species identification

Weed species recorded during the phytosociological surveys were identified using standard floristic references for Algeria, North Africa and the Mediterranean region. Primary identification was based on the “Nouvelle Flore de l’Algérie et des Régions Désertiques Méridionales” by Quezel and Santa (1963), which remains the principal taxonomic reference

for Algerian flora. Additional confirmation was obtained using specialized manuals on cereal weeds, notably "Les mauvaises herbes des céréales d'hiver en Algérie" (ITGC, 1976).

To refine identification and resolve doubtful taxa, complementary floras were consulted, including the "Flore de France" (Guinochet and de Vilmorin, 1973) and the "Flore de l'Afrique du Nord" (Maire, 1957). Species nomenclature and taxonomic consistency were checked against authoritative botanical literature, following current taxonomic standards. This combined use of regional and Mediterranean floristic references ensured reliable identification of weed species across the study area.

Phytosociological parameters and data analysis

Within each quadrat (1 m²), all weed species, including dicotyledons and grasses, were identified and counted. Several phytosociological parameters were calculated to characterize the structure of weed communities, following classical phytosociological methodologies (Clements, 1905; Curtis and McIntosh, 1950; Oosting, 1956).

Frequency (F) expresses the distribution of a species within the sampled area and corresponds to the percentage of quadrats in which a given species occurs. It was calculated as the ratio between the number of quadrats in which the species was present and the total number of quadrats surveyed, multiplied by 100 (Oosting, 1956):

$F (\%) = (\text{Number of quadrats in which the species occurs} / \text{Total number of quadrats studied}) \times 100.$

Density (D) reflects the numerical importance of a species and represents the average number of individuals per unit area. It was calculated as the total number of individuals of a species recorded across all quadrats divided by the total number of quadrats studied (Curtis and McIntosh, 1950):

$D = \text{Total number of individuals of the species in all quadrats} / \text{Total number of quadrats studied}.$

Abundance (A) provides information on the mean number of individuals of a species in the quadrats where it occurs. It was determined by dividing the total number of individuals of a

species by the number of quadrats in which that species was present (Oosting, 1956):

$A = \text{Total number of individuals of the species in all quadrats} / \text{Number of quadrats in which the species occurred}.$

To allow comparison among species, relative values were calculated. Relative frequency (RF), relative density (RD), and relative abundance (RA) were obtained by expressing the frequency, density, and abundance of each species as a percentage of the sum of the corresponding parameter for all species (Curtis and McIntosh, 1950):

$RF (\%) = (\text{Frequency of a species} / \text{Sum of frequencies of all species}) \times 100,$

$RD (\%) = (\text{Density of a species} / \text{Sum of densities of all species}) \times 100,$

$RA (\%) = (\text{Abundance of a species} / \text{Sum of abundances of all species}) \times 100.$

Finally, the Importance Value Index (IVI) was calculated for each species as the sum of RF, RD, and RA, providing an integrated measure of the ecological importance and dominance of each species within the weed community (Curtis and McIntosh, 1950; Khan *et al.*, 2011a, 2011b):

$IVI = RF + RD + RA.$

This quadrat-based approach allowed for a standardized and comparable assessment of weed community structure across the study area.

Raw field data obtained from phytosociological surveys were first organized and processed using Microsoft Excel to calculate basic descriptive parameters, including totals, means and preliminary phytosociological indices. Subsequently, statistical analyses and species classification were performed using IBM SPSS Statistics for Windows, version 26.0.0.0. Although many weed species were recorded, only the most ecologically relevant and structurally dominant species were retained for detailed phytosociological analysis. Species were classified using the two-step cluster analysis based on frequency (F), density (D), and the Importance Value Index (IVI), which provides an objective classification suitable for large ecological datasets (Chiu *et al.*, 2001). This analysis generated three species groups, and the group with the highest F, D, and IVI

Table 1. Distribution of weed species and genera among botanical families and taxonomic groups (dicotyledons and monocotyledons) in the surveyed cereal fields

Taxonomic groups	Family	Number of species	Number of genera
Dicotyledons	Asteraceae	48	37
	Fabaceae	22	11
	Brassicaceae	15	13
	Apiaceae	10	9
	Papaveraceae	10	5
Monocotyledons	Poaceae	17	11

values was selected for detailed interpretation 33 species, whereas rare or sporadic species were excluded.

Results and Discussion

Weed diversity and floristic structure in cereal fields

Weed-crop competition represents a major ecological constraint in cereal agroecosystems, as weeds often emerge earlier than crops and exploit available resources more efficiently, thereby reducing crop performance through both above- and belowground interactions (Savić *et al.*, 2025). Understanding weed community structure is therefore essential for identifying the most influential species and improving weed management strategies.

The floristic survey highlighted a high weed species richness in the surveyed cereal fields, with a total of 192 species belonging to 29 botanical families and 135 genera. The distribution of weed species and genera varied markedly among botanical families (Table 1). Asteraceae was the most represented family, comprising 48 species distributed across 37 genera, followed by Fabaceae with 22 species and 11 genera, Poaceae with 17 species and 11 genera, and Brassicaceae with 15 species and 13 genera. Other families, such as Apiaceae (10 species, 9 genera) and Papaveraceae (10 species, 5 genera), showed moderate representation.

The dominance of Asteraceae in cereal weed communities reflects the strong ecological adaptability of this family to disturbed agroecosystems, supported by high plasticity and stress-tolerant adaptive traits that enhance establishment under challenging conditions (Rajbala, 2025). Similar Mediterranean agro-systems have reported Asteraceae as the most dominant family, followed by Poaceae and Fabaceae, confirming the major role of these

taxa in structuring weed assemblages (Eljebri *et al.*, 2025). The prominence of Poaceae is further explained by its global diversity and evolutionary success, partly linked to physiological innovations such as multiple independent origins of C4 photosynthesis, which may increase competitive ability in cereal fields (Huang *et al.*, 2022). Moreover, dominant weed taxa and their adaptive life-history traits are key drivers of weed community structure in agricultural areas (Chen *et al.*, 2024).

Overall, the predominance of dicotyledonous weeds (representing approximately 86% of the total recorded species) compared to monocotyledons (13.9%) is consistent with previous findings in cereal systems of northern Algeria and other Mediterranean regions (Abdelkrim, 1995; Balos, 2023; Santos *et al.*, 2024) (Table 1). The strong presence of annual species within these families suggests a high level of adaptation to recurrent agricultural disturbances and emphasizes the need for timely weed control measures targeting early growth stages. In terms of biological types, the flora was clearly dominated by annual weeds, with 153 annual species (about 80% of the recorded flora), whereas perennials and biennials were much less represented, accounting for 21 species (about 11%) and 18 species (about 9%), respectively (Fig. 1). This pattern is consistent with cereal agroecosystems exposed to frequent and recurrent disturbances such as tillage, weeding, and seasonal drought, which favor short-lived species able to complete their life cycle rapidly and maintain persistent soil seed banks. Under Mediterranean conditions, seed dormancy and the accumulation of annual seeds in the soil further contribute to the dominance of annual weeds (Gandía *et al.*, 2022). By contrast, perennial species depend on belowground storage organs for long-term persistence, which may be progressively weakened by repeated mechanical disturbance

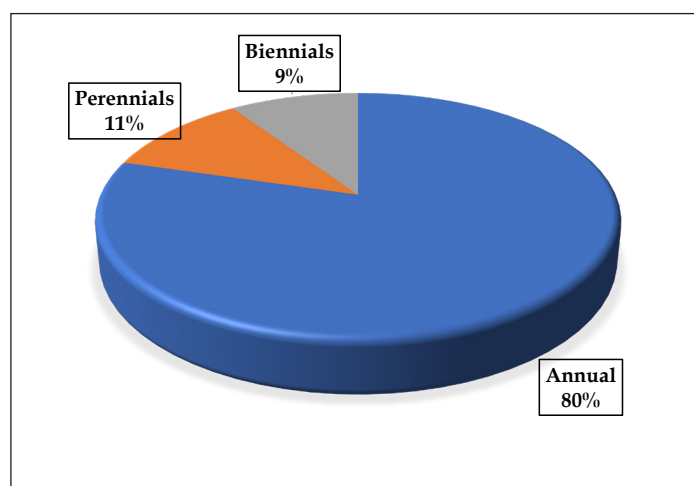


Fig. 1. Distribution of weed species according to their biological type in the surveyed cereal fields.

and control practices, reducing their competitive success in intensively managed fields (Weigel *et al.*, 2024). Biennials are also less frequent because their two-season life cycle makes them more vulnerable to interruption before flowering and seed production. Overall, recent evidence confirms that agricultural practices strongly shape weed community composition and tend to promote opportunistic annual taxa over longer-lived species (Esposito *et al.*, 2023).

Phytosociological structure and dominant weed species

Although a total of 192 weed species were recorded across the surveyed cereal fields, only a subset of species was retained for detailed phytosociological analysis. To identify the most ecologically relevant weeds, Species were classified using a Two-Step cluster analysis, based on key phytosociological indicators, namely frequency, density and the Importance Value Index (IVI). This classification resulted in three distinct species groups.

The Two-Step classification identified three weed groups with contrasting phytosociological importance (Supplementary Information). Cluster 1, which contained the largest number of species, included weeds such as *Anchusa italica* Retz., *Vaccaria hispanica* (Mill.) Rauschert, *Picnemon acarna* (L.) Cass., and *Eruca vesicaria* (L.) Cav., generally showing comparatively low values of frequency, density and IVI. In contrast, Class 2 comprised ecologically important weeds, including *Convolvulus arvensis* L., *Anacyclus clavatus* (Desf.) Pers., and *Scolymus hispanicus* L., characterized by relatively high phytosociological values and

a wider spatial distribution. Class 3, despite being the smallest group, gathered the most dominant and agronomically significant weeds, namely *Sinapis arvensis* L., *Silybum marianum* (L.) Gaertn., *Bromus rigidus* Roth, *Avena sterilis* L., and *Papaver rhoeas* L., which exhibited the highest frequency, density and/or IVI values, reflecting a strong contribution to weed community structure.

Figure 2 further refines this classification by jointly presenting cluster size and the relative contribution of the phytosociological variables used for clustering. Although Class 1 included most of the recorded species (82.8%), it was characterized by very low mean values of frequency (0.01), density (0.07) and IVI (0.69), indicating limited ecological and agronomic impact. In contrast, Classes 2 and 3, despite their smaller sizes, showed a clear and progressive increase in all variables, with particularly high values in Class 3 (frequency = 0.26, density = 4.53 and IVI = 11.73), reflecting the dominance and competitive strength of the species within this group. Overall, these results demonstrate that weed community structure is driven primarily by a limited number of highly influential species rather than by overall species richness, emphasizing the need to prioritize management efforts toward the most phytosociologically dominant weed groups.

The phytosociological analyses presented in this study focused on the 33 species belonging to Classes 2 and 3, which together represent the dominant and most influential weed taxa in the cereal-growing plains of Sétif. This approach allowed the analysis to concentrate on species

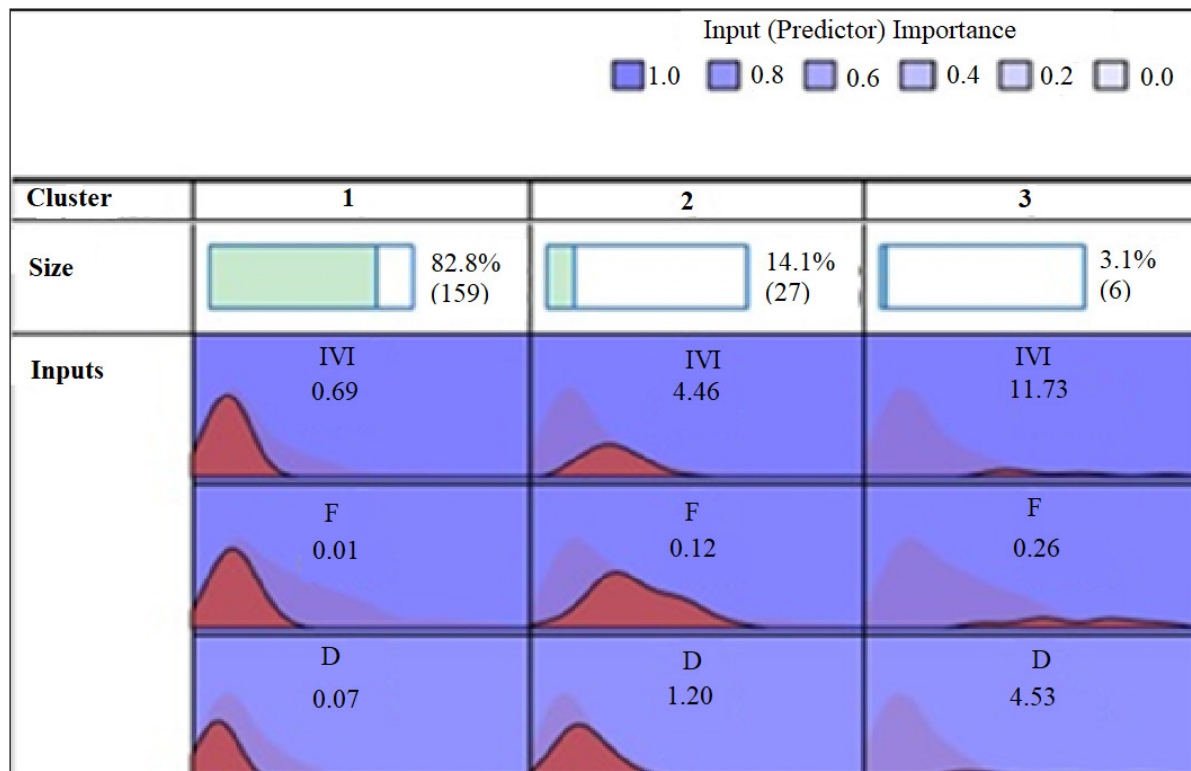


Fig. 2. Cluster structure and differential contribution of phytosociological variables (frequency, density and IVI) to weed species classification derived from the Two-Step cluster analysis.

with the greatest ecological relevance and management implications, while avoiding dilution of results by rare or incidental species (Table 2).

Beyond floristic composition, phytosociological indices provided deeper insight into weed community structure (Table 2). Relative frequency (RF) revealed marked differences in species spatial distribution across the sampled fields. *Sinapis arvensis* (RF = 5.43), *Silybum marianum* (L.) Gaertn. (RF = 4.60), and *Bromus rigidus* (RF = 4.23) were the most widely distributed species, occurring in a large proportion of the surveyed quadrats. High frequency values indicate broad spatial occurrence and suggest strong ecological adaptability to the prevailing environmental and management conditions.

However, as previously emphasized, reliance on frequency-based metrics, including relative frequency, alone is highly sensitive to sampling design and spatial heterogeneity and may overrepresent widespread species while underestimating locally concentrated taxa (Bonham, 2013; Nkoa *et al.*, 2015; Blank *et al.*, 2020).

The present results indicate that high relative frequency does not necessarily translate into high ecological importance. For example, *Sinapis arvensis* exhibited the highest frequency (F = 0.37; RF = 5.43) but only moderate density (D = 4.14) and abundance (A = 11.08), resulting in a moderate IVI value (12.16). This pattern reflects a wide but sparse distribution, indicating broad dispersal rather than strong local aggregation.

In contrast, *Bromus rigidus* showed a lower frequency (F = 0.29; RF = 4.23) but the highest density (D = 8.83) and high abundance (A = 30.25), leading to the highest IVI value (19.11). Similarly, *Avena sterilis*, despite its relatively low frequency (F = 0.14; RF = 1.97), exhibited very high abundance (A = 45.52) and density (D = 6.19), resulting in a high IVI value (14.31). These contrasting patterns confirm that weed species distribution within cereal fields is spatially heterogeneous and often patchy, as reported by Blank *et al.* (2020) and Cordeau *et al.* (2022).

Based on the combined interpretation of relative frequency and importance value index, weed species in the studied fields can be grouped into distinct ecological categories. The first

Table 2. Phytosociological attributes of weeds in cereal crops in Sétif

Weed species	TQ	TQI	TNI	F	A	D	RF	RA	RD	IVI
<i>Anacyclus clavatus</i> (Desf.) Pers.	353	73	503	0.21	6.89	1.42	3	0.54	2.02	5.56
<i>Avena sterilis</i> L.	353	48	2185	0.14	45.52	6.19	1.97	3.58	8.76	14.31
<i>Bromus rigidus</i> Roth	353	103	3116	0.29	30.25	8.83	4.23	2.38	12.5	19.11
<i>Bunium pachypodium</i> P. W. Ball	353	67	625	0.19	9.33	1.77	2.75	0.73	2.51	5.99
<i>Calendula arvensis</i> (Vaill.) L.	353	57	617	0.16	0.82	1.75	2.34	0.85	2.47	5.67
<i>Carthamus pinnatus</i> Desf.	353	41	343	0.12	8.37	0.97	1.69	0.66	1.38	3.72
<i>Colchicum filifolium</i> (Cambess.) Stef.	353	2	105	0.01	52.5	0.3	0.08	4.12	0.42	4.63
<i>Convolvulus arvensis</i> L.	353	67	514	0.19	7.67	1.46	2.75	0.6	2.06	5.42
<i>Coronilla scorpioides</i> (L.) W.D.J. Koch	353	32	166	0.09	5.19	0.47	1.32	0.41	0.67	2.39
<i>Erodium cicutarium</i> (L.) L'Hér.	353	27	185	0.08	6.85	0.52	1.11	0.54	0.74	2.39
<i>Fumaria parviflora</i> Lam.	353	64	578	0.18	9.03	1.64	2.63	0.71	2.32	5.66
<i>Galium tricornutum</i> Dandy	353	78	921	0.22	11.81	2.61	3.21	0.93	3.69	7.83
<i>Hordeum murinum</i> L. subsp. <i>leporinum</i> (Link) Arcang.	353	21	992	0.06	47.24	2.81	0.86	3.71	3.98	8.55
<i>Hypocoum procumbens</i> L.	353	29	180	0.08	6.21	0.51	1.19	0.49	0.72	2.4
<i>Lactuca serriola</i> L.	353	30	285	0.08	9.5	0.81	1.23	0.75	1.14	3.12
<i>Launaea nudicaulis</i> (L.) Hook.	353	61	498	0.17	8.16	1.41	2.51	0.64	2	5.15
<i>Lolium rigidum</i> Gaudin	353	53	889	0.15	16.77	2.52	2.18	1.32	3.57	7.06
<i>Malva parviflora</i> L.	353	55	192	0.16	3.49	0.54	2.26	0.27	0.77	3.3
<i>Medicago polymorpha</i> L.	353	55	460	0.16	8.36	1.3	2.26	0.66	1.84	4.76
<i>Melilotus sulcatus</i> Desf.	353	22	357	0.06	16.23	1.01	0.9	1.27	1.43	3.61
<i>Onopordum macracanthum</i> Schousb.	353	37	114	0.1	3.08	0.32	1.52	0.24	0.46	2.22
<i>Papaver rhoeas</i> L.	353	73	956	0.21	13.1	2.71	3	1.03	3.83	7.86
<i>Polygonum aviculare</i> L.	353	40	653	0.11	16.33	1.85	1.64	1.28	2.62	5.55
<i>Ranunculus arvensis</i> L.	353	26	452	0.07	17.38	1.28	1.07	1.37	1.81	4.25
<i>Reseda alba</i> L.	353	30	237	0.08	7.9	0.67	1.23	0.62	0.95	2.8
<i>Scandix pecten-veneris</i> L.	353	43	650	0.12	15.12	1.84	1.77	1.19	2.61	5.56
<i>Scolymus hispanicus</i> L.	353	85	371	0.24	4.36	1.05	3.49	0.34	1.49	5.32
<i>Silene vulgaris</i> (Moench.) Garcke	353	14	282	0.04	20.14	0.8	0.58	1.58	1.13	3.29
<i>Silybum marianum</i> (L.) Gaertn.	353	112	958	0.32	8.55	2.71	4.6	0.67	3.84	9.12
<i>Sinapis arvensis</i> L.	353	132	1463	0.37	11.08	4.14	5.43	0.87	5.87	12.16
<i>Sonchus asper</i> (L.) Hill.	353	38	158	0.11	4.16	0.45	1.56	0.33	0.63	2.52
<i>Veronica hederifolia</i> L.	353	43	909	0.12	21.14	2.58	1.77	1.66	3.65	7.07
<i>Vicia monantha</i> Retz.	353	34	160	0.1	4.71	0.45	1.4	0.37	0.64	2.41

TQ, Total no. of quadrats; TQI, Total no. of occurrence of individual species; TNI, Total no. of individual species in all quadrats in which the species occur.

group includes species that are widespread but moderately important, such as *Sinapis arvensis*, which exhibited high relative frequency but only moderate IVI values, reflecting broad distribution with limited local aggregation. A second group comprises species that are both widespread and highly important, exemplified by *Bromus rigidus*, which combined relatively high frequency with the highest IVI value, indicating wide occurrence coupled with strong local abundance. A third group includes species

that are less widespread but locally abundant and ecologically important, such as *Avena sterilis*, which showed comparatively low relative frequency but high IVI values due to dense local populations.

Similar contrasts between widespread species and locally abundant but ecologically influential taxa have been reported in recent weed community studies, although the specific grouping observed here is derived from the

present dataset (Fried *et al.*, 2021; Cordeau *et al.*, 2022).

The analysis of weed species in the surveyed cereal fields revealed notable variation in both abundance (A) and relative abundance (RA). The highest abundance value was recorded for *Colchicum filifolium* (Cambess.) Stef. (A = 52.50), followed by *Hordeum murinum* L. subsp. *leporinum* (A = 47.24) and *Avena sterilis* L. (A = 45.52), and then *Bromus rigidus* Roth (A = 30.25), indicating that these species formed dense local populations in the quadrats where they occurred. However, relative abundance (RA), which reflects the proportional contribution of each species to the overall weed community, showed a different pattern. *Colchicum filifolium* exhibited the highest RA (4.12), followed by *Hordeum murinum* subsp. *leporinum* (RA = 3.71) and *Avena sterilis* (RA = 3.58), highlighting their strong contribution to community-level composition. Other species such as *Bromus rigidus* (RA = 2.38), *Veronica hederifolia* L. (RA = 1.66), *Silene vulgaris* (Moench.) Garcke (RA = 1.58), and *Papaver rhoeas* L. (RA = 1.03) also contributed substantially, whereas species including *Onopordum macracanthum* Schousb. (RA = 0.24) and *Coronilla scorpioides* (L.) W.D.J. Koch (RA = 0.41) showed low representation across fields. Overall, these results indicate that high local abundance does not necessarily imply the highest community-level contribution, emphasizing the distinction between local infestation intensity and overall weed community structure.

Similar discrepancies between local abundance and community-level representation have been reported in wheat systems in Pakistan (Yousaf *et al.*, 2021) and China (Chen *et al.*, 2025), underscoring the importance of distinguishing between local infestation intensity and overall community structure. Comparable patterns were also documented in Algerian cereal fields, where weed community composition differed between wheat and barley, highlighting crop-related variability in weed assemblages (Kellil *et al.*, 2024). Such evidence supports the need to integrate several phytosociological indicators for a reliable interpretation of weed communities. Furthermore, these patterns can be explained by niche-based processes mediated by functional traits and ecological specialization. Regional frequency of arable weeds may be indirectly driven by traits associated with specialization

to arable habitats (e.g., high requirements for light and nitrogen), whereas local abundance is more directly determined by traits related to rapid resource acquisition and growth (Fried *et al.*, 2021).

In this context, *Sinapis arvensis* and *Silybum marianum* combine broad ecological tolerance with strong specialization to disturbed agricultural environments, promoting wide spatial distribution and high frequency despite moderate local abundance. Abundant grass weeds such as *Bromus rigidus* and *Avena sterilis* display trait syndromes associated with rapid growth and efficient resource use, characteristic of ruderal strategies adapted to frequent agricultural disturbance (Fried *et al.*, 2021).

These traits allow *Bromus rigidus* to combine widespread occurrence with high local abundance, resulting in both high relative frequency and the highest IVI. Overall, these findings demonstrate that reliance on relative frequency alone may lead to an incomplete or misleading interpretation of weed community structure. Integrating relative frequency with density, abundance, and the importance value index (IVI) provides a more comprehensive and ecologically meaningful assessment of weed assemblages. This integrative approach improves the identification of the most influential weed species and enhances the reliability of weed management prioritization in cereal cropping systems.

In the cereal-producing areas of northeastern Algeria, weed control relies mainly on selective herbicides, complemented by mechanical or manual weeding and cropping system management such as crop rotation. Integrated weed management, combining preventive measures, cultivation techniques, and mechanical, biological and chemical controls, is generally considered more effective and profitable than relying on a single method (Tanji, 2005; Rodriguez and Gasquez, 2008; Santín-Montanyá *et al.*, 2013). However, herbicide-based control remains the dominant strategy in cereal agroecosystems, which may drive shifts in weed composition and contribute to the emergence of resistant genotypes (Coble and Schroeder, 2016; Stankiewicz-Kosyl *et al.*, 2020; Kellil *et al.*, 2024). Such management pressure may partly explain the dominance

of highly competitive weeds such as *Bromus rigidus* and highlights the value of combining phytosociological indicators (RF, RD, RA and IVI) to better prioritize weed management actions.

Integrated analysis of weed co-occurrence and network patterns in cereal fields

The chord diagram and co-occurrence heatmap collectively reveal complex ecological networks and spatial associations among the ten most frequent weed species across 353 quadrats (sampling sites) in cereal fields, providing additional insight into weed community structure and potential management constraints. The thickness of the links in the chord diagram reflects the intensity of shared quadrat occurrences, with *Sinapis arvensis* (131 quadrats) and *Silybum marianum* (112 quadrats) emerging as the most widespread species (Fig. 3). The heatmap further quantifies pairwise co-occurrences, showing that these two species co-occurred in 49 quadrats, representing the strongest association observed among the dominant taxa (Fig. 4).

The overall network structure suggests that weed assemblages in these cereal fields are not randomly distributed, but rather exhibit recurrent patterns of co-occurrence that likely

reflect shared ecological requirements and similar responses to agricultural disturbance. Such non-random spatial organization and structured associations among arable plant species have been previously reported in cultivated fields, indicating that weed communities tend to form consistent assemblages across sampling units rather than occurring independently (Borgy *et al.*, 2012).

Bromus rigidus (103 quadrats) and *Scolymus hispanicus* (85 quadrats) occupied intermediate positions in both prevalence and connectivity, potentially acting as frequent components linking several mixed-species assemblages. In addition, *Anacyclus clavatus* (72 quadrats) and *Galium tricornerutum* (78 quadrats), despite lower overall prevalence, displayed consistent associations with multiple other species (36-38 shared quadrats in the heatmap), suggesting that they may represent persistent members of these weed communities.

From an agronomic perspective, mixed weed populations can impose substantial competitive pressure on cereal crops. Uncontrolled weed infestations may considerably reduce cereal yields by competing with crops for essential resources such as light, water, and nutrients, and by interfering with crop development, resulting in substantial yield losses under field

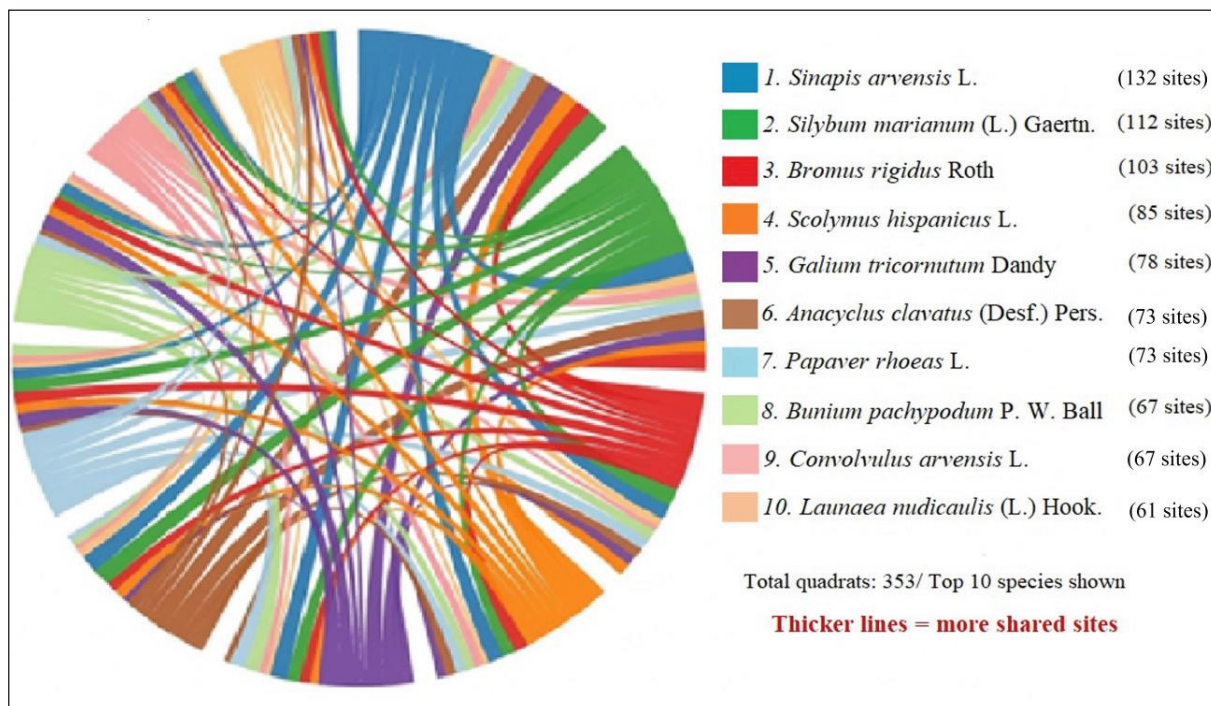


Fig. 3. Weed species co-occurrence network.

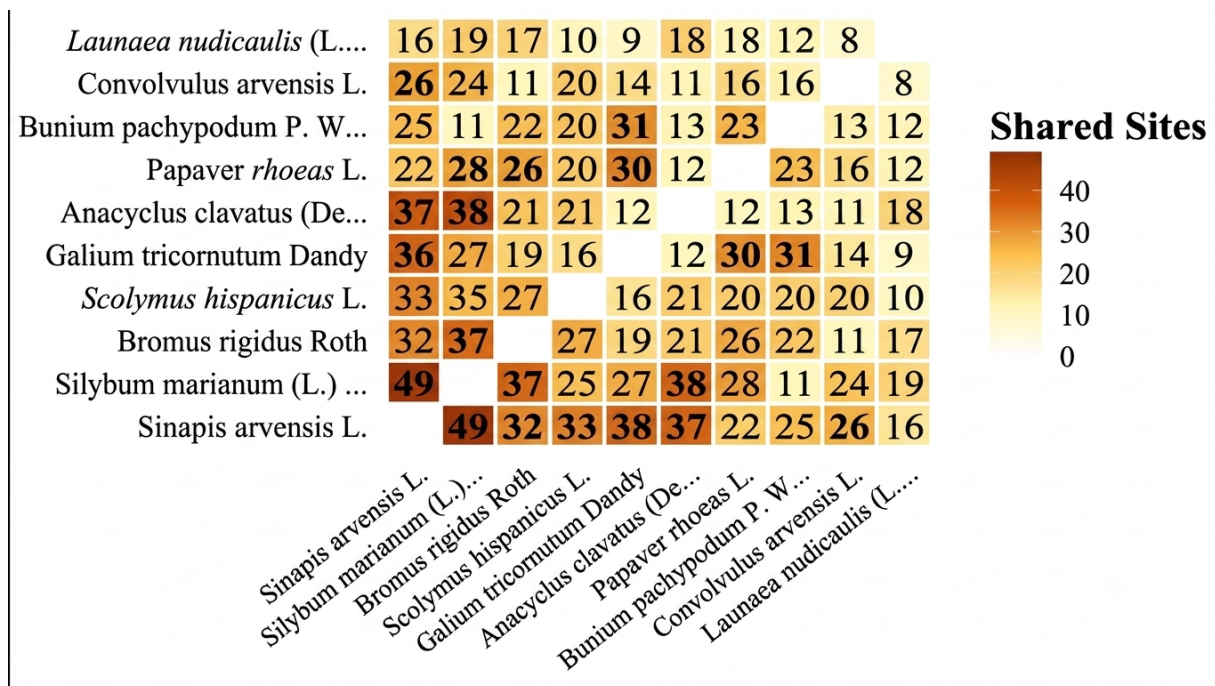


Fig. 4. Co-occurrence heatmap of the top ten weed species.

conditions (da Silva *et al.*, 2020), particularly when several dominant species co-occur within the same fields (Oerke, 2006). Species-specific impacts have also been reported, with *Sinapis arvensis* capable of causing notable yield reductions in wheat (Zimdahl, 2018). Similarly, *Convolvulus arvensis*, recorded in 65 quadrats and showing multiple co-occurrence links, is widely recognized as a highly competitive perennial weed due to its extensive root system and smothering growth habit (Wiese and Binning, 1987).

These network patterns further suggest that controlling individual species in isolation may be insufficient, as suppression of one dominant taxon may facilitate competitive release of co-occurring weeds and shifts in community composition. Such limitations have been documented in Mediterranean cereal systems, where simplified or single-herbicide strategies did not sustainably prevent yield losses (Barros *et al.*, 2018). Moreover, the co-occurrence of grass weeds such as *Bromus rigidus* with diverse broadleaf taxa may complicate management, as it often requires combining grass-selective and broadleaf herbicides, while also considering the risk of herbicide resistance in species such as *Papaver rhoeas* (Cirujeda *et al.*, 2019).

Beyond yield losses, weed infestations can also negatively affect grain quality by

increasing contamination, promoting moisture retention that favors fungal development, and complicating harvesting operations, which ultimately reduce grain marketability (Wilson *et al.*, 2016; Wawrzyniak, 2021).

The central position of *Sinapis arvensis* and *Silybum marianum*, evidenced by their high occurrence and strong co-occurrence links, indicates that they should be priority targets for management interventions, as their suppression may contribute to destabilizing associated weed assemblages and reducing overall weed pressure. Overall, the high level of co-occurrence among dominant weeds suggests that cereal fields may face simultaneous competition from multiple species, increasing weed pressure and reinforcing the need for integrated long-term control strategies combining herbicide rotation, competitive crop stands, mechanical control, and crop diversification, rather than reliance on reactive chemistry alone (Travlos, 2012).

Conclusions

This study provides a regional-scale assessment of weed diversity and community structure in cereal fields of the Sétif High Plains. A total of 192 weed species were recorded, dominated by annual dicotyledons and mainly represented by Asteraceae, Fabaceae and Poaceae. Phytosociological analysis showed

contrasting dominance patterns, with *Sinapis arvensis* being widespread but moderately abundant, *Bromus rigidus* combining high frequency and high IVI, and *Avena sterilis* forming dense local patches despite lower frequency. Co-occurrence analysis revealed non-random weed assemblages, indicating that management should target weed communities rather than single species. These findings support integrated weed management through crop rotation, competitive crop stands, and herbicide mode-of-action rotation to reduce weed pressure and resistance risks. In the semi-arid context of the Sétif High Plains, characterized by rainfall variability and recurrent water stress, these dominance and co-occurrence patterns highlight the strong role of dryland conditions in shaping weed community structure and competitive interactions with crops. Consequently, integrating weed community ecology into dryland crop management is essential to improve water-use efficiency and enhance yield stability under increasing climatic variability. Future research should link weed patterns to agronomic practices and monitor long-term shifts in dominant weed complexes.

References

- Abdelkrim, H. 1995. Contribution à la connaissance des mauvaises herbes des cultures du secteur algérois: Approches syntaxonomique et morphologique. *Thèse de Doctorat*, Université Paris-Sud, Orsay, France, 151 p.
- Allilouche, A. and Bouchafaa, B. 2025. Analysis of the performance of cereal farms based on durum wheat production cost estimates in the Algerian Highlands. *Agricultural Science Digest* 44(1): 53-57.
doi:10.18805/ag.DF-743
- Baldy, C. 1974. *Étude fréquentielle du climat. Influence sur la production des zones céréalières en Algérie*. Document MARA, 52 p.
- Balos, M.M. 2023. Determination of weeds and their floristic investigation in vineyards in some districts of Şanlıurfa (Turkey). *International Journal of Nature and Life Sciences* 7(2): 1-17.
- Barros, J.F.C., et al. 2018. Weed diversity and community structure in Mediterranean cereal fields. *Agriculture, Ecosystems and Environment* 251: 348-356.
- Benarab Haddouda, B. 2008. *Contribution à l'étude des mauvaises herbes des vergers de la région nord de Sétif*. Mémoire de Magister, Université Ferhat Abbas, Sétif, Algérie.
- Blank, L., Rozenberg, G. and Gafni, R. 2020. Spatial and temporal aspects of weeds distribution within agricultural fields - A review. *Crop Protection* 134: 105161.
doi:10.1016/j.cropro.2020.105161
- Bonham, C.D. 2013. *Measurements for Terrestrial Vegetation*. 2nd ed. Wiley-Blackwell, Oxford.
- Borgy, B., Gaba, S., Petit, S. and Reboud, X. 2012. Non-random distribution of weed species abundance in arable fields. *Weed Research* 52(5): 383-389.
doi:10.1111/j.1365-3180.2012.00920.x
- Cano-Ortiz, A., Musarella, C.M. and Cano, E. 2025. Phytosociological research and meaningful learning: Constructivist approaches for teaching vegetation. *Diversity* 17(3): 172.
doi:10.3390/d17030172
- Chauhan, B.S., Mahajan, G. and Abugho, S. 2015. Phytosociological analysis of major weeds in paddy fields: Methodology and applications. *Advances in Plants & Agriculture Research* 7(2): 00248.
doi:10.15406/apar.2017.07.00248
- Chen, G., Huang, Z., An, K., Chen, Y. and Xue, J. 2024. Diversity and life history traits of native weed communities in agricultural areas: A case study in Eastern China. *Biology* 13(9): 704.
doi:10.3390/biology13090704
- Chen, G., Huang, Z., Xue, J., Zhu, F., Chen, Y. and Wu, Y. 2025. Succession of weed community on wheat lands in the past 25 years: A case study in Eastern China. *Biology* 14(8): 943.
doi:10.3390/biology14080943
- Chiu, T., Fang, D., Chen, J., Wang, Y. and Jeris, C. 2001. A robust and scalable clustering algorithm for mixed type attributes in large database environments. *Proceedings of the Seventh ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, pp. 263-268.
- Cirujeda, A., et al. 2019. Herbicide resistance in *Papaver rhoeas* populations from Spanish cereal fields. *Crop Protection* 119: 134-140.
- Clements, F.E. 1905. *Research Methods in Ecology*. University Publishing Company, Lincoln.
- Coble, H.D. and Schroeder, J. 2016. Call to action on herbicide resistance management. *Weed Science* 64(1): 661-666.
doi:10.1614/WS-D-15-00032.1
- Cordeau, S., Baudron, A., Busset, H., Adeux, G., et al. 2022. Legacy effects of contrasting long-term integrated weed management systems. *Frontiers in Agronomy* 3: 769992.
doi:10.3389/fagro.2021.769992
- Curtis, J.T. and McIntosh, R.P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* 31: 434-455.

- da Silva, E.M.G., de Aguiar, A.C.M., Mendes, K.F. and da Silva, A.A. 2022. Weed competition and interference in crops. In: Mendes, K.F. and da Silva, A.A. (eds), *Applied Weed and Herbicide Science*. Springer, Cham.
doi:10.1007/978-3-031-01938-8_2
- Djaouti, M. 2010. *Renforcement des capacités des acteurs de la filière céréales en Algérie dans le cadre d'un partenariat Nord-Sud. Cas de la wilaya de Sétif*. Dissertation, CIHEAM-IAM Montpellier, France.
- Eljebri, S., Bouskout, M., Ouahmane, L., et al. 2025. Floristic diversity and ecological characteristics of weeds in irrigated agro-system with a Mediterranean climate. *Vegetos* 38: 883-899.
doi:10.1007/s42535-024-00834-2
- Esposito, M., Westbrook, A.S., Maggio, A., Cirillo, V. and DiTommaso, A. 2023. Neutral weed communities: The intersection between crop productivity, biodiversity, and weed ecosystem services. *Weed Science* 71(4): 301-311.
doi:10.1017/wsc.2023.27
- Fortas, B., Rouabhi, A. and Mekhlouf, A. 2021. Study of the effect of different types of previous crops on the dynamics of the weed flora under no-till condition in Algeria. *Egyptian Journal of Agronomy* 43(3): 379-390.
- Fried, G., Armengot, L., Storkey, J., Bourgeois, B., Gaba, S., Violle, C. and Munoz, F. 2021. Do ecological specialization and functional traits explain the abundance-frequency relationship? Arable weeds as a case study. *Journal of Biogeography* 48(1): 37-50.
doi:10.1111/jbi.13980
- Gandía, M.L., Del Monte, J.P. and Santín-Montanyá, M.I. 2022. Efficiency of methodologies used in the evaluation of the weed seed bank under Mediterranean conditions. *Agronomy* 12(1): 138.
doi:10.3390/agronomy12010138
- Guinochet, M. and De Vilmorin, R. 1973. *Flore de France*. Éditions du Centre National de la Recherche Scientifique, Paris, 366 p.
- Hamadache, A. 2011. *Éléments de phytotechnie générale : le blé*. 1ère éd. ITGC, Algérie, 256 p.
- Hannachi, A. 2013. Étude floristique et écologique des mauvaises herbes des cultures de la région de Batna (Algérie). *Revue Agriculture UFAS-Sétif*, janvier 2013.
- Huang, W., Zhang, L., Columbus, J.T., Hu, Y., Zhao, Y., Tang, L., Guo, Z., Chen, W., McKain, M., Bartlett, M., Huang, C.-H., Li, D.-Z., Ge, S. and Ma, H. 2022. A well-supported nuclear phylogeny of Poaceae and implications for the evolution of C4 photosynthesis. *Molecular Plant* 15(4): 583-598.
doi:10.1016/j.molp.2022.01.015
- Hussein, E.A., Abd El-Ghani, M.M., Šilc, U. and Shalabi, L.F. 2025. Importance of environmental factors and crop type on weed diversity associated with cereals in Egypt. *Hacquetia* 24(1): 41-55.
doi:10.3986/hacq-2025-0008
- ITGC 1976. *Les mauvaises herbes des céréales d'hiver en Algérie*. Institut Technique des Grandes Cultures, Algeria, 150 p.
- Karkour, L. 2012. *La dynamique des mauvaises herbes sous l'effet des pratiques culturales dans la zone des plaines intérieures*. Mémoire de Magister, Université Ferhat Abbas, Sétif, Algérie.
- Kellil, H., Mohguen, K., Ouldammam, H., Hamdaoui, N. and Zeraoulia, N. 2024. Diversity of weeds associated with wheat and barley crops under tillage in a semi-arid climate (Eastern Algeria). *Tropical Agriculture (Trinidad)* 101(4): 431-444.
- Khan, I.A., Ullah, Z., Hassan, G., Marwat, K.B., Jan, A., Shah, S.M.A. and Khan, S.A. 2011a. Impact of different mulches on weed flora and yield of maize. *Pakistan Journal of Botany* 43: 1601-1602.
- Khan, S.M., Harper, D.M., Page, S. and Ahmad, H. 2011b. Residual value analyses of the medicinal flora of the Western Himalayas: The Naran Valley, Pakistan. *Pakistan Journal of Botany* 43: 97-104.
- Lahmar, R. 1993. Intensification céréalière dans les hautes plaines sétifiennes : quelques résultats. *Cahiers Options Méditerranéennes* 2: 93-97.
- Maire, R. 1957. *Encyclopédie biologique. Flore de l'Afrique du Nord*. Vol. VI. Éditions Paul Lechevalier, Paris, 170 p.
- Matelionienè, N., Supronienè, S., Shamshitov, A., Zavtrikovienè, E., Janavičienè, S. and Kadžienè, G. 2022. Weeds in cereal crop rotations may host *Fusarium* species that cause Fusarium head blight and grain weight losses in wheat. *Agronomy* 12(11): 2741.
doi:10.3390/agronomy12112741
- Melakhessou, Z. 2020. *Étude de l'effet des mauvaises herbes sur les caractéristiques morphologiques, agronomiques et leurs pouvoirs allélopathiques sur le blé dur (Triticum durum Desf.)*. Thèse de Doctorat en Sciences Agronomiques, Université Ferhat Abbas, Sétif, Algérie.
- Meriem, H. and Rafika, L. 2021. Effectiveness of herbicides on the weed flora of winter cereals in the region of Sétifian high plains, Algeria. *Plant Cell Biotechnology and Molecular Biology* 22(13-14): 63-72.
- Nkoa, R., Owen, M.D.K. and Swanton, C.J. 2015. Weed abundance, distribution, diversity, and community analyses. *Weed Science* 63(SP1): 64-90.
doi:10.1614/WS-D-13-00075.1
- Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Saunders Company, Philadelphia, London, Toronto, 574 p.

- Oerke, E.C. 2006. Crop losses to pests. *Journal of Agricultural Science* 144(1): 31-43.
- Oosting, H.J. 1956. *The Study of Plant Communities: An Introduction to Plant Ecology*. 2nd ed. W.H. Freeman and Company, London, pp. 383-411.
- Quezel, P. and Santa, S. 1963. *Nouvelle flore de l'Algérie et des régions désertiques méridionales*. Éditions du CNRS, Paris.
- Rajbala 2025. Study on adaptive strategies found in family Asteraceae for better survival. *International Journal of Botany Studies* 10(5): 47-51.
- Rodriguez, A. and Gasquez, J. 2008. Gestion de la flore adventice en grandes cultures. *Innovations Agronomiques* 3: 107-120.
- Rouabhi, A., Hafsi, M. and Monneveux, P. 2019. Climate change and farming systems in the region of Setif (Algeria). *Journal of Agriculture and Environment for International Development* 113(1): 79-95.
doi:10.12895/jaeid.20191.928
- Santín-Montanyá, I., Zambrana-Quesada, E. and Tenorio-Pasamón, J.L. 2013. Weed management in cereals in semi-arid environments: A review. In: *Herbicides* (A.J. Price and J.A. Kelton). IntechOpen.
doi:10.5772/55970
- Santos, M.S.D., Silva, M.P.P., Almeida, E.I.B., da Silva, M.S., Sousa, A.M.D., dos Santos, C.A.F., Furtado, M.B., da Silva de Sousa, W., Parra-Serrano, L.J. and da Silva-Matos, R.R.S. 2024. Weed phytosociology survey in a Brazilian native pineapple, variety Turiaçu. *Australian Journal of Crop Science* 18(8): 460-465.
doi:10.21475/ajcs.24.18.08.p4083
- Savić, A., Popović, A., Đurović, S., Pisinov, B., Ugrinović, M. and Jovanović Todorović, M. 2025. A framework for understanding crop-weed competition in agroecosystems. *Agronomy* 15(10): 2366.
doi:10.3390/agronomy15102366
- Stankiewicz-Kosyl, M., Synowiec, A., Haliniarz, M., Wenda-Piesik, A., Domaradzki, K., Parylak, D., Wrochna, M., Pytlarz, E., Gala-Czekaj, D., Marczevska-Kolasa, K. and Praczyk, T. 2020. Herbicide resistance and management options of *Papaver rhoeas* L. and *Centaurea cyanus* L. in Europe: A review. *Agronomy* 10(6): 874.
doi:10.3390/agronomy10060874
- Taibi, S., Meddi, M., Souag, D. and Mahe, G. 2013. Evolution et régionalisation des précipitations au nord de l'Algérie (1936-2009). In: *Climate and Land Surface Changes in Hydrology*, Proceedings of H01, IAHS-IAPSO-IASPEI Assembly, Gothenburg, Sweden. 55: 191.
- Tanji, A. 2005. *Adventices du blé et de l'orge au Maroc*. INRA, Rabat, Morocco, 448 p.
- Travlos, I.S. 2012. Competition between *Sinapis arvensis* L. and winter cereals. *Planta Daninha* 30(4): 873-880.
- Wawrzyniak, J. 2021. Model of fungal development in stored barley ecosystems as a prognostic auxiliary tool for postharvest preservation systems. *Food and Bioprocess Technology* 14: 298-309.
doi:10.1007/s11947-020-02575-x
- Weigel, M.M., With Berge, T., Salonen, J., Lötjönen, T., Gerowitt, B. and Brandsæter, L.O. 2024. Combining disturbance and competition to control creeping perennial weeds in arable farming. *Frontiers in Agronomy* 5: 1330222.
doi:10.3389/fagro.2023.1330222
- Wiese, A.F. and Binning, L.K. 1987. Calculating the threshold temperature of development for weeds. *Weed Science* 35(2): 177-179.
- Wilson, C.E., Castro, K.L., Thurston, G.B. and Sissons, A. 2016. Pathway risk analysis of weed seeds in imported grain: A Canadian perspective. *Neobiota* 30: 49-74.
doi:10.3897/neobiota.30.7502
- Yousaf, A., Khalid, N., Aqeel, M., Rizvi, Z.F., Alhaithloul, H.A.S., Sarfraz, W. and Qari, S.H. 2021. Assessment of composition and spatial dynamics of weed communities in agroecosystem under varying edaphic factors. *PLOS ONE* 16(12): e0261234.
doi:10.1371/journal.pone.0261234
- Zimdahl, R.L. 2018. *Fundamentals of Weed Science*. 5th ed. Academic Press, London, United Kingdom, 758 p.

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