Diversity of weeds associated with wheat and barley crops under tillage in a semi-arid climate (Eastern Algeria)

Hadia Kellil[1*], Khalissa Mohguen[2], Hanane Ouldammar[1], Nawal Hamdaoui[1], and Naoual Zeraoulia[1]

[1] Faculty of Nature and Life Sciences, Abbes Laghrour University of Khenchela, Algeria
[2]Faculty of Nature and Life Sciences, Ferhat Abbas University of Setif, Algeria

* *Corresponding author email:* kellil_agr@yahoo.fr

In Algeria, weeds are a formidable problem for cereal crops grown in conventional planting methods and in a semi-arid climate. During the 2015/2016 crop cycle an experiment was carried out in the Khenchela region, in two cereal fields, during a period from the full tillering stage until the end of the stem elongation, in order to know the diversity and spatial-temporal dynamics of the weed flora associated with the crops. The fields contained the soft wheat (*Triticum aestivum* L.) HD1220 variety, and barley (*Hordeum vulgare* L.), El-Fouara variety and the temporal dynamics of the weed flora associated with these crops was studied. A quadrat was used to sample the weeds. Seven weed species were identified, belonging to five orders and five botanical families, with a total of 1258 individuals. Both fields were infested with the same weed species. The species *Sinapis arvensis* (18.5%) was the most frequent in the wheat field, while *Carduus pycnocephalus* (17.4%) was the most dominant in the barley field. The relative abundance (RA%) values of the species surveyed were higher in the stem elongation stage than in the tillering stage. The Shannon index (*H′*) value did not exceed 2.8 bits, and the equitability (*E*) was 0.98, which shows a balance in the floristic stands. ANOVA comparison between the two crops, wheat and barley, for the phenological stages of the host plant showed significant to very highly significant results for weed species at the tillering stage. In contrast, during the stem elongation stage, wheat maintained the significant results noted during the tillering stage, while barley showed no significant results.

Keywords: Soft wheat, barley, weed flora, phenological stages, Algeria

In agronomy, weeds represent an important component of the agro-ecosystem and are one of the factors that significantly limit the yields of crops grown in conventional agriculture (Doucet 2013; Mehdizadeh 2016; Matelionienė et al. 2022). Weed species populations are affected by applied agricultural techniques (Bhausaheb 2021). In this context the world's agricultural production reported a rate of 9.7% of losses caused by weeds; in Africa, this rate is in the order of 10 - 56 % (Karida and Ali 2009). There are many publications on the impact of weeds that prevent and hinder the growth and development of cultivated cereal plants including Gaba et al. (2010), Santín-Montanyá et al. (2013), and Hunter and Ireland (2017); weeds compete directly with crops (Boulal et al. 2007; Dangwal et al. 2010; Doucet 2013). The overall yield reduction of wheat (*Triticum aestivum* L.) due to weeds has been estimated to be 13.1% (Oerke et al. 1994). In Algeria, annual weed losses of wheat range from 56% in dry areas to 38% in sub-humid areas (Hamadache 2011). A considerable loss of wheat yields directly affects food-sufficiency on a global scale (Alsherif 2020). Weed management will be more effective and profitable when the farmer opts for integrated pest management including a diversity of methods, such as prevention, cultivation techniques, and also mechanical, biological and chemical controls (Tanji 2005; Rodriguez and Gasquez 2008; Santín-Montanyá et al. 2013). Currently, the key management strategy in cereal agro-ecosystems is the application of herbicides, but this has led to the emergence of genotypes of weeds resistant to plant protection products (Coble and Schroeder 2016; Stankiewicz-Kosyl et al. 2020). The objectives of this study were to determine the diversity of the adventitious flora present in the Khenchela region, to monitor the spatial and temporal dynamics of the weed populations recorded in two conventional cereal agro-ecosystems, and to propose a suitable management method for these weed species.

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Materials and methods

Description of the study area and crops

The experiment was conducted at the pilot farm LAATAR Lakhemissi, located at 6°56′ east and 35°29′ north, in the commune of Kaïs, wilaya de Khenchela in the east of Algeria. The climate of the region is semi-arid. During the period of this investigation, April was warmer and wetter than the other months. The soil type of the study fields is clay-loam, rich in organic matter (3.78%) and low in nitrogen (0.076%), a result of years of monoculture farming (Table 1).

Table 1: Temperature (T), precipitation (P) and soil analysis of the experimental site

Mean temperature and precipitation [El-Hamma weather station, 2016]			Physical and chemical properties of soil [Data from the Pilot Farm, 2013]			
Month	T (°C)	P (mm)	Parameter	Value (%)	Parameter	Value (%)
January	8.6	22.9	Clay	28	Organic matter	3.78
February	9.2	13.5	Loam	25	Total nitrogen	0.076
March	10.15	23	Sand	14	C/N	28.94
April	15.9	54.2	Carbon	2.2	P_2O_5 (mg/g)	1

The pilot farm is used for the cultivation of cereals, soft wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) on 320 ha. Single varieties of the two cereals were used in the study; wheat: HD1220 and barley: El-Fouara. Table 2 describes these varieties and their cultivation techniques in the fields studied.

Table 2: Characteristics of the varieties studied (Boufenar-Zaghouane and Zaghouane 2006) and their cultivation details **(**Data from the pilot farm 2016**)**

	Soft wheat/HD1220 (Hiddab)	**Barley/El-Fouara (DeirAlla)**
Description of the varieties		
Year of registration/ origin	1998/CIMMYT (Mexico)	2001/ICARDA (Syria)
Adaptation area	Coastline, inland plains	Highlands
Planting	November-December	Mid-November
Date vegetative cycle	Semi-early to early	Late
Grain yield	6 t/ha	3 t/ha
Cultivation details		
Field area	2 ha	2 ha
Previous crop	Fallow	Fallow
Planting date	Beginning of November 2015.	20/11/2015
Fertilisation/irrigation	None	None
Phytosanitary treatments	None	None

Sampling method

The quadrat sampling method was used to evaluate and quantify the diversity of two agro-ecosystems analysed (Punia et al. 2017; Singh et al. 2018). A total of 128 quadrats were taken from the two fields, the area of each quadrat sample was 0.25 m^2 and eight replicates were performed on a zigzag path at 25 m intervals during each survey. Sampling started at the tillering stage and ended at stem elongation, a period of 3 months, February, March and April of the 2015/2016 crop cycle.

Identification of the weed species inventoried

The identification and the systematic classification of the weed species are based on the works of the floras (Tanji 2005) using the software Tela Botanica (www.tela-botanica.org).

Data analysis and processing

In order to assess the structure and organisation of the weed species populations surveyed, a number of parameters and indices were calculated. These were for relative abundance (RA%), frequency of occurrence (C%) (both as noted by Faurie et al. 2003), Shannon diversity (*H’*) and the equitability index (*E*) (both as noted by Magurran 2004)

$$RA = \frac{n_i}{N} \times 100$$

n_i: population of species i; N: total population of the stand.

$$C = \frac{p_i}{P} \times 100$$

p_i: number of occurrences of species i;
P: total number of samples.
Based on the value of C, the species is:
C = 100% (omnipresent); 75% ≤ C < 100% (constant); 50 % ≤ C < 75 % (regular); 25 % ≤ C < 50 % (accessory); 5 % ≤ C < 25 % (accidental).

$$H' = -\sum (P_i \log_2 \times P_i)$$

The diversity index is equal to 0 for individuals of the same species. The value of the index generally varies between 1.5 and 3.5, it rarely exceeds 4.5.

$$E = \frac{H'}{H'\max}$$

$H'_{max} = \log_2 S$; H' = Shannon diversity;

S = species richness.

One-way analyses of variance were carried out to test the differences in abundance of weed species identified and their botanical families. The quantities dependent response variables (y) were the number of each species and the number of their botanical families, according to the two qualitative explanatory variables (x), the crop (wheat; barley) and the phenological stages. Analysis of variance and the ascending hierarchical classification (AHC) were performed with XLSTAT 2016. The histograms presented were drawn by the software GraphPad Prism 5 Demo.

Results and discussion

Diversity of weed species

The floristic inventory shows a specific richness (*S*) of seven weed species (Table 3). As shown by Punia et al. 2017, weeds can be very different from one area to another, from one plot to another and even between different points in the same plot (Santín-Montanyá et al. 2013). Environmental conditions, crop type, irrigation method and chemical weed control measures, have a significant influence on the diversity and intensity of weed infestation (Gabriel et al. 2006).

However, the results obtained appear homogeneous at the botanical family level and the weed species between the two crops sampled. In the two fields studied, cropping practices such as fallow, cropping history, tillage before sowing, and physio-chemical characteristics of the soil were identical. These practices have an effect on the floristic diversity; thus, the low diversity of weeds can be explained by the rate of occupation of the soil by monoculture cereal crops during several years (Kazi Tani et al. 2010).

Table 3: List of weed species inventoried and their frequency of occurrence C (%)

Order	Family	Species	Vernacular name	C (%) Wheat	C (%) Barley
Asterales	Asteraceae	*Sonchus oleraceus* L., 1753	Common sowthistle	87.5	87.5
Asterales	Asteraceae	*Carduus pycnocephalus* L., 1763	Italian thistle	100	100
Capparales	Brassicaceae	*Sinapis arvensis* L., 1753	Field mustard	100	100
Fabales	Fabaceae	*Vicia sativa* L., 1753	Common vetch	100	100
Papaverales	Papaveraceae	*Papaver rhoeas* L., 1753	Corn poppy	100	87.5
Cyperales	Poaceae	*Hordeum murinum* L., 1753	False barley	100	100
Cyperales	Poaceae	*Bromus rubens* L., 1753	Foxtail brome	100	100

The listed species belong to five orders and five families. The two botanical families Asteraceae and Poaceae are ranked first with two species for each. Hamadache (2018) noted that the richness of these two families represents 40% of 250 weed species reported worldwide. Other work carried out in cereal fields located in two different bioclimatic areas in Algeria, semi-arid (Melakhessou et al. 2020; Fortas et al. 2021; Hani and Lebazda 2021), and arid (Eddoud et al. 2018; Hattab 2022), confirmed these results.

In contrast, in the semi-arid Mediterranean climate, the Poaceae, Asteraceae, Brassicaceae and Fabaceae families are classified among the most dominant of the weed flora and the richest in seed bank (Salama et al. 2016), and they have a remarkable adaptation to different disturbed environments (Taleb and Maillet 1994).

For the species inventoried, dicotyledons were more dominant than monocotyledons. This dominance has been observed in most cereal agro-ecosystems (Turk and Tawaha 2003; Singh et al. 2018; Alsherif 2020). The invasion of cereal fields by competitive monocotyledons and dicotyledons weeds causes great expenses every agricultural cropping cycle (Siddiqui et al. 2010; Kouadria et al. 2019).

Previous studies have shown that the collected species compete with cereal crops; monocotyledons foxtail brome (Vázquez-García et al. 2021), false barley (Owen et al.2015), dicotyledonscorn poppy (Pérez-Porras et al. 2022), common sowthistle (Ahmad et al. 2021), Italian thistle (Heidarian et al. 2015), field mustard (Zargar et al. 2021), and common vetch (Aarssen et al. 1986).

These species are therophytes. This dominance of annual weeds in cereal crops is explained by their development cycle in parallel with these crops (Lososová et al. 2006). Fertout-Mouri (2018) reported that 75.9% of annual weed species occur each agricultural season because of tillage, which redistributes their seed stock. Studies carried out in Algeria by Fertout-Mouri (2018), Hamadache (2018), and Melakhessou et al. (2020) confirm these observations.

The frequency of occurrence (C) of the species recorded in each crop reveals that the weed species are omnipresent (100 %), with the exception of *P. rhoeas* in barley and *S. oleraceus* in both crops which are reported as constant (87.5 %). Weed species that share the same ecological requirements have a high tendency to occupy the same fields (Andreasen et al.1991).

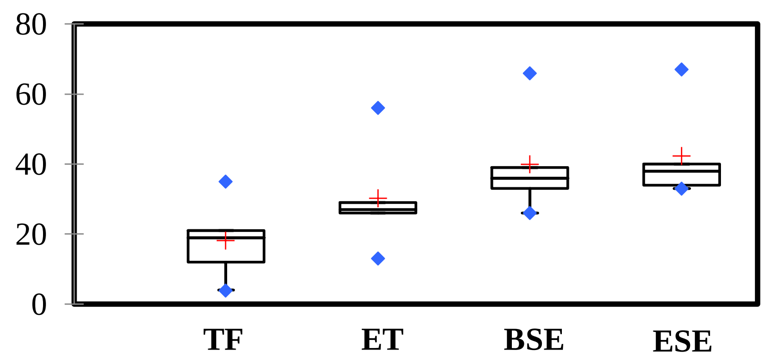
The Shannon index (H') was 2.75 and 2.77 bits in the soft wheat and barley fields, respectively. This value confirms that the diversity is the same in the two fields studied. A low value of H' results in a less diversified stand with dominant species (Faurie et al. 2003). In both fields, the same value of E was obtained (0.98). This value tends towards 1, which means that each species in the stand is represented by a similar number of individuals and the stand is well balanced (Ramade 2003).

Structure of weed stands

Effect of the botanical families

Figure 1 shows the number of individuals of each weed family present at four phenological stages. In wheat there were between 4 and 67 family individuals at the various stages, and for barley there were between 2 and 60 individuals. The end of tillering (ET), beginning of stem elongation (BSE) and end of stem elongation (ESE) stages had almost similar median and mean values for both crops. The tillers formed (TF) stage had median 19 and mean 18.2 ± 11.5 individuals in wheat and median 12 and mean 13.4 ± 10.3 individuals in barley. For both crops there were fewer individuals at the TF stage than at the later stages. The early stages of cereal crop development are more sensitive to weed competition (Santín-Montanyá et al. 2013; Hamadache 2018; Kouadria et al.2019). This competition becomes very competitive at the tillering stage (Caussanel 1989).

For all stages and in both crops, the high and low values of relative abundance (RA) represent the two families, Poaceae and Papaveraceae respectively, with the exception of the high value of 9.76% of the ESE stage of barley which is specific to Asteraceae (Table 4). In this context, the two families Poaceae and Asteraceae are the most dominant in barley during the BSE and ESE stages. In the Algerian semi-arid zone, weed grasses exert their competition throughout the cereal cycle; on the other hand the dicotyledonous species begin their competition as of heading (Boulal et al. 2007). These results are compatible with the theory which states that poaceae weeds are always the most important in numbers in cereal fields (Eddoud et al. 2018; Fertout-Mouri 2018); this can be explained by the allelopathic effect exerted by wheat and barley crops on the growth of weeds belonging to other families (Kremer and Ben-Hammouda 2009; Alsherif 2020).



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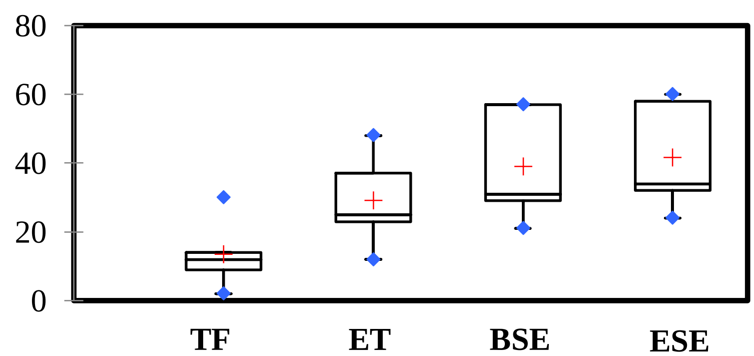

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Figure 1: Box plots representing the number of individuals of the five families according to the phenological stages of the two crops a) wheat and b) barley. TF: tillers formed; ET: end of tillering; BSE: beginning of stem elongation; ESE: end of stem elongation.

Table 4: Relative abundance (RA%) of botanical families for each wheat and barley phenological stage

Crops	Wheat				Barley			
	Phenological stages							
Families	**TF**	**ET**	**BSE**	**ESE**	**TF**	**ET**	**BSE**	**ESE**
Asteraceae	1.83	4.43	5.96	6.12	2.28	6.02	9.27	9.76
Brassicaceae	2.91	4.13	5.50	5.81	1.95	4.07	5.04	5.53
Fabaceae	3.21	3.98	5.05	5.20	1.46	3.74	4.72	5.20
Papaveraceae	0.61	1.99	3.98	5.05	0.33	1.95	3.41	3.90
Poaceae	5.35	8.56	10.09	10.24	4.88	7.80	9. 27	9.43

TF: tillers formed; ET: end of tillering; BSE: beginning of stem elongation; ESE: end of stem elongation

Effect of weed species

Figure 2 shows the relative abundance of each weed species present at the tillering and stem elongation stages. During the tillering stage, the weed species *V. sativa* and *H. murinum* were ranked first in wheat with a value of 7.2%, followed by *S. arvensis* (7.0%) and *B. rubens* (6.7%). Weeds that appear early in the wheat crop are often the most harmful compared to late species, therefore competition between them starts from tillering until flowering (Kouadria et al. 2019).

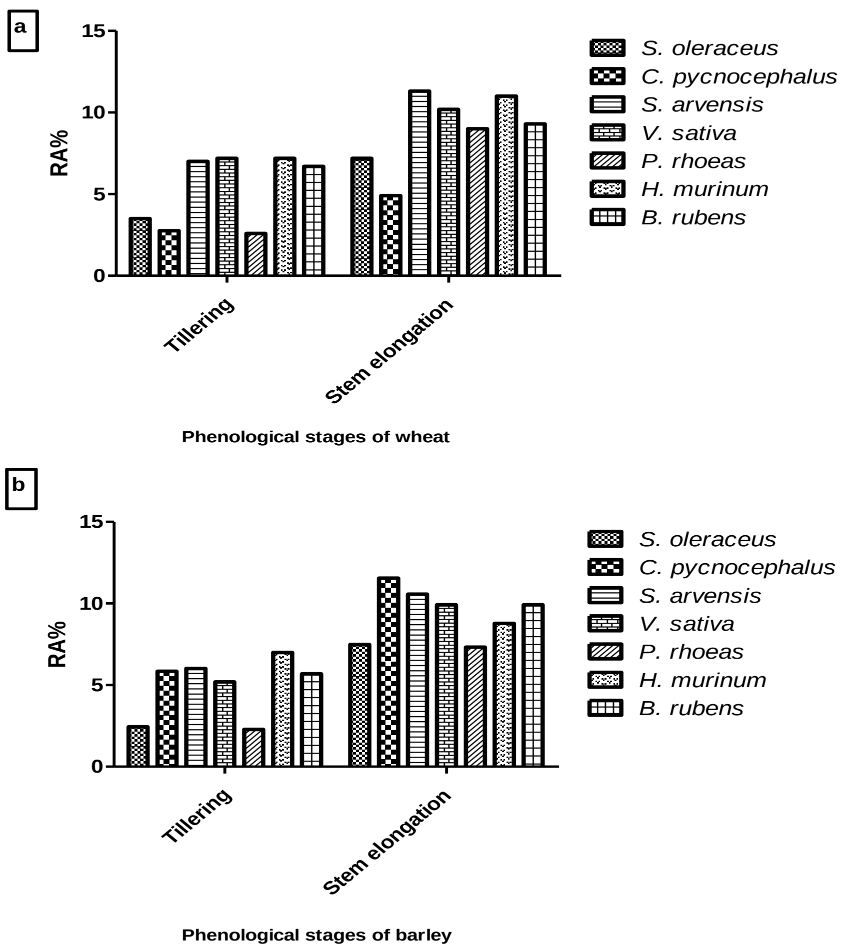


Figure 2: Relative abundance (RA) of each weed species at tillering and stem elongation stages, a) wheat, b) barley.

In barley at the tillering stage *H. murinum* and *S. arvensis* were the most common with RA of 7.0 and 6.0%, respectively. The species *C. pycnocephalus*, *B. rubens* and *V. sativa* had very similar RA between 5.85 and 5.20%.

In barley fields, the absence of appropriate management for several years of *S. arvensis* can considerably reduce the total nitrogen level, and cause serious yield losses ranging from 47 - 70% (Didon and Bostrom 2003). In wheat fields, *S. arvensis* can cause a significant yield loss when it reaches about 32 plants /m^2 (Zargar et al. 2021). The spring (March and April) of the year of study was humid with 77.2 mm rainfall, this type of climate can favour the invasion of fields by weeds. Santín-Montanyá et al. (2013) stated that cereal fields receiving heavy precipitation in spring promotes early weed emergence. In studies by Redlick et al. (2017) and Gherekhloo et al. (2018), comparing wet spring to dry spring, *S. arvensis* had a detrimental effect on cereal yield, as its competition with the crop was high. To minimise interspecific competition between *S. arvensis* and two cereal crops, a study carried out in Greece showed that nitrogen fertilisation (150 kg/ha) has a positive effect on the very slight reduction in dry weight (1.5%) and grain yield (3.5%) and no reduction in total nitrogen content for barley, compared to a very significant reduction in these three parameters respectively (31%; 26%; 20%) for wheat (Dhima and Eleftherohorinos 2005).

In both crops, the tillering stage was marked by low abundances of *P. rhoeas* and *S. oleraceus*, plus *C. pycnocephalus* for wheat. These results differ from those found by Hani and Lebazda (2021) who showed that the most numerical weeds in each of the three crops studied, soft wheat, durum wheat and barley were *S. oleraceus* and *P. rhoeas*. During the present study, the average winter temperature of 8.9°C influenced the growth and reproduction of the weed flora. For example, the seeds of *P. rhoeas* have a prolonged morpho-physiological dormancy; if they are subjected to temperatures over 15 °C in the soaked state, they can germinate (Baskin et al. 2002). In cereal fields, *P. rhoeas* can contribute to the formation of a huge and persistent seed bank in the absence of competition, these seeds can remain viable in the soil for decades (Lutman et al. 2002).

The stem elongation stage saw the highest abundances of *S. arvensis* (11.3%) and *H. murinum* (11.0%) for wheat, while in barley, *C. pycnocephalus* (11.5%) and *S. arvensis* (10.6%) were most abundant (Figure 2). The stem elongation stage of barley recorded continuing low values for the two species reported at tillering, *P. rhoeas* (7.3%) and *S. oleraceus* (7.5%). The latter species caused direct damage due to the massive production of small seeds, which is allowed for the invasive success of this weed (Widderick et al. 2010), because more than 95% of these seeds are dispersed by the wind (Manalil et al. 2019). This species has seeds that live for 2 to 3 years, and also, it consumes valuable amounts of water during the fallow period (Widderick et al. 2010; Hunter and Ireland 2017).

C. pycnocephalus (4.9 %) had the lowest relative abundance during the wheat stem elongation but was the most dominant in barley. The difference between the two crops could be attributed to the kind of competition exerted by the weed on the host plant itself; wheat can compete with their weed species mainly for light (Lemerle et al. 1996), while barley can compete with their weed species for soil fertility (Taylor et al. 2001). In the study of Forcella and Wood (1986), dry summer conditions followed by heavy rain in March favoured germination of *C. pycnocephalus*.

During the crop development cycle, several weed species can become a real nuisance, depending on the crops put in place (Santín-Montanyá et al. 2013). Weeds emerge and develop rapidly during the different vegetative stages of the cultivated cereal plant. They can continue to the early stages of reproduction (Bhausaheb 2021). Emergence, growth, flowering and even seed production in weeds are related to the phenological stages of crops, and they offer key results for programming suitable control strategies (Chauhan et al. 2006).

Karida and Ali (2009) stated that the presence of a constant evolutionary relationship between the host cereal plant and their weeds is generally linked to different parameters such as climatic conditions, cultivation techniques applied, type of crop and notably the infestation category and the period of weed emergence.

Statistical analysis of data

Statistical analysis by means of ANOVA of the interaction of the variables phenological stage number of botanical families and weed species led to significant to very highly significant results during all phenological stages (TF, ET, BSE, ESE) of wheat and only for the two tillering stages (TF, ET) of barley (Table 5). Two stages (BSE, ESE) in barley recorded no significant differences, for family and species means (P > 0.05). From a floristic point of view, the two fields studied are characterised by a similar flora of weed species, but which vary significantly with the phenological stage factor of the crop. Santín-Montanyá et al. (2013), noted that weeds always remain under pressure from several abiotic and biotic factors, in this case, it is important to evaluate each factor independently.

Table 5: ANOVA analysis for weed families and species in each crop according to phenological stages

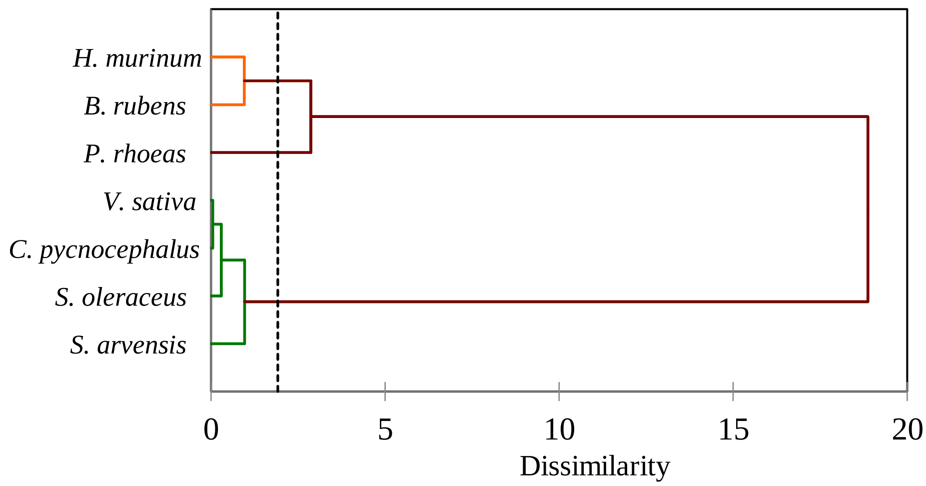
Variables		**Family**				**Species**			
Crops		Wheat		Barley		Wheat		Barley	
Phenological stages		F	P > F	F	P > F	F	P > F	F	P > F
Tillering stage	**TF**	11.846	< 0.0001***	6.227	0.000***	16.322	<0.0001***	7.505	< 0.0001***
	ET	7.054	< 0.0001***	4.284	0.003**	5.093	<0.000***	4.083	0.001**
Stem Elongation stage	**BSE**	5.608	0.000***	1.067	0.376ns	4.089	<0.001**	1.792	0.108ns
	ESE	5.276	0.001**	0.922	0.454ns	4.455	<0.000***	1.637	0.144ns

F value =observed value of the test statistic; P >F = critical probability; TF: tillers formed; ET: end of tillering; BSE: beginning of stem elongation; ESE: end of stem elongation

Spatio-temporal distribution by means of the ascending hierarchical tree (AHC) made it possible to structure the weed species identified in the wheat and barley fields into three groups (Figure 3). These groups present a distinction between the species according to their distribution in the sampling quadrats, during the phenological stages (TF, ET, BSE, ESE) of the plants studied.

In both fields, the first group includes two species, *B. rubens* and *H. murinum*. These species belong to the group of messicolous weeds of the Poaceae family. In the Mediterranean region, cereals are threatened by annual and winter grass weeds, such as rat barley (Rabey and Al-Malki 2013; Iqbal et al. 2019; Melakhessou et al. 2020), and bromes (Makhlouf et al. 2002; Hamadache 2018; Vázquez-García et al. 2021). These are virulent weeds to cereals, especially wheat (Zidane et al. 2010; Singh et al. 2018; Alsherif 2020), they can host pathogenic species such as powdery mildew (*Erysiphe graminis*), black rust (*Puccinia graminis* f. sp. *tritici*) and barley yellow dwarf virus (BYDV) (Taleb et al.1999).

In the barley field the second group encompassed four species belonging to three different families, and the third group was a single species group of *V. sativa*. In the wheat field, the second group contains only *P. rhoeas* which showed some dissimilarity to the other species, and the third group contained the same species as the second group of barley, with the exception of *P. rhoeas* replaced by *V. sativa.*



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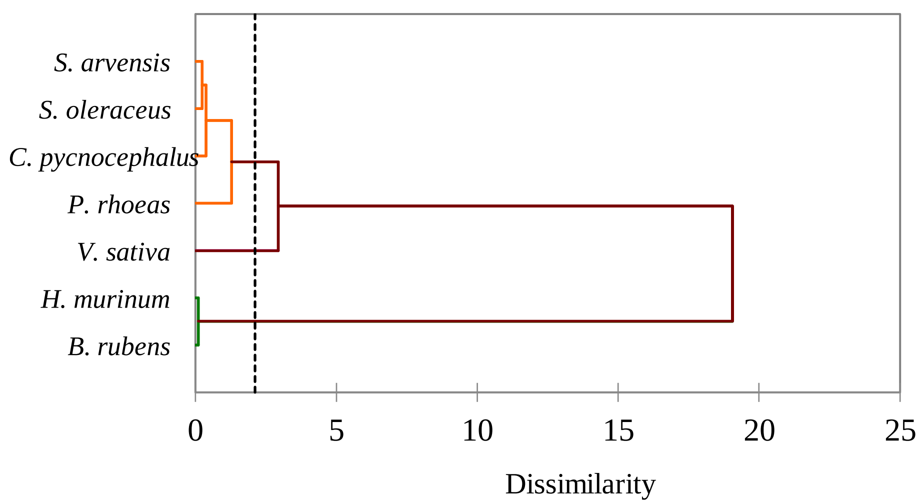

b)

Figure 3: Dendrograms of the ascending hierarchical classification (AHC) of the spatio-temporal variation of weed numbers in the two studied fields grouped by dissimilarity, a) wheat, b) barley.

The spatial-temporal distribution of weed species in these two fields showed similarity during the different phenological stages. The main driver in the distribution of weeds is the vitality of their seeds, because depending on the weed, seed banks have an ecological interest in the dynamics and evolution of weed stands (Mayor and Dessaint 1998; Hamadache 2011).

The main purpose of this study was to determine the weed species and their spatio-temporal distribution "phenological stages and culture", in order to propose a suitable control method. Early detection at the right time will minimise their presence in both fields. As suggested by Hani and Lebazda (2021), in semi-arid regions chemical weeding early applied in cereal fields is essential in order to increase grain and even straw yield. In this regard, Hamadache (2018) has shown the importance of chemical weeding control. If Algeria properly weeds 1 million ha of cereals, the yield gain, in an ordinary agricultural year, would be 1.1 million tonnes.

Conclusion

The qualitative floristic analysis identified seven weed species during the phenological stages of both crops. The composition was similar between the two crops due to the same cropping system applied in both fields. The quantitative analysis described the agronomic value of the species identified according to their relative abundance. These abundance data are different for the two crops, especially during the tillering and stem elongation stages, although they have an identical environment and competition from the same weed species. This knowledge on weed species and their evolution with the phenological stages of cereals is necessary for the development of weed management and control strategies in a cereal agro-ecosystem under a semi-arid climate.

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References

Aarssen, L.W., I.V. Hall, and K.I.N. Jensen. 1986. “The Biology of Canadian Weeds 76: *Vicia angustifolia* L., *V. cracca* L., *V. sativa* L., *V. tetrasperma* (L.) Schreb. and *V. villosa* Roth.” *Canadian. Journal of Plant Science* **66**:711−737. DOI: https://doi.org/10.4141/cjps86-092.

Ahmad, F., El.T. Abdallah, and M. Kamil. 2021. “Scientific Studies on Aerial Parts of *Sonchus oleraceus* Linn” *Medicinal and AromaticPlants* **7 (2)**: 196−214. DOI: https://doi.org/10.48347/IMIST.PRSM/ajmap-v7i2.26287.

Alsherif, E.A. 2020. “Cereal Weeds Variation in Middle Egypt: Role of Crop Family in Weed Composition.” *Saudi Journal of Biological Sciences* **27 (9)**: 2245−2250. DOI: https://doi.org/10.1016/j.sjbs.2020.07.001.

Andreasen, C., J.C. Streibig, and H. Hass. 1991. “Soil Properties Affecting the Distribution of 37 Weed Species in Danish Fields.” *Weed Research* **31 (4)**: 81−187. DOI: https://doi.org/10.1111/j.1365-3180.1991.tb01757.x.

Baskin, C.C., P. Milberg, L. Anderson, and J.M. Baskin. 2002. “Non-deep Simple Morphological Dormancy in Seeds of the Weedy Facultative Winter Annual *Papaver rhoeas*.” *Weed Research* **42 (3)**: 194−202. DOI: https://doi.org/10.1046/j.1365-3180.2002.00275.x.

Bhausaheb, T.N. 2021. “Effect of Pre and Post Emergence Herbicides on Weed Management in Sweet Corn (*Zea mays saccharata* Sturt.).” *Journal of Research in Weed Sci*ence **4 (4)**: 286−291.

Boufenar-Zaghouane, F., and O. Zaghouane. 2006. “Guide des Principales Variétés de Céréales à Paille en Algérie (blé dur, blé tendre, orge et avoine).” ICARDA, Algeria 154p.

Boulal, H., O. Zaghouane, M. El-Mourid, and S. Rezgui. 2007. “Guide Pratique de la Conduite des Céréales d’automne (blés et orge) dans le Maghreb (Algérie, Maroc, Tunisie).” ICARDA, Algeria 176p.

Caussanel, J.P. 1989. “Nuisibilité et Seuils de Nuisibilité des Mauvaises Herbes dans une Culture Annuelle: Situation de Concurrence Bispecifique.” *Agronomie* **9 (3)**: 219−240. DOI: https://doi.org/10.1051/agro:19890301.

Chauhan, B.S., G. Gill, and C. Preston. 2006. “Factors Affecting Seed Germination of Annual Sowthistle (*Sonchus oleraceus*) in Southern Australia.” *Weed Science* **54 (5)**: 854−860. DOI : https://doi.org/10.1614/WS-06-047R.1.

Coble, H.D., and J. Schroeder. 2016. “Call to Action on Herbicide Resistance Management.” *Weed Science* **64 (1)**: 661−666. DOI: https://doi.org/10.1614/WS-D-15-00032.1.

Dangwal, L.R., A. Singh, T. Singh, and C. Sharma. 2010. “Effects of Weeds on the Yield of Wheat Crop in Tehsil Nowshera.” *Journal of American Science* **6 (10)**: 405−407.

Dhima, K., and I. Eleftherohorinos. 2005. "Wild Mustard (*Sinapis arvensis* L.) Competition with Three Winter Cereals as Affected by Nitrogen Supply." *Journal of Agronomy and Crop Science* **191 (4)**: 241−248. DOI: https://doi.org/10.1111/j.1439-037X.2005.00152.x.

Didon, E.M.U., and U. Bostrom. 2003. "Growth Development of Six Barleys (*Hordeum vulgare* ssp. *vulgare* L.) Cultivars in Response to a Model Weed (*Sinapis alba* L.)." *Journal of Agronomy and Crop Science* **189 (6)**: 409−417. DOI : https://doi.org/10.3390/agronomy11112306.

Doucet, R. 2013. "Les Mauvaises Herbes Agricoles." Berger. A.C. Inc. Québec 367p.

Eddoud, A., E. Buisson, L. Achour, K. Guediri, S. Bissati, and H. Abdelkrim. 2018. "Changes in Weed Species Composition in Irrigated Agriculture in Saharan Algeria." *Weed Research* **58 (6)**: 424−436. DOI: https://doi.org/10.1111/wre.12328.

Faurie, C., Ch. Ferra, P. Medori, J. Devaux, and J.L. Hemptienne. 2003. "Ecologie, Approche Scientifique et Pratique." 5[ème] éd. Lavoisier Tec & Doc, Paris 407p.

Fertout-Mouri, N. 2018. "Étude Phytoécologique de la Flore Adventice des Agrosystèmes Céréaliers de la Région de Tessala (Algérie Nord-Occidentale)." *Bulletin de la Société Royale des Sciences de Liège* **87**:70−99. DOI: 10.25518/0037-9565.8051.

Forcella, F., and H. Wood. 1986. "Sequential Flowering of Thistles (Cynareae, Asteraceae) in Southern Australia." *Australian Journal of Botany* **34**:455−461.

Fortas, B., A. Rouabhi, and A. Mekhlouf. 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. DOI: 10.21608/agro.2021.90486.1274.

Gaba, S., B. Chauvel, F. Dessaint, V. Bretagnolle, and S. Petit. 2010. "Weed Species Richness in Winter Wheat Increases with Landscape Heterogeneity." *Agriculture Ecosystems and Environment* **138 (3−4)**: 318−323. DOI: https://doi.org/10.1016/j.agee.2010.06.005.

Gabriel, D., I. Roschewitz, T. Tscharntke, and C. Thies. 2006. "Beta Diversity at Different Spatial Scales: Plant Communities in Organic and Conventional Agriculture." *EcologicalApplications* **16 (5)**: 2011−2021. DOI: 10.1890/1051-0761(2006)016[2011:bdadss]2.0.co;2.

Gherekhloo, J., Z.M. Hatami, R. Alcántara-de la Cruz, H.R. Sadeghipour, and R. De Prado. 2018. "Continuous Use of Tribenuron-methyl Selected for Cross-Resistance to Acetolactate Synthase-Inhibiting Herbicides in Wild Mustard (*Sinapis arvensis*)." *Weed Science* **66 (4)**: 424−432. DOI: https://doi.org/10.1017/wsc.2018.23.

Hamadache, A. 2011. "Elément de Phytotechnie Générale: Le blé." 1[ère] éd. ITGC, Algeria 256p.

Hamadache, A. 2018. "Elément de Phytotechnie Générale: Protection Raisonnée des Grandes Cultures." 4 [ème] éd. ITGC, Algérie 205p.

Hani, M., and R. Lebazda. 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)**: 63−72.

Hattab, M. 2022. "Study of Infestation and Harmfulness Degree of Weeds on Fodder Barley (*Hordeum vulgare* L.) in an Arid Region (Laghouat-Algeria)." *Ukrainian Journal of Ecology* **12 (3)**: 66−73. DOI: 10.15421/2022_355.

Heidarian, M., S.M. Masoumi, and M. Atri. 2015. "Ecological Study of *Carduus pycnocephalus* L. Weed and Associated Species in Hamedan Province, Iran." *Journal of Advances in Biology and Biotechnology* **2 (1)**: 71−78. DOI: 10.9734/JABB/2015/11468.

Hunter, G.C., and K.B. Ireland 2017. "Nomination of a Target Weed for Biological Control: Common Sowthistle

(*Sonchus oleraceus*).” Invasive Plants & Animal Committee via NSW DPI representative, CSIRO Heath & Biosecurity, Australia, 1-20. Accessed February 2 2023. https://agrifutures.com.au/wp-content/uploads/2017/07/Appendix-16-Hunter-and-Ireland-2017-Nomination-sowthistle.pdf.

Iqbal, N., A.A. Bajwa, S. Manalil, A.M. Khan, L. Kebaso, D. Frimpong, H.H. Ali, P. Jha, and B.S. Chauhan. 2019. “Biology and Management of Two *Hordeum* Weedy Species: A Review.” *Crop Protection* **125**:104908. DOI: https://doi.org/10.1016/j.cropro.2019.104908.

Karida, T., and M. Ali. 2009. “Etude Phyto-écologique des Adventices dans les Agro-Écosystèmes Élaeicoles de la Mé et de Dabou.” *European Journal of Scientific Research* **31 (4)**: 519−533. DOI: 10.4314/jab.v104i1.13.

Kazi Tani, C., T. Le Bourgeois, and F. Munoz. 2010. “Aspects Floristiques de la Flore des Champs du Domaine Phytogéographique Oranais (Nord-Ouest Algérien) et Persistance d’espèces Rares et Endémiques.” *Flora Mediterranea* **20**:5−22.

Kouadria, M., A. Hassani, and D. Ghezali. 2019. “Désherbage des sols Céréaliers Cultivés en Semis Direct (Région des Hauts Plateaux Algériens) par Utilisation de L’extrait Aqueux des Feuilles d’*Eucalyptus globulus*.” *Revue Marocaine des Sciences Agronomiques Vétérinaires* **7 (1)**: 65−70.

Kremer, R.J., and M. Ben-Hammouda. 2009. “Allelopathic Plants. 19. Barley (*Hordeum vulgare* L.).” *Allelopathy Journal* **24 (2)**: 225−242.

Lemerle, E., B. Verbeek, R.D. Cousens, and N.E. Coombes. 1996. “The Potential for Selecting Wheat Varieties Strongly Competitive Against Weeds.” *Weed Research* **36 (6)**: 505−513. DOI: 10.1111/j.1365-3180.1996.tb01679.x.

Lososová, Z., M. Chytrý, I. Kühn, O. Hájek, V. Horáková, P. Pyšek, and L. Tichý. 2006. “Patterns of Plant Traits in Annual Vegetation of Man-Made Habitats in Central Europe.” *Perspectives in Plant Ecology, Evolution and Systematics*. **8 (2)**: 69−81.DOI: doi:10.1016/j.ppees.2006.07.001.

Lutman, P.J.W., G.W. Cussans, K.J. Wright, J.B. Wilson, G.M. Wright, and H.M. Lawson. 2002. “The Persistence of Seeds of 16 Weed Species Over Six Years in Two Arable Fields.” *Weed Research.* **42 (3)**: 231−241. DOI: 10.1046 /J.1365-3180.2002.00281.x.

Magurran, A.E. 2004. “Measuring Biological Diversity.” Wiley-Blackwell Australia 256p.

Makhlouf, M., A. Hamadache, and N. Harkati. 2002. “Effets de la Date et de L’outil de Travail du Sol sur Le Comportement des Bromes et Le Rendement du Blé Dur dans La Région de Sétif.” *Céréaliculture* **37**:24−29.

Manalil, S., H.H. Ali, and B.S. Chauhan. 2019. “Interference of Annual Sowthistle *(Sonchus oleraceus*) in Wheat.” *Weed Science* **68 (1)**: 98−103. DOI: https://doi.org/10.1017/wsc.2019.69.

Matelionienė, N., S. Supronienė, A. Shamshitov, E. Zavtrikovienė, S. Janavičienė, and G. Kadžienė. 2022. “Weeds in Cereal Crop Rotations May Host *Fusarium* Species that Cause *Fusarium* Head Blight and Grain Weight Losses in Wheat.” *Agronomy* **12 (11)**: 27−41. DOI: https://doi.org/10.3390/agronomy12112741.

Mayor, J.P., and F. Dessaint. 1998. “Influence of Weed Management Strategies on Soil Seedbank Diversity.” *Weed Research* **38(2)**: 95−105. DOI: 10.15406/mojfpt.2016.02.00054.

Mehdizadeh, M. 2016. “Effect of Pesticide Residues on Agricultural Food Production; A Case Study: Sensitivity of Oilseed Rape to Triasulfuron Herbicide Soil Residue.” *MOJ Food Processing and Technology* **2(6)**: 187−189. DOI: 10.15406/mojfpt.2016.02.00054.

Melakhessou, Z., F. Demnati, and Z. Boubaker. 2020. “Diagnostic de la Diversité des Plantes Adventices dans les Agrosystèmes: Cas des Champs de Blé dans les Aurès.” *Bulletin de la Société Royale des Sciences de Liège* **89**: 39−54. DOI: 10.25518/0037-9565.9465.

Oerke, E.C., H.W. Dehne, F. Schönbeck, and A. Weber. 1994. *Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops*. Amsterdam: Elsevier. 808p.

Owen, M.J., N.J. Martinez, and S.B. Powles. 2015. “Herbicide Resistance in *Bromus* and *Hordeum spp.* in the Western Australian Grain Belt.” *Crop and Pasture Science* **66 (5)**: 466−473. DOI: https://doi.org/10.1071/CP14293.

Pérez-Porras, F.J., J. Torres-Sánchez, F. López-Granados, and F.J. Mesae-Carrascosa. 2022. “Early and On-Ground Image-Based Detection of Poppy (*Papaver rhoeas)* in Wheat Using YOLO Architectures.” *Weed Science* **71 (1)**: 1−9. DOI: 10.1017/wsc.2022.64.

Punia, S.S., S. Singh, D.B. Yadav, V.K. Sindhu, and A. Duhan. 2017. “Abundance, Distribution and Diversity of Weeds in Wheat in Haryana.” *Indian Journal of Weed Science* **49 (2)**: 187−190. DOI: 10.5958/0974-8164.2017.00048.x.

Rabey, H., and A.L. Al-Malki. 2013. “Application of Randomly Amplified Polymorphic DNA (RAPD) Markers and Polyphenol Oxidases (PPO) Genes for Distinguishing Between the Diploid (*glaucum*) and the Tetraploid (*leporinum*) Accessions in the *Hordeum murinum* Complex.” *African Journal of Biotechnology* **10 (61)**: 13064−13070. DOI: 10.5897/AJB11.1515.

Ramade, F. 2003. “*Elément d’écologie fondamentale*.” 3ème éd. Dunod, Paris 690p.

Redlick, C., H.S.N. Duddu, L.D. Syrovy, C.J. Willenborg, E.N. Johnson, and S.J. Shirtliffe. 2017. “Effect of Seeding Rate on Dose Response of Wild Mustard (*Sinapis arvensis*) to Fluthiacet-methyl.” *Weed Science* **65 (4)**: 525−533. https://doi.org/10.1017/wsc.2017.9.

Rodriguez, A., and J. Gasquez. 2008. “Gestion de la Flore Adventice en Grandes Cultures.” *Innovations Agronomiques* **3**:107−120.

Salama, F.M., M.M.A. El-Ghani, N.A. El-Tayeh, A. Amro, and H.S. Abdrabbu. 2016. “Weed Flora of Common Crops in Desert Reclaimed Arable Lands of Southern Egypt.” *Taeckholmia* **36 (1)**: 58−76.

Santín-Montanyá, I., E. Zambrana-Quesada, and J.L. Tenorio-Pasamón. 2013. “Weed Management in Cereals in Semi-Arid Environments: A Review.” In *Herbicides*, edited by A.J. Price, and J.A. Kelton. IntechOpen DOI: 10.5772/55970.

Siddiqui, I., R. Bajwa, Z. E-Huma, and A. Javaid. 2010. “Effect of Six Problematic Weeds on Growth and Yield of Wheat.” *Pakistan Journal of Botany* **42 (4)**: 2461−2471.

Singh, A., S. Singh, and L.R. Dangwal. 2018. “Diversity of Weed Species in Wheat Fields of District Rajouri, Jammu and Kashmir.” *Agricultural Science Digest* **38 (1)**: 1−10. **DOI:**10.18805/ag.D-4382.

Stankiewicz-Kosyl, M., A. Synowiec, M. Haliniarz, A. Wenda-Piesik, K. Domaradzki, D. Parylak, Wrochna, M., E. Pytlarz, D. Gala-Czekaj, K. Marczewska-Kolasa, and T. Praczyk. 2020. “Herbicide Resistance and Management Options of *Papaver rhoeas* L. and *Centaurea cyanus* L. in Europe: A Review.” *Agronomy* **10(6)**: 874. DOI : https://doi.org/10.3390/agronomy10060874.

Taleb, A., and J. Maillet 1994. “Mauvaises Herbes des Céréales de la Chaouia (Maroc) II. 530 Aspect écologique.” *Weed Research* **34 (5)**: 353−360.

Taleb, A., B. Ezzahiri, and M. Bouhachem. 1999. “Liste Annotée des Adventices Hôtes des Ennemis des Céréales et Légumineuses Alimentaires au Maroc.” *Proceeding de Séminaire Symposium Régional sur Les Maladies des Céréales et des Légumineuses Alimentaires*, Nabeul, Tunisia 295−303.

Tanji, A. 2005. "Adventices du Blé et de L'orge au Maroc." INRA, Rabat, Morocco 448p.

Taylor, B.R., C.A. Watson, E.A. Stockdale, R.G. McKinlay, D. Younie, and D.A.S. Cranstoun. 2001. "Current Practices and Future Prospects for Organic Cereal Production: Survey and Literature Review." HGCA Research Review No. 45, HGCA, London 90p.

Turk, M.A., and A.M. Tawaha. 2003. "Weed Control in Cereals in Jordan." *Crop Protection* **22 (2)**: 239−246.

Vázquez-García, J.G., P. Castro, H.E. Cruz-Hipólito, T. Millan, C. Palma-Bautista, and R. De Prado. 2021. "Glyphosate Resistance Confirmation and Field Management of Red Brome (*Bromus rubens* L.) in Perennial Crops Grown in Southern Spain." *Agronomy* **11 (3)**: 535. DOI: https://doi.org/10.3390/agronomy 11030535.

Widderick, M.J., S.R. Walker, B.M. Sindel, and K.L. Bell. 2010. "Germination, Emergence, and Persistence of *Sonchus oleraceus*, a Major Crop Weed in Subtropical Australia." *Weed Biology and Management* **10 (2)**: 102−112. DOI: https://doi.org/10.1111/j.1445-6664.2010.00370.x.

Zargar, M., N.J. Kavhiza, M. Bayat, and E. Pakina. 2021. "Wild Mustard (*Sinapis arvensis*) Competition and Control in Rain-Fed Spring Wheat (*Triticum aestivum* L.)." *Agronomy* **11 (11)**: 2306. https://doi.org/10.3390/agronomy11112306.

Zidane, L., S. Salhi, M. Fadli, and M. El Antri. 2010. "Étude des Groupements d'adventices dans le Maroc Occidental." *Biotechnologie, Agronomie, Société et Environnement* **14 (1)**: 153−166.