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Pesticide Plants: Diversity and Use in Crop Protection in a Southern Mediterranean Area: Case Study of Chlef in North-West Algeria

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biological control

ABSTRACT:
In order to identify the pesticidal plants present in the region of Chlef northwest Algeria, monthly surveys were conducted over a period of 1 year in three distinct area (coastal zone, plain zone and mountain zone), as a result 47 plant species distributed over 21 different botanical families were identified as biopesticides. The most represented families were the Lamiaceae, Asteraceae, Apiaceae and Cupressaceae. While in terms of plant life form, the most dominant forms were the Therophyte and Hemicryptophytes. For most of the identified species the toxic molecules were largely located in the leaves and flowers. It was also observed that forested areas were characterized by a limited number of pesticidal plants with a higher coverage rate, while the opposite is true in fallow lands and scrublands.

Introduction

Chemical pesticides are characterized by their high toxicity which makes them particularly dangerous for humans, animals, living organisms and the environment as whole (Ravindran *et al.*, 2016). It is estimated that that each year, between 5.000 and 20.000 deaths are attributed to pesticides (Alewu *et al.*, 2011), and between 500.000 to 1 million people are poisoned by these toxic substances (Yadav *et al.*, 2015). It is therefore necessary to explore other effective ways of protection, less toxic and less polluting especially biopesticides.

Biopesticides, as a part of biological control methods, can be derived from bacteria, fungi, viruses, nematodes, and plants (Vincent, 1998) and offer many advantages, including. They can be produced in large quantities to meet the needs of industry, and their application is compatible with conventional sprayers, thus facilitating their adoption by farmers (Wachenheim *et al.*, 2021).

Any plant whose chemical properties can be exploited to control pests, thereby significantly reducing the pressure of bio-aggressors and the need for synthetic pesticides, is called a pesticide plant (Amoatey & Acquah, 2010) (Yarou *et al.*, 2017) .

"In addition to plant molecules with insecticidal, fungicidal, or herbicide properties, recent research has highlighted the capabilities of plant compounds in plant defense mechanisms. These findings open up new perspectives in terms of stimulating the plant's natural defenses or developing chemical and biological processes to valorize these molecules as phytosanitary products or strategies (Regnault-Roger *et al.*, 2008) (Berestetskiy , 2023).

This paper reviews the current status of research plants and their active substances to identify potential sources of biological and natural pesticides, has become a concern for researchers in recent years. In this context, the present work aims to identify and determine pesticide plants in different environments in the region of Chlef (Algeria) that can be the subject of tests and studies for their use in the protection of crops against pests and pathogens.

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Methods

Study sites

The study region (Chlef) is located in Northwest Algeria, at an altitude of 116 meters, at 36.21° North latitude and 1.33° East longitude. It includes three distinct geographical zones: a coastal zone, a plain zone, and a mountain zone. In each of these three zones, we chose three different stations (wasteland, scrubland, and forest) where we conducted our floristic surveys (fig 1). These stations or study sites are located in Beni Haoua for the coastal zone, in Oued Fodda for the plain zone, and in Beni Bouatab for the mountain zone.

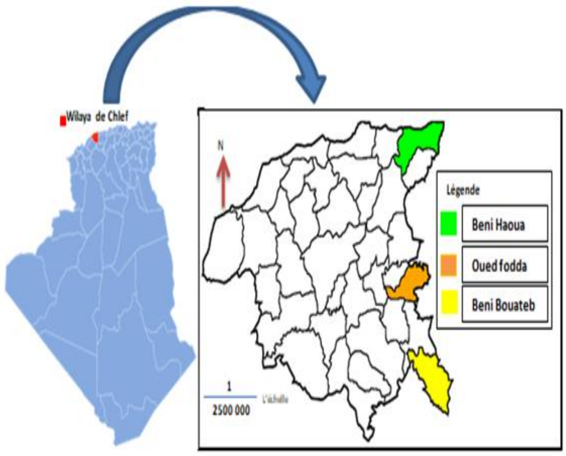

Fig 1: Geographic location of the region and study sites

In each station (forest, scrubland, and wasteland) of the three zones mentioned above, a monthly plant survey is conducted throughout an entire year. This is done in 10m² plots chosen at random in different locations of the study station (fig 2).

During each survey, the frequency of pesticide plants is estimated according to the phytosociological method of Braun-Blanquet and the determination of the biological type was made according to the Raunkiær classification (1934).

Fig 2: Plant census and frequency estimation methods

To facilitate plant identification, we used different guides to the Algerian flora described by Gubb (1930), Maire (1959), Quezel and Santa (1962 and 1963), Bremness (2005), and Ilbert *et al*. (2016). In addition, to distinguish pesticide plants from the entire set of identified plants, we referred to, on the one hand, the work on the pesticide effect of plants carried out in Algeria and elsewhere, and on the other hand, to the testimonies and opinions of Algerian passants and farmers who have already used this practice in the protection of their cultures.

Frequency calculation

To calculate the frequency of plants in different environments, we delineated plots of 10 m² within which we estimated the areas occupied by each plant at the level of each environment. Then we calculated the frequency of territory occupied by the plant in the environment in question. This is obtained as follows:

$$fr = \frac{\text{area occupied by the plant}}{\text{delimited area}} \times 100$$

Statistical analysis: Correspondence Analysis (CA)

To determine the correlations between the different plants identified, on the one hand, and the correlations of these plants with the study environments, on the other hand, the data collected underwent a correspondence analysis (CA) using the software (IBM SPSS Statistics (2020).

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Results

Table 1: Inventoried pesticide plants, their botanical families, their toxic parts, and their target insects

Familly	Scientific name	Part used	Target pest	Bibliography reference
Lamiacées	*Lavandula stoechas*	Flowers and leaves	*Aphis fabae*	Ketoh (1998)
	Rosmarinus officinalis	Leaves	*Aphis fabae* *Penicillium digitatum*	Sehari et *al.* (2018) Daferera (2000)
	Thymus vulgaris	Leaves	*Ceratitis capitata*	Oulebsir- Mohandkaci et *al.* (2015)
	Origanum vulgare	Leaves	*Penicillium digitatum* *Aspergilus sp*	Daferera (2000) Carmo et *al.* (2008)
	Origanum majorana	Flowers and leaves	*Spodoptera littoralis*	Souguir et *al.* (2013)
	Mentha rotundifolia	Leaves	*Ephestia kuehniella*	Aouadi et *al.* (2020)
	Salvia officinalis)	Flowers and leaves	*Aphis fabae Scopol*	Benoufella-kitous (2015)
	Marrubium vulgare	stem with leaves	*Sitophylus oryzae*	Sehari et *al.* (2018)
	Phlomis crinita	Leaves	*Agrobacterium sp, Erwinia amylovora*	Fettah (2011)
	Mentha pulegium	Leaves	*Sitophylus oryzae*	Sehari et *al.* (2018)
Asteraceae	*Chamaemelum nobile*	Flowers	*Tribolium castaneum*	Hashem & Ramadan (2021)
	Chrysanthemum cinerariaefolium	Flowers	*Aphis fabae*	Ketoh (1998)
	Calendula officinalis	Flowers	*Aphis fabae*	Bouzeraa et *al.* (2019)
	Inula viscosa	Flowers and leaves	*Cladosporium cladosporioides*	Touhidul et *al. (2022)*
	Bellis annua	Flowers and leaves	*Aphis fabae*	Smith et Boon (2004)
	Anacyclus clavatus	Flowers	*Aphis fabae*	Khabbach et *al.* (2012)
	Echinops spinosus	Leaves	Bactrocera oleae	Belabes et *al.* (2020)
	Calendula arvensis	Flowers	*Tribolium castaneum*	Abudunia et *al.* (2014)
	Artemisia absinthium	Leaves	*Sitophilus zeamais*	Abbott (1925)
Apiaceae	*Ammoïdes verticillata*	Flowers and leaves	*Acanthoscelides obtectus*	Bittner et *al.* (2008)
	Daucus carota	Flowers and leaves	*Ceratitis capitata*	Duyck (2002)
	Foeniculum vulgare	Seeds	*Sitophilus zeamais*	Zoubiri & Aoumeur (2011)
	Daucus Crinitus	Flowers and leaves	*Tuta absoluta*	Benyahia-Bouayad Alam (2015)

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Cupressaceae	*Juniperus oxycedrus*	Flowers and leaves	*Sitophilus oryzae* *Tribolium confusum*	Athanassiou et *al*. (2013)
	Juniperus phoenicea	Leaves	*Aphis sp*	Amokrane et *al*. (2023)
	Cupressus sempervirens	Leaves	*Tribolium castaneum*	Saada et *al*. (2022)
	Tetraclinus articulata	Flowers and leaves	*Culicidae*	Aouinty et *al*. (2006)
Myrtaceae	*Myrtus comminus*	Flowers	*Tribolium confusum* *Callosobruchus maculatus*	Khani and Basavand (2013)
	Eucalyptus globulus	Leaves	*Myzus persicae*	Oulebsir- Mohandkaci et *al*. (2015)
Cucurbitaceae	*Ecballium elaterium*	Flowers and leaves	*Aphis fabae*	Maria et *al*. (1999)
	Colocynthis vulgaris	Fruit	*Phytophtora infestans* *Myzus persicae*	Maqsoud et *al*. (2022)
Asparagaceae	*Drimia maritima*	Flowers	*Drosophila melanogaster*	Saadane et *al*. (2020)
Poaceae	*Cymbopogon shoenanthus*	Leaves	*Callosobruchus maculatus*	Ketoh et al. (2006)
Agavaceae	*Agave americana*	Leaves	*Sitophylus oryzae*	Maazoun (2019)
Fabaceae	*Genista scoparia*	Flowers and leaves	*Aphis fabae*	Ketoh (1998)
Tamaricaceae	*Tamarix aphylla*	Leaves	*Aspergillus sp*	Bibi et *al*. (2015)
Rhamnacées	*Ziziphus lotus*	Leaves	*Thaumetopoea Pityocampa*	Bammou et *al*. (2015)
Rutacées	*Ruta montana*	Leaves	*Acanthoscelides obtectus*	Bittner et *al*. (2008)
Pinacées	*Pinus sylvestris*	Flowers and leaves	*Botrytis cineria*	Capieau et *al*. (2004)
Anacardiacées	*Pistacia lentiscus*	Leaves	*Aphis sp*	Amokrane et *al*. (2023)
Zygophyllacées	*Peganum harmala*	Seeds	*Locusta migratoria*	Benzara et *al*. (2011)
Apocynacées	*Nerium oleander*	Flowers	*Chaitophorus leucomelas*	Zaid et *al*. (2022
Urticacées	*Urtica dioica*	Leaves	*Culex pipiens*	Toubal et *al*. (2019)
Oléacées	*Olea europaea*	Leaves	*Ephestia uehniella*	Lahcene et *al*. (2018)
Asphodelacées	*Asphodelus microcarpus*	Flowers and leaves	*Tribolium castaneum*	Saada et al (2022)
Euphorbiacées	*Ricinus communis*	Roots	*Macrosiphum rosae*	El Haddad et *al*. (2022)
	Mercurialis annua	Flowers	*Tribolium confusum*	Ben Nasr et *al*. (2021)

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In the present study, we have identified 47 plant species that are potentially useful as biopesticides for crop protection against pests and pathogens. These are distributed over 21 botanical families, the most represented of which are Lamiaceae with 10 species and Asteraceae with 9 species. They are followed by Apiaceae with 4 species, Cupressaceae with 4 species, Myrtaceae and Cucurbitaceae with 2 species, and finally the other families with 1 species each (table 1).

According to the literature, the substances or molecules with pesticide effects are largely located in the leaves and flowers. Thus, in 21 species, only the leaves are toxic compared to 9 species in which only the flowers are toxic, while 14 other species are toxic through the leaves and flowers at the same time.

Distribution of inventoried plants by biological type:

The enumeration of species by biological type is carried out on all the species inventoried in the study stations (Table 2). Thus, the percentage of the different types is recorded in Fig 3. It appears that the hemicryptophytes and phanerophytes are the most represented with 17 species (36.17%) and 15 species (31.92%), respectively. They are followed by therophytes with only 9 species, or 19.15%, then chamaephytes with 4 species (8.51%) and finally geophytes with only 2 species (4.25%).

Table 2: Biological types of pesticide plants found in the study sites:

Types Biologiques	Espèces
Phanerophtes,	*Agave Americana, Cupressus sempervirens, Ziziphus lotus, Myrtus communis, Nerium oleander, Olea europaea, Tetraclinus articulata, Tamarix aphylla, Pinus sylvestris ,Pistacia lentiscus, Ricinus communis, Eucalyptus globulus, Genista scoparia, Juniperus oxycedrus, Juniperus phoenicea*
Therophytes	*Ammoides verticillata, Anacyclus clavatus, Bellis annua, Calendula arvensis, Calendula officinalis Chrysanthemum cinerariaefolium, Colocynthis vulgaris, Mercurialis annua, Urtica dioica*
Heicryptophytes	*Chamaemelum nobile ,Artemisia absinthium, Cymbopogon shoenanthus; Daucus carota, Daucus crinitus, Mentha rotundifolia; Mentha pulegium, Marrubium vulgare, Thymus vulgaris, Ruta Montana, Salvia officinalis, Inula viscosa, Phlomis crinita, Origanum vulgare, Origanum majorana , Ecballium elaterium, Echinops spinosus*
Chamaephytes	*Peganum harmala, Foeniculum vulgare, Lavandula stoechas ,Rosmarinus officinalis*
Geophytes	*Asphodelus microcarpus ,Drimia maritima*

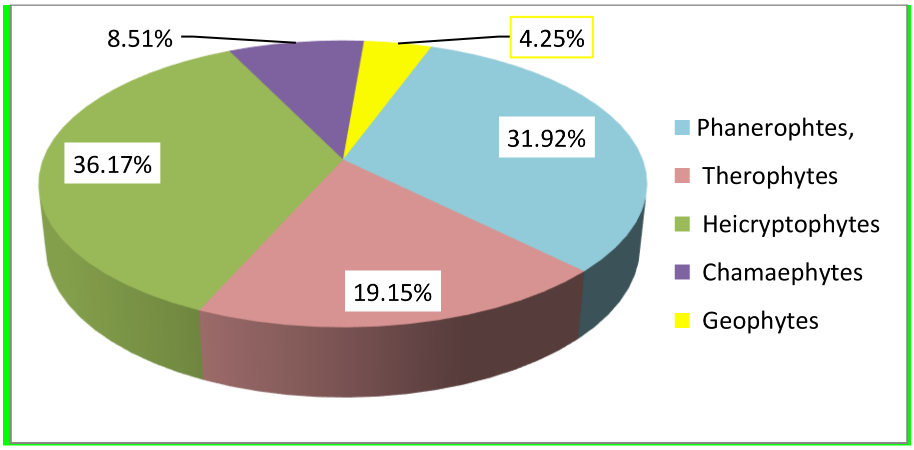

Fig 3: Frequency of biological types in the study areas

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Table3: Frequency of each pesticidal plant found in each of the surveyed sites

Region Species	Mountain region			Plain region			Coastal region		
	Wasteland	**Scrubland**	**Forest**	**Wasteland**	**Scrubland**	**forest**	**Wasteland**	**Scrubland**	**Forest**
Agave americana		2						1,5	
Ammoides verticillata	0,8	0,15		1,25			0,55		
Anacyclus clavatus	4,5	0,5		8,45	0,3		2,5		
Artemisia absinthium		0,8		0,4	0,8				
Asphodelus microcarpus	0,1	4	0,05				0,05	0,55	
Bellis annua	1,5	0,15		3,2	0,2		0,85		
Calendula arvensis	1,15			0,95			0,85		
Calendula officinalis	1,25			0,5			2,5		
Chamaemelum nobile	0,8			2,5					
Chrysanthemum cinerariaefolium	1,85	0,25		5,55			1,55		
Colocynthis vulgaris	2,35								
Cupressus sempervirens		0,8	2					0,02	1,2
Cymbopogon shoenanthus	1,85	0,25					1,25	0,3	
Daucus carota	0,08	0,02		0,1	0,02				
Daucus crinitus	0,8			1,95	0,15		0,55		
Drimia maritime	0,3	0,1	0,05				0,1	0,08	
Ecballium elaterium	0,4			0,25					
Echinops spinosus	0,25			0,2			0,1		
Eucalyotus globulus						65			
Foeniculum vulgare	1,2	0,04			0,55				
Genista scoparia		1,35	0,25				0,25	3,55	0,75
Inula viscosa	0,5	0,08		0,75	0,08				
Juniperus oxycedrus		3,2	2,15					1,5	
Juniperus phoenicea		0,75	3,04						
Lavandula stoechas	2,8	0,25					3,1	0,75	
Marrubium vulgare	0,55			1,2					
Mentha pulegium					0,05				
Mentha rotundifolia				1,2					
Mercurialis annua	0,15	0,08		0,25	0,1				
Myrtus communis								2,2	1,4
Nerium oleander					5,25				
Olea europaea		3,5	3,25					4,2	2,2
Origanum majorana	0,25						0,4		
Origanum vulgare	0,08			0,25	0,03				
Peganum harmala		0,03							
Phlomis crinite	0,08	0,03					0,05		
Pinus sylvestris		3.50	65					8,5	70

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Pistacia lentiscus		10,25	5,25					15.35	6,5
Ricinus communis					8,5				
Rosmarinus officinalis		0,85							
Ruta Montana	1,2						0,65		
Salvia officinalis	0,75	0,25					0,8	0,25	
Tamarix aphylla		2,5			50				
Tetraclinus articulate		6,25	3,25					7,55	2,35
Thymus vulgaris	0,75	0,9							
Urtica dioica	0,45			3,55	4,25				
Ziziphus lotus				0,5	3			1,5	
Total coverage by pesticidal plants (%)	**26.74**	**42.83**	**84.29**	**33**	**73.28**	**65**	**16.1**	**47.8**	**84.4**

Total coverage by pesticide plants was high in forests, ranging from 65% to over 84% depending on the zone, slightly less in scrublands (42.83% to 73.28%) and low in wastelands (16% to 33%). In any case, the presence of this type of plant is very marked in the study area, although the coverage rate differs according to the type of environment (table 3).

Forested areas are characterized by a reduced number of plant species, but their frequencies (coverage rate) are very high. Thus, it was noted that *Pinus sylvestris* has a frequency of 70% and 65% in two surveyed forest areas, and *Eucalyptus globulus* covers 65% of the forest area at the station in the Oued Fodda region (plain area). Scrublands are characterized by a mixture of herbaceous plants and shrubs. Sometimes, the dominance of certain species is noted, but their frequencies are lower than those mentioned in forest environments. We note *Tamarix aphylla* with a frequency of 50% in scrubland of Oued fodda (Plain area), *Pistacia lentiscus* whose frequency was 10.25% in the scrubland of Beni Bouatab (mountain area) and 15.35% in that of Beni Haoua (coastal area).

As for wastelands, characterized by a single herbaceous layer with a low coverage rate, the best frequencies noted are those of *Anacyclus clavatus*, which reached 8.45% in the site of Oued Fodda (Plain area) and 4.5% in that of Beni Bouatab (mountainous area), as well as that of *Lavandula stoechas*, which was 3.1% in the site of Beni Haoua (coastal area).

Distribution and correlation of pesticide plants through a CA

The presence-absence of pesticide plants in the different surveyed sites underwent a CA of which we only retained the results of the first two axes which represent 64.24% of inertia (Fig4). From this, it appears three distinct groups. The first group appears on the positive side of axis 1 and includes plants correlated with forest environments (FtM and FtL) and scrublands (GM and GL). These are *Myrtus communis* (Myc*)*, *Tetraclinus articulate* (Tea), *Pinus sylvestris* (Pis), *Cupressus sempervirens* (Cus), *Pistacia lentiscus* (Pis), *Cupressus sempervirens*(Cus), *Pistacia lentiscus* (Pil), *Olea europea* (Ole), *Juniperus oxycedrus* (Juo), *Juniperus phoenicea (Jup)*, *Agave americana* (Aga), *Rosmarinus officinalis* (Roo) et *Peganum harmala* (Peh). The second group represents the plant species correlated exclusively with scrubland environments. This has been individualized on the positive side of axis 2. These are *Mentha pulegium* (Mep), *Nerium oleander* (Neo), *Ricinus communis* (Ric), *Ziziphus lotus* (Zil), *Artemisia absinthium* (Ara), *Foeniculum vulgare* (Fov), *Tamarix aphylla* (Taa), *Urtica dioica* (Urd), *Daucus carota* (Dac), *Origanum vulgare* (Orv), *Inula viscosa* (Inv), *Mercurialis annua(Mea)* and *Daucus crinitus* (Dar). The third group appeared on the negative side of axis 2 and concerns plants correlated with wastelands. These plants are *Origanum majorana* (Orm), *Calendula arvensis (Caa)*, *Ruta montana* (Rum), *Echinops spinosus* (Ecs), *Cymbopogon shoenanthes*(Cys), *Calendula officinalis*(Cao),*Chamaemelum nobile*(Chn), *Colocynthis vulgaris* (Cov), *Phlomis crinite (*Phc),

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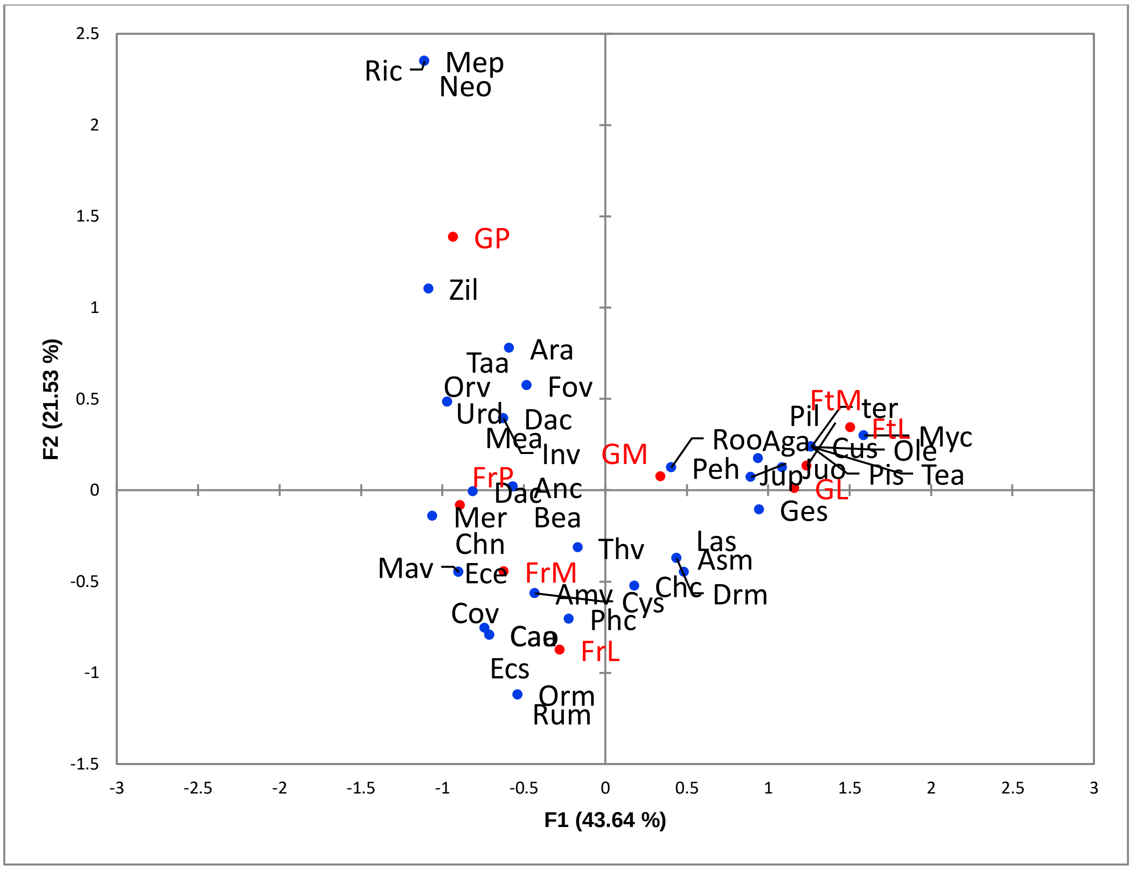
Chrysanthemum cinerarifoliem (Chc), *Lavandula stoechas* (Las), *Ecballium elaterium (*Ece), *Ammoides verticillata (*Amv), *Marrubium vulgare* (Mav), *Mentha rotundifolia* (Mer), *Asphodelus microcarpus* (Asm), *Thymus vulgaris (*Thv), and *Bellis annua* (Bea).



FrP: Scrubland plain, FrM: Scrubland mountain, FrL: Scrubland Coastal
FtP: Forest plain, FtM: Forest mountain, FtL: Forest Coasta
GP: wasteland plain, GM: wasteland mountain GL: wasteland Coastal

Fig 4: Correlations of pesticidal plants - environments through CA

4. Discussion

The number of pesticide plants inventoried in the study area indicates a significant richness and diversity. In Algeria, no study has been devoted to the census of pesticide plants, but some attempts to know the aromatic and medicinal plants have been undertaken in some regions of the country such as those of Belouad (1998) and Kazi tani & Dali yahia (2020). An ethnobotanical study conducted in the southeast of Chlef allowed the determination of 84 spontaneous medicinal species (Maamar Sameut *et al.*, 2020). In West Africa, Yarou *et al* (2017) cited 23 plants used to control arthropod pests of vegetable crops and 14 plants used against fungi and nematodes.

From a systematic point of view, this pesticide flora is dominated by Lamiaceae and Asteraceae, and a little less by Apiaceae and Cupressaceae. A study of medicinal and aromatic plants in the same study area revealed the dominance of the families of Lamiaceae and Asteraceae (Maamar Sameut *et al.*, 2020). It is worth noting that these two botanical families are commonly associated with Mediterranean regions (Johnson, *et al*., 2008).

These plants produce active substances with insecticidal, antiseptic, or plant and insect growth

regulating properties. Most often, these active substances are secondary metabolites that originally protected plants from herbivores. These substances are largely located in the leaves and flowers. Plant pesticide extracts are less dangerous than synthetic pesticides and can have comparable efficacy in some conditions. They differ from them by their rapid decomposition and low polluting effect (Yarou *et al.*, 2017). The use of certain biopesticides in rotation or in combination with other biopesticides or with chemical products can help reduce the amount of chemical inputs, as well as the emergence of new strains resistant to pests (Xu *et al.*, 2011).

The pesticide plants in the Chlef region are dominated by therophytes, and much less by hemicryptophytes, chamaephytes, and phanerophytes. Maamar Sameut *et al*. (2020) noted that spontaneous medicinal and aromatic plants in the Chlef region are also dominated by therophytes and hemicryptophytes (27.38%) against 23.81% for phanerophytes and only 13.10 and 8.33% for chamaephytes and geophytes, respectively. Therophytes are considered a form that is resistant to drought and high temperatures in arid and semi-arid zones; they also adapt to winter cold and environmental disturbances due to grazing and cultivation (Kerzabi *et al.*, 2011), while Aidoud (1983) reports that in the Algerian high plateaus the increase in therophytes is directly related to a gradient of increasing aridity.

Biological types are morphological characteristics that allow plants to adapt to the environments in which they live (Dajoz, 1977). However, they express the form presented by plants in an environment without taking into account their systematic affiliation and translate a biology and a certain adaptation to the environment (Barry, 1988).

Overall, this distribution of biological types reflects the adaptation of plants to environmental conditions and survival strategies. The abundance of therophytes and hemicryptophytes can be associated with disturbed habitats or short life cycles, while the presence of chamaephytes and phanerophytes may indicate an adaptation to more rigorous and stable conditions. This understanding of biological types contributes to the knowledge of the structure and dynamics of plant communities in the ecosystem under study.

The results of species frequency reveal interesting variations in the distribution of plant species. Thus, some species are specific to certain zones (coastal, plain, or mountain) or stations (wasteland, scrubland or Forest), while others are present in a more or less uniform manner.

Forested areas include fewer plant species, but their frequencies (coverage rate) are very high, given the nature and architecture of the plants present there (trees) such as *Eucalyptus globulus* and *Pinus sylvestris.* According to Johnson *et al.* (2008), the first species is adapted to hot and dry climates and frequents plains and regions with moderate precipitation, while the second species is adapted to mountain climates. These two forest plants have a bioinsecticidal effect against *Myzus persicae* (Oulebsir Mohand-Kaci *et al.*, 2015) and a biofungicidal effect against *Botrytis cinerea* (Capieau *et al.*, 2004), respectively.

In contrast to forests, wastelands and scrublands areas are composed mainly of herbaceous plants or at least a few shrubs, which are numerous but have low coverage. Among the abundant plants in these environments, we noted *Anacyclus clavatus*, whose insecticidal effect has been proven against *Tribolium castaneum* (Maria *et al.*, 1999), as well as *Lavandula stoechas* having a biocidal effect against *Aphis spiraecola* and *Tuta absoluta* (Amara *et al*., 2020) as well as certain insects of stored products, including *Rhizopertha dominica* and *Tribolium castaneum* (Ncibi, 2020).

The variations in the frequencies of pesticide plants from one area to another can be influenced by environmental factors, interactions between species and their habitat, as well as anthropogenic factors such as human activity (Anderson, 2016).

The correspondence factor analysis allowed us to identify among the pesticide plants found in the study area the forest species, those in scrublands and those in fallows, although it is difficult to attribute a plant species to a single environment. Forest species can be found in more open environments and vice versa. Significant correlations are noted between forest plants and those in scrubland. Hakou (2023) noted that about 80% of the forest plants in the Rabat region (Morocco) are aromatic and medicinal. These plants, which in most cases have a pesticide effect on herbivores and other phytopathogenic agents, can be used in biological crop protection. In general, it is important to continue research efforts in Algeria and elsewhere to understand pesticide plants and explore their potential as alternatives to chemical pesticides. Such studies could

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provide valuable information for sustainable agriculture, environmental protection, and human health.

Conclusion

Algeria is debatably the country with the most to gain from developing natural plant-based pesticides. This study allowed us to identify 47 species with pesticidal properties have been quantified from Chlef region. These plants are distributed over 21 different botanical families; the most represented being the Lamiaceae and Asteraceae. They are dominated by therophytes, followed by hemicryptophytes, then chamaephytes and phanerophytes. Forested areas are characterized by a small number of plant species, but their frequencies or coverage rates are very high, in contrast to wastelands and scrublands where plants are numerous but with low frequencies.

References bibliographiques

1. Abbott, W.S. (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18:265-267.
2. Abudunia, A.M., Ansar, M., Taoufik, J., Ramli, Y, Essassi, E.M., Ibrahimi, A. and Khedid K. (2014). Evaluation of antibacterial activity of extracts from Calendula arvensis flowers, Journal of Chemical and Pharmaceutical Research, 6(8), pp156-16.
3. Aidoud, A. (1983). Contribution à l'étude phytosociologique des formations végétales de la steppe du Nord-Ouest Algérien (Régions de Tiaret et Tlemcen). Thèse de doctorat, Université de Lyon.
4. Alewu, B., and Nosiri, C. (2011). Pesticides and Human Health. Pesticides in the Modern World - Effects of Pesticides Exposure. Edité par Margarita Stoytcheva InTech. http://dx.doi.org/10.5772/18734.
5. Amara, N., Boukhatem, M.N., Laissaoui, O. and Kaibouche, N. (2020). Valorisation de l'Huile Essentielle de la Lavande Papillon comme Bioinsecticide. Algerian journal of natural products. 8 (1): 733-739
6. Amoatey, C.A. and Acquah, E. (2010): Basil (*Ocimum basilicum*) intercrop as a pest mangement tool in okra cutivation in the Accra plains. *Ghana J. Hortic*., 8, 65-70.
7. Anderson, JT. (2016). Plant fitness in a rapidly changing world. *New Phytol* 210: 81–87.
8. Aouadi, G., Haouel, S., Soltani, A., Ben Abada, M., Boushih, E., Elkahoui, S., Taibi1, F., Mediouni -Ben Jemâa, J. and Bennadja, S. (2020). Screening for insecticidal efficacy of two Algerian essential oils with special concern to their impact on biological parameters of Ephestia kuehniella (Zeller) (Lepidoptera: Pyralidae), Journal of Plant Diseases and Protection 127:471–482.
9. Aouinty, B., Oufara, S., Mellouki, F. and Mahari, S. (2006). Evaluation préliminaire de l'activité larvicide des extraits aqueux des feuilles du ricin (*Ricinus communis* L.) et du bois de thuya (*Tetraclinis articulata* (Vahl) Mast.) sur les larves de quatre moustiques culicidés : *Culex pipiens* (Linné), *Aedes caspius* (Pallas), *Culiseta longiareolata* (Aitken) et *Anopheles maculipennis* (Meigen). S E Biotechnol. Agron. Soc. Environ. 2006 10 (2), 67 – 71
10. Athanassiou, C., Kavallieratos, N., Evergetis, E., Katsoula, A.M. and Haroutounian S.A. (2013). Insecticidal Efficacy of Silica Gel With Juniperus oxycedrus ssp. oxycedrus (Pinales: Cupressaceae) Essential Oil Against Sitophilus oryzae (Coleoptera: Curculionidae) and Tribolium confusum (Coleoptera: Tenebrionidae). Journal of economic entomology. 106(4):1902-10
11. Bammou, M., Daoudi, A., Slimani, I., Najem, M., Bouiamrine, E.H., Ibijbijen, J. and Nassiri, L. (2015). Valorisation du lentisque « Pistacia lentiscus L. » : Étude ethnobotanique, Screening phytochimique et pouvoir antibactérien. J. Appl. Biosci.,86: 7966– 7975.
12. Barry, J.P. (1988). Approche écologique des régions arides de l'Afrique. Université de Nice.ISS de Nouakchout. 107p.
13. Belabbes, R., Mami, I. R., Dib, M.E.A., Mejdoub, K., Tabti, B., Costa, J.and Muselli, A. (2020). Chemical Composition and Biological Activities of Essential Oils of

Echinops spinosus and Carlina vulgaris Rich in Polyacetylene Compounds. Current nutrition & food science. Volume 16, Issue 4, 563-570
14. Beloued, A. (1998). *Plantes médicinales d'Algérie*. 5 Ed Office des publications universitaires, Alger, 184p.
15. Ben Nasr, R., Baudelaire, E.D., Dicko, A., and Hela El Ferchichi, O.H. (2021). Phytochemicals, Antioxidant Attributes and Larvicidal Activity of *Mercurialis annua* L. (*Euphorbiaceae*) Leaf Extracts against *Tribolium confusum* (Du Val) Larvae (*Coleoptera*; *Tenebrionidae*). Biology (Basel) . 10(4): 344
16. Benoufella-Kitous, K., (2015). Bioecologie des pucerons de differentes cultures et leurs ennemis naturels a Oued-Aissi et Draa Ben Khedda (Tizi-Ouzou).These de doctorat ENSA.El Harrach.Alger.234p.
17. Benyahia-Bouayad Alam, S. (2015). Activités antimicrobiennes et insecticides de Thymus capitatus, Daucus crinitus et Tetraclinis articulata sur la mineuse Tuta absoluta (Meyrick) et la microflore pathogène de la tomate Lycopersicum esculentum. Thèse de Doctorat en Ecologie et environnement. Université de Tlemcen.
18. Benzara ,A., Benabdelkrim, A and Khalfi-Habes, O.(2011). Effets des extraits aqueux des graines de Peganum harmala L. (Zygophyllaceae) sur les larves de 5ème stade de Locusta migratoria cinerascens (Fabricus,1781), (Orthoptera : Oedipodinae). Neuvième conférence internationale sur les ravageurs en agriculture. Montpellier- 26 et 27 Octobre 2011.
19. Berestetskiy, A. (2023). Modern Approaches for the Development of New Herbicides Based on Natural Compounds, *Plants 12*(2), 234.
20. Bibi, S. , Afzal, M ., bibi, K., aziz, N., aziz, S and Raheem, A. (2015). Antifungal Activity of Tamarix aphylla (L.) Karst. Stem-bark Extract Against Some Pathogenic Fungi. International journal of pharmacological research. 5 (2) : 44-48
21. Bittner, M. L., Casanueva, M. E., Arbert, C. C., Aguilera, M. A., Hernández, V. J., and Becerra J. V.(2008). Effects Of Essential Oils From five plant species againt the granary weevils Sitophilus zeamais and Acanthoscelides obtectus (Coleoptera). J. Chil. Chem. Soc, 53 (1), pp: 1455-1459
22. Bouguerra,N., Tine.Djebbar,F and Soltani,N. (2019). Oregano Essential Oilas Potential Mosquito arvicide , Transylvanian Review. Vol XXVII, No. 39.
23. Bouzeraa, H., Bessila-Bouzeraa, M. and Labed, N.(2019). Repellent and fumigant toxic potential of three essential oils against Ephestia kuehniella, Biosyst. Divers, 27(4).
24. Bremness, L. (2005). Fleurs sauvages des régions méditerranéennes. Delachaux et Niestlé.
25. Capieau, K., Stenlid, J and Stenstro, E.(2004). Potential for Biological Control of Botrytis cinerea in Pinus. Scand. J. For. Res. 19: 312/319
26. Carmo, E.S., Lima, E.D.O. and De Souza, E.L.(2008). The potential of Origanum vulgare L. (Lamiaceae) essential oil in inhibiting the growth of some food-related Aspergillus species. Brazilian Journal of Microbiology 39, pp 362-367.
27. Daferera, D.J., Ziogas, B.N. and Polissiou, M.G. (2000). GC-MS analysis of essential oils from some Greek aromatic plants and their fungitoxicity on Penicillium digitatum.J. Agric. food. Chim., 48(6):2576-81
28. Dajoz, R. (1977). Précis d'écologie (2ème édition). Dunod.
29. Duyck, P.F.(2002). Survival and development of different life stages of three Ceratitis spp. (Diptera: Tephritidae) reared at five constant temperatures.
30. El Haddad, D., Toubal, S., Bouchenak, O., Boumaza, S., Merah, M. , Yahiaoui, K. and Arab, K. (2022). Insecticidal activity of algerian castor extracts Ricinus communis against the green rose aphid Macrosiphum rosae. Revue Agrobiologia 12(1): 2827-2833
31. Fettah, A. (2011). Activités anti-microbienne des extraits aqueux de deux plantes médicinales : Phlomis crinita L. (Lamiaceae) et

Carthamus coereleus L. (Asteraceae). Thèse de master.Université de Blida.78p.
32. Gubb, A S. (1913). La flore algérienne : Naturelle et Acquise. Ed Adolphe Jourdan,Alger, 318p.
33. Habes, D., Kilani-Morakchi, S., Aribi, N., Farine, J.P and Soltani, N. (2006). Boricacid toxicity of theGerman cockroach, Blattella germanica: Alterations in midgut structure, and acetycholinesterase and glutathione S-transferase activity. Pestic. Biochem. Physiol,84, 17-24.
34. Hakkou, S., Sabir, M. and Machouri, N. (2023). Principales plantes aromatiques et médicinales forestières dans la région Rabat-Salé-Kénitra, Maroc. 11(1) : 1-13
35. Hashem, A.S. and Ramadan, M.M. (2021). Nanoemulsions of Chamomile and Cumin Essential Oils: As an Alternative Bio-rationalControl Approach against the Red Flour Beetle, Tribolium castaneum. Journal of Plant Protection and Pathology. Volume 12, Issue 1, Page 11-17 **https://doi.org/10.3390/plants12020234**
36. Ilbert, H., Hoxha, V., Sahi, L., Courivaud, A. & Chailan, C. (2016). Le marché des plantes aromatiques et médicinales. analyse des tendances du marché mondial et des stratégies économiques en Albanie et en Algérie. Montpellier : CIHEAM/France AgriMer (Option méditerranéenne, Série B : étude et recherche. N° 73, 222p.
37. Johnson, M. P., O'Brien, D. M., and Vellend, M. (2008). Les effets de la richesse en éléments nutritifs du sol sur la composition de la communauté végétale. Ecology, 89(9), 2467-2476.
38. Kazi tani, C. and Dali yahia, K. (2020). Quatre-vingt-quatorze plantes médicinales odonto-stomatologiques d’Algérie. Al Yasmina 1 : 12/1-22.
39. Kerzabi, R., Abdessamad, M. and Stambouli Meziane, H. (2016). Floristic Diversity of Atriplexaies in Western Algeria. Biosciences Biotechnology Research Asia, 13(2) : 761-767
40. Ketoh, G.K., Koumaglo, H.K. and Huignard, J. (2006). Comparative effects of *Cymbopogon schoenanthus* essential oil and piperitone on *Callosobruchus maculatus* development. Fitoterapia. 77(7-8):506-10
41. Ketoh, G.K.(1998). Utilisation des huiles essentielles des quelques plantes du Togo comme biopesticides dans la gestion des stades de développement de Callosobruchusmaculatus (Coleoptera : Bruchidae). Thèse de doctorat. Univ. Lomé, Bénin, 141p.
42. Khabbach, A., Libiad, M., Enabili, A. and Bousta, D. (2012). Medicinal and comsmetic use of plants from the province of Taza, Northem Morocco. Boletin Latinoam ericano y del Caribe de Plantas Medicinales y Aromaticas. Vol. 11, n°1, pp 40-60.
43. Khani, A. and Basavand, F. (2013). Chemical Composition and Insecticidal Activity of Myrtle (Myrtus communisL.) Essential Oil against Two Stored-Product Pests. Journal of Medicinal Plants and By-products. 2: 83-89
44. Lahcene, S., taibi, F., Mestar, N., Ali Ahmed, S., Boumendjel, M., Saida, O. and Houali, K. (2018).Insecticidal effects of the Olea europaea subsp. laperrinei extracts on the flour Pyralid Ephestia kuehniella. Cellular and molecular biology 64(11):6-12
45. Maamar Sameut, Y., Belhacini, F. and Bounaceur, F. (2020). Étude éthnobotanique dans le sud-est de Chlef (Algérie occidentale). Revue Agrobiologia 10(2):2044-61
46. Maazoun, A.M., Haouel Hamdi ; S., Belhadj, F., Mediouni BenJemâa, J., Messaoud, C. and Marzouki, M.N. (2019). Phytochemical profile and insecticidal activity of *Agave americana* leaf extract towards *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). *Environmental Science and Pollution Research*. 26, 19468–19480
47. Maire, R. (1959) : Flore de l'Afrique du Nord (Vol. 8). Paul Lechevalier.
48. Maqsood, A., Sajid, A.R., Javeed, A., Aslam, M., Ahsan, T, Hussain, D., Mateen, A., Li, X., Qin, P. and Ji, M. (2022). Antioxidant, antifungal, and aphicidal activity of the triterpenoids spinasterol and 22,23-

dihydrospinasterol from leaves of *Citrullus colocynthis* L. Scientific Reports. 12: 4910.

49. Maria, J., Pascual-Villalobos, M.J., Robledo, A. (1999). Anti-insect activity of plant extracts from the wild flora in southeastern Spain. Biochemica Systemics and Ecology. 27 : 1-10
50. Ncibi ,S . (2020). Potentiel bioinsecticide des huiles essentielles sur deux ravageurs des céréales stockées Rhyzopertha dominica (Fabricius, 1792) et Tribolium castaneum (Herbst, 1797) et Identification de leurs ennemis naturels. Thèse de Doctorat, INAT de Tunis, 315p.
51. Oulebsir- Mohandkaci, H., Ait Kaki, S. and Doumandji-Mitiche, B. (2015). Essential Oils of two Algerian aromatic plants Thymusvulgaris and Eucalyptus globulus as Bio-insecticides against aphid Myzus persicae (Homoptera: Aphididae). Wulfenia journal, Vol 22, No. 2; 185-197
52. Quezel, P., and Santa, S. (1962). Nouvelle flore de l'Algérie et des régions désertiques méridionales. Ed CNRS. Vol.1, Paris, pp.1-565.
53. Raunkiær, C. (1934).The life forms of plants and statistical plant geography being the collected papers of C. Raunkiær, with 189 photographs and figures. Ed Oxford University Press, Oxford, xvi, 632 p.
54. Ravindran, Jayaraj., Pankajshan Megha and Puthur Sreedev, (2016). Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment, Interdiscip Toxicol. 9(3 -4) : 90-100. doi: 10.1515/intox-2016-0012
55. Regnault-Roger, C. and Philogène, B. J. R and Vincent, C. (2008). Recherche de nouveaux biopesticides d'origine végétale à caractère insecticides: démarche méthodologique et application aux plantes aromatiques méditerranéennes. (coord) Biopesticides d'origine Végétale, 2nd édition. Lavoisier, Paris, France, p. 25–50.
56. Saada, I., Mahdi, K., Boubeka, N., Benzitoune, N. and Salhi, O. (2022). Variability of insecticidal activity of *Cupressus sempervirens* L., *Juniperus phoenicea* L., *Mentha rotundifolia* (L.) Huds, and *Asphodelus microcarpus* Salzm. & Viv. extracts according to solvents and extraction systems. Biochimical Systematics and Ecology.Volume 105. , 104502
57. Saadane, F.Z., Habbachia, W., Habbachia, S., Boublataa, N.E., Slimanib, A. and Tahraouia, A. (2020). Toxic effects of Drimia maritima (Asparagaceae) ethanolic extracts on the mortality, development, sexual behaviour and oviposition behaviour of Drosophila melanogaster (Diptera: Drosophilidae). J Anim Behav Biometeorol (2021) 9:2102
58. Sehari, H. N., Benchaben, H., Sehari, M. and Maatoug M. (2018). Insecticide effect of pennyroyal and rosemary essential oils onthe rice weevil Ukrainian, Journal of Ecology, 8(1), 696–702 doi: 10.15421/2018_268.
59. Smith, M. and Boon, H. (2004). The Complete Natural Medicine Guide to the 50 Most Common Medicinal Herbs. Ed.Robert Rose. 352p.
60. Souguir, S., Chaieb, I ., Beicheikh-Affene, Z . and Laarif, A. (2013). Activité Bio-insecticide des huiles essentielles de Marjolaine (Origanum majorana) et de Fenouil (Foeniculum vulgare) sur les larves de *Spodoptera littoralis*. Conference: Quatrièmes Journées Scientifiques sur la Valorisation des Bioressources 04 - 05 mai 2013. Tunisie
61. Toubal, S., Elhaddad, Dj., Bouchenak, O., Yahiaoui, K., Sadaoui, N. and Arab, K.(2019). L'importance des extraits d'Urtica dioica L. dans la lutte contre Culex pipiens (Linné, 1758). Algerian journal of environmental science and technology. Vol 5, N 1,
62. Touhidul, I., Anowarul, H., Nur Uddin, M., Dipali, R. G. and Tofazzal, I. (2022). In vitro compatibility of entomopathogenic fungus, Cladosporium cladosporioides with three plant extracts. Plant Protection Science, 58, (3): 213–219
63. Vincent, C. (1998). Biopesticides: An overview of their mode of action and their use in pest control. Outlooks on Pest Management, 9(6), 203-208.

64. Wachenheim, C., Fan, L., Zheng, S. (2021). Adoption of unmanned aerial vehicles for pesticide application: Role of social network, resource endowment, and perceptions, Technology in Society Volume 64, , 101470
65. Xu, X., Jeffries, P., Pautasso, M. and Jeger, M. (2011). Combined use of biocontrol agents to manage plant disease in theory and practice. *Phytopathology*, 101(9), 1024-1031.
66. Yadav, I. C., Devi, N. L., Syed, J. H., Cheng, Z., Li, J. and Zhang, G. (2015). Current status of persistent organic pesticides residues in air, water, and soil, and their possible effect on neighboring countries: a comprehensive review of India. *Sci. Total Environ.* 511 123–137.
67. Yarou, B.B., Silvie, P., Assogba Komlan, F., Mensah, A., Alabi, T., Verheggen, F. and Francis, F. (2017). Plantes pesticides et protection des cultures maraichères en Afrique de l’Ouest (synthèse bibliographique). Biotechnol. Agron. Soc. Environ. 21(4), 288-304
68. Zaid, R., Canela-Garayoa, R., Ortega-Chacon, N.M. and Mouhouche, F. (2022). Phytochemical analyses and toxicity of *Nerium oleander* (Apocynaceae) leaf extracts against *Chaitophorus leucomelas* Koch, 1854 (*Homoptera: Aphididae*). Journal of saudi society of agricultural scence. 21 (5) : , Pages 310-317
69. Zoubiri, S. and Aoumeur, B. (2011). Chemical composition and insecticidal peropertier of some aromatic herbs essential oils form Algeria. Food chemistry129179-182.