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Course and Practical Work Handout

Intended for Master 1 students

Weed science

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UNIVERSITY OF AMAR TELIDJI - LAGHOUAT

FACULTY OF SCIENCES
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DEPARTMENT OF AGRICULTURAL SCIENCES

Course notes

Intended for students of the
1st Year Academic Master's Degree :
Specialization : Plant Protection

WEED SCIENCES

Directed by :
Dr. Mériem MARFOUA

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FOREWORD

Weed Science is a semester-long module taught during the first semester of the Master's program in Plant Protection (see Appendix 1). It includes lectures and practical sessions.

The module consists of three hours per week (1.5 hours of lectures and 1.5 hours of practical sessions).

The objectives of this module are to enable students to:

- ✓ Acquire basic knowledge about weeds applied to plant protection.
- ✓ Gain concepts related to the collection,
- ✓ Preservation, and the establishment of a herbarium.

Weed science, or the study of weeds, plays a crucial role in agronomic sciences and the management of agricultural ecosystems. Weeds, often perceived as mere nuisances, have profound impacts on crop productivity, biodiversity, and the sustainability of agricultural systems. This discipline focuses on the study of weeds, their biology, their ecology, and the methods to manage them effectively and sustainably.

The aim of this course is to provide an in-depth understanding of the complex interactions between weeds, crops, and the environment. It highlights the challenges posed by these plants in agricultural production systems, including their competition for resources, their role in the spread of diseases, and their economic impact.

Beyond traditional chemical control methods, this course explores integrated approaches, combining cultural, biological, and chemical techniques, while considering the imperatives of sustainability and environmental protection. It thus prepares students to address the challenges of weed management in diverse agricultural contexts.

Finally, this course is designed from both scientific and practical perspectives, aiming to train students capable of identifying, evaluating, and proposing management strategies tailored to the specificities of ecosystems and the local and global socio-economic challenges.

GENERAL OVERVIEW OF WEEDS

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Weed science refers to the collection of sciences and techniques dedicated to studying "weeds" that grow spontaneously. Its purpose is to understand weeds, with two main objectives:

- ✓ To determine the effects of these plants on agricultural production (traditionally referred to as their harmfulness).
- ✓ Consequently, to identify means of managing them.

Weeds, also called adventitious plants, are naturally occurring plants that grow in cultivated fields or gardens. They are adapted to the same soils and climatic conditions as cultivated plants. Practices that benefit crops also favor the growth of weeds. These are plants that spread naturally (without human intervention) in natural or semi-natural habitats **(Brunel et al., 2005)**.

Weeds have been described as "plants growing in the wrong place." More specifically, they are plants that compete with those we want to grow. They compete for water, sunlight, and nutrients in the soil. In some cases, their seeds contaminate seed crops and reduce their value. Certain weeds have the ability to subtly alter soil chemistry, with harmful effects on plant species and, consequently, on animals.

I.1.- DEFINITIONS

Weeds are defined differently depending on biological, agronomic, and ecological contexts:

I.1.1.- General definition

A weed is a plant that grows in an undesired location, usually competing with crops or occupying space in areas managed by humans.

Adventitious plant (Botany): A plant species that is foreign to the native flora of a territory, accidentally introduced, and capable of establishing itself.

This term also applies to plants that grow spontaneously in a cultivated area and whose presence is more or less harmful to the crops. For example, a wheat field infested with Wild Mustard (*Sinapis arvensis*).

Competitive effects on plants: Competition for space, water, light, and nutrients in the soil. Competition within the system for water and soil nutrients. For example, comparing a cereal crop with an adventitious plant of the legume type and observing the nature of their root systems.

Weeds, often referred to as adventitious plants, represent a diverse group of plants that coexist with agricultural crops or thrive in human-altered environments. They pose various challenges due to their impact on agricultural productivity, their ecological roles, and their adaptability. This chapter provides a general introduction to weeds, focusing on their definitions and biological types.

I.1.2.- Agronomic definition

Any plant that reduces crop productivity, disrupts agricultural operations, or decreases the quality of harvested products is considered a weed.

Weed (weed science): An undesired herbaceous or woody plant found where it is not wanted.

In agronomy, an "adventitious plant" refers to any plant growing in a cultivated field without being intentionally sown by the farmer during the current growing season.

I.1.3.- Ecological definition

Weeds are opportunistic plants that take advantage of ecosystem disturbances to establish, reproduce, and thrive. They are often characterized by:

- Their ability to reproduce rapidly,
- A staggered germination over time,
- Tolerance to environmental stresses.

I.2.- BIOLOGICAL TYPES OF WEEDS

Weeds can be classified based on their life cycle, morphological adaptations, and ecological adaptations. Here are the main biological types:

I.2.1.- Classification based on life cycle

I.2.1.1.- Annual weeds

These plants complete their life cycle (germination, growth, reproduction, and death) in a single season or year.

a

b

Examples: **(a)** *Chenopodium album* (white goosefoot), **(b)** *Amaranthus retroflexus* (redroot pigweed).

Main characteristic: They produce large quantities of seeds to ensure their survival.

I.2.1.2.- Biennial weeds

These plants have a two-year life cycle. The first year is devoted to vegetative growth, while reproduction occurs in the second year.

a

Example: **(a)** *Daucus carota* (wild carrot).

I.2.1.3.- Perennial weeds

These plants persist for several years through storage organs (rhizomes, tubers, bulbs).


a **b**

Examples: **(a)** *Cynodon dactylon* (Bermuda grass), **(b)** *Convolvulus arvensis* (bindweed).

Main characteristic: They often spread vegetatively.

I.2.2.- Classification based on ecological adaptations

I.2.2.1.- Crop weeds

Adapted to agricultural ecosystems, they thrive in fertile, disturbed soils.


a **b**

Examples: **(a)** *Echinochloa crus-galli* (barnyard grass), **(b)** *Avena fatua* (wild oats).

I.2.2.2.- Ruderal weeds

Present in environments disturbed by humans (roadside, construction sites).

a

Example: **(a)** *Taraxacum officinale* (dandelion).

I.2.2.3.- Invasive weeds

Introduced species that spread quickly, outcompeting local species and disrupting natural ecosystems.

a

Examples: **(a)** *Parthenium hysterophorus*.

I.2.3.- Morphological classification

I.2.3.1.- Herbaceous weeds

Plants with non-woody stems (annuals, biennials, or perennials).

a

Example: **(a)** *Stellaria media* (chickweed).

I.2.3.2.- Woody weeds

Shrubs or trees that colonize crops or grassland.

a

Example : **(a)** *Prosopis juliflora* (mesquite).

ECONOMIC IMPORTANCE

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Weeds represent a major challenge for farmers due to their negative effects on agricultural yields and production costs. However, when managed effectively, they can also offer significant economic opportunities, particularly in the fields of medicine, ecology, and industry. Integrated weed management is essential to minimize their harmful effects while leveraging their potential benefits.

a. Negative economic impacts

Weeds are often associated with significant economic losses in agricultural systems and other human activities:

- ✓ **Competition with crops:** Weeds compete with crops for essential resources (water, light, nutrients), leading to reduced yields. *For example, Striga spp., a cereal parasite, can reduce maize or sorghum production by up to 80%.*

  In Algeria, this competition is particularly detrimental in arid and semi-arid regions, where water is a limiting resource.

- ✓ **Increased production costs:** Farmers must invest in control methods (manual weeding, herbicides, machinery), thereby increasing expenses. Algerian farmers must invest in weed management practices such as chemical herbicides, mechanical and manual weeding, and cultural techniques (crop rotation, plowing). These management costs significantly reduce agricultural income.

- ✓ **Effects on agricultural product quality:** Some weeds can contaminate harvests, affecting their market quality or nutritional value. For example, certain grassy weeds can reduce the quality of crops, impacting their market value.

- ✓ **Spread of diseases and pests:** Weeds can sometimes host pathogens or harmful insects that attack main crops. *For instance, black nightshade (Solanum nigrum) can harbor aphids that transmit viruses to vegetable crops.*

  Excessive herbicide use: Over-reliance on herbicides to control weeds can lead to soil and water pollution, chemical residues in agricultural products, and the emergence of herbicide resistance in some weed species.

b. Positive economic impacts

When managed appropriately, weeds can also provide economic and ecological benefits:

- ✓ **Livestock forage:** Some weeds are used as animal feed, particularly in arid or semi-arid regions. For example, wild alfalfa and other spontaneous species can be harvested for grazing.
- ✓ **Use in pharmacology:** Several weed species have medicinal properties or are used in pharmaceutical products. For instance, purslane (*Portulaca oleracea*) is valued for its anti-inflammatory and antioxidant properties.
- ✓ **Biodiversity enhancement:** Weeds help maintain biodiversity by providing habitats for pollinators and other beneficial species.
- ✓ **Industrial applications:** Some weeds can be used to produce essential oils, natural dyes, or even biofuels.
- ✓ **Soil protection:** Certain weeds prevent soil erosion by anchoring the substrate with their roots, especially in uncultivated areas.
- ✓ **Role in biodiversity and ecosystem preservation:** Some weed species provide habitats and food sources for wildlife, promoting agricultural biodiversity.
- ✓ **Potential in biocontrol and traditional medicine:** Some weeds have bioactive properties that can be used in biological control against other weeds or pathogens, or even in traditional medicine.
- ✓ **Use in forage and soil fertilization:** Some weeds can be used as supplementary livestock feed or green manure, reducing agricultural production costs.

Conclusion and recommendations

Weeds have a significant economic impact in Algeria, primarily negative due to reduced agricultural yields and high management costs. However, certain species have economic and ecological potential that could be better exploited.

Sustainable agricultural practices, integrating integrated weed management and the valorization of their benefits, should be promoted to minimize their negative effects and maximize their advantages.

II.1.- IN THE WORLD

Weeds, often considered undesirable plants in agricultural crops, play a complex role in global ecosystems and economies. Although they are generally perceived as harmful due to their impact on agricultural yields, they can also have beneficial effects in certain contexts.

II.1.1.- Global agricultural context

II.1.1.1.- Reduction in agricultural yields

Weeds are one of the primary causes of yield loss in agriculture. They compete with crops for essential resources such as water, soil nutrients, and light. According to the FAO (Food and Agriculture Organization of the United Nations), weeds can reduce agricultural yields by 10 to 50%, depending on the crops and regions.

II.1.1.2.- Costs of weed control

Farmers spend significant amounts of money to control weeds. This includes costs associated with herbicides, mechanical weeding, and cultural practices aimed at minimizing infestation. Globally, annual expenditures on herbicides amount to billions of dollars.

For example, in the United States, herbicide expenses represent a significant portion of agricultural production costs.

II.1.1.3.- Herbicide resistance

The intensive use of herbicides has led to the emergence of resistant weeds, complicating their management and increasing costs for farmers. Herbicide resistance is a growing problem in many regions of the world, requiring additional investments in research and development to find new solutions.

II.1.2.- Positive economic impacts of weeds

II.1.2.1.- Biodiversity and ecosystem services

Some weeds contribute to biodiversity by providing habitat and food for various animal species. They can also play a role in preventing soil erosion and regulating hydrological cycles. These ecosystem services have an indirect economic value, although it is difficult to quantify.

II.1.2.2.- Medicinal and food uses

Some weeds have traditional uses in medicine and cuisine. *For example, the dandelion (Taraxacum officinale) is used in some cultures for its medicinal properties and as a food ingredient*. These uses can generate income for local communities and contribute to the informal economy.

II.1.2.3.- Biofuels and bioproducts

Some weeds, such as water hyacinth (*Eichhornia crassipes*), are being studied for their potential in producing biofuels and other bioproducts. If these technologies are developed on a large scale, they could offer new economic opportunities while contributing to the management of invasive species.

II.1.3.- Regional perspectives

II.1.3.1.- Developed countries

In developed countries, where agriculture is highly mechanized and reliant on chemical inputs, weeds represent a major challenge in terms of management costs and yield losses. However, these countries also have the resources to invest in research and development of new control methods.

II.1.3.2.- Developing countries

In developing countries, weeds can have an even more significant impact due to the greater reliance on subsistence agriculture and limited resources for their management. Yield losses caused by weeds can exacerbate food insecurity and poverty.

Weeds have considerable economic importance on a global scale, with both negative and positive impacts. While their detrimental effects on agricultural yields and management costs are well-documented, it is also important to recognize their potential contributions to biodiversity, ecosystem services, and the informal economy. Integrated and sustainable weed management, combining chemical, biological, and cultural approaches, is essential to minimize their negative impacts while maximizing their potential benefits.

Recommendations

1. **Invest in Research:** Increase investments in research on weed control methods, including alternatives to chemical herbicides.

2. **Promote Sustainable Agricultural Practices:** Encourage the adoption of sustainable agricultural practices that reduce reliance on herbicides and promote ecosystem health.

3. **Education and Training:** Provide education and training to farmers on integrated weed management methods.

4. **Value Alternative Uses:** Explore and promote alternative uses of weeds, such as biofuels and medicinal products, to create new economic opportunities.

By adopting a balanced and multifaceted approach, it is possible to reduce the negative economic impacts of weeds while harnessing their potential benefits for ecosystems and local economies.

II.2.- IN ALGERIA

In Algeria, as in many other countries, weeds represent a major challenge for agriculture while also having complex economic implications.

This report examines the economic importance of weeds in Algeria, focusing on their negative impacts on agricultural yields, management costs, as well as their potential uses in specific contexts.

II.2.1.- Agricultural context in Algeria

Agriculture is a key sector of the Algerian economy, contributing approximately 12% of GDP and employing a significant portion of the workforce. Major crops include cereals (wheat, barley), vegetables, fruits, and industrial crops such as potatoes and tomatoes. However, agriculture in Algeria faces several challenges, including drought, soil degradation, and weed pressure.

II.2.2.- Negative economic impacts of weeds

II.2.2.1.- Reduction in agricultural yields

Weeds are one of the primary causes of yield loss in Algeria. They compete with crops for resources such as water, nutrients, and light, which is particularly problematic in a context of water stress and often poor soils.

For example, in cereal crops, weeds can reduce yields by 20 to 40%, depending on the region and management practices.

II.2.2.2.- Costs of weed control

Algerian farmers spend significant amounts of money to control weeds, particularly on purchasing herbicides and using manual or mechanical weeding methods. These costs represent a considerable portion of agricultural expenses, especially for smallholders with limited resources. The excessive use of herbicides can also lead to environmental issues, such as soil and water pollution.

II.2.2.3.- Herbicide resistance

As in other countries, the intensive use of herbicides in Algeria has led to the emergence of resistant weeds, complicating their management and increasing costs for farmers. For example, certain weed species, such as ryegrass (*Lolium spp.*), have developed resistance to commonly used herbicides, requiring more costly and complex management approaches.

II.2.3.- Positive economic impacts of weeds

II.2.3.1.- Traditional and medicinal uses

Some weeds in Algeria have traditional uses in medicine and cuisine. For instance, milk thistle (*Silybum marianum*) is used for its hepatoprotective properties, while dandelion (*Taraxacum officinale*) is consumed as a vegetable in some regions. These uses can generate income for local communities and contribute to the informal economy.

II.2.3.2.- Biodiversity and ecosystem services

Some weeds contribute to biodiversity by providing habitat and food for various animal species. They can also play a role in preventing soil erosion, a major issue in Algeria due to land degradation and arid climatic conditions.

II.2.4.- Regional perspectives in Algeria

II.2.4.1.- Cereal-growing areas in the North

In the northern regions of Algeria, where cereals are widely cultivated, weeds such as ryegrass and Bermuda grass (*Cynodon dactylon*) pose significant problems. These regions, which benefit from relatively higher rainfall, are also more prone to weed proliferation, requiring increased management efforts.

II.2.4.2.- Arid and semi-arid zones

In the arid and semi-arid zones of the south and the high plateaus, weeds are often adapted to drought conditions and can compete with crops for water, an already limited resource. Species such as saltbush (*Atriplex spp.*) and purslane (*Portulaca oleracea*) are common in these regions.

II.2.5.- Challenges and opportunities

II.2.5.1.- Challenges

- **Water resource management:** Weeds exacerbate competition for water, a scarce resource in Algeria.

- **High management costs:** Smallholders often struggle to finance weed control methods.

- **Lack of training:** Many farmers lack knowledge about integrated weed management methods.

II.2.5.2.- Opportunities

- **Valorization of weeds:** Some weeds could be exploited for their medicinal or food uses, creating new income sources.

- **Sustainable agriculture:** Promoting sustainable agricultural practices, such as crop rotation and mechanical weeding, could reduce reliance on herbicides.

Conclusion

Weeds have significant economic importance in Algeria, primarily due to their negative impacts on agricultural yields and management costs. However, they also offer opportunities, particularly through their traditional uses and their role in biodiversity.

Integrated and sustainable weed management, combining chemical, biological, and cultural approaches, is essential to minimize their negative impacts while harnessing their potential benefits.

Recommendations

1. **Strengthen agricultural research:** Invest in research on weed control methods adapted to local conditions.

2. **Promote sustainable practices:** Encourage the adoption of sustainable agricultural practices, such as crop rotation and agroecology.

3. **Awareness and training:** Train farmers in integrated weed management methods.

4. **Value alternative uses:** Explore and promote the medicinal and food uses of weeds to diversify income sources.

By adopting a balanced approach, Algeria can reduce the negative economic impacts of weeds while leveraging their potential benefits for ecosystems and local communities.

Weeds play an ambivalent role in agricultural and ecological systems. In Algeria, they represent a major challenge for agriculture, directly influencing crop productivity and incurring significant management costs. However, some weeds also offer ecological and economic benefits.

HARMFULNESS

III

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The harmfulness of weeds refers to their ability to cause damage to crops, ecosystems, and human activities. This impact can be direct or indirect, varying depending on the weed species, the affected crops, and environmental conditions.

Understanding weed harmfulness is essential for developing effective management strategies.

III.1.- NATURE OF DAMAGE

Weeds cause damage in various ways, directly affecting crops and ecosystems. This damage can be classified into several categories:

III.1.1.- Competition for resources

Weeds compete with crops for access to essential resources, reducing plant growth and yield. The main resources affected are:

*__Water__: In arid regions like Algeria, water competition is particularly critical. Weeds absorb soil moisture, reducing its availability for crops.

*__Nutrients__: Weeds extract essential nutrients from the soil (nitrogen, phosphorus, potassium), limiting crop nutrition.

*__Light__: Tall or fast-growing weeds can shade crops, reducing photosynthesis and plant productivity.

III.1.2.- Allelopathy

Some weeds produce inhibitory chemical substances, known as allelopathic compounds, which are released into the soil and affect crop germination and growth.

For example, Bermudagrass (*Cynodon dactylon*) produces compounds that inhibit the growth of neighboring plants.

III.1.3.- Physical damage

Weeds can cause physical damage to crops by hindering farming operations (plowing, sowing, harvesting) or by inflicting mechanical injuries on cultivated plants. For example, creeping weeds can wrap their stems around crops, limiting their growth.

III.1.4.- Impact on harvest quality

The presence of weeds can affect the quality of agricultural products. For instance, seeds from certain weeds can mix with harvests, reducing their market value. Additionally, some weeds can alter the taste or texture of products.

III.1.5.- Proliferation of diseases and pests

Weeds often serve as intermediate hosts for pathogens (fungi, bacteria, viruses) and pest insects. For example, ryegrass (*Lolium spp.*) can harbor fungi responsible for cereal diseases, thereby increasing the risk of infestation.

III.2.- BIOLOGICAL INTERACTIONS

Weeds interact with other organisms in agricultural ecosystems, which can amplify or mitigate their harmfulness. These biological interactions are complex and influence the dynamics of weed and crop populations.

III.2.1.- Interactions with crops

***Interspecific competition**: Weeds and crops compete for the same resources, which can lead to reduced growth and yield of crops.

***Microclimate modification**: Weeds can alter microclimatic conditions around crops, for example, by increasing relative humidity, which promotes the development of fungal diseases.

III.2.2.- Interactions with soil microorganisms

***Impact on the rhizosphere**: Weeds can alter the composition and activity of soil microorganisms, thereby affecting nutrient availability for crops.

***Competitive symbioses**: Some weeds compete with crops for beneficial symbiotic associations, such as mycorrhizae, which enhance nutrient uptake.

III.2.3.- Interactions with insects and other animals

***Hosts for pests**: Weeds can serve as refuges or food sources for pest insects, increasing their populations and their impact on crops.

***Hosts for beneficial organisms**: Conversely, some weeds can harbor beneficial insects (predators or parasitoids) that contribute to pest regulation.

III.2.4.- Interactions with other weeds

***Intraspecific Competition**: Weeds of the same species can compete with each other for resources, thereby limiting their proliferation.

***Interspecific Competition**: Weeds of different species can also compete, influencing the composition of weed communities in fields.

III.2.5.- Interactions with agricultural practices

***Effect of crop rotations**: Crop rotations can influence weed dynamics by disrupting their life cycle and reducing their adaptation.

***Impact of herbicides**: The use of herbicides alters biological interactions by eliminating certain weed species, which can promote the emergence of resistant or more competitive species.

Conclusion

The harmfulness of weeds is a complex phenomenon resulting from their interactions with crops, microorganisms, insects, and agricultural practices. The damage caused by weeds is multifaceted, ranging from competition for resources to the proliferation of diseases and pests. A thorough understanding of these biological interactions is essential for developing integrated weed management strategies aimed at minimizing their negative impacts while preserving ecological balances.

In Algeria, where climatic conditions and limited resources exacerbate the challenges posed by weeds, a holistic and sustainable approach is necessary to optimize agricultural productivity while protecting ecosystems.

III.3.- HARMFULNESS DUE TO WEEDS

The harmfulness of weeds is a central concept in agriculture, as it describes their ability to cause damage to crops and ecosystems. It is influenced by numerous factors, including the nature of the weeds, environmental conditions, and agricultural practices. Understanding this harmfulness is essential for implementing effective management strategies.

III.3.1.- Concept of harmfulness

The harmfulness of weeds refers to their negative impact on crops and ecosystems. It can be assessed through two main concepts: the **potential flora** and the **actual flora** **(Fig. 01)**.

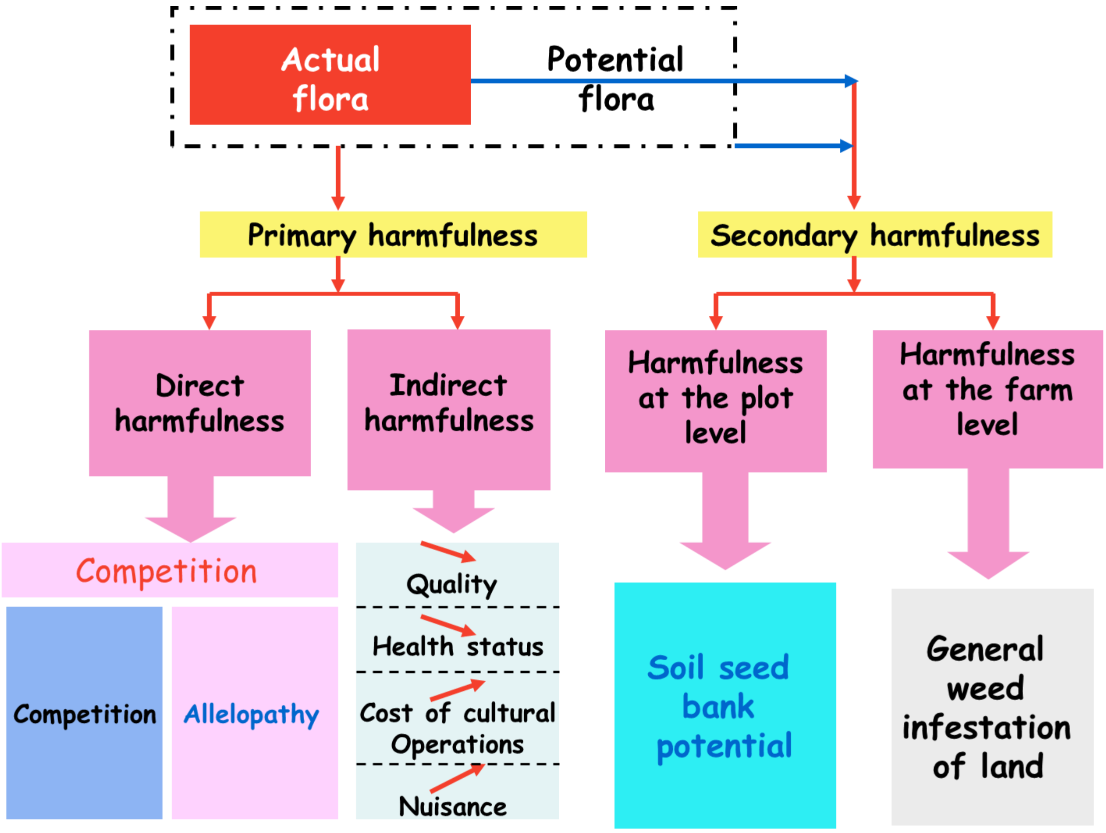

Figure 01 : Types of weed harmfulness in crops.

III.3.1.1.- Harmfulness due to potential flora

The potential flora represents all the weed species present in a given region that are capable of developing in crops. This concept includes:

- Species already established in the area.
- Species likely to establish themselves due to climatic, edaphic (soil-related), and cultural conditions.
- Potential harmfulness is a theoretical estimate of the damage these species could cause if left uncontrolled.

III.3.1.2.- Harmfulness due to actual flora

The actual flora corresponds to the weed species effectively present in a field or agricultural plot at a given time. It is influenced by:

- Farming practices (crop rotation, plowing, weeding).
- The use of herbicides.
- Environmental conditions (climate, soil).
- Actual harmfulness is measured by the observed damage to crops, such as reduced yields or deterioration in harvest quality.

III.3.2.- Aspects of harmfulness

The harmfulness of weeds manifests through several aspects, which can interact and amplify their negative impacts.

III.3.2.1.- Biological interactions between weeds and cultivated plants

Weeds interact with cultivated plants in complex ways:

- **Competition:** For resources (water, nutrients, light).
- **Allelopathy:** Production of inhibitory chemical substances.
- **Microclimate modification:** Weeds can increase humidity around crops, promoting fungal diseases.

III.3.2.2.- Competition due to weeds

Competition is one of the primary mechanisms of harmfulness. Weeds compete with crops for:

- **Water:** Essential for growth, especially in arid regions.
- **Nutrients:** Nitrogen, phosphorus, potassium, etc.

- **Light:** Tall weeds can shade crops, reducing photosynthesis.

III.3.2.3.- Depletion of nutrients

Weeds absorb nutrients from the soil, reducing their availability for crops. This can lead to :

- Nutritional deficiencies in cultivated plants.
- Long-term decline in soil fertility.
- Increased costs for fertilization to compensate for losses.

III.3.2.4.- Accidental crossbreeding and loss of homogeneity

Some weeds can crossbreed with cultivated plants, especially in the case of related species. This results in :

- Reduced genetic purity of crops.
- Loss of harvest homogeneity, affecting quality and market value.
- Risks of spreading undesirable genes (e.g., herbicide resistance).

III.3.2.5.- Allelopathy due to weeds

Allelopathy is a phenomenon where certain weeds release chemical substances into the soil, inhibiting the germination and growth of cultivated plants. Examples: Bermuda grass (*Cynodon dactylon*) produces allelopathic compounds. Johnsongrass (*Sorghum halepense*) releases toxins that affect neighboring crops.

III.3.3.- Harmfulness thresholds

Harmfulness thresholds are indicators used to determine when weeds must be controlled to avoid significant economic losses. They are divided into two main categories:

III.3.3.1.- Biological harmfulness threshold

The biological harmfulness threshold corresponds to the level of weed presence at which they begin to cause significant damage to crops. This threshold depends on:

- The weed species.
- The growth stage of the crop.

- Environmental conditions (climate, soil).
- For example, a low density of weeds may be tolerable early in the crop cycle but becomes problematic if it persists.

III.3.3.2.- Economic harmfulness threshold

The economic harmfulness threshold is the level of weed presence at which the cost of their control is justified by the economic losses they cause. This threshold takes into account :

- The cost of control methods (herbicides, manual weeding).
- The economic value of the crop.
- Expected yield losses.
- For example, if the cost of weeding exceeds the value of avoided yield losses, intervention is not economically justified.

Conclusion

The harmfulness of weeds is a multifactorial phenomenon involving biological interactions, competition mechanisms, and allelopathic effects. Harmfulness thresholds, both biological and economic, are essential tools for guiding weed management decisions.

In Algeria, where water and nutrient resources are often limited, integrated weed management is crucial to minimizing their negative impacts while optimizing agricultural productivity.

A balanced approach, combining chemical, biological, and cultural methods, is necessary to achieve this goal. This includes :

- Regular monitoring of weed populations.
- Using harmfulness thresholds to guide interventions.
- Promoting sustainable farming practices, such as crop rotation and agroecology.

EVOLUTION OF WEED FLORA

IV

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The evolution of weed flora is a dynamic process influenced by ecological, biological, and anthropogenic factors. Understanding this evolution is crucial for developing effective weed management strategies. This section explores the ecology of germination, evolutionary mechanisms, and factors influencing changes in weed populations.

IV.1.- GERMINATION ECOLOGY

Germination is a critical phase in the weed life cycle, determining their establishment and spread. The ecology of germination involves several key aspects:

IV.1.1.- Dormancy and germination triggers

Seed dormancy: Many weed seeds exhibit dormancy, a survival mechanism that prevents germination under unfavorable conditions. Dormancy can be: Physical (hard seed coats). Physiological (internal inhibitors).

Germination triggers : Weed seeds often require specific environmental signals to break dormancy, such as :

- Temperature fluctuations.
- Light exposure (photoblastic seeds).
- Soil moisture and oxygen levels.
- Soil disturbance (e.g., tillage).

IV.1.2.- Soil seed bank dynamics

The soil seed bank is the reservoir of viable weed seeds present in the soil, playing a crucial role in weed population persistence and evolution.

Factors influencing soil seed bank dynamics include:

- Seed longevity (some weed seeds remain viable for decades).
- Seed production (many weeds have a high reproductive capacity).
- Seed predation and decomposition.

IV.1.3.- Germination niches

Weeds often exploit specific germination niches, such as disturbed soils, crop rows, or areas with particular microclimates.

Understanding these niches helps predict weed emergence patterns and design targeted control measures.

IV.2.- EVOLUTIONARY MECHANISMS

Weed populations evolve through various mechanisms, allowing them to adapt to environmental changes and management practices.

IV.2.1.- Natural selection

Natural selection favors weed traits that enhance survival and reproduction, such as:

- Herbicide resistance.
- Rapid growth and early flowering.
- High seed production.
- Over time, these traits become more prevalent within the population.

IV.2.2.- Genetic diversity

Weeds often exhibit significant genetic diversity, providing a foundation for adaptation. Sources of genetic diversity include :

- Sexual reproduction (cross-pollination).
- Mutations and genetic recombination.
- Hybridization with related species.

IV.2.3.- Herbicide resistance

The intensive use of herbicides has led to the evolution of resistant weed populations. The resistance mechanisms include :

- Target site mutations (e.g., modified herbicide binding sites).

- Enhanced detoxification (e.g., metabolic resistance).
- Reduced herbicide absorption or translocation.

IV.2.4.- Phenotypic plasticity

Phenotypic plasticity allows weeds to adjust their growth and development in response to environmental conditions. Examples include :

- Changes in leaf size or root architecture under stress.
- Adjustments in flowering time based on competition.

IV.3.- EVOLUTIONARY FACTORS

The evolution of weed flora is influenced by a combination of natural and anthropogenic factors.

IV.3.1.- Agricultural practices

- **Tillage**: Frequent tillage can stimulate weed seed germination and alter the soil seed bank dynamics.
- **Crop rotation**: Monocultures promote the dominance of certain weed species, while diverse rotations can suppress them.
- **Herbicide use**: Overreliance on herbicides selects for resistant weed populations.

IV.3.2.- Environmental changes

- **Climate change**: Variations in temperature, precipitation, and CO_2 levels can influence weed distribution and competitiveness.
- **Soil degradation**: Changes in soil health, such as nutrient depletion or erosion, can favor certain weed species.

IV.3.3.- Biological interactions

- **Competition**: Weeds compete with crops and other weeds, driving the evolution of competitive traits.

- **Predation and disease**: Natural enemies of weeds (e.g., insects, pathogens) can influence their evolution.

IV.3.4.- Human activities

- **Introduction of invasive species**: Human activities, such as trade and travel, can introduce new weed species into ecosystems.
- **Land use changes**: Urbanization, deforestation, and agricultural expansion modify habitats and favor certain weeds.

Conclusion

The evolution of weed flora is a complex process influenced by ecological, genetic, and anthropogenic factors. Understanding seed germination ecology, evolutionary mechanisms, and influencing factors is crucial for predicting weed behavior and developing sustainable management strategies.

In agricultural systems, the evolution of herbicide resistance and the adaptability of weeds to environmental changes pose significant challenges. A proactive approach, integrating diverse control methods and promoting ecological balance, is necessary to mitigate the impacts of evolving weed populations.

Key recommendations :

1. **Diversify management practices**: Combine chemical, cultural, and biological methods to reduce selection pressure.
2. **Monitor weed populations**: Regularly assess weed diversity and resistance to guide management decisions.
3. **Promote sustainable agriculture**: Adopt practices such as crop rotation, cover crops, and reduced tillage to suppress weeds and enhance ecosystem resilience.
4. **Invest in research**: Study weed ecology and evolution to develop innovative control strategies.

By addressing weed evolution factors and promoting adaptive management, it is possible to maintain agricultural productivity while minimizing the negative impacts of weeds.

IV.4.- STUDY OF THE SOIL SEED BANK

The soil seed bank represents the total viable weed seeds present in the soil that can germinate and give rise to new plants. Studying the seed bank is essential to understanding weed population dynamics, predicting their emergence, and developing effective management strategies. This study involves several key aspects:

IV.4.1.- Seed bank composition

The seed bank consists of seeds from various weed species, each with specific characteristics in terms of longevity, dormancy, and germination capacity.

- **Species diversity**: The seed bank may contain seeds from multiple species, some dominant and others rarer.
- **Seed quantity**: The number of seeds per unit area or soil volume varies based on agricultural practices, environmental conditions, and field history.

IV.4.2.- Sampling and analysis methods

The study of the seed bank requires precise sampling and analysis methods to assess its composition and density.

IV.4.2.1.- Soil sampling

Soil samples are collected at different depths (typically 0-10 cm and 10-20 cm) to evaluate the vertical distribution of seeds.

Samples are taken randomly or systematically to ensure a representative assessment of the field.

IV.4.2.2.- Seed extraction

Seeds are extracted from the soil using physical methods (sieving, flotation) or chemical methods (density-based solutions).

Extracted seeds are then identified and counted to determine the seed bank’s density and composition.

IV.4.2.3.- Germination tests

Extracted seeds are subjected to germination tests in laboratories or greenhouses to evaluate their viability.

These tests help determine the germination potential of seeds and their future contribution to the weed flora.

IV.4.3.- Factors influencing the seed bank

Several factors influence the composition and dynamics of the soil seed bank:

IV.4.3.1.- Agricultural practices

Tillage: Burying seeds deeper can prolong dormancy or protect them from predators.

Crop rotation: Diverse rotations reduce the dominance of specific weed species.

Herbicide use: Herbicides may temporarily reduce the seed bank, but excessive use can select for resistant species.

IV.4.3.2.- Environmental conditions

Climate: Temperature and rainfall variations affect seed germination and survival.

Soil type: Texture, structure, and fertility influence seed persistence in the seed bank.

IV.4.3.3.- Biological interactions

Predation: Seeds are consumed by insects, birds, and rodents, reducing the seed bank.

Decomposition: Soil microorganisms break down non-viable seeds, altering the seed bank composition.

IV.4.4.- Importance of studying the seed bank

The study of the soil seed bank is crucial for several reasons:

IV.4.4.1.- Prediction of future infestations

By assessing the composition and density of the seed bank, future weed infestations can be predicted, allowing for preventive management strategies

IV.4.4.2.- Evaluation of weed control practices

Studying the seed bank helps assess the effectiveness of weed control strategies, such as mechanical or chemical weed control.

IV.4.4.3.- Biodiversity conservation

In natural ecosystems, the seed bank plays a key role in plant regeneration and biodiversity maintenance.

IV.4.5.- Annual decay rate (ADR)

The Annual Decay Rate (ADR), in the context of weed science or agronomy, is an indicator used to measure the annual decrease in the population of weed seeds in the soil. It is generally expressed as a percentage (%) and helps assess the persistence of seeds in the soil over time.

- **Definition of ADR (Annual Decay Rate)**

The ADR represents the proportion of weed seeds that disappear each year from the seed bank present in the soil. This disappearance can be due to:

- Germination: Seeds germinate and give rise to plants.
- Predation: Seeds are eaten by animals or insects.
- Decomposition: Seeds naturally degrade in the soil.
- Natural mortality: Seeds lose their viability over time.

- **Formula for calculating ADR :**

The ADR is calculated using the following formula:

$$\boxed{ADR = (1 - Nt / N0) \times 100}$$

Where:

N0 = Initial number of seeds in the soil.

Nt = Number of seeds remaining after one year.

Example calculation:

If you have 1,000 seeds in the soil at the beginning of the year (N0) and 300 remain after one year (Nt), the ADR will be:

$$ADR = (1-300/1000) \times 100 = 70\%$$

This means that 70% of the seeds have disappeared in one year.

Interpretation of ADR:

A high ADR (e.g., 70%) indicates a rapid decline in the seed bank. This may be due to favorable conditions for germination or high predation.

A low ADR (e.g., 20%) suggests that seeds persist in the soil for a long time, which can pose long-term weed management challenges

- **Importance of ADR in weed science**

- Weed management: Knowing the ADR helps adapt weed control strategies (crop rotation, tillage, etc.).
- Infestation forecasting: A low ADR means that seeds can remain viable for several years, requiring increased vigilance.
- Impact of agricultural practices: The ADR can be influenced by plowing, herbicides, or cover crops.

Conclusion

The study of the soil seed bank is an essential tool for understanding and managing weed populations. By providing information on composition, density, and dynamics, it enables the prediction of future infestations and the development of sustainable weed management strategies.

In an agricultural context, proactive seed bank management, combined with adaptive cultural practices, is necessary to minimize the negative impacts of weeds while preserving crop productivity and ecosystem health.

Practical applications

The results of seed bank studies can be used to:

1. **Develop integrated management strategies**: Combine chemical, cultural, and biological methods to reduce the seed bank.
2. **Optimize crop rotations**: Select crops and practices that suppress dominant weeds.
3. **Prevent herbicide resistance**: Avoid repeated use of herbicides with the same mode of action to reduce resistance selection.

SYSTEMATICS AND PHENOLOGY OF WEEDS

V

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Adaptive capacity of weeds

It is well established that weeds, or adventitious plants, tend to develop within a cultivated field through two modes of propagation: isolated or in clusters. These modes are heavily dependent on the agricultural practices carried out on the field, as well as on the plants' mode of reproduction (sexual or vegetative propagation).

Regarding soil tillage, it can promote the dispersal of seeds in the direction of the field's cultivation, creating oval-shaped clusters. However, it can also randomly distribute roots and seeds that remain attached to tine tools (such as plows), before being deposited further away in the field.

Concerning the plants' mode of reproduction, it also significantly influences the distribution of weeds. So-called "annual" plants will have the spatial distribution of their seeds conditioned either by the wind (which can lead to random distribution) or by plowing, which will stretch this distribution following an aggregative pattern. In contrast, so-called "perennial" plants, which only need a fragment of vegetation to reproduce, will have a more random spatial distribution due to the various agricultural activities carried out on the field that disperse them.

Weeds are adapted to the same soils and climatic conditions as cultivated plants. Thus, practices that favor crops also favor weeds. Weeds can be dicotyledons or grasses.

The development of weeds depends on a number of pheno-morpho-physiological characteristics, including:

-Phenological resemblance to cultivated plants.

-Synchronization of seed maturity with that of the crop.

-Discontinuous germination.

-Vegetative propagation.

-A self-compatible fertilization system.

-Significant seed production under favorable conditions, but also possible under stress conditions **(Tab. 01)**.

Table 01: Number of seeds per parent plant for some weed species.

Species	Number of seeds per parent weed plant
Papaver rhoeas	50 000
Matricaria chamomilla	45 000
Cirsium arvense	20 000
Daucus carota	10 000
Raphanus raphanistrum	6 000
Sinapis arvensis	4000
Agrostemma githago	2 000
Agrostis capillaris	1 500 à 3 000
Lolium spp.	1 500
Galium aparine	1 100
Stellaria media	150 à 250
Veronica persica	150 à 200
Avena fatua	50 à 250

-Rapid growth, particularly at the seedling stage.

-High adaptability to variable conditions.

-Long seed longevity (25–100 years) **(Tab. 02)**.

Table 02: Maximum longevity of seeds for some weed species.

Years	Species
5 ans	*Agrostemma githago, Centaurea cyanus, Glebionis segetum*
10 ans	*Plantago lanceolata, Veronica hederifolia*
15 ans	*Alopecurus myosuroides, Avena fatua*
20 ans	*Matricaria chamomilla, Persicaria maculosa, Daucus carota*
40-60 ans	*Papaver rhoeas, Chenopodium album, Portulaca oleracea, Amaranthus retroflexus*
80 ans	*Anagallis arvensis, Polygonum aviculare, Sinapis arvensis, Rumex crispus.*

The study of weeds is based on their classification (systematics) and their developmental cycle (phenology). Understanding these aspects is essential for developing effective and sustainable management strategies.

V.1.- GROUPING OF WEEDS

Weeds can be classified according to several criteria:

V.1.1.- Botanical classification

Weeds belong to various botanical families, the most common being:

- ***Poaceae* (Grasses)**: Ex. *Echinochloa crus-galli, Avena fatua*

- ***Asteraceae* (Composites)**: Ex. *Sonchus oleraceus, Taraxacum officinale*

- ***Fabaceae* (Legumes)**: Ex. *Medicago polymorpha, Trifolium repens*

- ***Brassicaceae* (Crucifers)**: Ex. *Capsella bursa-pastoris, Raphanus raphanistrum*

V.1.2.- Ecological classification

Weeds are grouped according to their habitat and adaptation to environments:

- **Weeds of annual crops**: Short-cycle species adapted to cultivated soils (*Chenopodium album, Amaranthus retroflexus*).

- **Weeds of meadows and natural areas**: Perennial species resistant to mowing (*Rumex crispus*, *Cirsium arvense*).

- **Weeds of wet environments**: Adapted to waterlogged soils (*Cyperus rotundus*, *Juncus spp.*).

- **Weeds of dry and arid environments**: Xerophilic species tolerant to drought (*Salsola kali*, *Artemisia herba-alba*).

V.1.3.- Classification by life cycle

V.1.3.1.- Annual weeds

Complete their life cycle in one season (*Capsella bursa-pastoris*).

Annual weeds are of two types: summer annuals and winter annuals. To develop an effective weed control program, it is important to distinguish between these two types.

a.- Summer annuals

Summer annual plants germinate in spring and summer, produce vegetative organs, flowers, and seeds, and die within the same year. Summer annual weeds share the characteristic of rapid growth and high seed production. New plants that emerge in autumn are usually killed by frost.

b.- Winter annuals

Winter annual plants germinate from late August to early November and overwinter as rosettes. The following spring, they grow rapidly, flower, produce seeds, and die by the end of the season.

V.1.3.2.- Biennial weeds

Germinate in the first year, flower, and fruit in the second year (*Daucus carota*).

Biennial weeds germinate in spring, develop vegetative organs during the first year, overwinter as rosettes, then flower, produce seeds, and die in the second year.

V.1.3.3.- Perennial weeds

Survive for several years thanks to underground organs (*Convolvulus arvensis, Cynodon dactylon*).

Perennial weeds regrow year after year and are particularly difficult to eradicate once established. All perennial plants can reproduce vegetatively or by seeds. New plants can arise from specialized vegetative structures such as rhizomes, tubers, stolons, or underground stems.

Some perennial weeds grow as solitary plants and are called simple perennials. They primarily reproduce by seeds but can also reproduce vegetatively when roots are cut and dispersed by tillage. Other perennial weeds grow in large colonies or patches from networks of roots or underground rhizomes. These are called creeping perennials. Creeping perennials reproduce both vegetatively and by seeds.

V.2.- IDENTIFICATION

The identification of weeds relies on several morphological and physiological criteria.

V.2.1.- Morphological criteria

- Leaves: Shape (lanceolate, oval, linear), arrangement (opposite, alternate, whorled), venation (parallel in monocots, reticulate in dicots).

- Stems: Presence of hairs, cross-section (round, square, angular), growth habit (erect, creeping, climbing).

- Roots: Taproot, fibrous, rhizomatous, tuberous.

- Flowers: Number of petals, color, inflorescence type (spike, head, raceme, panicle).

V.2.2.- Identification methods

- Field observation: Identify species directly in the field based on morphological characteristics.

- Use of identification keys: Illustrated guides that allow species identification through successive elimination.

- Seed analysis: Some species are recognizable by the morphology and size of their seeds (*Lolium spp.*, *Bromus spp*.).

- Germination tests: Identify species based on seedling emergence and development.

V.2.3.- Importance of identification

- ✓ Facilitates the application of tailored control strategies.
- ✓ Helps distinguish harmful species from beneficial or less competitive weeds.
- ✓ Aids in monitoring the emergence of new invasive species or those resistant to herbicides.

To identify weeds, it is essential to rely on:

- **Morphology**: Shape of leaves, type of stem, structure of flowers and seeds.
- **Life cycle**: Annual, biennial, or perennial.
- **Reproduction mode**: By seeds, rhizomes, or stolons.
- **Growth conditions**: Preferences for wet, dry, saline soils, etc.

V.3.- PHENOLOGY

The phenology of weeds refers to the different stages of their biological cycle in response to environmental factors. Understanding this helps optimize control strategies by targeting the sensitive phases of weed development.

V.3.1.- Main phenological phases

- Germination: Depends on temperature, moisture, and photoperiod. Some seeds require prior dormancy (*Polygonum aviculare*, *Setaria spp.*).

- Vegetative growth: Development of stems and leaves, a phase where weeds compete with crops for resources (water, light, nutrients).

- Flowering: Production of flowers and seed formation, often influenced by photoperiod (*Ambrosia artemisiifolia* flowers under short-day conditions).

- Fruiting and dispersal: Seed dispersal by wind (*Taraxacum officinale*), water (*Bidens tripartita*), animals (*Xanthium strumarium*), or human activity (*Avena fatua*).

- Dormancy: Some seeds persist in the soil for several years (*Chenopodium album*, *Amaranthus spp.*).

V.3.2.- Influence of environmental factors

- Temperature: Some species germinate at low temperatures (*Veronica persica*), while others prefer warm conditions (*Echinochloa crus-galli*).

- Light: Some species are photoblastic and require light to germinate (*Phleum pratense*).

- Moisture: Influences growth and reproduction (*Cyperus rotundus* thrives in wet environments).

V.3.3.- Importance of phenological studies

- Optimization of control strategies: Targeting early developmental stages with herbicides or mechanical methods.

- Infestation prediction: Understanding a species' cycle helps anticipate its spread.

- Resistance management: Adjusting agricultural practices based on the periods of weed susceptibility.

Conclusion

The study of weed systematics and phenology is essential for effective and sustainable management. Classifying weeds helps identify dominant species in an agroecosystem, while understanding their biological cycle aids in anticipating their development and applying tailored control strategies.

Key Takeaways:

- ✓ Weeds are classified based on their taxonomy, life cycle, and environmental adaptation.
- ✓ Identification relies on morphological criteria, identification tools, and seed analysis.
- ✓ Phenology helps understand the biological cycle of weeds and adapt control strategies to target sensitive phases.

An integrated approach combining identification, phenological monitoring, and preventive management is key to minimizing the impact of weeds on crops while promoting the sustainability of agroecosystems.

V.4.- DESCRIPTION AND IDENTIFICATION OF MAJOR WEEDS IN ALGERIA

In Algeria, weeds pose a significant challenge to agriculture due to their impact on crop yields and their ability to adapt to local conditions. Below is a detailed description of the major weeds found in Algerian fields, along with keys for their identification.

V.4.1.- Weeds in cereal crops

Cereals (wheat, barley) are particularly vulnerable to weeds, which compete with crops for resources.

V.4.1.1.- Ryegrass (*Lolium spp.*)

Description : Annual or perennial plant with narrow leaves and spike-like inflorescences.

Identification: Linear, hairless leaves with a split sheath. Dense, compact spikes bearing flattened spikelets..

Impact: Intense competition for nutrients and water, especially in winter crops.

V.4.1.2.- Wild oat (*Avena fatua*)

Description: Annual grass resembling cultivated oats.

Identification: Broad, rough leaves. Loose panicle inflorescence with drooping spikelets. Seeds with a twisted awn.

Impact: Reduced yields and contamination of harvests.

1.3. Corncockle (*Agrostemma githago*)

Description: Annual plant with pink or purple flowers.

Identification: Opposite, narrow, and hairy leaves. Solitary flowers with five notched petals. Capsules containing black, toxic seeds.

Impact: Toxicity of seeds to livestock and contamination of harvests.

V.4.2.- Weeds in vegetable crops

Vegetable crops (tomatoes, potatoes, etc.) are often infested by broadleaf weeds.

V.4.2.1.- Black nightshade (*Solanum nigrum*)

Description: Annual plant from the *Solanaceae* family.

Identification: Oval, slightly toothed leaves. White flowers in clusters, followed by black berries. Branched, slightly hairy stems.

Impact: Competition for resources and hosting of viruses and pest insects.

V.4.2.2.- Purslane (*Portulaca oleracea*)

Description: Fast-growing annual succulent plant.

Identification: Fleshy, smooth, oval leaves. Reddish, creeping stems. Small yellow flowers.

Impact: Competition for water and nutrients, especially in dry soils.

V.4.2.3.- Lamb's quarters (*Chenopodium album*)

Description : Annual broadleaf plant.

Identification: Triangular leaves covered with a white powder. Panicle inflorescence with small green flowers. Black, shiny seeds.

Impact: Strong competition for nutrients and water.

V.4.3.- Weeds in industrial crops

Industrial crops (sugar beet, sunflower) are also affected by specific weeds.

V.4.3.1.- Canada thistle (*Cirsium arvense*)

Description: Perennial plant with rhizomes, highly invasive.

Identification: Spiny, deeply lobed leaves. Purple flower heads. Erect, branched stems.

Impact: Intense competition and difficulty in control due to its rhizomes.

V.4.3.2.- Redroot pigweed (*Amaranthus retroflexus*)

Description: Fast-growing annual plant.

Identification: Oval leaves with a pointed tip. Dense, green or reddish spike-like inflorescence. Black, shiny seeds.

Impact: Strong competition for resources and massive seed production.

V.4.4.- Weeds in arid and semi-arid zones

In the arid and semi-arid regions of Algeria, certain weeds are particularly adapted to drought conditions.

V.4.4.1.- Bermuda Grass (*Cynodon dactylon*)

Description: Highly resistant perennial grass.

Identification: Narrow, pointed leaves. Creeping rhizomes and above-ground stolons. Digitately arranged spike-like inflorescences.

Impact: Competition for water and difficulty in control due to its rhizomes.

V.4.4.2.- Saltbush (*Atriplex spp.*)

Description: Halophyte plant adapted to saline soils.

Identification: Fleshy, often silvery leaves. Inconspicuous flowers grouped in spikes. Seeds enclosed in bracts.

Impact: Competition in marginal and saline areas.

Conclusion

Weeds in Algeria are diverse and adapted to various environments, from the cereal-growing regions in the north to the arid zones in the south. Accurate identification is crucial for implementing effective management strategies. A combination of cultural, mechanical, and chemical methods, tailored to the specific characteristics of each species, is necessary to minimize their impact on crops and preserve agricultural productivity.

By investing in research and farmer training, it is possible to better understand and control these weeds while promoting sustainable agricultural practices.

WEED CONTROL IN AGRICULTURE

VI

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Weed control is an essential aspect of agricultural management, as these weeds compete with crops for resources such as water, nutrients, and light, thereby reducing yields. Effective weed management requires a combination of strategies tailored to the weed species, crop type, and environmental conditions.

VI.1. - CULTURAL CONTROL

Cultural control relies on agricultural practices that prevent or reduce the establishment and growth of weeds. These methods are preventive and aim to create unfavorable conditions for weeds while promoting crop growth. Cultural control involves the use of standard farming practices to favor crops over competing weeds. Key practices include:

VI.1.1.- Crop rotation

Rotating crops with different life cycles and growth habits disrupts weed adaptation and reduces the buildup of specific weed species. Example: Alternating cereals with legumes to break the cycle of grassy weeds.

VI.1.2.- Cover crops

Planting cover crops (e.g., clover, rye) during fallow periods suppresses weed growth by competing for resources and shading the soil. Cover crops also improve soil health and reduce erosion.

VI.1.3.- Tillage practices

Tillage helps uproot weeds from the soil, bury them, cut them, or weaken them by breaking roots or above-ground parts. Generally, the younger and smaller the weeds, the easier they are to eliminate. Plowing and harrowing can bury weed seeds deep in the soil, preventing their germination.

Reduced tillage or no-till techniques can also be used to minimize soil disturbance and limit the emergence of weed seeds. Weeds respond to their environment. No-till reduces root disturbance and breaks dormancy, increases soil moisture, lowers soil temperature, and all these changes lead to shifts in the number and type of weeds.

VI.1.4.- Planting density and arrangement

Increasing crop density and reducing row spacing shades the soil, reducing the light available for weed germination and growth.

VI.1.5.- Sanitation

- ✓ Clean farm equipment to prevent the spread of weed seeds.
- ✓ Use certified, weed-free seeds to avoid introducing new species.

VI.1.6.- Advantages of cultural control

- Environmentally friendly and sustainable.
- Reduces reliance on herbicides.
- Improves soil health and crop productivity.

VI.2. - BIOLOGICAL CONTROL

Biological control involves using natural enemies or organisms to suppress weed populations. This method is often integrated into a comprehensive weed management system. Biological weed control is the deliberate use of natural enemies of a target weed to reduce its population to an acceptable level.

There are key approaches:

VI.2.1.- Herbivorous insects

Introducing insects that feed on specific weeds can effectively reduce their populations.

Example: The use of the *Neochetina* beetle to control water hyacinth (*Eichhornia crassipes*).

VI.2.2.- Grazing animals

Livestock, such as goats or sheep, can be used to graze on weeds in pastures or non-cultivated areas.

VI.2.3.- Pathogenic microorganisms

Fungi, bacteria, or viruses can be used to infect and kill specific weeds. Example: The fungus *Puccinia xanthii* is used to control cocklebur (*Xanthium strumarium*).

VI.2.4.- Allelopathy

Some plants release natural chemicals that inhibit the growth of nearby weeds. Example: Sorghum produces allelopathic compounds that suppress weed germination.

VI.2.5.- Advantages of biological control

- Reduces the need for chemical herbicides.
- Targets specific weeds without harming crops.
- Environmentally and economically sustainable in the long term.

VI.2.6.- Challenges of biological control

- Requires careful selection and monitoring of biological agents.
- May take time to show significant results.

VI.3. - CHEMICAL CONTROL

Chemical control involves the use of herbicides to eliminate or suppress weeds. It is one of the most widely used methods due to its effectiveness and speed.

The use of herbicides to control weeds is an important component of any integrated weed management program. However, herbicides cannot compensate for poor management. If herbicides are chosen, they must be used responsibly and judiciously, and should be considered as just one element of a comprehensive program.

Key aspects include:

VI.3.1.- Types of herbicides

- **Selective herbicides** Target specific weed species without harming crops (e.g., 2,4-D for broadleaf weeds in cereals).
- **Non-Selective herbicides** : Destroy all vegetation (e.g., glyphosate).

VI.3.2.- Application methods

- **Pre-emergence**: Applied before weed seeds germinate.
- **Post-emergence**: Applied after weeds have emerged.

VI.3.3.- Mode of action

Herbicides can disrupt photosynthesis, cell division, or amino acid synthesis in weeds.

VI.3.4.- Resistance management

Overuse of herbicides can lead to the emergence of resistant populations. Strategies include rotating herbicides with different modes of action and integrating non-chemical control methods.

VI.3.5.- Advantages of chemical control

- Highly effective and fast-acting.
- Can be applied on a large scale.

VI.3.6.- Challenges of chemical control

- Environmental issues, such as soil and water contamination.
- Risk of weed resistance development.
- Potential impact on non-target organisms, including beneficial insects and crops.

VI.3.7.- Key factors for effective herbicide application in agriculture

VI.3.7.1.- Conditions for successful chemical weed control

Chemical weed control is an effective method for managing weeds, but its success depends on several key factors.

Improper application can lead to reduced effectiveness, crop damage, or negative environmental impacts. Essential conditions for successful chemical weed control include:

a. Accurate weed identification

Knowing the weed species present in the field allows for the selection of the appropriate herbicide and avoids unnecessary treatments.

Example: Distinguishing between dicotyledons (broadleaf) and grasses to select a selective herbicide.

b. Choosing the right herbicide

Select an herbicide based on its spectrum of action (selective or non-selective), mode of action, and the growth stage of the weeds.

Example: Use a pre-emergence herbicide for dormant seeds or a post-emergence herbicide for already developed weeds.

c. Respecting recommended doses

Apply the appropriate dose to avoid under-dosing (ineffectiveness) or over-dosing (risk of toxicity to crops and the environment).

d. Favorable weather conditions

Avoid applying herbicides during rain, strong winds, or extreme temperatures (too hot or too cold).

Example: Apply herbicides early in the morning or late in the afternoon to avoid evaporation and maximize absorption.

e. Condition of the crop and weeds

- ✓ Treat weeds at their most vulnerable growth stage (usually early vegetative stage).
- ✓ Ensure the crop is healthy and capable of tolerating the herbicide.

VI.3.7.2.- Conditions for herbicide effectiveness

The effectiveness of herbicides depends on several factors related to the product formulation, application, and environmental conditions.

a. Quality of dilution water

- ✓ Use clean, non-calcareous water to avoid neutralizing the herbicide.
- ✓ Adjust the water pH if necessary (ideally between 5.5 and 7).

b. Herbicide formulation

- ✓ Choose a formulation suited to field conditions (liquid, granular, powder).
- ✓ Check compatibility with other products if mixing.

c. Penetration and absorption

- ✓ Ensure good coverage of leaves or soil to maximize herbicide absorption.
- ✓ Use adjuvants (e.g., surfactants) to improve adhesion and penetration.

d. Weed growth stage

- ✓ Apply herbicides when weeds are most vulnerable (usually young and actively growing).

e. Absence of resistance

- ✓ Verify that weeds are not resistant to the chosen herbicide.
- ✓ Rotate herbicides with different modes of action to prevent resistance.

VI.3.7.3.- Conditions for herbicide application

Proper application of herbicides is crucial to ensure their effectiveness and minimize risks to crops and the environment.

a. Sprayer calibration

Check flow rate, pressure, and droplet size to ensure uniform application. Example: Use appropriate nozzles to avoid drift and maximize coverage.

b. Uniform application

Apply herbicides evenly across the field to avoid untreated or over-treated areas.

c. Respecting doses and volumes

Use the recommended water volume to ensure proper product distribution. Example: 200 to 400 liters of water per hectare, depending on the herbicide type and weed stage.

d. Optimal environmental conditions

- ✓ Apply herbicides during calm weather (wind < 10 km/h) to avoid drift.
- ✓ Avoid applications if rain is expected within 24 hours.

e. Application safety

- ✓ Wear personal protective equipment (PPE): gloves, mask, coveralls.
- ✓ Respect buffer zones to protect watercourses and non-target areas.

VI.3.7.4.- Conditions for proper sprayer use

The sprayer is an essential tool for herbicide application. Its proper functioning and maintenance are crucial for precise and effective application.

a. Pre-use inspection

- ✓ Inspect nozzles, filters, hoses, and the pump for potential malfunctions.
- ✓ Clean the sprayer after each use to avoid cross-contamination.

b. Regular calibration

Check the sprayer’s flow rate and pressure to ensure they match the manufacturer’s recommendations. Example: Use a flow meter to measure the volume of water applied per hectare.

c. Choosing the right nozzles

Select nozzles based on the herbicide type and application conditions. Example: Use fine droplet nozzles for better foliar coverage.

d. Regular maintenance

- ✓ Clean the sprayer after each use to prevent chemical residue buildup.
- ✓ Rinse the tank, hoses, and nozzles with clean water.

e. Proper storage

- ✓ Store the sprayer in a dry, frost-free location.
- ✓ Completely empty the tank and conduits before long-term storage.

The success of chemical weed control depends on a combination of factors, including the choice of herbicide, application conditions, and proper use of the sprayer. By adhering to these conditions, farmers can maximize treatment effectiveness, protect crops, and minimize environmental impacts. Special attention must be paid to safety, precision, and equipment maintenance to ensure optimal results. Key points to remember include:

- Identify weeds and choose the appropriate herbicide.
- Respect doses, weather conditions, and growth stages.
- Use and maintain the sprayer correctly for precise application.
- Adopt safe and environmentally friendly practices.

Conclusion

Effective weed control in agriculture requires an integrated approach combining cultural, biological, and chemical methods. Cultural practices prevent weed establishment, biological control targets weeds naturally, and chemical control provides immediate results. By integrating these strategies, farmers can reduce weed pressure, minimize environmental impacts, and maintain sustainable agricultural systems. Here are some key points to remember:

- **Cultural control**: Focuses on prevention through crop rotation, cover crops, and tillage.
- **Biological control**: Uses natural enemies or organisms to suppress weeds.
- **Chemical control**: Relies on herbicides for quick and effective management.

Adopting an integrated weed management (IWM) approach ensures long-term sustainability and reduces reliance on any single control method.

HERBICIDES

VII

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Herbicides are chemical substances used to control or eliminate unwanted plants (weeds). They play a crucial role in modern agriculture by improving crop yields and reducing competition for resources. However, their use requires careful management to minimize environmental and health risks.

VII.1.- GENERALITES

Herbicides are an essential tool in weed management, but their effectiveness and safety depend on proper understanding and application.

VII.1.1.- Presentation of herbicides

VII.1.1.1.- Definition

Herbicides are chemical products designed to kill or inhibit the growth of unwanted plants (weeds) while minimizing damage to crops.

Herbicides are sometimes referred to as weedkillers, particularly in horticulture. They are *active ingredients or formulated products with the ability to kill plants*.

Their importance in agriculture lies in the fact that:

- They help reduce competition between weeds and crops for resources such as water, nutrients, and light.
- They improve crop yields and quality by controlling weed populations.

VII.1.1.2.- Composition

Like all other pesticides, an herbicide product corresponds first to the commercial name of the product marketed by a distributor or manufacturer. This commercial product or commercial formulation consists of two types of components: the **active ingredients** that provide its herbicidal activity, and the **formulants** that complete the formulation.

The formulants are either carriers or solvents that only serve to dilute the active ingredients, or products that enhance the preparation:

- For its quality :
  - Stability (emulsifying, dispersing, etc.),

- Presentation (coloring, fragrance, repellent, etc.),
- Ease of use (emetic, etc.),

- For its physical behavior during spraying: wetting, adhesive, etc.
- For its biochemical activity: surfactant, phytoprotectant (*safener*).

VII.1.1.3.- Formulation

Formulation refers to the physical form in which the phytopharmaceutical product is marketed; obtained by mixing active ingredients and formulants, it comes in a multitude of forms, either solid or liquid. The most commonly used are as follows :

- For solid formulations: water-soluble granules (abbreviations: SG), wettable powders (WG);
- For liquid formulations :
  - Soluble concentrates (SL), composed of water-soluble products,
  - Emulsifiable concentrates (EC), composed of liquid products in emulsion within the product,
  - Concentrated suspensions (SC), sometimes called "flowable" (from the English term "flowable"), composed of solid particles dispersed in the product.

The type of formulation is of great importance in the handling of products: manufacturing, transport, storage, preparation of sprays; for example, concentrated suspensions tend to sediment over time, and it will be essential to shake them before use.

VII.1.1.4.- Characteristics

The characteristics of a herbicide product include the designation of the active ingredient(s), the commercial product name, the manufacturer, and possibly the local distributor, the concentration of the active ingredient(s) in the product, the type of formulation, the application method, the application rate, and the target crop.

The concentration of active ingredient(s) is expressed in g/l for liquid formulations and as a percentage (%) for solid formulations.

The application rate of the commercial product is expressed in l/ha for liquid formulations and in kg/ha (or sometimes g/ha) for solid formulations. The application rate of the active ingredient is always expressed in g/ha.

VII.1.2.- Modes of action of herbicides

Herbicides are distinguished based on their mode of penetration into plants and their movement within the plant:

• **Root-absorbed herbicides:** applied to the soil, they penetrate through the underground organs of plants (roots, seeds, seedlings). These are pre-emergence herbicide treatments, carried out before the emergence of the target plant (crop or weed);

• **Foliar-absorbed herbicides:** applied to the foliage, they penetrate through the aerial organs of plants (leaves, petioles, stems). These are post-emergence herbicide treatments, carried out after the emergence of the target plant (crop or weed).

Herbicides are also distinguished based on their movement within the plant:

- **Contact herbicides:** these act after more or less deep penetration into the tissues, without any migration from one organ to another in the treated plant;

- **Systemic herbicides:** these are capable of acting after penetration and migration from one organ to another in the treated plant.

Among the most commonly used products, the following examples can be cited in the four categories:

1 - Root-absorbed contact herbicide: Metolachlor, applicable in cotton or maize crops;

2 - Root-absorbed systemic herbicide: Atrazine, used in maize crops;

3 - Foliar-absorbed contact herbicide: Paraquat, used for total weed control;

4 - Foliar-absorbed systemic herbicide: Glyphosate, a herbicide effective against perennial species.

Herbicides act by disrupting essential physiological processes in plants, such as photosynthesis, cell division, or amino acid synthesis. They affect various processes related to plant growth and development, interfering with:

- Plant physiology: Photosynthesis or membrane permeability.
- Growth : Cell division, elongation, etc.
- Biosynthesis of cellular components : Lipids, carotenoid pigments, amino acids, etc.

The **effectiveness** of a herbicide depends on the applied dose: a threshold dose of effectiveness is defined, which may vary depending on the target plant and the timing of application. The efficacy spectrum corresponds to the range of species controlled by a product at a given dose.

VII.1.3.- Selectivity

By definition, an herbicide is a product that has the property of killing plants. However, in cultivated environments, the goal is to destroy weeds while preserving the treated crop. Herbicides are considered **selective** when, used under normal conditions, they spare certain crops and target specific weeds in those crops. They are termed **total** or non-selective when, used at recommended doses for this purpose, they are capable of destroying or preventing the development of all vegetation, with varying durations of action

The selectivity of herbicides corresponds to a modification in at least one of the phases of the product's action in the plant: contact with the target, penetration, potential transport, site of activity, and degradation metabolism. Different types of selectivity are distinguished:

• **Positional selectivity:** pre-emergence herbicides, applied to the soil surface, are distributed only in the superficial layer of the soil, a few centimeters deep. This is the zone where most weed species, with small seeds, germinate. Upon contact with the herbicide, they are affected by its herbicidal activity. In contrast, crop seeds are planted deeper and avoid contact with the herbicide, which therefore has no effect on their germination.

• **Application selectivity:** this involves avoiding contact between the herbicide and the cultivated plant during spraying. The herbicide is applied only to the weeds in the inter-row space, taking care not to reach the crop row. This technique is mainly used with total herbicides in widely spaced crops.

• **Anatomical selectivity:** this type of selectivity primarily concerns post-emergence products.

Penetration through the leaves can be hindered by the presence of hairs or the thickness of the epidermal cuticle. The orientation of the leaves also affects the adherence of the spray to their surface: the upright and narrow leaves of grasses retain droplets less effectively than the broad and spread-out leaves of dicotyledons.

• **Physiological selectivity:** selectivity can arise from differences in physiological behavior between plants. For example, the selectivity of atrazine for maize is partly due to its reduced transport in maize compared to sensitive species, and especially to the presence of enzymes that degrade the atrazine molecule before it reaches its site of action, the chloroplast.

VII.1.4.- Environmental factors and herbicide behavior

Environmental factors influence the effectiveness of herbicides, the success of spraying, and their selectivity. Any factor that improves the efficacy of a product or spraying will simultaneously reduce its selectivity. Four key elements can be considered: climate, soil, the treated plant, and application techniques.

VII.1.4.1.- Climate

The impact of climatic factors on herbicide behavior occurs before, during, and after spraying.

• **Before application:**

- If the treated plant experiences a **drought** period, the leaf cuticle tends to thicken, making it harder for post-emergence products to penetrate the leaves.

- Rain before application increases soil moisture, enhancing the diffusion and availability of root-absorbed herbicides

• During application:

- High **temperatures** or dry air can cause spray droplets to evaporate before reaching their target, especially in low-volume spraying.

- **Dew**: Light dew improves product dilution and facilitates leaf penetration, while heavy dew (where droplets fall when plants are touched) can capture the spray, wash it to the ground, and render it ineffective.

- **Wind**: Strong winds are discouraged during herbicide application due to the risk of spray drift, which can misplace the product and potentially damage neighboring fields.

• After application:

- For root-absorbed herbicides (pre-emergence products) applied to bare soil, **rain** improves product availability on the soil surface. However, erosive rain can wash the product away through runoff.

- For foliar-absorbed herbicides (post-emergence products) applied to foliage, rain reduces efficacy by washing away the deposit. The required interval between spraying and rain depends on the product and rainfall intensity.

VII.1.4.2.- Soil

Pre-emergence herbicides are highly dependent on the physical state of the soil:

• Applications will be irregular on cloddy soil, and the breakdown of **clods** exposes untreated soil.

• Dense **mulch** can capture the spray, preventing it from reaching the root zone.

• Availability in the soil solution depends on **texture**: the product is adsorbed by clay layers or organic matter colloids. In such cases, the application rate must be increased. With clay, the adsorbed product is gradually released, increasing persistence. Conversely, persistence is low in organic-rich soils due to rapid microbial degradation. Sandy soils increase the risk of phytotoxicity, as all applied product remains available.

• Surface diffusion is effective only if soil moisture is sufficient.

VII.1.4.3.- The plant

Herbicide efficacy depends on two factors related to the target: its species and growth stage:

• The specificity of herbicides is crucial for product selection, both for targeting weeds and protecting crops. It is defined by the efficacy spectrum and selectivity of the products.

• Destroying a weed at the seedling stage requires less product than targeting a mature plant. Post-emergence sprays struggle to reach the lower parts of overdeveloped plants due to a "canopy effect."

• Plant sensitivity varies with growth stage. For example, the cuticle of maize leaves thins from the sixth leaf stage, increasing the risk of phytotoxicity from post-emergence products.

VII.1.4.4.- Application conditions

The success of herbicide application depends on the following rules:

• The **product** is chosen based on the weed flora to be controlled and the crop's technical itinerary. Mixing products during the same application or planning treatments over the crop cycle must consider the characteristics of each active ingredient to avoid unnecessary combinations and adjust application rates.

• Application **rates** must be respected. Farmers often reduce rates to cut costs and avoid phytotoxicity, leading to uneven application, under-dosed (ineffective) areas, and over-dosed (phytotoxic) zones.

• The product must be applied at the recommended **time**. For example, pre-emergence herbicides should not be applied to already emerged plants, while post-emergence herbicides are applied based on weed growth stages, especially for contact-acting products. Younger targets are more susceptible; for instance, propanil in rice cultivation must be applied at the 3-4 leaf stage for effective control of *Poaceae*.

• **Equipment** adapted to herbicide spraying, equipped with flat-fan nozzles, is essential. Farmers often misuse insecticide sprayers (with cone nozzles or motorized atomizers). Proper calibration, maintenance, and cleaning of equipment are critical.

• **Calibration** must be regularly checked to correct equipment defects (e.g., nozzle wear) or operator errors. The volume of spray per hectare must be determined for accurate dilution calculations.

• **Spray** preparation is crucial: use high-quality water, filters, and ensure mixture homogeneity to avoid nozzle clogging.

• **Application technique** must be mastered to ensure even distribution, requiring consistent sprayer output and forward speed.

• Safety **precautions** and toxicity risks must not be overlooked.

• Pre-emergence herbicide use affects subsequent technical itineraries, such as the inability to till the soil after application.

VII.1.5- Fate of herbicides in the environment

Like other pesticides, herbicides degrade at varying rates after application:

- ✓ They partially participate in the metabolism of the target plant.
- ✓ In temperate climates, a small portion is lost through volatilization, runoff, or leaching into deeper soil layers.
- ✓ A portion is adsorbed by clay and organic matter before undergoing biochemical and microbial degradation

Persistence or **residual** activity refers to the duration a herbicide remains active. It is essential to ensure no residual effects on subsequent crops.

VII.1.6.- Toxicity of products

As shown in **Table 3**, with the exception of paraquat and ioxynil, herbicides generally exhibit a relatively moderate level of toxicity.

Table 03: Examples of lethal dose 50 (LD 50) for herbicides, pesticides, and some common consumer products.

Active ingredient			**LD 50 (Rat ingestion) mg/kg**
Herbicides	Pesticides	**Common products**	
	Methyl parathion (insecticide)		14
		Nicotine	50
Paraquat			157
	Cypermethrin (insecticide)		251
2,4-d			375
Bentazone			1.100
	Triadimenol (fongicide)		1.160
		Aspirin	1.750
Metolachlor			2.780
Atrazine			3.080
Diuron			3.400
		Table salt	3.850
Glyphosate			4.900

Precautions for use are nevertheless necessary during handling, preparation of sprays, and application. Spraying equipment must be carefully cleaned, and product containers must be destroyed. The operator should rinse off and change clothes.

VII.1.7.- Choosing the herbicide

Implementing a weed control technique cannot follow a one-size-fits-all approach but involves a complex decision-making process that depends on:

- ✓ The potential or existing weed infestation (weed species, growth stage),
- ✓ The crop (pure or intercropped),
- ✓ The technical itinerary practiced,
- ✓ Constraints of the cropping calendar,
- ✓ The field surface condition (soil type, tillage method, moisture),
- ✓ The available equipment,
- ✓ Economic aspects (profitability of the operation, financial availability),
- ✓ Supply possibilities for herbicides.

In the case of intercropping, the essential factor is the selectivity of the herbicides used in relation to all crops present in the association. Therefore, among the herbicides applicable to one or the other crop, it is necessary to verify that at least one herbicide is selective for each crop at the applied dose, depending on the timing of application and the growth stages of the cultivated plants.

VII.1.8.- Herbicide rotation

The continuous use of the same herbicide products inevitably leads to flora selection, meaning often monospecific populations consisting of species on which these active ingredients are not effective. This is sometimes referred to as flora inversion. These new populations can only be controlled if weed control techniques are modified or, at the very least, if the products used are diversified by choosing other chemical families with different modes of action.

In flora inversions, two types of behavior must be distinguished:

• Either the species is not part of the efficacy spectrum of the product used, and its selection by the herbicide treatment is entirely predictable. In this case, there is simply inefficacy of the herbicide on this species, which is said to be tolerant;

• Or it is a population on which the product is normally effective, but it may happen that some individuals are not affected by the product. These undestroyed plants will develop and multiply, creating a new population, which is then described as resistant.

VII.1.9.- Genetically modified herbicide-resistant varieties

The selection of resistant varieties or the introduction of herbicide resistance genes into cultivated varieties opens a new path in weed control. This is the case, for example, in the control of weedy rice. The product, generally a total herbicide but perfectly selective for the genetically modified variety, could be applied with high efficacy on weeds and without risk to the crop.

However, the problem of gene escape for herbicide resistance arises in the case of weed species very closely related to the crop, such as weedy rice. Cross-pollination could occur between weedy rice and cultivated rice. This could lead to an invasion by resistant weedy rice, which would be even faster if strong herbicide pressure were applied over several successive cycles. Thus, there is a potential risk of genetic pollution if rice varieties derived from genetic transformations are developed.

VII.2. - CLASSIFICATION

Herbicides can be classified according to various criteria, including their mode of action, timing of application, and chemical structure. Understanding these classifications helps in selecting the right herbicide for specific weed problems.

VII.2.1.- Classification based on mode of action

Herbicides are grouped according to their effect on plants:

- **Photosynthesis inhibitors**: Disrupt the photosynthesis process (e.g., atrazine).
- **Cell division inhibitors**: Prevent cell division and growth (e.g., trifluralin).
- **Amino acid synthesis inhibitors**: Block the production of essential amino acids (e.g., glyphosate).
- **Growth regulators**: Mimic plant hormones, causing abnormal growth (e.g., 2,4-D).
- **Lipid synthesis inhibitors**: Disrupt fatty acid production (e.g., sethoxydim).

VII.2.2.- Classification based on timing of application

- **Pre-emergence herbicides**: Applied before weed seeds germinate. They create a chemical barrier in the soil (e.g., pendimethalin).
- **Post-emergence herbicides**: Applied after weeds have emerged. They target actively growing plants (e.g., glyphosate).

VII.2.3.- Classification based on selectivity

- **Selective herbicides**: Target specific weed species or groups (e.g., dicamba for dicotyledons).
- **Non-selective herbicides** : Destroy all plants (e.g., paraquat).

VII.2.4.- Classification based on chemical structure

Herbicides are grouped by chemical families:

- **Triazines**: e.g., atrazine.
- **Phenoxy acids**: e.g., 2,4-D.
- **Glyphosates**: e.g., glyphosate.
- **Sulfonylureas**: e.g., chlorsulfuron.
- **Imidazolinones**: e.g., imazapyr.

VII.2.5.- Classification based on environmental persistence

- **Residual herbicides**: Remain active in the soil for weeks or months, providing long-term control (e.g., atrazine).
- **Non-residual herbicides**: Break down quickly and do not persist in the environment (e.g., glyphosate).

Conclusion

Herbicides are a powerful tool for weed management, but their use must be carefully planned and executed. Understanding their general properties and classifications helps farmers choose the right herbicide for their specific needs while minimizing risks to crops, the environment, and human health. Integrated Weed Management (IWM) strategies, which combine herbicides, cultural methods, and biological controls, are essential for sustainable agriculture.

Key takeaways

- Herbicides are classified based on their mode of action, timing of application, selectivity, chemical structure, and persistence.
- Proper selection and application of herbicides are crucial for effective weed control and environmental safety.
- Integrated approaches reduce reliance on herbicides and promote sustainable agricultural practices.

VII.3.- APPLIED EXAMPLES

VII.3.1.- Example 1

1- What is the crop being cultivated? Rainfed rice cultivation.

→ The available products for rice are:

• Pre-emergence products

- Oxadiazon
- Pretilachlor + dimethametryn combination
- Triclopyr + propanil combination

• Post-emergence products

- Triclopyr + propanil combination

2- What are the dominant weeds to control?

Two species are dominant: a grass, *Digitaria horizontalis*, and an *Asteraceae*, *Ageratum conyzoides*. Oxadiazon is effective against grasses but not *Asteraceae*.

3- When to intervene?

The farmer wishes to intervene at the pre-emergence stage of the crop → The pretilachlor + dimethametryn combination can be used.

4- Should the application dose be adjusted?

The dose will be increased if the soil is highly clayey.

VII.3.2.- Example 2

1- What is the crop being cultivated? Cotton cultivation

→ The available products are :

• Pre-emergence products

- Diuron
- Fluometuron + prometryn combination
- Metolachlor + dipropetryn combination
- Pendimethalin

• Post-emergence grass-specific products

- Fluazifop-P-butyl

2- What are the dominant weeds to control?

The weed flora is dominated by a grass, *Rottboellia cochinchinensis*.

Pendimethalin and fluazifop-P-butyl are effective against *Rottboellia cochinchinensis*.

3- When to intervene?

The farmer wishes to intervene at the post-emergence stage of the crop → Fluazifop-P-butyl will be suitable.

4- Should the application dose be adjusted?

The dose will be adjusted based on the growth stage of the weed population.

VII.3.3.- Example 3

1- What is the crop being cultivated? Intercropping of yam and maize

→ The available products for yam are:

• Pre-emergence products

- Metribuzin
- Metolachlor + atrazine combination
- Ametryn + atrazine combination

• Post-emergence grass-specific products

- Fluazifop-P-butyl

→ The available products for maize are:

• Pre-emergence products

- Metolachlor + atrazine combination

• Post-emergence products

- Nicosulfuron

→ The metolachlor + atrazine combination can be used for both crops.

2- What are the dominant weeds to control?

The weed flora is diverse, including grasses (*Digitaria horizontalis*) and dicotyledons (*Amaranthus viridis*, *Tridax procumbens*): a broad-spectrum product is needed → The metolachlor + atrazine combination is suitable.

3- When to intervene?

The farmer wishes to intervene at the pre-emergence stage of the crops → The metolachlor + atrazine combination is suitable.

4- Should the application dose be adjusted?

The dose will be increased if the soil is highly clayey.

THE MAIN FAMILIES OF HERBICIDES

VIII

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An herbicide is an active substance or a phytosanitary preparation with the property of killing plants. The term "weed killer" is synonymous with herbicide. Herbicides belong to the family of pesticides, which itself is included in the family of biocides.

Herbicides are used in crop protection, on golf courses, in forestry, and to control weeds that compete with cultivated plants, whether herbaceous or woody. Depending on their mode of action, they can be used pre- or post-emergence.

They are classified into :

- Selective herbicides (the most numerous);
- Brush killers and chemical stump removal products;
- Total herbicides (the most widely used);
- Defoliants, which destroy the aerial parts of plants. They are used, for example, for the mechanical harvesting of potatoes or sugar beets;
- Anti-sprouting agents, which prevent the growth of bulbs or tubers intended for food (such as onions or potatoes);
- Silvicides, which specifically target forest species or the natural regeneration process.

"Phytocide" is a generic term that encompasses all these products.

VIII.1.- MINERAL HERBICIDES

These were mainly used at the beginning of the twentieth century. The most commonly used today are :

- **Calcium cyanide ($Ca(CN)_2$)**, It enters through the roots and penetrates the sap, accumulating in the leaves.
- **Iron sulfate ($FeSO_4$)**, A contact herbicide used to control mosses and accelerate the humification of plant waste,
- **Sodium chlorate ($NaClO_3$)** Destroys deeply rooted plants. A powerful oxidant, it primarily enters through the roots and is transported by the sap to the leaves. Its action is non-selective and can persist in the soil for up to six months. It is degraded by limestone, organic matter, and reducing agents, and can also be leached by infiltrating water. It is slightly toxic to humans but is a comburant (used in the manufacture of

explosives). It can be used for stump devitalization. Due to its danger (risk of explosion), it is increasingly being replaced by organic substances.

VIII.2.- ORGANIC HERBICIDES

These constitute the vast majority of herbicides on the market today. For convenience, they are grouped according to their mode of penetration into plants:

- **Glyphosate:** A total herbicide, meaning it is non-selective. Its mechanism of action is systemic, blocking the enzyme enoyl pyruvyl shikimate 3-phosphate synthase (EPSPS). It is an irritating and toxic product, best known under the brand name Roundup.

VIII.2.1.- Root herbicides

- **Dinitroanilines (toluidines)**

Introduced in 1960, these are poorly soluble in water, highly volatile, and often photodegradable. They are incorporated into the soil before planting.

They act by stopping seedling growth shortly after germination. They are incorrectly termed "anti-germinative" but are more accurately antimitotic. They are used pre-emergence against grasses. Their toxicity is low, and their persistence varies from a few weeks to a year. Examples include benfluraline, trifluraline, and pendiméthaline.

- **Substituted ureas (NH2-CO-NH2)**

These are exclusively herbicides. Their absorption is primarily through the roots. Transported by the raw sap, they accumulate in the leaves where they inhibit photosynthesis. They have very low water solubility and exhibit a relatively long persistence in the soil (2 to 3 months), though this varies depending on ecological conditions (soil, rain, temperature). They are effective against grasses and certain dicotyledons. They are used in pre- or post-emergence applications. Their toxicity is virtually negligible. Their names typically end with the suffix “uron.” Examples include: chlortoluron, chloroxuron, cycluron, diuron, ethidimuron, fenuron, isoproturon, linuron, monolinuron, methabenzthiazuron, metobromuron, metoxuron, monuron, thiazafluron, tebuthiuron, siduron, neburon…

- **Triazines**

This group features a cyclic structure. They act through competitive inhibition at the level of photosystem II. The active molecules replace plastoquinone at the active site of the D1 protein in the thylakoids, thereby inhibiting the reduction of plastoquinone and, consequently, electron transport. This results in an excess of electrons in photosystem II, leading to oxidative stress and a reduction in sugar synthesis. They enter through root absorption and are transported by the raw sap. They are applied directly to the soil. Corn is highly tolerant to these compounds, particularly atrazine. Sorghum is also tolerant, but wheat and soybeans are sensitive to them. Their toxicity is low, and their selectivity is often good. They have limited water solubility, which means they are less likely to leach into the soil. Their persistence can range from 6 to 12 months for some compounds.

Examples include: atrazine, cyanazine, methoprotryne, propazine, terbuthylazine, simazine, simetryn, secbumeton, terbutryn, ametryn, desmetryn, prometryn, terbutryn…

VIII.2.2.- Root and foliar herbicides

- **Imidazolinones**

Some products in this family are total herbicides, while others are selective. Absorbed through both foliar and root pathways, they are unaffected by climatic conditions. They work by blocking the activity of the AHAS (or ALS) enzyme, which is essential for the synthesis of three key amino acids: valine, leucine, and isoleucine. This prevents plant growth and leads to premature senescence. This mode of action explains the low toxicity of these substances to animals and humans, as they cannot synthesize these amino acids and must obtain them from plants. Used on cereals or for total weed control, they are highly versatile. Their persistence lasts several months.

Examples include: imazamethabenz, imazapyr…

- **Sulfonylureas**

They act on the same enzyme as imidazolinones, acetolactate synthase (ALS). Examples include chlorsulfuron and amidosulfuron…

- **Diphenyl-ethers**

First synthesized in 1964, these molecules consist of two benzene rings connected by an oxygen atom. They are absorbed through both leaves and roots. Their translocation within the plant is very limited, giving them a contact-based action. They inhibit meristem growth and are therefore typically used in pre-emergence or early post-emergence applications against grasses. They also inhibit respiration. Their water solubility is low, and they persist in the soil for 2 to 4 months. Their toxicity to mammals is low. Their names generally end with the suffix "fène." Examples include: acifluorfen-sodium, aclonifen, bifenox, bromofenoxime, chlomethoxyfen, diclofop-methyl, fluorodifen, fomesafen, lactofen, nitrofen, oxyfluorfen.

VIII.2.3.- Foliar herbicides

- **Synthetic phytohormones**

Discovered in 1942, they are absorbed through the foliage and transported by the sap. They are non-caustic. There are two main groups:

- The first group consists of synthetic auxins. They cause abnormal growth in plants (dicotyledons), leading to death. The most well-known is 2,4-D (2,4-dichlorophenoxyacetic acid), widely used for selective weed control of monocotyledons, which are less sensitive to it compared to dicotyledons. 2,4,5-T is used as a brush killer.

- Compounds derived from propionic and butyric acids: These are absorbed through the foliage and accumulate in areas of intensive cell division (meristems, buds, roots), where they cause abnormal growth. Their persistence in straw makes the latter unsuitable for use in horticulture. Examples include: 2,4-D, 2,4-MCPA and its esters, triclopyr, diclofop-methyl, 2,4,5-T and its amine salts in particular; 2,4-DP (dichlorprop), MCPP (mecoprop), 2,3,6-TBA, dicamba, picloram, clopyralid, flurenol...

- Nitro dyes (phenol derivatives, dinitrophenol): Derived from benzene, this group includes molecules that are toxic to both animals (insecticides) and plants. They are yellow in color. They were widely used against a broad range of dicotyledons at the seedling stage for the protection of cereals in post-emergence treatments. These are contact herbicides with rapid action, causing necrosis in tissues, which then dry out and die.

They act on cell membranes, making them permeable to H+ ions, significantly lowering the pH within the cells. They do not translocate within the plant; only the parts directly contacted by the herbicide are affected, resulting in burns at the point of impact.

They are hazardous to humans and the environment due to their high toxicity. DNOC, in its dry form, also poses an explosion risk. Nitro dyes are now being replaced by more selective products. Examples include: DNBP (dinoseb), DNOC (dinitro-ortho-cresol), dinoterb, and PCP (pentachlorophenol).

- **Carbamates**

Developed in 1945 for the control of grasses, these herbicides are divided into four categories:

1. Derivatives of carbamic acid (NH2-COOH): These act on cell division.

2. Derivatives of thiocarbamic acid (NH2-CO-SH): These inhibit the synthesis of long-chain lipids and gibberellins.

3. Derivatives of dithiocarbamic acid (NH2-CSSH): These prevent germination.

4. Biscarbamates: These inhibit photosynthesis.

These herbicides share common characteristics such as low toxicity and varying degrees of volatility. They disrupt cell division (antimitotic) and the general physiology of the plant, causing the "basket handle" effect, where leaves fail to unfurl properly.

They are most commonly used in pre-emergence (thiocarbamates) or post-sowing applications, and sometimes in post-emergence (e.g., phenmediphame, barban). With the exception of allate compounds, which persist in the soil for several months, their persistence is almost negligible. Examples:

1. Carbamic acid derivatives: Asulam, barban, chlorbufam, chlorpropham, propham, carbetamide.

2. Thiocarbamates: Butylate, cycloate, diallate, triallate, EPTC, molinate, prosulfocarb, vernolate, pebulate, thiobencarb.

3. Dithiocarbamates: Metam sodium, nabam.

4. Biscarbamates: Desmedipham, phenmedipham, karbutilate.

- **Quaternary ammoniums (Bipyridyls)**

Synthesized in the 1950s, these compounds are formed by the association of two pyridine rings. They act as photosynthetic electron acceptors, targeting the light-dependent reactions of photosynthesis, which halts CO2 assimilation. They also cause the degradation of unsaturated fatty acids, leading to plant death.

They are characterized by their rapid action and lack of selectivity (total herbicides), with the exception of difenzoquat. They penetrate aerial plant parts but have limited translocation, making them primarily contact herbicides. They are highly water-soluble and have no effect when applied to soil, as they are strongly absorbed by clay particles, where they degrade very slowly. They are highly toxic to humans and animals, and there are few or no known antidotes (depending on the specific molecule). Examples: diquat, paraquat, difenzoquat.

- **Fops/dims and pinoxaden** ;

These are anti-grass herbicides that inhibit acetyl-coenzyme A carboxylase (ACCase) in chloroplasts. Numerous cases of resistance have emerged, some due to modifications in the enzyme within the plant, while others result from different mechanisms (non-target-site resistance). Examples: Alloxydim-sodium, Clodinafop-propargyl.

CEREAL WEEDS

IX

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Cereal weeds, also known as 'cornfield weeds,' are wild plants that grow in cereal crops, particularly in fields of wheat, barley, oats, and other annual crops. Although these plants are often considered undesirable by farmers due to their competition with crops, they play an important ecological role and are an integral part of the biodiversity of agroecosystems.

IX.1.- CHARACTERISTICS OF CEREAL WEEDS

- **Adaptation to crop cycles :**

Cereal weeds are perfectly adapted to the cycles of cereal crops. They germinate, grow, and flower in synchrony with the cereals, allowing them to thrive in cultivated fields. Their life cycle is often annual, and they produce abundant seeds, ensuring their persistence from one year to the next.

- **Species diversity :**

Cereal weeds encompass a wide variety of species, such as the common poppy (*Papaver rhoeas*), corncockle (*Agrostemma githago*), cornflower (*Centaurea cyanus*), and wild chamomile (*Matricaria chamomilla*). These plants are often associated with traditional agricultural landscapes and contribute to the beauty of the fields.

- **Competition with crops :**

Cereal weeds compete with crops for essential resources such as water, nutrients, and light. This competition can reduce agricultural yields, which is why they are often considered pests.

IX.2.- ECOLOGICAL IMPORTANCE OF CEREAL WEEDS

- **Biodiversity :**

Cereal weeds contribute to the biodiversity of agroecosystems by providing habitats and food resources for many insects, birds, and small mammals. For example, the flowers of poppies and cornflowers attract pollinators such as bees and butterflies.

- **Ecosystem services :**

These plants play a role in soil health by preventing erosion and improving soil structure through their root systems. They can also serve as indicators of soil quality and the health of the agroecosystem.

- **Cultural and landscape heritage :**

Cereal weeds are part of the cultural and landscape heritage of many agricultural regions. Their presence in fields is often associated with traditional farming and picturesque rural landscapes.

IX.3.- THREATS AND DECLINE OF CEREAL WEEDS

- **Agricultural intensification :**

The intensive use of herbicides, monoculture, and modern farming practices have led to a significant decline in cereal weed populations. Selective herbicides, in particular, target these plants, reducing their presence in fields.

- **Habitat loss :**

The conversion of agricultural land into urban or industrial areas, as well as the abandonment of traditional farming practices, has contributed to the disappearance of cereal weeds in many regions.

- **Climate change :**

Changes in climate patterns, such as prolonged droughts or irregular rainfall, can affect the germination and growth of cereal weeds, threatening their survival.

IX.4.- CONSERVATION MEASURES AND SUSTAINABLE MANAGEMENT

- **Environmentally friendly farming :**

The adoption of sustainable agricultural practices, such as crop rotation, organic farming, and reduced herbicide use, can promote the coexistence of cereal weeds and crops.

- **Creation of refuge areas :**

Establishing grass strips or untreated zones within fields can provide habitats for cereal weeds and other wild species.

- **Conservation programs :**

Conservation initiatives, such as reintroducing cereal weed seeds into fields and raising awareness among farmers about their ecological importance, can help preserve these plants.

- **Research and monitoring :**

Scientific studies on the biology and ecology of cereal weeds, as well as monitoring their populations, are essential for developing tailored management strategies.

Conclusion

Cereal weeds, although often perceived as pests, are key components of agroecosystems. Their decline reflects the pressures exerted by intensive agriculture and environmental changes. Balanced management, integrating both agricultural needs and biodiversity conservation, is essential to preserve these plants and the ecosystem services they provide.

IX.5.- SOME CEREAL WEEDS (MESSICOLES)

These plants are often associated with cereal crops (wheat, barley, oats, etc.) and cultivated fields:

1. **Annual mercury** (*Mercurialis annua*) (*Euphorbiaceae*)

- Annual plant, 10 to 50 cm tall, with erect stems and oval, toothed leaves.
- Small, greenish flowers without petals.
- Common in cultivated fields, gardens, and wastelands.
- Toxic to livestock.

2. **Lambsquarters** (*Chenopodium album*) (*Chenopodiaceae*)

- Annual plant, up to 1.5 m tall, with triangular, mealy leaves.
- Greenish flowers in dense clusters.
- Very common in crops and nitrogen-rich soils.
- Considered a competitive weed.

3. **Redroot pigweed** (*Amaranthus retroflexus*) (*Amaranthaceae*)

- Robust annual plant, up to 1 m tall, with oval leaves and dense flower spikes.
- Native to America, naturalized in Europe.
- Frequent in crops and disturbed soils.
- Herbicide-resistant.

4. **Persian speedwell** (*Veronica persica*) (*Plantaginaceae*)

- Small annual creeping plant, with pale blue flowers and dark stripes.
- Oval, toothed leaves.
- Common in fields, gardens, and roadsides.
- Blooms almost year-round.

5. **Common groundsel** (*Senecio vulgaris*) (*Asteraceae*)

- Annual plant, 10 to 40 cm tall, with lobed leaves and yellow flower heads.
- Very common in crops, wastelands, and gardens.
- Toxic to animals due to pyrrolizidine alkaloids.

6. **Common purslane** (*Portulaca oleracea*) (*Portulacaceae*)

- Annual creeping plant, with fleshy stems and thick leaves.
- Small, inconspicuous yellow flowers.
- Common in crops, gardens, and dry soils.
- Edible and rich in omega-3.

7. **Dandelion** (*Taraxacum officinale*) (*Asteraceae*)

- Perennial plant with a rosette of toothed leaves and yellow flower heads.
- Fruits with white pappus (dispersed by wind).
- Very common in meadows, crops, and gardens.
- Used in traditional medicine and cooking.

8. **Curled dock** (*Rumex crispus*) (*Polygonaceae*)

- Perennial plant, 50 to 120 cm tall, with lanceolate, wavy leaves.
- Greenish flowers in dense clusters.
- Common in fields, meadows, and moist soils.
- Roots used in herbal medicine.

9. **Sheep sorrel** (*Rumex acetosella*) (*Polygonaceae*)

- Perennial plant, 10 to 40 cm tall, with arrow-shaped leaves.
- Reddish flowers in loose clusters.
- Common in acidic and poor soils.
- Considered a weed in crops and pastures.

10. **Scarlet pimpernel** (*Anagallis arvensis*) (*Primulaceae*)

- Annual creeping plant, with small red or blue flowers.
- Oval, opposite leaves.
- Common in fields, vineyards, and gardens.
- Toxic to animals.

11. **Pineappleweed** (*Matricaria matricarioides*) (*Asteraceae*)

- Annual plant, 10 to 40 cm tall, with finely divided leaves.
- Yellow flower heads without petals.
- Common in crops, pathways, and disturbed soils.
- Emits a strong odor.

12. **Shaggy soldier** (*Galinsoga quadriradiata*) (*Asteraceae*)

- Annual plant, 10 to 60 cm tall, with oval leaves and white flowers with yellow centers.
- Native to America, naturalized in Europe.
- Very common in gardens and crops.
- Highly competitive and difficult to eliminate.

13. **Sun spurge** (*Euphorbia helioscopia*) (*Euphorbiaceae*)

- Annual plant, 10 to 40 cm tall, with oval leaves and yellow-green flowers in umbels.
- Secretes a toxic white latex.
- Common in crops, gardens, and wastelands.
- Considered an invasive weed.

14. **Common chickweed** (*Stellaria media*) (*Caryophyllaceae*)

- Annual creeping plant, with small white star-shaped flowers.
- Oval, pointed leaves.
- Common in crops, gardens, and rich soils.
- Grows rapidly and forms dense mats.

15. **Shepherd's purse** (*Capsella bursa-pastoris*) (*Brassicaceae*)

- Annual plant, 10 to 50 cm tall, with rosette leaves and heart-shaped fruits.
- Small, inconspicuous white flowers.
- Common in crops, gardens, and disturbed soils.
- Used in traditional medicine.

16. **Common poppy** (*Papaver rhoeas*) (*Papaveraceae*)

- Annual plant, 30 to 80 cm tall, with bright red flowers and deeply divided leaves.
- Common in cereal fields and disturbed soils.
- Symbol of wheat fields and agricultural landscapes.
- Flowers used in infusions for their calming properties.

17. **Rigid ryegrass** (*Lolium rigidum*) (*Poaceae*)

- Annual plant, 20 to 80 cm tall, with erect stems and narrow, rigid leaves.
- Dense, flattened spikes, green when mature.
- Very common in cereal fields, disturbed soils, and roadsides.
- Highly competitive, herbicide-resistant, and reduces crop yields.

18. **Sterile oat** (*Avena sterilis*) (*Poaceae*)

- Annual plant, 30 to 100 cm tall, with robust stems and broad leaves.
- Loose spikes with drooping spikelets.
- Frequent in wheat and barley fields, as well as in rich and disturbed soils.
- Severe competition for resources and difficult to control.

19. **Wild mustard** (*Sinapis arvensis*) (*Brassicaceae*)

- Annual plant, 30 to 80 cm tall, with lobed leaves and bright yellow flowers.
- Flowers in terminal clusters, with four petals.
- Common in cereal fields, fallow lands, and nitrogen-rich soils.
- Competes for nutrients and can harbor pests.

20. **Cleavers** (*Galium aparine*) (*Rubiaceae*)

- Annual climbing or creeping plant, with stems covered in small hooks.
- Small, white flowers in loose clusters.
- Frequent in cereal fields, hedgerows, and rich soils.
- Invades crops and can smother cereal plants.

21. **Corn marigold** (*Chrysanthemum segetum*) (*Asteraceae*)

- Annual plant, 20 to 60 cm tall, with lobed leaves and yellow flowers.
- Solitary flower heads with bright yellow centers.
- Common in cereal fields and poor soils.
- Competes for nutrients and reduces yields.

22. **Wild radish** (*Raphanus raphanistrum*) (*Brassicaceae*)

- Annual plant, 30 to 80 cm tall, with lobed leaves and yellow or white flowers.
- Flowers in terminal clusters, with four petals.
- Frequent in cereal fields and disturbed soils.
- Competes for resources and can harbor diseases.

23. **Brome** (*Bromus* spp.) (*Poaceae*)

- Annual or perennial plant, 30 to 100 cm tall, with erect stems and narrow leaves.
- Loose, drooping spikes with flattened spikelets.
- Common in cereal fields, grasslands, and disturbed soils.
- Highly competitive, it reduces yields by absorbing nutrients and water.
- Some species are herbicide-resistant.

WEEDS OF ORCHARDS AND VINEYARDS

X

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Weeds in orchards and vineyards represent a major issue for fruit and grape producers. These weeds, although often perceived as harmful, also play a complex ecological role in these agricultural ecosystems. Their management requires a balanced approach, taking into account both production needs and the preservation of biodiversity.

X.1.- CHARACTERISTICS OF WEEDS IN ORCHARDS AND VINEYARDS

- **Species diversity :**

Weeds in orchards and vineyards include a wide variety of species adapted to the specific conditions of these perennial crops. Among the most common are:

- Grasses: such as couch grass (*Elymus repens*) or ryegrass (*Lolium* spp.).
- Dicotyledons: such as thistle (*Cirsium* spp.), bindweed (*Convolvulus arvensis*), or amaranth (*Amaranthus* spp.).
- Perennial plants: such as dock (*Rumex* spp.) or plantain (*Plantago* spp.).

- **Adaptation to perennial crops :**

Unlike annual crops, orchards and vineyards provide a stable environment where weeds can establish and spread over several years. Their life cycle is often synchronized with that of the trees or vines, allowing them to thrive despite cultural interventions.

- **Modes of propagation :**

Weeds primarily spread by seeds, but some species, such as couch grass or bindweed, also reproduce through rhizomes or stolons, making them particularly difficult to eradicate.

X.2.- IMPACTS OF WEEDS ON ORCHARDS AND VINEYARDS

- **Competition for resources :**

Weeds compete with fruit trees and vines for water, nutrients, and light. This competition can reduce crop growth, affect fruit quality, and decrease yields.

- **Effects on fruit quality :**

The presence of weeds can promote soil moisture, increasing the risk of fungal diseases such as gray mold (*Botrytis cinerea*). Additionally, some weeds can harbor harmful insects or pathogens.

- **Hindrance to cultural operations :**

Weeds can complicate pruning, harvesting, and maintenance operations in orchards and vineyards, increasing labor costs.

- **Ecological impacts :**

Although often considered harmful, weeds play an important ecological role by providing habitats and food resources for pollinating insects, natural predators of pests, and other beneficial organisms.

X.3.- WEED MANAGEMENT STRATEGIES

- **Cultural methods :**

- Tillage: Plowing or mechanical weeding can reduce weed presence but must be used cautiously to avoid damaging tree or vine roots.

- Mulching: The use of organic mulches (straw, wood chips) or synthetic mulches (plastic sheets) can limit weed seed germination and conserve soil moisture.

- Cover crops: Planting cover crops (clover, alfalfa) between vine rows or fruit trees can suppress weeds while improving soil structure and fixing nitrogen.

- **Chemical methods :**

- Herbicides: The use of selective or non-selective herbicides can be effective for weed control but must be managed carefully to avoid environmental and human health impacts.

- Integrated management: Combining herbicides with other control methods to reduce doses and minimize resistance risks.

- **Biological methods :**

- Thermal weeding: The use of heat (flame, steam) to destroy weeds is a non-chemical alternative.

- Biological control: The introduction of specific insects or microorganisms to control certain weed species.

- **Ecological management :**

- Maintaining biodiversity: Leaving some areas grassy or planting flower strips can promote beneficial insects (predators, pollinators) and reduce weed pressure.

- Practice rotation: Alternating control methods to prevent weed adaptation.

X.4.- SPECIFIC CHALLENGES IN ORCHARDS AND VINEYARDS

- **Deep root systems :**

Fruit trees and vines have deep root systems, limiting soil tillage options without damaging the crops.

- **Dormancy period :**

Weeds can take advantage of the dormancy period of trees or vines to establish themselves, requiring proactive management.

- **Impact on wine and fruit quality :**

The presence of certain weeds can influence fruit and wine quality, particularly by altering soil composition or harboring pathogens.

Conclusion

Weeds in orchards and vineyards present a complex challenge for producers, requiring an integrated approach that combines cultural, chemical, biological, and ecological methods. Balanced management not only limits the negative impacts of weeds on crops but also preserves the biodiversity and ecosystem services they provide.

By adopting sustainable practices, viticulturists and arboriculturists can enhance the resilience of their production systems while protecting the environment.

X.5.- SOME EXAMPLES OF WEEDS IN ORCHARDS AND VINEYARDS

These plants are often found in orchards, vineyards, and perennial areas.

1. **Stinging nettle** (*Urtica dioica*) (*Urticaceae*)

- Perennial plant, 50 to 150 cm tall, with oval, toothed leaves covered in stinging hairs.
- Greenish flowers in hanging clusters.
- Common in nitrogen-rich soils, along paths, and in wastelands.
- Used in cooking (soups) and herbal medicine.

2. **White clover** (*Trifolium repens*) (*Fabaceae*)

- Creeping perennial plant with trifoliate leaves and white flower heads.
- Common in meadows, lawns, and orchards.
- Nitrogen-fixing plant, often used as green manure.

3. **Field horsetail** (*Equisetum arvense*) (*Equisetaceae*)

- Creeping perennial plant with trifoliate leaves and white flower heads.
- Common in meadows, lawns, and orchards.
- Nitrogen-fixing plant, often used as green manure.

4. **Broadleaf plantain** (*Plantago major*) (*Plantaginaceae*)

- Creeping perennial plant with trifoliate leaves and white flower heads.
- Common in meadows, lawns, and orchards.
- Nitrogen-fixing plant, often used as green manure.

5. **Ribwort plantain** (*Plantago lanceolata*) (*Plantaginaceae*)

- Creeping perennial plant with trifoliate leaves and white flower heads.
- Common in meadows, lawns, and orchards.
- Nitrogen-fixing plant, often used as green manure.

6. **Common daisy** (*Bellis perennis*) (*Asteraceae*)

- Creeping perennial plant with trifoliate leaves and white flower heads.
- Common in meadows, lawns, and orchards.
- Nitrogen-fixing plant, often used as green manure.

7. **Hedge bindweed** (*Convolvulus sepium* ou *Calystegia sepium*) (*Convolvulaceae*)

- Climbing perennial plant with arrow-shaped leaves and white, funnel-shaped flowers.
- Common in hedges, orchards, and vineyards.
- Considered an invasive weed due to its spreading rhizomes.

8. **Couch grass** (*Elymus repens*) (*Poaceae*)

- Perennial plant, 30 to 120 cm tall, with creeping rhizomes and narrow leaves.
- Common in crops, orchards, and disturbed soils.
- Very difficult to eradicate due to its resilient rhizomes.

9. **Bermuda grass** (*Cynodon dactylon*) (*Poaceae*)

- Creeping perennial plant with robust stems and narrow leaves.
- Common in dry soils and warm climates.
- Used as fodder but considered an invasive weed.

10. **Canada thistle** (*Cirsium arvense*) (*Asteraceae*)

- Perennial plant, 50 to 150 cm tall, with spiny leaves and pink flower heads.
- Common in crops, orchards, and rich soils.
- Highly competitive and difficult to eradicate.

11. **Spear thistle** (*Cirsium vulgare*) (*Asteraceae*)

- Biennial plant, 50 to 150 cm tall, with very spiny leaves and purple flowers.
- Common in wastelands, along paths, and in disturbed soils.
- Considered an invasive weed.

12. **Greater burdock** (*Arctium majus*) (*Asteraceae*)

- Biennial plant, 1 to 2 m tall, with large oval leaves and purple flower heads.
- Fruits are spiky balls that cling to clothing and animals.
- Common in rich soils and along paths.

13. **Wood sorrel** (*Oxalis acetosella*) (*Oxalidaceae*)

- Small perennial plant with heart-shaped trifoliate leaves and white or pink flowers.
- Common in woodlands and acidic soils.
- Considered a weed in gardens.

14. **Yellow wood sorrel** (*Oxalis stricta*) (*Oxalidaceae*)

- Annual or perennial plant with trifoliate leaves and yellow flowers.
- Common in gardens, crops, and disturbed soils.
- Can become invasive.

15. **Black nightshade** (*Solanum nigrum*) (*Solanaceae*)

- Annual plant, 30 to 60 cm tall, with oval leaves and star-shaped white flowers.
- Fruits are black and toxic when ripe.
- Common in crops, gardens, and rich soils.

16. **White deadnettle** (*Lamium album*) (*Lamiaceae*)

- Perennial plant, 20 to 60 cm tall, with leaves resembling nettles but non-stinging.
- White, lipped flowers.
- Common in hedges, along paths, and in rich soils.

17. **White campion** (*Silene latifolia*) (*Caryophyllaceae*)

- Perennial plant, 30 to 100 cm tall, with star-shaped white flowers.
- Common in wastelands, along paths, and in disturbed soils.
- Blooms in the evening and attracts nocturnal moths.

18. Common sowthistle (*Sonchus oleraceus*) (*Asteraceae*)

- Annual plant, 30 to 100 cm tall, with lobed leaves and yellow flower heads.
- Common in orchards, vineyards, and rich soils.
- Competes with crops for nutrients and water.
- Can harbor pests and diseases.

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GLOSSARY

Active ingredient: Component of a preparation that is responsible for its efficacy, either fully or partially.

Association: Preparation containing multiple active ingredients.

Broadcast herbicide treatment: Treatment applied over the entire surface of the plot.

Contact herbicide: Herbicide that acts after penetrating plant tissues to a certain extent, without migrating from one organ to another within the treated plant.

Content: Quantity of active ingredient contained in a unit of mass or volume of a preparation; expressed as a weight percentage for solid formulations and in g/L for liquid formulations.

Directed herbicide treatment: Treatment using a non-selective herbicide while protecting the cultivated plant during application.

Dose: Quantity of active ingredient or preparation applied per unit of treated surface (to avoid any ambiguity, active ingredient doses are expressed in grams, while doses of formulations are expressed in kilograms or liters).

Early post-emergence herbicide treatment: Treatment applied before the emergence of the crop but after weed emergence, combining a pre-emergence and a post-emergence herbicide.

Formulant: Any substance added to the active ingredient(s) to obtain the formulated product.

Formulation:

1. Combination of various compounds designed to make the product effectively usable for the intended purpose.
2. Physical form in which the plant protection product is marketed (e.g., WP: wettable powder; SL: soluble concentrate; EC: emulsifiable concentrate; SC: suspension concentrate; etc.).

Graminicide: Herbicidal substance or preparation specifically targeting grasses while being selective for dicotyledons.

Localized herbicide treatment: Treatment applied to a specific part of the soil, crop, or weeds.

Phytotoxicity: Property of a substance or preparation that causes temporary or lasting damage to a plant.

Post-emergence herbicide treatment: Treatment applied after the emergence of the targeted plant (crop or weed).

Post-sowing herbicide treatment: Treatment applied immediately after crop sowing.

Pre-emergence herbicide treatment: Treatment applied before the emergence of the targeted plant (crop or weed).

Preparation or formulated product: Ready-to-use mixture of an active ingredient and formulants (see Association).

Pre-sowing herbicide treatment: Herbicide applied after soil preparation and before crop sowing, allowing the incorporation of volatile or photodegradable products.

Residual activity or persistence of action: Duration during which an herbicide remains active.

Selective herbicide: Herbicide that, when used under normal conditions, preserves certain crops while controlling specific weeds within these crops.

Specialty: Formulated product with a defined composition, authorized for sale under a brand name.

Spectrum of efficacy: Range of species controlled by a product at a given dose.

Systemic herbicide: Herbicidal substance or preparation capable of acting after penetration and migration from one organ to another within the treated plant.

Tank mix or extemporaneous mixture: Mixture prepared by the user at the time of application.

Total herbicide: Herbicide that, when used at the recommended doses, can destroy or prevent the development of all vegetation, with varying persistence of action.

Treatment program: Series of herbicide applications carried out on a plot throughout the crop cycle.

ANNEX

Annex 01: Teaching sheet for a course

Teaching unit (TU): Fundamental

Instructor(s) responsible for the TU:

Semester of the UE: Semester 1

Subject course: Weed science

Instructor(s) responsible for the course: Mériem MARFOUA

Weekly hourly volume: Lecture: 1h30 / Tutorial: 1h30 / Practical work: 00

Assessment methods:

1. **Duration of the end-of-semester exam:** Medium-length test (1h30) and Resit test (1h30).

2. **Continuous assessment:** (Specify the weighting of each element in the following table according to the subject composition):

Tutorials			Practical work			Presentation	
Attendance	**Participation**	**Quiz**	Attendance	Participation	Reports	Written	Oral
05 pts	**05 pts**	**10 pts**	pts	pts	pts	pts	pts

Course objectives (2 to 4 lines):

The objective of this course is to provide basic knowledge about weeds applied to plant protection. It aims to develop an understanding of the collection, preservation, and establishment of a herbarium.

Course content (Chapters and paragraphs, maximum 10 lines):

Review of basic concepts

Chapter 1: General overview of weeds

1. Definitions

2. Biological types of weeds

Chapter 2: Economic importance

1. Worldwide

2. In Algeria

Chapter 3: Harmfulness

1. Nature of damage

2. Biological interactions

Chapter 4: Evolution of weed flora

1. Germination ecology

2. Evolution mechanisms

3. Evolution factors

Chapter 5: Weed systematics and phenology

1. Weed groupings

2. Identification

3. Phenology

Chapter 6: Weed control in agriculture

1. Cultural control

2. Biological control

3. Chemical control

Chapter 7: Herbicides

1. Generalities

2. Classification

Chapter 8: Main families of herbicides

Chapter 9: Arable land weeds

Chapter 10: Orchard and vineyard weeds

Tutorials:

- DW 1: One session on phenology

- DW 2: Herbarium establishment