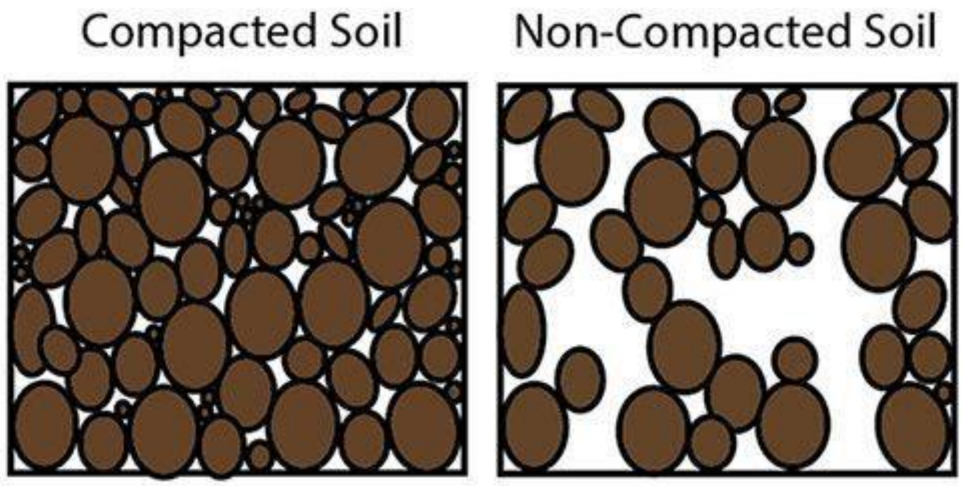
III. Main Crop Care Practices

Main crop care practices—encompassing **fertilization**, **weed control**, and **pest and disease management**—are fundamental to achieving sustainable agricultural productivity. These practices not only enhance crop yields but also contribute to environmental conservation and long-term soil health.

☞ ***What makes soil productive?***

Any soil, no matter how compact, can be improved by adding **organic matter**, becoming a nutrient-rich environment for any plant. Like humans, roots and soil organisms breathe and require sufficient air and water to thrive. As a result, good soil is not "solid," instead, between 40 and 60 percent of the soil volume is pores. The pores may be infused with water or air, making both available to plants. The minor pores store water, and the largest pores control the aeration and circulation of water through the soil and are primarily the result of **earthworm** or **root growth**.



https://www.advancedturf.com/resources/soil-compaction-symptoms-problems-and-best-practices/

Fertile soils are a dynamic community of many genera of fungi, bacteria, insects, and mites that depends on organic matter as a fuel source. Without these organisms, minimal soil formation would take place. Therefore, these organisms, with earthworms and plants, provide the glue that holds the soil together and gives it structure. Consequently, rich soil provides physical support, water, air, and nutrients to plants and soil-dwelling organisms. Ref. (https://ucanr.edu/blog/garden-notes/article/soil-amendments)

3.1 Fertilization

Fertilization remains a cornerstone of successful crop management, aiming to replenish essential nutrients in the soil and directly support plant development. It involves careful planning regarding the type, timing, and method of nutrient application, ensuring optimal plant growth while minimizing environmental impacts.

Macronutrient (>0.5 g/kg plant dry weight)		Micronutrient (<0.5 g/kg plant dry weight)	
C	Carbon	Fe	Iron
H	Hydrogen	Mn	Manganese
O	Oxygen	Cu	Copper
N	Nitrogen	Zn	Zinc
P	Phosphorus	Mo	Molybdenum
K	Potassium	B	Boron
S	Sulfur	Cl	Chlorine
Ca	Calcium	Ni	Nickel
Mg	Magnesium	(Na)	Sodium
(Si)	Silicon	(Co)	Cobalt

Table *; Classification of macro and micronutrients
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a. General Concepts

Fertilization provides plants with vital nutrients such as nitrogen (N), phosphorus (P), and potassium (K), along with secondary nutrients and micronutrients Table *. These nutrients are indispensable for physiological processes like photosynthesis, energy transfer, and cellular division. Modern fertilization strategies emphasize **precision**: nutrients must be delivered **in the right amount**, at **the right time**, and in the **right place to maximize efficiency** (Agriculturelore, 2024).

Importantly, fertilization is classified into several types depending on timing and method:

- **Basal fertilization** (also called "starter" or "pre-plant fertilization") is applied before sowing to enrich the soil and prepare it for seedling development. (NPK)
- **Top-dressing** fertilization is applied during crop growth, especially at key stages such as vegetative growth, flowering, and fruiting. (Urea)

- **Foliar fertilization** involves spraying nutrients directly onto plant leaves, allowing rapid absorption when root uptake is limited (e.g., during drought or soil stress).

Each growth stage requires specific attention:

- **Before sowing**: Focus on basal fertilization to ensure strong root establishment.
- **During germination**: Minimal nutrient application is required to avoid seed burn.

- **Vegetative stage**: Increased nitrogen supply is crucial for leaf and stem development.
- **Flowering stage**: Emphasis shifts towards phosphorus and potassium to promote flowering and reproductive success.
- **Fruiting stage**: Continued potassium supplementation supports fruit filling and ripening.

In addition, it is important to distinguish between **fertilizer application** and **plant hormone application**. Fertilizers supply nutrients that plants need in large or moderate quantities for general metabolism and structure, whereas **plant hormones** (such as auxins, gibberellins, cytokinins) are signaling molecules that regulate growth, development, and responses to environmental stimuli. While fertilization ensures nutrient availability, hormone treatments modulate physiological responses like root initiation, flowering induction, or fruit enlargement.

b. Soil Amendments

☞ **What is an amendment?**

Amendment: Any matter added into the soil to enhance its **physical** attributes, such as water retention, permeability, drainage, aeration, and structure. They are indirectly affecting plant growth.

☞ **Organic amendments**, such as compost, manure, and green manure, enhance soil structure, water retention, and microbial life.

☞ **Mineral amendments**, on the other hand, target specific chemical characteristics of the soil. The main mineral amendments include **lime** (to raise soil pH and correct soil acidity), **gypsum** (to improve soil structure without altering pH), and **sulfur** (to lower soil pH when soils are too alkaline).

Amendments are essential for correcting imbalances: **lime neutralizes acid soils** favoring better nutrient availability, while **gypsum** is often used **in compacted or saline soils to enhance permeability**. Sulfur is applied when crops prefer slightly acidic conditions, such as blueberries. Therefore, before applying amendments, a thorough soil analysis is necessary to identify specific needs and avoid unnecessary interventions.

c. Mineral Fertilizers

Mineral fertilizers, also known as inorganic or synthetic fertilizers, are manufactured products that supply nutrients in readily available forms. They are categorized based on the nutrients they provide: straight fertilizers contain a single nutrient (e.g., urea for nitrogen), while compound fertilizers offer a combination of nutrients (e.g., NPK blends).

The advantages of mineral fertilizers include their high nutrient concentration, predictable nutrient content, and immediate availability to plants, which can lead to rapid crop responses. However, their misuse or overuse can result in environmental issues such as soil acidification, nutrient runoff, and reduced soil microbial activity. Therefore, integrating mineral fertilizers with organic practices and adhering to recommended application rates are essential for sustainable crop production.

3.2 Weed control

A **weed** is a **plant** considered undesirable in a particular situation, growing where it conflicts with human preferences, needs, or goals. Plants with characteristics that make them hazardous, aesthetically unappealing, difficult to control in managed environments, or otherwise unwanted in **farm land, orchards, gardens, lawns, parks**, recreational spaces, residential and industrial areas, may all be considered weeds. The concept of weeds is particularly significant in agriculture, where the presence of weeds in fields used to grow crops may cause major losses in yields. **Invasive species**, plants introduced to an environment where their presence negatively impacts the overall functioning and biodiversity of the ecosystem, may also sometimes be considered weeds.

☞ Weed control is a fundamental aspect of crop care, aiming to minimize competition between weeds and cultivated plants for vital resources such as water, light, nutrients, and space. Weeds can drastically reduce crop yields if not managed properly, as they often have faster growth rates and greater adaptability than crops. Effective weed management enhances crop establishment, optimizes resource use, and facilitates harvesting.

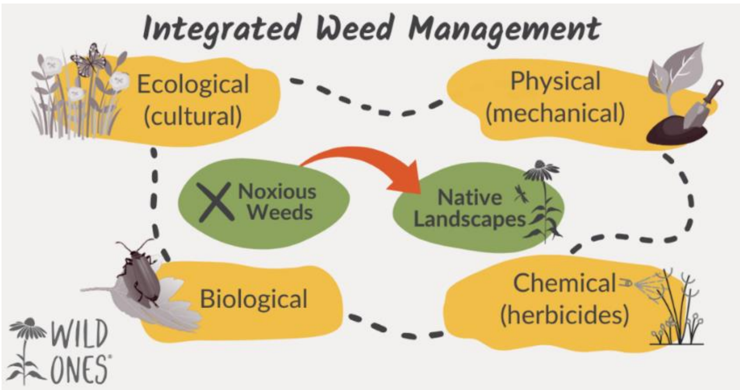
☞ Several strategies are used to manage weeds:

- **Cultural practices** like crop rotation, delayed sowing, and cover cropping disrupt weed life cycles and reduce their prevalence.
- **Mechanical control** such as tillage, hoeing, and mowing physically removes weeds.
- **Chemical control** with herbicides remains widely used, though growing concerns about herbicide resistance and environmental impacts encourage integrated approaches.

An **Integrated Weed Management (IWM)** system, combining different methods, is now strongly recommended to sustainably manage weed populations and reduce chemical dependency (Duke, 2021).

Maintaining a **critical weed-free period**, generally the first 30–60 days after crop emergence, is crucial to avoid irreversible yield losses.

Integrated weed management is a multifaceted, ecosystem-based approach to managing invasive plants, weeds, and pests. This blog mainly discusses physical management techniques. Ecological weed management involves techniques such as varying planting density to “outcompete” invasive or undesired plants. Biological control is the intentional introduction of natural enemies (insects, mites and pathogens) of a target weed. ►



☞ **Focus on Specific Problematic Weeds**

Several aggressive weed species pose particular challenges to crops worldwide, requiring targeted strategies:

- ***Bromus* spp. (e.g., *Bromus rigidus,* picture)**

Bromus species, commonly called brome grasses, are highly competitive annual weeds. They germinate early and quickly dominate fields if not controlled.
➔ **Best practices**: Early shallow tillage before sowing to stimulate germination and eliminate seedlings, pre-emergence herbicides (such as pendimethalin), and crop rotations with spring crops are effective (Beckie et al., 2019).

- ***Phalaris* spp. (e.g., *Phalaris minor,* picture)**

Phalaris, especially *Phalaris minor*, is a major problem in cereal crops like wheat, leading to significant yield reductions.
➔ **Best practices**: Use of resistant wheat varieties, adjusting sowing dates (delayed sowing after weed flushes), deep plowing, and herbicides such as clodi nafop-propargyl or fenoxaprop-p-ethyl (Chhokar et al., 2007).

- ***Lolium* spp. (Ray Grass, e.g., *Lolium rigidum*, picture)**

Ray grass is highly problematic in winter crops due to its herbicide resistance and aggressive growth.
➔ **Best practices**: Rotation with non-cereal crops, use of non-selective herbicides in fallow periods, and mechanical seedbank reduction throug h harvest weed seed control (HWSC) (Powles et al., 2010).

- ***Avena fatua* (Wild Oat)**
  Wild oats infest cereal fields worldwide, competing strongly with crops for light, nutrients, and water.
  ➔ **Best practices**: Rotations with broadleaf crops, pre-emergence and post-emergence herbicides (triallate, pinoxaden), early seeding, and rigorous sanitation of farm equipment to prevent seed spread (Beckie et al., 2020).

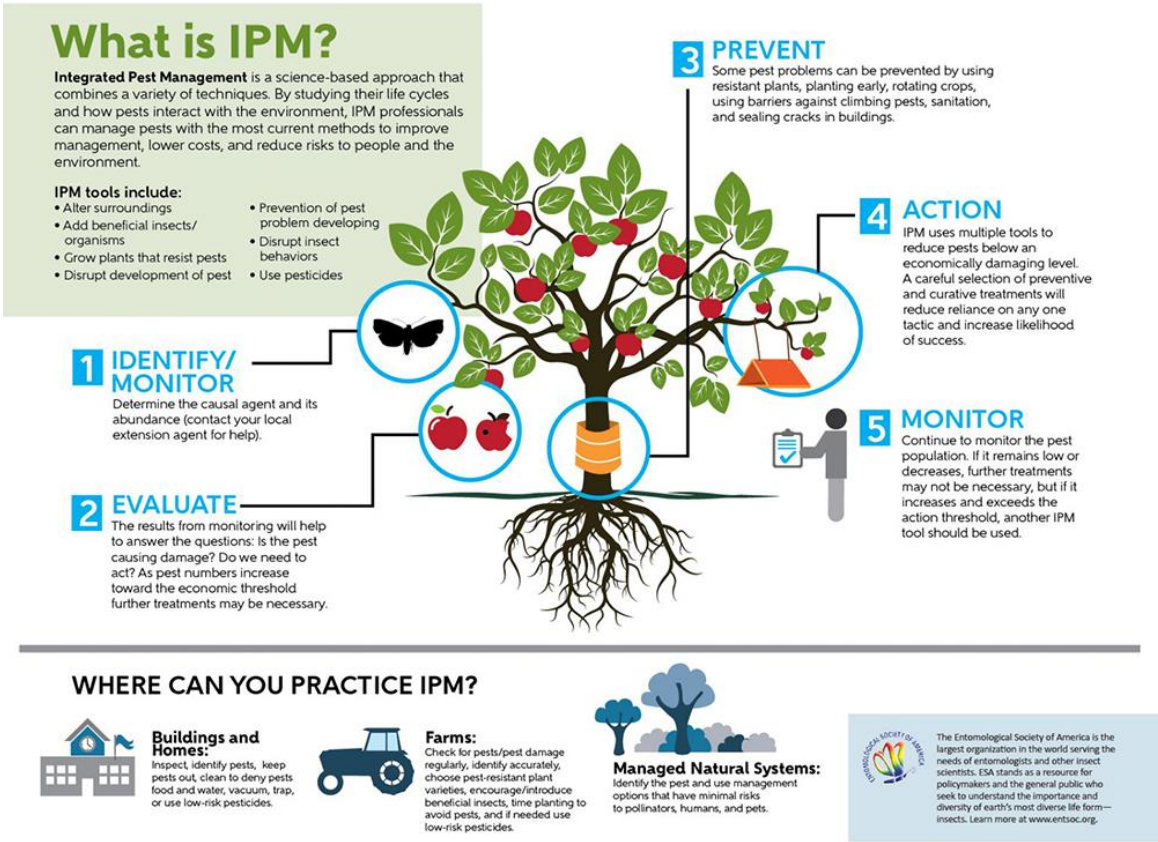
🌱 Summary Table: Key Weeds and Best Management Practices

Weed Species	Key Crops Affected	Best Management Practices
***Bromus* spp.**	Cereals, Pastures	Early tillage, Pre-emergence herbicides, Crop rotation
***Phalaris* spp.**	Wheat, Barley	Delayed sowing, Herbicides, Resistant varieties
***Lolium* spp.**	Wheat, Barley	Crop rotation, Fallows, Seedbank management
Avena fatua	Cereal crops	Early seeding, Herbicides, Equipment sanitation

3.2 Pest and Diseases control

Pests (such as insects, nematodes, and mites) and diseases (caused by fungi, bacteria, and viruses) represent major threats to crop productivity worldwide. Unchecked, they can result in significant yield losses, affect food security, and necessitate costly interventions. Effective pest and disease management is therefore essential to ensure sustainable crop production and protect the economic viability of agricultural systems.

Fig. Infectious plant diseases. From left to right, top row: tomato mosaic virus, downy mildew of lettuce, bacterial blight of cauliflower, rye ergot, middle row: potato spindle tuber viroid (William M. Brown Jr, amended), lettuce bacterial blight, mixed viral infection on the ramson (cucumber mosaic virus, tobacco rattle virus, tobacco mosaic virus), Septoria blight of celery; bottom row: Fusarium blight of dill, onion rust, black rot (alternariosis) of carrots, and tomato leaf curl virus. **Learn more!!**



Modern crop protection strategies aim not only to eliminate pests and pathogens but also to prevent their establishment and spread, while minimizing environmental impacts. Integrated Pest Management (IPM) has become the standard approach: combining biological, cultural, mechanical, and chemical methods to achieve effective, sustainable control.

☞ **Key Concepts in Pest and Disease Management**

- **Monitoring and Early Detection**

  Regular field scouting and the use of tools like pheromone traps, predictive models, and remote sensing technologies help in early detection of pest and disease outbreaks. Early interventions are often less costly and more effective than late-stage treatments.

- **Cultural Practices**

  Crop rotation, resistant crop varieties, proper spacing, and sanitation measures (e.g., removing infected plant debris) can significantly reduce pest and disease pressures. Managing sowing dates and irrigation can also limit favorable conditions for pathogens.

- **Biological Control**

  Encouraging natural enemies like ladybugs, parasitic wasps, entomopathogenic fungi, and nematodes helps maintain pest populations below damaging thresholds. Biocontrol is gaining importance as an eco-friendly alternative to chemical treatments.

- **Chemical Control**

When necessary, selective and well-timed applications of pesticides or fungicides are employed. However, resistance management strategies (e.g., rotating active ingredients) must be implemented to prevent the rapid development of pesticide resistance (Gould et al., 2018).

- **Host Plant Resistance**

Breeding and using resistant cultivars are a cornerstone of disease management. Resistance genes can target specific pathogens or pests, reducing the need for chemical inputs.

- **Integrated Pest Management (IPM)**

IPM emphasizes prevention, monitoring, and control through a combination of practices. It aims to minimize environmental impact, avoid pest resistance, and reduce chemical residues on crops.

🌾 Example of Pest and Disease Management Practices

Problem	**Management Strategy**
Aphid infestation	Use of parasitic wasps (Aphidius spp.), insecticidal soaps
Fusarium wilt (fungal)	Crop rotation, resistant varieties, soil solarization
Nematodes (root-knot)	Use of nematode-resistant crops, organic soil amendments
Fall armyworm invasion	Pheromone traps, selective insecticides, push-pull strategy

☞ Important Note

Climate change is altering pest and disease dynamics: warmer temperatures and increased humidity can expand the range of many pests and pathogens, requiring continuous adaptation of management practices.

☞ Case studies

🌱 Case Study 1: Integrated Pest and Disease Management in Tomato Crops (*Solanum lycopersicum*)

Tomato crops are highly sensitive to pests like whiteflies (*Bemisia tabaci*) and diseases like late blight (*Phytophthora infestans*). An effective IPM strategy for tomatoes combines several practices:

- Monitoring: Yellow sticky traps are installed to detect early whitefly invasions. Regular field inspections help in early detection of blight symptoms.
- Cultural practices: Crop rotation with non-solanaceous crops (e.g., cereals) breaks disease cycles. Drip irrigation minimizes leaf wetness, reducing fungal disease risks.
- Biological control: Predatory insects like *Encarsia formosa* are released to control whiteflies naturally.
- Chemical control: Only when necessary, targeted fungicides (like copper-based products) are applied at key growth stages. Insecticides are rotated to prevent resistance.

- Resistant varieties: Cultivars like 'Defiant PhR' and 'Iron Lady' are bred for resistance to late blight and other diseases.

Yellow sticky traps ►

Result: Significant reduction in chemical pesticide use, improved yield, and healthier fruit quality.

🌾 **Case Study 2: Integrated Pest and Disease Management in Wheat Crops (*Triticum aestivum*)**

Wheat is vulnerable to diseases like rusts (e.g., *Puccinia striiformis*, *Puccinia graminis*) and pests like the Hessian fly (*Mayetiola destructor*). Key IPM measures for wheat include:

- Monitoring: Disease surveillance programs and disease prediction models (like RustTracker) inform farmers about potential outbreaks.
- Cultural practices: Early sowing in some regions helps wheat escape peak Hessian fly attacks. Crop residues are managed to reduce pathogen carry-over.
- Biological control: Natural enemies like parasitic wasps help manage Hessian fly populations in some systems.
- Chemical control: Fungicides (e.g., triazoles) are applied at the flag leaf stage if rust pressure is high. Threshold-based insecticide use is preferred for pest outbreaks.
- Resistant varieties: Deployment of rust-resistant wheat varieties like 'Norman' or 'Kariega' is critical (Singh et al., 2016).

Result: Reduced reliance on chemicals, greater yield stability, and lower production costs.