



# **Pruning in Horticulture: A Blend of Art and Science**

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## **Authors' contributions**

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## ABSTRACT

Pruning is a critical horticultural practice that skilfully combines scientific principles with artistic techniques to enhance plant health, aesthetics, and productivity. This process involves the strategic removal of plant parts, such as branches, buds, or roots, to influence growth patterns, improve flowering and fruiting, and maintain structural integrity. From a scientific perspective, pruning is grounded in plant physiology, understanding how plants respond to wounds, and the redistribution of resources like hormones and nutrients. This knowledge allows horticulturists to make precise cuts that encourage desirable growth, prevent disease, and enhance the plant's overall vigour. Artistically, pruning requires an eye for symmetry, balance, and the natural growth habits of each plant species. Techniques range from basic thinning and heading cuts to more sophisticated methods like espalier and topiary. These methods are tailored to different horticultural objectives, whether it's shaping a plant for ornamental purposes, improving air circulation and light penetration, or maximizing fruit production. The art of pruning lies in making cuts that not only promote health but also enhance the plant's aesthetic appeal. By merging scientific knowledge with artistic vision, pruning optimizes plant health and yields, contributing to the beauty and functionality of gardens and landscapes. This dual approach ensures that plants are both visually appealing and biologically robust, supporting sustainable and productive horticultural practices. Effective pruning can transform a garden, creating a harmonious balance between nature's intrinsic beauty and human design, ultimately fostering a thriving, sustainable environment.

*Keywords: Pruning; methods; knowledge; health; scientific; aesthetic.*

## 1. INTRODUCTION

Pruning is a procedure in horticulture that includes removing or decreasing sections of a plant, tree, or vine that are not essential for growth or production, are visually unpleasant, or are damaging to the plant's health or development [1]. Pruning can be done in terms of eliminating or lowering the size of the plant, tree, or vine. In home gardening, it improves plant form and blooming potential, and it is commonly used in the management of orchards and vineyards for the purpose of enhancing flowering and fruiting [2]. It has come to be acknowledged that the old method of cutting off branches in a manner that is flush with the limb is not recommended. It is recommended that pruning be performed slightly above the collar, or bulge, and that ragged bark be carefully cut if it is present. It is not required to prune paint or

dressings; nevertheless, thin coastlines may be applied for aesthetic reasons [3].

Pruning that is not done correctly can result in the loss of flowers and fruits, as well as leave the plant susceptible to harm from insects and diseases. An experienced tree surgeon is required to do extensive repairs on trees that have been damaged by ice, high winds, lightning, fire, or disease [4]. For example, removing branches that are broken, dead, or diseased; cutting back limbs that obstruct traffic; thinning to allow air circulation; removing branches that rub against others to prevent wounding and decay; judicious cutting to compensate for root loss and promote blossom formation; and heading back to revitalize an aged tree are all common procedures that are performed during tree surgery [5].



**Fig. 1. Pruning: A procedure in horticulture that includes removing or decreasing sections of a plant**

## 2. PRINCIPLES ASSOCIATED WITH PRUNING

The process of pruning trees and shrubs is a complicated one that calls for creative aptitude in addition to technical expertise. When evaluating a plant from an artistic point of view, it is necessary to have a keen eye in order to assess what has to be done in order to attain the desired appearance [6]. It is equally crucial, from a scientific point of view, to be aware of when, when, and how to trim a plant. Pruning is an art form that begins before a plant is planted in the ground. The "Right Plant, Right Place" approach is a method that assists gardeners in avoiding duties that are both needless and tedious. With this method, the location of the plant that will be planted is taken into consideration, and the plant that is most suitable for the area is selected [7]. In order to avoid plants from overgrowing their area, getting too close to structures, obscuring windows, or impeding walkways, it is important to take into consideration the mature size of the plant [8]. It is also important to consider the natural form of a plant while attempting to comprehend how the plant need to appear. The decision of whether or not to make a hedge or topiary with the plants in their garden is influenced by the preferences and preferences of the individual gardener [9]. Allowing plants to keep their natural form and limiting pruning to just structural and emergency trimming will result in a landscape that is both appealing and low-maintenance. This is because a neatly maintained hedge or topiary requires more effort than the majority of gardeners have the time or patience to do [10]. The plant may sustain damage and stress as a result of pruning, but it is critical to reduce the amount of damage and stress that occurs whenever it is feasible to do so. When a plant is under stress, it is more likely to be attacked by insects and diseases, as well

as to suffer damage from drought and cold. When it comes to correctly pruning plants, the science that goes into it can be broken down into three categories: the "3 Ts of Pruning" techniques, tools, and timing [11]. An essential first step is to acquire high-quality tools, with hand pruners, pruning loppers, and a pruning saw being among the most vital instruments to acquire. By-pass pruners offer a more exact cut compared to classic pruners of the anvil type. However, for branches that are larger than 1 ½ inches, it is necessary to have a high-quality pruning saw [12]. Additionally, shears, chainsaws, and pole saws could be required, depending on the gardening style of the individual [13]. Pruning is the second "T" in the pruning process, and standard criteria for pruning are dependent on when the plant blossoms. When a plant is produced for the purpose of producing flowers, the time to prune it is determined by when the plant blossoms [14]. When it comes to pruning, spring-blooming shrubs should be pruned soon after they have finished flowering, but plants that are not grown for flowers should be pruned between the months of August and June. In conclusion, technique is a topic that is deserving of its own devoted literature, and there is a logical beginning sequence for pruning any tree or shrub [15]. The removal of wood that is damaged, diseased, or dead should be done at any time since neglecting to do so might leave the plant vulnerable to additional attacks from insects or diseases. To protect the plant from harm and to avoid fusion, it is important to remove branches that are crossing each other and rubbing against each other as soon as possible. In order to promote new growth, enhance air circulation, and increase the amount of light that is exposed to the inside of the plant, it is necessary to remove any old wood [16].

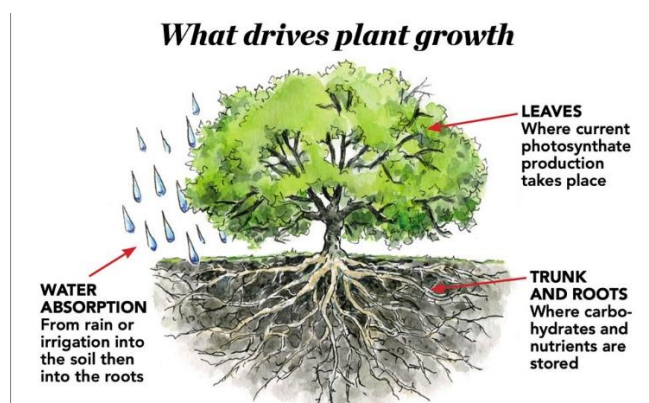


Fig. 2. Drivers for plant growth

### 3. IMPORTANCE OF PRUNING

Pruning is a crucial practice in the cultivation of horticultural crops, offering a multitude of benefits that enhance plant health, productivity, and overall aesthetics. Here are some key reasons why pruning is important:

#### 1. Enhanced Plant Health:

- **Disease and Pest Control:** Removing diseased, dead, or damaged parts of the plant reduces the risk of infections and pest infestations, promoting a healthier plant environment [17].
- **Improved Air Circulation:** Thinning dense canopies allows better air movement, reducing the humidity that fosters fungal diseases.

#### 2. Increased Yield and Quality:

- **Optimal Light Penetration:** Pruning ensures that sunlight reaches all parts of the plant, enhancing photosynthesis and leading to better fruit and flower development [18].
- **Resource Allocation:** By removing unnecessary growth, the plant can allocate more resources (nutrients, water, and energy) to the production of fruits and flowers, improving their size and quality [19].

#### 3. Structural Integrity and Safety:

- **Strengthening Plant Structure:** Pruning helps in developing a strong framework, reducing the risk of branch breakage under the weight of fruit or during strong winds.
- **Eliminating Hazards:** Removing weak or overhanging branches that pose risks to people and property ensures safety [20].

#### 4. Aesthetic Appeal:

- **Shaping and Styling:** Pruning allows horticulturists to shape plants, enhancing the visual appeal of gardens and landscapes. Techniques like topiary and espalier are used to create aesthetically pleasing forms [21].
- **Maintaining Size:** Regular pruning keeps plants within desired dimensions, preventing them from becoming overgrown and unsightly.

#### 5. Rejuvenation and Longevity:

- **Stimulating Growth:** Pruning can invigorate older plants by encouraging the growth of new shoots, effectively rejuvenating them and extending their productive lifespan [22].
- **Seasonal Preparation:** Preparing plants for different seasons through pruning can improve their resilience and readiness for changing environmental conditions.

#### 6. Facilitating Management:

- **Ease of Harvesting:** Proper pruning makes harvesting easier and more efficient by ensuring that fruits are accessible and reducing the risk of damage during the process [23].
- **Monitoring and Maintenance:** Pruned plants are easier to monitor for pests, diseases, and other issues, enabling timely intervention and maintenance [24].

### 4. PRUNING IN FRUIT CROPS

In fruit crops, pruning serves multiple purposes. It helps to shape the plant, maintain structural integrity, and ensure that sunlight penetrates the canopy to reach all parts of the plant. This is crucial for photosynthesis, which in turn affects the plant's ability to produce high-quality fruits. Additionally, pruning aids in the removal of diseased or damaged wood, which can help in preventing the spread of pathogens and pests. By directing the plant's energy towards the production of fruits rather than excessive vegetative growth, pruning also helps in improving the size, flavour, and overall quality of the fruit [25].

The practice of pruning is both an art and a science. It requires a deep understanding of the biological mechanisms that govern plant growth, as well as an aesthetic sense to shape the plants in a way that maximizes their productivity and beauty. This article will delve into the various aspects of pruning in fruit crops, from the scientific basis of the practice to specific techniques for different types of fruit plants. We will explore the tools and equipment needed, best practices to follow, common challenges faced by growers, and future trends in the field [26]. By the end of this comprehensive guide, readers will have a thorough understanding of the importance of pruning in fruit crop management and how to implement effective pruning strategies in their own orchards [27].

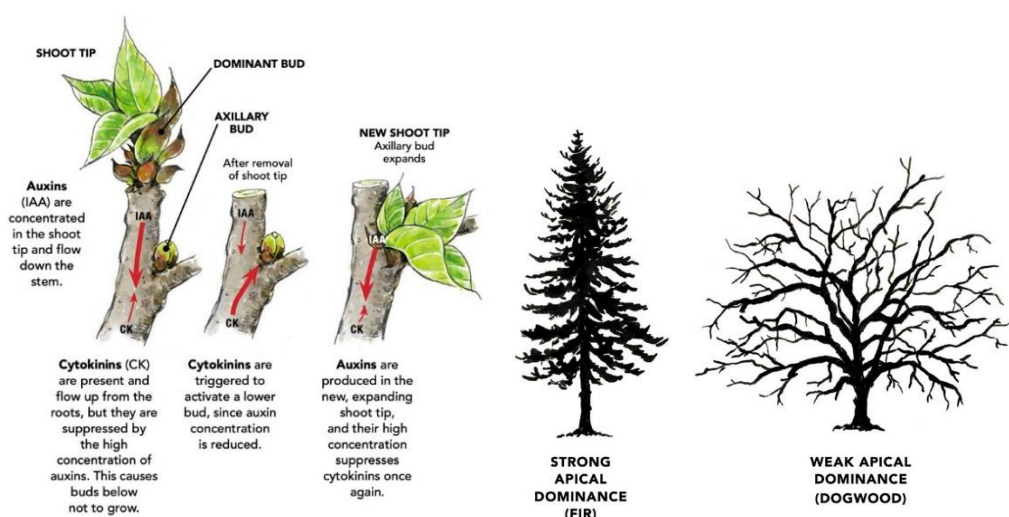


Fig. 3. Pruning in fruit crop

## 5. SCIENTIFIC BASIS OF PRUNING

Pruning is grounded in a deep understanding of plant physiology and the way plants respond to wounds and resource redistribution. When a part of a plant is removed, the plant undergoes a series of physiological changes that can be leveraged to improve health and productivity. One of the key aspects of this response is the hormonal changes that occur within the plant [28]. Plants produce several hormones that regulate growth and development, including auxins, cytokinins, gibberellins, and ethylene. Auxins, which are produced in the apical meristem (the growing tip of the plant), play a crucial role in apical dominance, where the main central stem of the plant is dominant over other side stems. Pruning can disrupt this dominance by removing the apical meristem, leading to the redistribution of auxins and encouraging the growth of lateral buds. This process can result in a bushier plant with more potential sites for fruit production [29].

The timing of pruning is also crucial and can have a significant impact on the plant's response. Pruning during the dormant season, typically in late winter or early spring before new growth begins, is often recommended for many fruit crops. This timing allows for the removal of dead or diseased wood without interfering with the plant's active growth phase. However, some fruit crops may benefit from summer pruning, which can help to control vigorous growth and improve light penetration to the developing fruits [30]. Resource allocation within the plant is another important consideration. By removing certain

parts of the plant, pruning can help to direct the plant's energy and nutrients towards the production of fruit rather than excessive vegetative growth. This can result in larger, higher-quality fruits and an overall more productive plant [31].

## 6. TYPES OF PRUNING

Pruning techniques can vary widely depending on the goals and the type of fruit crop. Here are some common types of pruning:

1. **Thinning:** This involves the removal of entire branches or shoots back to their point of origin. Thinning helps to reduce overcrowding, improve air circulation, and allow more light to penetrate the canopy. It is particularly useful for fruit trees that tend to develop dense, tangled growth [32].
2. **Heading:** Also known as topping or tipping, this technique involves cutting back the tips of branches to a bud or lateral branch. Heading encourages the growth of side shoots, which can lead to a fuller, bushier plant. This technique is often used to shape young trees and encourage the development of a strong, balanced structure [33].
3. **Renewal Pruning:** This technique is used to rejuvenate older plants by removing old, unproductive wood and encouraging the growth of new shoots. Renewal pruning is particularly important for berry bushes and



certain types of fruit trees that produce best on younger wood [34].

#### 4. Specialized Pruning Techniques:

- **Espalier:** This involves training fruit trees to grow flat against a wall or trellis, creating an attractive, space-saving form. Espalier requires regular pruning to maintain the desired shape and ensure good fruit production.
- **Topiary:** While more commonly associated with ornamental gardening, topiary can also be applied to fruit crops to create interesting shapes and forms. This technique requires a high level of skill and regular maintenance [35].

### 7. PRUNING TECHNIQUES FOR SPECIFIC FRUIT CROPS

Different fruit crops have unique pruning needs and techniques. Here are some guidelines for a few common types:

- **Apple Trees:** Apple trees benefit from a central leader system, where a single main stem is maintained with evenly spaced lateral branches. Annual pruning is necessary to remove dead or diseased wood, encourage air circulation, and improve light penetration. Thinning cuts are preferred over heading cuts to maintain the tree's natural shape [36].
- **Citrus Trees:** Citrus trees typically require less pruning than other fruit trees. However, it is important to remove any suckers (vigorous shoots that grow from the rootstock) and dead or crossing branches. Light pruning can help to maintain the tree's shape and improve fruit quality [37].
- **Stone Fruits (Peaches, Plums, Cherries):** Stone fruit trees often require an open-centre or vase-shaped pruning system to allow sunlight to reach the inner branches. This involves removing the central leader and encouraging the growth of several main lateral branches. Annual pruning is essential to remove old, unproductive wood and stimulate new growth [38].
- **Berry Bushes (Raspberries, Blackberries):** Berry bushes produce best on younger canes, so it is important to remove old, unproductive canes each

year. For raspberries, this involves cutting back the previous year's fruiting canes to ground level and thinning the new canes to allow for better air circulation.

- **Grapevines:** Grapevines require regular pruning to manage their vigorous growth and ensure good fruit production. There are several pruning systems used for grapevines, including the spur pruning and cane pruning methods. Both involve removing excess growth and training the vines to a trellis system [39].
- **Tropical Fruits (Mangoes, Guavas):** Tropical fruit trees may require different pruning techniques based on their growth habits. For mangoes, it is important to remove dead or diseased branches and thin out the canopy to improve light penetration. Guavas can be pruned to maintain a manageable size and encourage new growth [40].

### 8. TOOLS AND EQUIPMENT FOR PRUNING

Using the right tools is essential for effective and safe pruning. Here are some common tools and equipment used in pruning fruit crops:

- **Pruning Shears:** Also known as secateurs, these are used for making precise cuts on small branches and shoots. They come in different types, including bypass and anvil shears.
- **Loppers:** These are similar to pruning shears but have longer handles, allowing for greater leverage and the ability to cut thicker branches [41].
- **Pruning Saws:** Used for cutting larger branches, pruning saws come in various shapes and sizes. They are essential for making clean cuts on thick wood.
- **Pole Pruners:** These tools have a cutting mechanism mounted on a long pole, allowing for the pruning of high branches without the need for a ladder [42].
- **Safety Equipment:** Safety is paramount when pruning. Protective gloves, safety glasses, and sturdy footwear are essential to prevent injuries. When working with larger trees, a hard hat and harness may also be necessary [43].

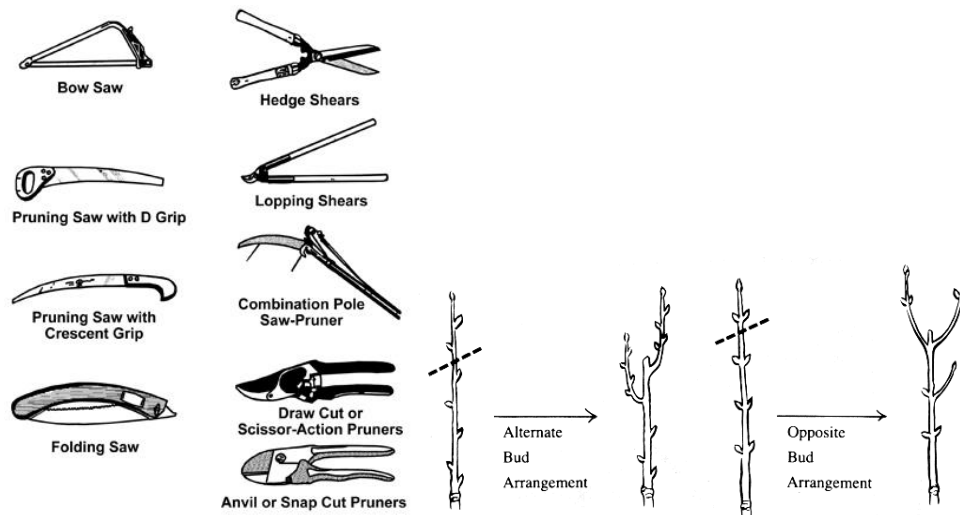


Fig. 4. Tools and Equipment for Pruning

## 9. BEST PRACTICES IN PRUNING

To achieve the best results from pruning, it is important to follow some key best practices:

- **Proper Cut Techniques:** Making clean cuts is crucial to minimize damage and promote quick healing. Cuts should be made at a slight angle just above a bud or branch junction. Avoid leaving stubs, which can become entry points for pests and diseases [44].
- **Sanitation Practices:** Keeping pruning tools clean and disinfected is important to prevent the spread of diseases. Tools should be disinfected between cuts, especially when working with diseased plants.
- **Post-Pruning Care:** After pruning, it is important to monitor the plant for any signs of stress or disease. Providing adequate water and nutrients can help the plant recover quickly. In some cases, applying a wound sealant may be beneficial, although this is generally not necessary for most fruit crops [45].

**Common Challenges and Solutions:** Pruning fruit crops can present several challenges, but with the right knowledge and techniques, these can be effectively managed:

- **Dealing with Overgrown Plants:** Overgrown plants can be challenging to prune. It is often best to approach this gradually over several seasons, removing a portion of the excess growth each year to avoid stressing the plant [46].

- **Managing Diseases and Pests:** Pruning can help manage diseases and pests by removing affected parts of the plant and improving air circulation. However, it is important to be vigilant and address any issues promptly to prevent them from spreading.
- **Correcting Poor Pruning Practices:** If a plant has been poorly pruned in the past, it may require corrective pruning to restore its health and shape. This can involve removing poorly placed cuts, encouraging new growth, and gradually reshaping the plant [47].

**Case Studies and Examples:** Successful pruning practices can vary widely depending on the region and type of fruit crop. Here are a few examples of effective pruning strategies:

- **Apple Orchards in Washington State:** Washington State is known for its high-quality apple production. Growers in this region often use a combination of thinning and heading cuts to maintain a balanced tree structure and ensure good light penetration. Regular pruning helps to produce large, flavourful apples and maintain the health of the orchards [48].
- **Citrus Groves in Florida:** Citrus growers in Florida face unique challenges, including the threat of citrus greening disease. Pruning plays a crucial role in managing this disease by removing infected branches and promoting healthy growth. By maintaining an open canopy, growers can improve air circulation and reduce the risk of fungal infections [49].

**Table 1. Effects of pruning on various fruit crops with specific examples [97,98,99,100,101,102]**

<b>Fruit Crop</b>	<b>Pruning Effect</b>	<b>Examples</b>
Apple	Enhances air circulation, light penetration, and reduces disease risk.	Regularly pruned apple trees produce larger and better-quality fruits.
Peach	Encourages new growth and helps maintain tree shape and size.	Annual pruning results in better fruit size and quality.
Grape	Increases fruit size, improves air circulation, and prevents disease.	Proper pruning of grapevines leads to higher yield and better-quality grapes.
Cherry	Controls tree size, improves sunlight exposure, and reduces disease.	Pruning cherries helps produce larger and more uniform fruits.
Citrus (e.g., Orange)	Improves light penetration and air circulation, and removes diseased branches.	Pruned citrus trees have higher fruit quality and reduced pest issues.
Blueberry	Encourages new growth and improves fruit production.	Regular pruning results in larger and more abundant blueberries.
Pear	Enhances light penetration and air flow, reducing disease incidence.	Properly pruned pear trees produce more consistent and higher-quality fruit.
Plum	Controls tree size and shape, encourages new growth.	Annual pruning of plum trees results in better fruit size and quality.
Kiwi	Improves light penetration and air circulation, increasing fruit quality.	Pruning kiwifruit vines enhances fruit size and overall yield.
Mango	Controls tree height and spread, improves sunlight exposure and fruit quality.	Pruned mango trees produce more uniform and better-quality fruits.

- **Vineyards in California:** California's vineyards are renowned for their high-quality grapes. Pruning is essential for managing the vigorous growth of grapevines and ensuring good fruit production. Techniques such as spur pruning and cane pruning are commonly used to balance the growth and fruiting of the vines [50].

**Pruning in vegetable crops:** Pruning vegetables involves the selective removal of certain parts of the plant, such as leaves, shoots, or stems, to improve health, yield, and quality. By understanding the specific needs of different vegetable crops, gardeners can enhance growth, prevent diseases, and maximize production [50].

**Types of Pruning:**

1. **Topping:** Removing the growing tip of the plant to encourage bushier growth and more lateral branches.
2. **Thinning:** Removing excess shoots, leaves, or fruits to reduce competition and improve air circulation.
3. **Sucker Removal:** Commonly done in tomatoes, where side shoots or "suckers" are removed to focus energy on fruit production [51].

**10. PRUNING TECHNIQUES FOR SPECIFIC VEGETABLE CROPS**

**Tomatoes:** Tomatoes are one of the most commonly pruned vegetable crops. Pruning tomatoes involves removing suckers, which are the shoots that grow between the main stem and the leaf axils. There are two main types of pruning for tomatoes: determinate and indeterminate [52].

- **Determinate Tomatoes:** These tomatoes have a predetermined growth limit. Minimal pruning is required, mainly to remove suckers below the first flower cluster.
- **Indeterminate Tomatoes:** These continue to grow and produce fruit throughout the season. Regularly removing suckers and excess foliage helps in focusing the plant's energy on fruit production and improving air circulation [53].

**Peppers:** Pruning peppers can help in increasing fruit size and reducing disease incidence. Early in the season, pruning the first few flowers can help the plant focus on vegetative growth, leading to a more robust plant. Removing excess leaves and branches can also improve air flow and light penetration [54].



**Cucumbers:** Pruning cucumbers involves removing lower leaves and lateral shoots to improve air circulation and prevent diseases. For vine cucumbers, removing side shoots and training the main vine can improve fruit quality and make harvesting easier [55].

**Squash and Zucchini:** Pruning squash and zucchini involves removing damaged or diseased leaves and excess foliage to improve air circulation. Removing some of the larger leaves can also help in reducing the incidence of powdery mildew [56].

**Tools and Equipment for Pruning:** Using the right tools ensures clean cuts and minimizes damage to the plants. Common tools for pruning vegetables include:

- **Pruning Shears:** Essential for making precise cuts on small stems and branches.
- **Scissors:** Useful for more delicate pruning tasks, such as removing small suckers or flowers.
- **Sharp Knife:** Can be used for thicker stems or vines [57].

#### Best Practices in Pruning:

1. **Sanitation:** Always disinfect tools before and after pruning to prevent the spread of diseases.
2. **Timing:** Prune early in the day when plants are hydrated and temperatures are cooler.
3. **Techniques:** Make clean cuts just above a node or bud to promote healthy regrowth [58].

**Pruning in Flowers:** Pruning is an essential horticultural practice not only for fruit and vegetable crops but also for flowering plants. Proper pruning of flowers can promote healthier growth, enhance blooming, and extend the life of the plants. Understanding the unique requirements and growth patterns of various flowering plants is key to successful pruning [59].

**Introduction:** Pruning flowering plants involves the selective removal of parts of the plant, such as stems, leaves, or spent flowers, to improve the plant's health, shape, and flowering potential. This practice is crucial

for maintaining the vitality and aesthetics of gardens and landscapes. By employing effective pruning techniques, gardeners can ensure continuous and abundant blooms, manage plant size, and prevent disease [60].

**Scientific Basis of Pruning:** Pruning flowers is grounded in the principles of plant physiology. It influences plant hormone distribution, encourages the growth of new shoots, and removes old, diseased, or dead plant material. By strategically cutting parts of the plant, gardeners can redirect energy towards the production of flowers and overall plant health [61].

#### Types of Pruning:

1. **Deadheading:** Removing spent flowers to encourage the plant to produce more blooms. This prevents the plant from investing energy in seed production.
2. **Thinning:** Removing excess stems and branches to improve air circulation and light penetration, reducing disease risk and encouraging stronger growth [62].
3. **Shearing:** Cutting back the outer growth to maintain shape and encourage denser foliage and blooms.
4. **Rejuvenation Pruning:** Cutting back older plants to stimulate new growth and improve overall vigour [63].

## 11. PRUNING TECHNIQUES FOR SPECIFIC FLOWERING PLANTS

**Roses:** Roses benefit greatly from regular pruning. Pruning roses involves removing dead or diseased canes, cutting back to healthy outward-facing buds, and shaping the plant to improve air circulation.

- **Hybrid Tea Roses:** Prune in early spring before new growth starts. Remove dead wood and thin out the centre to create an open structure.
- **Shrub Roses:** These can be lightly pruned to maintain shape and remove any dead or crossing branches [64].

**Hydrangeas:** Pruning hydrangeas depends on the species, as some bloom on old wood and others on new wood.

- **Bigleaf and Oakleaf Hydrangeas:** Prune after flowering since they bloom on old wood. Remove spent flowers and thin out the plant to maintain shape [65].
- **Panicle and Smooth Hydrangeas:** Prune in late winter or early spring. These bloom on new wood, so cutting them back encourages robust new growth and more blooms.

**Clematis:** Clematis pruning varies depending on the flowering group:

- **Group 1 (Early Bloomers):** Prune immediately after flowering. These bloom on old wood, so only light pruning to shape is necessary [66].
- **Group 2 (Repeat Bloomers):** Prune lightly in late winter or early spring to remove dead or weak stems.
- **Group 3 (Late Bloomers):** Prune hard in late winter or early spring, cutting stems back to about 12-18 inches above the ground [67].

**Perennials:** Many perennials benefit from deadheading and rejuvenation pruning:

- **Daylilies:** Remove spent flower stalks and dead leaves to encourage continuous blooming.
- **Echinacea and Rudbeckia:** Deadhead regularly to prolong the flowering period and cut back in late fall for winter protection [68].

**Tools and Equipment for Pruning:** Using the right tools ensures effective pruning and minimizes damage to plants:

- **Pruning Shears:** For making precise cuts on small stems and branches.
- **Loppers:** For cutting thicker stems and branches [69, 70, 71].
- **Pruning Saws:** For larger branches that cannot be cut with shears or loppers.
- **Scissors:** Useful for delicate pruning tasks, such as deadheading small flowers [72].

**Table 2. Various pruning tools used in horticultural crops, along with their descriptions and typical applications [93,94,95,96]**

Tool	Description	Typical Applications
Hand Pruners (Secateurs)	Small, handheld pruning tools suitable for cutting small branches and stems.	Ideal for precise cuts on small branches, flowers, and young shoots.
Loppers	Long-handled pruners with larger blades, providing more leverage for cutting thicker branches.	Used for medium-sized branches that are too thick for hand pruners but too thin for saws.
Pruning Saws	Saws with curved or straight blades designed for cutting larger branches.	Suitable for cutting through thicker branches and limbs that cannot be cut with pruners or loppers.
Hedge Shears	Scissor-like tools with long blades designed for trimming and shaping hedges.	Ideal for maintaining and shaping hedges and shrubs.
Pole Pruners	Pruners attached to long poles, allowing for cutting branches high up in trees without a ladder.	Used for high branches that are out of reach from the ground.
Anvil Pruners	Pruners with a single cutting blade that closes against a flat surface (anvil).	Best for dry, dead wood where clean cuts are less critical.
Bypass Pruners	Pruners with two blades that pass by each other to make a clean cut.	Suitable for live, green wood as they make cleaner cuts that heal more quickly.
Electric Pruners	Battery or electric-powered pruners that reduce the manual effort required.	Useful for frequent pruning tasks, especially in larger gardens or orchards.
Tree Pruners	Combination tools with a saw and pruner, often extendable, designed for tree maintenance.	Used for a variety of tree pruning tasks, including high branches.
Pruning Knives	Specialized knives with curved blades for delicate pruning tasks.	Ideal for precise cuts and grafting in plants and trees.



**Fig. 5. Pruning techniques for specific flowering plants**

## 12. APICAL DOMINANCE AND REACTION TO PRUNING

It is possible for the natural pattern of shoot growth of a woody plant to play a role in determining the form and appearance of the plant. When a seed germinates and begins to expand, there is only one point of growth that occurs, and that is the apex or terminal bud [73]. When a terminal bud begins to grow after being dormant, it leaves a bud scale scar on the branch. This scar may be counted to establish the age of a limb or tree by determining the number of scars that are present. During the process of the new shoot's elongation, structures known as nodes are developed [74]. At each of these nodes, one to three lateral buds are produced. A hormone known as auxin is produced by the terminal bud, which is responsible for directing the growth of lateral buds. This hormone flows downward in the shoot (toward the center of the Earth) from the apex of the shoot, and it limits the growth and development of lateral buds. Apical dominance is the term used to describe this phenomena [75]. When it comes to apical dominance, the degree of intensity differs from one type of plant to another. There are certain plants that do not produce their lateral buds until the second growing season, while there are other plants that develop both their lateral shoots and their terminal buds during the first growing season at the same time. Not only does apical dominance affect the quantity of shoot-forming lateral buds and the lengths of the lateral shoots that are developed, but it also affects the angle at which the shoots emerge from the main limb [76]. By having an effect on apical dominance, the position of the limbs along the main branch has a significant impact on the development of the plant. Apical dominance is most pronounced in shoots or limbs that are situated vertically or

uprightly [77]. When it comes to vertical limbs, rapid shoot growth takes place close to the terminal bud, whereas the number of lateral shoots decreases as the distance from the apex increases. Additionally, apical dominance is completely lost on horizontal limbs, and the lateral buds that are located on the top side of horizontal limbs grow into robust, upright shoots that are referred to as water sprouts [78]. By temporarily destroying apical dominance and stimulating the development of lateral buds into shoots, pruning is a revitalizing activity that may be used to rejuvenate a plant [79]. A flush of growth, also known as regrowth, occurs as a result of pruning, which decreases the size of the area of the plant that comes above ground in comparison to the root system. When the pruning is more severe, the regrowth that is produced is also more significant [80]. Generally speaking, pruning often encourages regrowth in the vicinity of the cut, with robust sprout development typically happening within six to eight inches of the pruning cut. The regrowth that occurs on limbs that are angled at an angle of 45 to 60 degrees from the vertical will originate further away from the incision [81]. An increase in the amount of light that is able to enter the canopy of the plant is one of the ways that pruning might indirectly encourage the growth of lateral shoots [82].

## 13. CHALLENGES IN PRUNING HORTICULTURAL CROPS

### 1. Lack of Knowledge and Training

Pruning requires specific knowledge about plant physiology, growth patterns, and appropriate techniques for different crops. Many gardeners and farmers may lack the necessary training, leading to improper pruning that can harm plants [83].

**Solution:** Providing educational resources and training programs can equip growers with the knowledge needed for effective pruning. Extension services and workshops can also be valuable.

## 2. Timing Issues

Pruning at the wrong time can disrupt the growth cycle of plants, leading to reduced yields and poor plant health. Different crops have specific periods when pruning is most beneficial, and missing these windows can cause problems [84].

**Solution:** Developing and adhering to a pruning schedule based on the specific needs of each crop can help ensure that pruning is done at the optimal time. Calendar reminders and consultations with horticultural experts can also assist in this regard [85].

## 3. Over-Pruning or Under-Pruning

Striking the right balance in the amount of pruning is crucial. Over-pruning can stress plants and reduce their ability to photosynthesize, while under-pruning can lead to overcrowding, poor air circulation, and increased disease susceptibility [86].

**Solution:** Implementing guidelines that specify the extent of pruning needed for different crops can prevent over-pruning or under-pruning. Regular monitoring and adjustments based on plant response are also important [87].

## 4. Disease and Pest Spread

Pruning can inadvertently spread diseases and pests if tools are not properly sanitized between cuts. This can lead to widespread infection and significant crop loss.

**Solution:** Establishing strict sanitation protocols, including disinfecting tools between cuts and pruning infected plants last, can minimize the risk of disease and pest spread. Using appropriate disinfectants and tools designed for easy cleaning is also beneficial [88].

## 5. Labour Intensity and Cost

Pruning is labour-intensive and can be costly, especially for large-scale operations. The need for skilled labour and the time required for proper pruning can strain resources.

**Solution:** Investing in mechanized pruning equipment can reduce labour costs and increase

efficiency. Additionally, training workers to be proficient in pruning techniques can improve productivity and reduce the overall labour required [89].

## 6. Climate and Environmental Factors

Weather conditions and environmental factors can impact the timing and effectiveness of pruning. For instance, wet conditions can increase the risk of disease spread, while extreme temperatures can stress plants.

**Solution:** Monitoring weather forecasts and adjusting pruning schedules accordingly can help mitigate the impact of adverse conditions. Using protective measures, such as pruning in the early morning or late afternoon during hot weather, can also be beneficial [90].

## 7. Plant-Specific Challenges

Different horticultural crops have unique pruning requirements, and a one-size-fits-all approach is not effective. Understanding the specific needs of each crop and adapting pruning practices accordingly is essential.

**Solution:** Developing crop-specific pruning guides and maintaining detailed records of past pruning practices and their outcomes can help tailor pruning strategies to the needs of each plant species [91].

## 8. Aesthetic Considerations

In ornamental horticulture, pruning is not only about plant health but also about achieving a desired aesthetic form. Balancing these two objectives can be challenging.

**Solution:** Combining knowledge of plant physiology with design principles can help achieve both health and aesthetic goals. Consulting with landscape designers and horticulturists can provide valuable insights [92].

## 14. CONCLUSION

The art and science of pruning in horticulture encapsulate a vital practice that enhances plant health, productivity, and aesthetic appeal. Rooted in plant physiology and requiring a nuanced understanding of each species' needs, pruning involves the selective removal of plant parts to direct energy, promote growth, and manage size and shape. Challenges such as

timing, disease spread, labour intensity, and climate impact necessitate informed and precise techniques. Proper training, adherence to best practices, and the use of sanitized tools are essential to mitigate these issues. Advances in technology, such as mechanized pruning equipment and precision tools, offer promising solutions to increase efficiency and reduce labour costs. Sustainable pruning practices and adaptive strategies in response to climate change are also becoming increasingly important. By mastering these principles, gardeners and farmers can ensure healthier, more productive plants, leading to vibrant, thriving gardens and landscapes. As horticulture continues to progress, integrating innovative methods and maintaining a balance between science and art in pruning will be key to fostering robust plant growth and achieving long-term success in crop management.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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