# *Nicotiana tabacum* L.

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Agricultural Science

# Table of Contents

# Chapter 1. Introduction

*Nicotiana tabacum,* commonly known as cultivated tobacco, is one of the most economically significant non food crops in the world. Native to South America, particularly regions corresponding to present day Bolivia and northern Argentina, Nicotiana *tabacum* has undergone extensive domestication and global dissemination since its early cultivation by Indigenous peoples.

Historically, tobacco held deep cultural, medicinal and ceremonial importance among indigenous societies in the Americas long before European contact. Today, it is cultivated in more than 120 countries, adapting to a wide range of climates, although it performs best in warm, frost free environments with well drained soils.

Despite its economic importance, tobacco production is also associated with significant social and health considerations due to the widespread consumption of nicotine containing products. The dial nature being both a valuable agricultural commodity and a source of public health concern makes *Nicotiana tabacum* a particularly relevant subject of study in modern agricultural science.

This monograph seeks to explore the agroecology, biology, propagation, management, and global significance of *Nicotiana tabacum.* By analyzing its ecological requirements, physiological characteristics, and role in global markets, this work seeks to provide a comprehensive understanding of the plant and its importance in both agricultural systems and human society.

# Chapter 2. Agroecology

## 2.1 Taxonomy

As seen in Table 1 below, ***Nicotiana tabacum*** is a member of the **Plant** kingdom, which means it is a multicellular, photosynthetic, eukaryotic organism. This means it uses photosynthesis to produce its own food using sunlight.

**Table 1**
Taxonomy of Tobacco (USDA, 2025)

| **TAXONOMIC RANK** | **TAXONOMIC NAME (AUTHORITY)** |
|---|---|
| Kingdom | *Plantae* |
| Subkingdom | *Tracheobionta* |
| Superdivision | *Spermatophyta* |
| Class | *Magnoliopsida* |
| Subclass | *Asteridae* |
| Phylum | *Tracheophyta* |
| Family | *Solanaceae* |
| Order | *Solanales* |
| Genus | *Nicotiana L.* |
| Species | *Nicotiana tabacum* |

Sundberg (2023) explains it is in the **subkingdom Tracheobionta** because it is a vascular plant with specialized tissues like the xylem, which transports water, and the phloem, which works for distributing glucose produced in photosynthesis. This allows it to develop its stem, roots, and leaves.

*Nicotiana tabacum* is part of the **Spermatophyta superdivision** since it reproduces through seeds, not spores. The main characteristic of members of the **spermatophyta** superdivision is the presence of ovules that develop into seeds after fertilization.

The **Magnoliopsida class** includes dicotyledonous plants, and *Nicotiana tabacum* has two cotyledons, net-like veins, and a taproot system.

*Nicotiana Tabacum* is part of the **Asteridae Subclass** because of its fused petals and the arrangement of stamens

*Nicotiana tabacum* belongs to the phylum **Magnoliophyta** because it is a flowering plant that produces seeds in fruits, a characteristic of angiosperms.

Tobacco belongs to the **family** of **Solanacae**, also known as the nightshade family, includes plants that often produce alkaloids and have similar flower structures with five fused petals.

The **Order Solanales** consists of the flowered dicot plant having flowers with petals fused into a tube and usually five stamens. Members of this group usually produce alkaloids, and tobacco is one among them producing nicotine.

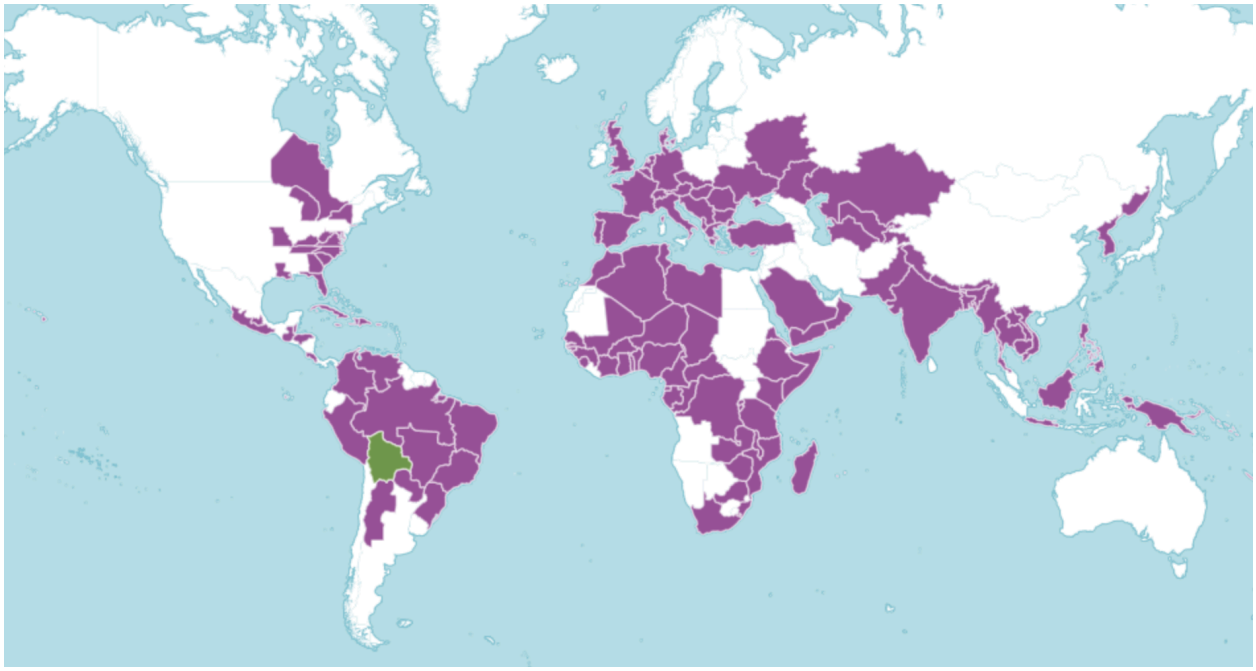
The genus **Nicotiana** includes plants known for their tubular flowers and the production of nicotine alkaloids. *Nicotiana tabacum* fits this genus because it shares these traits and similar floral structures.

The **species *Nicotiana tabacum*** is distinguished by its huge sticky leaves containing a high concentration of nicotine. It is the primary tobacco species cultivated worldwide in the production of tobacco products, (USDA, 2025).

As shown in the Map 1 below, *Nicotiana Tabacum* is native to Bolivia, and has been introduced to most of northern South America, some parts of North America, Europe, Asia, and some of northern Africa. (Royal Botanic Gardens, Kew, 2025).

**Map 1**

Distribution of *Nicotiana tabacum* (Royal Botanic Gardens, Kew, 2025)



*Tobacco* (*Nicotiana tabacum*) grows best in warm, frost-free climates with a growing season of about 90 to 120 days. It prefers average daily temperatures between 20°C and 30°C and needs a dry period for the leaves to ripen properly. Too much rain makes the leaves thin and light, which lowers their quality (FAO n.d.)

Light, sandy, well-drained soils with a pH of 5 to 6.5 that are slightly acidic are ideal for growing the crop. Waterlogging can harm or even kill the plants, which it cannot withstand. Tobacco is typically planted in seedbeds, and after 40 to 60 days, the young plants are transplanted. Grain rotation using crops like sorghum or maize keeps the soil healthy and helps keep pests away (FAO, n.d.)

*Tobacco* needs 400-600 mm of water while it's growing. Moderate water stress done scarcely can make it stronger and improve growth. Excessive irrigation or a lot of rain can reduce leaf quality. If done correctly, farmers can produce 2 to 2.5 tons of cured leaves per hectare (FAO, n.d.)

## 2.2 Fossil Record

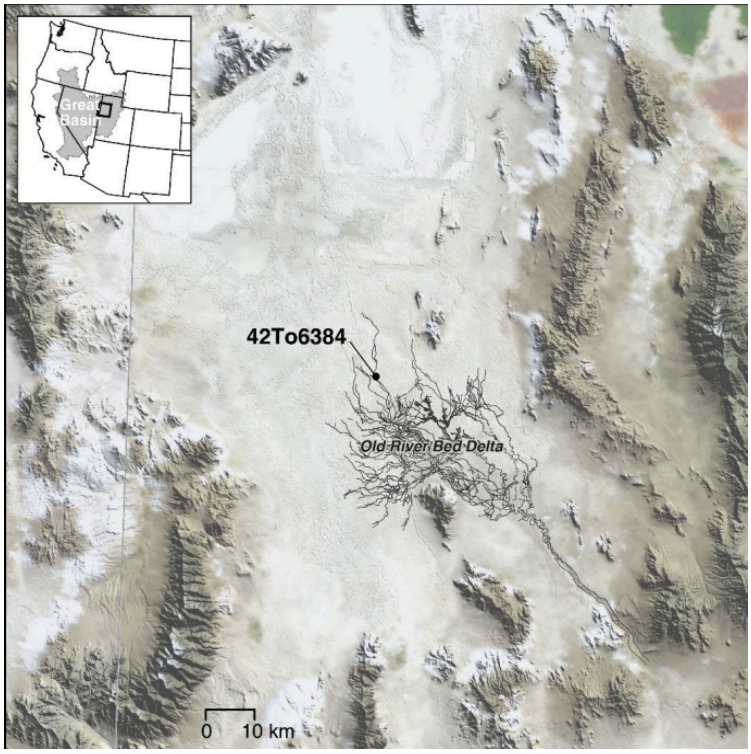
The fossil record of *Nicotiana Tabacum* is very limited because herbaceous plants don't fossilize well. The Times of Malta ("Diggers find 2.5-million-year-old tobacco," 2010) reported that fossilized tobacco leaves estimated to be about 2.5 million years old were discovered in Peru, however, this isn't commonly cited in academic journals and isn't as reliable. As seen in figure 1 below, are fossilized tobacco leaves.

**Figure 1**
A cluster of fossilised tobacco leaves (Nicotiana tabacum), presumably belonging to the Pleistocene era. Photo: Museo Paleontologico Meyer/ AFP (Times of Malta, 2010)

The earliest reliable evidence is from the Wishbone site in the Great Salk Lake of North America, dating back to around 12,300 years. "Archaeological excavations at the Wishbone site, directed at the hearth-side activities of the early inhabitants of North America's desert west, have uncovered evidence for tobacco approximately 12,300 years ago, 9,000 years earlier than previously documented" (Duke et al., 2021) Below in map 1 is the site where it was found.

**Map 2**

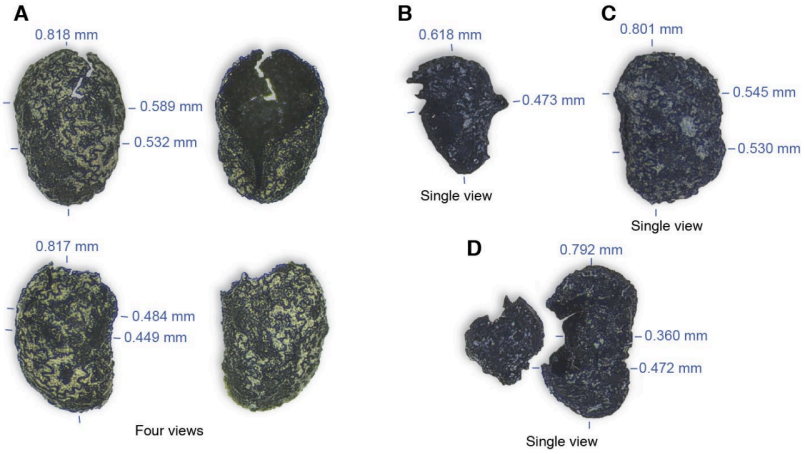
Location of 42TO6384 and important physiographic features. The ORBD channels are based on GIS mapping of extant landforms using aerial imagery (courtesy U.S. Army Dugway Proving Ground). (Duke et al., 2021)




Below in figure 2 measurements and images of the found leaves are shown.

**Figure 2**

Nicotiana seeds and measurements from the Wishbone site. (A) Specimen 1-35-98-1. (B) Specimen 1-40-98-2. (C) Specimen 1-40-98-1. (D) Specimen 2-40-98-1. (Duke et al., 2021)



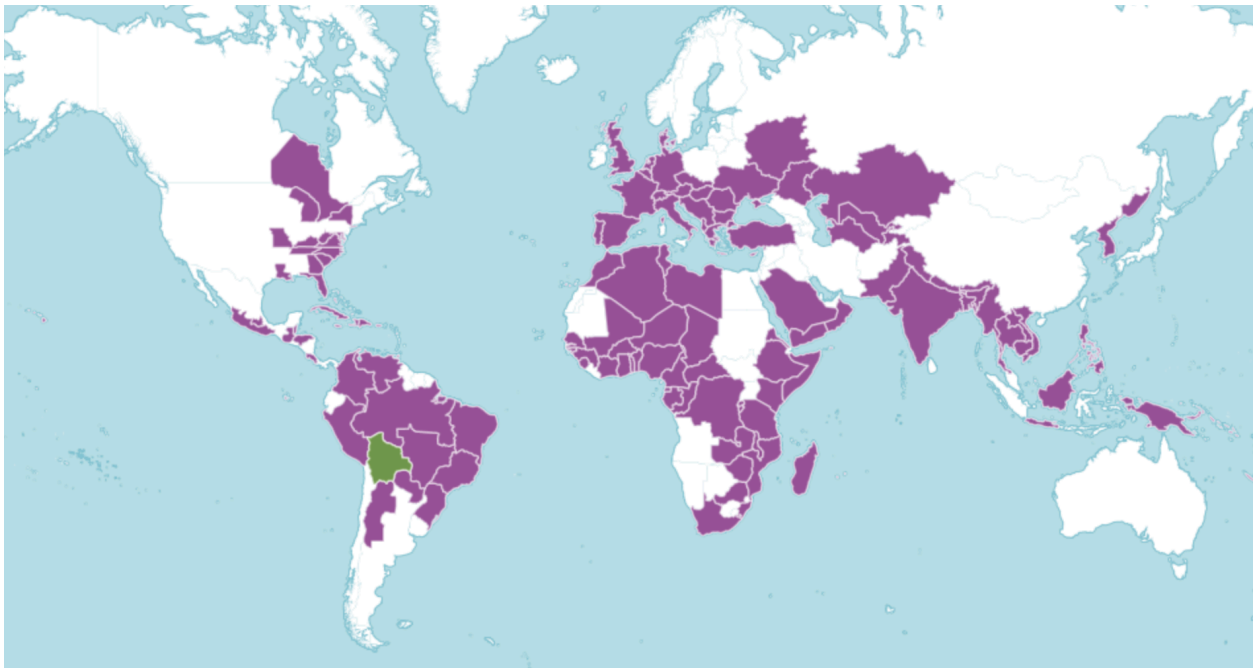
### 2.2.1 Origin of the Plant

The Nicotiana genus originated in South America according to scientific evidence which shows that its first presence occurred in Andean Mountain areas in Bolivia. Scientists have determined through genetic and evolutionary research that Nicotiana tabacum emerged from hybridization between its parent species Nicotiana sylvestris and Nicotiana tomentosiformis. The hybridization process most likely happened in the Andean area which now exists as Bolivia and northern Argentina before Indigenous people started to cultivate the plant.

Indigenous cultures from South and Central America established widespread tobacco cultivation and usage before they encountered Europeans according to both archaeological and historical evidence. European exploration into the Americas during the 15th and 16th centuries enabled tobacco to spread across Europe and Africa and Asia through international trade routes. This can be observed in Map 3 below.

**Map 3**

Distribution of *Nicotiana tabacum* (Royal Botanic Gardens, Kew, 2025)



## 2.3 Ecoregion and Climate

The cultivated tobacco plant, *Nicotiana tabacum*, grows best in warm temperate and tropical ecoregions. Although tobacco is now cultivated around the world, it originally developed in regions of Central and South America, where climates are generally warm and have moderate rainfall. These environments allowed the plant to evolve traits such as large leaves and rapid seasonal growth.

## 2.4 Climate Requirements

Tobacco grows best in climates with warm temperatures, moderate rainfall, and plenty of sunlight. Ideal growing temperatures are usually between 20 °C and 30 °C. Temperatures below about 10 °C can slow plant growth, while frost can damage or kill the plant. Because tobacco is sensitive to cold, it is generally grown during the warmer months in temperate regions.

Rainfall and water availability are also important for tobacco cultivation. The plant generally requires moderate amounts of water throughout the growing season to produce large, healthy leaves. If there is too little water, the leaves may become small and weak. However, too much water can also cause problems such as root diseases and nutrient loss in the soil. Because of this, tobacco grows best in soils that drain well but can still hold some moisture.

Soil conditions also affect how well tobacco grows. The plant prefers light to medium soils, such as sandy or loamy soils, that allow roots to grow easily and prevent water from building up around the plant. Tobacco also grows best in soils that are slightly acidic to neutral, usually with a pH between about 5.5 and 7.0. These soil conditions help the plant absorb important nutrients needed for growth.

## 2.5 Soils and geology

The performance and quality of Nicotiana tabacum depend on the physical and chemical properties of soil which get determined by the geological factors and soil development processes. Tobacco research has mainly focused on three types of soils: loamy sand and sandy loam and sandy soils which emerge from the weathering of alluvial and sedimentary parent materials that create well-drained soil profiles with good airflow and medium water retention. The light to moderate soils create a balance between porosity and moisture availability, which enables oxygen movement to the root zone while stopping extended saturation that would block root respiration and result in plant stress. Research on soil texture effects has demonstrated that tobacco cultivation in loamy sand and sandy loam soils produces different soil pH levels and plant compound adsorption patterns because texture and parent geology determine soil chemical behavior and physical characteristics. (Food and Agriculture Organization of the United Nations [FAO], n.d.)

The chemical conditions which include soil pH and nutrient availability, play a crucial role in tobacco growth because they get determined by both soil mineralogy and management techniques. Studies in tobacco rhizospheres have shown that moderately acidic soils, which is around pH 5.8–6.2 (North Carolina State University Extension, n.d.) are common under tobacco cultivation, and the interaction between soil texture and biological processes can alter soil acidity over time as nicotine and other exudates interact with soil minerals. The slightly acidic environment enables better nutrient absorption for essential minerals such as calcium and magnesium and potassium while blocking the movement of harmful substances. The process of soil formation together with geological factors determines how soils develop their texture and mineral composition and their ability to resist changes in pH. (Food and Agriculture Organization of the United Nations [FAO], n.d.)

## 2.6 Light, temperature and water

The environmental temperature patterns which occur during both daytime and seasonal periods control the growth and development of Nicotiana tabacum plants. Tobacco as an agricultural product grows best during warm seasons when the average daily temperature remains between 20 to 30 degrees Celsius. The plant experiences significant growth loss when temperatures drop below 15 °C because all plant stages of development show high frost vulnerability. Tobacco plants need continuous warm conditions for their vegetative growth and leaf development because they do not need cold dormancy for their growth cycle. Continuous exposure to temperatures above 35 °C leads to faster leaf development which results in lower leaf quality because it increases respiration rates and changes how nicotine develops.

Tobacco plants need light at two different levels because both the quantity and the quality of light affect their physiological processes. Nicotiana tabacum grows best under direct sunlight because its heliophytic nature needs strong light levels for optimal photosynthetic activity and leaf biomass growth. Full sunlight conditions create thicker leaves which produce more carbohydrates while shaded areas decrease leaf thickness together with structural density, yet controlled shading methods find use in cigar-wrapper production to achieve specific leaf texture results. The length of daylight determines when flowering occurs because tobacco plants need short-day conditions to start flowering which happens when day length becomes shorter, but many commercial cultivars have been bred for reduced photoperiod sensitivity. The process of evapotranspiration which includes both soil evaporation and plant transpiration results in water loss that interacts with light and temperature conditions. Water availability is a critical factor in the growth and leaf quality of Nicotiana tabacum. The crop typically requires between 400–600 mm of water during the growing season, supplied through rainfall or irrigation, to sustain leaf expansion and maintain physiological processes such as photosynthesis and nutrient transport (Food and Agriculture Organization of the United Nations [FAO], n.d.). Because tobacco has a relatively shallow root system, it is sensitive to both drought stress and waterlogging; insufficient moisture reduces leaf size and yield, while excessive soil water limits root aeration and increases disease risk. Effective water management must therefore balance soil moisture with adequate drainage to support optimal growth and evapotranspiration demands.

# Chapter 3. Biology

## 3.1 Chromosome Complement

*Nicotiana Tabacum* is an allotretaploid species with a chromosome number of 2n = 4x = 48, it originated through the hybridization of two diploid progenitors, which were *Nicotiana sylvestris* (2n = 24) which was its maternal donor, and *Nicotiana tomentosiformis* (2n = 24) which was its parental donor. It originated about 200,000 years ago. (Sierro et al, 2014.)

Tobacco has a big and complex genome because of its extra sets of chromosomes. This allows it to constantly adapt to different environments and produce chemical compounds like nicotine.

## 3.2 Life Cycle and Phenology

Tobacco seeds usually take about 7-14 days to germinate in 21C-27C weather. As seen in figure 3 and 4 below, the tobacco seed is made up of the outer layer, called the seed coat, protecting the seed from damage and drying out. Inside the seed is the endosperm, which stores nutrients that provide energy for the developing plant. The embryo is the young plant inside the seed and includes structures that will grow into the plant. The cotyledons act as seed leaves and help store or absorb nutrients. The shoot meristem develops into the stem and leaves, while the root meristem grows into the plant's root system. Tobacco is a plant which lives usually for just one season, with its life cycle being about 3-5 months, depending on climate. Seeds are very small and need warm temperatures, light, and moisture to germinate. The plant starts making large leaves after germination, which is the most important part for commercial production.

**Figure 3:**
Seeds of two flowering plants: tobacco (left) and Arabidopsis seeds (right). (Tepfer & Leach, 2006)

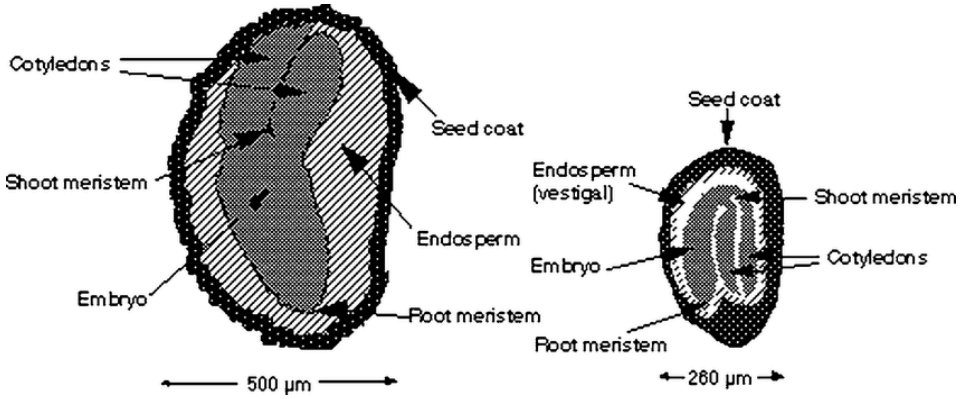
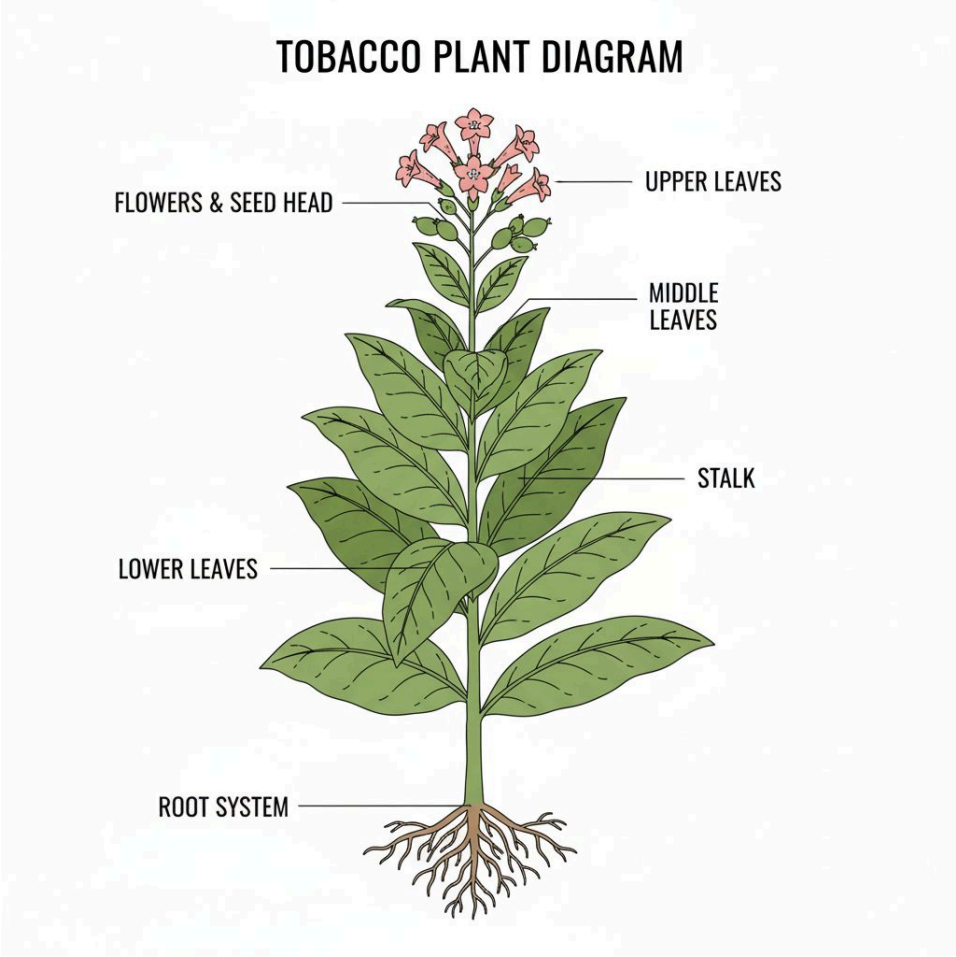



**Figure 4:**
Diagram of a Tobacco Plant (Orchid Tobacco Dubai, 2025)



## 3.3 Reproductive Biology

Tobacco flowers contain both male and female parts, so the plant can fertilize itself. This is called self-pollination. Although insects like moths can help transfer pollen, most cultivated tobacco plants reproduce on their own. This is helpful in farming because it keeps plant traits consistent. After fertilization, the flower develops into a small dry capsule that contains thousands of tiny seeds. One of the most interesting parts of the plant is nicotine production. “Nicotine is formed by a pyrrolidine and a pyridine ring in a process involving several enzymes. The pyridine ring of nicotine is derived from nicotinic acid, whereas the pyrrolidine ring originates from polyamine putrescine metabolism. After synthesis in root cortical cells, a set of transporters is known to transport nicotine upward to the aerial part and store it in leaf vacuoles. Moreover, nicotine can be metabolized in leaves, giving rise to nornicotine through the N-demethylation process.” (Fleig Zenkner et al., 2019)

## 3.4 Ecophysiology

Tobacco plants require warm temperatures together with direct sunlight for their optimal growth, it also requires strong light because it needs this energy source to perform photosynthesis. The most suitable temperature range for the process operates between 20 and 30 degrees Celsius. The plant experiences growth interruptions when temperatures fall below a specific threshold because low temperatures combined with frost conditions lead to plant death, the extreme heat conditions result in decreased quality of the leaves.

Water stands as a crucial requirement. The plant requires sufficient moisture to develop its leaves however too much water may damage it because the roots need to get oxygen from the soil. During dry periods, leave production is reduced but nicotine content increases.

# Chapter 4. Propagation and Management

## 4.1 Natural Regeneration

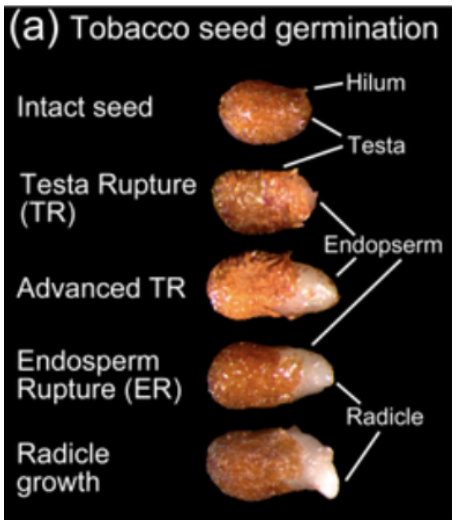
The tobacco plant, Nicotiana tabacum, naturally reproduces through seeds. After flowering and fertilization, the plant produces dry capsule fruits containing thousands of very small seeds. These seeds are easily dispersed by wind or water and can germinate when they land in warm, moist soil with sufficient light. However, natural regeneration is not commonly relied upon in agriculture because it leads to uneven plant growth and lower yields (Goodspeed, 1954).

## 4.2. Nursery Propagation

Generally, tobacco is grown with nursery propagation as the seeds are so small they cannot be buried and must be placed on the surface of wet soil. To germinate, they require warm temperatures (20–30 °C), light, and constant moisture. This is demonstrated in figure 5 below.

**Figure 5**

**Different stages of the germination process showing testa rupture (Grainge, G. et al., 2022)**



Seedlings are grown in protected environments (seedbeds or trays) to avoid the dangers of diseases or insects and also to prevent exposure to bad weather. Once they reach 8 inches in height, they are ready to be transplanted. (Urban Farmer, n.d.)

## 4.3. Planting

As stated by Cherlinka, V. (2023) “For a few weeks after transplanting, cover the seedbeds to shield young plants from harsh weather to which they are now vulnerable. Space plants 24 to 28 inches (61 to 71 cm) apart within rows, with 36 to 48 inches (91 to 122 cm) between rows. This arrangement not only facilitates the efficient use of standard tobacco cultivation equipment but also ensures adequate space for root expansion and foliar growth.” In the early growing season, plants benefit from nitrogen fertilization for leaf development, and later they require potassium fertilization.

## 4.4. Management of Pests and Diseases

Tobacco farmers struggle with a lot of pests and diseases. Some of these are tobacco hornworms, aphids, and cutworms. However, these all have treatments as shown in **Table 2** below.

**Table 2**

**Control measures for major tobacco pests and diseases (Cherlinka, V., 2023)**

| PEST/DISEASE | CAUSAL AGENT | CONTROL |
|---|---|---|
| **Tobacco hornworms** | **Manduca sexta** | **Handpicking (in small plantings); natural enemies; sucker control; insecticide applications; crop residue removal** |
| **Aphids** | **Myzus nicotianae; Aphis gossypii** | **Neem oil applications; insecticidal soap applications; natural enemies** |
| **Cutworms** | **Agrotis ipsilon** | **Soil treatments with beneficial nematodes; collars around plants; insecticide applications; weeding and crop residue removal** |
| **Blue mold** | **Peronospora tabacina** | **Growing resistant varieties; 3–4-year crop rotations; companion planting; fungicide applications; plant spacing for good air circulation; improved drainage** |
| **Black shank** | **Phytophthora nicotianae** | **Growing resistant varieties; field sanitation; 3–4-year crop rotation; soil fumigation; improved drainage** |

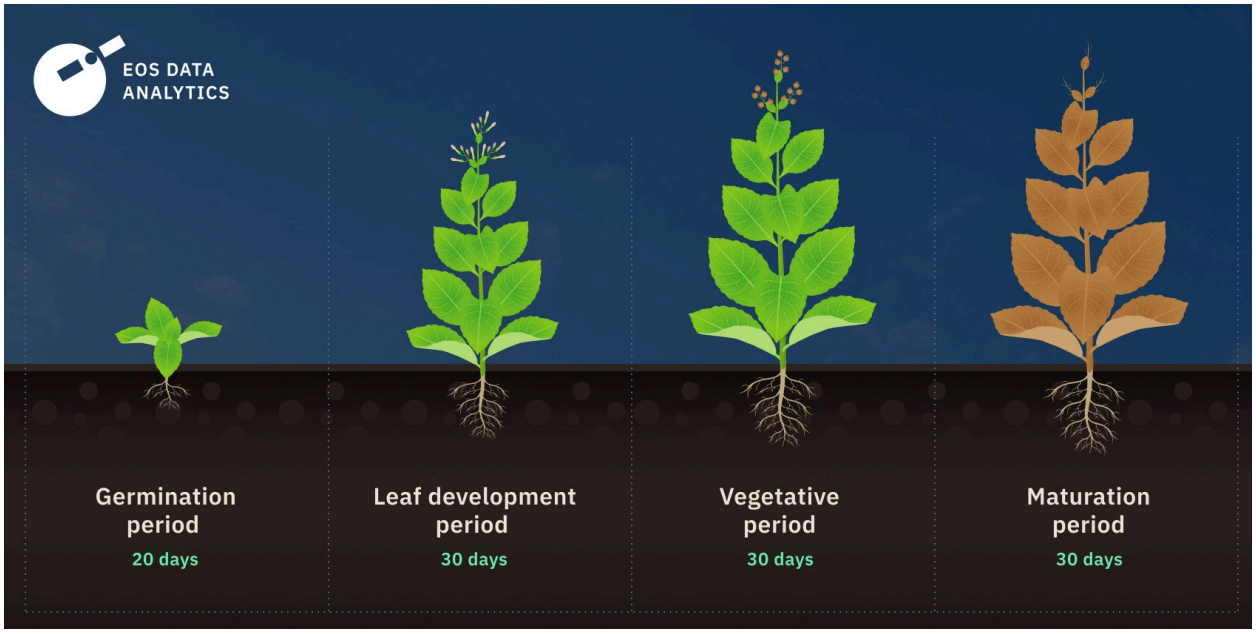
| | | |
|---|---|---|
| **Root rot** | **Pythium spp.; Fusarium spp.** | **Growing resistant varieties; fungicide applications; improved drainage; sufficient watering** |

## 4.5. Growth Stages

***Nicotiana Tabacum*** usually takes 90-130 days to grow depending on the variety. Low growing temperatures, nutrient deficiency, and moisture shortages might also delay the time it takes for the plant to fully mature. The stages of growth can be observed in **Figure 6** below.

**Figure 6**

**Tobacco's Stages of Growth (Cherlinka, V., 2023)**



## 4.6. Harvesting

Tobacco leaves are harvested when they reach maturity, which is shown by changes in color and texture. Leaves may be picked individually or the whole plant may be cut. After harvesting, the leaves are cured (dried) to improve flavor and preserve them (Cherlinka, V., 2023)

# Chapter 5. Importance, Markets and Uses of Tobacco

## 5.1 Global and Regional Importance

Tobacco is one of the world's most lucrative non-food agricultural commodities; it is produced in over 120 countries and is an important agricultural commodity for the economies of many developing countries. Over six million metric tons of tobacco are produced annually around the world, with China, India, Brazil and the United States being the top producing countries (FAO, 2025).

Tobacco provides livelihoods to millions of farmers and workers. Many developing countries have turned to tobacco as a way of generating income for smallholder farmers because of its high economic return compared to other crops that are commonly grown in these regions. An example of this would be in Colombia, where tobacco is an important component of the agricultural economy and contributes to both employment and trade within a region (FAO, 2025).

Although people are becoming more aware of the health risks associated with consuming tobacco products, tobacco continues to be a commercially viable product due to the ongoing demand for nicotine-based products from consumers and the established consumer market for these products.

## 5.2 Market Structure and Trade

The global tobacco market is highly structured and dominated by a small number of multinational corporations. CompaniesMarketCap (n.d.) states that the biggest tobacco companies by market capitalization are China National Tobacco Corporation, Philip Morris International, British American Tobacco, Altria Group, and Japan Tobacco International. These companies control a significant share of manufacturing, branding, and distribution.

## 5.3 Uses

Tobacco is rarely consumed in its raw form and undergoes extensive processing, resulting in a wide range of value-added products. The most common product is cigarettes, which account for the majority of global tobacco consumption (WHO, 2025).

Other traditional products include cigars, pipe tobacco, and smokeless tobacco such as snuff and chewing tobacco. In recent years, new technologies have led to the development of electronic cigarettes and heated tobacco products, as well as new smokeless products such as snuss, expanding the market and diversifying product offerings.

Processing significantly increases the value of raw tobacco leaves through curing, blending, manufacturing, and branding, making tobacco a highly profitable agricultural commodity despite relatively low raw material costs (FAO, 2025).

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