UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE

Tropical Fruit Production LPLK10367U

Notes taken during the course, including lectures, exercises, curriculum, and practicals

Lucas Daniel Paz Zuleta, TZS159
MSc student at the University of Copenhagen

Last compiled: 02-09-2025
Link to Git repo.: https://github.com/DanishUnicorn/dnf_dpa

Course Description

Education

MSc Programme in Agriculture
MSc Programme in Environment and Development
MSc Programme on Global Environment and Development

Content

The course focuses on developing capacities for sustainable production of tropical crops. The students will be exposed to major crop science elements that are instrumental for a sustainable crop production. Focus is on optimizing the use of agrobiodiversity and management practices considering the socio-economic characteristics and climate change challenges.

Main disciplines are:

i. Agronomy with reference to tropical conditions.
Tropical crop physiology; crop genetic resources, agrobiodiversity and breeding; crop management; crop protection; soil fertility. Cultivation of crops under challenging conditions of climate change (e.g drought, salinity).

ii. Tropical Crops
An overview of major tropical crops groups in relation to their uses (roots and tubers; legumes; minor cereals; spices; stimulants; underutilized species), their intrinsic properties and their cultivation with special emphasis on small-holder conditions and resilience for climate change.

iii. Cropping systems
Crop production optimization strategies for sustainable production (intercropping, use of legumes for mitigation/adaptation). Innovations to optimize sustainable production systems (crop: phenotyping, breeding, protection). The use of agrobiodiversity for diversification, sustainable intensification and value chain enhancement.

Learning Outcome

Provide students, having a BSc-level background in agricultural, social sciences or sciences involved with development of the tropical region, with a comprehensive understanding of the properties of selected tropical environments, crop species and their management facing climate change. Focus is on climate related production constraints; that is abiotic and biotic stresses, and human endeavor to optimize crop production in small-scale farming, within the context of poverty alleviation and sustainable crop production.

When students have completed the course, they should have attained:

Knowledge

- Manage key elements to characterize production systems in the tropics
- Demonstrate knowledge of the principles of tropical crop production
- Understand the characteristics of major tropical crops
- Demonstrate overview of tropical cropping systems in relation to agro-ecological and socio-economic conditions
- Demonstrate knowledge on different strategies to optimize production systems in the tropics
- Manage basic tools for participatory work and research

Skills

- Characterize production systems of tropical areas of the globe
- Design cropping calendars for selected major crops species
- Analyze and synthesize diverse types of information and data on tropical crop production
- Apply a relevant analytical software for statistics
- Apply relevant participatory rural appraisal methods
- Develop tropical crop production plans in relation to given agro-ecological and socioeconomic conditions
- Design and analyze the implementation of projects in a tropical crop production environment

Competences

- Data management, analysis, and critical approach
- Assess and formulate agronomic components of development support programmes
- Advice extension and research institutions in tropical countries
- Perform and interpret quantitative and qualitative statistical information to analyze scenarios of crop production and innovation
- Propose innovative optimization strategies for sustainable crop production in the tropics

Litterature

Papers and videos uploaded on Absalon
Tropical Crop Production I - Selected papers
Tropical Crop Production II – Manual for practical and theoretical exercises

Recommended Academic Qualifications

Basic courses in biology, statistics, social sciences and sciences related to sustainable development
Academic qualifications equivalent to a BSc degree is recommended.
Academic qualifications equivalent to a BSc degree is recommended .

Teaching and Learning Methods

The course applies blended learning with lectures supported by videos, digital tools, theoretical and practical exercises.

Workload

Table 1: *A table with an overview over the workload for the course.*

Category	Hours
Lectures	30
Preparation	68
Theory exercises	55
Practical exercises	24
Excursions	7
Project work	8
Guidance	10
Exam	4
Total	206

Exam

Table 2: *A table with an overview over the workload for the course.*

Credit	7.5 ECTS
Type of assessment	Oral examination, 30 min
Type of assessment details	During the course the student participate in group work in which they write a group report (approximate 10 pages). The students are individually examined in the content of the group report and are further examined in the rest of course curriculum. Examination in the report weight 35 % and examination in curriculum weight 65 %. No preparation time before the oral examination.
Examination prerequisites	Submitted and approval of the reports for theoretical and practical exercises
Aid	All aids allowed
Marking scale	7-point grading scale
Censorship form	• No external censorship • Several internal examiners
Re-exam	• As the ordinary exam. • If the student did not participate in a approved group report, an assignment is given three weeks before the exam. The student has to hand in an individual report based on the assignment (approximate 5 pages). At the oral examination the students will then be examined in the report and in the rest of the curriculum. Examination in the rapport weight 35 % and examination in curriculum weight 65 %.

Contents

1 Lecture Notes **1**
1 Lecture 01 - 02/09-2025 . . . 1
1.1 The Tropical Environment . . . 1
1.1.1 Aim . . . 1
1.2 What Determines the Climate? . . . 1
1.3 Classification: Latitudes . . . 1
1.4 Circles of Latitude and Longitude . . . 2
1.4.1 Earth's Movement and Tropical Rain Belt . . . 2
1.4.2 Earth's Orbit and Solar Energy . . . 2
1.5 The Tropics . . . 2
1.5.1 Characterize the tropics ! . . . 2
1.5.2 Precipitation . . . 2
1.6 Three Major Biomes . . . 3
1.6.1 Tropical biomes and annual precipitation (mm) . . . 3
1.7 Deforestation . . . 3
1.8 Daily Weather Cycle in the Tropical Rainforest . . . 3
1.9 Prevailing Winds . . . 3
1.9.1 Latitudinal Variation in Evapotranspiration and Precipitation . . . 3
1.10 Remember! . . . 4
1.11 Coriolis Force . . . 4
1.12 Tropical Storms . . . 4
1.12.1 Cyclones Around Australia . . . 4
1.13 Monsoons . . . 4
1.14 Southeast Asian Rainforests . . . 5
1.15 Tropical Rainforests . . . 5
1.15.1 Rainforest Burned Down in South America . . . 5
1.16 Tropical Desert . . . 5
1.16.1 Oasis with Date Palm . . . 5
1.16.2 External Resources / Ecosystem Map . . . 5
1.17 A Simple Illustration of the Major Crop Types in Relation to Climate . . . 6

2 Literature résumés **7**
1 1st Reading Material from the Curriculum . . . 7
1.1 Milk for Liquid Consumption . . . 7
1.2 Sterilized Milk . . . 8
1.2.1 Description . . . 8

1.3 Reconstituted Milk 8
1.4 Flavour 8
1.5 Nutritive Value 9
1.6 Infant Formulas 9

Chapter 1
Lecture Notes

1 Lecture 01 - 02/09-2025

1.1 The Tropical Environment

1.1.1 Aim

- Overview the most important aspects of tropical climates.
- Ability to figure out how the climate is likely to be in certain places in the tropics.
- Idea of which crop you can grow.

1.2 What Determines the Climate?

The climate is determined by several factors, including temperature and precipitation. Key aspects are the yearly average temperature and the yearly range in temperature, as some areas experience a larger difference between the highest and lowest temperatures than others. Similarly, average precipitation is important, but the yearly variation in rainfall also plays a significant role.

Core takeaway:

Climate is primarily defined by temperature and precipitation, considering both yearly averages and seasonal variations. Likely exam-relevant.

1.3 Classification: Latitudes

- Tropical zone from 0°–23.5°(between the tropics) latitude: Here, solar radiation reaches the ground nearly vertically, more water evaporates, and the air is often moist. A dense cloud cover reduces the effect of solar radiation on ground temperature.
- Subtropics from 23.5°–40°latitude: These regions receive the highest radiation in summer, have relatively thin cloud cover, and receive less moisture.
- Temperate zone from 40°–60°latitude: This zone is characterized by significantly differing seasons and day lengths, less frequent climate extremes, a more regular distribution of precipitation, and a longer vegetation period.

- Cold zone from 60°–90°latitude: The poles in this zone receive less heat through solar radiation, and day length varies the most. Vegetation is only possible during a few months and is often sparse.

Core takeaway:

Earth's climate zones are classified by latitude, each with distinct characteristics regarding solar radiation, temperature, precipitation, and vegetation periods. Likely exam-relevant.

1.4 Circles of Latitude and Longitude

1.4.1 Earth's Movement and Tropical Rain Belt

The Earth spins around its axis, akin to a top, a process known as Earth's rotation. Simultaneously, it orbits or revolves around the Sun. The tropical rain belt runs along the equator and extends to about the Tropic of Cancer (23.5°north latitude) and Tropic of Capricorn (23.5°south latitude). By approximately 30°north and south latitude, the air cools enough to sink back to the surface, creating high pressure (H) and drier conditions.

1.4.2 Earth's Orbit and Solar Energy

The Earth's revolution around the sun takes 365.24 days. At the equator, the Earth rotates at roughly 1,700 km per hour. The Earth is closest to the sun (perihelion) on January 3rd at 147 million km, moving faster at 27 km/s. It is furthest from the sun (aphelion) on July 4th at 152 million km, moving slower. Solar energy is relatively constant, approximately 400 W/m^2/year. About 300 W/m^2/year is lost as terrestrial re-radiation, leaving a surplus of 100 W/m^2 at the surface. Most of the radiation is absorbed by the Earth and warms it. Some of the outgoing infrared radiation is trapped by the Earth's atmosphere, which also contributes to warming.

Core takeaway:

Earth's rotation and revolution influence climate patterns, including the tropical rain belt, and its interaction with solar energy dictates global temperatures. Likely exam-relevant.

1.5 The Tropics

The tropics are characterized by a high input of solar radiation and high maximum temperatures, with little variation in temperature. Water supply is the most significant variable, marked by high rainfall variability and high rainfall intensity. The tropics cover 42% of the Earth's surface.

1.5.1 Characterize the tropics !

1.5.2 Precipitation

Precipitation patterns in the tropics include:

- Wet climate (between 5°and 10°of the equator).
- Wet dry climate (between 10°and 20°).
- Two wet seasons: typically 1000-2000 mm (e.g., Salvador, Abidjan).
- Two shorter rainy seasons (e.g., Nairobi).
- One long rainy season: monsoonal, 750-1500 mm (e.g., Manila).

- One short rain season: 250-750 mm (e.g., Darwin, Hyderabad).
- Dry climate (e.g., Alice Springs, Lima, Khartoum)

Core takeaway:

The tropics receive high solar radiation and experience consistent high temperatures, with water supply and significant rainfall variability being defining features across different precipitation zones. Likely exam-relevant.

1.6 Three Major Biomes

A biome is defined as a community of similar plants and animals occupying a large area. The three major biomes are Forest, Savanna, and Desert.

1.6.1 Tropical biomes and annual precipitation (mm)

Tropical biomes exhibit extremely high biodiversity, encompassing 50% of the world's terrestrial plant and animal species, despite covering only about 6% of the world's land area.

Core takeaway:

The tropics host three major biomes—Forest, Savanna, and Desert—which are critical for global biodiversity, harboring half of the world's terrestrial species in a small land area. Likely exam-relevant.

1.7 Deforestation

Before human intervention, rainforests covered 15% of the Earth's land area, but today they cover only 6%. In the last 200 years, the total area of rainforest has decreased from 1,500 million hectares to less than 800 million hectares. A third of tropical rainforests have been destroyed in just the last 50 years. Approximately 119,000 - 150,219 km^2 are lost each year, affecting the world's most spectacular ecosystems.

Core takeaway:

Deforestation has drastically reduced tropical rainforest coverage, leading to a significant loss of these vital ecosystems globally. Likely exam-relevant.

1.8 Daily Weather Cycle in the Tropical Rainforest

In the morning, the sun shines and heats up the ground, causing hot and wet air to rise. In the afternoon, dark clouds form, bringing rain and thunderstorms to the rainforest.

1.9 Prevailing Winds

1.9.1 Latitudinal Variation in Evapotranspiration and Precipitation

(figure, see slide 9)

1.10 Remember!

- Hot air weighs less than cold air.
- Hot air can contain more water than cold air.
- Air will flow from areas of high pressure towards areas with low pressure.
- Condensation of water releases energy.
- The temperature of the air drops approximately 1 degree for every 100 m, or 0.5 degrees if the air contains water.
- Objects moving in the northerly or southerly direction will be deflected clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere (Coriolis force) (see also Slide 10).

Core takeaway:

Atmospheric dynamics, driven by temperature, pressure, and the Coriolis force, dictate air movement, moisture content, and temperature changes critical for understanding weather patterns. Likely exam-relevant.

1.11 Coriolis Force

When the Earth rotates, a point close to the equator moves much faster than a point at one of the poles. This movement creates specific patterns on Earth and affects winds and ocean currents.

Core takeaway:

The Coriolis force, a result of Earth's rotation, deflects moving objects and significantly influences global wind and ocean current patterns. Likely exam-relevant.

1.12 Tropical Storms

Tropical storms include Hurricanes (in the Caribbean and United States) and Typhoons (in the Pacific Ocean). These storms are characterized by wind speeds exceeding 115 km/hour, low pressure, and a circular pattern of isobars with a diameter of 150-650 km. They bring extreme rainfall (up to 200 mm/day) and steep gradients that produce high wind speeds.

1.12.1 Cyclones Around Australia

1.13 Monsoons

Monsoons are large-scale sea breezes that occur when the temperature on land is significantly warmer or cooler than the temperature of the ocean. These temperature imbalances happen because oceans and land absorb heat in different ways.

Core takeaway:

Tropical storms like hurricanes and typhoons are intense low-pressure systems with high winds and extreme rainfall, while monsoons are seasonal wind shifts caused by differential heating of land and sea. Likely exam-relevant.

1.14 Southeast Asian Rainforests

Southeast Asian rainforests experience four different seasons: the winter northeast monsoon, the summer southwest monsoon, and two inter-monsoon seasons.

- The northeast monsoon season (November to March) has steady winds from the north or northeast, originating from Siberia, which bring typhoons and other severe weather. The east coasts of the Southeast Asian islands receive heavy rains during this time.
- The southwest monsoon season (May to September) has less wind and is slightly drier, though it still rains every day.
- During the inter-monsoon seasons, the winds are light. All seasons are hot and humid, with very little seasonal variation in temperature.

Core takeaway:

Southeast Asian rainforests experience distinct monsoon seasons driven by regional wind patterns, resulting in varied rainfall but consistently hot and humid conditions year-round. Likely exam-relevant.

1.15 Tropical Rainforests

Tropical rainforests are characterized by a type of tropical climate with no dry season, meaning all months have an average precipitation value of at least 60 mm (2.4 in). There are no distinct summer or winter seasons; it is typically hot and wet throughout the year, with both heavy and frequent rainfall. Around the equator, there are two seasons with heavy rainfall, receiving up to 10 meters a year. As one moves away from the equator, it becomes a bit drier in some months, but there is still more than 2 meters of rain annually. Most of the rainfall does not reach the ground directly, as the trees act as a canopy and catch the rain.

1.15.1 Rainforest Burned Down in South America

(image, see slide 14)

Core takeaway:

Tropical rainforests are defined by continuous high rainfall, consistent high temperatures year-round, and the significant role of their dense canopy in intercepting precipitation. Likely exam-relevant.

1.16 Tropical Desert

Major tropical desert areas include the Sahara and Kalahari deserts in Africa, Arabian, Iranian and Thar Deserts in Asia, Arizona and Mexican deserts in North America, and the Great Australian Desert.

1.16.1 Oasis with Date Palm

(image, see slide 15)

1.16.2 External Resources / Ecosystem Map

[Requires further research: This section primarily provides links to external resources (YouTube and a NOAA ecosystem map) and does not contain descriptive content within the slides themselves.]

1.17 A Simple Illustration of the Major Crop Types in Relation to Climate

[Requires further research: This slide title suggests an illustration but the content is not provided.]

Core takeaway:

Tropical deserts are extensive arid regions found across multiple continents, characterized by very low precipitation and extreme temperatures. Likely exam-relevant.

Chapter 2
Literature résumés

This section of the course notes is designed to streamline access to the key findings from each reading material (RM), providing a concise and accessible overview of essential information. Created through experimentation with various AI platforms, this chapter also serves to enhance prompt engineering skills, exploring diverse methods of note-taking for maximum efficiency and clarity. The procedures for creating these summaries have varied, but all methods share a common approach: each RM has been fully read, with summaries and notes prepared after completing each respective subsection. By using these AI-co-op'ed approaches, these notes aim to be both a reliable reference and a resource for continuous improvement in capturing complex microbiology concepts.

1 1st Reading Material from the Curriculum

1.1 Milk for Liquid Consumption

Liquid milk is treated by pasteurization or sterilization to ensure safety, extend shelf life, and retain flavour. Raw milk is considered unsafe and is restricted in many countries. Pasteurized milk retains better flavour, while sterilized milk offers longer shelf life, especially valued in cooking. Fat content is usually standardized, but low-fat and skim milks are also common. Some products are fortified or processed via ultrafiltration for consistent protein content, although this may be legally restricted. Quality attributes vary by use, and packaging is essential for hygiene [1].

Manufacture

Thermalization reduces lipase activity and psychrotrophic growth, aiding shelf life. Homogenization prevents creaming but increases lipolysis risk, requiring higher heat (e.g., 20 s at 75 °C). Low pasteurization (15 s at 72 °C) kills pathogens while preserving natural inhibitors, though heat-sensitive compounds like agglutinins and immunoglobulins are degraded in high-pasteurized milk. Packaging hygiene is crucial to prevent recontamination and preserve shelf life [1].

Shel Life

Shelf life is influenced by bacterial growth, enzymatic activity, and chemical/physical changes. Key factors include storage temperature, recontamination, and Bacillus cereus spore levels. Below 7 °C, psychrotrophs dominate spoilage. Hygiene in packaging is essential; rapid tests help detect recontamination [1].

Extended-Shelf-Life Milk

ESL milk combines long shelf life with near-fresh flavour. One method applies short-time direct UHT treatment (e.g., 2 s at 140 °C) with aseptic packaging; enzymes like plasmin may still affect taste after weeks. The second method involves microbial removal via microfiltration or bactofugation, often followed by partial UHT sterilization of retentate and cream. Aseptic packaging is essential. Cooked flavour is minimized by limiting heat to fat-rich fractions [1].

1.2 Sterilized Milk

1.2.1 Description

Sterilized milk must be microbe-free, shelf-stable at ambient temperature, and retain acceptable flavour and nutritional value. UHT sterilization (e.g., 1 s at 145 °C) minimizes browning, off-flavours, and vitamin loss. To prevent spoilage, packaging must be aseptic, and milk free from heat-resistant enzymes. Homogenization avoids creaming and coalescence. Lactulose content is used to identify UHT-treated milk [1].

Manufacture

Sterilized milk is made via in-bottle, mild in-bottle, or flow-through UHT processes. Psychrotroph enzymes (esp. from *Pseudomonas*) are heat-resistant, so raw milk must be fresh. UHT heating (>140 °C) ensures safety but risks casein aggregation, off-flavors, and vitamin loss. Aseptic homogenization and deaeration are crucial to prevent oxidized flavor. Oxygen- and light-tight packaging prolongs shelf life [1].

Shelf Life

Spoilage of in-bottle sterilized milk may result from surviving spores (e.g., *B. subtilis*, *B. stearothermophilus*) or leaky packaging. UHT milk mainly deteriorates via recontamination or residual heat-resistant enzymes, causing gelation, off-flavors, or plasmin-induced bitterness. Nonenzymatic spoilage includes oxidation, Maillard reactions, and light effects. Shelf life is tested via incubation, oxygen pressure, or ATP bioluminescence [1].

1.3 Reconstituted Milk

Reconstituted milk is made by dissolving milk powder in water; recombined milk adds anhydrous milk fat to reconstituted skim milk. It mimics whole milk but lacks natural fat globule membrane components. Filled milk uses vegetable oil instead of milk fat. Toned milk blends buffalo milk with skim milk to reduce fat content [1].

1.4 Flavour

Good flavour means a bland taste without off-flavours. Sources include microbial growth (e.g., *B. cereus*, *P. fragii*), plasmin, lipoprotein lipase, and oxidation by Cu or light. Heat causes cooked, UHT ketone, or sterilized-milk flavour, depending on thermal load. Sunlight flavour arises from methionine oxidation with riboflavin present [1].

1.5 Nutritive Value

This section addresses changes in nutritive value due to deliberate changes in composition, processing, and storage. For details on the nutritive aspects of milk components, see Subsections 2.1.2, 2.2.4, 2.3.3, 2.4.5, and Table 2.18 in the book [1].

Modification of Composition

Milk of modified composition includes low-fat, skim, or vitamin-fortified types. Filled milk uses vegetable oils, often rich in vitamins D and E, with added antioxidants. Calcium may be added as lactate or whey permeate. Lactose-free milk, produced by adding lactase after UHT treatment, has limited success due to cost and sweet taste. Functional foods and specialised products are also being developed [1].

Loss of Nutrients

Pasteurized and UHT-sterilized milk lose few nutrients, while in-bottle sterilized milk shows greater loss, especially of lysine and vitamins due to Maillard reactions. Losses mainly affect vitamin C and B vitamins (B_1, B_2, B_6, B_9, B_12). Oxygen and light accelerate degradation, with riboflavin acting as a catalyst. Packaging permeability is crucial to prevent losses [1].

1.6 Infant Formulas

Breast feeding is preferable, but when not possible, infant formulas based on cows' milk fractions are used. Unmodified cows' milk is unsuitable. Due to higher risk of microbial contamination, strict hygiene is essential during preparation and storage. Liquid formulas should be refrigerated [1].

Human Milk

Human milk differs from cows' milk in composition and varies by individual and lactation stage. It contains more essential fatty acids, cholesterol, and oligosaccharides, but less protein, casein, and minerals. It includes immunoglobulin A, lysozyme, and lactoferrin, and lacks β-lactoglobulin. Infant formulas require significant adjustment to mimic its properties [1].

Formula Composition and Manufacture

Infant formulas use skim milk and sweet whey (e.g., 1:5 ratio), often with added lactose, vegetable oils, vitamins, Fe, and Cu. Whey is partly desalted. Oligosaccharides or lactulose may be added. Manufacture involves wet mixing, pre-emulsification, pasteurization, and homogenization. Products may be UHT-sterilized, canned, or spray-dried [1].

Bibliography

[1] P. Walstra, J.T.M. Wouters, and T.J. Geurts. *Dairy Science and Technology*. 2nd ed. CRC Press, 2005. DOI: 10.1201/9781420028010. URL: https://doi-org.ep.fjernadgang.kb.dk/10.1201/9781420028010.