Starchy Staples
Roots

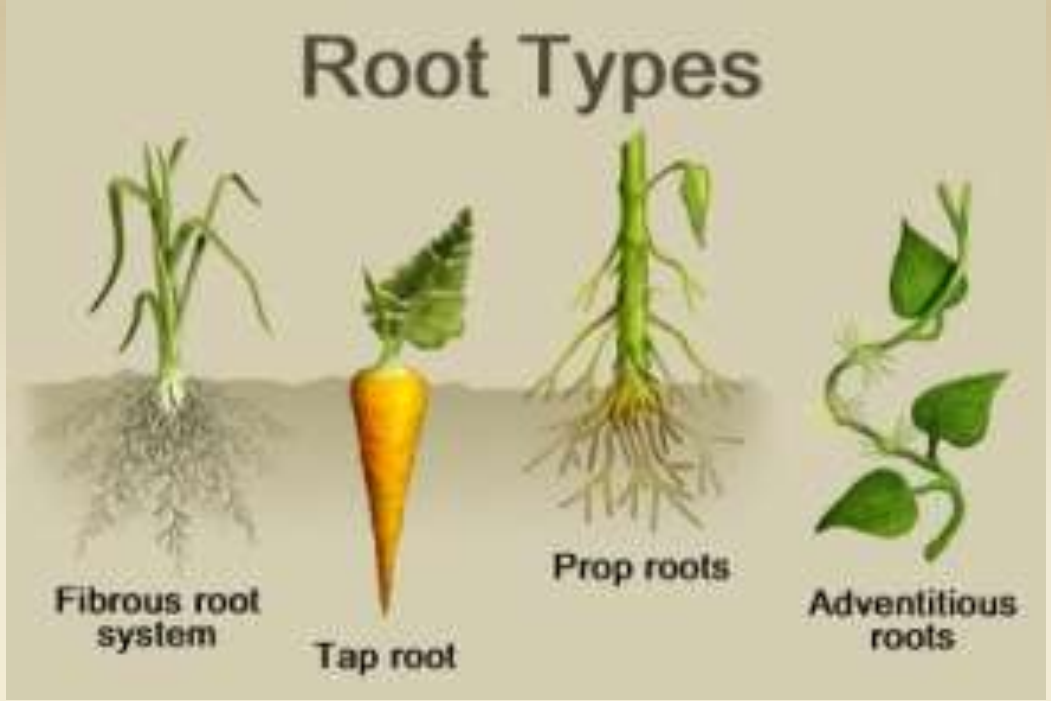
Introduction

- Root crops are underground parts of plants and include rhizomes, tubers, roots, stems, and leaves.
- Other than in the U.S., Western Europe and Japan, root crops are usually hand harvested.

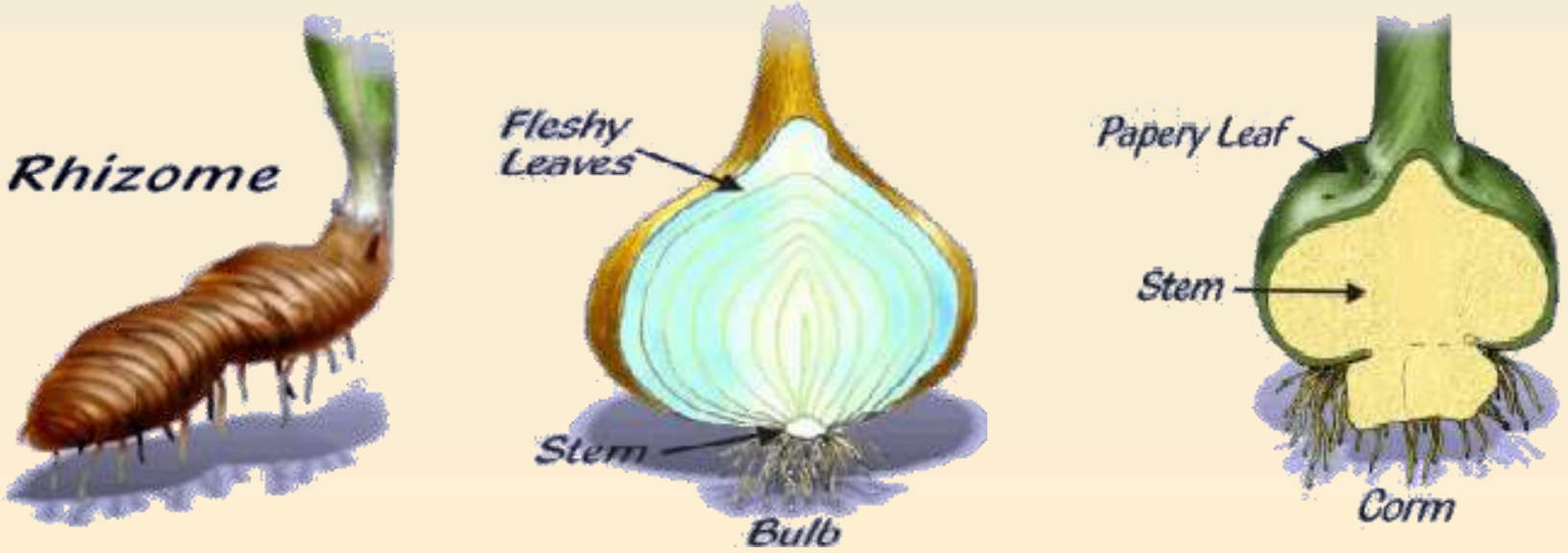
Domestication

- Very old. Possibly domesticated before seed crops. Used by most hunter-gatherer societies.
- Domestication has not affected many of them significantly. Usually larger size. Sometimes lower toxicity.

- Used in all cultures, but only major in a few: e.g., the potato in Europe and Andes, minor root crops in the Andes, and cassava in the lowland tropics.
- About as much grown in terms of tonnage as cereal grains, but much less nutritional value.
- The most important root crops are: cassava, potato and sweet potato.



Underground Stems



Plant Storage Organs

(a) Stolon

(b) Rhizome

(c) Tuber

(d) Bulb

(e) Corm

(f) Tuberous root

(g) Taproot

Figure 14.1 Modified stems and roots.

Painting by Christina Brodie, with examples counter-clockwise from top left of bulbs, corms, tubers, stolons, taproot, adventitious roots, and rhizomes

Root Storage Organs

Root crops in market in Peru

Root crops in a Peruvian market

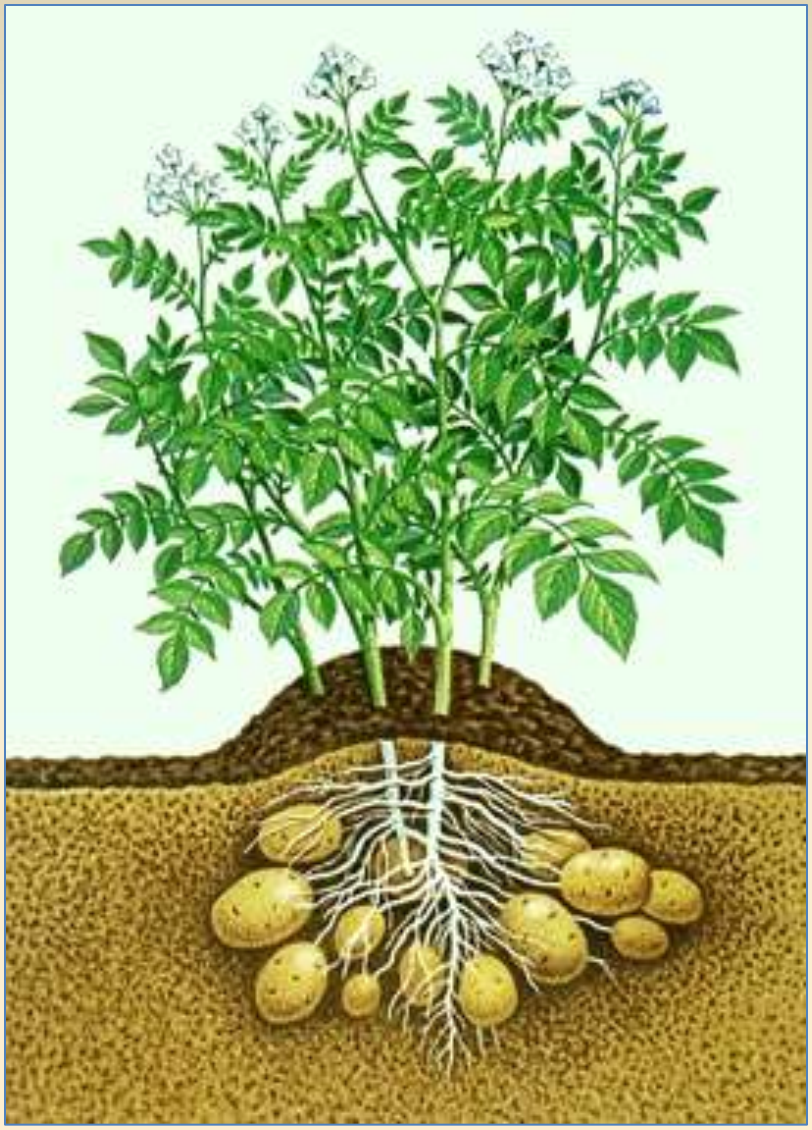
Root crops in a Philippines market

Root Crops

- Mostly water and starch.
- Shipping involves shipment of water (drying, chips, helps solve this problem).
- Little protein or fats.
- Most root crops spoil easily when harvested.
- Difficult to estimate production of many of these as they are consumed locally.
- Often reproduced vegetatively (division, cuttings).

Potato
Solanum tuberosum

Potato, *Solanum tuberosum*, Solanaceae



Potato - *Solanum tuberosum*

- Solanaceae - includes tomato, eggplant, tobacco
- Domesticated in Andean South America.
- Cultivated at least 4000 years ago.
- Potatoes will grow at elevations where few other crops can be cultivated.
- The early Spanish found potatoes from Colombia to Chile.

Potato was a staple of the Incan Empire

Incan farmers using a *chakitaqlla*
(Andean footplough)

Andean potato farmers

Potato Diversity in Andes

- Andean farmers have developed thousands of distinct varieties of potato, in a seemingly endless array of shapes, sizes and colors.
- 4,000-plus varieties of native potatoes grown in the Andean region today

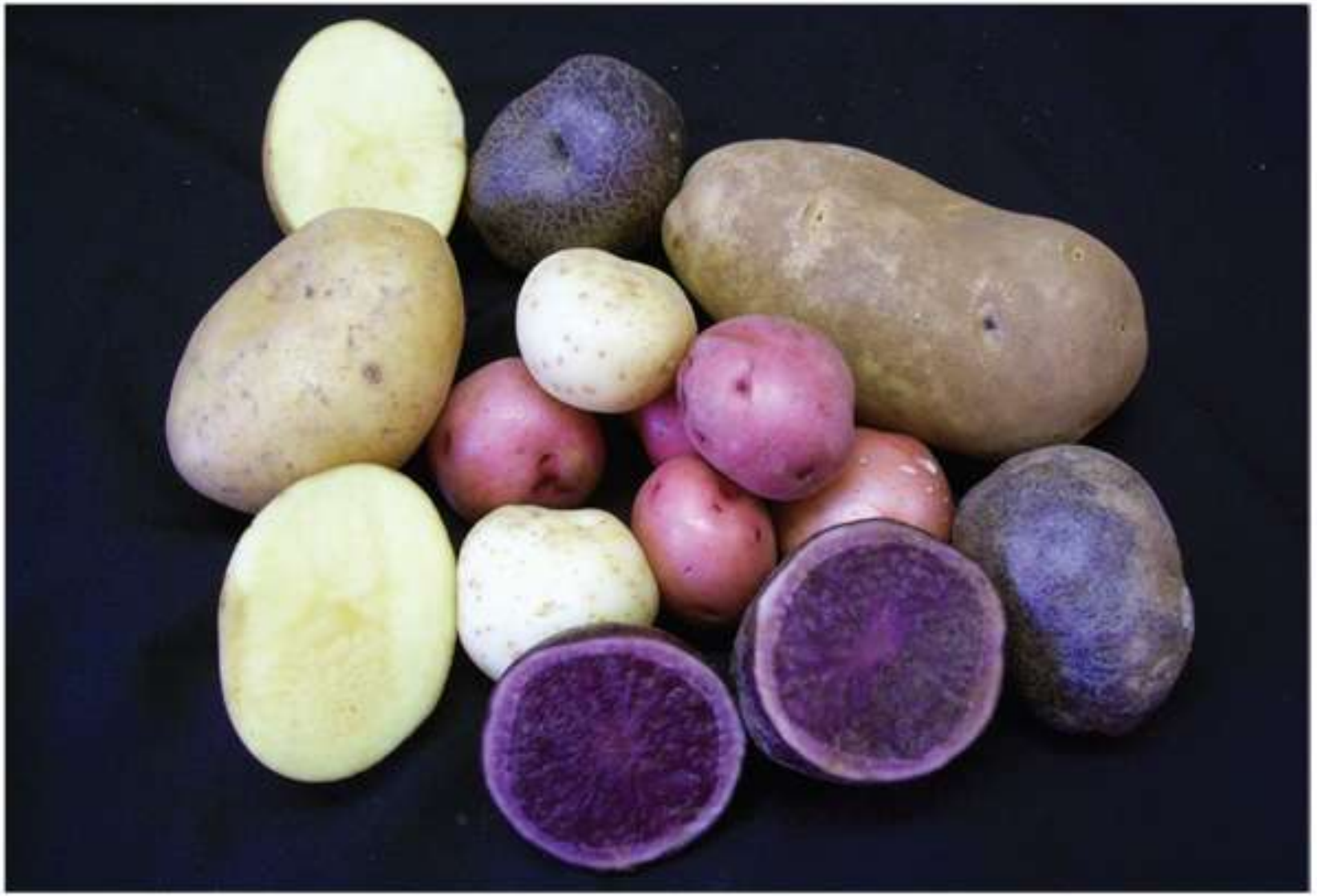


Figure 14.3 A few of the cultivars of *Solanum tuberosum*, including Yukon gold on the left and Peruvian purple in front and back.

Potatoes in Europe

- Potatoes were sent to Europe by 1570
- First considered a novelty
- Thought to be poisonous by many (green parts and fruits are poisonous!)
- Cultivated in gardens in Europe by 1600, and in Ireland by 1663
- Soon became a food staple throughout Europe, especially Ireland, where population grew rapidly.
- The climate in Ireland was particularly suited to growing potatoes. By the 1840's the Irish ate unbelievable quantities of potatoes. Men would eat 12-14 pounds per day.

The Potato Eaters – Vincent Van Gogh, 1885

Irish Potato Famine

- In 1845, the potato blight (*Phytophthora infestans*) struck and wiped out the potato crop.
- Ooomycete water mold, destroys leaves and stem. Probably originated in Mexico.
- Summer of 1845 was mild but very wet, perfect weather conditions for the blight to spread.
- Between 1846 and 1851 an estimated 1.5 million people died.
- At least another million came to the U.S.
- People began to realize the hazard of depending too heavily on one crop.
- Value of genetic diversity in crops

Potato Blight, *Phytophthora infestans* (fungus)

Healthy leaf

Blighted leaf

Potatoes damaged by blight

Irish Potato Famine

- Today potatoes are grown everywhere in upland tropical and in temperate parts of the world.
- Reproduced vegetatively. Seeds often sterile.
- In the U.S. most of crop goes into potato chips and freeze dried instant mashed potatoes.
- These processes solve much of shipping weight problem.

- **Luther Burbank** produced disease resistant Russet Burbank “Idaho” potato in 1875.

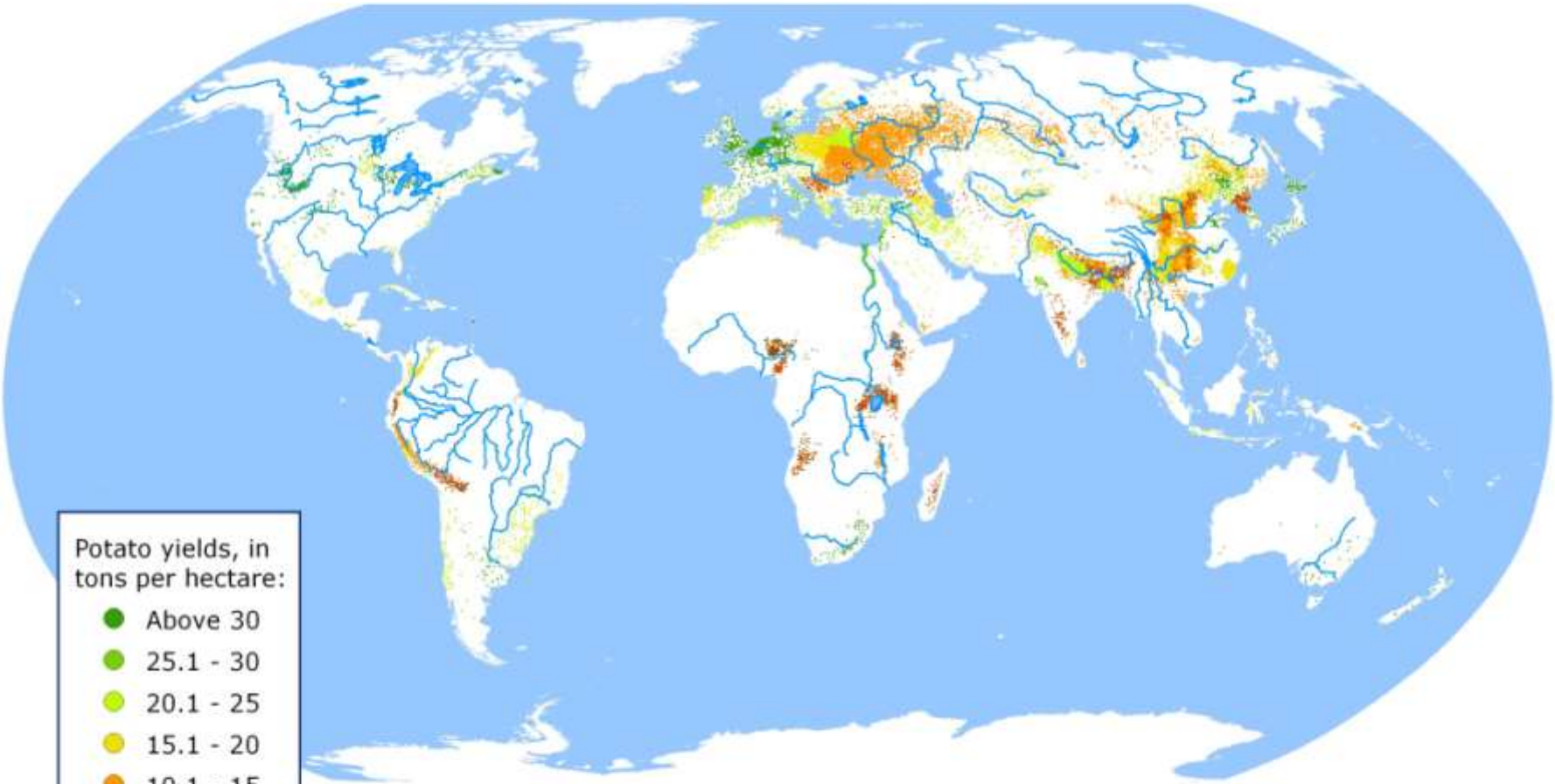
- In 2008, Idaho potato farmers planted 57 percent of their total acres with Russet Burbanks, while the variety accounted for 41 percent across the eight biggest potato-producing states.

- McDonald's buys more than 3.4 billion pounds of U.S. potatoes annually. Looking for alternative potato varieties.

- The **Yukon Gold** was first developed in Ontario in the 1960s, using yellow potatoes imported from Peru, and commercially released in the 1980s. It really took off in the 1990s, when restaurants in California recognized its appeal.

Nutrition Facts
Serving Size 1 medium (111 g)
Per Serving % Daily Value*
Calories 340
Calories from Fat 144
Total Fat 16g 25%
Saturated Fat 2.5g 12%
Polyunsaturated Fat 0g
Monounsaturated Fat 0g
Cholesterol 0mg 0%
Sodium 190mg 8%
Potassium 644mg 18%
Carbohydrates 44g 15%
Dietary Fiber 4g 16%
Sugars 0g
Protein 4g

Global Potato Cultivation



Potato Cultivation

Peru

U.S.

- Potato crop yields are determined by factors such as the crop breed, seed age and quality, crop management practices and the plant environment.

Improving Potato Yields

Despite appearances, not yet a priority for the Green Revolution

Transgenic Potatoes?

- Wild strains of potato have resistance to Blight, Colorado Potato Beetle and some viruses.
- The genes have been transferred to other potato varieties.
- Transgenic potatoes, GMOs
- There is much resistance to their release

Potato Categories – over 100 in the U.S.

[Russet Potatoes]
[Red Potatoes]
[White Potatoes]
[Yellow Potatoes]
[Purple/Blue Potatoes]
[Fingerling Potatoes]
[Petite Potatoes]

http://www.potatogoodness.com/all-about-potatoes/potato-types/

Potato YouTube Videos

Potato Biodiversity—Ensuring the Future
https://www.youtube.com/watch?v=iUSd2ju5pzE

The History of the Potato
https://www.youtube.com/watch?v=FBUN38PM76I

Irish Famine film
https://www.youtube.com/watch?v=9ks9e7GaORA

Potato Farming
https://www.youtube.com/watch?v=bTG83UdM_ZA

How to Plant, Grow, & Harvest Potatoes Organically from Start to Finish!
https://www.youtube.com/watch?v=ijWYOe5bp_o

Idaho Potato Harvest
https://www.youtube.com/watch?v=gVDFMDfxuEM

Unsustainable Monoculture Case of Potato Botany of Desire PBS

Unsustainable Monoculture_Case of Potato_Botany of Desire_PBS_2009_Part1.wmv
https://www.youtube.com/watch?v=6odEvT-YHxE

Unsustainable Monoculture_Case of Potato_Botany of Desire_PBS_2009_Part 2.wmv
https://www.youtube.com/watch?v=ZH9dMqKNSTI

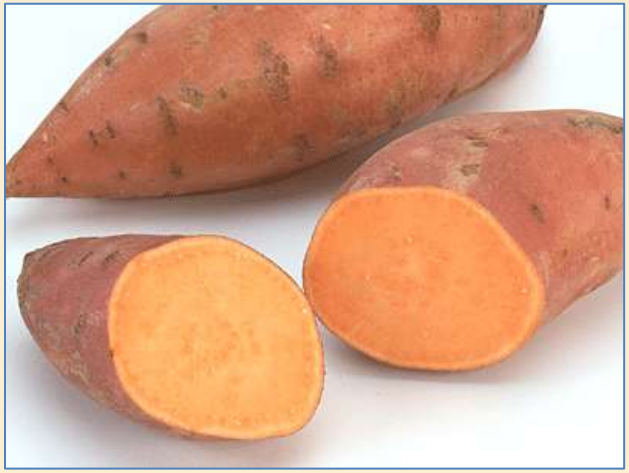
Unsustainable Monoculture_Case of Potato_Botany of Desire_PBS_2009_Part 3.wmv
https://www.youtube.com/watch?v=N1GiynGNfjk

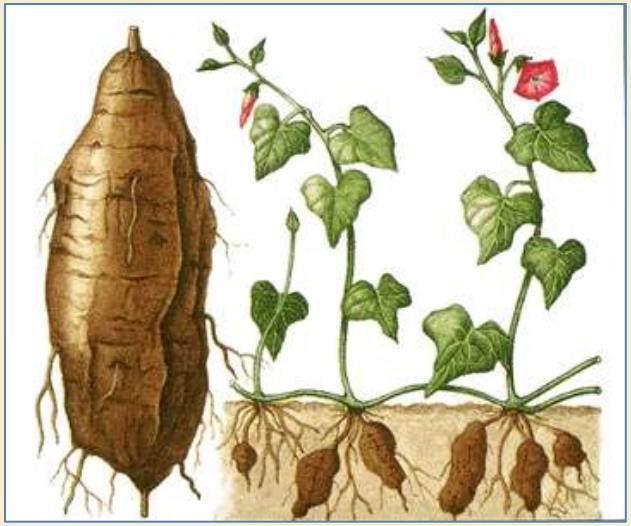
Unsustainable Monoculture_Case of Potato_Botany of Desire_PBS_2009_Part 4.wmv
https://www.youtube.com/watch?v=yMkyMGtu5vQ

The Botany of Desire - Full Length High Definition (a free PBS documentary on the evolutionary relationship between humans and plants)
https://www.youtube.com/watch?v=OIChx00z7aw

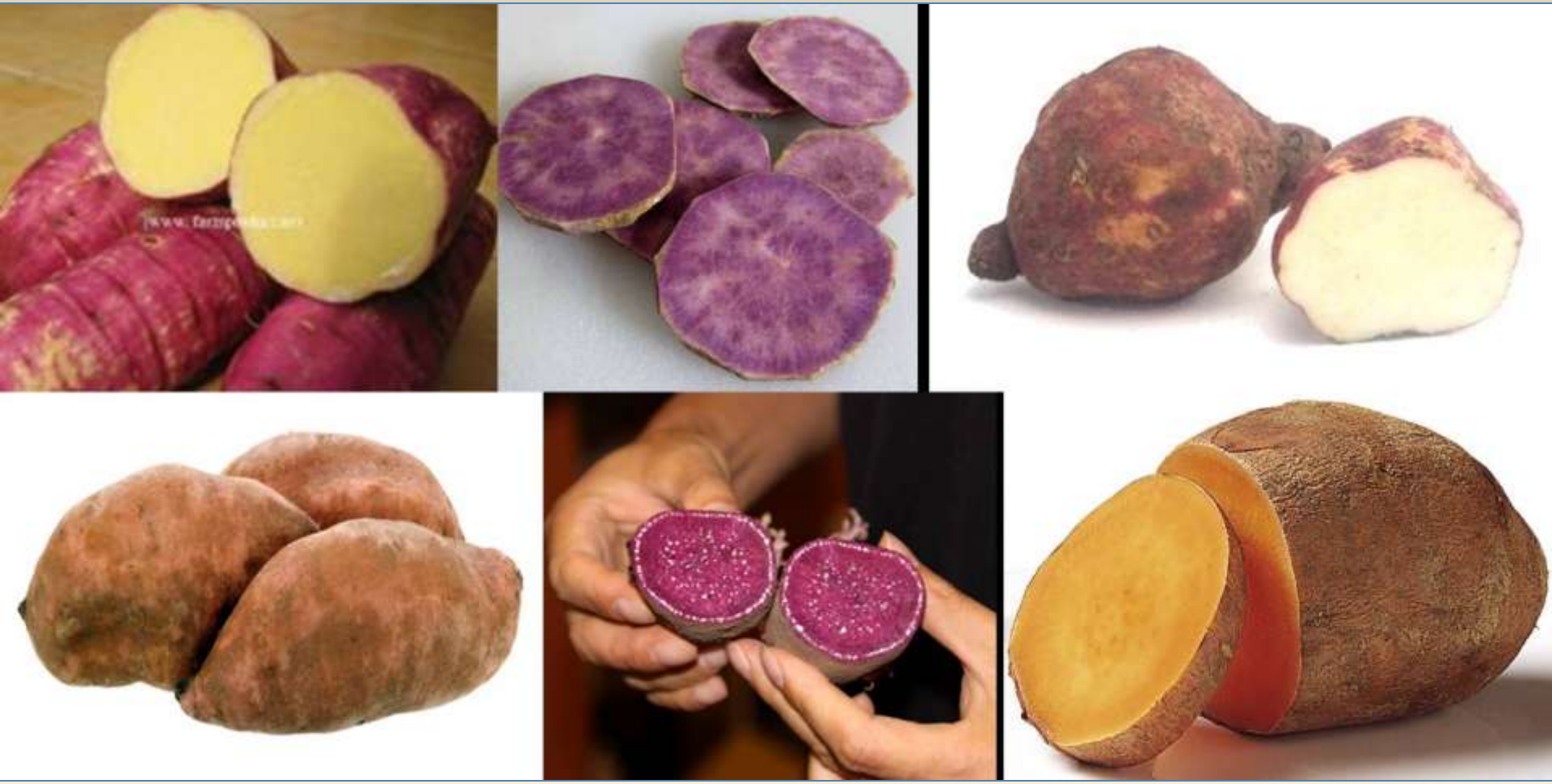
Sweet Potato - *Ipomoea batatas*

- Convolvulaceae – Morning Glory Family, vine
- A true root, a storage root
- Not related to potato (a tuber) or *Dioscorea* yams
- Important in sub-Sahara Africa, parts of Asia
- Domesticated more than 5,000 years ago in Latin America
- Lots of vitamin A





Sweet Potatoes



Sweet potatoes (*Ipomoea batatas*)

- Probably native to northwestern South America.
- Cultivated 8,000-10,000 years ago
- Taken very early to the South Pacific area and many considered them native there. Pre-Columbian Voyagers or early Portuguese sailors
- A hexaploid, wild forms are not known with certainty

- In Japan, (especially) sweet potatoes are a major crop. They are used there to prepare starch, wine and alcohol. They are also widely fed to animals.
- China is easily the world's leading producer.
- Widely eaten in the southern U.S. Not eaten particularly in Europe.

Sweet Potato Cultivation

- Plant is a perennial, but is usually grown as an annual.
- Seldom produces seed, usually propagated by vegetative means, stem cuttings or roots saved from the previous year.
- Takes from four to eight months to mature.
- Susceptible to rot diseases and to frost, and do not store well.

Sweet Potato Cultivation

Hawii

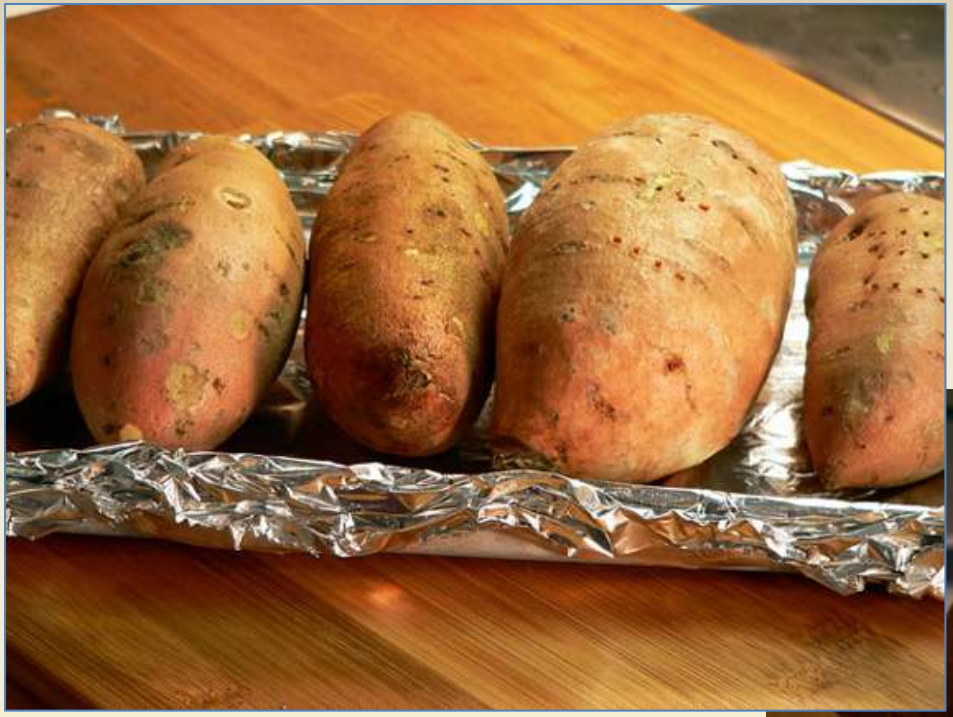
Sweet Potato Varieties North Carolina

http://www.farm-fresh-produce.com/spvarieties.html

Sweet Potato Use and Production

- Consumed in the US on a much smaller scale than potatoes with the per capita consumption now about 5.8 kg.
- Use is seasonal revolving around Thanksgiving, Christmas, and Easter.
- Preferred types are red or white skinned, cream to white flesh, non-sweet or very slightly sweet, and dry in texture.
- Purchased fresh, canned (whole or cut), as a reconstituted patty, and in baby food
- Grown mostly in the boot-heel region of Missouri
- Has potential for development, new markets

Baked Sweet Potatoes



Sweet Potato Pie

Sweet Potato Chips (and Fries)

Sweet Potato Flour

St. Louis Sweet Potato Project

http://sweetpotatoprojectstl.org/

The mission of the Sweet Potato Project is to restore economic activity in North St. Louis by creating alternative and progressive ways of producing and distributing locally grown products and to teach young men and women sustainable business and entrepreneurial skills that can change their lives.

Sweet Potato Project STL "Mission" Video
https://www.youtube.com/watch?v=a8Zyu0Xl1jg
SPP First Four Weeks
https://www.youtube.com/watch?v=ImNOI4nF_DI#t=304

Sweet Potato Project – Class of 2014

Sweet Potato YouTube Videos

The Sweet Truth about Sweet Potato Production in Louisiana
https://www.youtube.com/watch?v=EGFo3bZj_SM

Sweet Potatoes: History & Nutrition
https://www.youtube.com/watch?v=zEB0NqZD8s8

Growing Sweet Potatoes
https://www.youtube.com/watch?v=LtsC7SglFxs

Emily Marigu Ireri's Sweet Potatoes - Kiaragana Village Njeru-ri - Kenya
https://www.youtube.com/watch?v=CKI4ab8fuuI

Growing a Better Sweetpotato
https://www.youtube.com/watch?v=-ELXY_MoQbE

St. Louis Sweet Potato Project
https://www.youtube.com/watch?v=1b7D6wJ0QKA
https://www.youtube.com/watch?v=cqsFTj7pZms

Cassava

Cassava - *Manihot esculenta*

- Cassava (also known as manioc, mandioca, or yuca) is widely eaten.
- Native to central South America and has been cultivated for thousands of years.
- Sixth leading food crop, after potatoes

Cassava – roots similar to sweet potatoes, but much larger

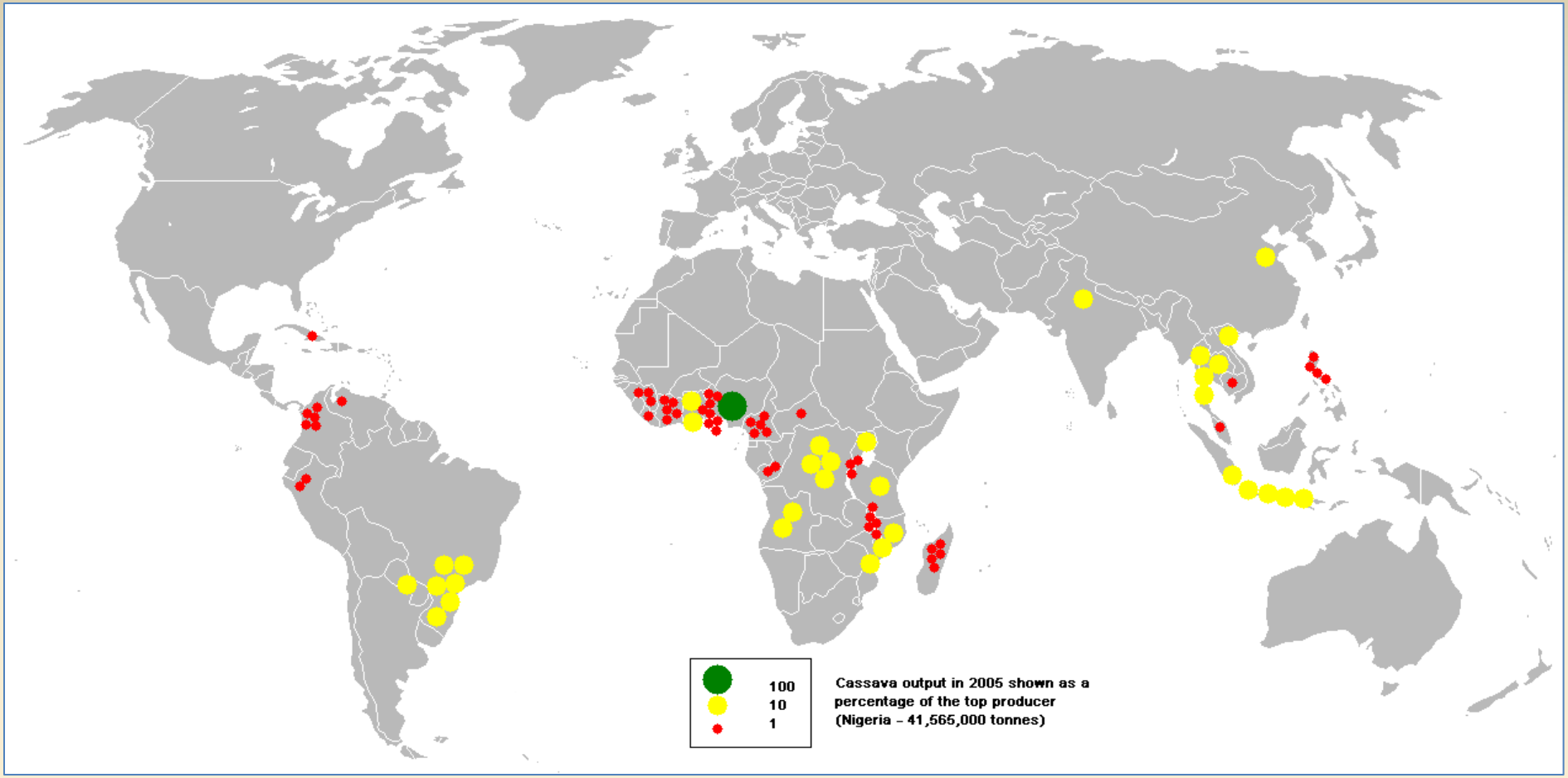
Cassava - Important for several reasons:

- Grows well in depleted soils, where rainforest vegetation has been cleared or in savanna areas.
- Roots are easy to plant, harvest, and store.
- Can be planted at different times of the year.
- Yields lots of calories, up to 20 tons of fresh roots per acre, more than any other crop.
- Not subject to many diseases.

Cassava – Yield is very high

Figure 14.6 *Manihot esculenta*, cassava. Starch reserves are stored in the large, tuberous roots visible in the photo. Courtesy CGIAR/IITA

Cassava Output



Cassava Harvest

It will keep in the ground for years. That makes it “the perfect food-security crop”

Cassava

- Drawback is that roots consist primarily of starch (30-35%), only about 1% protein.
- Cyanogenic glycosides (HCN) must be removed before consumption. Deadly bitter principal removed by boiling or squeezing
- Deteriorates rapidly after harvest (worthless after 48 hours)
- Low tech crop - no profit for large companies

Paul Anderson, Ph.D., Executive Director
Institute for International Crop Improvement

Vitamin A Fortified Cassava Traditional Cassava

Cassava YouTubes

An introduction to cassava (Guyana)
https://www.youtube.com/watch?v=aehoo13UIV4

Cassava Planting Materials - Training Video
https://www.youtube.com/watch?v=Sca4nzHXrH8

How To Remove The Poison From Cassava Flour in English
https://www.youtube.com/watch?v=09UHqc313Us

Ghana cuisine: the making of fufu
https://www.youtube.com/watch?v=vxPKGw8r0vk

Cassava Flour Processing
https://www.youtube.com/watch?v=gDyj-ZKLvEQ

Cassava Detoxification

- Peeled cassava root is grated
- Pounding releases starch grains from cells
- Boiled for a long time--this drives off the poison as a gas.
- Some African and Amazonian cultures express the poison by squeezing the roots in a "tipitipi" or by pressing and pounding grated root with heavy stones or logs.
- Soaking roots is another technique.

Squeezing grated Cassava roots in a Tapiti

Figure 14.7 In traditional preparation of cassava meal, farinha, the peeled roots are grated and the juice containing HCN is expressed through a "tapiti," a woven basket, shown here.

Cassava Uses

- Once the cassava is detoxified, the root may be eaten warm,
- Made into a paste ("fufu" in West Africa), or
- Prepared as a flour or meal ("farinha" or "gari") that can be made into bread, flat bread, biscuits, or tapioca.
- Tapioca is eaten dry or in puddings and sauces.
- This is the food of many impoverished people, who can barely afford to purchase a pound of tapioca for a few cents.
- Starch from cassava can be used for producing sugar, acetone, and alcohol

Drying tortas and tortas in market

Tapioca

- Tapioca-based desserts are popular in many countries.
- Tapioca is also sold as a thickening agent (pies) and a flour
- Considered a gluten-free food.

Yams - *Dioscorea*

- Herbaceous twining plants
- Produce large, edible **tubers**
- Monocots belonging to the family Dioscoreaceae.
- The genus *Dioscorea* includes over 600 species worldwide.
- About ten species are currently cultivated
- mostly perennial species, grown as annual crops

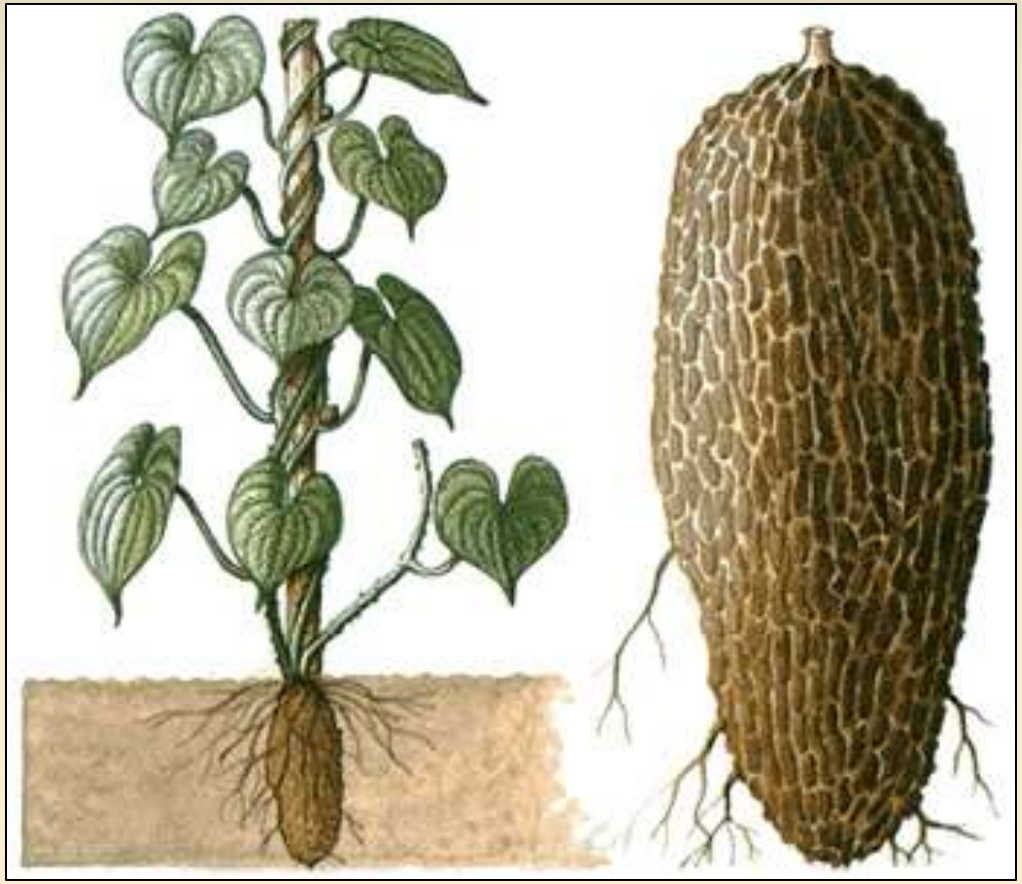
Dioscorea rotundata
Drawing courtesy IITA, Nigeria

Yams or Ñame

- Yams are *Dioscorea* species and members of the Dioscoreaceae.
- Not to be confused with the sweet potato (Convolvulaceae).
- Ignaime (French) or ñame (Spanish) ... but probably originally from an African language.
- Different species cultivated in Africa (where they were especially important), Asia, and the Americas.
- Probably tubers.

Dioscorea is a vine with a very large, white-fleshed tuber, which can grow to up to 120 pounds in weight

D. alata



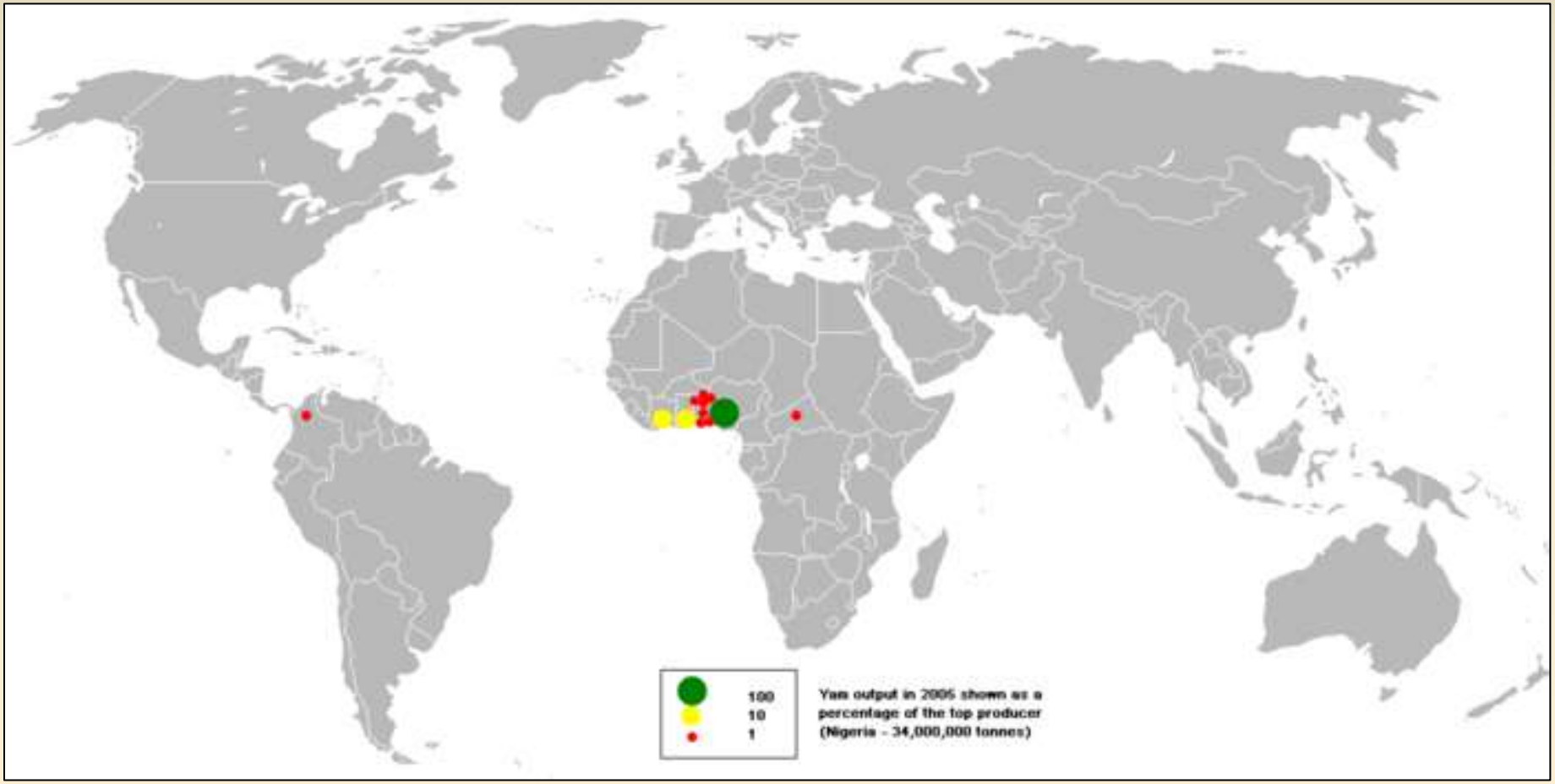
True Yams - *Dioscorea*

- More than 500 species,
- Most of them found in tropical and subtropical regions.
- Grown in deep, well-drained soil.
- Tuberous roots weigh up to 30 pounds (14 kg) and are rich in carbohydrates.
- Eaten boiled, fried, or roasted
- ground into flour.
- Some used as livestock feed, others are grown as ornamentals.
- One species yields a drug that is used in some oral contraceptives.
- The word "yam" is often used to refer to the sweet potato, a similar but unrelated plant.

True Yams - *Dioscorea*

- Reproduction asexual.
- Many are poisonous and must be peeled and/or cooked to remove toxic principles.
- Yams relatively high in protein for root crops.
- In most places where yams were formerly cultivated, they have been replaced by sweet potatoes or cassava.

Nigeria is by far the world's largest producer of yams, accounting for over 70–76 percent of the world production



Yam in Market, Nigeria

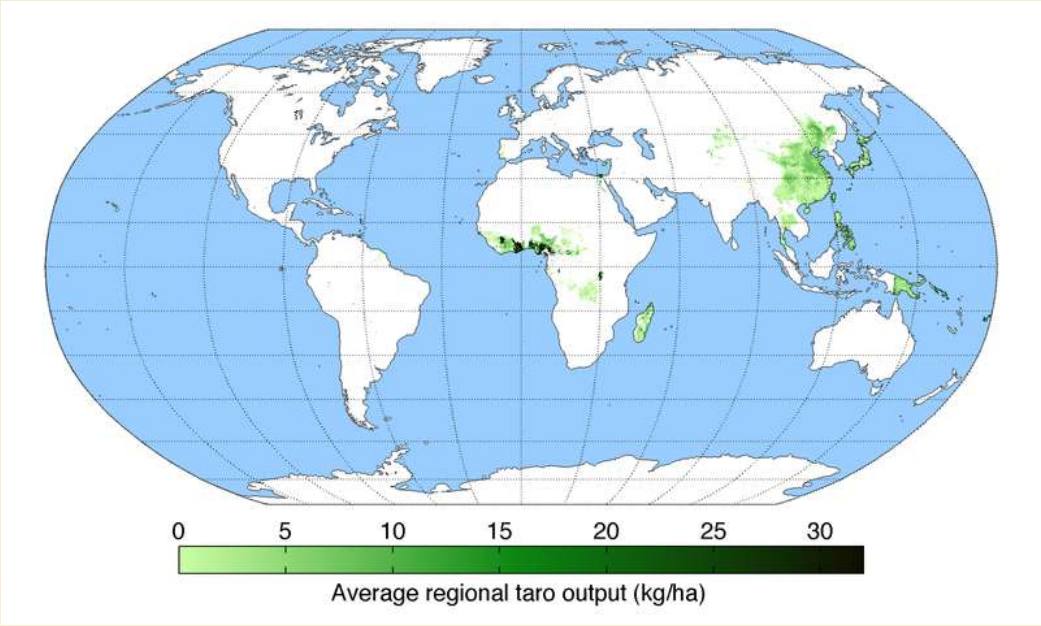
Tongan farmer showing off his prize yams

Figure 14.8 True yams, *Dioscorea* spp., are important staples in many tropical areas.

Taro – *Colocasia esculenta*

- Tropical plant produces edible underground stems. Native to tropical Asia.
- Large, heart-shaped leaves
- Grows to 7 feet (2.1 meters) in height.
- Corms - fleshy underground stems, prepared and eaten like potatoes.
- Grown extensively in the Far East and the Pacific islands, including Hawaii.

Taro – Food from a Corm



Taro and its relatives

- Araceae - members of this family domesticated as root crops in both the Old and New World.
- *Colocasia esculenta* is native to Asia.
- Corm - about 30% starch, 3% sugar. Must be boiled to be eaten.
- A staple in the Polynesian area. In Hawaii, they use taro to make poi. Hawaiians used to eat 10-20 lbs. per day.

Taro, *Calocasia esculenta*, Araceae

Cultivated taro from the Maui Nui Botanical Gardens, Hawaii.

Taro Field, Kauai, Hawaii

http://www.dreampusher.com/kauai-august2005/

Representative Mele Carroll pulling taro on Maui.

Jerusalem Artichokes

Jerusalem Artichoke
Helianthus tuberosus

- Asteraceae – sunflower family
- native to Midwest, Great Plains
- tubers, can be eaten raw in salads or cooked any way one would cook a potato
- have no starch
- the plant stores carbohydrates as inulin
- easy to grow

End