

# *Solanum tuberosum*

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## *A Monograph*

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## INTRODUCTION

*Solanum tuberosum* has not only provide humans a good source of nourishment but also has helped globally in terms of the economics and has other usage rather than just eating it and making good recipes out of it. In this monograph you will find a deep informative investigation all about potatoes. To start on, in chapter one it is clear to see the ecology part of this vegetable. In other words, it is the chapter where you will find the nature and family group where *Solanum tuberosum* are located. All its nature, classification, origin and family roots are found in this first chapter. It is precise to see the location where this crop is best grown at and the country that has the best reproduction and distribution above all in the world, which in this case we are talking about China. Also, you can find factors such as the best climate and soils in which potatoes grow best. In the same manner, in chapter two it is evident to find information about all the biological elements that potatoes posse. Its life cycle, reproduction, fruit development and seed set of the *Solanum tuberosum* are factors, which are described, in this second chapter. As chapter three is called propagation and management it is clear to find all about the natural regeneration of potatoes as well as it propagation from seeds. It is also given in a direct way how to storage and plant best the *Solanum tuberosum*. Finally, the management of pest and diseases control is known to be able to have a strong and healthy potato plant. Lastly, on chapter four, it is clear to inform yourself about the marketing of potatoes. In other words, it is precise to find information about the emerging products and protein markets, the overall picture as a world wise view of *Solanum tuberosum*, its food items based on pulp, skin and juice. At the end, you will find other ways and importances in witch potatoes have had protagonist at. Not only at the kitchen but also on medical uses, magic and ritual significance is a part of this last chapter of the *Solanum tuberosum* monograph.

## Chapter 1 Ecology

### 1.1 Ecology

#### Affinities

To locate our selves a little, potatoes are part of the nightshade *Solanum* family. Meaning the white, red, yellow and blue-skinned potato varieties that are not as common in our daily diet. However, sweet potatoes and yams are not part of this family, the nightshades. NetMidas, B. (2015) states that there are several species of potatoes around the world that are not really common at markets nowadays but they form part of this big family. Starting with the most common ones *Russet burbank* (russet potato), red potato, white potato follow by yellow potato, purple/blue potato, fingerling potato and petite potato, which they all belong to the nightshade family. Finally, in the American Continent there are about 200 species of wild potatoes but unfortunately cultivated potatoes have lost genetic variation throughout domestication.

#### 1.1.1 Origin

It begins about 8,000 years ago near Titicaca Lake. Titicaca Lake is located on the border of Peru and Bolivia, 3,800 meters above sea level in the mountain range of los Andes, South America as it is evident in the map below (Figure 1). But, mainly they are found from southwestern United States to southern Chile, with most species concentrated in Peru and Bolivia. The communities that had first settling in the south of the continent were hunters and gatherers. For this reason at least 7,000 years before, they began domesticating wild plants including potatoes since it was a tuber that around the Titicaca Lake it existed in abundance. In fact, what we know today as a “potato” it is just a very little tiny piece of its real genetics since there are approximately 151 known species of wild potato and 5,000 varieties that today farmers still keep cropping in los Andes.



Figure 1- Lake Titicaca Location

### 1.1.2 Present distribution

The total world *Solanum tuberosum* production is estimated at 364.808.768 tonnes in 2012 (FAOSTAT, 2014). The developing world's potato production exceeded that of the developed world. “China is now the biggest potato producer, and almost a third of all potatoes are harvested in China and India” (FAO, 2005), as it is evident in the map below (Figure 2). According to FAOSTAT, China is ranked as the first country producing potato out of the top 25 countries potato producing in the world. The production in China is of about, 95,987,500 tones of potato per year as it shown in the table below (Figure 3) (FAOSTAT, 2015).

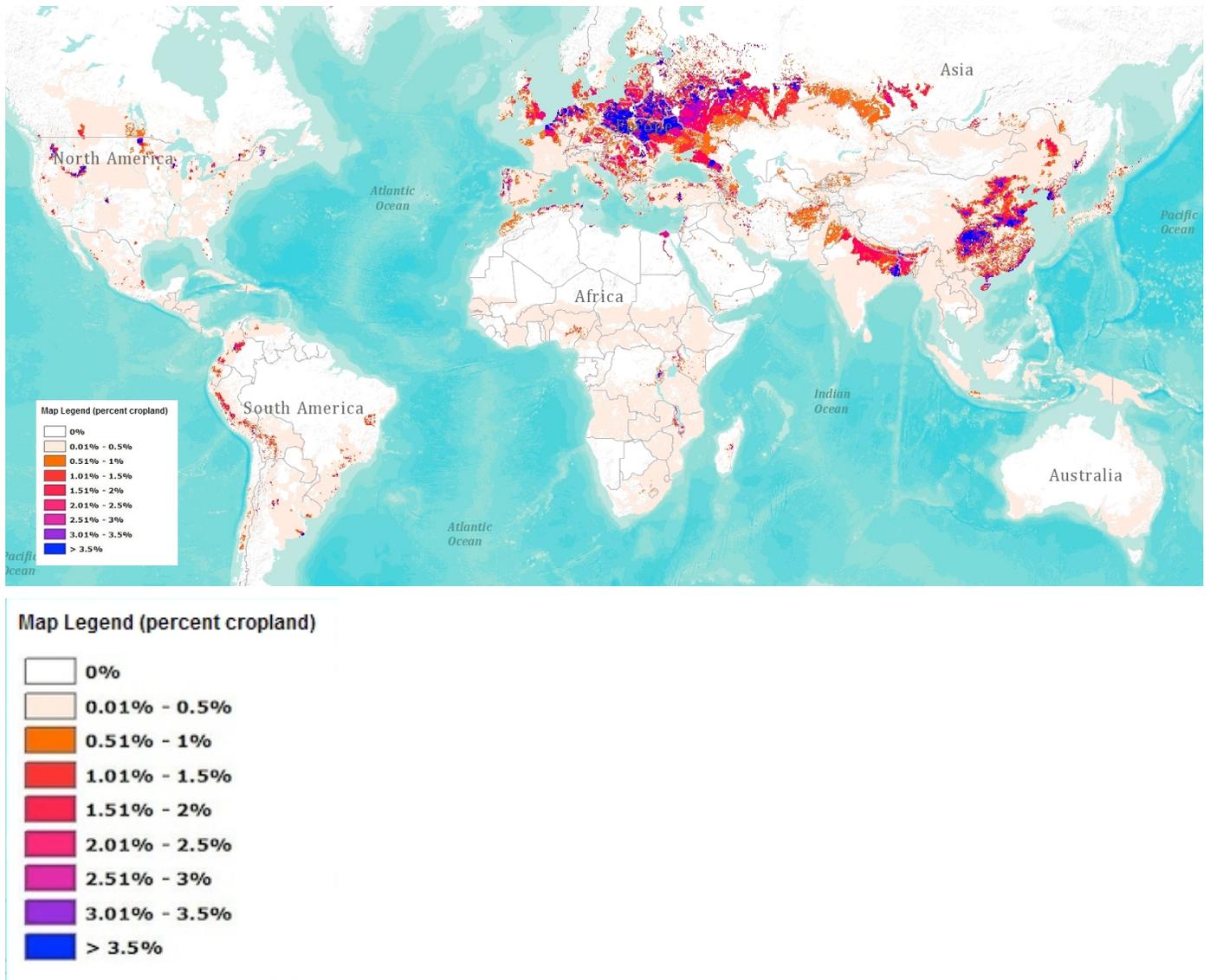


Figure 2. (Source: RTB Maps)

### Top 10 Potato Producing Countries

Rank	Country	Potato Production [tonnes]
1	China	95,987,500
2	India	45,343,600
3	Russian Federation	30,199,100
4	Ukraine	22,258,600
5	United States	19,843,900
6	Germany	9,669,700

7	Bangladesh	8,603,000
8	France	6,975,000
9	Netherlands	6,801,000
10	Poland	6,334,200

Figure 3. (Source: FAOSTAT, 2013)

## 1.2 Environmental factors in distribution

### 1.2.1 Elevation

In terms of elevation, *Solanum tuberosum* has been known from the tropical areas of high altitude. Potatoes have a wide elevation and climate growing's since they can grow from the dry desert along the Peruvian coast to the inter-Andean valleys, up to altitudes of 4,200 meters above sea level.

### 1.2.2 Climate

Potatoes actually grow in many different soils and climates. But, they grow best in regions where there is a cool temperate since it is q positive and helpful growing weather, sample rainfall, and deep fertile soil. In more detail, early varieties bred for temperate climates required a day length from about 15 to 17 hours, while the late varieties produced good yields under both long or short day conditions. Water Development and Management Unit says that potatoes varieties can be grouped into early, medium and late varieties. The early ones take about 90 to 120 days, the medium ones about 120 to 150 days and the late ones about 150 to 180 days. It al depends on their cool conditions at planting to slow emergence which can cause to extend the growing period.

### 1.2.3 Temperature regime

Most yields are being affected by temperature since their optimum mean daily temperatures are about 18 to 20°C. In fact, Robert J (2001) stated that a perfect night temperature is below 15°C since it those circumstances the potatoes are allowed to grow faster and with a much better result.

## 1.3 Geology and soils

Potatoes are a warm-season crops so their optimum soil temperature for normal tuber growth is proximately from 15°C to 18°C. According to Susan C, states that potatoes grow best in well-drained soils and loose ones.

### 1.3.1 Where is found best

Potatoes are a vegetable, which are easy to grow in many areas, climates and countries around the world. One country in which potatoes are abundant, not because of their production but because of their good soils are southern Peru and extreme northwestern of Bolivia. Actually, this two countries where one the first ones in which potatoes where domesticated. It is important to know that in Peru and Bolivia, potatoes are not number one producers of it. But, they are the countries in which *Solanum tuberosum* is found best because of their qualities as told previously.

## Chapter 2 Biology

### 2.1 Chromosome Complement

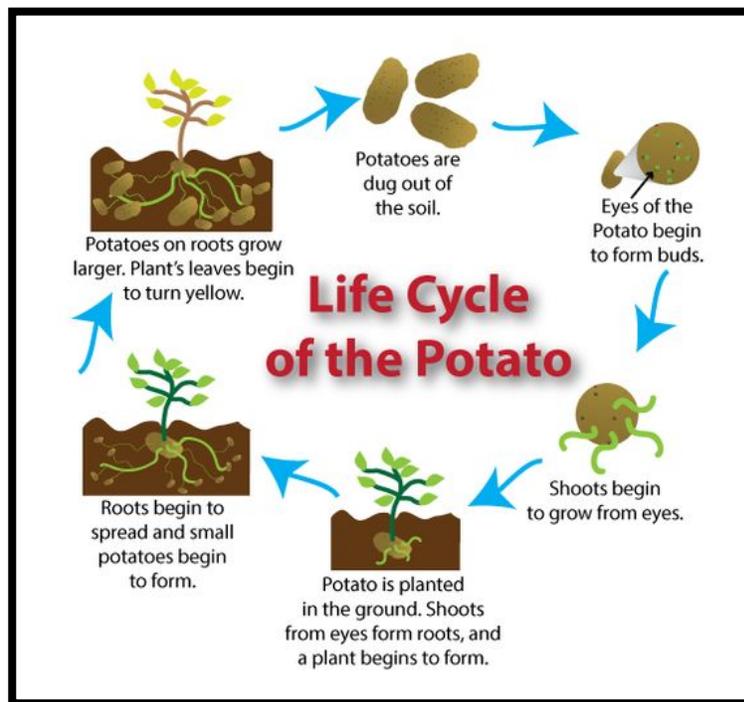
*Solanum tuberosum* has more chromosomes than what humans have. It is composed by 48 diploid (2n) numbers of chromosomes (Theoretical and Applied Genetics, 1982). According to a study, “Chromosome variation [of *Solanum tuberosum*] was found between calluses, within calluses and even within shoot cultures” (Theoretical and Applied Genetics, 1982).

### 2.2 Life cycle and phenology

#### 2.2.1 Life cycle

Potatoes are characterized by their short life. Approximately their range of life would be “from 80 to 150 days from planting to maturity, with differences existing between varieties” (Nemos, 2008). *Solanum tuberosum* life starts by the initiation and growth continuing with the period of dormancy and finishing with the “sprouting resulting in the next (vegetative) generation” (Nemos, 2008). It is important to know that the *Solanum tuberosum* development “stages are often described in terms of tuberization and tuber development” (Nemos, 2008). The stages that are part of the growing process of potatoes are six in total as it is evident in the graph below (Figure 1). Starting by the Sprouting tuber, followed by the

Vegetative stage, the tuber initiation, developing tuber, mature tuber and finally the last stage is the dormant tuber when the potato is nicely grown and ready to be eaten.



*The Life Cycle of the Potato - Figure 1. (Nemos, 2008).*

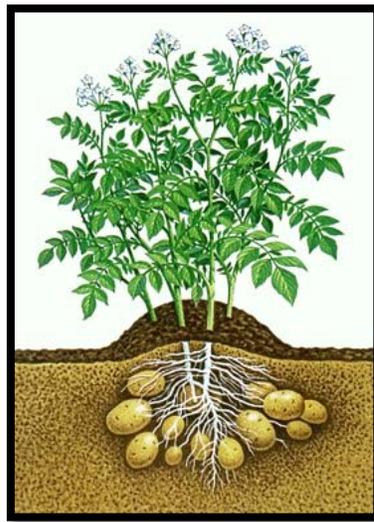
## 2.3 Reproductive Biology

### 2.3.1 Pollen

“The pollen of four varieties of potatoes has been stored successfully at  $-20^{\circ}\text{C}$  for eleven months” (Howard, 1958). This means that different kinds of potatoes have different kinds of pollens in different temperatures and not all of the potatoes are available to give out their pollen since some of them have diseases that don't let their pollen come out as they usually does. Actually, *Solanum tuberosum* pollen is very effective and necessary for several experiments and tests. “Other minor uses for pollen storage may involve more specific goals such as preservation for allergenic activity studies, use in apiary culture and generation of desired monploids and haploids through microspore or pollen culture” (Towill).

### 2.3.2 Sexuality

*Solanum tuberosum* are classified as asexual and sexual reproduction since potatoes are born under soil and their seeds are small and their strong roots that permit them to grow underground such as it is evident in the picture below (Figure 2) (Steane). Potatoes are sexually reproductive since they have to have seeds to be able to grow and they “reproduce sexually naturally via pollination by bees between potato plants” (Steane). Also, “[Their] cells involved for sexual reproduction in plants” (Steane). But, *Solanum tuberosum* can also be grown asexually “through vegetative reproduction” (Richard Steane).



*Potato Roots - Figure 2. (Richard Steane).*

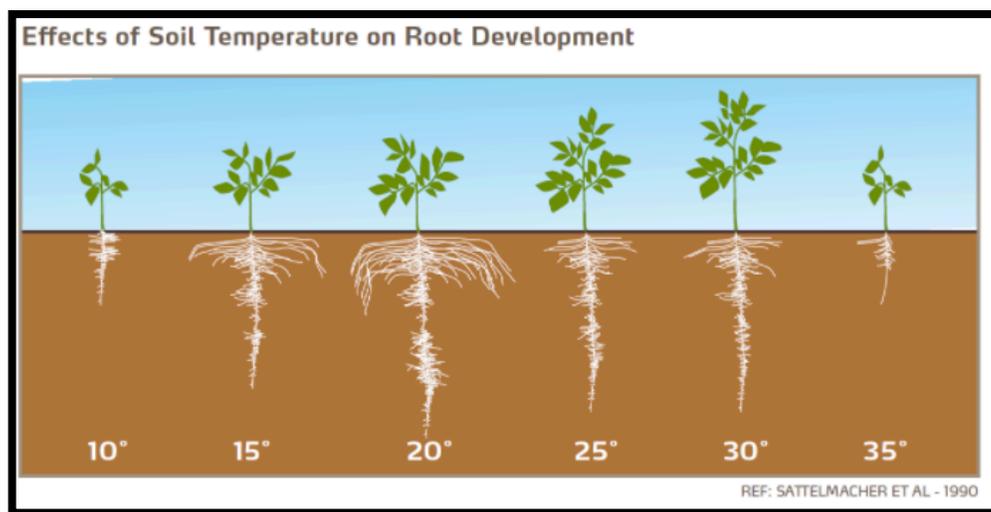
### 2.3.3 Fruit development and seed set

“The potato tuber is an enlarged portion of the stolon. The initiation of this tuber is triggered by short day lengths (photoperiods), and involves growth hormones” (Yara.us). To be able to grow fast and healthy the temperature that the *Solanum tuberosum* needs it is very important and necessary since it all depends in the temperature to be able to have good fruits development. “The optimum soil temperature for tuber initiation is 15 to 20°C” (Yara.us). According to the previews conditions, the potato fruit development would be in perfect conditions without too high temperatures neither too low ones since in both cases this could affect the growth of the tuber since it is very sensitive to strong temperature changes. Also, “the potato plant will have short stolons and shoots. Longer day lengths delay tuber initiation and favor the growth of the stolon and shoot” (Yara.us). In *Solanum tuberosum* seeds are

very productive, meaning “the number of tubes penetrating the style was about 6 times the number of seeds produced” (E. Cabanillas, 1966).

## 2.4 Eco Physiology

*Solanum tuberosum* “produce a fibrous root system. These roots are at best no more than 24in long” (Yara.us). Because of this, most of the time, potatoes are not allowed to give out all their nutrients and soil moisture at a 100%. In terms of the root, the best indicated temperature for soil to be able that potatoes roots grow healthy and strong are between “10 to 35°C at their best” (Yara.us). In terms of the leaf, the perfect and indicate growth happens at temperatures “between 7 to 30°C, but optimal growth is at around 20 to 25°C” (Yara.us) as it is clear in the picture below (Figure 3).



*Effects of Soil Temperature on Root Development - Figure 3. (Sattelmacher, 1990).*

## Chapter 3 Propagation and management

### 3.1 Natural Regeneration

To be able to regenerate potatoes it is important to have in mind that the process will only be effective

*“...Insufficient seeds or plant propagates is available for conservation or distribution.”* (Dumet, Adeleke, & Faloye, 2008).

To be able to regenerate a potato seed it is important to plant the seeds in to “two seeds per hole, 2–3 cm deep and make holes 20 cm apart” (Dumet, Adeleke, & Faloye, 2008). It is important to have “80 to 50 sow seeds” so that the regeneration will be much healthier and easier. Another strategy can be to “germinate seeds in an incubator and sow in pots in a greenhouse” (Dumet, Adeleke, & Faloye, 2008) and finally move to the field when small plants are grown.

## **3.2 Nursery Propagation**

### **3.2.1 Propagation from seeds**

The preparation of the seeds and the soil is important for a successful growing result. In general, *Solanum tuberosum* are grown in countries, which its temperature is tropical or subtropical since these conditions simulate a good and healthy potato. In other words,

*“Potato is planted in early spring in temperate zones and late winter in warmer regions, and grown during the coolest months of the year in hot tropical climates”* (Fao.org, 2008).

*Solanum tuberosum* are adaptable plants, which can grow in minimum conditions without the perfect soil, and the ideal weather but there is always optimum conditions so that a plant can reproduce as it's best (Fao.org, 2008). For examples, famers who grow potatoes never stay in the same soil in 3 years continuously since the seeds, as much as good as they are, can get pest and diseases. Instead, they rotate their crops so that the bacteria, that is always in the soil and around the area, doesn't habituate to be in the potato crops.

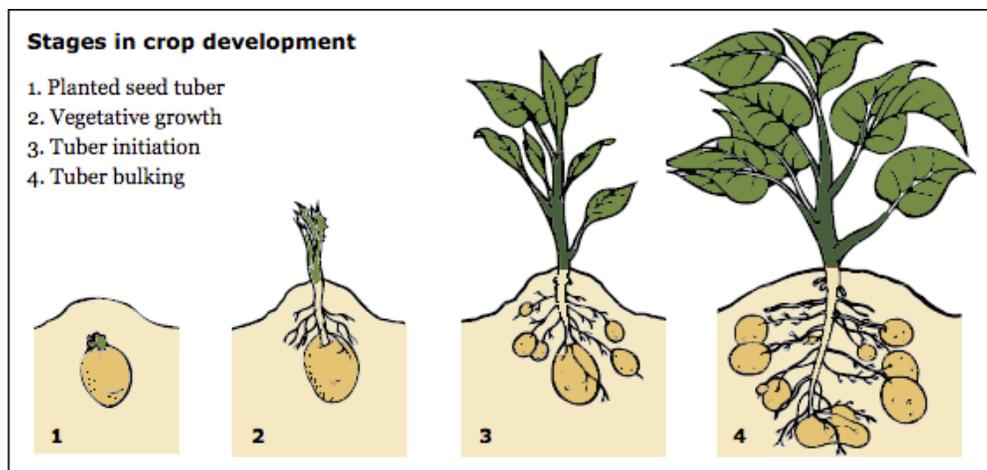
*“With good agricultural practices, including irrigation when necessary, a hectare of potato in the temperate climates of northern Europe and North America can yield more than 40 tones of fresh tubers within four months of planting”* (Fao.org, 2008).

### **3.2.1.1 Storage**

When storing potatoes it is important to search and see for any potato that is in bad conditions. This means that all of the potatoes that will be storage have to be in the best characteristics as possible, if not it could contaminate the other ones and would end up with a bunch of dirty and raw potatoes. It necessary to use a cabinet or a basket to put potatoes since it helps to keep them clean by organizing them by layers dividing each layer with kitchen paper so that they can't get more moister. Potatoes best storage is in a dark and room temperature place since to cool temperature of a fridge will harm their physical look and also taste.

### **3.3 Planting**

There are seven to eight main steps. There are necessary to follow to be able to plant healthy and good quality potatoes. Starting by planting the seed with a “pieces of whole potato or a small whole potato, with at least 2 eyes per piece” (The Old Farmer’s Almanac, 1792). It is important that the soil where the potatoes are going to be planted is smooth and of good quality since will help in their process of growing with nutrients, vitamins and their roots will be grown with stronger. “Spread and mix in rotted manure or organic compost in the bottom of the trench before planting” (The Old Farmer’s Almanac, 1792). It is important that each potato that is planted has a minimum of one foot of space in between each other and a minimum of four inches deep so that the potato have enough space to develop, grow. “Potatoes thrive in well-drained, loose soil” (The Old Farmer’s Almanac, 1792) this means that they need frequently and enough water when they start to form. Usually it will take no more than 10 weeks of the process growth. In the figure 1 below there is a visual example of its process.

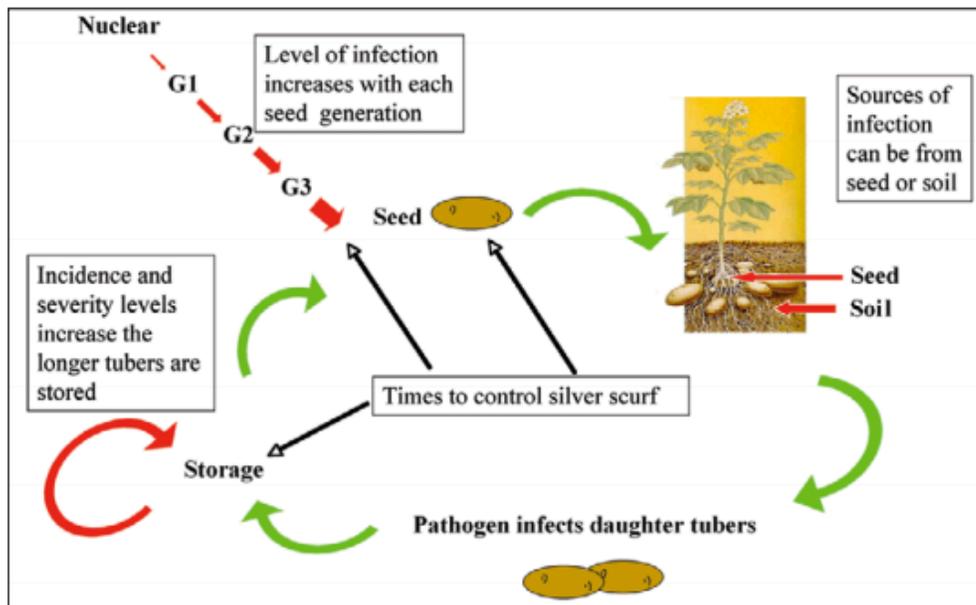


*Stages in Crop Development of a Potato - Figure 1. (Fao.org, 2008)*

### 3.4 Management

#### 3.4.1 Pest and diseases control

As all fruits and vegetables insects and diseases in plants are inevitable. In terms of potatoes, in weather place a huge protagonist when talking about diseases such as the National Gardening Association Editors, 2008 “Moisture and temperature conditions may trigger certain diseases, which will spread rapidly through the potato rows. It is important to start planting healthy and trustable seeds since it is the start of the plant. “These are chemical mixtures that prevent some diseases such as late blight” (National Gardening Association Editors, 2008). Sprays and other products that are selling are good quality products if there are well applied on the vegetable or fruit. In the case of a *Solanum tuberosum* must be applied this products in their “foliage every [seven to ten days], beginning when the plants emerge from the ground” (National Gardening Association Editors, 2008). Another important fact to have in mind when growing healthy potatoes is the HP of the plant and soil. In other words, “when the soil PH is below 5.4” (National Gardening Association Editors, 2008) it is necessary to lower the PH since it means that the plant is not growing in best conditions. Lastly, as it is evident in Figure 2 below, “The fungus likely attacks all potato cultivars, but it causes the most economic damage on those sold fresh for market” (Hamm, 2013). In other words, it is the recycle in which potatoes past by when they have a disease and in the planation which will affect the whole natural process in which potatoes develop.



*Pest and Disease Control Cycle - Figure 2. (Brad Geary, Brigham Young University, 2013)*

## Chapter 4 Marketing

### 4.1 Emerging products and protein markets

#### 4.1.1 The overall picture

The total world *Solanum tuberosum* production is estimated at 364.808.768 tonnes in 2012 (FAOSTAT, 2014). The developing world's potato production exceeded that of the developed world. “China is now the biggest potato producer, and almost a third of all potatoes are harvested in China and India” (FAO, 2005), as it is evident in the map below (Figure 1). According to FAOSTAT, China is ranked as the first country producing potato out of the top 25 countries potato producing in the world. The production in China is of about, 95,987,500 tones of potato per year as it shown in the table below (Table 1) (FAOSTAT, 2015).

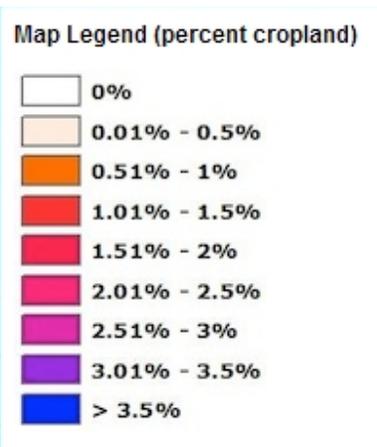
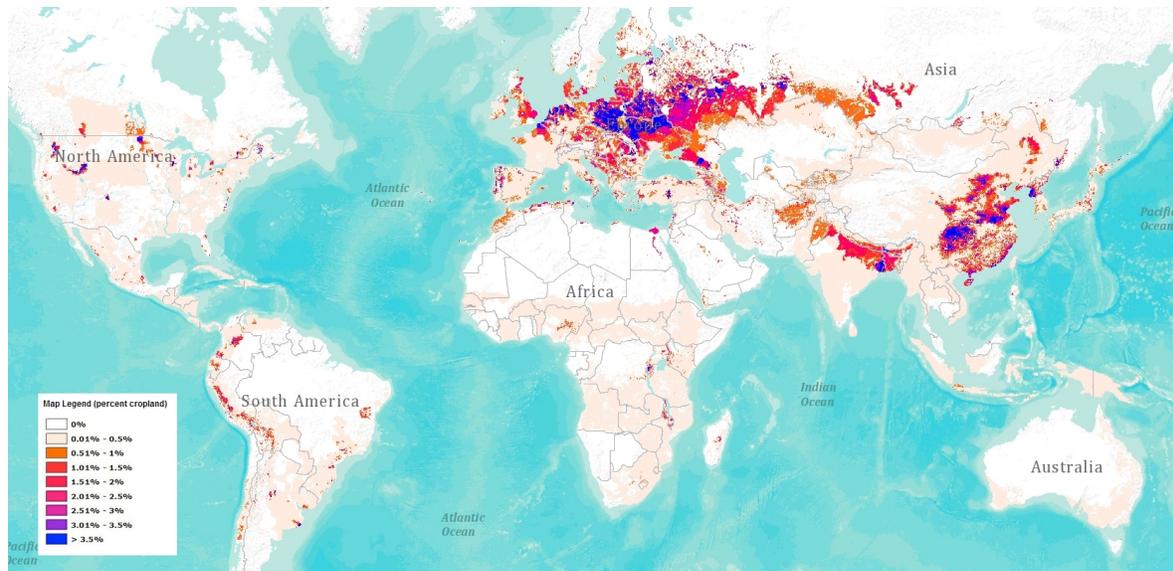


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Top 10 Potato Producing Countries.

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*Top 10 Potato Producing Countries - Table 1. (Source: FAOSTAT, 2013)*

#### 4.1.2 Food items based on pulp, skin and juice

Potatoes are best known to eat them in several different ways. There are many dishes and recipes around the world that potatoes are involve and have a big protagonist. It is common to eat mashed potato, fried potato, baked potato, and cooked potato. But, potatoes don't exist only to satisfy our desire to eat since *Solanum tuberosum* has another face in terms of usage. For example, with potatoes it is possible to create electricity. According to Felix Dennis, a nature science investigator, established that with only potatoes, “wires, some copper, and a zinc-coated nail and one of the tubers, you can power a clock, a light bulb, and many other small electronics” (Dennis, 2016). The amount of electricity that potatoes can produce is very small but as Dennis said (2016), it is useful. Another usage that potatoes are available to do rather than only use it for food is making bio plastic. According to Dennis, “The concentration of starches and cellulose in a potato can be used to make plastic, and the plastic made out of potatoes can be burned and composted with much less impact on the environment” (Dennis, 2016). This is very helpful right now in our society since our Earth planet is getting contaminated so fast because of human's usage. Finding out that of potatoes it is possible to get bio plastic is a good resource that factories should start implementing in their industries since it is friendlier with our planet.

## 4.2 Medical and traditional non-wood uses

### 4.2.1 Medical uses

Fruits and vegetables are always known of being good sources of getting lots of vitamins and minerals just as potatoes do. It is common to say that if you include many vegetables and fruits in your daily diet you will be consider a healthy person. What potatoes brings to your body is much more than being just a healthy person since above those benefits *Solanum tuberosum* helps you prevent of many other diseases rather of only being a healthy person. One of the medical uses witch potatoes are a protagonist are at maintaining your bones health strong and healthy due to the rich components that potatoes have such as phosphorous,

magnesium, iron, zinc and calcium since with all of these potatoes helps to build and conserve a good and strong bone structure.

*“Iron and zinc play crucial roles in the production and maturation of collagen. Though phosphorus and calcium are both important in bone structure, the careful balance of the two minerals is necessary for proper bone mineralization - consumption of too much phosphorus with too little calcium can result in bone loss” (Ware, 2016).*

Not only consuming *Solanum tuberosum* helps maintaining strong and healthy bones but they also to keep a good and low blood pressure in your body. “Maintaining a low sodium intake is essential for maintaining a healthy blood pressure, however, increasing potassium intake may be just as important because of its vasodilation effects” (Ware, 2016). Vitamins and minerals such as calcium, magnesium and potassium, witch are all present in potatoes, helps in a natural way to decrease and maintain your blood pressure stable. Other than the benefits of including in your daily diet potatoes that are already mention there are other important benefits which eating *Solanum tuberosum* may help in your daily life to live healthier. For example, digestion and regularity because “... of their fiber content, potatoes help to prevent constipation and promote regularity for a healthy digestive tract” (Ware, 2016). Lastly, eating potatoes also helps to low down inflammation that you may have in your body. “Choline is an important and versatile nutrient present in potatoes; it helps with sleep, muscle movement, learning, and memory. Choline also helps to maintain the structure of cellular membranes, aids in the transmission of nerve impulses, assists in the absorption of fat, and reduces chronic inflammation” (Ware, 2016).

#### **4.2.2 Magic/ritual significance**

As lots of plants, fruits and vegetables are consider holy and with a very special meaning for some human beings groups, *Solanum tuberosum* is also consider as one. According to the anthropologist, Luis Millones, an expert on the beliefs and customs of Andean peoples states “The potato plays a central role in the myths and rituals that define the Andean vision of the world. In their conception of the universe, potatoes inhabit the Uku Pacha, or inner world, a

place of seeds and corpses, of future and past, as opposed to the Kay Pacha, or the world of the present. This idea dates back to before the time of the Incas, who adopted the beliefs of the people they conquered” (Millones, 2011).

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## Glossary

**Regenerate:** (verb) Of a living organism, grow (new tissue) after loss or damage.

**Propagates:** (verb) Breed specimens of (a plant or animal) by natural processes from the parent stock.

**Adaptable:** (adjective) Able to adjust to new conditions.

**Yield:** (verb) Produce or provide (a natural, agricultural, or industrial product).

**Moister:** (noun) Water or other liquid diffused in a small quantity as vapor, within a solid, or condensed on a surface.

**Trigger:** (verb) Cause (a device) to function.

**Foliage:** (noun) Plant leaves collectively.

**Smooth:** (adjective) having an even and regular surface; free from perceptible projections, lumps, or indentations.

**Bio-plastic** (noun): a type of biodegradable plastic derived from biological substances rather than petroleum.

**Starches** (verb): stiffen (fabric or clothing) with starch.

**Cellulose** (noun): an insoluble substance, which is the main constituent of plant cell walls and of vegetable fibres such as cotton. It is a polysaccharide consisting of chains of glucose monomers.

**Mineralization** (noun): in soil science is decomposition or oxidation of the chemical compounds in organic matter into plant-accessible forms.

**Inflammation** (noun): a localized physical condition in which part of the body becomes reddened, swollen, hot, and often painful, especially as a reaction to injury or infection.

**Inhabit** (verb): Of a person, animal, or group live in or occupy a place or environment.