Ipomoea batatas

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Monograph

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Introduction

The purpose of this monograph is to write a detailed report on the different aspects of the sweetpotato. This project was the students of agricultural science at the beginning of the school year. Each student was assigned a different plant, and I was assigned *Ipomoea batatas,* Sweet Potatoes.

This monograph is one of many made by the students of Agricultural Science. Given that there has been no other monographs to come out of this class before, there is nothing to compare this one to except the ones being released alongside this one. It will start with the Ecology of the plant, then moves onto the Biology, then the Propagation and Management of the plant, and it will end with it's Importance Around the World.

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1 Ecology

1.1 Distribution

Ipomoea batata (or sweet potatoes) are native to the American Tropics. They were introduced and cultivated in many tropical and subtropical countries, becoming an important food crop, especially in India, China, Philippine Islands, and the South Seas Islands.

1.1.1 Affinity

Sweet potatoes are members of a big genus of vines called *Ipomoea or morning glories.* Some, but not many, other morning glories also have root-tubers. And, just because a morning glory has a root tuber doesn't make it edible. The bush morning glory's tuber is solidly woody and you need a saw to cut it open. *Ipomoea pandurata,* Indian potato of the US Southeast, is noted in many books as edible but morning glory expert Dan Austin argued persuasively that that is the result of historical authors confusing it with other plants. Native Americans used it as a purgative and did not eat it. The tuber of any *Ipomoea* species except *Ipomoea batatas*, sweet potato, is eaten by anyone.

Another big genus of vines, *Dioscorea*, is also found across the tropics and has edible tubers. While *Ipomoea batatas* is native to the Americas, there are species of *Dioscorea* with edible tubers in Central and South America, Africa and tropical Asia. In all three areas, *Dioscorea* species have been in cultivation since at least 3000 BC. Yam is the common name for plants in the genus *Dioscorea.* (Keeler, 2013)

1.1.2 Fossil Record

Sweet potatoes are native to the Americas, where they have been cultivated for millennia. They were probably one of the earliest domesticated plants. Sweet potatoes have been found at sites in Peru dated to 8,000 - 10,000 BC. They were in widespread cultivation in both Mexico and Peru by 2500 BC. (Roullier, 2013)

1.1.3 Origin

Evidence shows that sweetpotato originated from either Central or South American lowlands with later dispersal to North America, Europe, Africa, Asia and the Pacific islands. A total of 71 polymorphic RAPD molecular markers were used to assess the genetic relationships amongst 74 sweetpotato varieties originating from a total of 23 sweetpotato producing countries within six geographical regions, namely, South America, Central America/Caribbean, United States of America (USA), East Africa, Asia and Oceania. Genetic distance (PhiST) calculated with AMOVA and multidimensional scaling (MDS) revealed that the South American and the Central American/Caribbean genotypes formed two separate clusters. East African varieties, which have unique characteristics from other traditional varieties, were distinct from other traditional varieties from South America and Oceania. These results support the reported hypothesis of the origin and dispersal of the sweetpotato and indicate that the primary centre of diversity probably has two distinct gene pools. It is proposed that the dispersal of the sweetpotato from its origin may have mainly involved varieties from Central America/Caribbean as opposed to varieties from South America. There is an indication that new gene pools may be evolving in Africa and Asia due to hybridisation and adaptation to the local environments. (Roullier, 2013)

1.1.4 Present Distribution

Sweet potatoes are cultivated for food in more than 100 countries, sometimes as a staple food but usually as an alternative food. Because of their fast growing period and low input and work requirements, sweet potatoes are often planted in Africa as a security crop or famine prevention crop. They are now widely cultivated between 40°N and 32°S, up to an altitude of 2000 m (and

up to 2800 m in equatorial regions) . The main sweet potato producers are China, Indonesia, Vietnam, India, Philippines and Japan in Asia, Brazil and the USA in the Americas and Nigeria, Uganda, Tanzania, Rwanda, Burundi, Madagascar, Angola and Mozambique in Africa. The area under cultivation was 8.5 million ha in 2009. It is one of the seven food crops with an annual production of more than 100 million tons. (Roullier, 2013)

1.2 Environmental Factors Affecting Distribution

1.2.1 Elevation

Sweet potato grows up to an altitude of 2000 meters outside the equatorial regions, and up to 2800 meters in equatorial areas. (Monteiro, 1992)

1.2.2 Climate

Sweet potatoes are somewhat drought-tolerant as well as hardy during summer dry spells. However, low humidity impairs growth even if the plant receives water following stress or drought. (Monteiro, 1992)

1.2.3 Rainfall

Sweet potatoes are cultivated wherever there is enough water to support their growth: optimal annual rainfall for growth ranges between 750 and 2000 mm. Where the rainfall is below 850 mm irrigation may be necessary, but it should be stopped before harvest in order to prevent the tubers from rotting. (Monteiro, 1992)

1.2.4 Temperature

The sweet potato is a warm-season annual, requiring 20-25°C average temperatures and full sunlight for optimal development. It needs a frost-free period of 110-170 days and growth may be hampered with an average day temperature below 20°C. (Roullier, 2013)

1.2.5 Temperature and soils

Sweet potatoes thrive in well-drained loamy soils with a high humus content that provides a warm and moist environment for the roots. Optimal soil pH is between 5 and 7. (Roullier, 2013)

1.2.6 Evapotranspiration

Sweet potatoes are mildly drought-tolerant and can survive dry spells during the summer. However, low humidity impairs crop quality even if the plant resumes growth after water stress. (Roullier, 2013)

1.3 Vegetative Components

1.3.1 Environments it's found in

It is mainly found in tropical and subtropical environments around the world. It originated from Central America, and has been spread around the world since then. (Roullier, 2013)

1.3.2 Associated Species

Ipomoea Batata are part of the Morning Glory family, which is a common name for over 1000 flowering plants that belong to the Convolvulaceae family. However, many people group sweet

potato with the likes of Solanum tuberosum, and Cassava. Which are commonly grown alongside Sweet Potato. (Keeler, 2013)

1.3.3 Interactions on Plant Soils

Sweet Potatoes do not seem to change the pH, potassium, or nitrogen levels of the soil in any way, however it itself is affected greatly by levels of potassium especially. (Quimio, 1985)

1.3.5 Soil Environment

Sweet potatoes like to grow in soil with potassium level above 4%, it also having nitrogen levels above 3%, however, if potassium is also low, then nitrogen levels will not affect the growth of the plant. (Veasy, 2007)

1.3.6 Relationships with insects

Sweet Potatoes have a long history with sweet potato weevils, which have been described as “most important sweet potato pests in the world”, for they have been reported to destroy anywhere between 5% to 97% of the crop. There are a multitude of different insects that are harmful to sweet potatoes, such as the sweet potato hornworm, which will eat the entire leaf of a plant. The sweet potato vine borer, which bores into the vines of the plant and killing it. Lastly there is the root knot nematode, which can cause a decline in the growth of the plant and even kill it. (Monteiro, 1992)

2 Biology

This chapter is concerned with the biology of Ipomea Batatas and focuses mainly on the state of knowledge of the life cycle, phenology, and reproductive biology. All these are in works of past literatures, but we hope to make a compilation of all the work for ease of usage with this plant.

2.1 Chromosome Complement

The chromosome number has been found to be 2n=90 in 80% of the cells observed. (Quimio, 1985)

2.2 Life cycle and Phenology

2.2.1 Life Cycle

The sweet potato plant, among all other flowering plants, features the most advanced condition of reproduction occurring in terrestrial plants. Using its flowers, which contain both male and female reproductive organs, the sweet potato plant undergoes sexual reproduction. Sexual reproduction occurs when genetic material from both male and female individuals come together to create a new individual.

The life cycle of a sweet potato plant alternates between a diploid sporophyte generation and a haploid gametophyte generation. Within the flowers of *I. batatas*, there are anthers that contain millions of diploid spores called microsporocytes. The anther is the male organ of the flower.

These microsporocytes divide by meiosis to produce haploid microspores. Each male microspore undergoes a mitotic division to produce a haploid male gametophyte called the microgametophyte, or better known as pollen grain.

The pistil consists of a stigma, style, ovary, and ovules. Ovules are in the ovary. A diploid megasporocyte exists in the ovule and divides by meiosis to create four haploid megaspores. Only one of these megaspores survives.
The megaspore divides by mitosis to produce seven haploid cells. The seven-celled structure makes up the female gametophyte or megagametophyte.

The male pollen grain lands on the stigma, initiating pollination of the female parts. Here the pollen grain germinates and a pollen tube grows down the style until it meets the female gametophyte. Two sperm from the pollen grain utilize the pollen tube for travel and enter the female gametophyte. One fertilizes the egg, forming a diploid zygote. The other fertilizes the two polar nuclei that are within the megagametophyte. The fertilization creates a triploid cell. This dual fertilization is called double fertilization. The zygote, which begins the next sporophyte generation, develops into the embryo. The seed germinates and when the sporophyte matures, the life cycle begins again. (Monteiro, 1992)

2.2.2 Phenology

2.2.2.1 Deciduousness

Sweet potato is an extremely hardy plant, and is not as susceptible to water stress as most other plants. Because of this, it has been considered as a drought tolerant and a backup food

during draughts. It does not shrink as badly or dry up as much as other plants that are exposed to water stress. Effects of climate on the physiology of the plant are scarce, however, since the plant is fairly hardy and is not affected by change in temperature or moisture in the air and soil. Veasey, 2007)

2.2.2.2 Flowering and Fruiting

The flowers of *Ipomoea Batata* are closely related to the Morning Glory Flowers. They rarely bloom and are considered a rarity and are highly sought after. Sweet Potatoes don't usually flower, and when they do it usually advisable to remove the flowers to promote the growth of the tubers themselves, so energy is not wasted on the flowers. However, when you are growing ornamental Sweet Potatoes (which go by the same latin name) removing flowers does not affect the growth and is usually an added bonus. (Keeler, 2013)

2.2.3 Year-to-year variation in flowering and fruiting

Ipomoea Batata always produce sweet potatoes every year, however , flowers that it can produce are not produced very often and only by certain variations. The flowers typically bloom alongside the growth of the potatoes themselves, if they bloom at all. (Keeler, 2013)

2.3 Reproductive Biology

2.3.1 Pollination and potential pollinators

If you look face on into a sweet potato flower, you see a rounded structure in the center. This is the female flower part called the stigma. The five male flower parts, called stamens, surround the stigma. They produce the pollen. In order to set seed, the stigma has to receive pollen grains, but it can't be from the same flower because sweet potato flowers are self-sterile and can't pollinate themselves. The pollen has to come from a completely different plant and even a completely different variety. In nature, a bumblebee carries the pollen from one flower to another. In U.S. gardens, if you want to try pollinating, which isn't necessary for the health or productivity of the plants, you need to be the pollinator. (Chaney)

2.3.2 Sexuality

Ipomoea Batata is a monecious plant, with both reproductive organs in the flower of the plant. However it can reproduce in three ways, through the flower, through the root, or through the vines. The second two of which are far more popular for agricultural use, since the plants stays genetically the same as the parent plant. (Veasey, 2007)

2.3.3 Anthesis

Since the flowers of *Ipomoea Batata* so closely resemble those of the Morning Glory variety, the information on the blooming of sweet potato flowers and morning glory flowers are to be the same. However, information on exactly how Morning Glories bloom seems to be scarce.

2.3.4 Fruit development and seed set

Does not contain fruits, so there are no seeds residing within the plant.

2.4 Ecophysiology

Nitrogen increases dry matter production by increasing the size of the leaves, which means her is more energy that can be converted into the growth of the sweet potatoes themselves. However, at fixed levels of potassium, and nitrogen levels were high in the leaf blade, energy from photosynthesis was used primarily in growth above the soil. Potassium, however, is the primary variable in the growth of the plant, as more potassium would increase the levels of photosynthesis in the leaves, without increasing the leaf area. More potassium also subdued excess top growth, which resulted in higher tubule growth. In general, more potassium will increase tubule growth by focusing the plant's energy into tubule growth.

Nitrogen levels would not affect the level of photosynthesis, if potassium was low or high, which would attribute to low and high photosynthesis levels. If Nitrogen was low (2.2%) but Potassium levels were high (4%) photosynthesis was very high in the leaf. While if Potassium was low (below 4%), then photosynthesis would decrease dramatically, even with nitrogen was about 3%. (Roullier, 2013)

3 Propagation and Management

3.1 Natural Regeneration

Shoots can easily be regenerated from explants of stems, petioles, leaves and roots, while callus cultures do not produce any shoots. The potential of somatic embryogenesis and plant regeneration via embryogenesis was evaluated for 10 cultivars of sweet potato. Protocols for plant regeneration from cultured protoplasts have also been developed. Since mesophyll was resistant to enzyme digestion, fragments of stems and petioles, callus and cell suspensions were used as source of protoplasts of sweet potato. Series of transfers of protoplast-derived calluses, particularly those which had been obtained from in vitro plants, to media containing a high level of zeatin resulted in successful formation of shoots in only two sweetpotato cultivars. In addition, the embryogenic potential was irreversibly lost through protoplast culture, since protoplasts isolated from embryogenic cell suspensions developed into non-embryogenic callus. Consequently, an alternative protocol is being successfully developed to improve plant regeneration from cultured protoplasts of sweet potato, involving first root formation from which shoots can then be regenerated. (Monteiro, 1994)

3.2 Nursery Propagation

Growers take stem cuttings from the vines, which then root and form new storage roots. In some colder climates, where vines do not develop well, producers will plant roots.

3.2.1 Vegetative

Sweet Potato can only be propagated through its vegetative components.(International Potato Center, 2014)

3.2.1.1 Cuttings

It first has its stem cuttings taken to be placed into the ground or into a propagation media, with dry, well rotted soil, to induce the plant to start growing. It then will mature within 4 months after placed into the ground.

3.3 Planting

If grown outdoors, sweet potatoes need moisture-retentive, free-draining soil, in a sheltered, sunny position (they are particularly happy in organic rich sand). Prepare the ground as necessary.

Use black polythene, to warm the soil and suppress weed growth. Lay the polythene over the soil several weeks before planting, from late March or April as the soil starts to warm up.

Grow the plants on in a bright, frost-free position in the greenhouse or on a sunny windowsill, until late May until early June, potting on as necessary.

If grown indoors, Grow sweet potatoes in a glasshouse in large tubs, growing-bags or the glasshouse border, transplanting from the pots once they have produced plenty of roots. The foliage can be trained up string, canes or trellis. Any good growing medium is satisfactory, including peat-free types.
Sweet potatoes crop best at temperatures between 21-26°C (70-80°F).

Keep greenhouse plants well watered, and feed every other week with a high-potassium liquid feed.

Overwinter plants in a frost-free greenhouse or windowsill. (Monteiro, 1992)

3.4 Management

Management in regards to the sweet potato seems to be centered around the control and killing of Sweet Potato Weevils. Which were discussed in a later section (Ch. 3.4.3, Pg. 18) as the most dangerous and prevailing insect to sweet potato. This is probably due to the fact that sweet potato does not require much tending to after it is planted, besides pest control.

3.4.1 Tending

Tending to the sweet potato is fairly limited as it does not require any tending to grow. Only proper irrigation and enough sunlight and heat, which are to be maintained after planting.

3.4.2 Harvesting and Storage

Sweet potato is matured at 4-6 months after being planted, if let to grow past that, unsellable “jumbo’s” might grow, and it increases the likelihood of sweet potato weevils to infect the crop. The plants are removed by the base of the vines and spaced out to. The tubers themselves are then cut from the vines and washed prior to storing

The plants are cured at 85°F at humidity levels of 90-95% for 4-7 days, and after curing can be stored for 4-7 months at 55-60°F and 85-90% humidity. (Monteiro, 1992)

3.4.3 Pest and Disease Control

There are many different insects and pests that are problems for the sweet potato, including Gulf Wireworms, Nematodes, Anthracnose, and many more. However the dominant insect is the Sweetpotato Weevil, or Cylas Formicarius Elegantus. The insects themselves do not cause the

damage, it is the larvae that can destroy an entire field of Sweet Potato. The larvae invade and spread through the plant, potentially having hundreds of larvae feeding off of one tuber. These plants become unmarketable, because of the presence of larvae, bitter taste, and rotten flesh of the potato. 15-30% of crop production is lost to them every year, however, if left unchecked, a field can lose 60-97% of its crop. To prevent them, farmers employ crop rotation to keep the pests from settling in one field. Along with checking the soil to make

sure they haven't invaded nearby. However, commercial remedies do exist for when the weevils are already in the crop. There are specific hormones that will attract the males away from the crops, making sure more weevils are not born. It has been shown that certain fungi and parasitic nematodes can also kill the weevils, however, more research needs to be done to see if these options are commercially viable. (*EDIS New Publications RSS,* 2014)

4 Importance

4.1 Importance Around the World

It has many health benefits, as it contains lots of Vitamin A, and the purple fleshed potatoes contain anti-oxidants. Due to these nutritional benefits, sweet potato has become a staple in Africa as it provides many nutrients that many Africans in poorer areas lack. (Sweet Potato, www.whfoods.org)

4.1.1 Uses

The products that sweet potato is able to make are really only the tubers themselves, however, the other parts of the plant can be eaten ,but it is not common to do so. The tubes can be prepared in a variety of ways to be eaten, anything from boiled to delicately sliced and made into a chip (the American kind of chip). Also, parts of the plant can be derived to form starch-derived industrial products. (Sweet Potato Processing and Uses, 2014)

4.1.2 Markets

Currently, North Carolina is the major producer of sweet potato in the United States, producing 53% of the plant for the rest of the country. Production of sweet potato in the U.S has also been

increasing substantially over the past 15 years, with a 6.1% production increase every season. (Naeve, 2015)

4.1.2.1 Where it is Used and Traded

It is mainly used in countries such as Africa, prepared in many different ways depending on the country in Africa. Its also used in many countries in Asia, such as Malaysia, Korea, Japan, and many others, mainly China. It has been used in the Americas as a food source, but it is not as popular of a food as other countries.

Data on where sweet potato is traded is scarce, but we can infer that the countries that use it the most and produce the most are the ones that trade with it the most. This includes countries listed in the paragraph above, China, Korea, Japan, South-African Countries, and the parts of the Americas.
(Naeve, 2015)

4.1.2.2 Major Producers

The country that produces the most sweet potato is, by far, China, with a total 81% market share in sweet potato selling and producing. The U.S on the other hand, only accounts for 1% of sweet potato production. In the U.S is North Carolina, with 12.4 million cwt (hundredweight), and the other states, such as Missouri, Louisiana, and California made up the rest of production in the U.S, totalling 26.5 cwt. (Huntrods, 2013)

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