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Developmental Stages of Cotton (*Gossypium spp*) Crop

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Abstract

Cotton plants have an indeterminate growth habit, meaning the plant can develop leaves, stems, flowers, fruit (bolls) and seed all at the same time. The branches on the cotton plant can be classified as either vegetative or fruiting branches. Vegetative branches have only one meristem and so grow long and straight, whereas fruiting branches have multiple meristems, each starting after the previous fruiting bud and as such exhibit a zig-zag growth habit. The first five main stem nodes support primarily vegetative growth and fruiting branches commence thereafter, with branches showing a ⅜ alternate phyllotaxy.

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Phyllotaxy, canopy, maturity, seedling, *Gossypium*

Introduction

Cotton has been used by humans for approximately 5,000 years. Archaeologists have found evidence that cotton has been used to produce garments in Africa, Pakistan and the Americas since 2500 BC (Stephens, 1975). Cultivated cotton produced today belongs to the genus *Gossypium* which consists of over 50 species. The majority of cotton produced worldwide today is *Gossypium hirsutum*, commonly known as upland cotton. There are 3 other species commercially produced including *G. barbadense* or Pima cotton and two Asian species, *G. herbaceum* and *G. arboreum.* These four species are commercially grown for the production of lint which can be spun into yarn (Applequist *et al.*, 2001).

Cotton production is an important industry worldwide, supplying the textile industry with raw fiber for the manufacturing of garments. Pressure from synthetic fibers has seen the industry become aware of the need for producing high yields of quality fiber in the most efficient manner. Precise management practices including fertilizer application and ground preparation play significant roles in accomplishing a superior product. Knowledge and experience of interactions between climate, plants, soils and microorganisms is needed to improve the efficiency and sustainability of cotton production. Therefore, the objective of this paper was:-to understand the various developmental stages of the Cotton crop growth.

Literature Review

Germination and Emergence

Planting of cotton seed should occur when the soil temperature reaches 14^{o}C at a depth of 10 cm for at least three days. Cotton seeds require more oxygen for germination than other plants such as maize, wheat and rice (Eaton, 1955). The seeds also require relatively high moisture and high soil temperatures for successful

germination. Cotton seeds imbibe water rapidly, generally taking 36 to 48 h (Hearn & Constable, 1984; Wanjura & Buxton, 1972) and begins when water enters through the chalaza and later through the whole testa entering the embryo (Oosterhuis, 1990). The seed swells and splits, allowing the radicle to emerge. The cotyledons are pushed above the soil after germination by the elongation of the hypocotyl (Eaton, 1955). Compaction or crusting of the soil surface can restrict the emergence of the cotyledons. In favorable conditions, cotton seedlings can emerge in 4 to 14 days after planting (Ritchie *et al.,* 2004).

Seedling Establishment

The cotyledons grow rapidly producing carbohydrates for 10 to 12 days before the first true leaf appears. Early development of the cotton plant focuses on root development, resulting in a relatively slow growth rate of the above ground portion (Oosterhuis, 1990). The radicle or primary root can reach a significant depth of up to 30 cm, before the cotyledons emerge (Ritchie *et al.,* 2004). The *Gossypium* genus is renowned for having strong taproots which can penetrate up to 3 m in a suitable soil (Hearn *et al.,* 1984). Lateral roots are also produced which can extend up to 1 m. The root activity declines as bolls develop, requiring more carbohydrates that are redirected from the roots (Oosterhuis, 1990).

Seedling development is an important stage in the growth cycle of a cotton plant. A good stand of healthy plants is important. The seedling faces many challenges and is vulnerable to soil borne fungi such as Pythium (*Pythium aphanidermatum*), Rhizoctonia or damping off (*Rhizoctonia solani*) and Thielaviopsis (*Thielaviopsis basicola*). Ensuring that the seeds are planted at a suitable depth of 3 to 5 cm and at a rate of 10 to 13 plants per m (Cotton Seed Distributors, 2004) will minimize the risk of seedling damage or loss by fungal pathogens. Other factors that influence healthy vigorous seedlings are soil temperature, moisture availability and compaction.

The main stem of a cotton plant develops from elongation of the terminal bud (Oosterhuis, 1990). The main stem consists of nodes and internodes and does not terminate in an inflorescence like sorghum or wheat (Hearn *et al.,* 1984). A node can be produced every 2 to 4 days if conditions are favorable. The length of the internodes and number of nodes are determined by environmental factors and genetics (Oosterhuis, 1990). The main stem ismonopodial or vegetative in supporting true leaves and sympodial or fruiting branches (Ritchie *et al.,* 2004). Branches develop from buds located at a node. A vegetative branch may develop which is structurally the same as the main stem. Vegetative branches generally occur if the terminal on the main stem has been damaged (Oosterhuis, 1990).

Fruiting branches develop from nodes on the main stem and other vegetative. When a fruiting branch develops, a leaf and a flower bud or square is also produced at the same node (Oosterhuis, 1990). The elongation of the internode behind the square enables the fruiting branch to extend away from the main stem. The development of the fruiting branch terminates in a square or fruiting position (Oosterhuis, 1990). This leads to a second leaf and fruiting bud to develop at the axil of the first leaf and the process continues with extension of the internode. It is common to see a fruiting branch with three to four fruiting positions. The fruiting pattern of a cotton plant can be described as spiraling outward and upward in a 3/8 phyllotaxy (Ritchie *et al.,* 2004).

Cotyledons, prophylls and true leaves are the three types of leaves present on a cotton plant. The cotyledons are the first leaves to appear. They are kidney-shaped and paired or opposite on the main stem. The prophylls are the first leaves to develop on a branch (Oosterhuis, 1990). The prophylls are small and lack a petiole. The true leaves of a cotton plant vary in size. On average, true leaves are approximately 10 to 15 cm wide when developed. Cotton leaves reach their full size in about 2 to 3 weeks without stress factors (Hearn *et al.,* 1984).

Main stem leaves are approximately twice the size of leaves found on the fruiting branches (Hearn *et al.,* 1984). True leaves can appear entire or deeply lobed (Oosterhuis, 1990). Cotton leaves have a thick waxy cuticle and small hairs on the surface. Similar to branches, cotton leaves are arranged in a spiral configuration up the main stem (Oosterhuis, 1990). The cotton leaf supports the growth of its nearest vegetative parts (Hearn *et al.,* 1984).

Leaf Area and Canopy Development

Vegetative growth provides support for later fruit development (Oosterhuis, 1990). The development of the canopy is also important for maximizing the amount of light intercepted for photosynthesis. The blade of the cotton leaf follows the sun throughout the day (Hearn *et al.,* 1984). Canopy closure is an effective tool for the suppression of weeds and the minimization of water loss

from the soil (Oosterhuis, 1990). The Leaf Area Index (LAI) is the measurement of the developing canopy. The optimum LAI occurs 3 to 5 weeks after flowering (Hearn *et al.,* 1984). Vegetative growth must be managed appropriately to maximize yield. Producers often apply Pix® (mepiquat chloride), a chemical which suppresses the vegetative growth of the plant and promotes reproductive or fruit growth (Munk *et al.,* 1998).

Flowering and Boll Development

Reproductive development occurs approximately 4 to 5 weeks after planting. At this time the floral buds are forming in the upper part of the plant (Oosterhuis, 1990). These floral buds are known commonly as squares.

The square consists of 3 bracts which purposely cover and protect the reproductive parts. Squares and young bolls are often shed by the cotton plant. Shedding is a natural occurrence which is aided by environmental factors such as water stress, overcast conditions and insect damage (Oosterhuis, 1990).

The first flower appears from the square about 7 to 8 weeks after planting. The flowers towards the bottom of the plant open first. The first flower will open from the first fruiting position on the first fruiting branch. It takes about 3 days for the next flower to open on the same position on the next fruiting branch (Oosterhuis, 1990). The next flower on the same fruiting branch will open 6 days after the flower on the previous fruiting position.

The cotton flower possess male and female reproductive parts. The stamen and anther are male and the stigma, stylet and ovary are female (Ritchie *et al.,* 2004). Flowers open at dawn and are generally fertilized within a few hours (Oosterhuis, 1990). Cotton flowers are usually self-pollinated (Hearn *et al.,* 1984) when pollen falls from the anther onto the sticky surface of the stigma. Insects, particularly bees, can increase the amount of cross pollination. The white or cream flower begins to turn pink after pollination has occurred and is shed a few days later. The fertilized ovules develop into hard coated seeds which produce lint (Hearn *et al.,* 1984).

Maturation

Boll development is essentially the progression of the cotton fiber development. Lint develops from the epidermal cells of the seed coat (Hearn *et al.,* 1984). Fiber development begins with initiation, where the epidermal cell expands (Seagull *et al.,* 2000). Elongation is the second stage which refers to the expansion phase of fiber development, followed by secondary wall synthesis, the major phase of fiber growth (Ritchie *et al.,* 2004). Secondary wall synthesis explains the process of depositing cellulose after elongation has occurred, strengthening the fiber whilst developing its thickness or micronaire (Seagull *et al.,* 2000). Maturation is the final stage of fiber development. This phase begins when the bolls open and the metabolically inactive cotton fiber dries out (Seagull *et al.,* 2000).

Cotton (*Gossypium ssp*. L.) is a significant fiber yielding crop of the world. It belongs to the family Malvaceae, grown in tropical and subtropical regions of more than 80 countries all over the world. Cotton is an important source of earning and for foreign trade is very significant.

Plant growths mostly rely on environmental factors, changes in weather condition, management, genotypes characteristics and planting pattern. Weather is the foremost feature of crop growth and yield in any particular area and it diverges from small scale to large agro-ecological zone

Gossypium hirsutum has an indeterminate growth habit which needs to be managed to produce lint in one growing season. Cotton development can be divided into 5 growth stages: germination and emergence, seedling establishment, leaf area and canopy development, flowering and boll development, and maturation.

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