Chapter 3

COTTON SEEDLING ROOTS

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INTRODUCTION

Cotton (*Gossipium hirsutum* L.) is classified as a dicotylednous plant which means that upon germination the organs to first penetrate the soil are the two cotyledons. However, the very first organ to penetrate the seed coat is the radicle or the primary root which is characteristic of all dicot plants. The primary root is generally referred to as the "tap" root and can elongate at the rate of 2 to 3 cm per day depending on the soil conditions of texture and moisture content (Oosterhuis, 1990).

Lateral roots develop from the taproot beginning prior to ten days after germination and continuing on through the life of the plant until harvest (Figure 1). Tertiary roots can also develop from the existing lateral roots to form a mass of roots for each plant that can extent to 50-60 in depth again depending on the soil conditions (Oosterhuis, 1990).

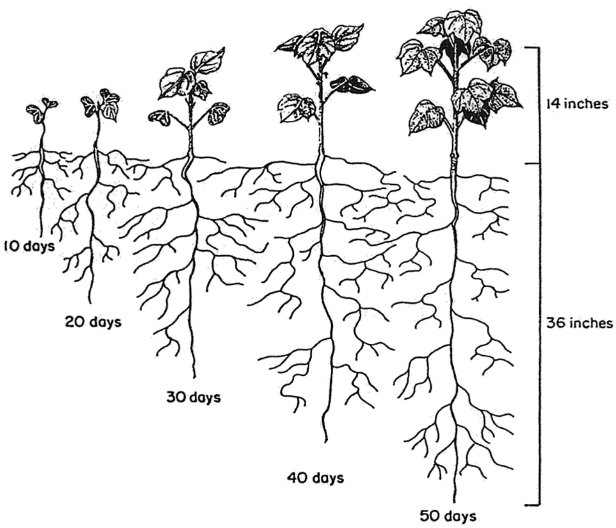

Figure 1. Root Development of the cotton plant. From: Oosterhuis 1990. Arkansas Cooperative Extension Service. Bulletin MP332.

The taproot has been described anatomically as having four to five distinct vascular "bundles" containing both xylem and phloem elements (Figure 2) (McMichael et al., 1985). The xylem elements are the organs in which water and nutrients are taken up by the developing seedling and transported to the entire plant. Also the total number of vascular bundles in the developing primary or taproot is critical in that the number of lateral roots developed along the taproot must have the connection between the lateral root primordia and the vascular or xylem elements in order for water and nutrients to be transported from the lateral roots to the taproot and finally to other parts of the seedling. The same organization applies to the connection between the lateral roots and the developing tertiary roots in the seedling.

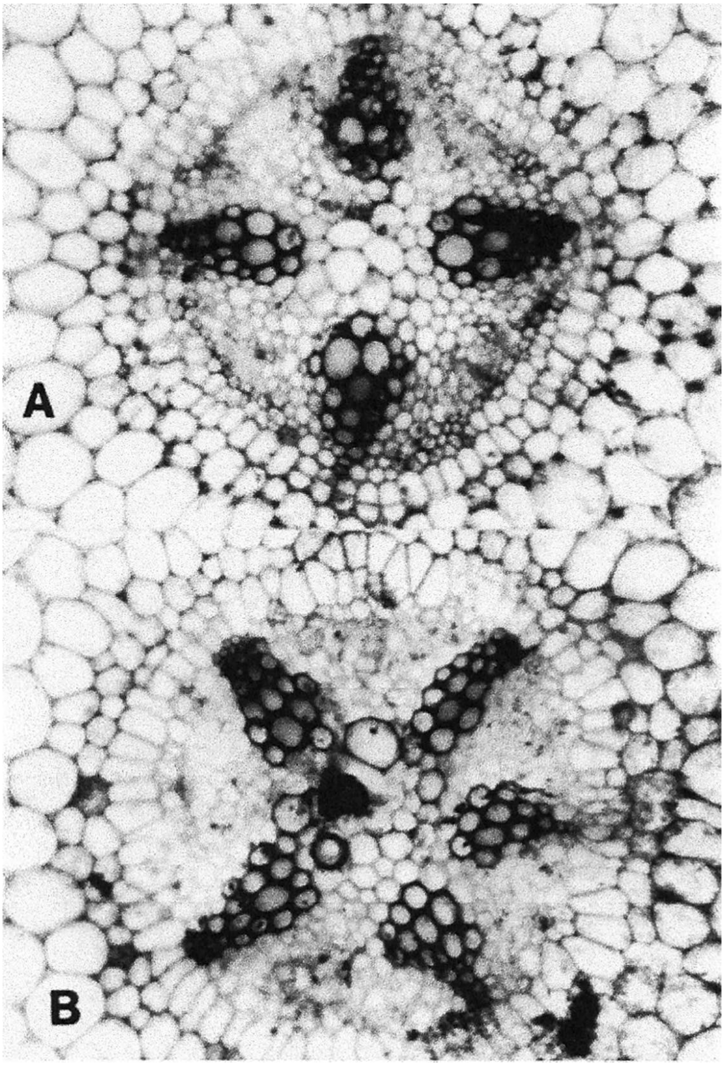

Figure 2. Xylem patter in primary roots of *G. hirsutum* cv. DPL-16 (A) and *G. hirsutum* cv. T25 (B). The tetrarch arrangement (A) is typical of cultivated cottons. The pentarch arrangement (B) has been found in drought tolerant types (X100). (From McMichael et al., 1983).

The seedling, which for this discussion I would consider to be 10-15 days after germination, develops a root system that is approximately not more that 15-20 g in dry weight. However, if the total length of the seedling root system is considered, these few grams equate to something on the order of several meters in length. Therefore, if the specific root length or length per unit weight is calculated, this number represents the changes in the diameter of the seedling root as development occurs.

PRODUCTION OF PLANT HORMONES

Certain plant hormones are produced in the roots and subsequently transported to the remanding parts of the developing seedling. Specifically, it has been shown that cytokinins are produced in the young root system and used in stems and leaves as the plant develops (MacAdam, 2009). Some gibberellic acid hormones may also be synthesized in the roots (MacAdam, 2009). Other plant hormones may influence root growth but are not specifically produced in the roots.

TEMPERATURE

The impact of temperature on seedling development has been covered extensively by other authors (McMichael et al., 2010; Taylor, 1983). However, the impact of these abiotic factors on seedling root development bears additional discussion. It has been shown that changes in soil temperature can have a significant effect on seedling root growth in cotton. In general, the optimum temperature for seedling root growth and development is 23-25°C (McMichael and Burke, 1994) (Table 1). If the temperature is reduced to 20°C, for example, the growth of the taproot is reduced and more importantly the initiation of lateral roots does occur but over a much longer period of time. Also, if the temperature is increased significantly from the optimum, (up to 40°C for example) the overall seedling root growth is reduced or stopped altogether (Figure 3) (McMichael, 1986).

Table 1. Development of 10-day-old cotton seedlings grown at four temperature regimes. Adopted from McMichael and Burke (1994).

Treatment		Root parameters			
Shoot temperature	Root temperature	Tap root length, cm	Later root length, cm	Total root length, cm	No. of laterals
28	20	3.08 ± 0.24*	0.0a	3.08± 0.24	0.0a
20	28	5.06 ± 0.28b	1.83 ± 0.35b	6.89 ± 0.54b	8.00 ± 0.83b
28	28	7.71 ± 0.59c	5.82 ± 1.15c	13.53 ± 1.07c	8.38 ± 0.90c
20	20	4.71 ± 0.35ab	0.0a	4.71 ± 0.35a	0.0a

* Means followed by the same letter are not significantly different at the 0.05 probability level based on Duncan's Multiple Range Test.

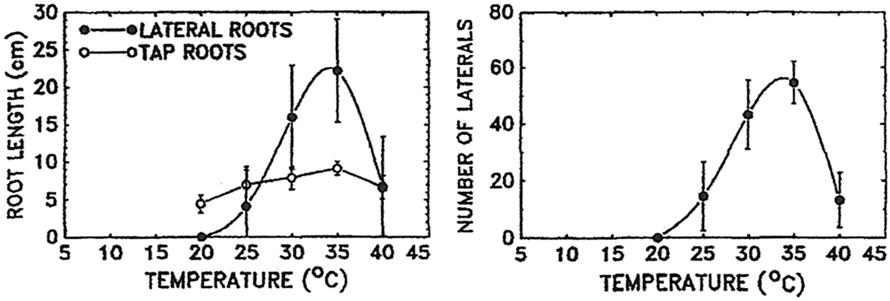

Figure 3. Root development of cotton seedlings as influenced by temperature. Vertical bars about each mean = 95% confidence limits. (From McMichael, 2010).

IMPACT OF STORED RESERVES

McMichael and Burke (1994) have shown that as stored reserves are depleted to supply nutrients to the entire seedling, the sensitivity to temperature changes of the organs including roots is increased therefore reducing the optimum temperature for maximum development.

SOIL COMPACTION

The degree of soil compaction can have a significant influence on the growth and development of seedling roots (Taylor, 1983). It has been shown that as soil compaction, specifically in clay soils, increases the growth of the roots decreases and the roots become thicker as they attempt to increase length (Glinski, 1990).

MYCORRHIZAE

The root systems of cotton plants become mycorrhizal or form a symbiotic association with the roots and the fungi depending on the initial levels of the fungi and other soil conditions (Nehl and McGee, 2010). The most common type of fungi to colonize cotton roots are termed arbuscular mycorrhizae (AM). The hyphae development by the fungi penetrates the cotton roots and moves internally across the cortex of the root. This symbiotic relationship thus provides the host plant (cotton) with additional phosphorus that might not otherwise be available to the plant, while the plant provides carbohydrates to the mycorrhizal fungi (Nehl and McGee, 2010). In general, therefore cotton plants whose root systems are devoid of AM fungi have been shown to have significantly reduced growth and development compared to plants that have formed mycorrhizae (Nehl and McGee, 2010).

SUMMARY

In summary, the growth of the root system of a cotton seedling is very dynamic with conditions that ultimately impact the outcome either act alone or in combination with other factors to produce a result. This brief account covers only a few of the abiotic as well as biotic factors that impact cotton seedling root growth in general. A more comprehensive account of the growth of cotton roots at this stage may be found in journal articles aimed specifically at the subject as well as books also written specifically describing cotton development (Pearson et al., 1970; Taylor, 1983).

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