Chapter 36

FIELD ENVIRONMENT AND STAND ESTABLISHMENT

Donald F. Wanjura
USDA-ARS
Lubbock, Texas

INTRODUCTION

Establishing a stand of cotton that consists of an adequate number of vigorous seedlings is important, because this is the first phase of the production cycle that sets a limit on yield potential. Everything that occurs subsequently only maintains or decreases the potential yield of the initial stand of cotton seedlings.

PHYSICAL FACTORS

The physical soil parameters that most often regulate hypocotyl elongation and seedling emergence under field conditions are temperature, moisture and physical impedance (Wanjura and Buxton, 1972b). Temperature regulates both the rate and maximum length that a hypocotyl can attain in the soil. Temperatures in the optimum range (20-30C) cause more rapid and longer maximum elongation than do lower or higher temperatures. Similarly, soil moisture influences the rate and maximum elongation of cotton hypocotyls. Moisture also affects the ratio of hypocotyl to radicle length (H/R). As moisture content decreases, the radicle elongates progressively more in relation to the hypocotyl, resulting in a decreasing value of H/R. Physical impedance also regulates the rate and maximum elongation of cotton hypocotyls. However, while temperature and moisture apparently regulate metabolic processes that produce elongation, physical impedance does not. Thus, hypocotyls that are prevented from elongating by physical impedance continue to grow, and the result is a thickening of hypocotyls (increasing diameter).

The stress imposed by low temperature and soil moisture causes increased variability of radicle elongation in germinating seedlings. In the temperature range from 38 to 15C and soil moisture tensions from -⅓ to -10 bars, a temperature decrease of 6.2C caused the same increase in variability of radicle length as a soil moisture tension increase of -1.1 bars when mean radicle length was 3 mm (Wanjura and Buxton, 1972a).

There are three primary characteristics of a seedling stand that determine yield potential—population, spacing uniformity and plant vigor. While all of these characteristics are important, plant vigor is the most difficult to evaluate. Speed or earliness of emergence correlates well with yield as a measure of plant vigor. Earliness of emergence was an indicator of plant vigor where differences in time of emergence were due to seed quality, planting depth or physical impedance (Wanjura *et al.*, 1969). In a field study, survival of plants emerging on the fifth, eighth and twelfth days after planting was 87, 70 and 30 percent, respectively, and the corresponding relative yields were 100, 46, and 29 percent.

In germination tests using seed of different sizes and densities, the rate of radicle elongation was an indicator of seedling vigor (Dalianis, 1982). Speed of seedling emergence was fastest for seed that had radicle emergence after germinating for 2 days at 20C, slightly less for seeds with radicles emerging on the third day, and significantly slower for seeds with radicles emerging on the fourth day. Plants from seeds where radicles emerged on the fourth day produced 14, 12 and 12 percent less dry weight after 32, 45 and 56 days of growth in the field, respectively, than did plants from seeds with radicles that emerged on the second day.

PLANTING FACTORS

The goal of the planting operation is to provide a good seed zone environment to germinate seed and emerge cotton seedlings. Because of the importance of the physical factors of the seed zone environment, the seedbed should be well prepared, and the planter should place seed in the soil at a uniform depth in firm contact with warm, moist soil at an acceptable spatial uniformity. When these planting conditions are met, moisture in the seed zone can be maintained long enough for seed to germinate.

Correct seed placement is important because depth affects the moisture and temperature environment around the seed and the time and energy needed for seedling emergence. Thus, seed vigor can affect emergence from a specific planting depth. In a study by Dalianis (1982) seedling emergence from seeds planted 4 cm deep was more rapid and complete than from seeds planted 7 cm deep. Deep planting had a greater adverse effect on emergence of seedlings that required four days for radicle emergence compared with seedlings that required only two or three days to accomplish radicle emergence. Average lint yield from seed lots of three different vigor levels, as measured by germination percentage, was 891, 865 and 717 kg/ha for planting depths of 5.1, 7.6 and 10.2 cm, respectively (Wanjura *et al.*, 1969). Seedcotton yields were 440 kg/ha higher for a planting depth interval of 2.5 to 5.1 cm than at a depth of 7.6-10.1 cm (Hudspeth and Jones, 1954).

POST-PLANTING FACTORS

The factors which most frequently cause poor emergence, even if seed are properly planted, are soil crusting due to rainfall and low temperature. The occurrence of either of these situations is largely uncontrollable once seed are planted. Soil crusting can be best managed if the planted bed profile provides for rapid drainage of rainfall away from the seed zone and permits the use of mechanical crust breaking tools. The best strategy for circumventing low temperatures is careful selection of planting date based on soil temperature.

Holekamp *et al.* (1966) used the results from a seven year field study to develop a procedure for selecting planting date for cotton on the Southern Great Plains based on soil temperature. The earliest recommended date for planting was when the 10-day average of the minimum soil temperatures at 20 cm reached 16C. Emergence generally increased as the temperature average increased up to 19C. Below a 16C average minimum soil temperature, less than 40 percent of the seed planted produced seedlings.

Procedures for estimating the length of time between planting and emergence usually include a factor that measures cumulative heat input. One simple measure that correlated well with initial cotton emergence was developed from the results of a three-year field study by Wanjura *et al.* (1967). In this procedure, whenever 103 hours of temperature above 18C at seed level had accrued after planting, initial emergence occurred from a 5.1 cm planting depth. In another study, predictive relationships were developed between times to initial, or 45 percent of final, emergence and cumulative average daily air temperature, or cumulative average daily minimum seed level temperature (Wanjura *et al.*, 1969). Correlations between measures of cumulative heat input, such as those above, and time periods for emergence are good, provided planting depth is not changed and other factors controlling emergence remain at nonlimiting levels.

If soil crusting occurs, the force created by emerging seedlings is very important in overcoming the resistance of the crusted surface. A study by Gerard (1980) showed that emergence force of cotton seedlings was a linear function of volumetric soil moisture, number of seedlings and cross-sectional area of emerging hypocotyls. Maximum diameters of hypocotyls constrained by a mechanical crust at 22, 27, 32 and 40C averaged 0.32, 0.41, 0.34 and 0.25 cm, respectively, and the maximum forces exerted were about 350, 600, 400 and 200 g, respectively. The time required to reach maximum exertion by the seedlings was temperature dependent and ranged from 40 to 48 hours at 32C and 50 to 60 hours at 27C. Bilbro and Wanjura (1982) showed that, as soil crust resistance increased from 100 to 1000 kPa, mean emergence date increased linearly, emergence percentage and emergence rate index decreased linearly, and seedling hypocotyl diameter increased in a positive, curvilinear manner.

In a greenhouse experiment using several levels of constant temperature, Wanjura and Minton (1981) studied the effects of soil crusting on emergence by delaying emergence for 50, 100 and 150 percent of the normal emergence time for noncrusted conditions. Seedling survival and hypocotyl diameter were minimal at 26 and 24C, respectively. Seedling emergence and survival were significantly reduced at delays between 50 and 100 percent of the normal emergence period. A similar study was conducted for 3 years under field conditions using emergence delays up to 100 percent of normal emergence time (Wanjura, 1982). Regression analysis estimated reductions in seedling survival from the expected survival under no emergence delay of 13, 32 and 58 percent, respectively, for emergence delays of 33, 66 and 100 percent. For these same levels of emergence delay, lint yield reductions averaged 10, 33 and 56 percent.

Soil salinity decreases the performance of germinating cotton seedlings according to Sexton and Gerard (1982). Results from their study indicated that each unit increase in soil salinity in the range of 4.0 to 17.0 mmhos/cm EC_e (the electrical conductivity of the soil solution) reduced the average emergence force of a cotton seedling by 23.5 g. The time required to reach maximum emergence force increased from 58 to 77 hours for soil salinities between 1.6 and 17.3 mmhos/cm, but a unit increase in salinity in the range of 17.3 to 29.7 mmhos/cm increased this time by 13 hours.

Cotton has a high Q_{10} for oxygen consumption during the germination stage (Coble, 1965). Oxygen requirements for normal respiration increased a minimum of 300 percent when temperature increased from 18 to 28C. The solubility of oxygen in water decreases about 20 percent, and the diffusion coefficient increases 30 percent over the same temperature range. Since solubility and diffusion affect oxygen availability in an opposite manner, the net effect is an apparent 10 percent increase in oxygen availability. However, Coble (1965) concluded that, if an oxygen limitation to cotton germination did occur, it would be more severe at higher temperatures. In a laboratory experiment by Bowen *et al.* (1971) cotton seed were planted in vermiculite and subjected to alternate periods of varying duration of water flooding followed by periods of drainage at different levels of constant temperature between 18 and 35C. The general trend at all temperature levels was for increased growth rate and more healthy seedlings as the ratio of drainage: flooding increased. The length of the drainage and flooding periods did not affect seedling performance at 18C. However, at higher temperatures growth rates and seedling vigor were reduced as the cycle lengths of drainage and flooding increased between 6, 12 and 24h, regardless of ratio of drainage: flooding time within cycles.