THE EFFECT OF POLYMER FILM COATINGS ON COTTONSEED IMBIBITION, ELECTRICAL CONDUCTIVITY, GERMINATION, AND EMERGENCE

T.H. Struve and N.W. Hopper
Graduate Research Assistant, Texas Tech University and Seed Physiologist, Texas Tech University and Texas Agricultural Experiment Station
Lubbock, TX

Abstract

Imbibitional chilling injury in cotton occurs as dry seeds rapidly imbibe cold water. The susceptibility to this type of injury could be potentially alleviated with the application of a polymer film coating, which slows water uptake. This study focused on determination of imbibition, electrical conductivity (EC), germination, and field establishment of cotton seed treated with polymer film coatings. The coating treatments included an uncoated control, a Landec polymer, and a Daran polymer. Among the coating treatments, the Landec coated seed exhibited a significantly slower imbibition rate through 24 hours when compared to the control. Data indicated that this reduction in imbibition rate protected the sensitive seed, as was evidence by reduced EC values and improved germination performance (increased normals and reduced abnormals). In addition, field data indicated that the Landec treatment resulted in a higher number of established seedlings (4WAP), when planted under cold soil conditions.

Introduction

The growing season on the Southern High Plains of Texas is short and thus prompts producers to plant early and take advantage of limited seasonal heat units. But one of the major obstacles for producers is acquiring a good stand under suboptimal spring planting conditions. Producers faced with the constraint of having to plant early risk high seedling mortality, delayed emergence, reduced yield, and lower fiber quality (Christiansen, 1964; Christiansen and Thomas, 1969; Thomas and Christiansen, 1971; Wanjura et al., 1969). Studies have indicated that when cotton is planted early under suboptimal temperature conditions, only 40% to 60% of the total seeds planted ever result in established and productive plants (Staus and Hopper, 1983; Gregory et al.,1986; Hopper and Gregory, 1986). One reason for this low survival is the susceptibility of germinating cotton seedlings to imbibitional chilling injury. Numerous studies have shown the detrimental effects of low temperature (chilling injury) on imbibing seeds and emerging seedlings (Christiansen, 1964; Christiansen, 1968; Cole and Wheeler, 1974). Christiansen (1967) reported two periods of seed chilling sensitivity. The first when seeds are initially imbibing water and the second after 18 to 30 hours of germination at 31°C. Chilling injury associated with imbibing seeds is manifested by radicle tip abortion while chilling the seedling after elongation of the embryonic axis has started results in root cortex disintegration (Christiansen, 1963). Most of these studies used temperatures from approximately 5° to 15°C to induce the chilling injury, although, Cole and Wheeler (1974) reported that temperatures below 20°C reduce germination of cottonseed and seedling emergence.

One of the proposed mechanisms by which cell damage occurs during imbibition at suboptimal temperatures is membrane rupture and subsequent loss of cellular constituents. The damage incurred at cold temperatures has been directly related to the rate at which the seed imbibes water (Tully et al., 1981; Powell and Matthews, 1978).

One method of reducing imbibitional chilling injury has been the use of a coating material on the seed to slow the entry of cold water. Powell and Matthews (1978) reduced chilling damage on dry pea embryos by slowing imbibition rates with Carbowax 4000. Priestley and Leopold (1986) reported that coating soybean and cottonseed with a thin coat of lanolin significantly reduced chilling injury to seedlings planted in a peat:soil mixture in the greenhouse. More recently seed coating and specifically film coating using polymer films have become available to the seed industry. Taylor (1987) saw slight improvements in chilled germination tests of snap beans treated with hydrophobic polymers capable of slowing the rate of imbibition.

Materials and Methods

Two widely planted cotton cultivars (Paymaster HS26 and Paymaster HS200) were utilized for this study. Each cultivar received treatments of no polymer seed coating (uncoated control), Daran SL112 (4% of seed weight), and a Landec Seed Coating LL176-17 (a product of Landec Corp.) applied at approximately 0.8% of the seed weight. The seed were then evaluated for water imbibition, germination, electrical conductivity (EC), and field establishment. Each of the following tests was conducted in 1994 and 1995.

Imbibition rates were determined by placing approximately 5 grams of seed from each treatment/replication onto foam mats (32 x 44 x 1 cm). The foam mat was rolled up and then saturated with water equilibrated to 12°C. After allowing the excess water to drain from the foam mat, they were placed into a chamber set at a constant 12°C . The seed were removed after 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 24.0 hours, blotted dry, and weighed. Imbibition rate is expressed as percent moisture based on initial seed weight.

In order to determine electrical conductivity values of seed leachate, five grams of seed from each treatment were placed in 50ml vials. The seed were then soaked in 30ml

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of distilled water for 24 hours at either 5°C or 25°C. After 24 hours, the leachate was decanted and allowed to equilibrate to room temperature. EC's were determined using a solute conductivity bridge. The data is expressed as the EC difference between 5°C and 25°C.

A germination test (modified) after chilling was also conducted. One hundred seed from each treatment were imbibed at 5°C for 24 hours in rolled germination towels, then moved to 30°C for an additional 3 days. Seedlings were evaluated as normals and abnormals and expressed as a percentage of seed that germinated.

The field study was planted in 4 row plots x 11 meters long. In 1994 the plots were planted on April 21 at a rate of 6 seeds per foot of row. In 1995 plots were planted on April 23 at a rate of 5 seeds per foot of row. Seedling emergence was evaluated using an establishment index. Four weeks after planting a stand count was made. The number of surviving seedlings expressed as a percentage of the total number of seed planted constituted the establishment index (4WAP).

Results and Discussion

Both years of imbibition data indicated that at 12°C (Figures 1a., and 1b.), the Landec coated seed had a lower moisture percentage than the uncoatedcontrol at each time interval (0.5, 1, 2, 4, 8, 16, and 24 hours). The Daran polymer had similar moisture percentages as the uncoated control except in 1994, when the Daran coated seed exibibted slightly higher moisture percentages (from 2 to 16 hours) than the uncoated control (Figure 1a.) Thus the data indicate of the two polymers evaluated in this study, the Landec polymer exhibits the hydrophic characteristics to slow the rate of imbibition through 24 hours.

Electrical conductivity (EC) values were also measured to determine the extent of cellular damage during imbibition at chilling temperatures and subsequent electrolyte leakage. In both years of the study, the amount of electrolytes measured at 5°C for the uncoated and Daran coated seed was much higher than at the 25°C readings (Figure 2). However, there was very little difference in the 5°C and 25°C readings for the Landec coated seed. The Landec polymer reduced ΔEC values by approximately 90% as compared to the control in 1994 and 1995.

Coating treatments had a significant effect on the number of normal and abnormal seedlings produced when imibibed at 5°C for 24 hours followed by germination at 30°C for 3 days. The Daran material which does not tend to slow imbibition, did not reduce the percentage of abnormal seedlings when compared uncoated control. However, in 1994 and 1995 the Landec polymer significantly ($P \leq 0.05$) reduced the number of abnormal seedlings as compared to the uncoated control (Figure 4). The Landec coated seed had fewer abnormal seedlings in the 1994 and 1995 studies (47% and 66% respectively), when subjected to the chilling treatment (5°C for 24 hours). In 1994, the Landec coating also had a significant effect on the number of normal seedlings, resulting in a 16% increase in normals as compared to the uncoated control (Figure 3). Similar results were noted in the 1995 study, with approximately 7% more normal seedlings (as compared to the control) when coated with the Landec material (Figure 3). However, in neither year of the study was the Daran coated seed significantly different than the control. Thus the data suggest that the Landec polymer has the potential to reduce cellular damage by slowing the rate of imbibition, and thus reduce the number of abnormal seedlings and increase the number of normal seedlings when exposed to chilling conditions (5°C) during imbibition.

In 1994 no differences in establishment percentages were noted among the coating treatments (Figure 5). We suggest that this was likely due to the unusually warm planting conditions to which the seed were subjected the first few days after planting in which very little imbibitional chilling injury was seen. However, 1995 planting conditions were extremely cold and the data suggest (Figure 5) that the Landec coating significantly ($P \leq 0.05$) increased the establishment percentage (4WAP) as compared to the uncoated control. The number of surviving seedlings (4WAP) was approximately 18% greater than the uncoated control. The Daran coating, which was previously reported to have little effect on slowing the rate of imbibition, was not different than the uncoated control.

These data suggest that reducing the imbibtion rate at chilling temperatures (ca 5°C) by using a polymer coating may result in less cellular damage incurred by the seed during hydration. Electrical conductivity values were dramatically reduced, as was seedling injury (increased normal and decreased abnormal seedlings). The field data also suggest that establishment can be increased (1994) by using a polymer that reduces imbibition rate under cold planting conditions.

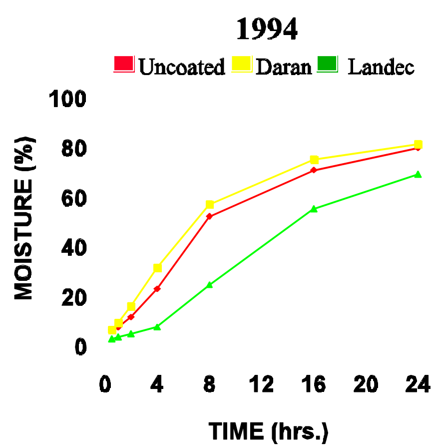

Figure 1a. Percent seed moisture for seed treated with no coating, Daran, and Landec polymers and imbibed @ 12C for 24 hours.

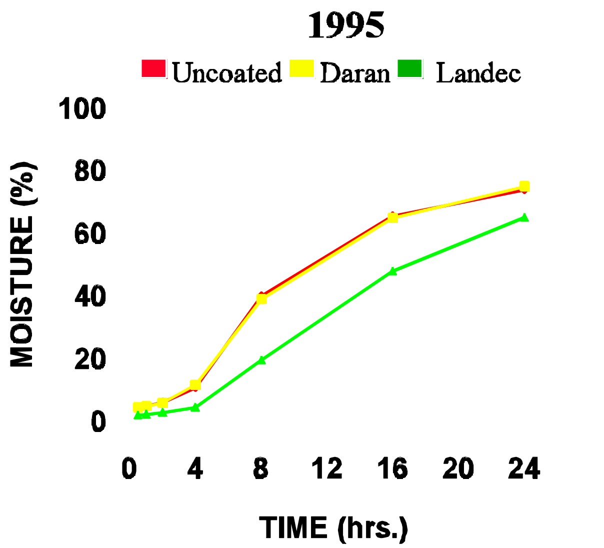

Figure 1b. Percent seed moisture for seed treated with no coating, Daran, and Landec polymers and imbibed @ 12C for 24 hours.

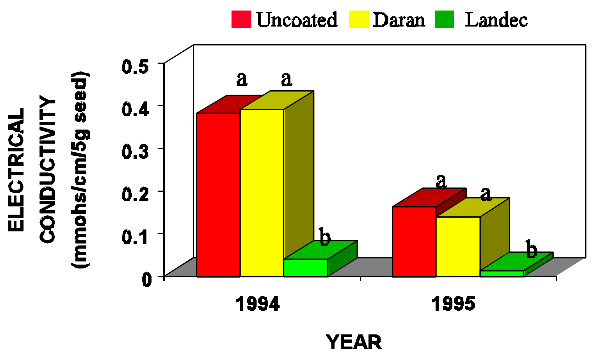

Figure 2. EC expressed as the difference in 5C and 25C for uncoated control, Daran, and Landec coated seed.

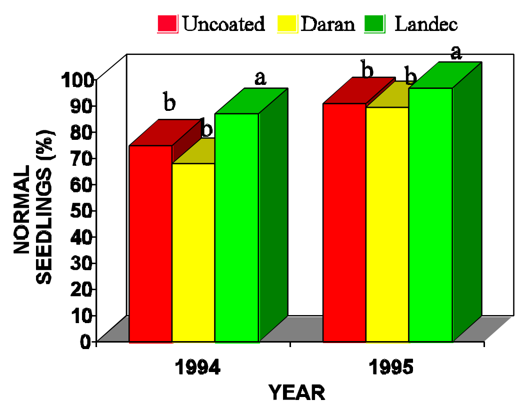

Figure 3. Normal seedlings expressed as a percentage of germinated seedlings.

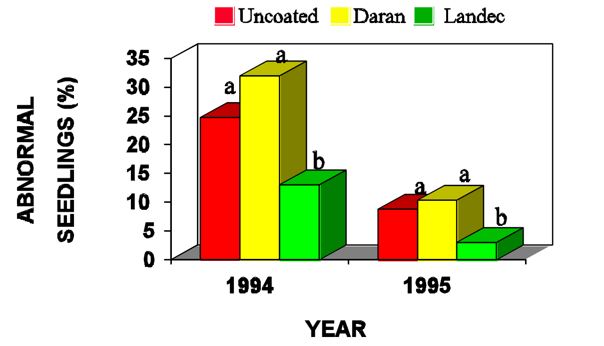

Figure 4. Abnormal seedlings expressed as a percentage of the number of germinated seedlings.

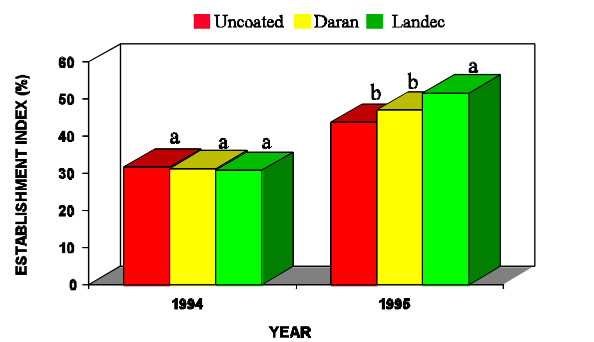

Figure 5. Establishment index percentages (4WAP) for seed treated with no coating, Daran, and Landec polymers.

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