# COTTON PERFORMANCE AS AFFECTED BY PARTICLE FILM AND MYCORRHIZAE TREATMENTS

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## Abstract

Cotton was planted in Weslaco, TX into a Raymondville clay loam soil on 26 Mar. 1999 to evaluate the potential use of a particle film and of VA mycorrhizal (*Gomes intaradices*, L.) inoculation in reducing abiotic plant stress. Four treatments consisting of control, 'Surround'-sprayed plants, mycorrhizal-treated seed, and the combination of the later two treatments were evaluated for their effect on plant water status, phenology, and lint yield. 'Surround' applications reduced canopy temperatures and increased leaf transpiration rates compared to control plants. Plants grown from mycorrhizal-treated seed had higher transpiration rates than control plants, improved plant stand, and higher levels of mycorrhizae associated with their root system when compared to untreated seed. 'Surround', mycorrhizae, or in combination, significantly reduced whole plot canopy temperatures and improved lint yields, when compared to the control treatment. Plant phenology, soil water profile, leaf chlorophyll, and leaf blade nutrient content were not affected by any of the treatments.

## Introduction

In arid environments, about 360 units of water are normally required to produce 1 unit of cotton (Hanson, 1990). As pressure to reduce water use from non-agricultural sectors increases, exploring alternative approaches to improve cotton plant water efficiency becomes even more important. Active leaf transpiration is necessary for normal physiological plant processes and is related to yield by the relationship Yield = $k_{\text{for specific crop}}$ X Transpiration / [100 - Relative Humidity], where k = 0.089 in the case of cotton (Hanson, 1990).

In this study, we considered two approaches to improving cotton plant water status, and thus increasing transpiration rate. The first approach was to reduce leaf heat load by reducing the total solar incident irradiation on the leaf by application of a particle film to the upper surface. A particle film has the advantage over an anti-transpirant by not interfering with stomatal closure and the regulation of internal leaf temperature. The particle film used in this study also has pesticidal attributes, as reported by Poprawski and Puterka (1999), for thrip and white fly control in onion. The second approach was to stimulate the occurrence of mycorrhizal association with cotton roots by treating the seed before planting. Cultural practices that stimulated mycorrhizal association with cotton in the Southern High Plains of Texas, also improved seed establishment and subsequent yields (Zak, et al. 1998). Mycorrhizae can also improve plant water potential when plants are subjected to drought stress (Augé, et al. 1986).

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## Materials and Methods

On March 26, 1999, seed of an experimental cotton line X2424 (Novartis, Minneapolis., MN) was sown either untreated or treated with a vesicular arbuscular mycorrhizal fungus (*Gomus intaradices*, Schenk & Smith; from Reforestation Technologies, Salinas, CA) and planted with a cone planter into a Raymondville clay loam (Fine mixed, hyperthermic Vertic Calciustolls) soil located at the ARS facility in Weslaco, TX (Lat. 26º 12'). Prowl (pendimethalin) was applied as a pre-emerge herbicide at 1.1 kg a.i./ha. Plot size was 9.1 x 2.3 m, three rows wide, on 0.76 m centers. Plants grown from both one-half of the untreated and mycorrhizal-treated seed were sprayed perodically with 'Surround', a clay-based particle film with separate surfactant (Engelhard Corp., Iselin, NJ) at a rate of 3% product to water (w:v). Thus, there were four treatments; (1) control, (2) 3% 'Surround'-sprayed plants, (3) mycorrhizal-treated seed, and (4) the combination of (2) and (3). 'Surround' application was renewed when approx. 25% of the plant surface was unprotected due to new growth, or after a rain. The six particle film applications were made between 4 May and 21 July.

Plots were pre-irrigated 19 Mar. before planting on 26 Mar. and irrigated again11 June. There were 292 mm of rainfall between 27 Mar. and 17 Aug. Soil moisture was measured five times during the growing season by neutron probe at depths of 25, 50, and 100 cm in access tubes located in the center of each plot in reps 2, 3, and 4 (five reps total). Continuous surface leaf canopy temperature was measured by IR thermocouples (Omega Engineering, Stanford, CT) with model OS36-2-T-80 units having a 1:2 aspect ratio and centered ca. 25 cm above the middle plot row, covering ca. 0.2 $m^2$ of row canopy. Interior temperatures were measured at 30 cm above the soil, within the plant canopy, by standard thermocouples. Every one to two weeks, the thermocouple sensors were rotated between treatments and installed in different reps. Average hourly temperatures were collected daily over a continuous five week sampling period.

Porometric water measurements were taken on the fifth leaf from the apex with a LI-COR Model 1600 porometer (Lincoln, NE) between 1100 and 1330 hrs on 8 June and 2 July. The same fully expanded leaves used for porometry were excised, placed in a sealable bag and returned on ice to the lab for water potential measurements which were determined with a 'Tru-Psi' psychrometric system (Decagon Devices, Pullman, WA). On sampling dates, plot canopy temperatures were also estimated around mid-day using an IR pyrometer (Omega Engineering).

Three plants per plot were removed on 10 June and 2 July to estimate phenological development and plant water content. On 10 June twenty leaf blades (fifth leaf from the apex) in each plot were sampled, frozen, lyophilized, ground through a 0.36 mm mesh screen and stored until analyzed. Samples were analyzed for chlorophyll and the leaf nutrients N, P, K, Ca, Mg, S, Mn, Na, Fe, Al, Zn, and B. On 3 Aug., roots from three plants/plot were removed to document the extent of mycorrhizal infection. On 18 Aug. plants from a 3.5 $m^2$ center plot area were hand harvested for seed and lint yield. The experiment was analyzed as a randomized complete block design with five replications and when sampling occurred, dates were treated as sub-plots.

## Results and Discussion

### Particle Film

Application of 'Surround', either alone or in combination with mycorrhizal-treated seed, reduced whole plot canopy temperatures on both sampling dates, compared to the control plants (Table 1). Although leaf water potentials were not significantly different between leaves of treated plants and control plants, transpiration rates were greater in treated leaves at the time of sampling, suggesting that these leaves were less stressed. At the time of sampling, light intensity, which can regulate stomatal aperture, was similar for all treatments.

'Surround' applications reduced average weekly exterior canopy temperature 0.8, 1.1, and 1.7 °C for sampling periods beginning 30 June, 13 July, and 23 July, respectively (Table 2). Corresponding interior plant canopy temperatures were reduced 0.3, 0, and 1.2 °C, respectively.

General plant phenology was not affected by any treatment. The means for plant water content, fresh and dry plant weight, closed bolls, and blossoms were numerically lowest in control plants compared to the same mean responses from treated plants, but were not statistically different (Table 3). Differences were observed between sampling dates. At harvest, lint yields (P=0.14) were significantly higher in treated plants compared to control plants (Table 4).

### Mycorrhizae

Leaves from mycorrhizal-treated seed had higher transpiration, lower plot temperatures and similar water potential compared to control plants on both sampling dates (Table 1). Plants appeared to be less stressed on the second sampling date. Unseasonable rain events occurred during this latter sampling period.

Plant performance (see particle film discussion) was not affected by seed treatment, but plant height and the number of squares at the time of sampling, had numerically lower means (Table 3). Three plants per plot may have been an inadequately small sub-sample. Treatments which had been inoculated with mycorrhizae had higher lint yield and had more mycorrhizae associated with the tap root than plants grown from non-treated seeds. When treatments were analyzed as a factorial (no mycorrhizae vs mycorrhizae) plant stand was also improved with mycorrhizal treatment ($P$ = 0.03, data not shown).

### Soil Moisture

Mean soil moisture throughout the soil profile, summed over the growning season, was 196, 197, 203, and 197 kg/$m^3$ for control, 'Surround'-, mycorrhizal-, and 'Surround' + mycorrhizal-grown plants, respectively. Soil moisture at 25, 50, and 100 cm depth was 183, 229, and 183 kg/$m^3$, respectively. Only depth, date, and their interaction were significant (data not shown). The inability to measure residual soil moisture differences may have been related to the frequent recharge mid-to-late in the season from rainfall or from plant roots reaching a relatively high water table.

There were no differences in leaf chlorophyll content between treatments (data not shown). In preliminary greenhouse experiments, plants receiving sequentially higher particle film rates had increasingly higher SPAD (greenness) readings. Leaf blade nutrient uptake did not appear to be influenced by any of the treatments (data not shown).

## Summary

Both particle film, as 'Surround', and mycorrhizal-treated seed are potential tools for improving cotton yields. They both appear to reduce plant stress, probably by different mechanisms, and resulted in improved lint yields compared to the untreated plants.

## References

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Table 1. Effect of 'Surround' and mycorrhizal seed treatment on plant leaf water status for two sampling dates.[1]

| | Water Potential (-bars) | Transpiration (μg cm$^{-2}$s$^{-1}$) | Light (μmol m$^{-2}$s$^{-1}$) | Plot Canopy Temperature (°C) |
|---|---|---|---|---|
| Date: | | | | |
| June 9 | -23.6 | 19.2 | 2048 | 37.7 |
| July 2 | -21.6 | 15.7 | 2215 | 36.8 |
| | ** | ** | ** | NS |
| Treatment: | | | | |
| Control | -23.2 | 15.1 b | 2151 | 38.4 a |
| Surround (S) | -22.0 | 17.7 a | 2041 | 37.2 b |
| Mycorrhizae (M) | -22.1 | 19.0 a | 2122 | 37.1 b |
| S + M | -23.0 | 17.9 a | 2213 | 36.3 b |
| | NS | 0.12[2] | NS | * |

[1]No significant interactions.
[2]Prob. > 'F' value. NS, *, ** = Not significant at P=0.05 and P=0.01, respectively. Mean separation at prob. level shown.

Table 2. Surface and interior plant canopy day temperatures (°C) of 'Surround'-sprayed and water control-sprayed cotton leaves during three weekly periods in the growing season [1]

| Beginning Dates | Exterior canopy | | Interior canopy | | |
|---|---|---|---|---|---|
| | Control | Surround | Control | Surround | Light[2] |
| June 30 | 28.6 ±1.8 | 27.8 ±1.1 | 30.0 ±2.1 | 29.7 ±2.0 | 3.96 |
| July 13 | 26.1 ±1.7 | 25.0 ±1.8 | 28.6 ±1.7 | 28.6 ± 1.8 | 3.74 |
| July 23 | 28.1 ±1.3 | 26.4 ±0.6 | 31.6 ±1.4 | 30.4 ± 1.0 | 4.45 |

[1]Weekly average hourly temperatures between 7 A.M. and 7 P.M. Exterior temperatures measured by IR-thermocouples, interior by standard thermocouples.
[2]Average total daily light, in W m$^{-2}$.

Table 3. Effect of 'Surround 'and mycorrhizal seed treatment on agronomic components of cotton plants on two sampling dates[1]

| | Plant Water Content (%) | Plant Height (cm) | Fresh Weight (g) | Dry Weight (g) | Squares (No.) | Closed Bolls (No.) | Open Bolls (No.) | Bloss-oms (No.) |
|---|---|---|---|---|---|---|---|---|
| Date: | | | | | | | | |
| June 10 | 75.5 | 56.2 | 118 | 28.4 | 10.3 | 5.2 | 0.0 | 1.8 |
| July 2 | 76.8 | 63.6 | 257 | 59.5 | 6.4 | 6.0 | 0.1 | 0.0 |
| | 0.09 [2] | ** | ** | ** | * | NS | 0.18 | ** |
| Treatment: | | | | | | | | |
| Control | 75.9 | 60.7 | 162 | 38.5 | 8.9 | 4.3 | 0.1 | 0.5 |
| Surround(S) | 76.2 | 62.1 | 209 | 49.0 | 8.1 | 6.2 | 0.0 | 0.9 |
| Mycorrhizae(M) | 76.6 | 55.8 | 177 | 40.2 | 6.3 | 5.2 | 0.0 | 1.0 |
| S + M | 76.0 | 61.1 | 201 | 48.2 | 10.2 | 6.7 | 0.1 | 1.3 |
| | NS | 0.17 | NS | NS | NS | NS | NS | NS |

[1]Three plant sub-samples were used per plot. There were no significant interactions.
[2]Prob. > 'F' value. NS, *****, ****** = Not significant or significant at P=0.05 and P=0.01, respectively.

Table 4. Effect of 'Surround' and mycorrhizal treated seed on cotton stand and yield

| Treatment | Plant Stand (x10$^4$/ha) | Lint Yield (Kg/ha) | Mycorrhizal Association (%) |
|---|---|---|---|
| Control | 9.3 | 688 b | 28.2 b |
| Surround (S) | 9.3 | 842 a | 44.7 b |
| Mycorrhizae (M) | 10.6 | 828 a | 87.1 a |
| S + M | 11.0 | 917 a | 93.5 a |
| | 0.22[1] | 0.14 | * |

[1]Prob. > 'F' value. NS, * = Not significant or significant at P=0.05, respectively. Mean separation at prob. level shown.