**Water Stress Development and Mitigation in West-Central North Dakota**

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**Objective**: To evaluate compounds known to slow transpiration (anti-transpirants) on the development of water stress in soybeans, and the effect on final yield.

**Background**: Soybean production is spreading west in North Dakota, into the drier parts of the state. Water shortage will limit yields in most years. Most farmers have already adopted advanced water-saving technologies, such as no-till and control of off-season weeds and volunteers. A little-studied possibility for the reduction of water stress is the area of anti-transpirants. The concept behind the use of anti-transpirants is that if water use can be slowed during vegetative stages of growth, there may be more water available during grain fill. In a previous study for the NDSC, we surveyed a large number of compounds previously shown to reduce transpiration by plants. That survey identified many compounds, but the most effective ones, the ones chosen for this study, were ethephon (a growth regulator), paclobutrazol (a growth regulator), and Priaxr (a "plant health" product). Along with these three materials, a film-based antitranspirant ("Wilt-pruf") and a reflective antitranspirant (white kaolinite clay) were used.

**Materials and Methods**

Three identical experiments were established on fields near Underwood, Cole Harbor, and Minot, ND. The experiments were placed either on farmer's fields (Underwood, Cole Harbor) or at the North Central Research Extension Center, on soybean fields after emergence. The variety was 'ND 17009GT' at Minot, and 'ND Bison' at the other two locations. All fields were in a no-till management program.

There were 12 treatments and the experimental design was a randomized complete block design with four replicates. The experimental treatments are shown in Table 1. The first application was made pre-flower, and the second application was made post-flower.

Soil water content was monitored in the control plots. The water status of the plant leaves was measured periodically. Plant water status was measured using the "relative water content" (RWC) method. With this method, upper trifoliolates, with petioles are taken from random plants, and placed immediately in a ziploc bag, and placed in a cooler. The leaves are weighed (weight A), and the cut ends of the petioles placed in distilled water overnight, after which they are weighed again (weight B). Then, the leaves are dried, and weighed again (weight C). The formula for % RWC is:

% RWC = 100 x [(A-C)/(B-C)]

From prior experience, values greater than 90% indicate little or no water stress, values between 80 and 90 indicate slight or moderate water stress, and values less than 80 indicate severe water stress.

At physiological maturity, two rows were taken from the center of the plot, the plants threshed, the seed cleaned, and grain yields calculated.

**Results**

The year 2017 was a difficult year for soybean growers in much of North Dakota. The water "deficit" (estimated evapotranspiration minus rainfall) exceeded 10 inches for many parts of the state (Figure 1). A deficit of up to 4-6 inches can be compensated for, if the soil is fully-charged with available water in the spring, but deficits much greater than that will reduce yield. The location of our plots was in one of the drier areas in North Dakota in 2017.

The results for the relative water contents of the upper leaves and grain yield for the Underwood site are shown in Table 2. This site received the most timely rainfall of the three sites. Leaf sampling on 8 and 17 August gave relative water contents greater than 90%, indicating good water availability. Samples taken on 31 August and 7 September were generally between 85 and 90%, suggesting only a slight or moderate water stress. The yield of the site, averaged across all treatments, was 28 bu/A, a good yield for that area in 2017. There were no significant effects of the experimental treatments on relative water content at any sampling date, or on final seed yield.

The results for the relative water contents of the upper leaves and grain yield for the Cole Harbor site are shown in Table 3. Water stress was more pronounced at this site than at the Underwood site, with moderate water stress at the 27 August, and very severe water stress at 3 September, and 7 September sampling dates. Kaolinite significantly increased RWC over the control on 17 August, and several of the ethephon treatments had significantly increased RWC over the control at 3 and 7 September. However, despite these measured increases in plant water status, seed yields were statistically the same for all treatments. Yields were very low, in the range of 10-13 bu/A.

The pattern of water stress was different at Minot. Upper trifoliolate sampling indicated a slight to moderate level of water stress at all sampling dates. None of the experimental treatments increased plant RWC, except for the late spray of ethephon on 27 August. Yields were intermediate between Underwood and Cole Harbor, with yields between 12 and 21 bu/A.

The overall patterns of late-season water stress at the three sites are shown in Figure 2. Relative water contents and yields averaged across treatment were used. For the Underwood site, plant water status was good until the final two samplings in late August and early September. Overall, yields were good, averaging 28 bu/A. At the Minot site, plant water levels indicated a slight to moderate water stress at all sampling dates, and a final yield of about 16 bu/A was obtained. The Cole Harbor site actually appeared more vigorous than the Minot for most of the growing season, but the end of the season ended with the most severe drought stress of the three sites, and the yields were the lowest of the three sites.

Table 1. Experimental treatments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | First application | | Second application | |
| Treatment | Material | Rate | Material | Rate |
|  |  |  |  |  |
| 1 | None | -- | None | -- |
| 2 | Ethephon | 0.25 lb/A | None | -- |
| 3 | None | -- | Ethephon | 0.25 lb/A |
| 4 | Ethephon | 0.25 lb/A | Ethephon | 0.25 lb/A |
| 5 | Paclobutrazol | 200 ppm | None | -- |
| 6 | None | -- | Paclobutrazol | 200 ppm |
| 7 | Paclobutrazol | 200 ppm | Paclobutrazol | 200 ppm |
| 8 | Priaxr | 8 oz/A | None | -- |
| 9 | None | -- | Priaxr | 8 oz/A |
| 10 | Priaxr | 8 oz/A | Priaxr | 8 oz/A |
| 11 | Wilt-pruf | 0.5 gal/A | Wilt-pruf | 0.5 gal/A |
| 12 | Kaolinite | 5% suspension | Kaolinite | 5% suspension |

Spray volume was 22 gallons per acre.

Table 2. Late-season relative leaf water content, and final yield, as influenced by growth regulators and antitranspirants, Underwood, ND, 2017.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Application | | Relative leaf water content (RWC) | | | | Seed |
| Trt | Early | Late | 8 Aug | 17 Aug | 31 Aug | 7 Sept | Yield |
|  |  |  | --------------------------- % --------------------------- | | | | bu/A |
| 1 | None | None | 95.1 | 92.6 | 87.5 | 83.8 | 31.6 |
| 2 | Ethephon | None | 95.2 | 93.7 | 88.0 | 86.7 | 28.7 |
| 3 | None | Ethephon | 94.9 | 92.3 | 87.9 | 87.0 | 26.1 |
| 4 | Ethephon | Ethephon | 96.9 | 95.1 | 88.8 | 87.0 | 28.9 |
| 5 | Paclobutrazol | None | 95.0 | 91.9 | 87.0 | 85.3 | 28.9 |
| 6 | None | Paclobutrazol | 96.2 | 91.1 | 87.5 | 85.5 | 27.1 |
| 7 | Paclobutrazol | Paclobutrazol | 96.8 | 93.3 | 87.5 | 85.0 | 27.5 |
| 8 | Priaxr | None | 94.7 | 91.8 | 88.6 | 88.0 | 25.4 |
| 9 | None | Priaxr | 95.4 | 92.2 | 88.7 | 85.4 | 29.0 |
| 10 | Priaxr | Priaxr | 95.4 | 92.2 | 88.1 | 84.8 | 28.3 |
| 11 | Wilt-pruf | Wilt-pruf | 94.7 | 92.6 | 88.4 | 85.2 | 28.7 |
| 12 | Kaolinite | Kaolinite | 95.9 | 91.5 | 87.1 | 83.3 | 28.0 |
|  |  |  |  |  |  |  |  |
|  | LSD (0.05) |  | NS | NS | NS | NS | NS |

Table 3. Late-season relative leaf water content, and final yield, as influenced by growth regulators and antitranspirants, Cole Harbor, ND, 2017.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Application | | Relative leaf water content (RWC) | | | | Seed |
| Trt | Early | Late | 14 Aug | 27 Aug | 3 Sept | 7 Sept | Yield |
|  |  |  | --------------------------- % --------------------------- | | | | bu/A |
| 1 | None | None | 91.6 | 85.7 | 74.7 | 70.3 | 11.0 |
| 2 | Ethephon | None | 89.8 | 86.7 | 76.0 | 71.0 | 13.1 |
| 3 | None | Ethephon | 91.7 | 86.2 | 79.4\* | 74.7 | 11.7 |
| 4 | Ethephon | Ethephon | 91.7 | 86.9 | 80.2\* | 79.2\* | 10.9 |
| 5 | Paclobutrazol | None | 90.2 | 86.7 | 75.0 | 69.7 | 11.5 |
| 6 | None | Paclobutrazol | 89.9 | 85.0 | 73.4 | 68.3 | 10.8 |
| 7 | Paclobutrazol | Paclobutrazol | 89.5 | 86.6 | 76.9 | 69.1 | 10.9 |
| 8 | Priaxr | None | 92.5 | 86.7 | 77.9 | 69.8 | 12.1 |
| 9 | None | Priaxr | 91.9 | 85.7 | 71.6 | 66.3 | 12.0 |
| 10 | Priaxr | Priaxr | 90.8 | 87.4 | 77.2 | 72.0 | 11.1 |
| 11 | Wilt-pruf | Wilt-pruf | 89.6 | 86.3 | 76.7 | 69.2 | 12.8 |
| 12 | Kaolinite | Kaolinite | 94.3\* | 86.5 | 74.7 | 69.0 | 11.9 |
|  |  |  |  |  |  |  |  |
|  | LSD (0.05) |  | 2.4 | NS | 4.7 | 4.6 | NS |

\*Significantly greater than the control, by the LSD test.

Table 3. Late-season relative leaf water content, and final yield, as influenced by growth regulators and antitranspirants, Minot, ND, 2017.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Application | | Relative leaf water content (RWC) | | | | | Seed |
| Trt | Early | Late | 27 July | 1 Aug | 10 Aug | 17 Aug | 27 Aug | Yield |
|  |  |  | ----------------------------------- % ----------------------------------- | | | | | bu/A |
| 1 | None | None | 83.3 | 81.3 | 85.0 | 87.1 | 86.7 | 18.0 |
| 2 | Ethephon | None | 84.1 | 82.4 | 87.1 | 88.3 | 86.5 | 16.5 |
| 3 | None | Ethephon | 82.6 | 82.8 | 87.7 | 89.0 | 90.1\* | 12.2 |
| 4 | Ethephon | Ethephon | 85.0 | 83.9 | 87.3 | 88.3 | 86.4 | 15.1 |
| 5 | Paclobutrazol | None | 83.1 | 80.3 | 86.2 | 87.9 | 87.5 | 16.9 |
| 6 | None | Paclobutrazol | 81.1 | 81.9 | 86.0 | 88.7 | 87.8 | 14.3 |
| 7 | Paclobutrazol | Paclobutrazol | 85.4 | 84.1 | 87.0 | 87.0 | 86.6 | 16.3 |
| 8 | Priaxr | None | 85.3 | 82.5 | 86.6 | 88.6 | 87.4 | 16.0 |
| 9 | None | Priaxr | 82.4 | 81.8 | 86.2 | 87.6 | 84.3 | 17.3 |
| 10 | Priaxr | Priaxr | 83.9 | 81.6 | 86.3 | 87.2 | 84.0 | 15.2 |
| 11 | Wilt-pruf | Wilt-pruf | 82.6 | 82.9 | 85.5 | 88.1 | 86.5 | 15.6 |
| 12 | Kaolinite | Kaolinite | 84.2 | 81.0 | 86.5 | 87.2 | 87.5 | 21.2 |
|  |  |  |  |  |  |  |  |  |
|  | LSD (0.05) |  | NS | NS | NS | NS | 2.8 | NS |

\*Significantly greater than the control, by the LSD test.

Figure 1. Estimated water deficit (growing season evapotranspiration minus rainfall) for the 2017 soybean growing season. Source: NDAWN.

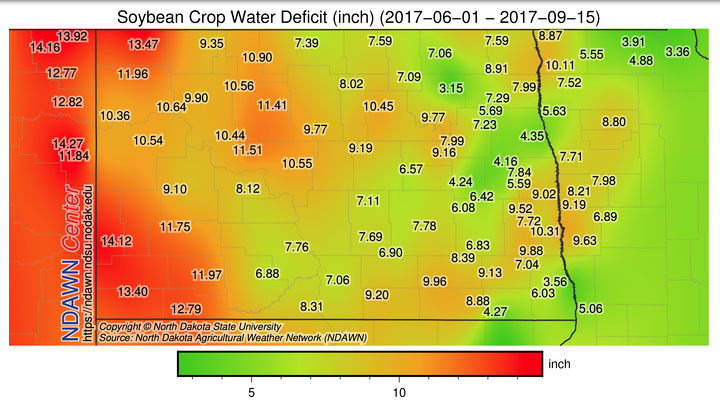


Figure 2. Late season relative leaf water contents as a function of date of sampling. Three sites, North Dakota, 2017.

