# Controlling Cotton Root Rot through Improved Fungicide Application Techniques

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Background

Cotton root rot (CRR) caused by the soil-borne fungi *Phymatotrichopsis omnivora* is a significant pest that affects Arizona cotton production. The only known method for controlling the disease is application of the fungicide flutriafol, marketed under the trade name Topguard™ Terra. The current product label allows for only two application methods. Both methods are at planting and involve either a "t-band" spray over the seed furrow or a modified in-furrow application at planting. Earlier evaluations have demonstrated phytotoxicity issues related to seed germination and seedling emergence using these techniques. Additionally, growers would prefer to apply the material either before planting or after emergence to avoid having to deal with the additional logistical issue of mixing chemicals during planting. For these reasons and because optimal timing and placement of flutriafol is not well understood, we have begun investigating alternative application techniques and their effectiveness. In previous Arizona trials, labeled and alternative application methods were found to reduce disease incidence, but results varied depending on location and year. Further research is needed to address the aforementioned issues and to get a better understanding of how flutriafol can best be utilized in cotton production. A unique aspect of this pathogen is the spatial distribution of the infection. In many cases, localized infection occurs in specific areas of the field resulting in a consistent pattern of disease distribution each year. Identifying these patterns may allow effective control using site-specific application methods which would lower costs and be more environmentally friendly. This technique merits investigation also.

## Objectives

The objectives of this study were to:

1) Determine the efficacy and viability of using various alternative techniques of applying flutriafol for control of CRR.
2) Investigate the feasibility of making precision directed applications of flutriafol for site specific control of CRR.
3) Transfer the knowledge gained from this research to producers and industry through various outreach means.

## Methods

Experimental trials with various timing and placement techniques for applying flutriafol were established at three sites in Arizona – Yuma, Marana, and Safford. Precision application techniques were employed at all sites except Yuma. The grower cooperator in Yuma did not have the historic spatial data required to create application maps. At this site, material was applied continuously throughout the plots rather than at prescribed locations. A 'verification-strip', where material was also applied continuously throughout the plot, was included at the Marana and Safford sites to evaluate the efficacy of the prescription application technique. Specific differences in treatments, plot size and layout at each site are described below.

### Yuma

At the Yuma location, experimental design was a randomized complete block with 5 treatments and 4 replications. Treatments included applying flutriafol 1.) at-planting T-band, 2.) in-season knifed

sidedress, 3.) in-season point injection 4.) in-season stem drench, and 5.) untreated control. Images depicting application techniques for treatments 1-4 are presented in Figs. 1-4. Plots were approximately 0.4 acres in size and measured 14' wide (4 beds) by 1250' long.

Disease incidence was evaluated by physically measuring the length of diseased plants in four rows from each plot and dividing the sum of these measurements by the total length of the rows measured. Results of this survey indicated that essentially no disease (<2%) occurred in any of the plots so the experiment was discontinued and no yield data were collected.

Dates associated with treatment applications and are shown in Table 1.

**Marana**

At the Marana location, experimental design was a randomized complete block design with 7 treatments and 4 replications. Treatments included the five implemented at the Yuma site and two additional treatments. These were applying flutriafol 1.) pre-plant injected and 2.) verification strip. Figure 5 illustrates the pre-plant injected application technique. Plots were approximately 1.1 acres in size and measured 38' wide (12 beds) by 1250' long (full length of irrigation run).

All treatment applications were made in accordance with the prescription application map shown in Fig. 6. The map was developed by identifying diseased areas of the field from aerial imagery taken the previous crop year. The 'verification strip' treatment, which consisted of a fully treated strip (not according the prescription), was made utilizing the point injection system application technique. This system was chosen as it was the best performing application method tested at this location in 2015.

Disease incidence was estimated by analyzing aerial imagery for diseased and healthy areas in each plot using Ag Leader SMS software. Yield estimations were made by harvesting all 12 plot rows and weighing the resultant seedcotton in a boll buggy equipped with load cells. Sub samples were collected from the harvested seedcotton and analyzed for percent lint determination and fiber quality.

Dates associated with treatment applications are shown in Table 2.

**Safford**

At the Safford location, experimental design was a randomized complete block design with 7 treatments and 4 replications. Treatments were identical to those used at the Marana site. Plots, approximately 1.5 acres in size, were 36' (12 beds) wide and extended the full length of the irrigation run (varied row length). All treatment applications were made in accordance with the prescription application map shown in Fig. 7. The map was developed by identifying diseased areas of the field from aerial imagery and yield monitor data from previous crop years. Again, the fully treated 'verification strip' was made utilizing the point injection system application technique.

Disease incidence at this location was estimated utilizing aerial imagery and Ag Leader SMS software to distinguish between diseased and healthy areas within each plot. Yield estimations were made by harvesting all 12 rows of each plot with a harvester equipped with a calibrated yield monitor. Spatial yield data was sampled using SMS software to obtain individual plot weights. The harvester used by the grower cooperator did not allow for the collection of sub samples or individual plot yields.

Dates associated with treatment applications are shown in Table 3.

At all sites, flutriafol was applied in the form of Topguard™ Terra (4.16 lb a.i./gal). Applications made as directed by the prescription map at the Marana and Safford locations were at the full label rate (8 fl oz/ac) in the treated areas and no material was applied in the untreated areas. Application rates for the verification strips were also at the full label rate of 8 fl oz/ac.

## Results

### Yuma

As mentioned earlier in this report, negligible levels of CRR were found in any of the plots at the trial site. Therefore, the decision was made near the end of August to not carry the trial any further and no additional data was collected.

### Marana

The Marana location developed strong disease pressure from CRR across the entire trial area. Aerial imagery of the plot area was collected in early November just prior to defoliation. Figure 7 shows aerial imagery with an outline of the individual plots overlaid on top of the aerial imagery. Definite patterns can be observed in treated areas particularly when compared to the untreated control plots. Evaluations of percent disease affected plants for each plot were estimated from aerial imagery and the results are presented in Table 4. Analysis of variance (ANOVA) performed on this data revealed a statistically significant response in reduction of disease incidence for all treatments when compared to the control. Observed disease incidence in the untreated plots averaged 44% while treated plots ranged from 21-26% depending on treatment technique. No statistical differences were observed in any of the application techniques.

Observed lint yield results demonstrated a non-statistically significant trend in yield with the untreated control producing the lowest yield averaging 807 lbs lint/acre (Table 4). Yield of treated plots were similar with a maximum difference of only 88 lbs lint/acre between treatments. The highest yielding treatment was the fully treated verification strip; however, yield was less than 11 lbs lint/acre higher than the next two best performing treatments (point injection and pre-plant injection). This result indicates that use of prescription application techniques is an effective CRR management tool. Although no significant differences in percent lint and fiber quality parameters were found between treatments, a trend in lower percent lint, micronaire, and uniformity index were observed with the untreated control.

### Safford

Cotton root rot pressure was significant and widespread in the plots at the Safford location in 2016. Untreated plots averaged nearly 50% infection (Table 5). Percent disease incidence was significantly reduced with the application of flutriafol, regardless of technique used. Average disease incidence in treated plots was very similar and ranged from a low of 21% to around 29%. There were no significant differences among any of the application techniques, again indicating that prescription application is a viable technique. Figure 8 shows the aerial imagery captured just prior to defoliation with an outline of the individual plot areas overlaid on top of the aerial imagery. Patterns of control can clearly be observed when comparing treated plots to the untreated control. Definite patterns among treated techniques are not discernable which is consistent with the disease incidence data.

Lint yield results have a similar trend to those observed at the Marana location, with the untreated control producing the lowest average yield at approximately 903 lbs lint/acre. All other treated plots produced an average lint yield in the range of 1065 to 1198 lbs lint/acre (Table 5). Even though lint yield

differences were not statistically significant, the results suggest there is a definite yield increase trend among the treated plots when compared with the untreated control.

**Conclusions**

Application of flutriafol for control of CRR was observed to be effective in 2016. This result is consistent with and supports the results from previous years. The trials in 2016 demonstrated an average reduction in disease incidence of 45% and 47% at Marana and Safford respectively. The magnitude of disease reductions was not as great as has been observed in previous studies (up to 70% reduction in 2015), perhaps due to the higher overall incidence of disease found in 2016. All application methods were equally effective at reducing disease incidence. Trends in lint yield response were observed in both test locations in 2016. Although no significant differences in lint yield were found, definite trends between all application techniques and the control were observed. Average lint yield among all treated plots when compared to the control produced a difference of 180 and 210 lbs lint/acre in Marana and Safford respectively. At an average cotton price of 65 cents/lb, a respectable 117 and 137 $/acre increase was observed at the Marana and Safford location respectively. This increase in return would easily cover the cost of material and application at the full label rate of 8 fl oz/acre. This analysis becomes even more economically attractive when it is considered that when site specific management is used, only a portion of the field is treated. In this study, only 79% and 50% of the field was treated at Marana and Safford respectively. A significant decrease in disease incidence or increase in yield in the verification plots would have indicated that the method used to generate prescription maps was not accurate and/or the prescription application technique was not effective. This did not occur at either location indicating, with a fair level of certainty, that the methods used to identify diseased areas of the field are effective and the technique is viable.

This work will continue in 2017 with similar evaluations conducted across Arizona to further refine recommendations for effective use of flutriafol for the control of cotton root rot.

**Outreach**.

Several events were conducted across Arizona to discuss the results from the 2015 trials and the projects executed in 2016 with growers and other stakeholders. The topic of CRR control through effective use of flutriafol was also presented at numerous meetings and field days. Some specific examples include: Southeast Arizona Ag Day, Graham County Farm, Home, and Ranch Day, Desert Ag Conference, Central Arizona Tent Talk meetings (3), and Maricopa and Safford Ag Center Annual Field Days.

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Table 1. Treatment dates and rates for the flutriafol evaluation in Yuma, AZ, 2016.

| Treatment | Application Date | Rate (fl oz/acre) |
|---|---|---|
| **Untreated Control** | N/A | 0 |
| **At-Planting T-Band** | 18 March | 8 |
| **Knife blade Side Dress** | 10 May | 8 |
| **Point Injection** | 10 May | 8 |
| **Stem Drench** | 11 May | 8 |

Table 2. Treatment dates and rates for the flutriafol evaluation in Marana, AZ, 2016.

| Treatment | Application Date | Rate (fl oz/acre) |
|---|---|---|
| **Untreated Control** | N/A | 0 |
| **Pre-plant Injection** | 7 April | 8 (on/off – prescription) |
| **At-Planting T-Band** | 16 May | 8 (on/off – prescription) |
| **Knife blade Side Dress** | 27 June | 8 (on/off – prescription) |
| **Point Injection** | 27 June | 8 (on/off – prescription) |
| **Stem Drench** | 27 June | 8 (on/off – prescription) |
| **Verification Strip (Point Injection)** | 27 June | 8 |

Table 3. Treatment dates and rates for the flutriafol evaluation in Safford, AZ, 2016.

| Treatment | Application Date | Rate (fl oz/acre) |
|---|---|---|
| **Untreated Control** | N/A | 0 |
| **Pre-plant Injection** | 27 April | 8 (on/off – prescription) |
| **At-Planting T-Band** | 2 May | 8 (on/off – prescription) |
| **Knife blade Side Dress** | 18 July | 8 (on/off – prescription) |
| **Point Injection** | 18 July | 8 (on/off – prescription) |
| **Stem Drench** | 18 July | 8 (on/off – prescription) |
| **Verification Strip (Point Injection)** | 18 July | 8 |

Table 4. Percent disease, yield and fiber quality results for each treatment in the 2016 flutriafol evaluation Marana, AZ, 2016.

| Treatment | Percent Disease | Lint Yield | Percent Lint | Staple | Micronaire | Strength | Uniformity |
|---|---|---|---|---|---|---|---|
| **Untreated Control** | 43.8 a | 807 a | 35.9 a | 36 a | 4.0 b | 29.7 a | 79.4 b |
| **Pre-plant Injection** | 26.3 b | 1015 a | 36.7 a | 35 a | 4.2 ab | 29.0 a | 79.9 ab |
| **At-Planting T-Band** | 21.3 b | 933 a | 37.1 a | 36 a | 4.3 ab | 29.6 a | 79.9 ab |
| **Knife blade Side Dress** | 25.0 b | 942 a | 36.6 a | 35 a | 4.4 a | 29.5 a | 80.4 a |
| **Point Injection** | 26.3 b | 1018 a | 37.0 a | 35 a | 4.3 ab | 29.6 a | 79.9 ab |
| **Stem Drench** | 22.5 b | 988 a | 36.1 a | 35 a | 4.3 ab | 29.3 a | 80.4 a |
| **Verification Strip (Point Injection)** | 22.5 b | 1026 a | 36.7 a | 36 a | 4.2 ab | 29.7 a | 79.6 ab |
| **LSD** | 7.2 | NS | NS | NS | NS | NS | NS |
| **OSL** | <0.0001 | 0.1481 | 0.9027 | 0.6845 | 0.3873 | 0.9679 | 0.3756 |
| **CV (%)** | 19.4 | 12.4 | 4.3 | 2.8 | 5.3 | 3.6 | 0.9 |

Table 5. Percent disease and yield results for each treatment in the 2016 flutriafol evaluation Safford, AZ, 2016.

| Treatment | Percent Disease | Lint Yield |
|---|---|---|
| **Untreated Control** | 47.5 a | 903 a |
| **Pre-plant Injection** | 26.3 b | 1078 a |
| **At-Planting T-Band** | 23.8 b | 1119 a |
| **Knife blade Side Dress** | 26.3 b | 1065 a |
| **Point Injection** | 21.3 b | 1198 a |
| **Stem Drench** | 25.0 b | 1114 a |
| **Verification Strip (Point Injection)** | 28.8 b | 1108 a |
| **LSD** | 9.3 | NS |
| **OSL** | 0.0003 | 0.2332 |
| **CV (%)** | 22.1 | 13.6 |

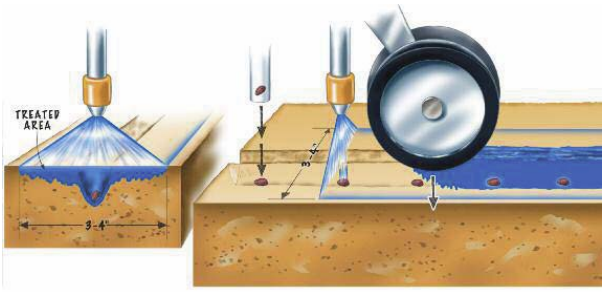


Figure 1. At-planting T-band application technique.

Figure 2. Sidedress application technique utilizing an injection knife.

Figure 3. Post-emergence point injection application technique.

Figure 4. Post-emergence stem drench application technique.

Figure 5. Pre-plant injection technique.

Figure 6. Prescription map developed from 2015 aerial imagery used to designate treated (blue) and untreated (green) areas for the 2016 flutriafol evaluation conducted in Marana, AZ.

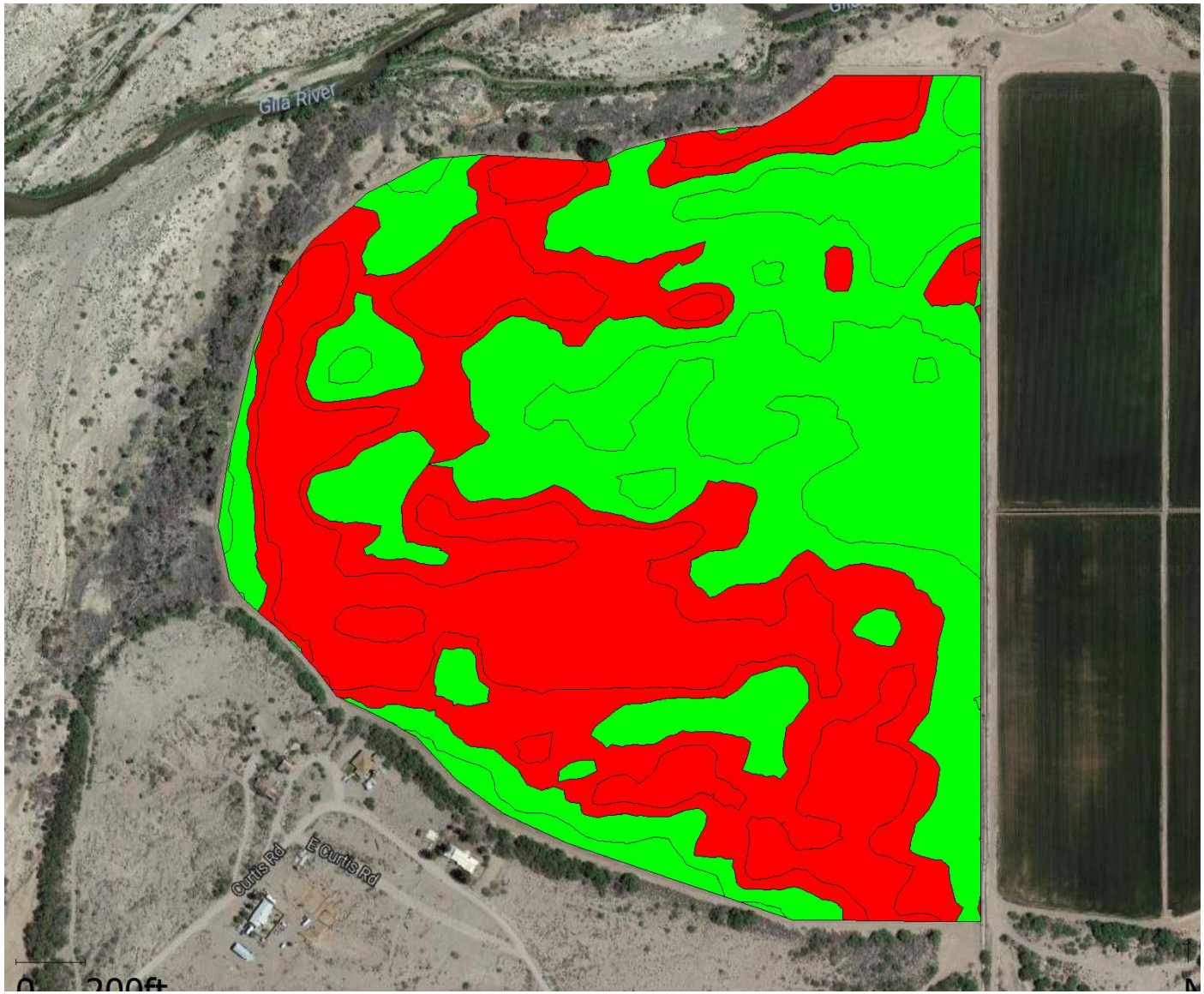

Figure 7. Prescription map developed from 2015 yield monitor data used to designate treated (green) and untreated (red) areas for the 2016 flutriafol evaluation conducted in Safford, AZ.

Figure 8. Aerial imagery collected just prior to defoliation with plot outlines overlain on top from the 2016 flutriafol evaluation, Marana, AZ.


Figure 9. Aerial imagery collected just prior to defoliation with plot outlines overlain on top from the 2016 flutriafol evaluation, Safford, AZ.