# Improving Integrated Management of Charcoal Rot Caused by *Macrophomina phaseolina*

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## Summary

**Management of charcoal rot, caused by *Macrophomina phaseolina*, relies on reduction of pathogen inoculum in the field and in-season application of fungicides. Besides fumigation, alternative approaches could be used to reduce *M. phaseolina* populations in crop residue and reduce charcoal rot incidence. In this study, commercially available products to degrade plant residue were tested, but did not reduce the weight of strawberry crowns nor accelerate their decomposition. In another trial, we determined that metam potassium (Kpam) applied at the labeled rate and following recommended field conditions and injection times (~ 3 hours) reduced populations of *M. phaseolina*, but shorter injection times were also effective. Additionaly, in-season management alternatives, such as chemigation (fungicide application through the drip system), could also be effective in suppressing charcoal rot. Topsin 4.5FL, Velum Prime, and Kenja 400SC were found effective when applied soon after inoculation and transplanting.**

## Methods

**Performance of products on the degradation of strawberry residue to reduce inoculum of *M. phaseolina***

At the end of the season, strawberry crowns and soil was collected from a field at GCREC-UF. Soil was steam-pasteurized twice for 4 hours at 180 °F. Plastic cups were filled with soil and 50 mL of water were added. Strawberry crowns were weighed and placed on top of the soil in each cup. **Thatch Buster** (enzymes), **Digest™** (mix of bacteria) and **Custom GP** (mix of *Trichoderma* species) were sprayed over the crowns (Figure 1) 1, 2, 3 or 4 times at 30-day intervals between applications (0, 30 ,60, and 90 days). Control treatments were sprayed with tap water. Each treatment consisted of 12 and 10 replicates for experiments 1 and 2, respectively. Cups were placed in a growth chamber at 82 °F under light (12 hours) and 72 °F in the dark (12 hours). Crowns were retrieved 120 days after the first application (time = 0), air-dried at room temperature and weighed to verify a possible reduction in mass that would indicate degradation.

**Figure 1.** Application of products to strawberry crowns.

**Effect of different injection periods of metam potassium on the reduction of *M. phaseolina* inoculum**

Different injection periods were simulated by evaluating different concentrations (ppm) of metam potassium (Kpam) for the reduction of artificial inoculum of *M. phaseolina*. Plastic-covered raised beds at GCREC were treated with the labeled rate of K-pam (62 gpta) using different volumes of water to

simulate five different concentrations, ranging from 2000 to 6000 ppm. The non-treated control did not receive the fumigant. Each treatment was replicated four times in 10-ft-long plots in adjacent beds. Applications were made through one central drip tape per plot with 10 emitters at 12-in. intervals each. *M. phaseolina* inoculum was prepared in the laboratory, bagged in double layer of nylon, and buried in the center, plant row, and shoulder of each plot at 3 in. deep. Each burial location was replicated twice in each plot. To evaluate the efficacy of the treatments, bags were retrieved 14 days after fumigant application. Samples were processed, plated on semi-selective medium and incubated at 86°F for 7 days in the dark and the survival of *M. phaseolina* inoculum was evaluated by counting the number of colonies.

**Alternative methods of application and delivery of fungicide products to manage charcoal rot during the season**

Bare root, cut-top 'Strawberry Festival' plants were transplanted to plastic pots with a commercial potting mix. Plants were inoculated 2 weeks after transplanting by placing two toothpicks colonized by two *M. phaseolina* isolates at 0.5 in. from each plant. Plants were fertilized biweekly with Miracle-Gro®. Treatments were organized in a factorial design with six fungicides: **Topsin 4.5FL** (thiophanate-methyl), **Rhyme** (flutriafol), **Velum Prime** (fluopyram), **Kenja 400SC** (isofetamid), **Inspire** (difenoconazole) and **pyraziflumid** and 5 application methods (1. dipping the plants in a fungicide suspension for 5 minutes before transplanting, 2. application in the planting hole, 3. drenching 3 and 15 days after inoculation, 4. drenching with first observed symptoms, and 5. dipping plants and drenching with first symptoms observed). Non-treated inoculated and non-inoculated controls were included. Evaluations of disease incidence were made weekly from October 2020 to February 2021 (16 weeks), starting 28 days after inoculation. Plants were counted as "symptomatic" when wilting symptoms were observed and as "dead" when they were totally collapsed. Incidence was calculated as the sum of "symptomatic" and "dead" per the total number of plants.

## Results

**Performance of products on the degradation of strawberry residue to reduce inoculum of *M. phaseolina***

Overall, none of the products was effective in reducing weight of the crowns. Weight reduction was also not observed when crowns were treated with multiple applications of the products (Figure 2). Although, some differences among treatments were observed for certain number of applications, those differences were not consistent.

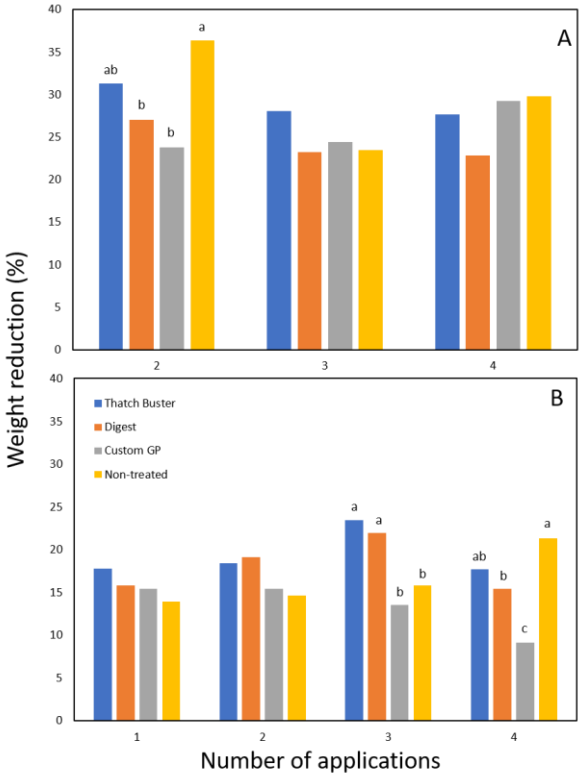


**Figure 2.** Reduction of weight (%) of strawberry crowns treated with different products and times of application: experiments 1 (A) and 2 (B).

**Effect of different injection periods of metam potassium on the reduction of *M. phaseolina* inoculum**

All the tested fumigant concentrations reduced inoculum of *M. phaseolina* compared to the non-treated control, regardless of burial location. The

concentration 3000 ppm, which corresponds to a 196 min (3 h 16 min) injection period, was one of the most effective treatments (Table 1).

**Alternative methods of application and delivery of fungicide products to manage charcoal rot during the season**

Overall, **drenching 3 and 15 days after inoculation** with **Topsin 4.5FL**, **Velum Prime**, **Kenja 400SC** or **pyrazyflumid** (not registered) were the most effective in reducing disease incidence (Table 2). Plants treated with Inspire had the highest incidence of all treatments, regardless of the application method. Rhyme is reported to be systemic, which could explain the lowest disease incidence when plants were dipped alone and dipped and drenched with first observed symptoms. Disease incidence on the inoculated controls was low, and this may be explained by the high moisture content of the potting mix.

## Summary and Recommendations

Strawberry fields with a history of charcoal rot should be destroyed as soon as possible after the end of the season. *M. phaseolina* inoculum will remain viable and build up during the summer, thus crop removal or any practice that accelerates crop decomposition is recommended. Unfortunately, commercially available products were not capable of accelerating crop residue decomposition, probably because they are not able to degrade lignin, the main component of strawberry crowns. Therefore, crop removal or destruction with fumigants should be considered. Crop destruction (and pre-plant fumigation) with metam products applied at the labeled rate and following recommended field conditions and injection periods have been shown to be effective in reducing inoculum. Moreover, during the season, some fungicide products have been effective in suppressing charcoal rot development when drenched or applied through the drip system soon after transplanting.

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**Table 1.** Efficacy of different injection periods of metam potassium (Kpam) applied at different concentrations on artificial inoculum of *M. phaseolina* in a small-plot field experiment at GCREC.

| Treatments (ppm) | Irrigation period (min) | *M. phaseolina* (CFU bag$^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Overall | | Center | | Plant Row | | Shoulder | |
| **0** | 0 | 474.7 | a | 472.8 | a | 501.4 | a | 450.0 | a[z] |
| **2000** | 294 | 1.5 | bc | 2.0 | bc | 0.3 | c | 2.3 | b |
| **3000** | 196 | 0.6 | c | 0.1 | c | 0.3 | c | 1.6 | b |
| **4000** | 147 | 1.2 | bc | 1.3 | bc | 0.5 | bc | 1.9 | b |
| **5000** | 118 | 4.1 | b | 4.3 | bc | 5.1 | b | 3.0 | b |
| **6000** | 98 | 2.5 | b | 4.6 | b | 0.9 | bc | 2.0 | b |
| **Probability of a greater F value** | | <0.0001 | | <0.0001 | | <0.0001 | | <0.0001 | |

[z] Treatments followed by the same letter within a column are not significantly different according to the Fisher's Protected LSD test ($p \leq 0.05$) on transformed data. Non-transformed means are presented.

**Table 2.** Incidence (%) of charcoal rot of strawberry in plants treated with different fungicides and application methods.

| Treatment | Charcoal Rot Incidence (%) | | | | | |
|---|---|---|---|---|---|---|
| | Dipping[z] | Hole[y] | Drench 3 & 15[x] | Drench symptoms[w] | Dipping + drench symptoms[v] | P value |
| **Topsin 4.5FL** | 12.5 | 33.3 | 0 c | 4.2 b | 20.8 ab[u] | 0.0011 |
| **Rhyme** | 4.2 | 29.2 | 12.5 b | 12.5 b | 4.2 cd | 0.0263 |
| **Velum Prime** | 12.5 | 20.8 | 0 c | 8.3 b | 29.2 a | 0.0224 |
| **Kenja 400SC** | 16.7 | 20.8 | 0 c | 12.5 b | 8.3 cd | NS |
| **Inspire** | 5 | 20.8 | 25 a | 33.3 a | 25 a | 0.0212 |
| **Pyraziflumid** | 20.8 | 25 | 0 c | 4.2 b | 8.3 cd | 0.0156 |
| **Non-inoculated** | 0 | 0 | 0 c | 0 b | 0 d | NS |
| **Inoculated** | 12.5 | 12.5 | 12.5 b | 12.5 b | 12.5 bc | NS |
| **Probability of a greater F value** | NS | NS | 0.0002 | 0.0102 | 0.0006 | |

[z] Dipping the plants in a fungicide suspension during 5 minutes before transplanting.
[y]: Product applied in the planting hole.
[x]: Drenching 3 and 15 days after inoculation.
[w]: Drenching when first symptoms were observed.
[v]: Dipping the plants in fungicide suspension during 5 minutes before transplanting and drenching when first symptoms were observed.
[u] Treatments followed by the same letter within a column are not significantly different according to the Fisher's Protected LSD test ($p \leq 0.05$).
NS = Non-significant.