

# THE EFFECT OF MULCH TYPE ON THE DISTRIBUTION AND EFFICACY OF DRIP-APPLIED INLINE AS SOIL FUMIGANT

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## **Introduction**

Virtually impermeable film (VIF) has been reported to improve retention of fumigants within the raised plastic-mulched bed. Improved fumigant retention could possibly provide ample time for the fumigant to diffuse at toxic levels to locations within the raised soil beds that are farther away from the wetting area. The objectives of this study were to: 1) to monitor the distribution of the fumigant under low density polyethylene (LDPE) and VIF at different times after drip application (chemigation), and 2) to determine the efficacy of InLine<sup>®</sup> as a soil fumigant in reducing the survival of *Rhizoctonia solani*, *Phytophthora capsici* and yellow nutsedge (*Cyperus esculentus* L.) under the two mulches.

## **Materials and Methods**

The experiment was performed at the Black Shank Farm of the University of Georgia's Coastal Plain Experiment Station, Tifton, GA on a Fuquay loamy sand (loamy, siliceous, thermic Arenic Plinthic Paleudults). InLine<sup>®</sup> (60.8% 1,3-dichloropropene [1,3-D] and 33.3% chloropicrin [Pic]) was applied at the rate of 30 gal/acre by injecting it into a drip irrigation system for eight hours three weeks prior to transplanting cucumber (cv. Thunder). A non-treated plot was included as the control. Beds were pre-irrigated for eight hours a day prior to chemigation. Tape used was Aqua-Traxx<sup>®</sup> Premium drip tape. Emitters were spaced one inch apart and had a flow rate of 1.14 l/hr at 0.069 MPa. Each bed measured 30 ft long and 30 in wide and pre-irrigated for eight hours a day prior to chemigation. Each bed received about 250 l of water after each 8 hours of drip irrigation. The experiment was arranged in a split-plot design which was replicated three times with the InLine<sup>®</sup> treatment and the control as the main plots and the mulch types (LDPE and VIF) as the subplots. InLine<sup>®</sup> concentrations in the soil atmosphere were measured from four pre-selected sites within the soil bed: 1) 10 cm below the drip tape, 2) 20 cm below the drip tape, 3) 10 cm deep and 20 cm away from the drip tip, 4) 10 cm deep and 30 cm away from the drip tape (shoulder). The gas measurements were performed at 3, 12, 24,

48, 72, 120 and 240 hours after chemigation by using Gastec<sup>®</sup> detection tubes with scales ranging from 50-500 ppm (132HA) and 2-25 ppm (132L).

The survival of *Phytophthora capsici*, *Rhizoctonia solani* and yellow nutsedge were determined by preparing sets of three nylon mesh packets: one packet containing 50 *P. capsici*-colonized beet seeds, a second packet containing 50 *R. solani*-colonized beet seeds a third packet containing 10 yellow nutsedge nutlets. Each set of packets were inserted at the above pre-selected sites and retrieved at gas sampling times enumerated in the above. After packet retrieval, colonized beet seeds were transferred onto plates containing Phytophthora- and Rhizoctonia-selective media, respectively. After 48 hrs of incubation at room temperature, pathogen survival was determined by counting the number of beet seeds that were positive for pathogen growth and expressed as a percentage of the total number of beet seeds tested for each pathogen. Yellow nutsedge tuber survival was determined by planting them in 12 oz. plastic cups containing sieved field soils and allowed to grow in the greenhouse for three weeks and the number of tubers that developed shoots and roots were counted

### **Summary**

The fumigant concentrations were generally higher under VIF than under LDPE at all four sites within the soil bed 3-48 hours after chemigation. Even at 20 cm and 30 cm away from the drip tape (shoulder), the fumigant concentrations were significantly higher under VIF than under LDPE from 3-72 hours after chemigation. The differences in fumigant concentrations at each site under the two mulches became less significant over time.

*P. capsici* and *R. solani* survival was generally reduced under VIF as early as 3 hours after drip application, except at two sites (Tables 2 and 3). *P. capsici* survival was reduced to 0% at the shoulder under both mulches at 48 hours after drip application while *R. solani* survival was reduced to 0% at the shoulder under VIF but not under LDPE.

Yellow nutsedge survival was generally lower under VIF than under LDPE. (Table 4). By 240 hours after drip application, yellow nutsedge survival was reduced to 0% at the shoulder under VIF but not under LDPE.

VIF resulted in higher fumigant concentrations in the soil atmosphere. Moreover, the data suggest that VIF enhanced the efficacy of InLine in reducing the survival of *R. solani* and yellow nutsedge at the shoulder of the beds.

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**Table 1. The relative fumigant concentrations (RFC, %) of InLine at different sites within the soil beds and at different times after chemigation under LDPE and VIF plastic mulches.**

| Plastic film                              | Site <sup>a</sup> |       |       |      |
|---|-------------------|-------|-------|------|
|   | 1                 | 2     | 3     | 4    |
| <b><i>3 hours after chemigation</i></b>   |                   |       |       |      |
| Low density polyethylene (LDPE)           | 140 b             | 213 b | 72 b  | 30 b |
| Virtually impermeable film (VIF)          | 238 a             | 270 a | 155 a | 83 a |
| <b><i>12 hours after chemigation</i></b>  |                   |       |       |      |
| Low density polyethylene (LDPE)           | 45 b              | 78 a  | 35 b  | 21 b |
| Virtually impermeable film (VIF)          | 88 a              | 85 a  | 55 a  | 46 a |
| <b><i>24 hours after chemigation</i></b>  |                   |       |       |      |
| Low density polyethylene (LDPE)           | 60 b              | 85 b  | 35 b  | 30 b |
| Virtually impermeable film (VIF)          | 140 a             | 140 a | 110 a | 77 a |
| <b><i>48 hours after chemigation</i></b>  |                   |       |       |      |
| Low density polyethylene (LDPE)           | 27 b              | 39 b  | 15 b  | 13 b |
| Virtually impermeable film (VIF)          | 63 a              | 62 a  | 57 a  | 45 a |
| <b><i>72 hours after chemigation</i></b>  |                   |       |       |      |
| Low density polyethylene (LDPE)           | 17 a              | 25 a  | 11 b  | 8 b  |
| Virtually impermeable film (VIF)          | 33 a              | 33 a  | 32 a  | 28 a |
| <b><i>120 hours after chemigation</i></b> |                   |       |       |      |
| Low density polyethylene (LDPE)           | 6 a               | 8 a   | 5 a   | 3 a  |
| Virtually impermeable film (VIF)          | 23 a              | 23 a  | 20 a  | 18 a |
| <b><i>240 hours after chemigation</i></b> |                   |       |       |      |
| Low density polyethylene (LDPE)           | 0 a               | 0 a   | 0 a   | 0 a  |
| Virtually impermeable film (VIF)          | 2 a               | 2 a   | 1 a   | 0 a  |

In a column, and within a time after chemigation, means of films from the two mulches with the same letters are not significantly different by LSD at  $p = 0.05$ .

<sup>a</sup>Sites: 1 = 10 cm below the drip tape; 2 = 20 cm below the drip tape; 3 = 10 cm deep, 20 cm away from the drip tape, and 4 = shoulder (10 cm deep, 30 cm away from the drip tape).

**Table 2. The survival (% survival = isolation frequency from artificially-infested beet seeds) of *Phytophthora capsici* after different times of exposure to the fumigant at different sites within InLine-treated soil beds.**

| Plastic film <sup>b</sup>          | Control <sup>a</sup> |      |      |       | <i>Phytophthora capsici</i> <sup>a</sup> |      |      |      |
|------------------------------------|----------------------|------|------|-------|--|------|------|------|
|                                    | 1                    | 2    | 3    | 4     | 1  | 2    | 3    | 4    |
| <b>3 hours after chemigation</b>   |                      |      |      |       |  |      |      |      |
| LDPE                               | 29 a                 | 41 a | 34 a | 41 a  | 15 a                                     | 20 a | 33 a | 85 a |
| VIF                                | 29 a                 | 54 a | 19 a | 26 a  | 0 b                                      | 1 b  | 2 b  | 90 a |
| <b>12 hours after chemigation</b>  |                      |      |      |       |  |      |      |      |
| LDPE                               | 29 a                 | 25 a | 26 a | 61 a  | 3 a                                      | 0 a  | 0 a  | 57 a |
| VIF                                | 15 a                 | 30 a | 31 a | 60 a  | 0 a                                      | 0 a  | 0 a  | 64 a |
| <b>24 hours after chemigation</b>  |                      |      |      |       |  |      |      |      |
| LDPE                               | 16 a                 | 19 a | 10 a | 20 a  | 0 a                                      | 0 a  | 28 a | 53 a |
| VIF                                | 30 a                 | 1 a  | 7 a  | 1 a   | 0 a                                      | 0 a  | 0 b  | 31 b |
| <b>48 hours after chemigation</b>  |                      |      |      |       |  |      |      |      |
| LDPE                               | 99 a                 | 63 a | 71 a | 100 a | 0 a                                      | 0 a  | 0 a  | 0 a  |
| VIF                                | 99 a                 | 70 a | 81 a | 60 a  | 0 a                                      | 0 a  | 0 a  | 0 a  |
| <b>72 hours after chemigation</b>  |                      |      |      |       |  |      |      |      |
| LDPE                               | 38 a                 | 11 a | 11 a | 27 a  | 0 a                                      | 5 a  | 0 a  | 0 a  |
| VIF                                | 33 a                 | 24 a | 4 a  | 15 a  | 0 a                                      | 0 a  | 0 a  | 0 a  |
| <b>120 hours after chemigation</b> |                      |      |      |       |  |      |      |      |
| LDPE                               | 99 a                 | 55 a | 99 a | 89 a  | 0 a                                      | 1 a  | 0 a  | 0 a  |
| VIF                                | 25 b                 | 60 a | 63 b | 92 a  | 0 a                                      | 0 a  | 0 a  | 0 a  |
| <b>240 hours after chemigation</b> |                      |      |      |       |  |      |      |      |
| LDPE                               | 3 a                  | 0 a  | 33 a | 39 a  | 0 a                                      | 0 a  | 0 a  | 0 a  |
| VIF                                | 0 a                  | 24 a | 0 b  | 11 a  | 0 a                                      | 0 a  | 0 a  | 0 a  |

<sup>a</sup>Sites: 1 = 10 cm below the drip tape; 2 = 20 cm below the drip tape; 3 = 10 cm deep, 20 cm away from the drip tape; and 4 = shoulder (10 cm deep, 30 cm away from the drip tape).

<sup>b</sup>Plastic film: LDPE = low density polyethylene, and VIF = virtually impermeable film.

In a column, and within a time after chemigation, means of the two films with the same letters are not significantly different by LSD at  $p = 0.05$ .

**Table 3. The survival (isolation frequency, % from artificially-infested beet seeds) of *Rhizoctonia solani* AG-4 after different times of exposure to the fumigant at different sites within InLine-treated soil beds.**

| Plastic film <sup>b</sup>                 | Control <sup>a</sup> |      |       |      | <i>Rhizoctonia solani</i> AG-4 <sup>a</sup> |      |       |       |
|---|----------------------|------|-------|------|---|------|-------|-------|
|   | 1                    | 2    | 3     | 4    | 1   | 2    | 3     | 4     |
| <b><i>3 hours after chemigation</i></b>   |                      |      |       |      |   |      |       |       |
| LDPE                                      | 81 a                 | 84 a | 73 a  | 68 a | 0 b   | 20 a | 100 a | 100 a |
| VIF                                       | 63 a                 | 77 a | 64 a  | 79 a | 33 a  | 0 a  | 0 b   | 40 b  |
| <b><i>12 hours after chemigation</i></b>  |                      |      |       |      |   |      |       |       |
| LDPE                                      | 73 a                 | 82 a | 73 a  | 72 a | 0 a   | 15 a | 31 a  | 85 a  |
| VIF                                       | 64 a                 | 61 a | 78 a  | 82 a | 0 a   | 0 a  | 45 a  | 37 b  |
| <b><i>24 hours after chemigation</i></b>  |                      |      |       |      |   |      |       |       |
| LDPE                                      | 80 a                 | 91 a | 74 a  | 85 a | 0 a   | 0 a  | 30 a  | 93 a  |
| VIF                                       | 73 a                 | 75 a | 77 a  | 63 b | 0 a   | 0 a  | 0 b   | 1 b   |
| <b><i>48 hours after chemigation</i></b>  |                      |      |       |      |   |      |       |       |
| LDPE                                      | 100 a                | 98 a | 100 a | 90 a | 0 a   | 0 a  | 0 a   | 72 a  |
| VIF                                       | 100 a                | 88 a | 100 a | 97 a | 0 a   | 0 a  | 0 a   | 0 b   |
| <b><i>72 hours after chemigation</i></b>  |                      |      |       |      |   |      |       |       |
| LDPE                                      | 83 a                 | 87 a | 87 a  | 73 a | 0 a   | 31 a | 31 a  | 54 a  |
| VIF                                       | 77 a                 | 72 a | 94 a  | 74 a | 0 a   | 0 b  | 0 b   | 0 b   |
| <b><i>120 hours after chemigation</i></b> |                      |      |       |      |   |      |       |       |
| LDPE                                      | 69 a                 | 58 a | 82 a  | 74 a | 0 a   | 0 a  | 35 a  | 2 a   |
| VIF                                       | 87 a                 | 57 a | 75 a  | 71 a | 0 a   | 0 a  | 0 b   | 0 a   |
| <b><i>240 hours after chemigation</i></b> |                      |      |       |      |   |      |       |       |
| LDPE                                      | 77 a                 | 15 b | 69 a  | 58 a | 0 a   | 0 a  | 52 a  | 66 a  |
| VIF                                       | 48 b                 | 56 a | 37 b  | 55 a | 0 a   | 2 a  | 0 b   | 0 b   |

<sup>a</sup>Sites: 1 = 10 cm below the drip tape; 2 = 20 cm below the drip tape; 3 = 10 cm deep, 20 cm away from the drip tape; and 4 = shoulder (10 cm deep, 30 cm away from the drip tape).

<sup>b</sup>Plastic film: LDPE = low density polyethylene, and VIF = virtually impermeable film.

In a column, and within a time after chemigation, means of the two films with the same letters are not significantly different by LSD at  $p = 0.05$ .

**Table 4. The survival (% nutlet germination) of yellow nutsedge (*C. esculentus*) after different times of exposure to the fumigant and different sites within InLine-treated soil beds.**

| Plastic film <sup>b</sup>          | Control <sup>a</sup> |      |      |      | Yellow nutsedge <sup>a</sup> |     |      |      |
|------------------------------------|----------------------|------|------|------|------------------------------|-----|------|------|
|                                    | 1                    | 2    | 3    | 4    | 1                            | 2   | 3    | 4    |
| <i>24 hours after chemigation</i>  |                      |      |      |      |                              |     |      |      |
| LDPE                               | 30 a                 | 30 b | 20 a | 40 a | 0 a                          | 0 a | 13 a | 27 a |
| VIF                                | 37 a                 | 57 a | 23 a | 37 a | 0 a                          | 3 a | 0 b  | 10 b |
| <i>72 hours after chemigation</i>  |                      |      |      |      |                              |     |      |      |
| LDPE                               | 53 a                 | 53 a | 13 b | 77 a | 7 a                          | 0 a | 30 a | 43 a |
| VIF                                | 37 a                 | 67 a | 63 a | 57 a | 0 a                          | 0 a | 0 b  | 7 b  |
| <i>240 hours after chemigation</i> |                      |      |      |      |                              |     |      |      |
| LDPE                               | 37 a                 | 50 a | 50 a | 63 a | 0 a                          | 0 a | 23 a | 20 a |
| VIF                                | 60 a                 | 60 a | 70 a | 63 a | 0 a                          | 0 a | 3 b  | 0 b  |

<sup>a</sup>Sites: 1 = 10 cm below the drip tape; 2 = 20 cm below the drip tape; 3 = 10 cm deep, 20 cm away from the drip tape; and 4 = shoulder (10 cm deep, 30 cm away from the drip tape).

<sup>b</sup>Plastic film: LDPE = low density polyethylene, and VIF = virtually impermeable film. In a column, and within a time after chemigation, means of the two films with the same letters are not significantly different by LSD at  $p = 0.05$ .