EFFICACY OF FINISH AND ITS MECHANISM OF ACTION

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Abstract

FINISH is a new cotton defoliant which contains two active ingredients: ethephon and cyclanilide. Cyclanilide is an ethephon synergist which enhances defoliation and inhibits regrowth even at low temperatures. The overall purpose of this research was to demonstrate the efficacy of FINISH in comparison to other defoliants, and to determine the mechanism by which cyclanilide enhances ethephon efficacy. When cyclanilide was combined with ethephon (Prep) approximately 90% defoliation was detected in cotton compared to 70% defoliation when Prep was applied alone. Prep induced 90% boll opening when applied alone or in combination with cyclanilide suggesting that cyclanilide does not interfere with Prep efficacy in boll opening. Regrowth was less when cyclanilide was combined with Prep. In the Midsouth and Southeast regions, FINISH enhanced both defoliation and boll opening. Some combinations of Prep with other defoliants such as Folex and Dropp resulted in adequate defoliation or boll opening; however, FINISH has the advantage of being a single package harvest aid. Combining NPA, a known auxin transport inhibitor, with low rates of ethephon resulted in enhanced defoliation similar to cyclanilide combined with ethephon suggesting that cyclanilide may act as an auxin transport inhibitor thereby enhancing ethephon efficacy. This hypothesis was further supported by experiments that demonstrated that cyclanilide can inhibit radiolabled auxin movement through corn coleoptiles similary to TIBA, another known auxin transport inhibitor. Furthermore, binding studies demonstrated that cyclanilide competes with ^{3}H-IAA binding in plasma membranes. Although cyclanilide binds with less affinity than IAA, our results suggest that cyclanilide could be inhibiting auxin transport by interacting with an auxin efflux protein.

Introduction

Defoliants are applied as a preharvest aid to remove leaves which could otherwise stain and lower the quality of the cotton fiber during the harvest process. FINISH is a new cotton defoliant that was developed by Rhone Poulenc Agricultural Company. This defoliant is composed of two active ingredients: ethephon and cyclanilide. Ethephon is an ethylene-releasing compound which was originally used by itself to enhance boll opening and defoliation. Cyclanilide is a new patented compound which is an ethephon synergist. Like any other agricultural chemical, the performance of defoliants can be unpredictable, and is dependent on environmental factors such as low temperatures which could reduce the efficacy of the compound. Cyclanilide enhances defoliation and inhibits regrowth when combined with ethephon even at low temperatures. FINISH is a single package harvest aid containing two active ingredients which applied together results in greater efficacy.

The overall purpose of this research was to demonstrate the efficacy of FINISH in comparison to other defoliants, and to determine the mechanism by which cyclanilide enhances ethephon efficacy. Two hormones are thought to control leaf abscission in plants (Osborne, 1989). While auxin suppresses leaf abscission, ethylene promotes the abscission process. In the first stages of leaf abscission, auxin transport through the petiole decreases. This stage is followed by an increase in ethylene production which induces various cell wall degrading enzymes and eventual shedding of the leaf. Since cyclanilide does not induce ethylene production, it is hypothesized that cyclanilide could be an auxin transport inhibitor thereby enhancing ethephon efficacy.

Materials and Methods

Cotton field experiments: To compare the effect of cyclanilide in combination with ethephon, three farm trials were conducted in Newton Grove, NC on DPL 50 cotton variety. Customary production practices were utilized, and plants were sprayed in October when the temperature dropped below 65 F. Treatments consisted of formulated ethephon (Prep) applied alone at 1.0 lb ai/A, Prep combined with either 0.125 lb ai/A or 0.25 lb ai/A cyclanilide, and Dropp alone applied at 0.1 lb ai/A. Defoliation, boll opening, and regrowth measurements were taken 7 and 14 days after treatment (DAT).

To compare the effect of FINISH with other commercial defoliants alone and in combination with Prep, experimental use permit (EUP) trials were conducted on spindle picked cotton in the Southeast (NC, SC, GA, AL) and Midsouth (AR, TN). Multiple cotton varieties were planted in 2-4 row plots, with 3-4 replications in a RCBD. Customary production practices were utilized for each location, and within a region data was averaged across locations. Treatments were srayed in volumes of 3-20 gallons per acre. Treatments consisted of CottonQuick, CottonQuick combined with Dropp, FINISH, and Prep combined with Folex or Dropp. These treatments were applied at various recommended rates. Percent defoliation and boll opening was determined 8-11 DAT.

Auxin transport: A whole plant experiment was conducted using two-week-old kidney bean plants to determine if naphthylphthalamic acid (NPA), a known

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auxin transport inhibitor, could enhance defoliation similarly to cyclanilide when combined with ethephon. Treatments were applied at 40 gallon per acre and consisted of applying various rates of ethephon alone, and various rates of NPA or cyclanilide combined with 0.06 lb ai/A. Number of leaves was counted over seven days.

To determine if cyclanilide inhibits auxin transport similarly to triiodobenzoic acid (TIBA), another known auxin transport inhibitor, experiments were conducted using etiolated corn coleoptiles according to Jones,1990. The apical end of a cut coleoptile was pulsed in 200 uL solution containing 1 μM radiolabeled auxin (^{3}H-IAA) alone or in combination with various concentrations of cyclanilde or TIBA. An agar block was placed at the basal end to collect any ^{3}H-IAA moving from the apical end through the coleoptile to the basal end. Agar blocks were replaced every 20 min over a 3 hour period. Amount of radioactivity in the agar blocks was determined by scintillation spectroscopy.

To determine if cyclanilide competes with indole acetic acid (IAA) for binding, plasma membranes were extracted from etiolated zucchini hypocotyls and assayed according to Muday et al., 1993. Binding assays were conducted in a total volume of 250 uL containing 10 nM ^{3}H-IAA and increasing concentrations of unlabeled IAA or cyclanilide. Samples were incubated for 1 hr at 4 C, and filtered through glass fiber filters which were subsequently rinsed with 5 mL binding buffer, pH 5.3. Amount of radioactivity in the filters was determined by scintillation spectroscopy.

Results and Discussion

Cotton field experiments: Combining cyclanilide with Prep at either 0.125 lb ai/A or 0.25 lb ai/A resulted in greater defoliation in comparison to Prep by itself or Dropp by itself. Seven DAT, plants treated with Prep plus cyclanilide exhibited 74-77% defoliation while Prep alone only exhibited 57% defoliation. At 14 DAT, plants treated with Prep alone exhibited 70% defoliation, and when combined with cyclanilide 88-90% defoliation was observed. Dropp caused 68% and 74% defoliation 7 and 14 DAT, respectively, which was similar to Prep alone. These results indicate that combining cyclanilide with Prep results in greater defoliation in less time compared to Prep alone or Dropp alone. In contrast to defoliation, cyclanilide did not enhance boll opening when combined with Prep. When Prep was applied alone, 80% and 94% boll opening was observed 7 and 14 DAT, respectively. Combining cyclanilide with Prep resulted in greater inhibition of terminal regrowth when compared to Prep alone. Only 8-9% terminal regrowth was detected 14 DAT in cotton treated with cyclanilide plus Prep while plants treated with Prep alone showed 13% regrowth. Together these results suggest that combining cyclanilide with Prep results in greater defoliation and inhibition of regrowth without affecting Prep efficacy at boll opening. FINISH was equally good at inducing defoliation and boll opening in the Midsouth and Southeast compared to other defoliants in combination with Prep; however, FINISH has the added advantage of being a single package defoliant. FINISH induced 94% defoliation and 95% boll opening in the MidSouth. In the Southeast region, FINISH induced 99% defoliation and and 94% boll opening.

Auxin transport: Whole plant experiments using kidney bean plants showed that NPA, a known auxin transport inhibitor, could enhance defoliation when combined with ethephon similarly to cyclanilide. When ethephon was applied alone at 0.06 lb ai/A no defoliation was detected 5 DAT; however, when 0.06 lb ai/A was combined with equal rates of NPA or cyclanilide there was approximately 60% defoliation. These results indicate that cyclanilide may be acting as an auxin transport inhibitor to enhance defoliation when combined with ethephon.

Auxin movement through etiolated corn coleoptiles was inhibited by 1-10 μM cyclanilide similarly to 10 μM TIBA, another known auxin transport inhibitor. These results suggest that cyclanilide inhibits polar auxin transport in corn coleoptiles. Auxin transport inhibitors such as NPA and TIBA are thought to bind at auxin efflux proteins located within the plant plasma membranes, thereby inhibiting auxin binding and efflux (Brunn et al., 1992). To determine if cyclanilide interacts with auxin at similar sites, competition binding experiments were conducted to determine if increasing concentrations of unlabled cyclanilide could compete with ^{3}H-IAA binding. Our results indicated that cyclanilide competed with ^{3}H-IAA for binding with an IC_{50} of 50 μM while the estimated IC_{50} for unlabeled IAA was 1 μM. These results suggest that cyclanilide could inhibit auxin transport by interacting with an auxin binding protein within the plasma membrane.

Conclusion

Our results indicate that cyclanilide is an effective ethephon synergist which enhances ethephon efficacy. FINISH, which contains both of these active ingredients, is a better defoliant than Prep alone. FINISH has the advantage of being a single packaged product producing harvest-ready defoliated cotton earlier than using Prep by itself. In addition, FINISH gives more adequate results at low temperature and inhibits regrowth. The mechanism by which cyclanilide could be enhancing ethephon efficacy may be by binding at auxin efflux proteins which could lead to inhibition of auxin transport through the petiole allowing ethephon to be more effective.

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