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Influence of Various Compounds and Temperature on Activity of Dropp® Defoliant on Cotton

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Summary

The influence of adjuvants was determined on the absorption, movement in the leaves, and subsequent defoliation of cotton with thidiazuron (Dropp®) defoliant applied over-the-top in 20 gallons of water per acre. These studies were conducted under laboratory conditions at Mississippi State University's Delta Research and Extension Center, Stoneville, Mississippi.

The effects of ammonium sulfate at 1 lb/A and crop oil concentrate at 1.25% vol/vol were determined at the high and low day/night temperatures of 85/70 °F and 70/55 °F. Five days after treatment (DAT) at 85/70 °F day/night temperatures, leaf drop was 17% with no adjuvant, 37% with addition of crop oil concentrate, 40% with ammonium sulfate, and 75% with both adjuvants combined. At 70/55 °F day/night temperatures, there was less than 10% leaf drop with all treatments at 5 DAT. At 10 DAT, leaf drop was not different among treatments between the high or low temperatures.

Shoot regrowth at both high and low temperatures was reduced 55 to 60% with addition of both adjuvants and 44 to 50% with each adjuvant or with no adjuvant when compared to plants defoliated by hand.

Absorption of Dropp was not affected by variations in temperature during the time of treatment but was affected by adjuvants. With no adjuvants, absorption was 7 to 10%. With 1.25% (by volume) crop oil concentrate, absorption was 33 to 46%. Addition of 1 lb/A ammonium sulfate resulted in 18 to 19% absorption, and the combination of ammonium sulfate and crop oil concentrate increased absorption to greater than 65%.

Movement of Dropp away from treated leaves was not detected by x-ray radiography. Under the warm environment, the addition of each paraquat and ethephon plus a surfactant increased absorption of Dropp into the leaf.

Introduction

Chemical termination of cotton growth improves harvestability and can preserve lint quality. Chemical defoliants available today provide adequate defoliation when certain factors are optimized. Favorable conditions for optimum defoliation include a vegetatively dormant and reproductively mature plant, high leaf moisture content and high temperature, humidity, and sunlight intensity (*1*). A nighttime temperature above 60 °F is necessary for defoliant chemicals to function properly. Because environment plays an integral part in chemical defoliation of cotton, success depends, in part, upon something that cannot be controlled or manipulated.

Several factors involved in the use of chemicals for defoliation have been evaluated in the past in an effort to offset unfavorable environmental conditions and/or suboptimum plant growth conditions. Cathey et al. (*2*) reported that TD 1123 (potassium, 3-4-dichlorosiothizo-t-carboxylate) was an effective harvest aid chemical when environmental conditions were not conducive to easy defoliation. One report on Dropp concluded that absorption was not different in leaves of different ages. However, several adjuvants applied with Dropp resulted in greater absorption over a 24-hour period than when applied alone[1].

Compounds such as glyphosate, paraquat, and others have been used either as adjuvants or conditioner treatments prior to application of defoliant chemicals. While some combinations and/or adjuvants have been evaluated, effectiveness has been erratic, not economically feasible, or has not produced responses of commercial importance.

The inorganic salts, ammonium suflate and potassium phosphate, added to spray mixtures increased activity of herbicides (3, 4, 5, 7, 11, 13, 14, 15, 19). Salisbury et al. (*8*) reported that the addition of ammonium sulfate enhanced initial control of johnsongrass [*Sorghum halepense* (L.) Pers.] by glyphosate and SC-0224 (trimethylsulfonium carboxymethylaminomethylphosphonate). Absorption and translocation of foliar-applied herbicides were greatest at high temperature and relative humidity (16, 17, 18, 20).

Basic knowledge of the influence of environment and adjuvants on defoliant activity is limited. Defoliants are applied in the fall when temperatures are lower than when herbicides are frequently applied. Dropp is widely used for cotton defoliation and is the only defoliant currently available that inhibits regrowth[2]. Dropp's regrowth inhibition properties make it a very desirable defoliant. However, it is not recommended when nighttime temperatures drop below 60 °F, which limits its use in late fall applications.

Earlier studies showed differences in defoliant activity with activators (*12*). Preliminary field trials with ammonium sulfate enhanced activity of Dropp in some cases (*10*). As a result, further research was needed to identify the interaction of temperature and ammonium sulfate and other adjuvants on performance of Dropp in an effort to provide more consistent defoliation results, especially under nighttime temperatures below 60 °F. Enhanced performance due to ammonium sulfate would be very cost effective. Therefore, the objective of this research was to determine the effect of temperature and adjuvants on leaf absorption of Dropp in cotton and on cotton defoliation.

Materials and Methods

Percent Defoliation

Experiments were conducted at the Delta Research and Extension Center, Stoneville, MS. Cotton was grown in the greenhouse in 4-inch-diameter plastic pots containing a 1:1 mixture of Bosket very fine sandy loam (fine-loamy, mixed, thermic, Mollic Hapludalf) and a commercial potting mixture.

Seeds of DES 119 cotton were planted at 3 to 5 per pot and thinned to one plant per pot one week after emergence. Plants were watered two or three times a day and fertilized as needed. Greenhouse air temperature during the day was 95±3 °F and nighttime temperature was 77±3 °F. Supplemental halide-lighting was used to provide a 14-hour light period. Treatments were applied when cotton had 15 to 20 leaves using a mechanical spray table.

Treated plants were placed immediately into enviornmentally controlled growth chambers for 48 hours with photoperiods of 14 hours light and 10 hours dark, then returned to the greenhouse. Dropp was applied at 0.05 lb ai/A in 20 gpa water with either no adjuvant, 1.25% (by volume) crop oil concentrate (83 parts paraffinic oil and 17 parts nonionic surfactant), 1 lb/A ammonium sulfate, or a combination of crop oil concentrate and ammonium sulfate at these rates.

Three replications of each treatment were placed into separate growth chambers, with one chamber at 85 °F day and 70 °F night and the other at 70 °F day and 55 °F night temperature. These growth chambers provided an illuminescence of 550 µEM-2s-1 at canopy height with a 14-hour photoperiod. After plants were returned to the greenhouse, defoliant activity was determined by counting the leaves dropped and by determining weight of new leaf regrowth.

Numbers of leaves that fell from plants were counted daily for 14 days after treatment (DAT). Since the rate of leaf drop was a consideration, number of leaves that dropped each day was calculated as the percent of the total number of leaves that dropped in 14 days. Leaf regrowth was determined at 21 DAT as fresh weight of leaves on treated and untreated plants. Leaves from untreated plants were removed by hand at time of treatment. The study was conducted four times.

Percent Absorption

Absorption of Dropp was determined by making the compound radioactive in a way that it could be detected at the molecular level. One of the carbon atoms in the formula for Dropp was replaced with a radioactive carbon-14 atom. This does not change the chemical activity of the compound but allows for the detection of the radioactive part of the molecule on radioactive sensitive photographic film and with radioactive counting machines. A measured quantity of Dropp containing a known amount of radioactivity was applied with and without adjuvants using a microsyringe.

Application was to a 3/4-square-inch area on the upper side of the second true leaf of cotton plants with 4 to 5 leaves. Treatments were applied inside environmentally controlled growth chambers and plants were maintained as previously described. Each treatment/temperature combination was replicated five or six times. Each experiment was conducted four times.

The unabsorbed Dropp remaining on the leaf surface was washed off after 24 hours into 1/3-ounce of water by first placing the excised treated section into a vial containing 1/6-ounce of water and swirling for 5 seconds on a test tube stirrer. The leaf section was then held above the solution and rinsed over the surface with an additional 1/6-ounce of water, which was combined with the first wash solution.

Radioactivity was determined with a radioactive counting machine. Absorption into the treated leaf section was calculated as that amount of radioactivity, which was not recovered after two or more washings of the treated leaf section.

Radioactivity remaining in treated leaf tissue was determined by combusting the treated section in a biological material oxidizer and analyzing with a radioactive counting machine. All data were corrected for radioactive background, quenching, and dilution factors, and expressed as percent counts per minute of standards with the same quantity of radioactivity as applied to the plant. Standard solutions of each formulation were collected in triplicate each time applications were made to plants. Remaining plant shoots were immediately frozen and freeze dried to prevent artificial movement of the radioactive Dropp and then exposed to x-ray film for approximately 6 weeks. Visual ratings of the dark coloration on the x-ray film were made to determine distribution of radioactivity in the plant.

In separate but similar experiments, various adjuvants were added to the radio-labeled Dropp mixture to evaluate their effectiveness. The adjuvants[3] LI 700 at 0.25% by vol, HM 8802A at 0.5% by vol, crop oil concentrate (COC) at 1.25% by vol, MYX 1220 or MYX 6121 at 2.0% by vol, or ammonium sulfate at 0.35% by wt/vol, were applied under the two temperature regimes described above. The adjuvants[4] X-77 at 0.25% by vol, paraquat at 0.07 lb ai or ethephon (Prep®) 1.0 lb ai in 20 gallons of water per acre were applied only at the warmer temperature regime described above. Each experiment was conducted four times. Procedures for plant growth and percent absorption of radioactive Dropp were as previously described.

All data reported for percent defoliation and percent absorption are averages of four runs for all experiments conducted. Differences for each experiment were similar, thus all data were subjected to analysis of variance across experiments and treatment means were declared significant at the 5% level of probability according to Duncan's Multiple Range Test or Least Significant Difference.

Results and Discussion

Percent Defoliation

Under warm temperatures, defoliation with Dropp at 5 DAT, was 17% with no adjuvant, 37% with the addition of COC, 40% with ammonium sulfate and 75% with ammonium sulfate + COC (Figure 1). Defoliation was less than 10% for all treatments at the low temperature. By 7 DAT, percent defoliation under both temperature regimes increased, and defoliation ranged from 66% to 90% and 39% to 70% under warm and cool regimes, respectively (Figure 2). At 10 DAT, defoliation was not different among most treatments at either temperature, indicating that rate of defoliation by Dropp was dictated primarily by cotton response to temperature (Figure 3).

Untreated plants produced equal amounts of regrowth under both temperature regimes (Figure 4). Equal regrowth would be expected since plants were exposed to different temperature for only 48 hours. Regrowth was inhibited equally by Dropp applied alone for both temperature regimes. However, addition of COC + ammonium sulfate increased inhibition of regrowth when compared to Dropp alone regardless of temperature.

Percent Absorption

In general, absorption of the radiolabeled Dropp in 24 hours was not affected by variation in temperature at time of treatment, but was affected by adjuvants added to treatment mixtures (Figure 5). Without adjuvants, absorption into treated leaves was 7 to 10%. Addition of ammonium sulfate increased absorption to 18 and 19% for low and high temperatures, respectively. COC was superior to ammonium sulfate, increasing absorption to 33 and 46% for low and high temperatures, respectively. Absorption of Dropp was greater under warm temperatures than cool when COC was the only adjuvant in the mixture. This indicated that absorption of Dropp in the presence of COC may be regulated by temperature more so than without COC or with ammonium sulfate only. This, combined with heat-driven plant processes, could induce less than desirable results in the field.

The COC plus ammonium sulfate combination resulted in 65 to 68% absorption, the highest of all treatment combinations evaluated. Absorption was not affected by temperature. With a 7-fold to 9-fold increase in absorption, Dropp rate adjustments may be necessary before field application with this combination of adjuvants.

In a similar absorption experiment with different adjuvants, under cool temperatures, percent absorption in 24 hours was increased from 5% to at least 35% with the various additives (Table 1).

Under cool temperatures, absorption did not vary among additives with the possible exception of COC. Dropp absorption was approximately 35% with COC under both temperature regimes, which was in contrast to the earlier experiment where differences in absorption occurred due to temperature (Figure 5). However, overall absorption with COC alone did not exceed 42% in either experiment.

Under warm temperatures, absorption varied for each additive, again illustrating the heat-regulated response by the cotton plant. Absorption for each adjuvant under warm temperatures ranged from 21% for MYX 6121 to 42% for HM8802A.

Increasing temperature did not influence absorption for MYX 1220, MYX 6121, and COC at both levels of probability tested. However, absorption was increased at the 10% level of probability but not at the 5% level by warmer temperature for the additives LI 700 and HM8802A.

Under the warm environment, X-77, ethephon, and X-77 + paraquat each increased absorption of Dropp into the leaf (Table 2). This increased absorption, in part, accounts for the increased defoliation response when Dropp and ethephon are used in combination (*9*). It was theorized that the fast action of paraquat when applied in combination with Dropp would kill the cotton leaf and reduce absorption of Dropp into the leaf. Based on these findings, reduced absorption does not occur.

Dramatic differences in the absorption of radiolabeled Dropp due to adjuvant were apparent in these studies. Subjecting plants to cool temperatures for 48 hours following treatment initially delayed defoliation response, but later evaluations indicated defoliation was similar across environments after 10 days (Figure 3). Returning these plants to the greenhouse after a 48-hour treatment period reinstated active plant responses that could have negated early defoliation differences. Environmental conditions at the time of application or for 3 to 5 days afterwards can influence plant response to defoliants (*1*). Thus, extending the length of low temperature exposure in the growth chamber would prolong the response period and result in lower defoliation percentages.

Use of adjuvants to facilitate absorption of Dropp is important for optimizing defoliant performance or activity. In these studies, absorption was greatly increased by adjuvant use, but defoliation was regulated by temperature. One exception to this was use of COC alone, with greater absorption of Dropp under high temperatures than under low temperatures in one experiment but not in a second. This illustrates the complex nature of Dropp absorption and prediction of subsequent plant response. This contrast may be explained by slight differences in growing conditions between the two experiments. Differences in cuticle thickness of cotton leaves can occur in response to varying environments (*6*).

Regrowth inhibition was greater for COC + ammonium sulfate under either temperature regime and was the only adjuvant mix that reduced regrowth below that of the no adjuvant control. The decreased regrowth would have practical implications during years when harvesting may be delayed due to wet weather or mechanical failures.

Of practical importance, is the relative amount of Dropp absorbed with the use of adjuvants relative to that without adjuvants. In all cases, absorption increased with the use of an adjuvant. Field research is needed to determine if Dropp rates can be lowered when used with these various adjuvants. More knowledge about the rate of Dropp entry into the leaf is also needed.

Increased absorption may enhance plant response, resulting in excessive leaf drying or boll shed. Although desiccation was not observed in greenhouse experiments, this does not preclude the possibility of excessive desiccation in the field when Dropp is tank-mixed with COC and applied during periods of high temperatures[3]. Ammonium sulfate was less responsive to temperature, but was due to less Dropp being absorbed.

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[2]Dropp 50WP, Nor-Am Chemical Co., A Schering Berlin Co., Agribusiness Division, Wilmington, DE 19803.

[3]LI 700 is a mixture of 80% phosphatidylcholine, methyl acetic acid, and alkyl polyoxyethylene ether manufactured by Loveland Industries, Inc., Greeley, CO. HM8802A is an organosilicone and methylated soybean oil surfactant, manufactured by Helena Chemical Corp., Memphis, TN. MYX 6121 and MYX 1220 are manufactured by Mycogen Corp., San Diego, CA.

[4]X-77 Spreader is a mixture of 90% alkylarylpolyoxyethylene free fatty acids, glycols, and isopropanol and 10% inerts, manufactured by Valent U.S.A. Corp., Walnut Creek, CA. Ethephon (Prep®) is a mixture of 55.4% (2-chloroethyl) phosphonic acid and 44.6% inerts, manufactured by Rhone Poulenc Ag. Co., 2 T.W. Alexander Drive, P.O. Box 12014, Research Triangle Park, NC. Paraquat (Starfire®) is a mixture of 23.2% paraquat dichloride (1,1'-dimethyl-4,4bipyridinum dichloride) and 76.8% inerts, manufactured by Zeneca Inc., Wilmington, DE.

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