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Potential Losses of Eptam During Sprinkler Application and the Influence of Soil Moisture Levels at time of Application on Efficacy

Project Leaders: Dr. Scott Nissen, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins; Dr. Susie Thompson-Johns, Department of Horticulture, San Luis Valley Research Center; in cooperation with Mr. Randal Ristau, San Luis Valley Water Quality Demonstration Project, Cooperative Extension, Monte Vista, CO.

Introduction

Eptam is effective for the control of annual grasses and several important broadleaf weed species such as pigweed and nightshade. It can be applied pre-emergence or post-emergence and can be ground applied and mechanically incorporated, ground applied and sprinkled in or chemigated. Chemigation is an efficient method of application that eliminates the need for mechanical incorporation and provides very uniform herbicide distribution assuming the irrigation system is properly designed and maintained.

Eptam controls weed when it is absorbed through emerging shoots. Research suggests that this absorption can occur when Eptam is present in the soil as a vapor. Eptam's availability as a vapor is important for weed control but this characteristic (a high vapor pressure) also means losses during application can be significant due to volatility. Producers need to understand the potential for Eptam volatility in order to properly and efficient use this product.

Corn growers in the mid-west have known for 15 years that repeated applications of carbamothioate herbicides, such as Eptam, can result in increased rates of herbicide degradation. Microorganisms that can rapidly degraded Eptam and other related herbicides increase in the soil and begin to degrade the herbicide immediately after application. Reduced herbicide persistence means substantial reductions in weed control and yield losses due to weed competition. It is possible that the extensive use of Eptam in the SLV could already be selecting for soil microorganisms that can effectively degraded Eptam, putting growers at risk for yield losses and reducing Eptam's effectiveness as a weed management tool for potato production.

The objectives of this research were to determine the extent to which Eptam could volatilize during chemigation, measure initial herbicide losses from chemigating to a wet or dry soil surface, and determine the persistence of Eptam under field conditions in the SLV. In addition, greenhouse bioassay studies were conducted at herbicide concentrations measured in the field to determine effective period of control for volunteer barley, wild oat, hairy nightshade and redroot pigweed. In 1997, we conducted more controlled experiments to determine the influence of air temperature on Eptam volatility. We have completed three field seasons and hope to continue this research to better understand the role of air temperature and relative humidity on losses of Eptam during chemigation. Increasing the number of soil samples collected in 1996 and 1997 provided very useful information about the potential for enhanced bio-degradation.

Materials and Methods

Study design: This study was initiated on June 4, 1995; June 3, 1996 and June 10, 1997 in a potato production field just north and east of Monte Vista. The soil type was a sandy loam pH 7.4 and with 1.4% organic matter. The rotation for all three years of the study was carrot/barley/potato. This is a little unusual for the SLV, but represents a rotation that should minimize any chance of enhanced bio-degradation.

The field experiment consisted of three pre-emergence Eptam treatments and one control with four replications arranged in a randomized complete block with 20 ft by 20 ft plots. Water samples were collected at the sprinkler head and at ground level. These samples were analyzed for Eptam concentration to determine losses during chemigation. The four Eptam treatments were as follows:

Treatment 1: chemigate to dry soil
Treatment 2: chemigate to wet soil.
Treatment 3: surface application with immediate sprinkler incorporation.
Treatment 4: untreated control

Chemigation treatments were applied by the cooperating growers. The targeted application rate was 4 pints of Eptam 7E per acre with 0.5" irrigation via low pressure center pivot irrigation with drop nozzles. The amount of water applied during chemigation varied over the three years. In 1995 and 1996 the amount of water applied during chemigation was 0.6 to 0.8 inches, while in 1997 the amount of water applied was only 0.4 inches. For pre-wetted soil, impact sprinklers were used to apply 0.5" to appropriate plots. Treatment 3 was applied with a CO_2-backpack sprayer and incorporated via irrigation within one half hour with impact sprinklers delivering 0.4" irrigation. Treatment 3 and the control were

shielded from chemigation by covering the plots with black plastic which was removed immediately after the pivot passed.

Sample collection: Soil samples were collected at four times in 1995 and seven times in 1996 and 1997. Sampling times in 1995 were immediately after application, 1, 15, and 38 days later, while soil samples were collected immediately after application, 1, 3, 7, 10, 15, and 38 days later in 1996 and 1997. All soil samples were collected using a 6" core sampling probe. In each plot at each sampling period six soil cores were pulled, pooled in a stainless steel bucket, sub-sampled into glass containers with teflon-lined screw cap closures, and placed on ice until they could be frozen. During sample collection care was taken to avoid sampling within 2 feet of plot borders. The bucket, stirring rod and coring device were cleaned with water between treatments. Chemigation water samples were collected and stored in glass containers with teflon-lined closures and stored under the same conditions as previously described.

Soil and water extraction: Soil samples were extracted by adding 25 ml toluene plus 50 ml water to 50 g soil in a glass container with teflon-lined closure and shaking at room temperature for two hours. After shaking, samples were centrifuged at 5C for 5 minutes and transferred to vials for gas chromatography-mass spectrometry (GC/MS) analysis. Butylate was used as internal standard. Water samples were extracted by adding 10 ml toluene to 100 ml water sample in a 4 oz amber, narrow mouth bottle with teflon-lined closure and shaking for one hour. The toluene layer was placed in a GC vial for MS analysis.

Sample analyses: Zeneca (the company that manufactures and markets Eptam) provided the method that was used for sample analyses. The method was derived from a publication entitled "Determination of Selected Nitrogen and Phosphorus Containing Pesticides in Water or Soil by Solvent Extraction and Capillary Gas Chromatography, Report No. 89-45. We deviated from this protocol with respect to gas chromatographic conditions and use of an internal standard. All samples were analyzed within 24 hours of extraction and were stored in the dark at 5C until analysis.

Analyses were performed on a Hewlett-Packard 5890IIe gas chromatograph and 30 m x 0.25 mm HP5-MS capillary column equipped with a 5972 MSD operated in SIM mode (M/Z 86). We determined a linear calibration range of 0.02 - 10 μg/ml of EPTC in toluene and all samples were adjusted to fit into this range.

GS/MS conditions were as follows:

Column temperature: isothermal at 90C one min., 20C/min. ramp to 230C.
Injector temperature: 200CMS temperature: 300C
Column flow: 35 psi inlet pressure for 0.05 minutes, then isobaric (7 psi).
Injection mode: splitless
Injection volume: 1 ul
Quantitation: on-line, peak area
Retention time: 7.5 minutes
Analytical run time: 9.5 minutes

Greenhouse bioassay: Based on the analysis of field samples and the initial application rate of 4pt/ac a greenhouse bioassay was conducted using barley and wild oat as indicator species. Barley and wild oat were planted ¾ inch deep in flats containing soil collected from the field site. Eptam rates were 0, 0.4, 1, 2, 3, and 4 pt/ac. Herbicides were applied using a greenhouse pot sprayer at 16 gal/ac. Immediately after application the herbicide was incorporated by placing flats on mist bench and applying approximately 0.5 in of water from overhead nozzles. Ten days later the above ground plant growth was harvested and plant fresh weight was compared between treatments. A similar procedure was used for bioassays with hairy nightshade and pigweed. The rate structure for hairy nightshade and pigweed included a 5 pt/ac rate.

Effects of Temperature on Eptam Losses: For the 1997 field season, a portable chemigation unit was designed to evaluate the effect of air temperature on Eptam losses during chemigation. The portable unit consisted of an Agri-Inject chemigation system attached by garden hose to a rectangle of PVC pipe. The PVC frame had 12 nozzles spaced 30 inches apart. At 25 psi pressure the system would apply 0.5 inches of water over an area of approximately 10 by 20 feet in 7 minutes. Nozzles were held at a height of 6 ft and water samples from the nozzles and ground level were collected at 6:30 am, 10:30 am and 2:30 pm to provide a range of air temperatures. Air temperatures ranged from 55 to 90 F.

Data analysis: Data were analyzed by ANOVA to compare residue levels at each time as a function of treatment and to compare barley and wild oat fresh weight among untreated controls and herbicide treatments. Eptam volatility was determined by dividing the Eptam concentration at the ground level by the concentration at the nozzles expressed as a percentage. Comparisons were made using least significant differences at p=0.5.

Results and Discussion

In 1995, Eptam losses during chemigation were minimal. Eptam concentrations at the sprinkler head and soil surface were 28.4±1.9 and 25.3±1.4 ppm,

respectively. While this does represent a 10% loss these values were not statistically different. Eptam losses during chemigation were significant in 1996. The concentration at the sprinkler was 23.3±1.1 ppm and 16.7±2.0 ppm at the soil surface. This represents a loss of approximately 28%. In 1997, Eptam losses during chemigation were also statistically significant with a loss of 15%.

Temperature and relative humidity at the time of application were very different in 1995 and 1996. In 1995, the pivot reached the plot area in the evening when the temperature was 48F and relative humidity was 82%. In 1996, the pivot reached the plot area at midmorning when the temperature was 70F and the relative humidity was 19%. Weather conditions were fairly similar in 1997, but losses were somewhat less than in 1996. Previous research (Washington State University) has shown that Eptam losses can be significant during chemigation when air temperatures are above 85F and relative humidity is low. It was surprising to have volatility losses of 28% with air temperatures of only 70F.

If split applications of Eptam were made the second application would be made when air temperatures are higher. This could significantly increase the amount of loss due to volatility. Multiple applications in a single year would also increase the chances of developing enhanced biodegradation and producers should expect considerably shorter persistence from the second Eptam application. Increasing the number of soil samples collected in 1996 and 1997, provided information on Eptam fate during the first week of application. The results show that significant degradation occurred during the first three days after application. In 1996, the Eptam concentration decreased by 15% in three days, but in 1997 the level of Eptam in the soil decreased by 50%. It this point, we are not able to distinguish between degradation and losses due to lower amounts of water used for incorporation in 1997 compared to 1996.

Chemigation to wet soil resulted in significant losses of Eptam in 1995, 1996 and 1997. Because the soil was more efficiently watered in 1996 and 1997 losses due to codistillation were much higher than in 1995. Eptam losses were 30,70, and 65% 1 day after application in 1995,1996 and 1997, respectively. In all three years chemigation to dry soil and ground application followed by sprinkler incorporation were the best treatments for maintaining higher levels of Eptam in the short term (Figure 1 and 2). There were no significant differences in the amount of Eptam remaining between ground applied and chemigation to dry soil 15 days after application.

A bioassay study was conducted to determine the relationship between herbicide persistence and the length of residual weed control. We assumed that the initial herbicide concentration was equivalent to 4 pt/ac for barley and wild oat and 5 pt/ac hairy nightshade and pigweed. Based on field sampling 15 days after application only 25% of the original concentration remained. This would be

equivalent to 1 pt/ac. Results of the greenhouse bioassay with field soil are shown in Figure 4 and Figure 5. The Eptam rate required to significantly reduce barley and wild oat biomass was 0.4 and 1 pt/ac, respectively. Based on these results Eptam would have significant activity against barley for approximately two weeks and somewhat longer for wild oat. It is interesting to note that even at the 4 pt/ac rate barley and wild oat coleoptiles emerged and appeared normal. Since plants were harvested 10 days after treatment it was not apparent if these plants would have eventually become competitive. Significant reductions in hairy nightshade and pigweed growth required Eptam applications of 4 to 5 pt/ac. This suggests that residual Eptam activity for control of hairy nightshade and pigweed is very short and volatility losses during application could be high enough to reduce residual activity even more.

Air temperature had a significant impact on Eptam volatility during chemigation. Eptam losses ranged from 15% at 55F to 45% at 90F and the effect of temperature on volatility was relatively linear over that temperature range. Using the portable chemical unit we were able to more accurately evaluate the influence of air temperature on Eptam losses due to volatility. These data suggest that growers should consider chemigating Eptam between 8 am and 8 pm to avoid these losses.

Objectives for 1998 Field season

- Determine the best method for reducing Eptam losses during chemigation.
- Determine the half-life of Eptam in common SLV soils with and without a history of Eptam.
- Determine the maximum amount of time between broadcast applications of Eptam and sprinkler incorporation.
- Demonstrate the attributes of Eptam, Dual, Frontier, Prowl, Matrix and Sencor/Lexone for the 1998 Field Tour at the San Luis Valley Research Station.

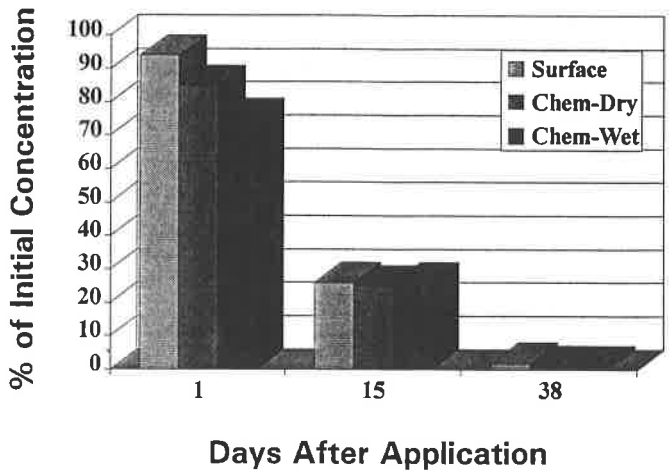

Figure 1. Amount of Eptam remaining as a percentage of initial concentration-1995.

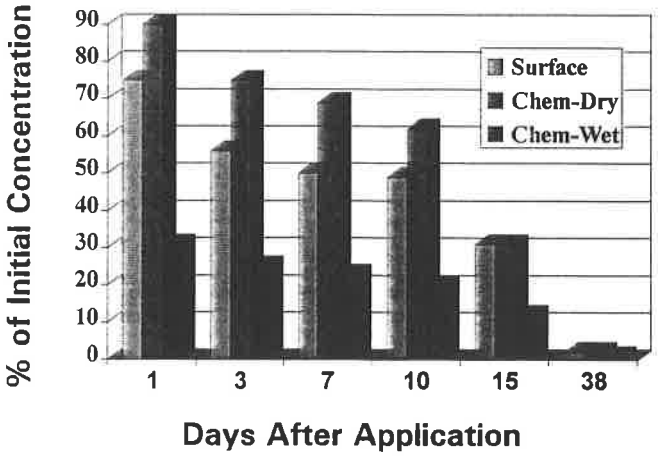

Figure 2. Amount of Eptam remaining as a percentage of initial concentration-1996.

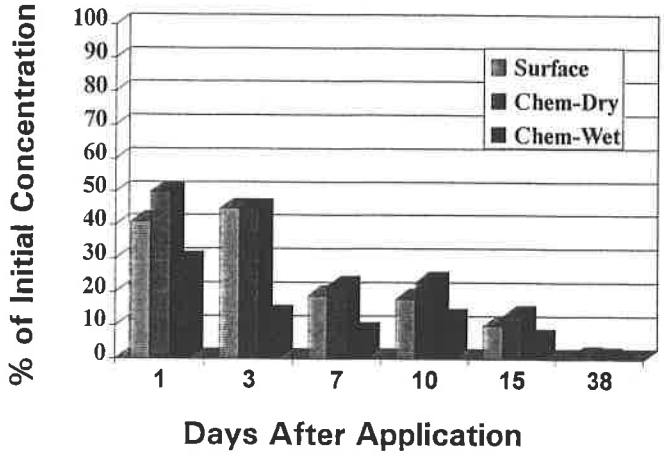

Figure 3. Amount of Eptam remaining as a percentage of initial concentration-1997.

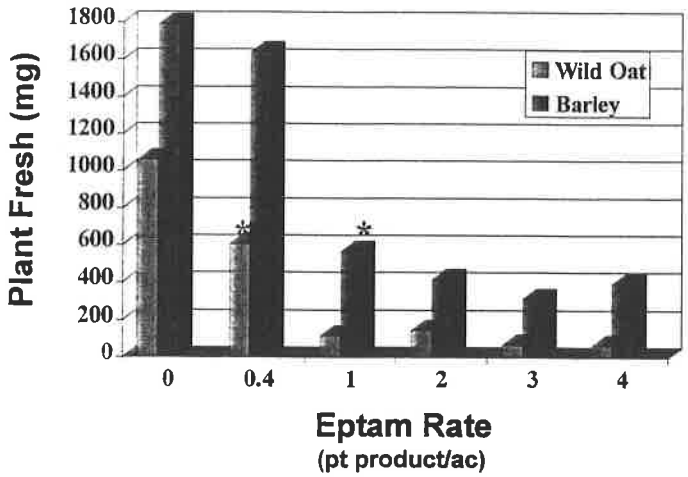

Figure 4. Bioassay of Eptam activity against wild oat and barley

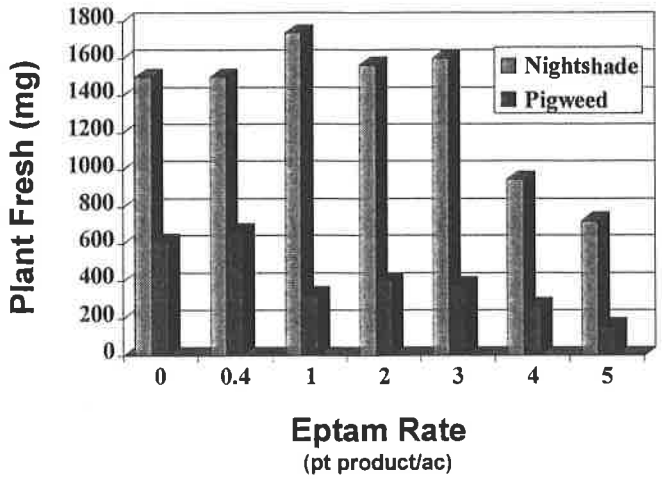

Figure 5. Bioassay of Eptam activity against hairy nightshade and pigweed.

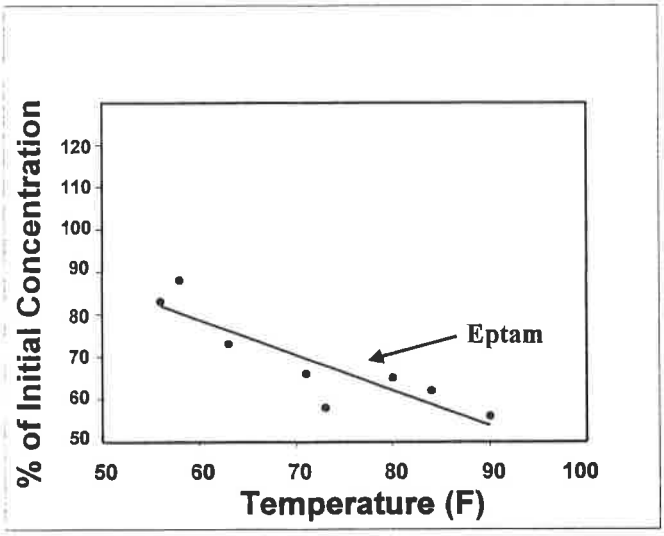

Table 6. Effects of temperature on volatility of Eptam, Dual and Frontier During Chemigation