DISLODGEABLE FOLIAR RESIDUES: INITIAL DEPOSITION ON VARIOUS CROPS IN CALIFORNIA #186

Sheryl L. Beauvais and Joseph P. Frank

Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA 95814

ABSTRACT

Dislodgeable foliar residue (DFR) is the pesticide residue that can be removed from both sides of treated leaf surfaces using an aqueous surfactant. DFR is assumed to be the portion of a pesticide applied to a crop that's available for transfer to people coming in contact with the foliage. DFRs are frequently used to estimate field worker exposures in pesticide risk assessments. For any given pesticidal active ingredient (AI), DFR data are available for a limited number of crops, and data from some crops may be used as surrogates for others. When data are lacking entirely for an AI, regulators often assume a default percentage (20%) of the AI applied. We examined DFR data collected on the day of application ("initial DFR") for several crops and active ingredients, to assess whether specific crops tend to have higher initial DFRs than others and the validity of the 20% default. Among the crops and chemicals investigated, we found that initial DFR often depended more on the chemical applied than on the crop. We also found that most initial DFRs were less than the 20% default, although several samples exceeded this value.

INTRODUCTION

Dislodgeable foliar residue (DFR) is the pesticide residue that can be removed from both sides of treated leaf surfaces using an aqueous surfactant. Based on studies showing a proportional relationship between DFR and measured field worker exposures, DFRs are assumed to be the portion of a pesticide applied to a crop that's available for transfer to people coming in contact with the crop foliage, such as field workers shown harvesting crops in Figure 1. Studies of field worker exposure suggest that the dominant route of exposure is dermal, from residues transferred as workers contact treated crop foliage.

DFR is measured on leaf discs collected with a punch-type sampler as shown in Figure 2. Leaf discs fall directly into the pre-cleaned jar, and the total leaf surface area is determined by the number of discs sampled. A surfactant solution is added to the jar, and the jar is shaken to dislodge residues from leaf surfaces into the solution, which is then extracted with an appropriate solvent. DFR results are reported as residue in µg dislodged from leaf surface area in cm^2 (i.e., $\mu g/cm^2$). DFRs are less resource-intensive to measure than exposure, and for this reason many estimates of field worker exposure used in pesticide risk assessments are based on DFRs.

For any given pesticidal active ingredient (AI), DFR data are available for a limited number of crops. Ideally, studies will include crops in which high-foliar-contact activities occur, such as grapes, as well as most crops on which an AI is likely to be used. In practice, resource constraints limit the number of studies conducted, and some crops of interest may not be represented. To bridge data gaps, DFRs from some crops may be used as surrogates for others. When data are lacking entirely for an AI, for purposes of estimating exposure regulators often assume an initial default percentage (20%) of the AI applied.

Estimated exposures to pesticides correlate with DFRs. Thus, if DFRs are underestimated then exposures are as well. Exposures are used to calculate risk, and if estimated exposures are too low the resulting risk is underestimated as well. We examined DFR data collected in California on the day of application ("initial DFR") for several crops and AIs, to assess whether some crops tend to have higher or lower initial DFRs than others. We also checked for measured initial DFR results above the 20% default.

Figure 1. Harvesting grapes and strawberries in California.

Figure 2. Collecting leaf punches for DFR.

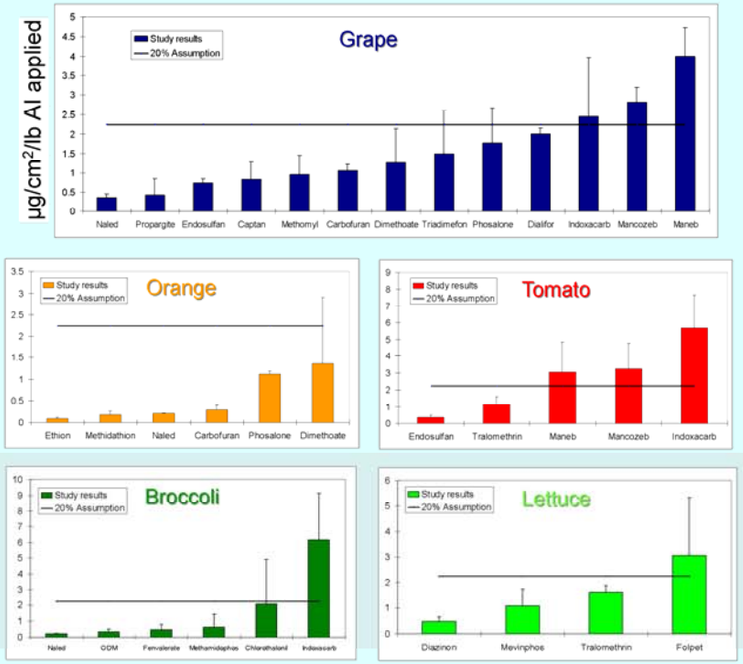
COMPARISONS WITHIN FIVE EXAMPLE CROPS

We reviewed data from studies conducted by the California Department of Pesticide Regulation (CDPR), studies conducted by outside investigators and submitted to CDPR, and studies published in the open literature. Only studies with sampling on the day of application, with replicated applications and samples, were included. Results were normalized for comparisons by dividing by pounds AI applied.

Figure 3 summarizes preliminary comparisons involving several pesticides on grape, orange, tomato, lettuce, and broccoli foliage. These represent some of the most commonly used crops in DFR studies conducted in California. Each bar in Figure 3 summarizes mean and standard deviation of the initial DFR from between two and eleven applications. The horizontal line on each graph represents the default assumption of 20% used by CDPR, which equals 2.24 $\mu g/cm^2$/lb AI applied.

Mean normalized initial DFR differed among chemicals applied to a crop. Among the five crops shown in Figure 3, the difference ranged from 6.5-fold on lettuce to 30-fold on broccoli. Most mean initial DFRs were below the 20% assumption, with the exception of three chemicals applied to both grape and tomato foliage (indoxacarb, mancozeb and maneb), one of which was also applied to tomato (indoxacarb), and a single chemical applied to lettuce (folpet). Appendix 1 summarizes selected characteristics of AIs applied to grapes.

Figure 3. Initial DFR of various active ingredients on multiple crops, normalized to pounds of active ingredient applied (µg/cm²/lb AI applied). Each bar represents mean ± SD (N between 2 and 11), and line represents the 20% initial DFR assumption (2.24 µg/cm²/lb AI applied).

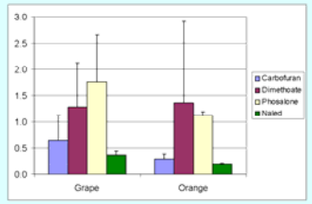


COMPARISONS BETWEEN CROPS

Figure 3 shows that some chemicals had initial DFR measured on two or more of the crops. For example, initial DFR was measured for naled on grape, orange, and broccoli; initial DFRs on these crops ranged 0.203—0.368 $\mu g/cm^2$/lb AI applied. In contrast, indoxacarb tended to yield higher initial DFRs, ranging 2.45—6.19 $\mu g/cm^2$/lb AI applied, on the three crops where its DFRs were measured (grape, tomato, and broccoli).

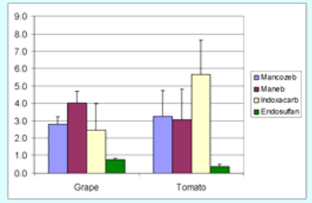
Figure 4 graphically illustrates comparisons among chemicals applied to grape foliage and either orange or tomato foliage. ANOVA tables next to each graph summarize statistical comparisons. In both sets of comparisons, chemical p-values are lower than crop p-values, suggesting that initial DFR depended more on the chemical applied than on the crop.

Figure 4. Initial DFR of active ingredients on pairs of crops, normalized to pounds of active ingredient applied (µg/cm²/lb AI applied). Each bar represents mean ± SD.



Source	DF	SS	Mean Square	F Value	Pr < F
Crop	1	1.16161763	1.16161763	2.36	0.1468
Chemical	3	4.11808761	1.37269587	2.79	0.0794*
Interaction	3	0.17714053	0.05904684	0.12	0.9469
Error	14	6.89338128	0.49238438		

* When dimethoate is omitted, total DF = 13 instead of 21, and crop and chemical are both significant (p = 0.0136 and 0.0034, respectively).



Source	DF	SS	Mean Square	F Value	Pr < F
Crop	1	11.86946762	11.86946762	5.05	0.0374*
Chemical	3	59.85665220	19.95221740	8.49	0.0010**
Interaction	3	6.68051957	2.22683986	0.95	0.4384
Error	14	42.2877006	2.3493167		

* Significant at p = 0.05.
** Significant at p = 0.005.

CONCLUSIONS

- Among the crops and chemicals investigated, preliminary comparisons suggest that initial DFR was influenced more by the chemical applied than by the crop.
  - However, an unpublished study by the Agricultural Reentry Task Force suggested that initial DFR results would tend to be lower on some crops (specifically, those with waxy foliage such as citrus and broccoli) than on other crops.
  - CDPR is continuing to examine other DFR studies with additional crops and chemicals to better understand the impacts of these and other factors (e.g., application method, weather, other chemicals in solutions) on initial DFR.
- Most mean initial DFRs were less than the 20% default, although some means and individual samples exceeded this value.
  - This suggests that 20% is generally a health-protective default, with a few exceptions.
  - CDPR is attempting to determine factors that might predict situations when 20% may be too low.