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Calculation of 1,3-D application factors based on HYDRUS flux estimates

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10/17/2019

Introduction

1,3-Dichloropropene (1,3-D) is a fumigant used to control nematodes, insects and disease organisms in the soil. It is commonly used as a pre-plant treatment that is injected into soil. It may also be applied through drip irrigation. Regardless of the application method, the possibility of offsite transport of this fumigant due to volatilization may subsequently cause human exposure through inhalation. To mitigate its potential cancer risk, the Department of Pesticide Regulation (DPR) limits the use of 1,3-D on a regional basis (township cap). The current township cap is 136,000 “adjusted” pounds during a calendar year in any township (six by six mile area). Adjusted pounds refers to the amount of 1,3-D active ingredient multiplied by an application factor (AF) to account for differences in air concentrations due to application method, region, and season of application.

AFs are multipliers that DPR originally intended to account for variation in cumulative flux density between different application methods (e.g., deep versus shallow shank injection). The basis for determination of an AF is the emission ratio (ER, also referred to in some documents as an 'emission rating'), an estimate of the emitted fraction of total applied mass over a given interval following completion of an application (ER = cumulative flux / mass applied). DPR derived the ER values currently used in AF calculations (Table A-1, appendix) from a small selection of field-estimated ER values obtained from field flux studies. The first field flux studies were for an untarped, deep injection application method, and DPR assigned an ER of 0.35 and an AF of 1.0 to this method (Johnson 2013a). The AFs for other methods are relative to this application method and ER (Johnson 2014). Currently, DPR applies additional mathematical adjustments to January AFs in an attempt to account for an increase in 1,3-D air concentrations due to seasonal and regional meteorological variation.

This document presents an alternate approach to generate AF estimates for each of the 17 approved field fumigation methods ('FFM', summarized in Table 1) for 1,3-D based on the HYDRUS modeling of ERs performed by Brown (2019). AF for each method is taken as the mean ER at 21 days post-application (modeled cumulative flux) across 16 representative soil types, normalized by 0.35. Because HYDRUS estimates ER for each method as a distribution of possible values, standard deviation (SD) of AF is also calculated based on the SD associated with each HYDRUS-estimated ER. The AFs calculated here do not

attempt to account for variation in seasonal or regional air concentrations resulting from meteorological factors (i.e., only flux is considered).

Table 1. List of approved 1,3-D application methods.

Field Fumigation Method (FFM) Code	Method Description
1201	1,3-D - Nontarpaulin/Shallow/Broadcast or Bed
1202	1,3-D - Tarpaulin/Shallow/Broadcast
1203	1,3-D - Tarpaulin/Shallow/Bed
1204	1,3-D - Nontarpaulin/Shallow/Broadcast or Bed w/ 3x Irrigation
1205	1,3-D - Tarpaulin/Shallow/Bed w/ 3x Irrigation
1206	1,3-D - Nontarpaulin/Deep/Broadcast or Bed
1207	1,3-D - Tarpaulin/Deep/Broadcast
1209	1,3-D - Tarpaulin/Chemigation/Bed
1210	1,3-D - Nontarpaulin/Deep/Strip
1211	1,3-D – Nontarpaulin/Deep/GPS-targeted
1242	1,3-D - TIF/Shallow/Broadcast - 60% credit[1]
1243	1,3-D - TIF/Shallow/Bed - 60% credit[1]
1245	1,3-D - TIF/Shallow/Bed w/ 3x Irrigation - 60% credit[1]
1247	1,3-D - TIF/Deep/Broadcast - 60% credit[1]
1249	1,3-D – TIF/Deep/Strip – 60% credit[1]
1259	1,3-D - TIF/Chemigation/Bed - 60% credit[1]
1290	1-3,D – Other Label Method

1. '60% credit' refers to a form of buffer zone reduction credit. TIF stands for 'totally impermeable film'.

Methods

HYDRUS ER estimates were those calculated by Brown (2019) and summarized in Table 2. ER for each method was estimated based on mean cumulative flux at 21 days post-application for HYDRUS simulations performed across 16 soil types described by soil core data collected by DPR staff from prepared fields prior to fumigation. The soil data obtained from those cores is intended to describe the distribution of likely soil conditions (including soil texture and soil moisture) typical of fumigated fields in California (Johnson 2013b). Although there may be differences in the distribution of soil conditions by region (with regional differences in soil texture having been previously evaluated by Johnson and Spurlock 2009), there is currently insufficient data to conclude whether these differences would significantly affect mean ER by region. At this time, SD associated with mean ER describes a lower bound of expected variability for each method due to field-to-field variation in soil conditions including soil texture and soil moisture, and does not account for other sources of variability such as changes in tarp permeability due to tearing, stretching, or gluing.

AF for each method was calculated from HYDRUS-estimated ERs using equation 1, below:

$$AF = ER / 0.35 \quad (1)$$

No ER estimates are available for FFM 1211 (Nontarpaulin/Deep/GPS-targeted) and FFM 1290 (Other Label Method). The AF for FFM 1211 is assumed equivalent to the AF for FFM 1206 (Nontarpaulin/Deep/ Broadcast), the method to which it is most similar. The AF for FFM 1290 is assumed equivalent to the highest estimated AF, here corresponding to FFM 1201 (Nontarpaulin/Shallow/Broadcast).

Table 2. HYDRUS-estimated ER by application method (from Brown 2019).

FFM code	Method description	ER @ 21 days	SD
1201	1,3-D - Nontarpaulin/Shallow/Broadcast	0.58	0.09
1202	1,3-D - Tarpaulin/Shallow/Broadcast	0.46	0.12
1203	1,3-D - Tarpaulin/Shallow/Bed	0.55	0.11
1204	1,3-D – Nontarpaulin/Shallow w/ 3x Irrigation	0.50	0.10
1205	1,3-D - Tarpaulin/Shallow/Bed w/ 3x Irrigation	0.52	0.11
1206	1,3-D - Nontarpaulin/Deep/Broadcast	0.38	0.13
1207	1,3-D - Tarpaulin/Deep/Broadcast	0.31	0.14
1209	1,3-D - Tarpaulin/Chemigation/Bed	0.48	0.08
1210	1,3-D - Nontarpaulin/Deep/Strip	0.39	0.14
1242	1,3-D - TIF/Shallow/Broadcast - 60% credit	0.14	0.05
1243	1,3-D - TIF/Shallow/Bed - 60% credit	0.26	0.10
1245	1,3-D - TIF/Shallow/Bed w/ 3x irrigation - 60% credit	0.20	0.06
1247	1,3-D - TIF/Deep/Broadcast - 60% credit	0.11	0.05
1249	1,3-D - TIF/Deep/Strip - 60% credit	0.14	0.07
1259	1,3-D - TIF/Chemigation/Bed - 60% credit	0.20	0.06

Results and Discussion

AF estimates are presented in Table 3 and Figure 1 alongside the current regulatory values. As described earlier, the current regulatory AF values were developed through a two-step process: first, a small collection of field flux studies was used to estimate ER for a given method; and second, a mathematical adjustment was applied to account for increases in January air concentrations due to meteorological factors unrelated to flux. With the exception of seasonal and regional temperature effects evaluated by Brown (2019), which were not found to be significant for the calculation of ER, the consideration of meteorological factors goes beyond the scope of HYDRUS modeling. Therefore, this approach to AF determination does not account for all of the parameters that have been used historically to calculate the AFs and the HYDRUS AFs in Table 3 and Figure 1 are presented as 'seasonally unadjusted' values which are best compared to the current regulatory AFs for February-November. A set of winter multiplication factors (historically ranging from 1.0 to 2.0) would need to be applied to the seasonally unadjusted HYDRUS AF values in Table 3 for the purposes of calculating January AFs as described by Johnson (2013a, 2014).

Table 3. Current regulatory and HYDRUS-estimated seasonally unadjusted AF by method.

	Current AF			HYDRUS AF	
FFM code	Jan[A]	Jan[A]	Feb-Nov [All locations]	Seasonally Unadjusted [All locations]	SD
1201	Prohibited	2.3	1.9	1.67	0.26
1202	Prohibited	2.3	1.9	1.30	0.33
1203	Prohibited	2.3	1.9	1.57	0.32
1204	Prohibited	2.3	1.9	1.42	0.29
1205	Prohibited	2.3	1.9	1.49	0.30
1206	1.9	1.2	1	1.10	0.37
1207	1.9	1.2	1	0.89	0.39
1209	1.16	1.16	1.16	1.38	0.23
1210	1.9	1.2	1	1.11	0.39
1211	1.9	1.2	1	1.10[B]	0.37[B]
1242	0.6	0.6	0.3	0.41	0.14
1243	0.6	0.6	0.3	0.74	0.30
1245	0.6	0.6	0.3	0.57	0.19
1247	0.6	0.6	0.3	0.31	0.16
1249	1.2	1.2	0.6	0.39	0.21
1259	1.16	1.16	1.16	0.57	0.19
1290	Prohibited	2.3	1.9	1.67[C]	0.26[C]

[A] All 1,3-D applications are prohibited during December.
[B] FFM 1211 ('1,3-D – Nontarpaulin/Deep/GPS-targeted') is assigned the value of FFM 1206.
[C] FFM 1290 ('1,3-D - Other Label Method') is by default assigned the highest calculated AF.

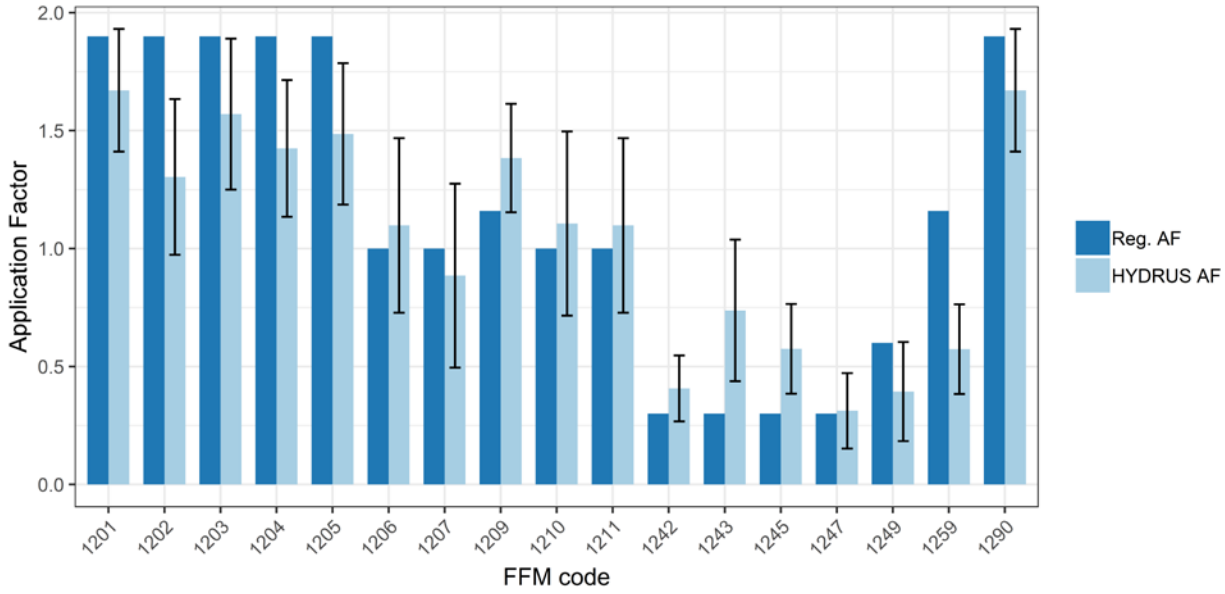

Figure 1. Summary of current regulatory AF (Feb-Nov values) and HYDRUS-estimated seasonally unadjusted AF by method. Error bars represent 1 SD around the mean due to field-to-field variation in soil conditions.

References:

Brown, C. (2019). HYDRUS-simulated flux estimates of 1,3-dichloropropene max period-averaged flux and emission ratio for approved application methods. Sacramento, CA: Department of Pesticide Regulation, California Environmental Protection Agency.

Johnson, B. (2013a). Calculation of use adjustment factors for 1,3-dichloropropene with the use of totally impermeable film for broadcast shank applications. Sacramento, CA: Department of Pesticide Regulation, California Environmental Protection Agency.

Johnson, B. (2013b). Study #286: Selected physical properties of California soils prior to broadcast or bedded fumigation treatments. Sacramento, CA: Department of Pesticide Regulation, California Environmental Protection Agency.

Johnson, B. (2014). How to calculate the application factor for new 1,3-dichloropropene application methods. Sacramento, CA: Department of Pesticide Regulation, California Environmental Protection Agency.

Johnson, B. and Spurlock, F. (2009). Dominant soil types associated with fumigant applications in ozone nonattainment areas. Sacramento, CA: Department of Pesticide Regulation, California Environmental Protection Agency.

Appendix A

Table A-1. List of current application factors (AF) adapted from Pesticide Use Enforcement Program Standards Compendium Volume 3, Appendix Section J.3 (Revision 41).

Location	Tarp Type	Months[1]	Fumigation Method	Application Factor
Within SJV	non-60% credit	Jan	Shallow	Prohibited
			Deep	1.9
			Drip	1.16
		Feb-Nov	Shallow	1.9
			Deep	1.0
			Drip	1.16
	60% credit	Jan	Shallow	0.6
			Deep	0.6
			Strip	1.2
			Drip	1.16
		Feb-Nov	Shallow	0.3
			Deep	0.3
			Strip	0.6
			Drip	1.16
Outside SJV	non-60% credit	Jan	Shallow	2.3
			Deep	1.2
			Drip	1.16
		Feb-Nov	Shallow	1.9
			Deep	1.0
			Drip	1.16
	60% credit	Jan	Shallow	0.6
			Deep	0.6
			Strip	1.2
			Drip	1.16
		Feb-Nov	Shallow	0.3
			Deep	0.3
			Strip	0.6
			Drip	1.16

[1] All applications prohibited during December.