UPDATE OF FILM PERMEABILITY MEASUREMENTS FOR USDA-ARS AREA-WIDE RESEARCH PROJECT

Scott R. Yates[*1], Dan O. Chellemi[2], Dong Wang[3], Suduan Gao[3],
Brad Hanson[3], Husein Ajwa[4], Greg Browne[5], Dan Kluepfel[5]
[1]USDA-ARS, Riverside, CA; [2]USDA-ARS, Fort Pierce, FL;
[3]USDA-ARS, Parlier, CA; [4]Univ. Calif., Davis, CA; [5]USDA-ARS, Davis, CA

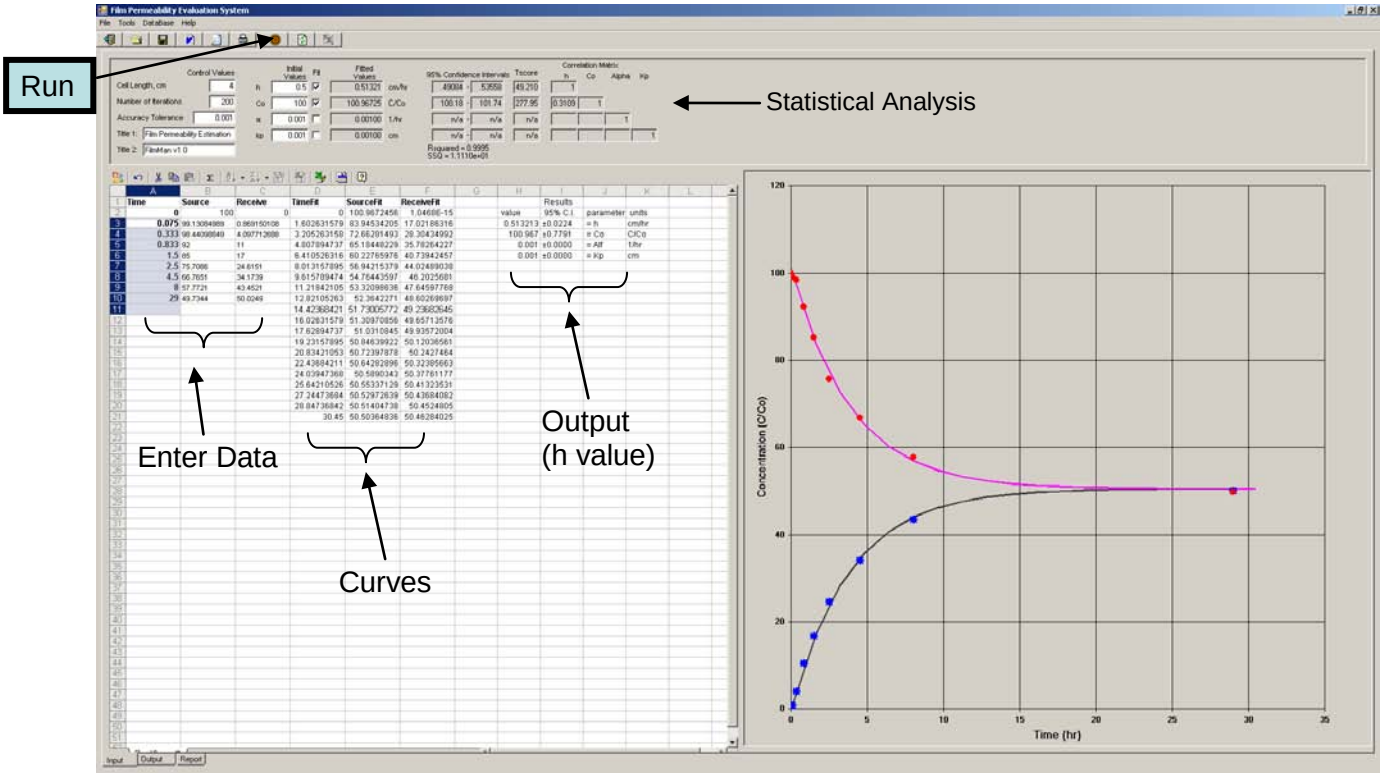
Plastic tarps currently used to control emissions of soil fumigants have been shown to be permeable to fumigant gases, resulting in appreciable losses to the atmosphere. New films are being developed with improved physical properties and low permeability to help reduce fumigant emissions and increase efficacy.

There is a need to have accurate film permeability values so that research scientists, producers and regulators can better understand the relationships between different types of film, agricultural practices, pest management, emissions and crop production.

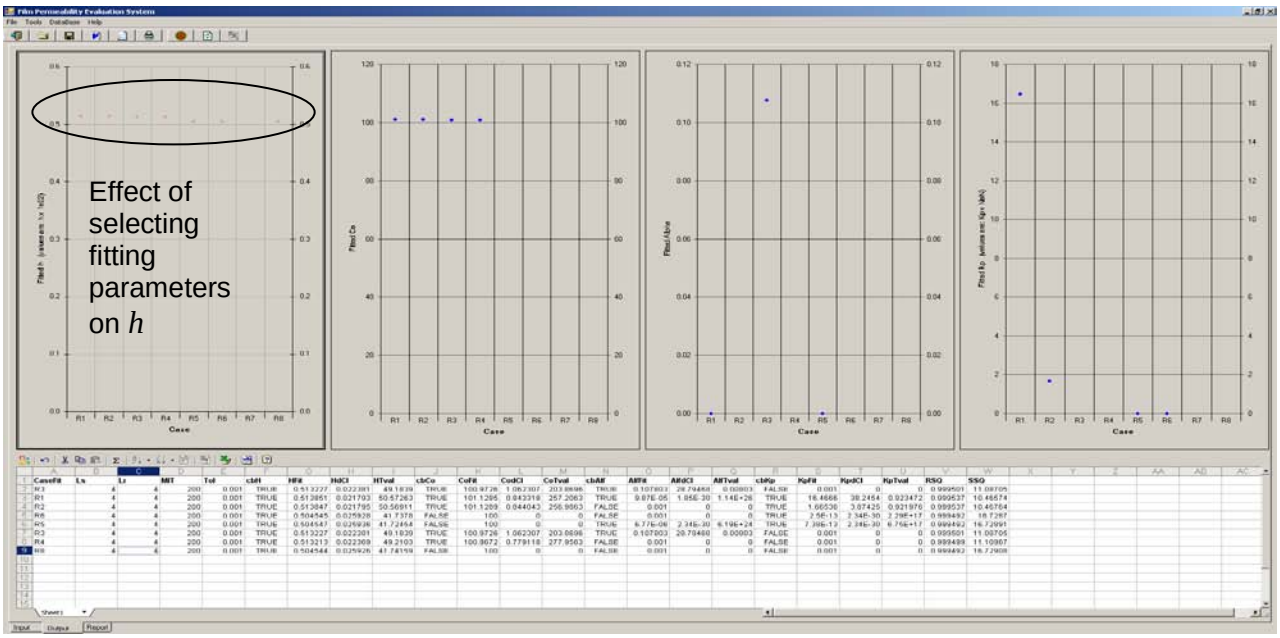
Therefore, a rapid, reliable, and sensitive method is required to measure the permeability of various films that may be used in new pesticide management practices. The method should be reliable, accurate, and independent of extraneous experimental conditions. A new approach has been developed for estimating the mass transfer coefficient (*h*) of fumigant compounds across agricultural films. A measure of the resistance to fumigant diffusion, *h,* is a function of the films chemical properties in combination with a fumigant and independent of the concentration gradient across the film. Therefore, each chemical-fumigant-temperature combination produces a unique *h* value, which is quite unlike typical permeability. This method uses static sealed cells and fumigant vapor is added to one side of the film. The concentrations on both sides of the film are then monitored until equilibrium is reached. An analytical mathematical model is used to obtain a value for *h* by fitting the model to the observed data. This model relies on a mass balance approach and includes sorption onto and diffusion across the film membrane. The method has been tested using various polyethylene and virtually impermeable films and has been shown to produce a sensitive and reproducible measure of film permeation.

The objectives of this presentation are to (a) describe the method to obtain accurate film permeability (i.e., mass transfer coefficient) values; (b) demonstrate a new Windows® program for calculating the mass transfer coefficient; (c) provide measured mass transfer coefficients for films used in the Area-wide research project; and (d) provide an estimate of total emissions for each film type, given a standard scenario.

Film Permeability Calculator Program (Input & Analysis Screen)



Film Permeability Calculator Program (Output Screen – parameter verification)



Film Permeability Calculator Program (Report Screen)

Film Permeability AnaLysis
(FilmPal v1.0)

Non-Linear Least-Squares Analysis: Levenberg-Marquardt algorithm

Film Permeability Model: Papiernik, S.K., Yates, S.Rand Gan, J
An approach for estimating the permeability of agricultural films
EnvironSci& Techn35:1240-12462001.

Author:
Dr. Scott R. Yates, U.S. Salinity Laboratory
450 W. Big Springs Road
Riverside, CA 92507
951-369-4803
scott.yates@ars.usda.gov

Film Permeability Estimation
FilmPAL v1.0
Date: 9/2/2008 3:29:10 PM

Cell Length: 4 cm
Max Number Iterations: 200
Accuracy Tolerance: 0.001

Time Units: hr
Length Units: cm
Mass Units: C/Co

Input Data

Time (hr)	Source (C/Co)	Receive (C/Co)
0.0000000	100.0000000	0.0000000
0.0750000	99.1308499	0.8691501
0.3333333	98.4409885	4.0977127
0.8333333	92.3428378	10.5040656
1.5000000	85.1441929	16.8404580
2.5000000	75.7085986	24.6150817
4.5000000	66.7651223	34.1738852
8.0000000	57.7721282	43.4521464
29.0000000	49.7343797	50.0248848

Values For Fitting Parameters

Iter	H	Co	Alf	Kp	SSQ
0	0.5000000	100.0000000	0.0010000	0.0010000	---
1	0.5128885	100.9539858	0.0010000	0.0010000	11.1096690
2	0.5132133	100.9672456	0.0010000	0.0010000	11.1084120
Coeff:	Fitted	Fitted	Not Fitted	Not Fitted	

Correlation Matrix:

	H	Co	alf	Kp
H	1.000000	0.310950	0.000000	0.000000
Co		1.000000	0.000000	0.000000
alf			1.000000	0.000000

Kp 1.000000

Fitted Concentrations:

Time (hr)	Cell Location	Input Conc (C/Co)	Fitted Conc (C/Co)	Conc Diff (C/Co)
0.00000	Source	100.00000	100.96725	-0.96725
0.07500	Source	99.13085	100.00495	-0.87410
0.33333	Source	98.44099	96.82862	1.61237
0.83333	Source	92.34284	91.24804	1.09479
1.50000	Source	85.14419	84.83830	0.30590
2.50000	Source	75.70860	77.06287	-1.35427
4.50000	Source	66.76512	66.39309	0.37203
8.00000	Source	57.77213	56.96400	0.80813
29.00000	Source	49.73438	50.51286	-0.77848
0.00000	Receive	0.00000	0.00000	0.00000
0.07500	Receive	0.86915	0.96229	-0.09314
0.33333	Receive	4.09771	4.13862	-0.04091
0.83333	Receive	10.50407	9.71918	0.78488
1.50000	Receive	16.84046	16.12891	0.71155
2.50000	Receive	24.61508	23.90432	0.71077
4.50000	Receive	34.17389	34.57404	-0.40016
8.00000	Receive	43.45215	44.00305	-0.55090
29.00000	Receive	50.02488	50.45366	-0.42878

Non-Linear Least Squares Analysis, Final Results

NAME	VALUE	95% CONFIDENCE LIMITS LOWER	UPPER	S.E.COEFF	T-VALUE
H	0.5132	0.4908	0.5356	0.0104	49.2103
Co	100.9672	100.1881	101.7464	0.3632	277.9563