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Institute of Food and Agricultural Sciences

Circular 1003

Managing Pesticides for Soybean Production and Water Quality Protection[1]

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WATER QUALITY CONSIDERATIONS IN SOYBEAN PRODUCTION

Concern about the harmful effects of pesticides on surface water and groundwater quality should motivate soybean producers to select pesticides with the least potential to cause water quality problems. Many soybean producers live in rural areas near where they and other producers grow soybeans, therefore, their personal water supply is susceptible to contamination. Unfortunately, information that allows producers to select pesticides less likely to affect water quality has not previously been readily available.

Our purpose is to provide information that can help producers select pesticides that will have a minimum adverse impact on water quality. The procedure considers the soil properties of the application site, the mobility and persistence of pesticides in these soils, and the toxicity of the pesticides in water to humans and aquatic species. A proper selection will decrease chances of adversely affecting surface water and groundwater quality. Certain combinations of soil and pesticide properties (along with weather conditions)can pose a significant potential hazard to water quality. Our goal is to identify and avoid these circumstances. Information contained in this circular can help soybean producers make better decisions about the pesticides that they use. This document in no way endorses any particular pest control product. All products must be used in accordance with the label.

MATERIALS NEEDED TO USE THIS PROCEDURE

To effectively use this procedure you will need the following source materials:

1) A copy of the current IFAS Pest Management Guides or other appropriate information sources that identify pesticides that control specific pests.

2) A copy of your county soil survey report to identify the soil types found in your fields.

3) A copy of the Soil Science Fact Sheet entitled "[Name of your county]: Soil Ratings for Selecting Pesticides" for your county, available from your

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county Cooperative Extension Office. The basis of these ratings are given in the IFAS Extension Circular 959 entitled "Soil Ratings for Selecting Pesticides for Water Quality Goals," which is also available from your county Cooperative Extension Office.

Note: If your county has not yet been mapped by the Natural Resources Conservation Service (formerly the Soil Conservation Service), you will need to contact the local NRCS office for a site evaluation and determination of soil types and ratings for leaching and runoff of pesticides.

IMPORTANT FACTORS THAT AFFECT PESTICIDE SELECTION

How pesticides behave in the soil is determined by many factors including properties of the pesticides and of the soil at the application site. Some of the factors that should be considered when selecting pesticides with minimal potential for water quality impacts are:

Pesticide Properties

1) The organic carbon adsorption coefficient, K_{oc}, describes the relative affinity or attraction of the pesticide to soil materials and therefore its mobility in the soil.

2) The biological degradation half-life, $T_{½}$, is a measure of persistence of the pesticide in soil.

3) The maximum contaminant level (MCL), or the lifetime health advisory level (HAL), or equivalent (HALEQ), is a measure of health risk to humans of pesticide contaminated drinking water.

4) Aquatic toxicity, LC_{50}, is a measure of the ability of the pesticide to cause 50% mortality in aquatic test species.

Soil Properties

1) Hydraulic permeability is a measure of the soils ability to allow water to percolate through it.

2) Organic matter is important for providing binding sites for pesticides, thus reducing their mobility and increasing their opportunity to be degraded by soil microorganisms.

3) Slope affects the potential for water to run off the land surface.

Management Practices

1) Pesticide application frequencies and rates determine the total amount applied. Lower frequencies and rates reduce the potential for contamination.

2) Application methods affect the amount of pesticide subject to transport by water. For example, if applied directly to the soil, there is a greater probability that more of the product will be available for leaching or runoff than if applied to the foliage. If the product is incorporated into the soil, leaching may be the most important loss pathway. Pesticides applied to the foliage may be lost to the atmosphere, decomposed by sunlight, or absorbed by the foliage, thereby reducing the amount available for wash-off and transport to water bodies.

3) Irrigation practices can also determine the loss pathways of pesticides. Pesticides often move with water, so the less excess water that is applied, the less potential there is for a pesticide to move past the crop root zone or to run off in surface water. Rainfall or overhead irrigation can wash off significant quantities of pesticides from foliage immediately after application.

INDICES USED TO SELECT PESTICIDES

Table 1 contains two important indices, the pesticide leaching potential (RLPI) and the pesticide runoff potential (RRPI). Both indices are relative. For a given soil, these indices rank the pesticides by their potential to move from the application site by the indicated pathway (leaching or runoff). The indices are based on the organic carbon sorption coefficient and degradation half-life values of each pesticide. Values for these parameters have been taken from scientific literature, technical manuals, and company product literature.

Relative Leaching Potential Index

The Relative Leaching Potential Index (RLPI) defines the relative attenuation(reduction in mass as it moves through the soil) of each pesticide in soil, and therefore its potential to leach to groundwater. Pesticides that are very mobile, for example, those that have K_{oc} values less than 100 in sandy soils, or 50 or less in fine-textured soils should be used with caution. There is some uncertainty in the data used to calculate this index. However, since the values are relative they can still be used. It is important to realize that the smaller the RLPI value of a pesticide, the greater is its potential to leach.

Relative Runoff Potential Index

The Relative Runoff Potential Index (RRPI) defines the relative immobility and availability of each pesticide in soil, and therefore its potential to remain near the soil surface and be subject to loss in the aqueous phase or sediment phase of runoff. There is some uncertainty in the data used to calculate this index. However, since the values are relative they can still be used. The smaller the RRPI value of a pesticide, the greater is its potential to be lost in runoff.

Maximum Contaminant Level, Lifetime Health Advisory Level or Equivalent

Table 1 also contains information on the toxicity of pesticides to humans and aquatic species. This information can be used as a secondary consideration in the pesticide selection procedure.

The Maximum Contaminant Level, MCL, is the highest allowable concentration in drinking water supplied by municipal water systems. It is a Primary Drinking Water Standard based on health considerations and is enforceable by the USEPA. Pesticides that may potentially cause chronic health effects such as cancer, birth effects, miscarriages, nervous system disorders or organ damage are assigned a MCL value by the USEPA. Although the MCL is usually expressed in milligrams per liter (mg/L), in this circular it will be expressed as micrograms per liter (µg/L, or ppb). The Lifetime Health Advisory Level, HAL, provides a measure of pesticide toxicity to humans. The HAL as defined bu the USEPA is the concentration of a chemical in drinking water that is not expected to cause any adverse health effects over a lifetime of exposure (70 years), with a margin of safety. If the chemical has not been assigned a MCL or HAL value, a health advisory level equivalent, HALEQ, (denoted by an asterisk) has been calculated using the same formula as the USEPA (HALEQ = R_fD x & 7000) where R_fD is the reference dose determined by the USEPA. For non-carcinogenic pesticides the calculated HALEQ should not differ by more than a factor of 10 from the value forthcoming from the USEPA. The Hal and the HALEQ have units of micrograms per liter (µg/L or ppb). If a pesticide has a MCL value assigned, we use that value rather than the HAL or HALEQ. The smaller the value the greater is the toxicity to humans.

Aquatic Toxicity

The Aquatic Toxicity provides a measure of pesticide toxicity to aquatic species. The values given in Table 1 are the lethal concentrations at which 50% of the test species die (LC_{50}). Unless otherwise noted by a lower case letter following the value, the test species was rainbow trout. The smaller the value the greater is the toxicity to aquatic species.

Data for K_{oc}, RLPI, RRPI, MCL/HAL/HALEQ, and aquatic toxicity are given for the active ingredient (common name) of a product. When using a product that is a mixture of two or more active ingredients use the RLPI, RRPI, MCL/HAL/HALEQ, and Aquatic Toxicity value for the most restrictive active ingredient in the mixture.

Important Note: The information presented in Table 1 **DOES NOT** supersede or replace the information on the pesticide container label or product literature.

PROCEDURE FOR SELECTING PESTICIDES TO REDUCE ADVERSE WATER QUALITY IMPACTS

A "Pesticide Selection Worksheet" is provided as a convenient way to organize the information needed to select pesticides to avoid water pollution by pesticides in a particular production or management unit. Instructions for using the worksheet are provided. The function of the worksheet is to match the soil leach and runoff ratings at the application site with the pesticide RLPI

(leaching) and RRPI (runoff) indices and toxicity values given in Table 1.

This will indicate the relative potential for pesticides to leach or run off from a particular site and consider the toxicity of the pesticides to humans or aquatic life if the pesticides leach into groundwater or if runoff enters surface impoundments or streams. The last two columns are for recording the soybean producer's choices and reasons for selecting particular products.

Our intent is to provide a decision support tool for the soybean producer. The producer is responsible for making the final choice. The completed worksheet can serve as a permanent record of the selection process used and decision made by the producer.

Using the Worksheet

1) **Target Pest:** Correct identification of the pests that need to be controlled is essential! Check with knowledgeable experts and utilize competent diagnostic laboratories so that a proper diagnosis can be made. Misdiagnosis results in the wasteful use of unnecessary pesticides and needless increases in production costs. List confirmed pests in column 1 of the PESTICIDE SELECTION WORKSHEET.

2) **Recommended Pesticides:** Use the current IFAS Pest Management Guides, or other appropriate information sources to identify the pesticides that control the pests of concern. List these pesticides in column 2 of the PESTICIDE SELECTION WORKSHEET.

3) **Pesticide Properties**: For each pesticide listed in column 2 on the PESTICIDE SELECTION WORKSHEET, copy the numeric value for K_{oc}, RLPI, RRPI, MCL/HAL/HALEQ, and Aquatic Toxicity from Table 1 into columns 3, 4, 5, 6, and 7 of the PESTICIDE SELECTION WORKSHEET.

4) **Soil Properties**: Consult the County Soil Survey Report soil map sheets to locate your production fields and to identify the soils that occur in these fields. Use the Soil Science Fact Sheet entitled "[Your County]: Soil Ratings for Selecting Pesticides" (available from your county Cooperative Extension Office) to determine the leaching and surface runoff rating of the soils in your fields. As you determine the soil leach rating and the soil runoff rating for each soil in each field, list the soil name, soil leach rating, and soil runoff rating in columns 8, 9, and 10, respectively, of the PESTICIDE SELECTION WORKSHEET.

5) **Selection of Pesticides**: Using information that you have compiled on the PESTICIDE SELECTION WORKSHEET, select appropriate pesticides using the **Pesticide Selection Criteria** to match soil and pesticide properties. The selection made can be recorded in column 11 and notes relating to the selection can be recorded in column 12.

Notes:

1) If the pesticide product selected is a formulated mixture or a tank mix, each active ingredient must be considered. The most restrictive pesticide in the mixture will determine the choice. Trade names in Table 1 followed by (M) are formulated mixtures.

2) Sometimes there may not be a clear choice from among the alternative chemicals available to control a particular pest. In these cases, first order screening using the RLPI or RRPI only can suffice.

3) Depth to groundwater and local geohydrology may influence your final selection. Shallow groundwater is more vulnerable to contamination Deep water tables with intervening impermeable geologic layers are much less vulnerable.

Criteria for Matching Soil Ratings with Pesticide Indices

Pesticides with less potential to adversely affect water quality can be selected by matching the soil ratings and pesticides with the following criteria:

PESTICIDE SELECTION CRITERIA				
IF SOIL RATINGS ARE:		THEN		
LEACH	RUNOFF	SELECT PESTICIDE WITH:		
HIGH	LOW	Larger RLPI value,	AND	Larger MCL/HAL/HALEQ value.
MEDIUM	LOW	Larger RLPI value,	AND	Larger MCL/HAL/HALEQ value.
LOW	LOW	Larger RLPI and RRPI values,	AND	Larger MCL/HAL/HALEQ and Aquatic Toxicity values.
HIGH	MEDIUM	Larger RLPI and RRPI values,	AND	Larger MCL/HAL/HALEQ and Aquatic Toxicity values.
MEDIUM	MEDIUM	Larger RLPI and RRPI values,	AND	Larger MCL/HAL/HALEQ and Aquatic Toxicity values.
LOW	MEDIUM	Larger RRPI value,	AND	Larger Aquatic Toxicity value.
HIGH	HIGH	Larger RLPI and RRPI values,	AND	Larger MCL/HAL/HALEQ and Aquatic Toxicity values.
MEDIUM	HIGH	Larger RRPI and RLPI values,	AND	Larger Aquatic Toxicity and MCL/HAL/HALEQ values.
LOW	HIGH	Larger RRPI value,	AND	Larger Aquatic Toxicity value.

4) Distance to surface water bodies may also influence your final selection. Surface waters adjacent to or near the pesticide application site are more vulnerable to contamination than those further away. If surface runoff from the application site usually infiltrates into the soil off site before reaching a surface water body, then the MCL/HAL/HALEQ should be considered as the secondary screening index.

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Table 1. Soybeans-Pesticide parameters for selecting pesticides to minimize water quality problems.

Trade name[1]	Common name	Application Type[2]		Sorption Coefficient[3]		Relative Losses		Toxicity		
		Soil	Foliar	K_{oc} (ml/g)		Leaching RLPI[4]	Runoff RRPI[5]	MCL, HAL or HALEQ[6] (ppb)		Aquatic LC_{50}[7] (ppm)
Herbicides										
Assure	quizalofop ethyl		x	510		85	32	60	*	0.87
Basagran	bentazon		x	34		nd	nd	0		510
Blazer	acifluorfen		x	119		nd	nd	0		17
Bugle	fenoxaprop-ethyl		x	9490		>2,000	11	20	*	0.48
Butoxone	2,4-DB dimethylamine salt		x	20	E	20	20	70	*	4
Butyrac 200	2,4-DB dimethylamine salt		x	20	E	20	20	70	*	4
Canopy (M)	metribuzin	INC,PRE		60		15	15	200		76
Canopy (M)	chlorimuron ethyl	INC,PRE		110	pH7	27	27	140	*	950a
Classic	chlorimuron ethyl		x	110	pH7	27	27	140	*	950a
Cobra	lactofen		x	10000	E	>2,000	33	10	*	nd
Dual	metolachlor	INC,PRE		200		22	22	100		2
Fusilade 2000	fluazifop-butyl		x	3000	E	1430	15	70	*	1.6
Gemini(M)	chlorimuron ethyl	x		110	pH7	27	27	140	*	950a
Genini(M)	linuron	x		400		66	41	10	*	16
Goal	oxyfluorfen		x	100000	E	>2,000	1	20	*	0.41
Gramoxone Extra	paraquat dichloride salt		x	1000000	E	>2,000	1	30		15
Lexone	metribuzin	x		60		15	15	200		76
Linex	linuron	x		400		66	41	10	*	16
Lorox	linuron	x		400		66	41	10	*	16

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		Soil	Foliar	K_{oc} (ml/g)		Leaching RLPI[4]	Runoff RRPI[5]	MCL, HAL or HALEQ[6] (ppb)		Aquatic LC_{50}[7] (ppm)
Poast	sethoxydim		x	100	EpH7	200	200	600	*	170
Prowl	pendimethalin	x		5000		555	2	300	*	0.199b
Pursuit	imazethapyr		x	10	E pH7	1	1	2000	*	340
Round-Up	glyphosate amine salt		x	24000	E	>2,000	1	700		8.3
Salute(M)	trifluralin	x		8000		1330	2	5		0.041
Salute(M)	metribuzin	x		60		15	15	200		76
Scepter	imazaquin acid	INC,PRE		20		3	3	1750		280
Sencor	metribuzin	x		60		15	15	200		76
Sonalan	ethalfluralin	x		4000		666	4	300	*	0.0075
Squadron(M)	pendimethalin	x		5000		555	2	300	*	0.199b
Squadron(M)	imazaquin ammonium salt	x		20	E pH7	3	3	2000	*	>100
Storm(M)	bentazon		x	34		nd	nd	0		510
Storm(M)	acifluorfen		x	119		nd	nd	0		17
Treflan	trifluralin	INC		8000		1330	2	5		0.041
Tri-Scept(M)	imazaquin ammonium salt	INC		20	E pH7	3	3	2000	*	>100
Tri-Scept(M)	trifluralin	INC		8000		1330	2	5		0.041
Turbo EC(M)	metribuzin	x		60		15	15	200		76
Turbo EC(M)	metolachlor	x		200		22	22	100		2
Insecticides/Miticides										
Agree	Bacillus thuringiensis		x	-1		nd	nd	nd		95b

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		Soil	Foliar	K_{oc} (ml/g)		Leaching RLPI[4]	Runoff RRPI[5]	MCL, HAL or HALEQ[6] (ppb)		Aquatic LC_{50}[7] (ppm)
Ambush	permethrin		x	100000		>2,000	1	350	*	0.0041
Asana XL	esfenvalerate		x	5300		1510	5	nd		0.00068j
Cygon/Dimethoate	dimethoate	INC	x	20		28	28	1	*	6.2
Cythion	malathion		x	1800		>2,000	555	200		0.2
Design	Bacillus thuringiensis		x	nd		nd	nd	nd		95b
Dimilin	diflubenzuron	INC		10000		>2,000	10	140	*	100
Dipel	Bacillus thuringiensis		x	nd		nd	nd	nd		95b
Disyston	disulfoton	PRE		600	E	200	55	0.3		1.85
Furadan 4F	carbofuran	INC		22		4	4	40		0.38
Guthion	azinphos-methyl		x	1000		1000	100	9	*	0.0043
Javelin	Bacillus thuringiensis		x	nd		nd	nd	nd		95b
Karate	cyhalothrin		x	0		nd	nd	0		0.00054
Lannate	methomyl		x	72		24	24	200		3.4
Larvin	thiodicarb		x	350		500	408	200	*	2.55
Lorsban	chlorpyrifos		x	6070		>2,000	5	20		0.0071
M-Pede	insecticidal soap		x	nd		nd	nd	0		nd
Malathion	malathion		x	1800		>2,000	555	200		0.2
Marlate/Methoxychlor	methoxychlor		x	80000		>2,000	1	400		0.062
Orthene	acephate		x	2		6	6	30	*	730

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Trade name[1]	Common name	Application Type[2]		Sorption Coefficient[3]		Relative Losses		Toxicity		
		Soil	Foliar	K_{oc} (ml/g)		Leaching RLPI[4]	Runoff RRPI[5]	MCL, HAL or HALEQ[6] (ppb)		Aquatic LC_{50}[7] (ppm)
Penncap-M/Methyl Parath	methyl parathion		x	5100	E	>2,000	39	2		3.7
Pounce	permethrin		x	100000		>2,000	1	350	*	0.0041
Pyrenone (M)	pyrethrins		x	100000	e	>2,000	1	70	*	114a
Pyrenone (M)	piperonyl butoxide		x	2500	E	nd	nd	100	*	0.0034
Rotacide	rotenone		x	10000		>2,000	33	30	*	0.031
Safer Soap	insecticidal soap		x	nd		nd	nd	0		nd
Scout	tralomethrin	INC		100000	E	>2,000	1	50	*	0.12
Sevin	carbaryl	INC		300		300	300	700		114
Sulfur	sulfur		x	nd		nd	nd	nd		non toxic
Temik	aldicarb			30		10	10	10		0.56
Thimet	phorate	INC	x	1000	E	166	16	4	*	0.013
Vydate L	oxamyl	INC		25		62	62	200		4.2
Warrior	cyhalothrin		x	0		nd	nd	0		0.00054
Xentari	Bacillus thuringiensis		x	nd		nd	nd	nd		95b
Nemtacides										
Furadan 4F	carbofuran	INC		22		4	4	40		0.38
Mocap	ethoprop	INC		70		28	28	0.1	*	13.8
Temik	aldicarb	INC		30		10	10	10		0.56
Fungicides										

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		Soil	Foliar	K_{oc} (ml/g)		Leaching RLPI[4]	Runoff RRPI[5]	MCL, HAL or HALEQ[6] (ppb)		Aquatic LC_{50}[7] (ppm)
Benlate	benomyl	x		1900		283	7	350	*	0.17
Bravo	chlorothalonil		x	1380		460	24	2		0.049
Mertect	thiabendazole	x		2500	E	62	1	700	*	low tox
Ridomil	metalaxyl	x		50		7	7	400	*	>100
Terraneb SP	chloroneb	x		1650		126	4	90	*	>4200b
Vitavax	carboxin	x		260		866	866	700		2
Fumigants										
Telone II	1,3-dichloropropene	INJ		32		32	32	0.2		5.5

[1]**Tradename:**	**(M) indicates that the product is a mixture of two or more active ingredients.**
[2]**Application Type:**	**INC: incorporated; INJ: injected; PRE: preemergence; X: applied to soil surface or foliage**
[3]**Sorption Coefficient:**	**E: estimated G: educated guess**
[4]**Relative Leaching Potential Index (RLPI):**	**Smaller number indicates greater leaching hazard.**
[5]**Relative Runoff Potential Index (RRPI):**	**Smaller number indicates greater runoff hazard.**
[6]**Drinking Water:**	**Maximum Contaminant Level (MCL), Lifetime Health Advisory Level (HAL); * Lifetime Health Advisory Level Equivalent (HALEQ);**
[7]**Aquatic Toxicity LC_{50}:**	**value is for rainbow trout 48 or 96 hr exposure time, unless otherwise specified. a=channel catfish b=bluegill c=carp j=fat head minnow**
nd: no data available	

PESTICIDE SELECTION WORKSHEET

Landowner/Operator Name:_____ County:_____ Date:_____

Crop:_____ Farm ID:_____ Field ID_____ Sheet____ of_____

Target Pest (1)	IFAS Recommended Pesticides (2)	K_{oc} Value (3)	Relative Losses		Toxicity		Soil Type (8)	Soil Leaching Rating (9)	Soil Runoff Rating (10)	Selected Pesticide (11)	Comments (12)
			Leaching RLPI (4)	Runoff RRPI (5)	MCL/HAL HALEQ (6)	Aquatic Toxicity (7)					

If the K_{oc} value is 100 or less or if the RLPI value is 10 or less and the soil leach rating is high, then the pesticide has a high potential for leaching and should be used with extreme caution. Alternative pesticides and reduced rates should be considered if possible. Apply pesticide during periods with low potential for rainfall if possible.