Evaluating Pesticides for Their Impact on Beneficial Organisms

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Introduction

The impact of pesticides on beneficial insects and microorganisms is a piece of information critical to pest managers that is not readily available. Companies registering new pesticides are not required to develop extensive information on the impact of the pesticide on organisms that may assist in IPM. Two laboratory techniques to screen pesticides against key beneficial organisms were developed. One technique was used to test the survival of a range of seven commonly occurring or purchased beneficial insects in the presence of 124 pesticides. A second technique was used to screen three beneficial microorganisms for survival in the presence of 124 pesticides. Results were summarized and indexed and will be made available electronically. In addition results of this study can be used to modify pesticide impact evaluation models such as the Environmental Impact Quotient (EIQ).

Objectives

1) Develop laboratory evaluations of the effect of pesticides on the survival of beneficial insects and beneficial microorganisms.
2) Test a broad range of pesticides for their effects on seven common beneficial insects and three common beneficial microorganisms.
3) Develop indices comparing the relative harm to the beneficial insects and microorganisms by different pesticides.

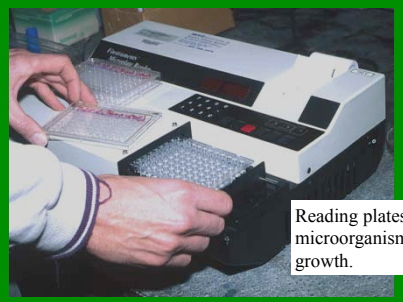
Procedures - Beneficial Insects

Seven commonly available and taxonomically diverse beneficial insects were chosen (Table 1, row 1, columns4-10) to screen against 124 insecticides. Pesticides were diluted to half the recommended field rate. The inside surfaces of glass vials were coated with the pesticide solution and allowed to dry. Live insects of each species were introduced into the treated and untreated control glass vials and allowed to remain for 24 hours. Percent mortality was assessed and compared to the untreated control. Based on work by Theiling and Croft (1988) an index with a rating of 1 (0-30% mortality), 3 (31%-70% mortality) or 5 (71%-100% mortality) was used to compare the pesticides' effects on each insect.

Introducing insects into pesticide treated vials

Procedures - Beneficial microorganisms

Three commonly available beneficial microorganisms (*Bacillus thuringiensis*, *Trichoderma harzianum*, and *Beauvaria bassiana*) were cultured in appropriate liquid culture media and introduced into 96 well micro-titer plates. Solutions containing de-ionized water or de-ionized water plus pesticides were added to the wells. Pesticides were filtered using a 0.45 µg sterile syringe filter to remove bacterial contaminants. Plates were incubated for 72 hours before being read for cloudiness using a microplate reader. Increased cloudiness in the well indicated increased growth of the test organism. Those pesticides that allowed growth of the test organism not statistically different from the control or increased growth compared to the control were placed in category 1. Those pesticides that inhibited organism growth at the highest statistical level were placed in category 5. The remaining pesticides were placed in category 3.



Reading plates for microorganism growth.

Table 1. Insect results

Common Name	Trade Name	Type	*Orius insidiosus*	*Coleomegilla maculata* larvae	*Delphastus pusillus*	*Encarsia formosa*	*Hippodamia convergens* adults	*Chrysoperla carnea*	*Trichogramma brassicae*	Avg Rating
acibenzolar-S	Actigard	PGR	1	1	1	1	1	1	5	1.57
butenoic acid	Retain	PGR	1	3	1	1	1	1	5	1.86
Bacillus subtilis	Serenade	PA	1	1	1	1	1	1	5	1.57
bifenazate	Floramite 2SC	M	1	1	1	1	1	3	5	1.86
clofentazine	Apollo	M	1	1	1	1	1	1	5	1.57
dicofol	Kelthane 35WP	M	5	5	1	3	5	3	5	3.86
dinocap	Karathane LC	M	1	1	5	5	1	1	5	2.71
etoxazole	Tetrasan 5 WDG	M	1	1	1	-	1	1	5	1.67
fenbutatin oxide	Vendex 50WP	M	1	1	1	1	1	1	5	2.43
pyridaben	Pyramite	M	5	5	3	5	5	1	3	3.86
abamectin	Agri-mek .15EC	I	1	1	5	5	3	1	5	3.00
acephate	Orthene 75SP	I	1	5	5	5	5	5	5	4.43
azadirachtin	Azatin XL	I	1	1	3	1	3	1	5	1.86
azinphos methyl	Guthion 50WP	I	5	5	5	5	5	3	5	4.71
buprofezin	Accolade SC	I	1	3	3	1	1	1	5	1.86
carbaryl	Carbaryl	I	1	5	5	5	5	3	5	4.14
carbaryl	Sevin XLR Plus	I	1	5	5	5	5	5	5	4.43
chlorpyrifos	Lorsban 4E	I	5	5	3	5	5	5	5	4.71
cinnamaldehyde	Cinnamite	I	1	3	3	3	1	1	5	2.71
cryolite	Kryocide	I	1	3	1	1	1	1	5	1.29
cyfluthrin	Baythroid 2	I	5	5	5	5	5	5	5	5.00
deltamethrin	Deltagard 5SC	I	5	5	5	5	5	1	5	4.43
dimethoate	Dimethoate 4EC	I	1	5	5	5	5	1	5	4.71
emamectin benzoate	Proclaim WDG	I	1	1	3	3	1	1	1	1.57
endosulfan	Endosulfan 3EC	I	5	5	5	5	5	1	5	4.43
esfenvalerate	Asana XL	I	5	5	5	5	5	5	5	5.00
fenoxycarb	Precision 75WF	I	1	1	3	1	1	1	1	1.29
fenpropathrin	Tame 2.4EC	I	5	5	5	5	5	5	-	5.00
fenpyroximate	Akari 5SC	I	1	3	5	1	1	1	5	2.00
fipronil	80 WP	I	1	5	1	5	1	1	5	2.71
formetanate hydrochloride	Carzol SP	I	3	3	3	3	1	3	5	3.29
imidacloprid	Admire 2F	I	3	5	5	5	5	1	5	4.14
imidacloprid	Provado 1.6EC	I	1	5	5	5	1	5	5	3.57
indoxacarb	Avaunt 30 WDG	I	1	5	1	1	1	1	3	1.86
lambda cyhalothrin	Warrior T	I	5	5	5	5	5	5	5	5.00
malathion	Malathion 4EC	I	5	5	5	5	5	5	5	5.00
methidathion	Supracide 25WP	I	5	5	5	5	5	5	5	5.00
methomyl	Lannate LV	I	5	5	5	5	5	5	5	5.00
methoxyfenozide	Intrepid 2F	I	1	1	1	5	1	1	1	1.57
novaluron	Tiara 10SC	I	1	1	1	-	3	1	5	2.00
oxamyl	Vydate L	I	5	5	5	5	1	5	5	4.43
oxydemeton-methyl	Metasystox-R	I	5	5	3	5	5	1	5	4.14
permethrin	Ambush	I	5	5	5	5	5	1	5	5.00
phosmet	Imidan 70W	I	1	5	1	5	1	1	5	3.29
pymetrozine	Fulfill 50WG	I	1	5	1	5	5	1	5	3.57
pyriproxyfen	Distance IGR	I	1	1	1	1	1	1	-	1.00
spinosad	SpinTor 2SC	I	1	5	1	5	1	1	5	2.43
tebufenozide	Confirm 2F	I	1	1	3	1	1	1	1	1.57
thiamethoxam	Actara 25WG	I	3	5	5	5	5	1	5	3.86
2, 4, D Amine	Weedar 64	H	1	1	3	1	-	1	-	1.40
atrazine	Aatrex 9-0	H	1	1	1	1	1	1	1	1.00
bensulide	Prefar 4E	H	1	1	1	1	1	1	1	1.00
bentazon	Basagran 4L	H	1	1	1	1	1	1	1	1.00
carfentrazone-ethyl	Aim 40 DF	H	1	1	1	5	1	1	1	2.33
clethodim	Select 2EC	H	1	3	1	1	1	1	1	1.29
clomazone	Command 4EC	H	5	5	3	5	3	1	5	4.14
clopyralid	Stinger 3EC	H	1	1	1	1	1	1	1	1.00
cyhalofop-butyl	Clincher EC	H	1	1	1	1	1	1	1	1.00
DCPA	Dacthal 75W	H	1	1	1	1	1	1	1	1.00
desmedipham	Betanex	H	1	1	1	1	1	1	1	1.00
dichlobenil	Casoron 4G	H	1	1	1	1	1	1	1	1.00
diflufenzopyr	Distinct 70WG	H	3	1	1	5	5	1	5	2.57
diuron	Karmex DF	H	1	1	5	1	3	1	1	1.86
endothal	Desi-cate II	H	3	5	5	5	3	1	5	4.00
EPTC	Eptam 7E	H	1	1	3	3	1	1	1	1.57
ethalfluralin	Sonalan HFP	H	3	3	3	5	3	1	5	3.00
ethofumesate	Nortron 4SC	H	3	1	1	5	1	1	5	2.43
fluazifop-P-butyl	Fusilade 2000	H	3	1	1	1	1	1	5	2.00
fomesafen	Reflex	H	5	1	1	1	1	1	1	1.67
imazamox	Raptor 1AS	H	1	1	1	1	1	1	5	1.57
imazapyr	Arsenal	H	3	1	1	1	1	1	5	1.86
imazethapyr	Pursuit	H	1	1	1	-	1	1	5	1.67
linuron	Linex 50DF	H	1	1	1	1	1	1	5	1.67
MCPB	Thistrol 2L	H	1	1	1	5	1	1	3	1.86
metribuzin	Sencor DF	H	1	3	5	1	1	1	5	2.14
napropamide	Devrinol 50DF	H	1	5	1	1	1	1	5	2.14
nicosulfuron	Accent	H	1	1	1	1	1	1	5	1.57
oryzalin	Surflan AS	H	1	1	1	1	3	1	5	1.86
oxyfluorfen	Goal 2XL	H	3	1	1	1	1	1	5	2.43
paraquat dichloride	Gramoxone Max	H	3	1	1	1	1	1	-	1.33
pendimethalin	Prowl 3.3EC	H	3	1	1	1	1	1	5	2.00
phenmedipham	Spin-aid	H	1	1	1	1	-	1	5	1.67
prometryn	Caparol 4L	H	1	1	1	1	1	1	5	1.00
pyrazon	Pyramin DF	H	1	1	1	5	1	1	3	1.86
quizalofop-P-ethyl	Assure II	H	1	1	1	3	1	1	5	1.57
rimsulfuron	Matrix 25DF	H	1	1	1	1	1	1	3	1.29
sethoxydim	Poast	H	1	1	1	1	3	1	5	2.33
simazine	Princep 4L	H	1	1	1	1	3	3	5	2.14
sulfosate	Touchdown 5	H	1	1	1	1	1	1	5	1.57
terbacil	Sinbar	H	1	1	1	1	1	1	5	1.00
triclopyr	Confront	H	1	1	1	1	3	1	5	2.00
trifluralin	Treflan HFP	H	1	1	1	1	-	1	1	1.00
aluminum tris	Aliette WDG	F	1	1	1	1	1	1	3	1.86
azoxystrobin	Abound F	F	1	1	1	5	1	1	5	2.14
azoxystrobin	Flint	F	1	1	1	1	1	1	5	1.57
benomyl	Benlate	F	3	1	1	1	1	1	3	1.57
captan	Captec 4L	F	1	1	3	3	1	1	5	1.86
chlorothalonil	Bravo Weather :	F	1	1	3	1	1	1	3	1.57
copper hydroxide	Kocide 4.5LF	F	1	1	1	1	1	1	3	1.57
cyprodinil	Vanguard WG	F	1	1	1	1	1	1	3	1.29
dimethomorph	Acrobat	F	1	1	1	1	1	1	3	1.57
dodine	Syllit 65W	F	1	1	1	1	1	1	3	1.29
fenarimol	Rubigan EC	F	1	1	1	3	1	1	5	1.86
fenbuconazole	Indar 75WSP	F	1	1	1	5	1	1	5	2.14
fenhexamid	Elevate 50WDG	F	1	1	1	1	1	1	5	2.43
fludioxonil	Medallion	F	1	1	1	1	1	1	3	1.29
iprodione	Rovral 4F	F	1	1	1	3	1	1	3	1.29
iprodione	Chipco	F	1	5	3	5	1	1	1	2.43
kresoxim-methyl	Sovran	F	1	1	1	5	1	1	5	2.14
mancozeb	Manzate 200DF	F	3	1	1	1	3	1	5	1.57
maneb	Maneb	F	1	1	1	1	1	1	5	1.86
manganese EBDC	Penncozeb 75DF	F	1	1	1	1	1	1	1	1.00
metalaxyl	Ridomil Gold EC	F	1	1	1	5	1	1	5	2.00
myclobutanil	Nova 40W	F	1	1	1	3	1	1	3	1.57
PCNB	Terraclor	F	3	1	1	1	3	1	5	2.14
propamocarb hydrochloride	Banol	F	1	1	3	3	1	1	3	1.86
propiconazole	Orbit	F	1	1	3	1	5	1	1	1.86
thiophanate methyl	Topsin M WSB	F	1	1	1	1	1	1	1	1.00
triadimefon	Bayleton 50WP	F	1	1	5	1	1	1	5	2.14
triflumizole	Procure	F	1	1	5	5	3	1	1	2.43
vinclozolin	Ronilan DF	F	1	1	1	1	1	1	1	1.00
ziram	Ziram 76DF	F	1	1	1	1	1	1	3	1.29
streptomycin-sulfate	Agri-mycin 17	B	1	1	1	1	1	1	3	1.29

PGR=plant growth regulator, PA=plant activator, M=miticide, I=insecticide, H=herbicide, F=fungicide, B=bactericide

Table 2. Microorganism results

Common Name	Trade Name	Type	*Beauvaria bassiana*	*Trichoderma harzianum*	*Bacillus thuringiensi s*	Avg Rating
acibenzolar-S	Actigard 50WG	PGR	1	1	1	1.00
butenoic acid	Retain	PGR	3	1	3	2.33
bacillus subtilis	Serenade	PA	1	1	1	1.00
bifenazate	Floramite 2SC	M	1	1	1	1.00
clofentazine	Apollo	M	1	1	1	1.00
dicofol	Kelthane 35WP	M	1	1	5	2.33
dinocap	Karathane LC	M	5	5	5	5.00
etoxazole	Tetrasan 5WDG	M	1	1	1	1.00
fenbutatin oxide	Vendex 50WP	M	1	1	5	2.33
pyridaben	Pyramite	M	1	1	3	1.67
abamectin	Agri-mek .15EC	I	3	1	1	1.67
acephate	Orthene 75SP	I	1	1	1	1.00
azadirachtin	Azatin XL	I	1	1	1	1.00
azinphos methyl	Guthion 50WP	I	3	3	3	3.00
buprofezin	Accolade SC	I	1	1	1	1.00
carbaryl	Carbaryl	I	1	1	3	1.67
carbaryl	Sevin XLR	I	5	1	3	2.33
chlorpyrifos	Lorsban 4E	I	3	3	5	3.67
cinnamaldehyde	Cinnamite	I	5	3	3	3.00
cryolite	Kryocide	I	3	1	1	1.67
cyfluthrin	Baythroid 2	I	1	1	1	1.00
deltamethrin	Deltagard 5SC	I	1	1	1	1.00
dimethoate	Dimethoate 4EC	I	1	1	1	1.00
dimethoate	Dimethoate 4EC	I	1	1	3	1.67
emamectin benzoate	Proclaim WDG	I	1	1	1	1.00
endosulfan	Endosulfan 3EC	I	3	1	5	3.00
esfenvalerate	Asana XL	I	1	1	1	1.00
fenbuconazole	Indar 75WSP	I	3	1	3	2.33
fenoxycarb	Precision 75WF	I	1	1	1	1.00
fenpropathrin	Tame2.4EC	I	5	1	1	2.33
fenpyroximate	Akari 5SC	I	1	1	1	1.00
fipronil	80 WP	I	3	1	3	2.33
formetanate hydrochloride	Carzol SP	I	3	1	3	2.33
imidacloprid	Provado 1.6EC	I	1	1	1	1.00
imidacloprid	Admire 2F	I	1	1	1	1.00
indoxacarb	Avaunt 30WDG	I	1	1	1	1.00
lambda cyhalothrin	Warrior T	I	1	1	3	1.67
limuron	Linex 50DF	I	1	1	1	1.00
malathion	Malathion 4EC	I	3	1	1	1.67
methidathion	Supracide 25W	I	1	1	3	1.67
methomyl	Lannate LV	I	5	1	3	2.33
methoxyfenozide	Intrepid 2F	I	1	1	1	1.00
novaluron	Tiara 10SC	I	1	1	1	1.00
oxamyl	Vydate L	I	1	1	3	1.67
oxydemeton-methyl	Metasystox R	I	3	1	3	2.33
permethrin	Ambush	I	3	1	1	2.33
phosmet	Imidan 70W	I	1	1	3	1.67
pyriproxyfen	Distance IGR	I	1	1	1	1.00
spinosad	SpinTor 2SC	I	3	1	1	1.67
tebufenozide	Confirm 2F	I	3	1	1	1.67
thiamethoxam	Actara 25WG	I	1	1	1	1.00
2, 4, D Amine	Weedar 64	H	1	1	3	1.67
atrazine	Aatrex 9-0	H	1	1	1	1.00
bensulide	Prefar 4E	H	1	1	1	1.00
bentazon	Basagran 4L	H	1	1	1	1.00
carfentrazone-ethyl	Aim 40 DF	H	1	1	1	1.00
clethodim	Select 2EC	H	1	1	1	1.00
clomazone	Command 4EC	H	3	1	3	2.33
clopyralid	Stinger 3EC	H	1	1	1	1.00
cyhalofop-butyl	Clincher EC	H	1	1	1	1.00
DCPA	Dacthal 75W	H	1	1	1	1.00
desmedipham	Betanex	H	1	1	1	1.00
dichlobenil	Casoron 4G	H	1	1	1	1.00
diflufenzopyr	Distinct 70WG	H	1	1	1	1.00
diuron	Karmex DF	H	1	1	1	1.00
endothal	DesiCate II	H	3	1	3	2.33
EPTC	Eptam 2E	H	5	3	3	3.67
ethalfluralin	Curbit	H	5	3	5	4.33
ethofumesate	Nortron 4SC	H	3	3	1	2.33
fluazifop-P-butyl	Fusilade 2000	H	3	1	3	2.33
fomesafen	Reflex	H	1	1	1	1.00
imazamox	Raptor 1AS	H	1	1	1	1.00
imazapyr	Arsenal	H	1	1	3	1.67
imazethapyr	Pursuit	H	1	1	1	1.00
kresoxim-methyl	Sovran	H	5	1	3	3.00
MCPB	Thistrol 2L	H	5	1	5	3.67
metribuzin	Sencor DF	H	5	1	3	2.33
napropamide	Devrinol 50DF	H	5	1	5	3.67
nicosulfuron	Accent	H	1	1	1	1.00
oryzalin	Surflan AS	H	1	1	1	1.00
oxyfluorfen	Goal 2XL	H	5	3	3	3.67
paraquat dichloride	Gramoxone Max	H	5	3	1	3.00
pendimethalin	Prowl 3.3 EC	H	5	3	1	3.00
phenmedipham	Spin-Aid	H	5	1	5	3.67
prometryn	Caparol 4L	H	1	1	1	1.00
pyrazon	Pyramin DF	H	1	1	1	1.00
quizalofop-P-ethyl	Assure II	H	1	1	1	1.00
rimsulfuron	Matrix 25 DF	H	1	1	1	1.00
sethoxydim	Poast	H	3	1	1	1.67
simazine	Princep	H	3	1	1	1.67
sulfosate	Touchdown 5	H	3	1	1	1.67
terbacil	Sinbar	H	1	1	1	1.00
triclopyr	Confront	H	5	3	3	3.67
trifluralin	Treflan HFP	H	3	1	1	1.67
aluminum tris	Aliette WDG	F	-	-	5	5.00
azoxystrobin	Abound F	F	5	5	1	3.67
azoxystrobin	Flint	F	5	5	3	5.00
benomyl	Benlate	F	5	5	3	3.67
captan	Captec 4L	F	5	5	3	3.67
chlorothalonil	Bravo W 5	F	5	5	5	5.00
copper hydroxide	Kocide 4.5LF	F	3	1	1	1.67
cyprodinil	Vanguard WG	F	3	1	3	2.33
dimethomorph	Acrobat 50WP	F	5	5	3	5.00
dodine	Syllit 65W	F	5	5	5	5.00
fenarimol	Rubigan EC	F	5	5	3	5.67
fenhexamid	Elevate 50WG	F	-	-	3	3.00
fludioxonil	Medallion 50WP	F	5	5	5	5.00
iprodione	Chipco 26019	F	5	5	1	3.67
iprodione	Rovral 4F	F	1	1	1	1.00
mancozeb	Manzate 200DF	F	5	5	3	4.33
maneb	Maneb 75DF	F	-	5	5	5.00
manganese ethylenebisdithio	Penncozeb 75 DF	F	5	5	5	5.00
metalaxyl	Ridomil Gold EC	F	5	5	3	3.67
myclobutanil	Nova 40W	F	1	1	1	1.00
PCNB	Terraclor 75WF	F	1	1	1	1.00
propamocarb hydrochloride	Banol	F	1	1	1	1.00
propiconazole	Orbit	F	1	1	1	1.00
thiophanate methyl	Topsin M WSB	F	1	1	1	1.00
triadimefon	Bayleton 50WP	F	3	1	3	2.33
triflumizole	Procure 50WS	F	1	1	1	1.00
vinclozolin	Ronilan DF	F	1	1	1	1.00
ziram	Ziram 76DF	F	1	1	3	1.67
streptomycin-sulfate	Agri-mycin 17	B	1	1	5	2.33

Results and Discussion

Table 1 shows the results for each pesticide screened against each of the seven insects reported by category of effect. Table 2 shows the results for each pesticide screened against the three beneficial microorganisms. Pesticides are listed alphabetically within type classification in both tables. The last column of each table contains an average of the category ratings for all organisms in the table.

This ranking system for pesticides can be used in several ways. Pesticide users can make an evaluation about the potential effect of a pesticide against a beneficial insect or microorganism of interest. Pesticide users can also evaluate the possible effects of their pesticide choice on a range of beneficial microorganisms. Finally, the information form this study can easily be plugged into overall pesticide rating systems such as the Environmental Impact Quotient (Kovach et al., 1992)

These data are relative ratings and were generated in the laboratory environment and do not take into account the likelihood of a particular organisms encountering a particular pesticide in the field. Some pesticides that are highly toxic to some beneficials may be applied in such a way that their impact on them can be minimized.

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