

## V. Preemptive Management Tactics

### A. Introduction

Preemptive control methods are applied in the anticipation of a pest problem. In arthropod pest management, the preemptive application of pesticides is not recommended because application must be based on direct assessment of pest populations. Decisions to apply an insecticide then are based on EILs. In pathogen management, however, when symptoms are apparent, it is usually too late to

apply a treatment, consequently pathogen management is based on the preemptive application of fungicides or bactericides based on predictive models for the incidence of the pathogen or on historical data for a particular field or region. In both situations, the decision to treat should consider the risk and benefits of the treatment, including the environmental risks and the economic advantages to the grower (Table 13).

**Table 13.** Relative selectivity of the major pesticide classes as measured by the average toxicity ratings to all natural enemies included in the database SELCTV. <sup>1</sup>

<b>Chemical group</b>	<b>Average toxicity<sup>2</sup></b>
<b>FUNGICIDES</b>	
Nitrophenol derivative	3.29
Carbamates	2.68
Inorganics	2.67
Miscellaneous organics	2.46
<b>ACARICIDES</b>	
Carbamates	4.45
Nitrophenol derivatives	3.18
DDT derivatives	2.80
Organotins	2.78
Organochlorines	2.33
Sulfur compounds	2.25
<b>INSECTICIDES</b>	
Pyrethroids	4.00
Organophosphates	3.88
Carbamates	3.75
DDT derivatives	3.69
Organochlorines	3.54
JH analogues	3.06
Inorganics	2.87
Botanicals	2.84
Chitin inhibitors	2.83
Microbials	2.20
<b>HERBICIDES</b>	
Nitrogen heterocyclics	3.28
Urea derivatives	2.93
Miscellaneous organics	2.57
Organometallics	2.17
Phenoxy-alkyl derivatives	2.00

<sup>1</sup>After: Croft, 1990.

<sup>2</sup>Index based on a rating scale of 1 to 5; where 1 = no effect, 2 = <10%, 3 = 10 to 30%, 4 = 31 to 90%, and 5 = >90%.

## B. Pathogen management & fungicides

Fungicides in soybean pathogen management are used mainly in seed treatment (Jacobsen, 1985). Foliar-applied fungicides and nematicides have a more limited use. Seed treatment fungicides are useful when seed quality is low because of fungal infection (*Alternaria*, *Colletotrichum*, *Cercospora* and *Phomopsis*) where seeds must be planted in seed beds, where germination will be delayed, where low seeding rates must be used or if there is a history of Phytophthora or/and Pythium seedling damping-off, and when Rhizoctonia pre- and post-mergence or damping-off (Plate 88) is expected (Sinclair and Jacobs, 1982). Fungicide seed treatment helps realize the germination potential of a seed lot (Sinclair, 1993). Seed treatments are not useful where germination is low because of mechanical damage or physiological factors.

Seed treatment may or may not translate into increased yield but will reduce the risk of nonuniform plant stands. Large gaps in field stands increase production costs by reducing the effects of fertilizer and herbicides. These materials are wasted if not utilized efficiently. It is difficult to evaluate the effect of seed treatments on yield and justify the cost because soybeans plants branch to fill in gaps in plant stands. However, these plants tend to lodge at maturity, making harvesting difficult and resulting in seed infection by fungi.

Only a small portion of marketed soybean seeds is

**Table 14.** Fungicides used for soybean seed treatment<sup>1</sup>

Chemical	Formulations <sup>2</sup>	Application method <sup>3</sup>	Rate lb. a.i. acre-1)
Benomyl	WP, SG	Foliar sprays	0.25-0.5
Captan	WP, SC	Seed treatment	0.025-0.047
Carboxin	SC	Seed treatment	0.0156-0.062
Chloroneb	WP, SC	Seed treatment	0.15
Chlorothalonil	SC	Foliar sprays	0.75-1 .875
Etridiazole	WP	Seed treatment	0.013
Maneb	SC	Seed treatment	?
Metalaxyl	SC, WP, D, EC	Seed treatment	0.009-0.019
Quintozene	SC, WP	Seed treatment	0.025-0.63
Thiabendazole	SC	Foliar sprays	0.178-0.297
SCSeed treatment			
Thiophanate-methyl	WP, SC	Foliar sprays	0.35-0.297
Seed treatment?			
Thiram	SC,WP	Seed treatment	0.016-0.062

<sup>1</sup> After: Kirby & Edwards, 1996.

<sup>2</sup> D=dust, SG=water soluble granule (dry flowable), EC=emulsifiable concentrate, SC=suspension concentrate (flowable), WP=wettable powder.

<sup>3</sup> Seed treatment includes direct or planter-box application. Follow label directions.

treated with a fungicide because the risk of financial loss to the seedsman is too great. Once seeds are treated with a fungicide, they can be used only for planting but not for food, feed, or processing. Soybean seeds cannot be stored commercially for over a year and maintain high viability. Thus, when soybean seeds are fungicide—treated, the chemical frequently is applied at planting time, and only the quantity of seeds required for sowing is treated.

Captan and thiram, alone or in combination, are used for broad spectrum pathogen control. They may be used alone or in combination with more specific narrow spectrum compounds such as carboxin or metalaxyl (Table 14) (Kirby & Edwards, 1996).

Seed-treatment fungicides, including formulated and flowables, liquids, or slurries may be used in commercial seed treaters. The fungicide is metered at recommended rates (see label directions) and agitated in the machine so that all seeds are uniformly covered. A dust or powder formulation may be applied by a commercial seed treater, by homemade drums, or by mixing in the planter box (Dhingra & Sinclair, 1995).

Foliage-applied fungicides can be used to improve seed quality through the control of seed-borne fungi, such as *Cercospora*, *Colletotrichum* (Plate 80), and/or *Phomopsis* (Plate 85) (Sinclair, 1986). The application of foliar fungicides on seed production fields is necessary when wet conditions

and temperatures above 25°C prevail during growth stages R1 to R5. In general, fungicides applied between growth stages R2 to R5 protect seed quality by reducing fungal infection. With increasingly more restrictive grading standards, reduced fungal infections could increase the market value of grain lots.

Fungicides applied after growth stage R6 result in little yield increase but can reduce fungal seed infection, thereby maintaining seed vigor and germination. Therefore, foliar fungicides should be considered for routine use for field production of breeder's and certified seeds and for increase of germ plasm in areas where warm, wet conditions prevail. Two applications usually are made, with a third added only if warm, wet weather persists. Generally, foliar fungicides are used on a small percentage of the total acreage, because the predictability of benefits is difficult and the profit margin may be minimal.

Soybean plants sprayed with benzimidazoles fungicide tend to remain green longer than non-

sprayed plants. Benomyl, thiabendazole, and thio-phante-methyl are the most commonly used foliar fungicides for soybeans (Sinclair & Backman, 1989). Chlorothalonil is not widely used because of its high cost.

Synoptic prediction systems (checklists) have been developed in the U. S. to aid both grain and seed producers in making decisions about foliar fungicide applications. Some point systems are based on field scouting, forecasts or historical weather data (or both), cropping history, yield potential, planting date, and maturity group. An example is Illinois checklist (Table 15) (Sinclair & Backman, 1989).

### C. Bradyrhizobium inoculant & fungicides

The effectiveness of *Bradyrhizobium japonicum* (Kirchner) Jordan inoculant may be reduced if applied to fungicide-treated seeds too far in advance of planting. Seeds treated with a fungicide and mixed with inoculant should be planted within

**Table 15.** Illinois checklist used to determine whether foliar fungicides should be applied to soybean<sup>2</sup>

Risk factor	Point value if answer is Yes <sup>3</sup>
Rainfall, dew, and humidity up to growth stages R1 to R3 are:	
below normal	0
normal	2
above normal	4
Soybean was grown in the field last year	2-3
Chisel plow, disk, or no-tillage was used	1
Pycnidia (black specks) are visible on fallen petioles <sup>3</sup> and Septoria brown spot is obvious on the lower leaves	
Early-maturing cultivar (not full-season)	1-2
Soybeans to be used or sold for planting seed	6
Yield potential is better than 35 bushels acre-1 (219 kg ha -1)	2
Seed quality at planting time is less than 85% germination in a warm test	1
Other conditions that favor disease development (weather forecast with a 30-day period of greater-than-normal rainfall and a field history of disease)	1-3

<sup>2</sup> Source: Jacobsen *et al.*, 1987.

<sup>3</sup> If the total point value is 15 or more, application will probably mean increased yields and higher seed quality.

<sup>3</sup> Only brown, fallen petioles should be assayed, and more than two-thirds to three-quarters of these petioles should show pycnidia.

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10 to 12 hours of treatment. Fungicides that reduce nodulation include captan, copper-based compounds, and oxycarboxin. The benzimidazoles and dithiocarbamates have little or no effect on nodulation. The effect of carboxin, chlorothalonil, quin-tozene, 2—(thiocyanomethyl—thio) benzothiazole, or thiram is uncertain (Agarwal & Sinclair, 1982).

Thermotherapy is a common method used to control certain seedborne pathogens, while leaving the host tissue viable. Soybean seeds rarely are heated in hot water because they imbibe water quickly, swell, and slough off their seed coats. Immersion of soybean seeds in heated maize, palm, soybean, or sunflower oils eliminates or reduces the levels of seedborne *Alternaria*, *C. kikuchii* (Plate 91), and *P. longicolla* (Pyndji *et al.*, 1973). Vegetable oil ther-motherapy is not practical for large—scale commercial use because the problem of heating seeds uniformly in large numbers. However, it can be used to treat small lots of seeds in germ plasm collections or samples sent into countries where these pathogens may not be established. It may be of practical use for small farmers to control soybean pathogens without the use of a fungicide, primarily in agriculturally-developing countries, where seeds are saved from year to year.

#### D. Pathogen management and nematicides

Nematicides are used to manage the following nematodes: soybean cyst (Plate 95), dagger, lance, root-knot and root-lesion, reniform, and stem. Nematicides generally are recommended only when adapted resistant cultivars are unavailable or when cultural management practices, such as rotation, are ineffective. The pesticides currently registered and labeled for use in the United States for control of soybean cyst and other nematodes on soybean should be checked before use. Most nematicides are available in granular form and are applied at planting by either in-furrow or row-banded methods. In the United States, only compounds such as chloropicrin, 1, 3—dichloropropene, and methan—sodium are applied in—row or broadcast well before planting to avoid crop injury.

#### E. Pathogen management and insecticides

Decisions about the use of insecticides to reduce arthropod damage should take into account the added damage from opportunistic fungi and bacteria. For example, consideration might be given to the prevention of fungal infections that follow pod-

feeding arthropods, such as the bean leaf beetle, grasshoppers, or stinkbugs. This is particularly true with stinkbugs (Plates 21 to 29) that transmit the fungus that causes yeast spot and with the bean leaf beetle, whose feeding causes pod injuries through which several seed—infesting fungi can gain entry. Insecticides generally are ineffective in controlling aphid-vectored viruses and rarely are used to control either thrip-transmitted viruses, such as tobacco ringspot virus (Plate 93), or beetle-transmitted viruses, such as the bean pod mottle virus. Using insecticides may increase the incidence of certain diseases by encouraging migration of arthropods associated with the casual agents.

#### F. Pathogen management and herbicides

Weeds growing in and around fields can serve as alternative hosts of bacterial, fungal, nematode, or viral pathogens; and for the buildup of arthropod populations. Weed management in soybean and rotation crops can be important in managing the soybean cyst root-knot nematodes. Uncultivated perennial weeds growing around fields often are alternative hosts of viruses, such as the tobacco ringspot, bean pod mottle, soybean mosaic (Plate 92), and bean yellow mosaic (Plate 94) viruses.

The selection of herbicides for weed management can influence disease development or management by other pesticides. Some herbicides increase the severity of *Phytophthora* and *Rhizoctonia* root rots. The herbicide alachlor reduces the effectiveness of nematicides in the control of the soybean cyst nematodes. Weeds growing in soybean fields compete for space, water, and nutrients, thereby increasing the likelihood of stress and stress-related diseases.

#### G. Weed management & herbicides

Controlling weeds is one of the most important activities in soybean production. It is estimated that a grower can lose a kilogram of dry matter in soybean to each kilogram of weed produced in a field. Chemical weed control using soil- and foliar-applied herbicides is the standard used throughout the world, except for subsistence farms where hand labor is utilized. The use of herbicides has allowed for the narrowing of soybean rows (drill planting) and double cropping and no-tillage planting. In the United States, more than 98% of the soybean acreage is treated with herbicides. Postemergence (foliar—applied) herbicides are used on about 30% of the soybean acreage to control

Table 16. 1994 and 1995 herbicide use in soybean in the United States<sup>4</sup>

<u>Herbicide</u>	<u>Treatment acres</u>				<u>Amount Used</u>			
	<u>Percent</u>		<u>1,000</u>		<u>lb. a.i./A</u>		<u>1,000 lb. a.i.</u>	
	<u>1994</u>	<u>1995</u>	<u>1994</u>	<u>1995</u>	<u>1994</u>	<u>1995</u>	<u>1994</u>	<u>1995</u>
Nonselective								
Preplant foliar								
2,4-D	10	10	4,465	5,184	0.40	0.45	1,777	2,418
glyphosate	16	20	6,801	10,368	0.51	0.61	3,497	6,318
paraquat	1	2	545	1,037	0.52	0.63	273	667
Selective soil-applied								
(primarily grass control)								
alachlor	7	4	2,996	2,074	1.94	1.99	5,801	3,930
metolachlor	8	7	3,568	3,629	1.91	1.96	6,830	6,995
dimethenamid	-	1	—	518	—	0.93	—	483
ethalfuralin	<1	1	341	518	0.76	0.83	260	262
pendimethalin	28	26	11	13,478	0.85	0.96	10,167	12,930
trifluralin	24	20	10,472	10,368	0.80	0.82	8,381	8,329
clomazone	4	4	1,609	2,074	0.58	0.61	933	1,223
Selective soil applied:								
(primarily broadleaf control)								
flumetsulam	2	2	883	1,037	0.06	0.06	54	65
imazaquin <sup>3</sup>	18	15	7,930	7,776	0.10	0.09	760	726
linuron <sup>4</sup>	2	2	729	1,037	0.52	0.43	379	348
metribuzin <sup>4</sup>	11	11	4,665	5,702	0.29	0.25	1,336	1,397
Selective foliar-applied								
(primarily broadleaf)								
acifluorfen	10	12	4,388	6,221	0.20	0.23	861	1,487
fomesafen	2	4	991	2,074	0.20	0.28	234	630
lactofen	4	5	1,891	2,592	0.08	0.08	152	202
bentazon	15	12	6,450	6,221	0.64	0.68	4,134	4,272
chlorimuron-ethyl <sup>5</sup>	16	16	6,905	8,294	0.02	0.02	131	154
imazethapyr <sup>5</sup>	43	44	18,364	22,810	0.06	0.06	1,034	1,332
thifensulfuron	14	12	6,048	6,221	0.006	0.003	18	20
Selective foliar-applied								
(grass control only)								
clethodim	4	5	1,821	2,592	0.10	0.09	185	262
fenoxaprop-ethyl	5	6	2,110	3,110	0.10	0.12	215	395
fluazifop-P-butyl	8	10	3,515	5,184	0.06	0.07	225	363
quizalofop-ethyl	7	6	2,826	3,110	0.05	0.05	131	160
sethoxydim	7	7	2,930	3,629	0.18	0.19	522	690

<sup>4</sup> Source: Pike & Knake, 1996.

<sup>2</sup> Source: NASS/ERS, 1995. Agriculture Chemical Use issued March, 1996

<sup>3</sup> Sometimes used foliar-applied

<sup>4</sup> Sometimes used directed foliar-applied

<sup>5</sup> Occasionally soil applied, i.e., chlorimuron + metribuzin premix; imazethapyr + pendimethalin premix

**Table 17.** Soybean herbicides: use, weed control, mode of action, and chemistry.<sup>5</sup>

**Herbicides used primarily for grass control**

Soil applied - meristematic inhibitor (some broadleaf control)

Dinitroaniline	pendimethalin (Prowl), trifluralin (Treflan, Trilin)
Chloroacetamide	alachlor (Lasso), dimethenamid (Frontier), metolachlor (Dual)

Soil applied - inhibitor of carotenoid synthesis (bleacher) (some broadleaf control)

Unclassified	clomazone (Command)
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Foliar applied - acetyl Co-A carboxylase (ACC-ase) inhibitor (no broadleaf control)

Cyclohexanedione	sethoxydim (Poast Plus), clethodim (Select)
Aryloxyphenoxy	fluzifop (Fusilade DX), quizalofop (Assure II), fenoxaprop (Option II)

**Herbicides used for broadleaf control (may control some grasses)**

Soil and foliar applied - acetolactate synthase (ALS) inhibitor (some grass control)

Imidazolinone	imazethapyr (Pursuit), imazaquin (Scepter)
Sulfonylurea	chlorimuron (Classic), thifensulfuron (Pinnacle),
Sulfonamide	flumetsulam (Broadstrike), chloransulam (FirstRate)

Soil applied - photosynthetic inhibitor (PSI) (some grass control)

Phenylurea	linuron (Lorox)
Triazine (triazinone)	metribuzin (Sencor, Lexone)

Foliar applied - photosynthetic inhibitor (PSI) (no grass control)

Benzothiadiazole	bentazon (Basagran)
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Foliar applied - protoporphyrinogen oxidase (PPO) inhibitor (minimal grass control)

Diphenylether	acifluorfen (Blazer), fomesafen (Flex, Flexstar, Reflex), lactofen (Cobra)
Other chemistry	flumiclorac (Resource), CGA-248757, or fluthiacet-methyl (proposed) KIH-9201 (Action)

Soil or foliar applied - protoporphyrinogen oxidase (PPO) inhibitor (minimal grass control)

Aryl-triazolinone	sulfentrazone (Authority)
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**Herbicides for grass and broadleaf control in transgenic soybean**

Foliar applied nonselective herbicides (require resistant soybean cultivars)

Aromatic amino acid synthesis (EPSP) inhibitor:	glyphosate "Roundup Ready" soybean
Glutamine synthetase (GS) inhibitor:	glufosinate "Liberty Link" soybean

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<sup>1</sup> After: Devine *et al.*, 1993

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grass weeds and on about 70% to control dicotyledonous weeds. The herbicides used during 1994 for soybean production in the United States are summarized (Table 16). Soybean growers have a choice of many types of herbicides and herbicide combinations, based on the weeds to be controlled, application method, and other factors.

Herbicides may be broad spectrum or specific. For example, there are herbicides used in soybean production for control of grasses, or broadleaf weeds plants, or both. A combination of herbicides with different modes of action minimize herbicide-resistant weeds (Table 17) (Casely *et al* 1991; Hager, 1996).