MATERIAL FACT SHEET
SPINOSAD

MATERIAL NAME: Spinosad

MATERIAL TYPE: Microbial (Derived from fermentation)

U.S. EPA TOXICITY CATEGORY: III, "Caution"

USDA-NOP: considered nonsynthetic, allowed. Preventive, cultural, mechanical and physical methods must be first choice for pest control, and conditions for use of a biological material must be documented in the organic system plan (7CFR 205.206(e)). The National Organic Standards Board reviewed this substance in May, 2002 and found it to be a permitted nonsynthetic substance (USDA 2002).

ACTIVE INGREDIENT DESCRIPTION: Spinosad is composed of spinosyns A and D, substances produced by aerobic fermentation of the actinomycete species *Saccharopolysora spinosa*. This rare species was found in soil samples from an island in the Caribbean in 1982. Actinomycetes are filamentous bacteria found in the soil that give it a sweet 'healthy' smell.

HOW IT WORKS: Spinosad is a fast-acting, somewhat broad-spectrum material that acts on the insect primarily through ingestion, or by direct contact with a spray droplet or a newly treated surface. It activates the nervous system of the insect, causing loss of muscle control. Continuous activation of motor neurons causes insects to die of exhaustion within 1-2 days. Foliar applications of spinosad are not highly systemic in plants although some movement into leaf tissue has been demonstrated. The addition of a penetrating surfactant increases absorption by tissues and activity on pests that mine leaves (Larson 1997).

APPLICATION GUIDELINES

AVAILABILITY AND SOURCES:
Spinosad is a patented product developed by Dow AgroSciences (Baker 1993; Boek et al. 1994). Several formulations are widely distributed.

OMRI LISTED PRODUCTS:

Conserve® Fire Ant Bait (Dow AgroSciences)
Entrust® , (Dow AgroSciences)

Justice® Fire Ant Bait(Dow AgroSciences)
GF-120 NF Naturalyte® Fruit Fly Bait (Dow AgroSciences)

NON OMRI -LISTED PRODUCTS:

Conserve® (Dow AgroSciences)
GF-120® Fruit Fly Bait (Dow AgroSciences)
Success® Naturalyte (Dow AgroSciences)
SpinTor® (Dow AgroSciences)
Tracer® (Dow AgroSciences)
Spinosad® Home and Garden (Dow AgroSciences)

FORMULATION AND APPLICATION GUIDELINES:

See labels for application guidelines. Entrust® is 80% spinosad. Entrust® is generally applied to plants at the rate of 0.5 to 3 oz/acre per application (Entrust® product label). This is equivalent to 25-150 grams/hectare of the active ingredient. According to the manufacturer, the rate of 1 ounce per acre is equivalent to 1/2 teaspoon per 1,000 square feet.

Resistance management should be practiced with Entrust® since studies have shown that some populations of the diamondback moth have developed resistance when this product is used intensively (Zhao et al. 2002). The main practice is to avoid applications of Entrust® on consecutive pest generations. Alternate spray controls with other effective products, and implement cultural controls.

Many crops have maximum yearly application restrictions. See the label for specifics.

REENTRY INTERVAL (REI): 4 hours

EFFECTS ON THE ENVIRONMENT

Leaf persistence: Spinosad is partly taken up by leaf tissue and this enhances its effectiveness over time. Dry surface residues do little harm to non-plant feeding insects. Spinosad residues on the leaf surface are be broken down by sunlight. Half-lives for spinosyn A were 1.6 to 16 days depending on the amount of sunlight received (Saunders and Brett 1997).

Fate in water: When spinosad is applied to water, very little breakdown (hydrolysis) occurs, and it can be persistent. However, in water exposed to sunlight, photodegradation occurs rapidly (Saunders and Brett 1997). In the absence of sunlight, the half lives of spinosyn A and D are at least 200 days.

Soil Persistence: Soil microbes degrade spinosad into other spinosyns that can persist in the soil for several months and remain biologically active. Repeated applications could lead to some build-up of spinosyns in soil. A 10-month field study in California and Mississippi showed that no degradation products were found in soil below 24 inches (Saunders and Brett 1997).

Leaching: Spinosyn A is more water-soluble than the other component of spinosad, spinosyn D, and therefore was the subject of soil mobility studies. However, spinosyn A and its soil metabolites bind to soil and have low soil mobility.

Wildlife: Spinosad shows slight toxicity to birds, moderate toxicity to fish, and slight to moderate toxicity to aquatic invertebrates. It is highly toxic to bees in laboratory tests and is highly toxic to oysters (US EPA 1997 a,b) and other marine mollusks (Dow 2001).

Beneficial insects: Care must be taken when applying spinosad while honeybees are foraging; after residues dry (a few hours) it is far less toxic to bees (Bret et al. 1997). Spray droplets can also harm *Trichogramma* wasps and other parasitoids (Suh et al., 2000; Tillman and Mullrooney, 2000; Bret et al., 1997). However, once the deposits dry, they are generally safe for beneficial insects. Studies in sweet corn have shown spinosad to be very effective against the European corn borer, while conserving its natural enemy complex (Musser and Shelton, 2003).

Other non-targets: Effects of spinosad on earthworms and soil microorganisms have been investigated in the laboratory. Results indicated that application rates of 25-150 g/ha should not cause significant effect on soil microflora respiration. Earthworms were not very susceptible to spinosad (LD_{50} > 970 mg/kg, Jachetta 2001). There is little research on the impact of spinosad on insect soil detritivores and their predators, including ants and springtails. However, since some spinosad products are targeted against fire ants, a soil dwelling species, it is likely that there would be some impact against other soil fauna

EFFECTS ON HUMAN HEALTH:

Acute toxicity: Spinosad has very low acute mammalian toxicity. The oral LD_{50} in rats is 3,738 mg/kg (male) and >5,000 mg/kg (female). According to an EPA factsheet (US EPA, 1997 b), acute dermal doses in rabbits are >2,000 mg/kg. The rat inhalation LC_{50} is >5.18 mg/liter (US EPA, 1997b; Jachetta, 2001; Dow, 1997).

Metabolism: Spinosad is rapidly absorbed and extensively metabolized in rats. Within 48 hours of ingestion, 60-80% of spinosad or its metabolites are excreted through urine or feces (US EPA 1997 a,b; Dow 1997).

Chronic Toxicity: 13-week dietary studies showed no-effect levels of 4.98 mg/kg/day in dogs, 6 mg/kg/day in mice and 8.6 mg/kg/day in cats. No dermal or systemic toxicity occurred in a 21-day repeated dose dermal toxicity study in rabbits of 1,000 mg/kg/day. Based on these data the EPA set the reference dose in humans at 0.0268 mg/kg/day. Presumably, daily doses of this amount would cause no harm (US EPA 1997b).

Cancer and Developmental: There was no evidence of carcinogenicity in two rodent species at any dose tested. Mutagenic studies showed no muta-

genic activity. There were no effects on normal development in rats and rabbits even at the highest dose tested.

Neurotoxicity: Spinosad did not cause neurotoxicity in rats in acute, subchronic, or chronic toxicity studies (EPA, 1997b). There may be some effects on the GABA and other nervous systems (Thompson et al. 2000; Salgado 1997; Salgado et al. 1998 a,b).

EFFICACY

Spinosad is principally toxic to plant-eating insects in the orders Lepidoptera (caterpillars), Coleoptera (beetles), Thysanoptera (thrips), and Diptera (flies). It is not a plant systemic, but will penetrate leaves to some extent and therefore has activity against some leafminers. Spinosad is not effective at controlling mites at normal use rates (Thompson et al., 2000; Cowles et al., 2000; Tjosvold and Chaney, 2001), although at high rates or in combination with some adjuvants it has miticidal activity (Gilrein 2004).

PEST SPECIFIC OBSERVATIONS

Colorado potato beetle

Spinosad shows very good control of all larval stages. The eggs and adults are virtually unaffected.

Flea Beetles

The few published studies show poor to intermediate efficacy. However, replicated lab studies conducted in 2003 show good control of cabbage flea beetles (Shelton, unpublished). Since populations tend to reestablish themselves a few days after application, several applications may be needed.

Striped and Spotted Cucumber Beetle

Spinosad has shown poor to intermediate efficacy with very few studies published.

Caterpillars (*Lepidoptera*)

Spinosad shows very good control for most pests.

Thrips (*Thysanoptera*)

The efficacy of spinosad is variable among crops and thrips species. Western flower thrips and onion thrips are susceptible to spinosad.

Aphids, whiteflies, leafhoppers (*Homoptera*):

Spinosad shows variable control of aphids. One study shows good control of whiteflies. One shows poor control of potato leafhopper, more trials are needed.

True bugs (*Hemiptera*)

Spinosad exhibits poor control for true bugs on various crops.

A summary of recent university field trials of spinosad products on vegetable

crops commonly grown in the Northeast was compiled. These university-based trials typically test products under unusually severe pest pressure.

In the table below, "good control" means statistically significant reductions in pest numbers or damage of 75% or more, compared to an untreated control."Fair control" includes those with significant reductions of 50-74%, and any non-significant reductions of over 50%. The "poor control" group includes any results with less than 50% reduction.

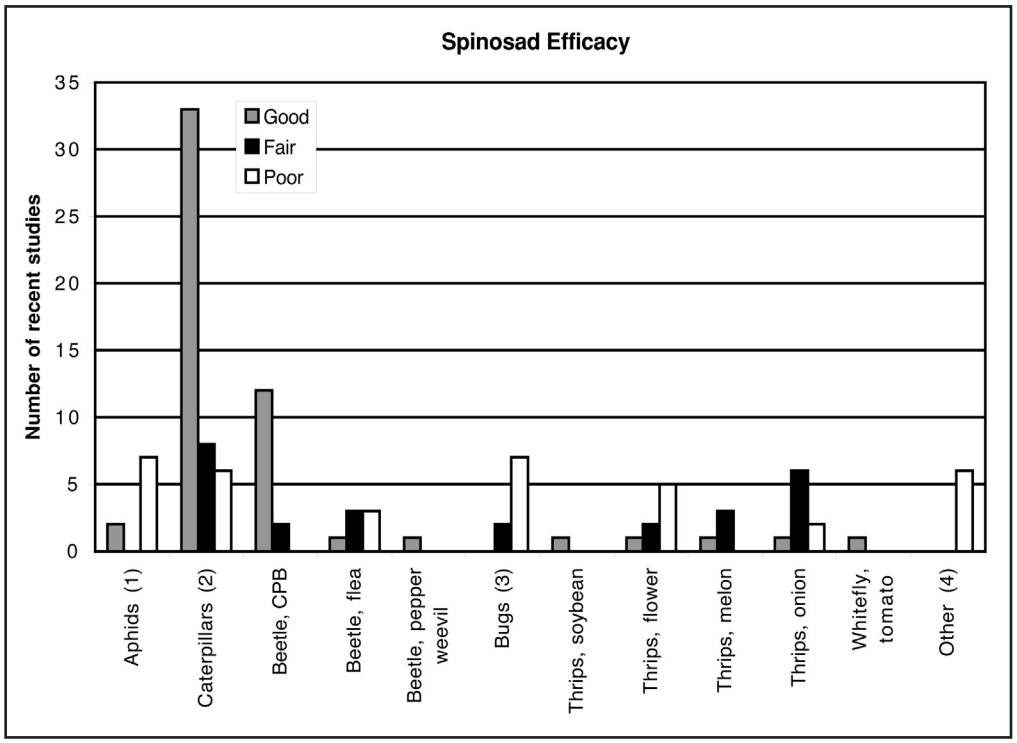
Species that performed similarly are grouped in the table below:

(1) Green peach and potato aphids.

(2) Common armyworm, beet armyworm, fall armyworm, corn earworm, cabbage looper, imported cabbageworm, diamondback moth, European corn borer, tomato hornworm, tomato pinworm, tomato fruitworm, and squash vine borer.

(3) Stink bugs, harlequin bug, lygus bug.

(4) One negative result was found for each of the following: sap beetle, striped cucumber beetle, pepper maggot fly, two spotted spider mite, potato psyllid, and potato leafhopper.



REFERENCES

Baker, P.J. 1993. Process for isolating A83543 and its components. US Patent No.5,227,295. Assigned to DowElanco.

Boek, L.D., C. Hang, T.E. Eaton, O.W. Godfrey, K.H. Michel, W.M. Nakatsukasa, and R.C. Yao. 1994. Process for producing A83543 com-

pounds. US Patent No. 5,362,634. Assigned to DowElanco.

Bret, B.L., L.L. Larson, J.R. Schoonover, T.C. Sparks and G.D. Thompson. 1997. Biological properties of spinosad. *Down to Earth* 52(1):6-13.

Copping, L.G. 1998. *The BioPesticide Manual*, 1st ed. British Crop Protection Council, Farnham, Surrey, UK. pp. 38-40 of 333 pp.

Cowles, R.S., E. A. Cowles, A. M. McDermott and D. Ramoutar. 2000. Inert formulation ingredients with activity: toxicity of trisiloxane surfactant solutions to twospotted mites. *J. Econ. Entomol.* 93(2):180-188.

Dow 1997. *Spinosad Technical Bulletin*. Dow AgroSciences. 15 pp.

Dow 2001. *Material Safety Data Sheet for Spinosad Technical.* Dow AgroSciences, Indianapolis, IN.

Dow 2003. Product Bulletin, Entrust* Rate Chart for Small Plantings. http://www.dowagro.com/label/product_results.asp

Gilrein, D. 2004. Department of Entomology, Cornell University, Personal communication.

Jachetta, J.J. 2001. *Petition for the Inclusion of Spinosad on the National Organic Standards Board List of Approved Organic Substances.* Indianapolis: Dow AgroSciences.

Larson, L. L. 1997. Effects of adjuvants on the activity of Tracer™ 480SC on cotton in the laboratory, 1996. *Arthropod Management Tests.* 22:415-416.

Musser, F.R. and A. M. Shelton. 2003. Bt sweet corn and selective insecticides: their impacts on sweet corn pests and predators. *J.Econ. Entomol.* 96: 71-80.

Salgado, V.L. 1997. The modes of action of spinosad and other insect control products. *Down to Earth* 52(1):35-43.

Salgado, V.L 1998a. Studies on the mode of action of spinosad: the internal effective concentration, and the concentration dependence of neural excitation. *Pesticide Biochem. Physiol.* 60:103-110.

Salgado, V.L., J. J. Sheets, G. B. Watson, and A. L. Schmidt. 1998b. Studies on the mode of action of spinosad: insect symptoms and physiological correlates. *Pesticide Biochem. and Physiol.* 60:91-102.

Saunders, D.G. and B.L. Bret. 1997. Fate of spinosad in the environment. *Down to Earth* 52(1):14-20.

Suh, C.P.-C, D.B. Orr and J.W. van Duyn. 2000. Effect of insecticides on

Trichogramma exiguum preimaginal development and adult survival. *J. Econ. Entomol.* 93(3):577-583.

Thompson, G.D., R. Dutton and T.C. Sparks. 2000. Spinosad—a case study: an example from a natural products discovery programme. *Pest Management Science* 56:696-702.

Tillman, P.G. and J.E. Mulrooney. 2000. Effect of selected insecticides on the natural enemies *Coleomegilla maculata* and *Hippodamia convergens, Geocoris punctipes,* and *Bracon mellitor, Cardiochiles nigriceps*, and *Cotesia marginventris* in cotton. *J. Econ. Entomol.* 93(6):1638-1643.

Tjosvold, S.A. and W.E. Chaney. 2001. Evaluation of reduced risk and other biorational miticides on the control of spider mites (*Tetranychus urticae*). *Acta Hort.* 547:93-96.

USDA National Organic Program. 2002. National Organic Standards Board Technical Advisory Panel Review: Spinosad. http://www.omri.org/spinosad_final.pdf

US EPA. 1997a. *Exposure Factors Handbook,* Washington, DC: National Center for Environmental Assessment. http://www.epa.gov/ncea/expos-fac.htm

US EPA. 1997b. *Spinosad Pesticide Fact Sheet No. HJ 501C.* EPA, Office of Pesticides and Toxic Substances http://www.epa.gov/opprd001/fact-sheets/spinosad.pdf

Zhao, J., H. L. Collins, L. Gusukuma-Minuto, R. F. L. Mau, G. D. Thompson and A. M. Shelton. 2002. Monitoring and characterization of diamondback moth resistance to spinosad. J. Econ. Entomol. 95:430-436.