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TURFGRASS TRENDS

NEONICOTINOIDS

Neonicotinoids Show Good Control With Sucking Insects

By David J. Shetlar

Over the last decade, the U.S. Environmental Protection Agency has been undergoing the process of reviewing previously registered pesticides under the dictates of the Food Quality Protection Act. This process uses higher standards for pesticide residues, potential exposure to "higher risk" groups such as children and pregnant women, total lifetime exposures and other factors.

The bottom-line result of this effort has been the restriction of most of the organophosphate and carbamate insecticides from urban landscape use. Most of these insecticides still can be used in agricultural production, but few companies wanted to go through the expense of supporting these insecticides for urban residential use when they were off patent, and there was no guarantee that EPA would allow the materials to be used even after gathering the new data. This has forced the chemical companies to look at alternate chemistries with a keen eye toward finding more selective materials and molecules that pose fewer risks to humans and the environment.

One of the first insecticides to satisfy this lower-risk category was imidacloprid. This was one of about a half-dozen molecules that were variously called nicotinoids, chloronicotinoids, thianicotinoids and similar names. Neonicotinoid is now the general category name accepted by most chemists. As the name implies, these chemicals resemble natural nicotine, and these molecules bind to the nicotinic-acetychloline receptor sites of post-synaptic nerves. The result is that neural transmission between two nerves is greatly restricted or even stopped. Apparently, insects and some other invertebrates can have 20 times or more of these specific nicotinic receptor sites than found in vertebrates. This results in a significant difference in susceptibility to neonicotinoids between insects and vertebrates. While imidacloprid was the first neonicotinoid to be registered for turf, the others in this category were generally received registrations in agricultural, nursery and greenhouse sites before residential turf registrations were obtained.

Part of this lack of registration for the turfgrass industry appears to have been a naive thought, "Oh, that's just another neonicotinoid!" This is like stating that isofenphos (Oftanol) technical, which has a rat oral LD50 (median lethal dose, or the amount required to kill 50 percent of the tested population) of 20 mg/kg, is the same as malathion technical which has an LD50 of 1,000 mg/kg. In addition to this difference in native toxicity, isofenphos and malathion affected and were registered for control

Continued on page 56

IN THIS ISSUE

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TABLE 1

Some properties of neonicotinoids registered for turf and landscape use.

	LD50[a]	H_2O sol.[b]	KOC[c]	Soil half-life[d]	H_2O stable[e]
Nitroguanidine subgroup					
Imidacloprid (Merit)	450	580	440	127	440
Clothianidin (Arena)	>5000	327	166	148	stable
Thiamethoxam (Meridian)	1563	4100	245	111	--
Dinotefuran (Safari)	>2000	39,830	22	82	stable
Pyridylmethylamine subgroup					
Acetamiprid (TriStar)	217	2950	200	8.2	stable

a Lethal dose (in mg toxicant/kg body weight) using rats and technical material.

b Water solubility (at neutral pH), in mg technical material per liter water.

c KOC - constant for binding capacity to organic carbon (the higher the number the greater potential to be bound to organic particles in the soil).

d Days for loss of one-half the toxicant in aerobic soil.

e Days for loss of one-half the toxicant in neutral water (-- = data not available).

Continued from page 55

of different insect pests. We are seeing these same nuances in the neonicotinoids as well as additional differences. Each neonicotinoid seems to have a spectrum of pests for which it is uniquely suited for control and each seems to have differing systemic action.

If we look at some of the common properties listed for pesticides (Table 1), the neonicotinoids seem to have a range of attributes. The more recent introductions — clothianidin, dinotefuran and thiamethoxam — are category III and possibly IV compounds (remember that formulated products are much less toxic than the technical materials and usually end up being in category III or IV).

Imidacloprid and clothianidin have the lowest water solubilities while acetamiprid and thiamethoxam are moderately soluble, and dinotefuran is highly soluble.

In a similar vein, the KOC (the constant for organic carbon binding potential) of all the neonicotinoids is fairly low except for dinotefuran, which is very low. The larger the KOC number, the more the chemical is bound to organic matter. Perhaps this is why dinotefuran has risen to the top of the heap for control of armored scales — it is highly soluble and doesn't get bound to organic matter. It should infuse plant tissues rather than concentrate in vascular bundles. All the materials are essentially stable in neutral water, and all but dinotefuran and acetamiprid have soil residual half-lifes of more than 100 days.

Studies on honey bee toxicity has produced some interesting differences among the neonicotinoids. Dinotefuran is the most toxic (LD50 = 0.0012) followed by imidacloprid (LD50 = 0.0037), clothianidin (LD50 = 0.004), thiamethoxam (LD50 = 0.024) and acetamiprid (LD50 = 8.09). These data support the toxicological information on neonicotinoids that they have great selectivity of action on insects due to insects having many more nicotinic acetylcholine receptors.

However, applying these insecticides to plants that are in flower or about to flower can have adverse effects on nectar and pollen-feeding insects.

Neonicotinoids target insects

Early data, based primarily on imidacloprid, indicated that neonicotinoids have excellent activity against sucking insects (primarily *Hemiptera*), *Coleoptera*, and hymenopterous (e.g., sawflies) pests, but poor activity against lepidopterous pests. Because caterpillars can be significant pests of turfgrasses and ornamental plants, neonicotinoids have been combined with pyrethroids. Pyrethroid combinations also appear to improve control of other surface-feeding pests, especially chinch bugs.

In our field evaluation studies, imidacloprid controlled the turfgrass ant, *Lasius neoniger*, only when applied in April or early May when the mound building was first noticed (Tables 2 and 3, p. 58). However, this control (usually 80 percent or better) did not occur until about six weeks to eight weeks after the application. We have three separate studies that demonstrated this phenomenon. However, when thiamethoxam was applied at the same time, control was nearly immediate (Table 3). In a subsequent study, applying thaimethoxam in July also resulted in control of the ants within two weeks. More recent studies have shown that clothianidin has this same rapid ant control action.

Concerning hairy chinch bug control, we have evaluated imidacloprid, clothianidin, thiamethoxam and acetamiprid and all produce excellent results in applications applied in June, July or August. However, when compared to the standard, bifenthrin, which can knock out the chinch bugs in three to five

Continued on page 58

TABLE 2

Efficacy of insecticides for suppressing ant mounds from *Lasius neoniger* on golf course fairway No. 11, Crockett's Green Hills Golf Course, Clyde, Ohio, 1999.

Treatment/	Rate	Active mounds/yd^2 and (% reduction)[b]				
Formulation[a]	lb.AI/acre	13DAT	30DAT	79DAT	128DAT	169DAT
Scimitar 0.88GC	0.06	0.1(97) de	3.1(57)cdefg	4.4(31)a	3.9(34)abcd	3.0(40)bc
Scimitar 0.88GC+	0.06+					
Merit 75WP	0.3	0.0(100)e	5.3(28)abc	5.1(20)a	2.5(57)e	1.3(75)cd
Merit 0.5G	0.4	3.4(29)b	6.3(14)ab	2.8(57)a	1.4(77)abc	0.9(83)d
MACH2 2LTI	1.5	1.8(63)b	3.8(48)bcdef	6.6(43)a	3.1(47)abc	3.1(38)b
Fipronil 0.05G	0.025	1.8(63)b	4.1(43)bcde	3.3(49)a	0.1(98)de	0.1(98)d
Talstar 0.66F	0.1	0.1(97)de	3.4(53)cdef	5.5(14)a	5.0(15)e	2.8(45)bc
Talstar 0.66F	0.2	0.0(100)e	1.4(81)fg	4.8(25)a	4.6(21)e	3.1(38)b
Check	-.-	4.8(--)a	7.3(--)a	6.4(--)a	5.9(--)ab	5.0(--)a

a Treatments applied 27 April 1999; plots 10x15ft replicated 4x, spray volume 1.5 gal/1,000ft2; no posttreatment irrigation.

b Data taken 10 May, 27 May, 15 July, 2 September & 13 October based on two 1 yd2 observations from each plot. Mound count sums analyzed by ANOVA and LSD @ " = 0.05. Means followed by the same letter are not significantly different (P < 0.001, < 0.001, = 0.193ns, <0.001, and <0.001 for 13, 30, 79, 128, and 169 DAT periods, respectively).

Continued from page 56

days, these neonicotinoids often take 10 to 14 days to achieve their maximum effect. In one study, we counted the different nymphal instars and adults, and imidacloprid took out the first through third instar nymphs in two to four days, but the larger nymphs took about a week to eliminate and the adults were the ones that took 10 days to 14 days to control.

Control of mole crickets with neonicotinoids has been inconsistent unless you carefully look at the timing of applications. When applied at egg lay to egg hatch, imidacloprid and thiamethoxam have produced very good results. This suggests that the mode of action is to cause the first instar nymphs to stop feeding or stop normal behavior. Of course, this is lethal for such small instars.

While imidacloprid controls the bluegrass billbug very well, it has generally produced poor control of the annual bluegrass weevil. However, recent studies with clothianidin have demonstrated that it has excellent activity against this weevil. This again illustrates that each of these neonicotinoids can affect different spectra of pests.

In our sod webworm control studies, imidacloprid has always resulted in poor control, but applications of clothianidin, thiamethoxam and acetamiprid have been quite effective. Again, this control commonly takes seven to 10 days to be maximized compared to the pyrethroids that achieve maximum control in three to five days.

In future studies, fellow entomologists and chemical companies should be encouraged to fully evaluate all of the neonicotinoids for expansion of their target spectra — especially mole crickets, chinch bug species, weevil species, caterpillar species, crane flies and scales (e.g., bermudagrass scale).

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TABLE 3

Season-long efficacy of insecticides for controlling the ant mounds of *Lasius neoniger* on a golf course fairway at Crockett's Green Hills Golf Course, Clyde, Ohio, 2000.

	Rate	Active mounds/yd2 and (% reduction)[b]					
Treatment[a]	lb.ai./A*	7 DAT	14 DAT	28 DAT	8 WAT	12 WAT	21WAT
Talstar 0.2G	0.20	2.4ef(87)	7.3cd(46)	10.5a(26)	10.1ab(0)	10.8a(0)	5.9a(2)
Fipronil 0.0143G	0.025	10.6bc(37)	11.0abc(18)	11.1a(22)	6.4c(20)	2.3cd(63)	0.8b(88)
Merit 75WP	0.40	11.1abc(11)	8.9bc(34)	5.8b(60)	0.3d(97)	0.1d(98)	2.4b(60)
Meridian 25WG	0.26	5.6de(60)	3.0de(78)	0.8c(95)	0.1d(98)	0.1d(98)	2.0b(67)
Meridian 25WG +	0.26						
Scimitar 0.88GC	0.06	0.4f(98)	0.0e(100)	1.4bc(90)	0.5d(94)	0.6d(90)	1.3b(79)
Check	-.--	14.8 a	13.4ab	14.3a	8.0bc	6.4b	6.0a
	ANOVA	<0.001	<0.001	<0.001	<0.001	<0.001	=0.001
	LSD@0.1	3.998	5.396	4.622	3.290	3.571	2.639

*a Treatments applied May 17, 2000, to plots 10 x 15 ft replicated 4x. No post-treatment irrigation. *Pound of Active Ingredient per Acre.*

b Data taken 25 May, 1 June, 15 June, 13 July, 10 August and 12 October based on the same central 2 yd^2 area observed each time within each plot. ANOVA and LSD on plot totals. Means followed by the same letter are not significantly different at " = 0.05 (NOTE: confidential products removed).