Comparison of toxicity and residual effectiveness of Actara® (Thiamethoxam®) with three pyrethroid insecticides against five Coleopteran species infesting stored – products.

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Abstract:

The purpose of this research is to present results from laboratory experiments designed to compare the toxicity and residual effectiveness of the neonicotinoide Actera (25%WG) to five coleopteran species pests of stored products with those of the three pyrethroid insecticides Copex (20%EC), Decis (2.5%EC) Vapcocidine (20%EC) using 24hr vial bioassays. One – day old adults of *Callosobruchus maculatus* Fab., *Trogaderma granarium* Everts. and 4 weeks old adults of *Sitophilus oryzae* L., *Tribolium costaneum* Herbst and *Tribolium confusum* J du val. were used throughout the tests.

The relative toxities (LC_{50} values) of the four insecticides to the five insect species were determined by exposing the adults to an insecticide deposit in glass vials (2.7*7.5cm) immediately (zero - time) after treating the vials. The results showed Actara to be the most toxic one followed in desending order of toxicity by Decis, Vapcocidin and Coopex. The susceptibilities of the five species to the four insecticides were in the order of *C.maculatus* > *T.granarium* >> *S.oryzee* >*T.costaneum* and *T.confusem*.

The results from residual test designed to evaluate the relative efficacies of the four insecticides 1 and 2- weeks after treating the vials showed Actara to be a little more effective than Decis and much more effective than Vapcociden and Coopex . The results also showed that the three pyrethroid msecticides, in general, lost activity against the five insect species faster than Actara, indicating that Actara is relatively more persistant than the three pyrethroids tested.

Key words:- Toxicity, Actara, Thiamethoxam, Residual Effectiveness, Stored product Coleopteran spicies, Pyrethoid insecticides

Introduction:

Neonicotinoids represent a fairly new and distinct chemical class of insecticides with remarkable chemical and biological properties. Actara® or Thiamethoxam® is the forerunner of the thianicotinyl sub-class, the seconed generation neonicotinoides. The compound which possess contact, stomach and systemic activity provides excellent control of a wide range of commercially important sucking and chewing insects in many crops [novartis crop protection AG, CH-4002 Basel, switzarland, technical information bulletin, 1998] (1).

Although there is a great deal of published work on the efficacy of Actara on insects of field crops, the number of investi -gations specifically designed to study its efficacy on insects of stored products are very limited. Recent laboratory experiments specifically designed to study the toxicity of Actara to insects of stored commodites are those conducted with red flour beetle, *Tribolium castaneum*, (2) and khapra beetle, *Trogoderma granarium*, (3). These laboratory trials have shown Actara® to be active against the two species employed. The results of these to studies opened up for the first time the possibility of using this compound for the control of insect pests of stored commodities. Several properties of this compound which permit it to be used for this purpose, with emphesis on the favourable safty profile, where enumerated by Maienfisch et al. (1).

Consequently, with the aim of evaluating further the potential of Actara® as a control of insect pests of stored commodities, a laboratory assessment of its toxicity and residual effectiveness by 24-hr vial bioassay to the adults of five major Coleopteran species pests of stored products was compared with those of the three pyrethroid insecticides Coopex, Decis and Vapcocidin.

Tools and methods:

Test insects:

Cultures of confused floure beetle, *Tribolium confusun* J du val., cowpea weevil, *Callosobruchus maculates* Fab, khapra beetle, *Trogoderma granaraum* Everts, red flour beetle, *T.castaneum* Herbst, and rice weevil, *Sitophilus oryzae* L., were maintained in the laboratory. All insects used were reared at 25 C^o and 60-65% r.h, media being whole meal flour and yeast (12:1) for *T.castaneum*, *T.confusun*, and *T.granariun* rice for *S.oryzae*, and cowpea for *C.maculatus*.

Newly emerged adults were collected daily. Adults to be treated as 4-weeks old were placed in 1Kg glass jars with small amounts of media and held under rearing conditions. Adult insects,1-dayold *C.maculatus* and *T.granarium* and 4-weeks old *T.castaneum*, *T.confusum*, and *S.oryzae* were used through-out the tests.

Insecticides:

The insecticides tested were the commercial formulations of the neonicotinoid Actara (25%WG) and the three pyrethroids Coopex (20%EC) Decis (2.5%EC) and Vapcocidin (20%EC).

Vial bioassay:

The bioassay procedures for the experiments were previously described (4,5). Serial dilutions of each of the 3-pyrethroid insecticides in acetone and of Actara in water – acetone mixture (9:1) were prepared at different concentrations. Insecticide solution was pipetted in 1ml aliquots in to the vials. This provided a known amount of insecticide per vial. Each vial was placed sideways on a rack of two glass rods and a laboratory drill controlled by reheostat was used to turn one of the glass rods, causing the vial to spin. The vials were spun until the solvent evaporated leaving the insecticide residue evenly spread on the inside surface of the vial. Control vials were treated with acetone only.

Relative toxicity tests:
Immediately after treating the vials, 10-adults of each species were separetly placed in each vial, and treatments with each of 6-concentrations of each insecticide were replicated at least 4-times. The vials were then held under rearing conditions for 24hr. The insects in the vials treated with Actara were monitered and the symptoms of poisoning were recorded.

Residual toxicity tests:
The residual toxicities of the insecticides were determined in the manner described above at 1 and 2-weeks after treating the vials. Treated vials to be used in these tests were kept in the incubator at rearing conditions.
To assess mortality, insects from each vial were placed on a filter paper, insects unable to hold on to the paper, fell off when the paper was turned over were judged dead. If mortality in the controls >10%, data were corrected with Abbott's formula (6). The trial was discarded if the mortality was > 20%. Mortality percentages were plotted against the concentrations on log – probit paper. Probit regression lines were fitted to the data by the method of least squares (7). LC_{50} values (per vial, gram for Actara and milliliter for the pyrethroid msecticides) with 95% fiducial limits were obtained.

Results and Discussion:
Data given in table1 show the relative susceptibilities of five coleopteran species of stored product insects to deposits of the tests materials in glass vials as indicated by LC_{50} values obtained by exposure of the adults to treated vials for 24hr immediately (zero-time) after treatment, along with the 95% fiducial limits and slops of the probit lines.

Table 1. Relative toxicities of Actara and three pyrethroid insecticide to the adults of five Coleopteran species by 24hr vial bioassay immediately (zero-time) after treating the vials.

insect	Insecticide	LC_{50}*	Fiducial limits** lower	upper	slope
Callobruchus maculatus	Actara	0.0017	0.0012	0.0023	1.4000
	Coopex	0.0038	0.0013	0.0160	2.9000
	Decis	0.0020	0.0006	0.0064	3.2000
	Vapcocidin	0.0024	0.0008	0.0075	3.3000
Sitophilus oryzae	Actara	0.0085	0.0015	0.0490	5.7000
	Coopex	0.0320	0.0096	0.1470	4.6000
	Decis	0.0140	0.0126	0.0155	1.1000
	Vapcocidin	0.0220	—	—	0.93
Tribolium costaneum	Actara	0.0260	0.0220	0.0310	1.1800
	Coopex	0.0940	0.0870	0.1020	1.0800
	Decis	0.0400	0.0351	0.0456	1.4000
	Vapcocidin	0.0750	0.0670	0.0840	1.1200
Tribolium confusum	Actara	0.0360	0.0220	0.0594	1.1800
	Coopex	0.1600	0.1143	0.2240	1.0800
	Decis	0.0500	0.0321	0.0780	1.4000
	Vapcocidin	0.1000	0.0654	0.1530	1.1200
Trogoderma granareum	Actara	0.00010	0.0002	0.0056	5.6000
	Coopex	0.0031	0.0017	0.0056	1.8000
	Decis	0.0014	0.0010	0.0019	1.4000
	Vapcocidin	0.0018	0.0015	0.0022	1.2000

* LC_{50}= g/ml for Actara and ml/ml for the pyrethroid insecticides per vial.
** Fiducil limits are given for p= 0.05 level.

It is obvious from the LC_{50} values that *T.granareum* is the most susceptible species to the insecticides tested followed in desending order of susceptibility by *C.maculatus*, *S.oryzae*, *T.costaneum* and *T.confusum*. The LC_{50} values obtained for both *C.maculatus* and *T.granareum* disclosed that the two species exihibited little variability in their suscept-ibility to Actara. Similar trend is also observed in the LC_{50} values obtained for both *T.castaneum* and *T.confusum*.
The LC_{50} values also indicate that Actara is generally much more toxic to the insects studied than the three pyrethroid insecticides and the toxicities are in the order of Actara > Decis >Vapcocidin > Coopex. Actara is 1.35, 1.8, 1.91, 2.1 and 2.2 times more toxic than Decis; 1.7, 2.3, 3.2, 3.7 and 3.8 times more toxic than Vapcocidin and 3.0, 4.2, 4.7, 4.9 and 5.8 times more toxic than Coopex to *C.maculatus*, *T.granareum*, *S.oryzae* *T.costaneam* and *T.confusum*, respectively. These findings are in full agreement with those of Al-Attar and Jumna (2) who reported that Actara is more toxic than Cypermether, Decis, Permithrin and Sumicidin to the fourth larval instar and 4-week old adults of red flour beetle, *T.costaneum*. These findings are also tally with those of Al-Mothafer (3) who reported that Actara is more toxic than Vapcocidin to five larval instaras of Khapra beetle, *T.granarium* Everts.
Data presented in Table 2 show the residual effectiveness of the deposits of the four insecticides against the adults of the insects tested as indicated by the LC_{50} values obtained by 24hr vial bioassays at 1 and 2 weeks post treating the vials, along with 95% fiducial limits and slops of the probit lines.

Table2. Residual effectiveness of Actara and three pyrethroid insecticides against the adults of five coleopteran species as indicated by LC_{50} values obtained by 24hr vial bioassays at 1and 2- weeks after treating the vials.

		Space of time after treating the vials (weeks)							
		1				2			
Insect	Insectide	LC_{50}*	Fiducial limits** lower	upper	Slope	LC_{50}*	Fiducial limits Lower	upper	slope
Callosobru-chus maculatus	Actara	0.0021	0.0018	0.0025	1.20	0.0026	0.0022	0.0030	1.17
	Coopex	0.0600	0.0200	0.1600	2.74	0.0900	0.0370	0.2200	2.46
	Decis	0.0029	0.0009	0.0096	3.30	0.0040	0.0013	0.0130	3.20
	Vapcocidin	0.0036	0.0011	0.012	3.21	0.0050	0.0016	0.0160	3.18
Tribolium costaneum	Actara	0.0350	0.0300	0.0410	1.1500	0.0420	0.0380	0.0460	1.10
	Coopex	0.1500	0.1440	0.1560	1.0400	0.2300	—	—	0.97
	Decis	0.0600	0.0550	0.0660	1.1000	0.0900	0.0860	0.095	1.05
	Vapcocidin	0.0850	0.0790	0.0920	1.0800	0.1300	0.1270	0.1330	1.02
Tribolium confusum	Actara	0.0420	0.0260	0.0680	1.6200	0.0560	0.0360	0.0870	1.55
	Coopex	0.2700	0.2200	0.3300	1.2400	0.0400	—	—	0.77
	Decis	0.0800	0.050	0.1200	1.5000	0.1300	0.0910	0.1900	1.43
	Vapcocidin	0.1200	0.080	0.170	1.4500	0.2000	0.1500	0.2600	1.30
Trogoderma granareum	Actara	0.0011	0.00021	0.006	5.4000	0.00130	0.00026	0.0065	5.00
	Coopex	0.0420	0.026	0.068	1.6200	0.05600	0.0370	0.0840	1.50
	Decis	0.0019	0.0015	0.0023	1.2500	0.0023	0.0020	0.0026	1.15
	Vapcocidin	0.0023	0.0021	0.0025	1.1000	0.0030	0.0028	0.0032	1.05
Sitophitus oryzae	Actara	0.0110	0.002	0.059	5.4000	0.0130	0.0027	0.0650	5.00
	Coopex	0.0450	0.011	0.190	4.3000	0.0680	0.0170	0.0270	3.90
	Decis	0.0200	0.019	0.022	1.0800	0.0290	0.0240	0.0350	1.20
	Vapcocidin	0.0350	—	—	0.9300	0.0450	—	—	0.87

* LC_{50}= g/ml for Actara and ml/ml for the pyrethroid insecticide per vial.
** Fiducial limits are given for p= 0.05 level.

It is seen from the LC_{50} values that the effectiveness rating of the insecticides to the insect species tested at the two periods is the same as that observed at Zero-time after treating the vials. It is further seen from the data that with the passage of time, the residual effectiveness of the insecticides went on decreasing (the amount of insecticide required to produce an LC_{50} increasing). The decrease in effectiveness of the most toxic insecticide, Actara, against any of the insects tested was generally much lower than the corresponding decreases of the three pyrethroids in generall and of vapcocidin and Coopex in particular.

At alag period of 1-week after treating the vials, Actara lost 10, 18, 29, 36 and 40 percent of its initial effectiveness against. *T.granareum*, *C.maculatus*, *S.oryzae*, *T.castaneum*, and *T.confusum*, respectively.

In contrast, the losses in effectiveness against the five insect species recored for the three pyrethroids were 28, 35, 50, 66 and 70 percent; 33, 42, 60, 73 and 80 percent and 40, 58, 67, 80 and 81 percent for Decis, Vapcocidin and Coopex, respectively.

The results obtained at a lag period of 2-weeks after treating the vials show that the losses in residual effectiveness remarkably decreased. It is apparent from the data that the loss in effectiveness of Actara to any of the five species tested did not exceed 75 percent. The least loss (40 percent) is recorded with *T.granareum* and the greatest loss (75 percent) is recorded with *T.confusum*. On the other hand, the corresponding losses of the three pyrethroids were, in general, much greater. Decis, Vapcocidin and Coopex lost between 60 to 140, 68 to 150 and 77 to 181 percent, respectively, of their initial effectiveness against the insect species tested. Thus, with the exception of their nominal effectiveness against *T.granarium* and *C.maculatus*, the three pyrethroids virtually lost effectiveness against the other three insect species employed.

The data presented here, regarding the residual effectiveness of Actara, are in consistency with those of Mellinger (8) who pointed out that foliar application of Actara provided 1 to 2 weeks of residual control.

The results regarding the 24hr toxicity data of the four insecticides described here underscore the efficacy of Actara against the five insect species tested. Moreover, the adult insects poisoned with Actara exihited hyperactivity during the initial 10 to 30 min. postexposure. The symptoms of hyperactivity were manifested by movement of the legs, antennae, mandibles and tremors of the legs and abdomen. There after, the insects became less mobile with the laps of time and death occurred within a few hours. These observations are in conformity with those cited in a resent report (9) which indicated that, in insects exposed to Actara, the symptoms started 15 to 30 min after exposure in aphids and Colorado potato beetle and after 1hr in adult whiteflies and death may occur within a few hour for some species or require as long as 48hr for others. The report adds that feeding is irreversibly stopped; sucking insects withdraw their stylets, stretch their legs and move their antennae forward.

Thus, the superiority of Actara over the three pyrethroid insecticides can be attributed, largely to its new mode of action. Unlike the pyrethroid group of insecticides which acts by keeping open the sodium channels in the neural membranes of the central and peripheral nervous systems (10), Actara acts primarily on the central nervous system, causing irriversibl blockage of postsynaptic nicotinergic acetylcholin receptors (11). Further, apart from its lethal effect, Actara has some sub-lethal effects, such as feeding and egg-laying deterrence (12).

This research also indicated that Actara was comparatively more persistant than the three pyrethroid insecticides. Factors that may acount for its longer persistency may include the slower rate of evaporation and/or breakdown.

To sumup, this research demons-trated that, under laboratory conditions, Actara has excellent insecticidal activity against the adults of the five insect species tested. Thus, it seems plausible that, under storage conditions, Actara would be extremely effective for controlling these insects, and could be used at a much lower rate of application than those of the three insecticides.

Under storage conditions, Actara may be even more effective against the species tested than the present results suggest, because there may be combined effects of this compound on both adults and immatures, which are not revealed in this study.

Therefore Actara is suitable for consideration in the control of stored product insects and it may soon be welcomed as a valuable addition to the list of insecticides used in stored products infestation control.

Finally, replicated tests under storage conditions with natural infestations are necessary to fully assess the value of this compound for the control of stored product insects and to establish application rates.

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مقارنة سمية المبيد اكتارا (ثياميثوكسام) وتأثيره المتبقي مع ثلاث مبيدات حشرية بايريثرويدية ضد خمسة أنواع من غمدية الأجنحة تصيب المنتجات المخزونة

هاني جهاد العطار

كلية التربية، جامعة الموصل، الموصل، جمهورية العراق

الملخص:

صُممَت هذه الدراسة المختبرية لمقارنة سمية المبيد الحشري النيونيكوتينويدي اكتارا (ثياميثوكسام) (٢٥% حبيبات قابلة للبلل) وتأثيره المتبقي ضد خمسة آفات رئيسية من غمدية الأجنحة تصيب المنتجات المخزونة مع المبيدات الحشرية البايريثرويدية كوبكس (٢٠% مركز قابل للاستحلاب) وديسيس (٢,٥% مركز قابل للاستحلاب) وفابكوسيدين (٢٠% مركز قابل للاستحلاب) بطريقة التعريض لراسب كل مبيد في قناني زجاجية صغيرة (٢,٧*٧,٥ سم). استخدمت في الاختبارات بالغات خنفساء اللوبياء الجنوبية *Callosobruchus maculatus* Fab وخنفساء الخابرا *Trogoderma granarium* Everts. بعمر يوم واحد وبالغات سوسة الرز *Sitophilus oryzae* L. وخنفساء الطحين الحمراء *Tribolium castaneum* Herbst وخنفساء الطحين المحيرة *Tribolium confusum* J du val. بعمر أربعة أسابيع.

تم تقدير سمية كل مبيد بتعريض البالغات إلى قناني زجاجية صغيرة أسطحها الداخلية مبطنة بالمبيد لمدة ٢٤ ساعة مباشرة بعد معاملة القناني.

أظهرت النتائج ان المبيد اكتارا هو الأكثر سمية تلاه بترتيب تنازلي للسمية المبيد ديسيس ثم فابكوسيدين ثم كوبكس، وان حساسية الحشرات المختبرة للمبيدات الأربعة هي على النحو *C.Maculatus* > *T.granareum* > *S.oryzae* > *T.castaneum* و *T.confusum*.

وأظهرت نتائج اختبارات تقيم فاعلية التأثير المتبقي للمبيدات الأربعة بعد ١ و ٢ أسبوع. ان المبيد اكتارا أكثر فاعلية من المبيد ديسيس بقليل وأكثر فاعلية من المبيدين فابكوسيدين وكوبكس بكثير ضد الأنواع الخمسة من الحشرات. كذلك أظهرت النتائج ان المبيدات البايريثرويدية الثلاثة بشكل عام فقدت فاعليتها أسرع من المبيد اكتارا مما يوحي بأن الأخير هو نسبياً أكثر ثباتاً.

الكلمات الدالة: سمّية، التأثير المتبقي، أكتارا (ثياميثوكسام)، مبيدات بايريثرويدية، أنواع غمدية الأجنحة، المنتجات المخزونة.