

## **Experimental Report on Effectiveness of the Insecticide**

### **Chloromethiuron 3.**

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No. 3 diflubenzuron is one type of benzoyl N-Phenylurea compound, a type of insect chitin synthesis inhibitor, and has a unique dissection mechanism. It can depress the chitinous formation on the insect epidermis, and make it die in the process of ecdysis or metamorphosis. It has particularly effective impact on lepidopterous larvae, and it can control many kinds of pests, such as armyworm, cabbage worm, cotton bollworm, *Clanis bilineata*, Pine caterpillar, *Hyphantria cunea*, mosquito screwworm etc. No. 3 diflubenzuron hardly has effect on imagoes, and has low virulence on higher animals; the medium lethal dose of white rats is 15,000 mg/kg on w/w basis. It has high virulence on target insects, but low virulence on non-target insects. This chemical has no specific smell, does not pollute the environment, and is safe for humans and animals. Thus, it is a new diflubenzuron with high-effect and low-virulence, and could replace some organochlorine insecticides such as DDT, Hexachlorocyclohexane and others.

*Mythimna separata* Walker is one of the main pests of crops in Jilin Province. The infested area per year is usually 5 – 10 million *mu* [666.7m<sup>2</sup>] in the whole province; and it will reach above 10 million *mu* in years of mass-outbreak. It leads to severe reduction of yield or even no yield if the *M. separata* are not controlled in time. In order to replace the organo-chlorine pesticides with their highly toxic residue, we have been doing experimental investigations and research on the chitin synthesis inhibitors - No. 1 diflubenzuron and No. 2 diflubenzuron - since 1977. In addition, we have done systemic research on No. 3 diflubenzuron supported by leaders in the Science Committee of our province since 1979. Our results are from indoor control experiments of No. 3 diflubenzuron colloidal suspension *M. separata*, which was synthesized and provided by the Tonghua Chemical Engineering Institute, and field-plot experiments and demonstration extension experiments within Jilin province. In this paper, the partial results of our research are summarized as follows.

#### **1. The biological activity of diflubenzuron**

The oral feeding method was used to measure the effect of stomach toxicity of No. 3

diflubenzuron on *M. separata* 3<sup>rd</sup> instar larvae; the LC<sub>50</sub> was 43 ppm. The filter paper pellicle method was used to measure the effect of contact toxicity of No. 3 diflubenzuron on *M. separata* 3<sup>rd</sup> instar larvae; the LC<sub>50</sub> was 53 ppm. The stomach toxicity of phoxim LC<sub>50</sub> was 118 ppm; the contact toxicity of phoxim LC<sub>50</sub> was 36 ppm. The effect of stomach toxicity of No. 3 diflubenzuron on the *M. separata* was stronger than that of phoxim; but the effect of contact poison of No. 3 diflubenzuron on the *M. separata* was weaker than that of phoxim.

The soaking root method was adopted to use the 15,000 ppm dose to soak corn seedlings for 24 hours and then pick pieces of leaves to feed to *M. separata* 3<sup>rd</sup> instar larvae; their survival rate was almost 100%. This was similar to the control, showing that No. 3 diflubenzuron had no influence on systemic conduction.

## **2. The unique killing mechanism and death symptom**

The killing mechanism of No. 3 diflubenzuron is to inhibit the formation of chitin on the insect epidermis, and make it incapable of normally exuviating, resulting in death. Survivors that did not die during ecdysis could not obtain food, then die of starvation or die in the next ecdysis.

Death symptoms due to treatment: armyworm larvae could not exuviate normally after being poisoned. Some exuviated half of the skin, some did not exuviate most of the skin, some did not exuviate at all, and the larvae became black and died. For others, although they had exuviated, the old head capsule did not exuviate, and they still could not survive. The poisoned larvae were inactive, their body fluid oozed out and they died gradually. For some armyworm larvae, due to the effects of No. 3 diflubenzuron, the thickness of the chitin formed on the epidermis was not even. They died following the froth secreted by the out-flow of the body fluid, which was produced by the effect of the intra-body pressure. Although the survivors exuviated well and smoothly, with activities at the beginning of ecdysis normal, since they could not get foods, they would die due to starvation. When old larvae exuviated and pupated, they could not exuviate normally. They formed malformed pupae with the half-pupae and half-larvae, which could not survive, or the pupae would not be able to emerge as normal imagoes by eclosion, and they died.

## **3. The experiment on field plots**

The control experiments of armyworm were done successively for wheat, millet, sorghum sub-zones from 1980 to 1984.

(1) The experiment on wheat fields: The Tonghua No. 3 diflubenzuron was sprayed in the sub-zone control experiment in 1983. The active ingredients per *mu* were 1, 10 and 20 grams. Hand-held ultra-low volume sprayers were used to spray the leaves; the results are shown in Table 1. The effect of controlling the armyworm for each treatment was above 70% after the treatment was sprayed for more than 7 days. Only the effect of spraying dichlorvos with 26.7 grams per *mu* was relatively ineffective. The effect of controlling the armyworm while using different doses of No. 3

diflubenzuron and on different sub-zones all reached above 90% after it was sprayed for more than 9 days. And the effect of controlling armyworms for phoxim treated zone was 79.9%. But the effects of spraying dichlorvos in two sub-zones were all below 60%. The effects of controlling the armyworm for No. 3 diflubenzuron in every sub-zone were all above 85% after the diflubenzuron was sprayed for more than 13 days. But the effects of spraying phoxim and dichlorvos in those sub-zones were all below 60%. And the number of the armyworms in the contrast sub-zone increased from 31.7 no./m<sup>2</sup> to 65 no./m<sup>2</sup>.

Table 1. Effect of controlling armyworms spraying different dosages of No. 3 diflubenzuron

Type of treatment	Number of armyworm before treatment (no./m <sup>2</sup> )	7 days later after using treatment		9 days later after using treatment		13 days later after using treatment	
		Number of alive armyworm (no./m <sup>2</sup> )	Effect of controlling armyworm (%)	Number of alive armyworm (no./m <sup>2</sup> )	Effect of controlling armyworm (%)	Number of alive armyworm (no./m <sup>2</sup> )	Effect of controlling armyworm (%)
8 g/mu of No. 3 diflubenzuron	461.1	81.7	90.2	24.4	97.4	30.6	92.5
10 g/mu of No. 3 diflubenzuron	64.4	27.2	76.6	8.9	93.3	8.3	85.3
20 g/mu of No. 3 diflubenzuron	42.2	16.1	78.9	0.6	99.4	4.4	83.0
16.7 g/mu of the phoxim	79.4	30.0	79.1	32.8	79.9	41.1	41.0
26.7 g/mu of the dichlorvos	55.6	63.3	36.9	51.7	54.7	23.3	52.1
53.3 g/mu of the dichlorvos	38.9	18.9	73.1	37.2	53.4	15.0	56.0
No contrast used	31.7	57.2	-	65.0	-	27.8	-

Note: In the seven days after spraying the treatments, four spells of rainfall totaling 23.6mm were recorded.

(2) The experiment on millet fields: The Tonghua [brand name] No. 3 diflubenzuron, Jintan [brand name] No. 3 diflubenzuron and No. 3 diflubenzuron, were sprayed with the dose of 10 g/mu in 1980. Hand-held ultra-low volume sprayers were used to spray the leaves of the millet seedlings. The hand-held power-sprayers sprayed 5% DDT powder with 1.65 kg/mu, which was used for comparison. Compared with the untreated check, there were 23.6 mm of rain after using the diflubenzuron for more than 8 days; the effects of Tonghua diflubenzuron, Jintan diflubenzuron and No. 3 diflubenzuron were 88.3%, 88.6% and 88.5% respectively. There were 67.9 mm of

rain after spraying the diflubenzuron for more than 13 days; the effects of Tonghua diflubenzuron, Jintan diflubenzuron and No. 3 diflubenzuron were 89.8%, 92.3% and 81.2% respectively. The effect of 5% DDT powder after it was sprayed for more than 8 and 13 days were 96.0% and 87.9% respectively. Thus, the effect of No. 3 diflubenzuron was almost the same as the DDT powder.

(3) The experiment on sorghum field control: We did the experiment with No. 3 diflubenzuron sprayed to control sorghum field armyworms in Shipu village, Lishu county in 1981. The doses of the diflubenzuron were 10 g/mu and 20 g/mu. Hand-held ultra-low volume sprayers were used to spray the leaves. The effects of the control after it was sprayed for more than 3 days were 73.1% and 56.6% respectively. In addition, the effects of the control after it was sprayed for more than 6 days all reached above 98%.

#### **4. The wide-area experimental demonstration and popularization in Jilin province**

In recent years, we cooperated with the Agricultural Technology Popularization Station of Jilin Province and related county, city and countryside plant protection stations and other agricultural technology popularization stations. We did the large-area experimental demonstration and popularization in 22 villages that belong to 13 counties and Lishu county farm, Taohe farm, Shengyuan farm and Jilin Agricultural Academy of Sciences farm. The 13 counties are Yushu, Jiutai, Nong'an, Dehui, Huaide, Lishu, Liaoyuan, Shuangliao, Hailong, Yongji, Fuyu, Wangqing, Tao'an etc. The 22 villages are Bingjiang (previously called Wukesong), Gongpeng, Xin'anzheng, Chenzijing, Zhonghe, Huayuan, Zhenchai, Sanbao, Xinliujia, Shijiapu, Lishu, Baishan, Shengli, Taojiao, Baiquan, Wangben, Luozigou, Wulajie, Tiantai, Shengyang, Huapichang and Tuchengzi etc. The area we controlled the armyworm on wheat, millet, sorghum and corn is around 50,000 *mu*. The Dongfanghong 18 model sprayers, Gongnong 16 model backpack sprayers, and hand-held ultra-low volume sprayers and airplane sprayers were used to spray diflubenzuron on leaves at the dose of about 10 g/mu when the second and third instars of armyworms were abundant. The effect of control was usually above 90%. The popularized area in only two years from 1983 to 1984 was more than 41,000 *mu*, in which millet takes up 33,000 *mu*, wheat takes up 2000 *mu*, core takes up more than 5000 *mu*, sorghum takes up more than 700 *mu*, and the area of the control of the secondary generation armyworm is about 7,000 *mu*. Many people have welcomed the popularization within our province very much during these four years. Especially in the situation of contract-obligation system, farmers plant several kinds of plants in one field; they don't worry about the damage risk of the treatment and rainfall. The farmers were often pleased to say that "diflubenzuron is really good, with powerful effects and low toxicity, low cost and few dosages, we need not worry about the rain after using the treatment, the natural enemies do not die, human and animals are not poisoned, crops are growing very well". The control effects of the demonstration and popularization are presented in Table 2, 3, 4 and 5.



Table 2. The effect of large-area control the first generation armyworm while spraying No. 3 diflubenzuron to wheat fields (1983)

Demonstration spot	Type of treatment	Dosage (active ingredient) g/mu	Dosage of the liquid (kg/mu)	Spraying tool	Number of armyworm before using treatment (no./5 meter)	6 days after spraying diflubenzuron		9 days after spraying diflubenzuron		Spraying date (month, day)
						Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	Number of alive armyworm (no./5m)	Reduction rate of # of malformed armyworm (%)	
Gongpeng village, Yushu County	No. 3 diflubenzuron, not spraying	10	2	Dong-18 model	102 107	16 265	94.5 -			6.21
Zhenchai village, Nong'an County	No. 3 diflubenzuron, not spraying	15	1.35	Dong-18 model	185 144	29 111	79.6 -	7 55	90.1 -	6.27
Xinliujia, Nong'an County	No. 3 diflubenzuron	15	30	Backpack sprayer	131	0	100.0	0	100.0	7.4
Chengzijie, Jiutai County	No. 3 diflubenzuron, 6%	10 1.33 kg/mu	15	Backpack sprayer	133 135	6 134	95.5 0.7	3 4	97.7 97.0	

	Hexachlorocyclohexanum power									
Taohe farm	No. 3	10	3.3	Airplane flying	109	51	63.3	19	90.0	6.27
	diflubenzuron, not spraying	10	3.3	ultra low	126	32	80.1	10	95.5	6.27
				Airplane flying	168	214	-	292	-	
				ultra low						

Table 3. The effect of large-area control the first generation armyworm while spraying No. 3 diflubenzuron to sorghum and corn fields (1983)

Type of crop	Demonstration place	Type of treatment	Dosage (active ingredient) (g/mu)	Dosage of the liquid (kg/mu)	Spraying tool	Number of armyworm before using diflubenzuron (no./5 meter)	6 days later after spraying diflubenzuron		9 days later after spraying diflubenzuron		Spraying date (month, day)
							Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	
sorghum	Xin'anzheng, Fuyu County	No. 3 diflubenzuron, not spraying	10	20	Dong-18 model	140 62	0 52	100.0 -			7.1
Corn	Huayuan village, Hailong County	No. 3 diflubenzuron, 5% armyworm, not spraying			Dong-18 model	268	36	87.9	12	97.6	6.24
						235	12	95.4	9	97.9	6.24
						218	229	-	302	-	



Table 4. The effect of large-area control the armyworm while spraying No. 3 diflubenzuron colloidal suspension to millet fields (1983)

Controlling Date	Demonstration spot	Type of treatment	Dosage (active ingredient) (g/mu)	Dosage of the liquid (kg/mu)	Spraying tool	Number of armyworm before using diflubenzuron (no./5 meter)	6 days later after spraying diflubenzuron		9 days later after spraying diflubenzuron		Spraying date (month, day)
							Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	
The control of the first generation armyworm	Bingjiang village, Yushu County	No. 3 diflubenzuron, not spraying	10	1.33	Dong-18 model	124	6	95.9	1	99.3	6.22
		No. 3 diflubenzuron, not spraying	10	1.33	Dong-18 model	121	143	-	137	-	6.23
						225	27	87.8	16	93.0	
						231	227	-	235	-	
	Gongpeng village, Yushu County	No. 3 diflubenzuron, not spraying	10	2.0	Dong-18 model	127	12	95.6			6.24
					122	263	-		-		

Zhenchai village, Nong'an County	No. 3 diflubenzuron, not spraying	10	2.7	Dong-18 model	108	8	90.7	2	94.6	7.1
						120	95	-	42	-
Chengziji e, Jiutai County	No. 3 diflubenzuron, dichlorvos	10	2.0	Dong-18 model	649	33	94.2	4	99.4	6.25
		53.3	2.0		Dong-18 model	594	35	94.1	40	93.3
Shengyuan farm	No. 3 diflubenzuron	10	0.8	Dong-18 model	575	29	95.0			6.16
Baishan village, Lishu County	No. 3 diflubenzuron, not spraying	10	1.0	Dong-18 model	725			10	93.5	
						614			563	-
Yuanzhong farm, Lishu County	No. 3 diflubenzuron, not spraying	10		Gongnong-16 model	191	15	92.0	7	96.4	
					152	151	-	156	-	
Lishu village, Lishu County	No. 3 diflubenzuron, not spraying	10	1.0	Handheld ultra-low volume sprayer	189	6	97.4	0	100.0	6.20
					197	252	-	274	-	

	Shijiapu, Lishu County	No. 3 diflubenzuron, not spraying	10	0.5	Dong-18 model	214  335	6  331	97.2  -			6.18
	Xian'an village, Fuyu County	No. 3 diflubenzuron, not spraying	10		Dong-18 model	145  120	11  120	92.4  -			6.26
The control of the second generation armyworm	Bingjiang village, Yushu County	No. 3 diflubenzuron, not spraying	10	1.33	Dong-18 model	290	28	91.7	5	98.3	8.14
		No. 3 diflubenzuron	7.14	1.33		114 187	133 35	- 31.3		31	83.4
	Xian'an village, Fuyu County	No. 3 diflubenzuron, not spraying	10	2.0	Dong-18 model	152  154	3  92	96.7  -			8.17

Note: The blank contrast area were not setup for Chengzijie, Jiutai county and Shengyuan farm. They were all the reduction rate of the number of malformed armyworm after spraying the diflubenzuron for more than 6 days and 9 days.

Table 5. The effect of large-area spraying No. 3 diflubenzuron to control armyworm in Jilin Province (June~July, 1984)

Type of crop	Control spot	Process -ing	Dosage (active ingredient) (g/mu)	Dosage of the liquid (kg/mu)	Spraying tool	Number of armyworm before using treatment (no./5 meter)	6 days later after spraying diflubenzuron		9 days later after spraying diflubenzuron		Remark
							Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	Number of alive armyworm (no./5m)	The reduction rate of the number of malformed armyworm (%)	
Millet	Bingjiang village, Yushu County	No. 3 diflubenzuron, Contrast	10	2	Dongfanghong - 18 model	248	32	88.0	11	96.3	Take the representative fields and investigate 5 of them; for each field, we recorded No. of armyworms for 1 meter
						155	274	-	303	-	
	Lishu village, Lishu County	No. 3 diflubenzuron, Contrast	10	1	Handheld sprayer with ultra-low volume	189	6	97.5	0	100.0	
						197	252	-	274	-	
	Shengli village, Lishu County	No. 3 diflubenzuron, Contrast	10	1	Handheld sprayer with ultra-low volume	241	39	87.3	19	94.9	
						120	160	-	185	-	

	Xianganzhen village, Fuyu County	No. 3 diflubenzuron, Contrast	10	20	Gongnong – 16 model	383	92	78.3	47	89.5	length, the number in the table is the sum of numbers from the five fields
						354	393	-	416	-	
	Chengzi , Jiutai County	No. 3 diflubenzuron, dichlorvos	10	15	Gongnong – 16 model	153	4		0		
			40	15		154	9		2		
Wheat	Sanbao village, Nongan County	No. 3 diflubenzuron, Contrast	10	1	Dongfanghong – 18 model	116			9	92.8	
						119			123	-	
	Wangben village, Shuangliao County	No. 3 diflubenzuron, Contrast	10	12	Gongnong – 16 model	67	2	92.1			
						71	27	-			
Corn	Hailong village, Zhonghe County	No. 3 diflubenzuron, Contrast	10	30	Gongnong – 16 model	865	84	89.5	35	95.5	The number in the table is the sum of numbers from 500 individual plants
						854	792	-	767	-	
sorghum	Bingjiang village,	No. 3 diflubenzuron,	10	2	Dongfanghong – 18 model	105	3	97.4			The number in

	Yushu County	Contrast				99	112	-			the table is the sum of numbers from 50 individual plants
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## 5. The residual period of treatment

The experiment on residual period of treatment was conducted in 1980. The Tonghua No. 3 diflubenzuron was sprayed on foliage in the wheat earhead formation period in the fields. We picked pieces of leaves to feed to *M. separata* 3<sup>rd</sup> instar larvae; the results are listed in Table 6. The residual period is about 20 days (the rainfall was 143mm during these 20 days) while the dose of the diflubenzuron sprayed was 10 g/mu. However, the effect of the treatment decreased to 62.1% due to the rainfall three days later after 5% DDT powder was sprayed; and decreased to below 10% ten days later.

Table 6. The experiment of the residual periods of treatment (Gongzhuling, 1980)

Processing	3 days later after spraying diflubenzuron		10 days later after spraying diflubenzuron		17 days later after spraying diflubenzuron		20 days later after spraying diflubenzuron	
	Number of armyworm released (no.)	Corrected mortality rate of armyworm (%)	Number of armyworm released (no.)	The malformed mortality rate of armyworm (%)	Number of armyworm released (no.)	Corrected mortality rate of armyworm (%)	Number of armyworm released (no.)	The malformed mortality rate of armyworm (%)
No. 3 diflubenzuron, 7.5 g/mu	50	59.8	49	87.6	17	51.9	34	51.1
No. 3 diflubenzuron, 10 g/mu	45	82.6	50	100.0	12	72.7	30	59.7
No. 3 diflubenzuron, 20 g/mu	48	76.8	53	100.0	16	79.5	28	100.0
5% DDT powder 1.65 kg/mu	47	62.1	49	-32.4				
Compared without spraying diflubenzuron	96	-	92	-	36	-	68	-

## 6. Rainfall has no influence on the effects of the treatment

(1) Experiment on artificial rainfall: the experiment on artificial rainfall with a dose of 10 g/mu was conducted in millet fields in 1983. The ultra-low volume

sprayers were used to spray leaves in this experiment. The artificial rainfall was conducted immediately after the leave became dry. Then the leaves were picked up and fed to indoor larvae. The results are presented in Table 7.

Table 7. The influence of rainfall on the effects of the treatment after spraying No. 3 diflubenzuron (Gongzhuling, July 1983)

Type of rainfall	Processing	Number of armyworm released (no.)	48 hours later after processing		96 hours later after processing	
			Number of death (no.)	The malformed mortality rate of armyworm (%)	Number of death (no.)	The malformed mortality rate of armyworm (%)
No rainfall	No. 3 diflubenzuron, 10 g/mu ”, 20 g/mu	33	15	42.3	21	60.3
		28	19	66.0	21	72.7
Artificial rainfall - 10mm	No. 3 diflubenzuron, 10 g/mu ”, 20 g/mu	31	17	52.1	23	71.9
		36	34	94.1	34	90.6
Contrast	Not using treatment	36	2	-	3	-
Artificial rainfall - 10mm + natural rainfall 20mm	No. 3 diflubenzuron, 10 g/mu ”, 20 g/mu	32	19	59.4	23	71.9
		39	30	76.9	34	87.2
Contrast	Not using treatment	39	0	-	0	-

The results show that rainfall has no obvious influence on the effects of the treatment.

(2) The residual period experiment of the treatment done in 1980 also showed that the residual period was still up to about 20 days under the conditions in which rainfall was 143mm during 20 days and the dose of No. 3 diflubenzuron sprayed was 10 g/mu. But the residual period was just about 10 days if DDT was sprayed. Therefore, it could be seen that rainfall has almost no influence on the effects of No. 3 diflubenzuron.

## 7. The influence on natural enemies



(1) The influence on ladybug (*Harmonia axyridis*)

A. Egg: The active ingredients of No. 3 diflubenzuron colloidal suspension with the dose of 5 g/mu, 10 g/mu and 20 g/mu were sprayed on fresh egg masses. No influence on egg hatching has been observed. The results are listed in Table 8.

B. The contact-poison influence on the *Harmonia axyridis* larvae: monocultured, individually reared larvae were sprayed on their body. The contact-poison influence of No. 3 diflubenzuron on the *Harmonia axyridis* larvae was observed. The results of the mortality rates from processing the *M. separata* 1<sup>st</sup> instar were 24.1%, 50% and 86.4% respectively, while the doses of diflubenzuron sprayed were 5 g/mu, 10 g/mu and 20 g/mu. These rates are all higher than contrast mortality rate 16%. No influence on the *M. separata* 3<sup>rd</sup> instar larvae has been observed. There is a little influence on the *M. separata* 4<sup>th</sup> instar ladybug according to our observation. And the mortality rates are between 65.5% and 80%, which is higher than the contrast rate 64.3%.

C. Pupae: No. 3 diflubenzuron with dosages of 5 g/mu, 10 g/mu and 20 g/mu was sprayed on pupae. There was no influence on the imago eclosion. The results are listed in Table 9.

Table 8. The influence on the hatch while spraying No. 3 diflubenzuron to process the *Harmonia axyridis* eggs (Gongzhuling, 1982)

Processing	Number of egg granules released (no.)	No. hatched (no.)	Rate of eclosion (%)
Contrast	105	32	30.5
No. 3 diflubenzuron, 5 g/mu	102	31	30.4
No. 3 diflubenzuron, 10 g/mu	104	31	29.8
No. 3 diflubenzuron, 20 g/mu	101	31	39.7

Table 9. The influence on the imago eclosion while spraying No. 3 diflubenzuron to process the *Harmonia axyridis* pupae (Gongzhuling, 1982)

Processing	Number of pupae released (no.)	Number of pupae by eclosion (no.)	Rate of eclosion (%)
Contrast	41	39	95.1
No. 3 diflubenzuron, 5 g/mu	42	42	100.0
No. 3 diflubenzuron, 10 g/mu	42	42	100.0

g/mu			
No. 3 diflubenzuron, 20 g/mu	41	41	100.0

D. Imago: We let the *Harmonia axyridis* adults have contact with the containers' surface that had been treated by different dosages of the diflubenzuron and observed its contact-poison influence. The mortality rate was below 50% 7 days after processing. No influence on egg laying and the egg hatch of survival imago was observed. The results are listed in Table 9.

Table 10. The influence on the contact-poison and egg laying while spraying No. 3 diflubenzuron to process the *Harmonia axyridis* imago (Gongzhuling, 1982)

Treatment	Number released (no.)	Treatment time (hour)	Cumulative adult mortality post-treatment over 2 days		Cumulative adult mortality post-treatment over 5 days		Cumulative adult mortality post-treatment 7 days		The egg laying and the hatching after processing			
			(no.)	(%)	(no.)	(%)	(no.)	(%)	Clump number of eggs	Granule number of eggs	Number hatched	Rate of hatch (%)
Contrast	22	22	1	4.5	3	13.6	3	13.6	3	59	51	86.4
5 g/mu	25	22	7	28.0	11	44.0	11	44.0				
10 g/mu	21	22	7	33.0	9	42.9	9	42.9	3	63	63	100.0
20 g/mu	22	22	7	31.0	9	40.9	11	50.0	1	27	27	100.0

E. The investigation of the influence on natural enemies under conditions of large-area control:

(1) The investigation was conducted after the large-area control of millet and wheat in Taojiatun and Gongzhuling, Huaide County in 1981 and 1982. No influence on the ladybug was observed while the dose of No. 3 diflubenzuron sprayed was 10 g/mu (active ingredient). The results are listed in Table 11 and 12.

Table 11. The influence on the natural enemies while spraying No. 3 diflubenzuron to control the millet field second generation armyworm (Taojiatun, Aug. 1981)

Processing area	9 days later after spraying diflubenzuron		14 days later after spraying diflubenzuron
	Ladybug imago (no./10m)	Corab crab Spider (no./10m)	<i>Harmonia axyridis</i> imago (no./5m)
20% of No. 1 diflubenzuron, 2 g/mu	13	1	4
25% of No. 3	6	1	4

diflubenzuron, 20 g/mu			
Contrast (not spraying diflubenzuron area)	5	1	3

Table 12. The comparison of the influence on the natural enemies while large-area controlling the armyworm in wheat fields (Gongzhuling, 1982)

Processing	Ladybug with Moire pattern		<i>Harmonia axyridis</i>		Other kind of ladybugs	Spraying date (month, day)	Investigation data (month, day)
	Larvae (no./10m)	Imago (no./10m)	Larvae (no./10m)	Imago (no./10m)	Imago (no./10m)		
No. 3 diflubenzuron, 10 g/mu	39	1	12	0	1	6.21	7.1
Dichlorvos 100 g/mu	1	1	0	0	0	6.21	7.1

(2) The influence on the natural enemies of parasitical armyworm:

500ppm of No. 3 diflubenzuron was sprayed to process the filter paper. The membrane method was used to process the parasitized armyworm larvae; then we fed them normally after 20 and 60 minutes. *Meteorus sp.*, *Apanteles ruficrus* (Haliday) and *Euplectrus sp.* were observed, which parasitized inside the bodies of armyworm. They were capable of getting out of armyworm larvae bodies and producing imago by eclosion. No influence was observed.

In addition, we observed the same results when we captured armyworm larvae and then bred them inside after control of the armyworm in wheat fields.

The above experiments showed that there was almost no influence on the ladybug and some parasitical natural enemies while we sprayed No. 3 diflubenzuron to control armyworm. Thus, it benefited integrated control.

## 8. The influence on crop reproduction

(1) The wheat soaking root method was adopted to measure the influence of No. 3 diflubenzuron on sprouting and rooting of wheat seeds. The results showed that the 1,000 ppm concentration had a little depressing influence, that 10,000 ppm concentration had notable depressing influence, but that 100 ppm concentration seemed to have the influence of stimulating growth.

(2) The field experiment of treatment damage showed that there were not any treatment damage symptoms on sorghum, corn, millet and soybean seedling while we sprayed No. 3 diflubenzuron with dosages of 50 g/mu, 100 g/mu, 150 g/mu and 200 g/mu (active ingredient) respectively. They all grew normally.

(3) The heights of individual plants were investigated in every experimental spot in 1981. The results showed that heights of wheat and millet individual plants sprayed with the doses of both 10 g/mu and 20 g/mu on the leaves were higher than those of individual plants in the DDT control area and the contrast area without spraying diflubenzuron.

Table 13. Comparison of the influence on crop reproduction while spraying diflubenzuron to control the armyworm in wheat and millet fields (1981)

Crop	Place	Processing	Plant height before using the diflubenzuron (cm)	Plant height after using the diflubenzuron (cm)	Difference of the two plant heights	Plant height difference and contrast (%)
Wheat field	Gongpeng village, Yushu County	25% of No. 3 diflubenzuron, 10 g/mu	64.1	94.0	29.9	114.1
		” 20 g/mu	61.9	97.9	36.0	137.4
		5% DDT powder, 1.35 kg/mu	64.1	89.7	25.6	97.7
		Contrast	65.2	91.4	26.2	100.0
Millet field	Gongpeng village, Yushu County	25% of No. 3 diflubenzuron, 10 g/mu	51.2	91.7	40.5	102.0
		” 20 g/mu	52.4	93.7	41.3	104.0
		5% DDT powder, 1.35 kg/mu	50.7	86.3	35.6	89.7
		Contrast	51.2	90.9	39.7	100
	Wukeshu village, Yushu County	25% of No. 3 diflubenzuron, 10 g/mu	54.3	127.0	72.7	120.8
		” 20 g/mu	62.2	128.3	66.1	109.8
		5% DDT powder, 1.65 kg/mu	59.4	120.3	60.9	101.2
		Contrast	58.0	118.2	60.2	100.0
	Chengzijie village, Jiutai County	25% of No. 3 diflubenzuron, 10 g/mu	66.3	111.2	44.9	178.2
		” 20 g/mu	60.5	107.2	46.7	185.3
		80% Dichlorvos (liquid)	63.6	99.4	35.8	142.1
		Contrast	70.1	95.3	25.2	100.0

Baiquan village, Liaoyuan City	25% of No. 3 diflubenzuron, 10 g/mu	35.6	58.3	22.8	92.7
	” 20 g/mu				
	5% DDT powder, 1.5 kg/mu	37.3	74.7	37.4	151.7
	Contrast	42.2	60.4	18.2	74.0
		34.2	58.8	24.6	100.0

## 9. The influence on the crop yields while spraying diflubenzuron to control armyworm

Experiments on field sub-zones were done in 1983 and 1984. The influence on yields of wheat was measured after No. 3 diflubenzuron was sprayed to control armyworm. The results showed that there were obvious influences of increasing the yields of wheat while spraying No. 3 diflubenzuron with dosages of 8 g/mu, 10 g/mu and 20 g/mu to control armyworm. The weights of wheat ears increased by 17.9%, 23.8% and 32.1% respectively compared with the contrast case without spraying diflubenzuron; and they increased by 7.1% and 6% respectively compared with the weights of wheat ears in areas sprayed by dichlorvos with a dosage of 0.6 kg/hectare. The thousand-grain weight and the weight by volume were all higher than those while no diflubenzuron was sprayed.

The wheat seedling came into ear early due to the drought in the seedling period in 1984. The period of controlling armyworm and spraying the diflubenzuron missed the wheat flowering season. Thus the yields did not increase notably. But the yields while spraying the diflubenzuron increased by 10% compared with that while not spraying the diflubenzuron. In addition, the wheat yield was positively related to the effect of the treatment.

## 10. The cost calculation

The cost of the treatment with the active dosage of 10 g/mu to control armyworm is 0.50 yuan. The cost of the dichlorvos with a dosage of 50-100 g/mu is 0.37~0.75 yuan. And the cost of spraying the diflubenzuron twice is 0.75~1.5 yuan/mu. It was rainy while spraying the diflubenzuron to control armyworm in Jilin Province, so the diflubenzuron was usually sprayed 2~3 times. But spraying once was enough to control the armyworm if No. 3 diflubenzuron was used. Therefore, it is still economical. The cost will be reduced once diflubenzuron is mass-produced by the pesticide factories.

## 11. Conclusions

- (1) The pesticide of No. 3 diflubenzuron has no stomach toxicity and contact-poison influence on armyworm, and has no systematic action.
- (2) No. 3 diflubenzuron colloidal suspension was sprayed using Dongfanghong 18 model sprayers, hand-held ultra-low volume sprayers, Gongnong 16 model

backpack sprayers and airplane sprayers, whose dosage was 10 g/mu (active ingredient). The effects of the control were all above 90%.

(3) Rainfall had almost no obvious influence on the effects of No. 3 diflubenzuron after it had been sprayed. The residual period of the diflubenzuron was long; and the residual period was about 20 days when the dose of No. 3 diflubenzuron sprayed was 10 g/mu.

(4) There was almost no influence on the *Harmonia axyridis*, *Meteorus sp.*, *Apanteles ruficrus* (Haliday) and *Euplectrus sp.* while spraying No. 3 diflubenzuron to control armyworm.

(5) There were no damage symptoms on crops such as wheat, millet, sorghum and corn etc. that were sprayed with No. 3 diflubenzuron to control armyworms. It seemed that it had the influence of stimulating growth and increasing yields.

(6) The cost of using the pesticide of No. 3 diflubenzuron to control armyworm is basically similar to the cost of using DDT or dichlorvos.