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Effects of Insecticides on Pest Populations and Their Natural Enemies in Soybean Field

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Abstract

In the 5-time field experiments and broad demonstrations, effects of volume and application formulae of several pesticides on the population densities of major inset pests and natural enemies in the soybean field were determined. Results from the Ducan's multiple range test indicated that 300 g/ha of Omethoate (fine granule) and 45 g/ha of Fenvalerate in the seedling stage and 300 g/ha of Chloromethiuron suspensoid in the flowering stage may control pests and protect major natural enemies. Application of these pesticides in the corresponding soybean stages is an effective way that mediates the conflict between chemical and biological controls in the field.

There are over 170 species of natural enemies whose hosts are known in the soybean field in China. These natural enemies play important roles in controlling the soybean pests. However, farmers still strongly rely on chemicals to control these pests because natural enemies are not able to timely curb the pest infestations when there is a pest outbreak. Frequent chemical application in a higher volume will ruin the ecological balance. The conflict between biological and chemical controls has become a hot issue in the soybean production worldwide. Our objectives in this study are to decide the effective low concentrations of commonly used pesticides, determine the effect of the third and fourth generations of pesticides on the major insect pests and natural enemies in the soybean field and propose feasible control methods by coordinating control and chemical controls.

Materials and Methods

In 1984-1985, we conducted field experiments and demonstrations for 5 times in the seedling, flowering and pod stages in Huiming Prefecture, Lijing County, Shandong Province. Soybean fields with similar growing conditions were selected as experimental plots. Pesticides included Fenvalerate, Omethoate, Chloromethiuron # 3, Neemix, JAP-822 and virus extracted from *Clanis bilineata*. Emulsion or solution were mixed with water at 90 kg/ha and sprayed by the compressed back sprayer. Fine-granules were applied through a single layer of gauze before dews on the plants evaporated. Water without chemical was used as control. Each treatment was replicated twice and randomly arranged. Soybean aphids on selected plants were surveyed. *Plusia agnata* was investigated randomly. Natural enemies were surveyed by sweeping net with a diameter of 0.33 m. The sweeping range was about 1.5 m and sweeping back and forth once was considered as 1 sweep. The net touched the soybean

leaves during sweeping. Sampling numbers of pests and natural enemies were determined by insect densities in the field. Some data were conversed using lg (x+1) or $Sin^{-1}\sqrt{p}$, and the majority of data were tested by the Ducan's multiple range test.

Results and Analysis

In the seedling stage, chemical effects were evaluated on soybean aphids and natural enemies including lacewings, syrphids and parasitoids (*Trioxys auctus* and *Aphelinus* sp.).

Under the regular volume, 600 g/ha of Omethoate (referred to effective ingredient, the same as below) and 75 g/ha of Fenvalerate had significant effects on soybean aphids, but the former had better control. The corrected aphid decline rate was about 80-90% in the treated plots. There was significant difference between treatment and control at 1% level. However, two pesticides also killed most of natural enemies (Table 1). In the experiment 1, we surveyed natural enemy numbers in 11 d following chemical application and found that the numbers per 50 sweeps in the treated and untreated plots respectively were about 3-5 and 18-68 i.e., numbers of natural enemies in the untreated plots were 10.7 times higher than that in the treated plots. We used the Ducan's multiple range test to compare each survey between treatment and control in the experiment 2 and discovered that total natural enemies from the treated plots were significantly different from the untreated one at 1% level except 1 d after spray.

When lower concentration was used, control effects of 300 g/ha of Omethoate and 45 g/ha of Fenvalerate were similar to or slightly lower than that by regular concentration. The corrected aphid decline rate was 70-90% and the highest was 100%. Neither of two pesticides was different significantly at regular or lower concentration at 5% level. Systematic investigations showed that fewer natural enemies were killed under lower concentration. In the experiment 2, there was not significant difference of *Picromerus* sp. numbers at 5% level between treatment and control 1 d after using Fenvalerate, while lacewing numbers did not differ significantly between treatment and control 7 d after Omethoate application.

In terms of application types, the same amount of effective ingredient of Omethoate emulsion or fine granule had similar effect on soybean aphids. The corrected aphid decline rate was about 80%. Experiment 3 revealed that fine granule had a shorter effect on natural enemies and their populations recovered faster. There was not significant difference at 5% level between treatment and control 7 d after applying fine granules, but application of emulsion was not the same case with a significant difference. Relative survival of natural enemies increased 61.7% when 300 g/ha of Omethoate fine granule were applied instead of 600 g/ha of emulsion.

Although JAP-822 and Neemix were safe to natural enemies, aphids built up quickly 11 d after application and the latter also caused direct damage to soybeans. Obviously, neither of the two pesticides is good candidates.

Table 1 Effects of pesticides on natural enemy numbers
in the seedling stage (7 days after application)

Hutan, Lijing, July 1985

Species / Treatment	Total natural enemies			Parasitoids			*Picromerus* sp.		
	No. living enemies	Significance		No. living wasps	Significance		No. living enemies	Significance	
		5%	1%		5%	1%		5%	1%
Untreated	15	a	A	12.4	a	A	2.2	A	A
2.5% Omethoate fine granule, 300 g/ha	10.8	ab	AB	8.4	ab	AB	1.4	A	A
20% Fenvalerate, 45 g/ha	8.6	b	AB	6	b	B	2	A	A
40% Omethoate emulsion, 300 g/ha	7	b	B	6.2	b	B	0.8	a	A

Experiment results show that in the soybean seedling stage, 300 g/ha of Omethoate or 45 g/ha of Fenvalerate instead of 600 g/ha or 75 g/ha respectively may be very important to protect ecological balance, reduce environment pollution, alleviate pest resistance to chemical and reduce chemical application cost. Fine granule is in particular important because it is easy to use without requiring special appliance, is not limited by water resource and has less effect on natural enemies under the circumstance of having the same control effect on pests as emulsion. Therefore, it may be considered as an ideal option for chemical control in the seedling stage.

In the flowering stage, the major pests in recent years included *Plusia agnata*, *Clanis bilineata*, and *Heliothis armigera* in late grown summer soybeans. In our study on natural enemies, spiders and *Picromerus* sp. were evaluated.

Two volumes of Chloromethiuron # 3 suspensoid had very good effects on the main foliage feeding pests in this stage (Table 2). The corrected pest decline rate was about 70-80%. There was a significant difference at 1% level between treatment and control except 9 d after applying 450 g/ha. Some pests did not display any symptom after poisoning, but they were not able to pupate. Thus, the real control effect should be higher than the data presented above. This pesticide had little effect on natural enemies. Relative survival of natural enemies in the treated plots with 450 g/ha of Chloromethiuron # 3 was about 84.7% (47.9-117%) of that in the untreated plots. The treated plots did not differ significantly from control at 5% level 9 d after application. There was not significant difference at 5% level between treatment and control except total natural enemy numbers and *Picromerus* sp. 9 d after 300 g/ha of Chloromethiuron # 3 was applied. Demonstrations in a wider areas in 1985 showed that under 300 g/ha, soybean plants grew very well with good shape of leaves and pest densities decreased steadily, which was contrary to the untreated plots.

Fenvalerate led to a pest mortality of 60-70% at two volumes, but it also killed some natural enemies. Therefore, it is not suitable to apply in this stage.

A mixture of pests develops and builds up quickly, and natural enemies also peak in the flowering stage. Numbers of natural enemies were 360,000-420,000 in August 1981. Conflict

between biological and chemical controls is most prominent in this period, and it is vital to determine an integrated control program. Based on the analyses of field experiments in the flowering stage and the laboratory experiments of controlling *Plusia agnata*, *Clanis bilineata* and *Heliothis armigera*, Chloromethiuron # 3 is an inhibitor of chitin synthesis which has a unique mechanism to kill pests especially lepidopterous larvae without affecting natural enemies. A volume of 300 g/ha may be used to control *Plusia agnata* and *Clanis bilineata*. If *Heliothis armigera* is also the target species, 450 g/ha needs to apply.

Table 2 Effects of pesticides on natural enemy populations in the soybean blooming stage

Wangmu, Boxing, August 1985

Treatment	All natural enemies						Spiders						*Picromerus* sp.						Parasitoids					
	6			9			6			9			6			9			6			9		
	No. living enemies*	Significance 5%	1%	No. living enemies	Significance 5%	1%	No. living spiders	Significance 5%	1%	No. living spiders	Significance 5%	1%	No. living enemies	Significance 5%	1%	No. living enemies	Significance 5%	1%	No. living parasitoids	Significance 5%	1%	No. living parasitoids	Significance 5%	1%
Untreated	4.6	A	A	19.6	a	A	0.6	a	A	1.6	a	A	2.6	a	A	9.6	a	A	4	a	A	6.8	a	A
50% Chloromethiuron # 3, 450 g/ha	6.8	A	A	15	a	AB	1	a	A	2.8	a	A	4.2	a	A	6.6	ab	AB	1.4	a	A	5	ab	A
50% Chloromethiuron # 3, 600 g/ha	5.4	A	A	9.4	b	A	1.6	a	A	0.8	a	A	2	a	A	4	bc	B	1.6	a	A	3.6	b	A
20% Fenvalerate emulsion, 45 g/ha	4	A	A	6.8	b	A	0.8	a	A	1.8	a	A	1.6	a	A	1.6	c	B	1.2	a	A	3.4	b	A

*Mean number of 5 sites X 20 sweeps.

Table 3 Effects of pesticides on survival of natural enemies

Treatment	Survey times	Mean relative survival (%)			
		Total natural enemies	Parasitoids	Lacewings	*Picromerus* sp.
40% Omethoate emulsion, 600 g/ha	4	25.6	34.6	6.3	20.2
2.5% Omethoate fine granule, 600 g/ha	4	33.2	70.4	3.8	21.6
40% Omethoate emulsion, 300 g/ha	4	34.9	60.5	1.3	16.2
2.5% Omethoate fine granule, 300 g/ha	8	41.4	68.2	4.5	26
20% Fenvalerate emulsion, 45 g/ha	8	36.2	63.5	5.1	25.5
20% Fenvalerate emulsion, 75 g/ha	12	56.2	75.1	2.5	47
50% Chloromethiuron #3, 600 g/ha	4	84.7	100.9	-	72.6
50% Chloromethiuron #3, 450 g/ha	4	103.7	111.7	-	104.2

Of all natural enemies, lacewings are most sensitive and *Picromerus* sp. and parasitoids are least sensitive to chemicals. Survival of lacewings, *Picromerus* sp. and parasitoids in the treated plots is 3.83% (0-14.8%), 37.5% (0-161%) and 70.2% (24-200%) of that in the untreated plots (Table 3). Comprehensive pest management programs need to be considered and appropriate chemical volume should be used when chemicals are applied, because lacewings and *Picromerus* sp. are dominant natural enemies in the soybean field.

References

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