11. MAJOR INSECT PESTS OF LEGUMINOUS CROPS IN JAPAN

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Introduction

About fifty species belonging to nine Orders are found as the major insect pest of the leguminous crop in Japan. As is shown in Table 1, the number of insect pest species of appropriate legumen is as follows; about thirty species for soybeans, about twenty for adzuki beans, kidney beans and cowpeas, and ten or so for broad beans, peas and peanuts, respectively. In the present paper, discussions are made on the insect pest of the soybean plant which has been cultured most extensively in Japan and has been damaged by the major polyphagous insects with the other leguminous crops, as well.

Table 1. Major insect pests to maln bean crops in Japan

Injured parts	Pests	Soybean	Kidney bean	Adzuki bean	Cowper	Peanut	Broad bean	Garden pea
seedling	*Hylemya platura*	○	○	○	○	○		
root	*Heterodera glycines*	○	○	○				
	Meloidogyne hapla					○		
	Pratylenchus penetrans					○		
	Scepticus uniformis					○		
	Anomala cuprea					○		
	Melanagromyza dolichostigma	○						
leaf	*Phytomyza atricornis*							○
	Paraluperodes nigrobilineatus	○						
	Colposcelis signata			○				
	Atrachya menetriesi	○	○					
	Anomala rufocuprea	○						
	Apion collare			○				
	Atractomorpha tata	○						
	Syllepte ruralis	○						
	Lamprosema indicata	○						
	Dasychira locupless confusa	○						
	Prodenia litura	○	○	○	○	○		
	Chauliops fallax	○						
	Tetranychus kanzawai	○	○	○				
	Acusta despecta	○	○	○	○	○	○	○
leaf, stem	*Profeltiella soya*	○						
	Anacanthocoris concoloratus			○				

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Table 1. Major insect pests to main bean crops in Japan (conuted)

Injured parts	Pests	Soybean	Kidney bean	Adzuki bean	Cowpea	Peanut	Broad bean	Garden pea
stem	*Melanagromyza soja*	○						
leaf stem, pod	*Aphis glycines*	○						
	Aphis craccivora			○				
	Acyrthosiphon pisum							○
	Megoura viciae japonica						○	
	Armandillidium vulgare	○	○	○	○	○	○	○
leaf, pod, seed	*Heliothis viriplaca adaucta*	○	○	○	○			
	Pyrrhia umbra	○	○	○	○			
leaf, stem, pod seed	*Matsumuraeses phaseoli*	○	○	○	○	○	○	
stem, pod, seed	*Ostrinia zaguliaevi*			○	○		○	○
bud, flower, pod, seed	*Lampides boeticus*						○	○
bud, flower	*Apion collare*			○				
pod, seed	*Asphondylia* sp.	○						
	Nezara autennata	○	○	○	○		○	○
	Nezara viridula	○	○	○	○		○	○
	Palomena angulosa	○	○	○	○			○
	Piezodorus hybneri	○	○	○	○		○	○
	Dolycoris baccarum	○	○	○	○		○	○
	Halyomorpha mista	○	○	○	○		○	○
	Riptortus clavatus	○	○	○	○		○	○
seed	*Grapholitha glycinivorella*	○						
	Etiella zinckenella	○						
	Callosobruchus chinensis			○				
	Bruchus rufimanus						○	
	Bruchus pisorum							○

Pest Insect Species of Soybean

Soybean pest consisting of more than 218 species belonging to 61 families of nine Orders has been found in Japan. The name of the Order appeared dominantly among the numerous species and the injured part of the plant are shown in Table 2, that is, Lepidoptera, Hemiptera and Coleoptera appeared numerously in this order. On the other hand, the number of species attacking leaves is the most numerous being followed by those attacking stems and pods. From the economical point of view, it is concluded that the species which attack pods and roots do the most destructive damage to soybean.

Table 2. Number of soybean insect pest species belonging to a certain Order

Injured part	Ordre										
	Collem-bola	Ortho-ptera	Derma-ptera	Thysano-ptera	Hemi-ptera	Lepido-ptera	Coleo-ptera	Hymeno ptera	Diptera	Total	Percentage
Root	1	1	—	—	3	—	8	—	4	17	5.4%
Stem	—	7	—	1	49	9	8	—	3	77	24.2
Leaf	2	13	1	8	40	73	35	2	8	182	57.2
Flower	—	—	—	4	—	1	1	—	—	6	1.9
Pod	—	4	—	—	24	7	—	—	1	36	11.3
Whole plant	2	19	1	9	55	77	40	2	13	218	100.0

Note: The injured parts are as follows:
1) Root: roots, nodules and underground port.
2) Stem: top part of the stem and petioles.
3) Leaf: cotyledon, primary leaf and matured leaves.
4) Flowers and buds.
5) Pod: pods and seeds. (Kuwayama, 1953)

Insect Injuries of Soybean

The severity of the soybean insect injury varied annually and locally. Table 3 shows an example of the percentage of the injured seed in a harvest season in various parts of this country. A Prefectural average of the total injured seeds in percentage is about 17 to 56 percent, and the major destructive species appeared differently according to the weather of the region. For examples, in the warm region, the prefectural average of the seeds injured by stink bugs is about 14–38 in percentage, while, in the cold region, that of the seeds injured by the soybean pod borer is about 10–14 in percentage.

The total percentage of injured seeds tends to be higher in warm region than in cold one, in island areas than in inland ones, on piedmonts than in plains, and in warm year than in cold year, respectively.

From the economical view-point, as for the insect damages on soybean, Tohoku District could be divided into three regions, as in Fig. 1. Region I is the area characterized by single dominant species of the soybean pod borer and covers the north of the isothermal line of $-1.5°C$ which is the mean temperature of January. Region III is the area characterized by more than two dominant species, the stink bugs and the soybean pod

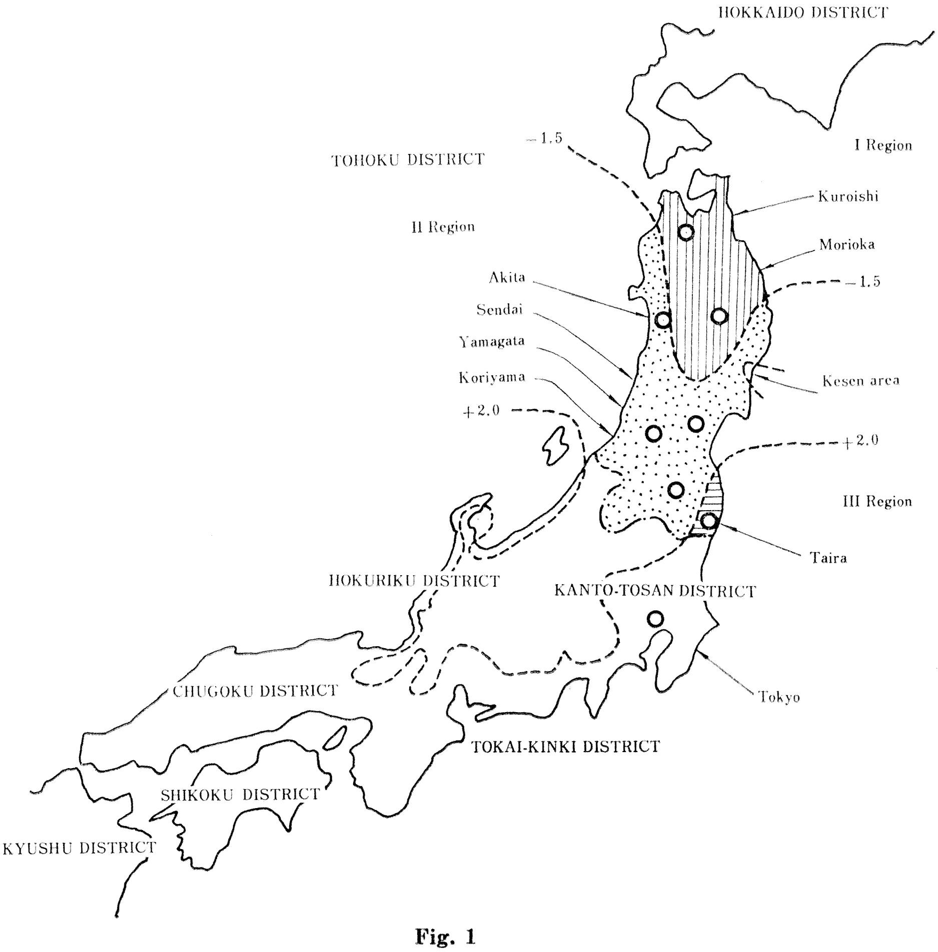


Fig. 1

Table 3. Percentage of the seeds injured by several species in a harvest season in various places of Japan

District	Prefecture	Percentage of the seeds injured by each species							Note			
		Stink bugs	Pod gall midge	Lima-bean pod borer	Adzuki pod worm	Soybean pod porer	Others	Total	Location or no. of varieties	Year	No. of years	Remarks
Tohoku	Aomori	1. 4	0. 2	0. 1	1. 0	13. 3	0. 2	16. 2	16. 6	'67—'71	5	Kobayashi (unpublished)
	Iwate	2. 8	0. 6	0. 0	0. 6	12. 8	0. 2	17. 0	27. 0	〃	〃	
	Akita	2. 5	1. 0	0. 1	2. 8	11. 5	0. 2	18. 1	13. 6	〃	〃	〃
	Miyagi	3. 8	3. 8	0. 2	2. 0	9. 9	0. 2	19. 9	25. 7	'66—'71	6	〃
	Yamagata	3. 6	2. 4	0. 2	2. 1	13. 2	0. 2	21. 7	27. 0	'67—'71	5	〃
	Fukushima	9. 3	1. 9	0. 6	2. 1	9. 0	0. 5	23. 4	17. 0	'67 '69 '71	3	〃
Kanto-Tosan	Nagano	34. 4	2. 4	11. 6	—	—	2. 4	50. 8	24. 0	1952	1	Chiku & Miyashita (1957)
	Chiba	17. 4	4. 5	7. 9	—	—	—	29. 8	5. 0	1953	1	Ichihara(1964)
Shikoku	Kagawa	37. 9	1. 9	4. 0	11. 4	1. 0	—	56. 2	33. 0	1950	1	Ishikura et al. (1952)
	Tokushima	13. 9	0. 1	0. 1	8. 2	6. 2	—	28. 5	4. 0	1950	1	〃

borer, and covers the south of the isothermal line of +2°C which is mean temperature of January. Region II, situated between Region I and III, is similar to Region I in a cold year, while it is similar to Region III in a warm year. Species used to appear only in warm areas are happened to be found in the southern part of Region III, however, the relationship between the species and the isothermal line is not yet known.

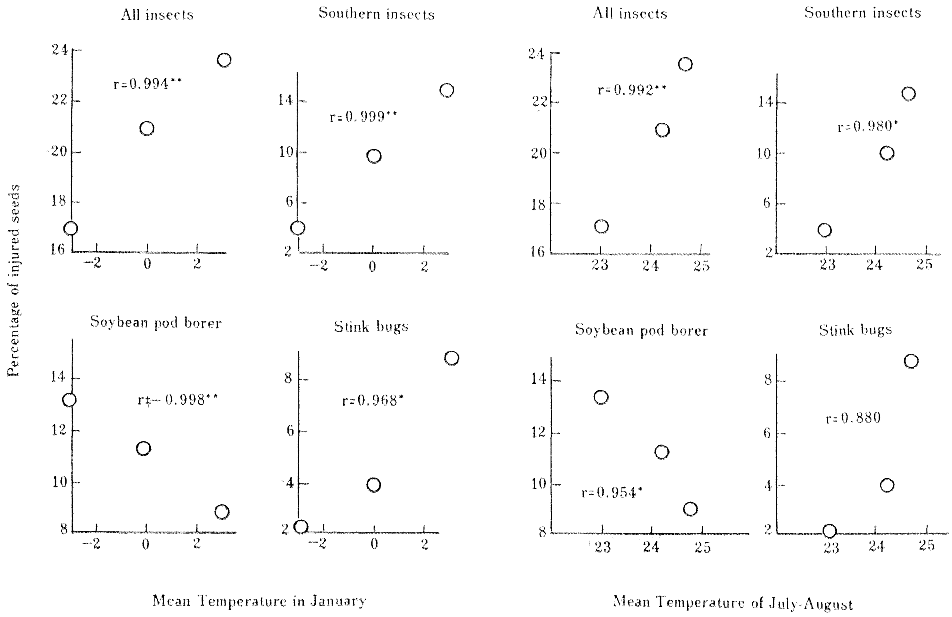
Hereon, three regions mentioned above can be recognized, in relation to the distribution of the indicator insect pests in soybean fields, as shown in Table 4.

Table 4. Distribution ef the indicator pests in soy beau fields of the 3 regions in Tohoku District

Species	Region Ⅰ	Region Ⅱ	Region Ⅲ
A stink bug (*Homalogonia obtusa*)	○	○	
Ezo green stink bug (*Palomena angulosa*)	○	○	
Bean bug (*Riptortus clavatus*)		○	○
Common green stink bug (*Nezara antennata*)		○	○
One-banded stink bug (*Piezodorus hybneri*)			○

Factors Affecting the Insect Damage

Soybean insect damages, mentioned above, are closely related to the temperatures of the coldest and hottest periods in a year. As Fig. 2 shows, extremely high correlations



Note : Data of the region I and II, and region III were obtained from the 5 year average of 1967 - 1971, and the 3 year average in 1967, 1969 and 1971, respectively.

The region I included Kesen area in this calculation. The meteorological observatories were Kuroishi and Morioka (Kuriyagawa) in the region I, Akita, Sendai, Yamagata and Koriyama in the region II, and Taira in the region III, respectively.

Fig. 2.

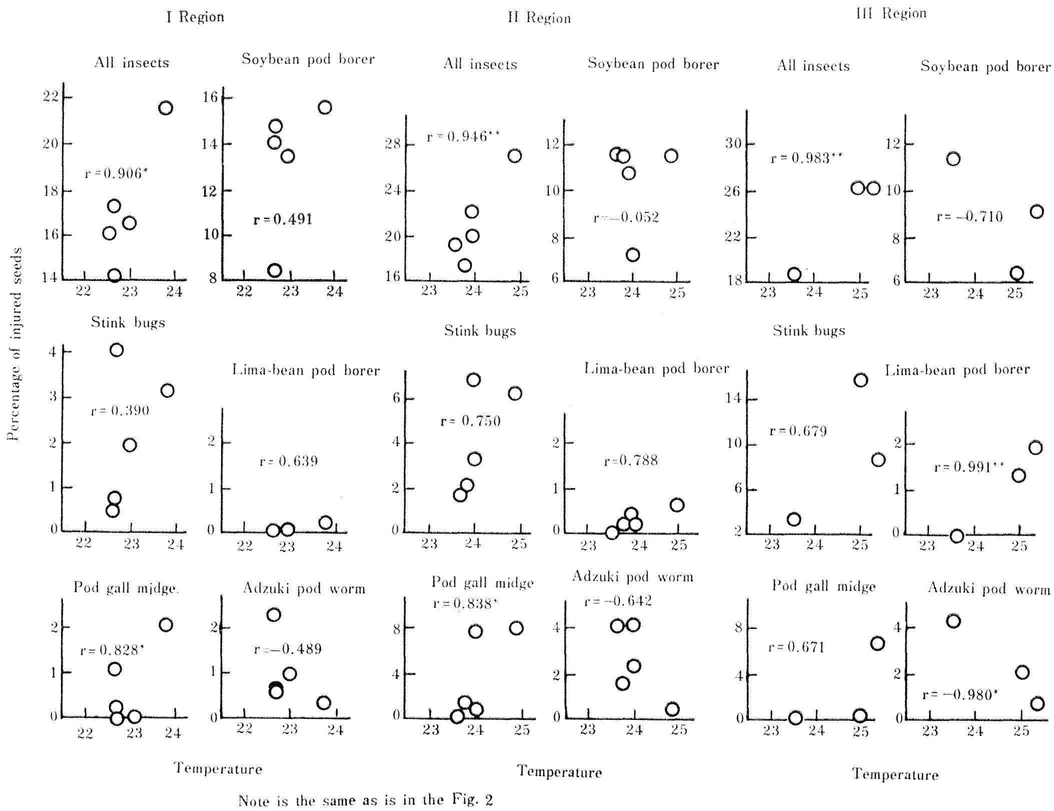


Fig. 3.

are observed between the average of injured seeds in percentage and the mean temperatures of January or those of July and August, for five or three years, in the three regions.

In Fig. 3, high correlations are also observed on some insects between the average of injured seeds in persentage and the mean temperatures of July and August, in five or three years' statistics, in each region

These results show that with some insects we might be able to estimate the injured seeds in percentage by using the linear regression equations, as shown in Table 5.

The number of the destructive species of insects for the soybean plant is as many as thirty or so, but here in the present paper, the most important species, stink bugs, pod worms and nematodes, are talked about.

Stink Bugs

Among 30 species of stink bugs attacked the soybean plant, the following three bugs, of which life cycles in Shikoku District are outlined in Fig. 4, are the most injurious ones.

(1) Common green stink bug (*Nezara antennata* Scott)

Distribution:

Japan (whole land), Korea, Taiwan, China, Tibet, etc.

Host plant:

About 80 species or so of twenty five families such as *Leguminosae, Gramineae, Solanaceae, Pedaliaceae, Compositae* and others (Kobayashi, 1959).

Table 5. Linear regression equations between the mean temperatures (X) of July-August and the percentage, of injured seeds (Y) in a harvest season

		Correlation coefficient	Sampling year
Region I (Colder area below an isothermal line of —1.5°C in monthly mean temperature of January)			
Mean temperature of July (X)			
All insects	Y =16.984+4.328 (X-22.700)	0.9311**	1967—1971
Pod gall midge	Y = 0.604+1.156 (X-22.700)	0.763	〃
Mean temperature of July and August (X)			
All insects	Y =16.984+5.233 (X-22.966)	0.906*	〃
Pod gall midge	Y = 0.604+1.559 (X-22.966)	0.828*	〃
Region II (Area of monthly mean temperature of —1.5°C〜+2.0°C in January)			
Mean temperature of July (X)			
All insects	Y =20.890+5.339 (X-23.610)	0.877*	1967—1971
Lima-bean pod borer	Y = 0.178+0.094 (X-23.610)	0.928**	〃
Pod gall midge	Y = 2.940+4.897 (X-23.610)	0.877*	〃
Mean temperature of July and August (X)			
All insects	Y =20.890+7.491 (X-24.114)	0.946**	〃
Lima-bean pod borer	Y = 0.178+0.104 (X-24.114)	0.788	〃
Pod gall midge	Y = 2.940+6.090 (X-24.114)	0.838*	〃
Region III (Warmer area above an isothermal line of +2.0°C in monthly mean temperature of January)			
Mean temperature of July (X)			
All insects	Y =23.497+3.427 (X-24.000)	0.999**	1967 '69 '71
Lima-bean pod borer	Y = 1.037+0.699 (X-24.000)	0.959	〃
Adzuki pod worm	Y = 2.207+1.314 (X-24.000)	—0.938	〃
Mean temperature of July and August (X)			
All insects	Y =23.497+4.733 (X-24.650)	0.983**	〃
Lima-bean pod borer	Y = 1.037+1.014 (X-24.650)	0.991**	〃
Adzuki pod worm	Y = 2.207+1.927 (X-24.650)	—0.980*	〃

Biology:

The adult common green stink bug hibernates in the thickets of evergreen trees and so forth. The number of eggs deposited by one female is about 110 consisting of 2.6 egg masses in average, the egg period is four to six days, and the nymphal stage is about 20 to 27 days. The adult is used to be attracted by the blue fluorescent light.

(2) One-banded stink bug (*Piezodorus hybnere* Gmelin)

Distribution:

Japan (Honshu, Shikoku and Kyushu), Taiwan, China, India, Tropical Orient, Australia, North Africa, etc.

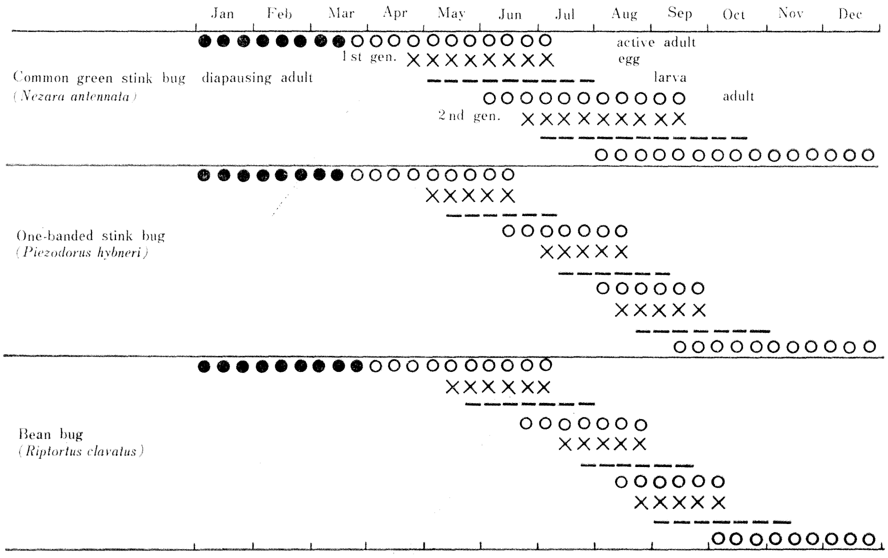


Fig. 4.

Host plant:

Leguminosae and *Veronica* spp.

Biology:

The adult bug hibernates in the sunny bushes. The number of eggs deposited by one female is about 170, consisting of seven egg masses or so in average. They have an egg period of three to five days and a nymphal period of about 16 to 21 days in Shikoku. The adult bugs are attracted by the blue fluorescent light.

(3) Bean bug (*Riptortus clavatus* Thunberg)

Distribution:

Japan (whole land), Taiwan, Korea etc.

Host plant:

About 30 species of the following five families; *Leguminosae, Gramineae, Convolvulaceae, Rosaceae* and *Pedaliaceae.*

Biology:

The adult bug hibernates in the sunny bushes. The number of eggs depositted by one female is 55–90 in average. The egg period is about six days and the nymphal period is about 16 to 23 days, respectively, in Shikoku. The adult bugs are attracted by the blue fluorescent light.

(4) Stink bug damage to soybean plant

Infestation period:

The stink bugs, mentioned above, are found of sucking juice from developing seeds, especially the middle seed-thickening stage of soybean plants as shown in Fig. 5.

Characteristics of the damage:

When the pods were injured by stink bugs, in the pod-elongation stage or in the early seed-thickening stage, pods become a flat shape with steriled seeds, usually wither up and fall, as is shown in Table 6. The damage is most destructive.

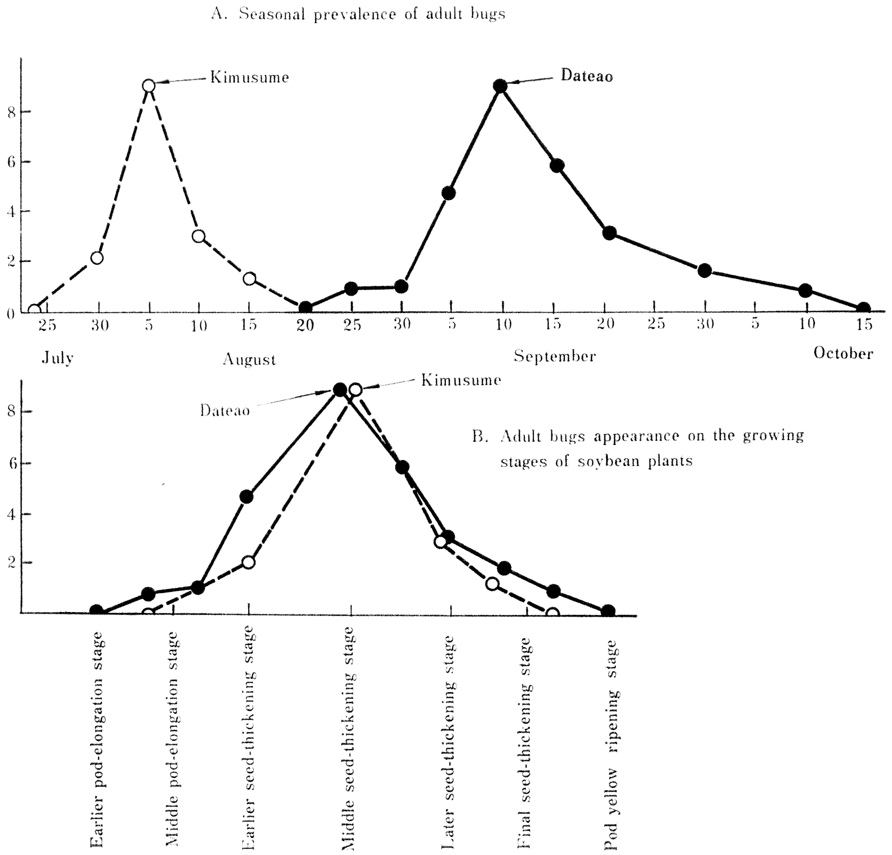


Fig. 5.

Table 6. Relationship between the numbers of bugs and the numbers of shedded pods at the early growing stage of the soybean pod

Species	(1) No. of the pests	(2) Injured days	(3) No. of total pods	(4) No. of shedded pods	(5) No. of shedded pods per day and head (4)/(1)×(2)
One-banded stink bug (*Piezodorus hybneri*)	0	0	108.0	7.5	—
	1	13	93.5	34.5	2.65
	3	13	114.5	36.0	0.92
	5	13	127.0	52.0	0.80
Bean bug (*Riptortus clavatus*)	0	0	58.0	6.5	—
	1	13	88.0	15.5	1.19
	3	13	82.0	33.5	0.86
	5	13	134.5	41.0	0.63

Note: Variety: Hachigatsu Daizu; Sowing: middle of July;
Injured period: Sept. 6∼Sept. 19, end of blooming, early pod elongation stage to early and middle seed-thickening stages. (Ishikura et al. 1955)

In the middle seed-thickening stage, the damage of the seed is pretty serious, but in the late seed-thickening stage, it is rather slight. The seeds attacked by stink bugs not only loss their weight by sucking, but also suffer from a qualitative change due to the injected saliva. The change can be well recognized by peeling the seed coat off or cutting the seed, and the damaged seed can be easily discriminated from sterile seeds caused physiologically. The seriously injured seeds lose germinating ability, and the slightly injured seeds, though they germinate, sometimes do not grow normally showing a distinctive feeding mark on the cotyledon.

Amount of the damages:

The extent of damage of the seeds caused by stink bugs depends upon the developing stages of pods and seeds, and it is greater in the earlier stage.

Judging with the two year data obtaned by the ten day observations from late July to late August, the daily average number of the seeds injured by one individual common green stink bug is 4.8 at the pod-elongation stage, 3.6 at the early seed-thickening stage, 3.0 at the middle seed-thickening stage and 1.6 at the last seed-thickening stage, respectively, as it is shown in Table 7.

The damages of soybean seeds are also variable according to the difference of insect species; One banded stink bug, Common green stink bug and Bean bug. Four insects of each species were released upon the soybean plants of an appropriate develoing stage to be injured, for ten days. Consequently the greatest damage was given by One banded stink bug, and the by Bean bug. (Table 8).

The appearacne of the injury of the soybean plant also depends on the stink bug species. The bean bug rather prefers to attack the young pods. One-banded stink bug tends to attack the developing young pods in the middle seed-thickening stage giving a heavy damage, and the common green stink bug usually attacks the pods in the same stage giving comparatively light damage.

(5) Control measures

Cultural control:

The late blooming varieties generally receive less damage as it is shown in Table 9. Even in the same variety, the damage decreases when the sowing period is delayed as Fig. 6 shows. Therefore, a careful consideration should be given not only to the choice of the variety but also to the sowing period so as to avoid the coincidence of the peak of bug occurrence and the podding period of soybean plant.

Fig. 7 shows that the relationship between the stink bug population in soybean field and the number of injured seeds at each pod-developing stage. That is, the damage appears from the early pod-elongation stage to the later seed-thickening stage, but it is mostly concentrated into the period of the last pod-elongation stage and the early seed-thickening stage.

Therefore it is recommendable to spray 0.05 percent solution of insecticides such as Baycid, Cyanox, Sumithion at about 1,000 liter per hectare, or these powders at about 40 kg per hectare twice or three times at intervals of about ten days from the beginning of the podding period. Even though they are affective, the insecticides which have acute or strong residual toxicity are not mentioned here from the viewpoint of the safety use and the avoidance of environmental contamination (the same consideration applies correspondingly to the followings.)

Pod worms

Major insect pests which feed on the pods and injure the seeds are the three spe-

Table 7. The relation between the seed developing stage of the soybean plant and the damage by the stink bugs

Injured period	Year	No. of pods	No. of shedded pods	Number of injured seeds				No. of injured seed per day and head	Average
				No. of seeds in shedded pods	No. of seeds in remained pods		Total		
					early stage	late stage			
Pod elongation stage (Jul. 25–Aug. 10)	1951	196	31	30	82	0	112	5. 60	4. 80
	1952	107	11	26	54	0	80	4. 00	
Early seed-thickening stage (Aug. 5–Aug. 14)	1951	210	2	5	14	57	76	3. 80	3. 55
	1952	123	1	2	10	54	66	3. 30	
Middle seed-thickening stage (Aug. 11–Aug. 20)	1951	156	0	0	0	66	66	3. 30	2. 98
	1952	105	0	0	0	53	53	2. 65	
Last seed-thickening stage (Aug. 11–Aug. 31)	1951	143	0	0	0	36	36	1. 80	1. 63
	1952	100	0	0	0	29	29	1. 45	

Note: Variety: Norin 1; Sowing: May 20; Method: After removing the pods of the other growing stages, the whole test plant of a certain growing stage was covered with wire-netcage and a couple of the common green stink bugs (*Nazara antennata*) was released, for 10 days. Replication; 5. (Ishikura et al., 1955)

Table 8. Comparison of the number of seeds injured by three species of stink bugs

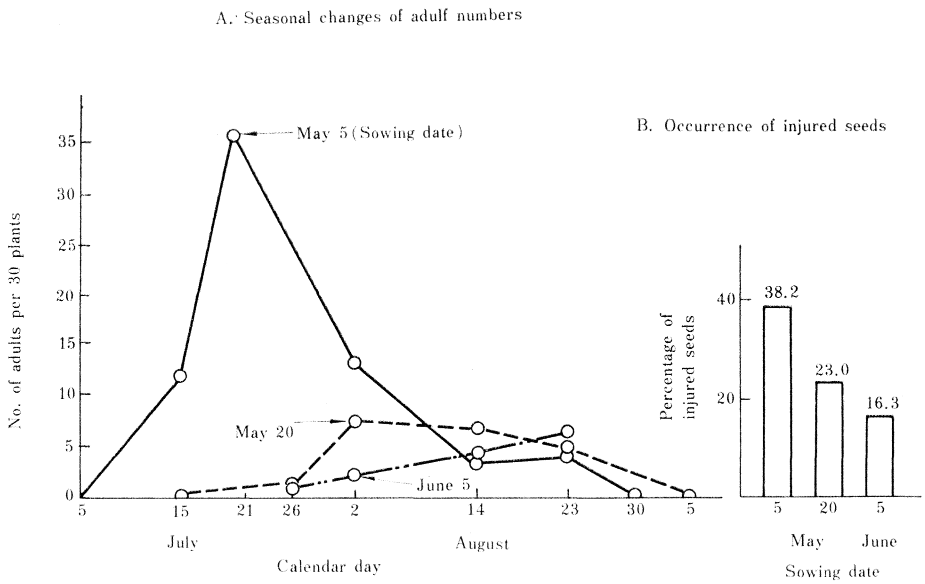
Species	Earlyseed-thickening stage	Middle and last seed-thickening stage		Total	No. of injured seeds per day and head
	No. of heavily injured seeds	No. of heavily injured seeds	No. of lightly injured seeds		
Common green stink bug (*Nezara antennata*)	10. 8	31. 5	31. 0	73. 3	1. 83
One-banded stink bug (*Piezodorus hybneri*)	17. 5	60. 0	8. 8	86. 3	2. 16
Bean bug (*Riptortus clavatus*)	29. 0	31. 3	2. 0	62. 3	1. 56

Note: (Ishikura et al., 1955)

Table 9. Difference of the damage of the soybean varieties by the stink bags

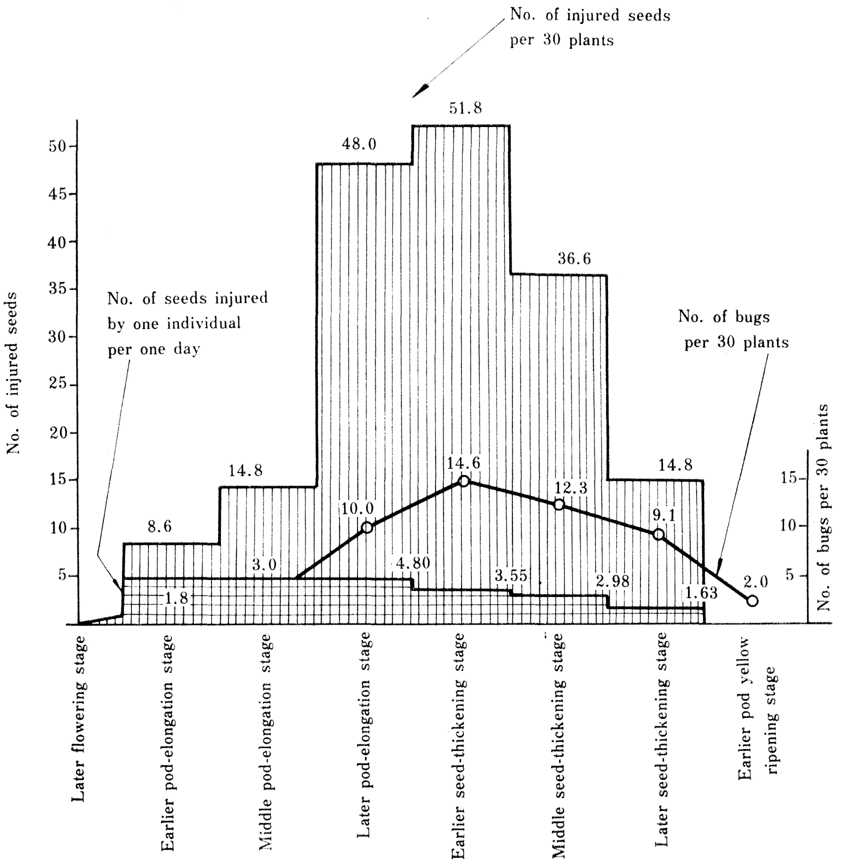
Varieyt type	Variety	Sterile	Lightly damaged	Total	Average
IIa	Onihadaka 7	51.6%	10.1%	61.7%	
	Onihadaka 1	37.1	13.1	50.2	
	Shirome	46.7	8.9	55.6	
	Norin 1	49.1	14.8	63.9	
	Kimusume 77	33.1	7.1	40.2	
	Kimusume	35.3	7.1	42.4	
	Aoji	44.1	7.7	51.8	
	Kisaya	25.3	13.8	39.1	50.6
IIbc	Ani	31.1	7.4	38.5	
	Shirome 9	28.5	3.0	31.5	
	Kurosaya	27.7	2.5	30.2	
	Norin 2	31.8	14.7	46.5	
	Mejiro 1	14.3	1.2	15.5	
	Tokichi	21.7	4.3	26.0	
	Daruma 2	41.9	3.3	45.2	33.3
IIIc	Asahi	12.9	1.7	14.6	
	Akasaya	11.2	1.4	12.6	
	Ginjiro	9.4	1.4	10.8	
	Bukomame	13.7	0.8	14.5	
	Dateao	16.1	2.8	18.9	
	Hachigatsudaizu	8.1	5.8	13.9	14.2
IVc, Vc	Tanuki 1	3.1	1.6	4.7	
	Kumazairai	3.1	1.2	4.3	
	Awashimazairai	5.0	0.3	5.3	
	Mejiro	2.9	1.0	3.9	
	Tamanishiki	3.2	0.0	3.2	
	Gindaizu	4.0	0.7	4.7	
	Nakate 11	6.8	0.5	7.3	
	Tanbaguro	4.3	1.0	5.3	
	Iyodaizu	4.1	0.0	4.1	
	Kochiakidaizu	6.5	0.8	7.3	
	Shiroohachirin	3.1	0.8	3.9	
	Bankurodaizu	0.5	0.3	0.8	
	Suzunari	5.0	0.5	5.5	
	Mammoth brown	5.0	1.2	6.2	
	Manshuzairai	2.4	0.7	3.1	
	Aso 1	5.1	0.6	5.7	
	Shirodaizu 1	4.3	0.6	4.9	
	Bansei 30	7.7	1.4	9.1	
	Aokimame	5.0	0.5	5.5	5.0

Note: (Ishikura et al., 1955)



A. Seasonal changes of adulf numbers
May 5 (Sowing date)
May 20
June 5
No. of adults per 30 plants
35
30
25
20
15
10
5
0
5
15
21
26
2
14
23
30
5
July
August
Calendar day
B. Occurrence of injured seeds
Percentage of injured seeds
40
20
38.2
23.0
16.3
5
20
5
May
June
Sowing date

Fig. 6.



No. of injured seeds per 30 plants
No. of seeds injured by one individual per one day
No. of bugs per 30 plants
No. of injured seeds
No. of bugs per 30 plants
8.6
14.8
48.0
51.8
36.6
14.8
1.8
3.0
4.80
3.55
2.98
1.63
10.0
14.6
12.3
9.1
2.0
Later flowering stage
Earlier pod-elongation stage
Middle pod-elongation stage
Later pod-elongation stage
Earlier seed-thickening stage
Middle seed-thickening stage
Later seed-thickening stage
Earlier pod yellow ripening stage

Fig. 7.

cies of *Lepidoptera* and the soybean pod gall midge, but only the formers shall be described here.

(1) Soybean pod borer (*Leguminivora glycinivorella* Matsumura)

Distribution:

Japan (whole land), Korea, Northern part of China, Siberia, etc.

Host plant:

Soybean, *G. ussuriensis,* and Kuzu-vine (arrowroot).

Ecology:

The soybean pod borer in cold areas has one generation a year, and emerges in the soybean podding period (in August), while the borer in warm areas has two generations a year, and emerges in early to middle August and in late September, respectively. The egg period is seven to nine days. The hatched larvae bore into the pods and eat away the seeds, and finally comeout of the pods hibernat in the larval stage in the ground. The extent of seed damage varies with varieties of soybeans. This is because the borers lay fewer eggs on the varieties with hairless pods than those with hairy pods. And because the mortality of the young larvae bored into the pods increases on the plants of long leaf-varieties. And it is also because, on the extra early varieties and on the late varieties the appearance of the adult moths does not coincide with the podding periods of the soybean plant, as it is shown in Fig. 8.

Control measures:

In above mentioned reasons, it is important to choose the borer resistant varieties and the suitable sowing period, as well. It is also desirable to adopt intercropping systems with tall crops like corn, and to adopt reasonable crop rotation on a large scale. For chemical control, it is of great use to spray the same insecticides as used for controlling the stink bugs twice or so in the period of peak oviposition (about four weeks after full blooming in the case of the late maturing variety).

(2) Lima-bean pod borer (*Etiella zinckenella* Treitschke)

Distribution:

Japan (whole land), Korea, China, Siberia, Taiwan, India, Africa, Europe, North and South America, etc.

Host plant:

Soybean, pea, cowpea, kidney bean, lima-bean, *Glycine Soja, Vicia* spp., *Lathyrus*

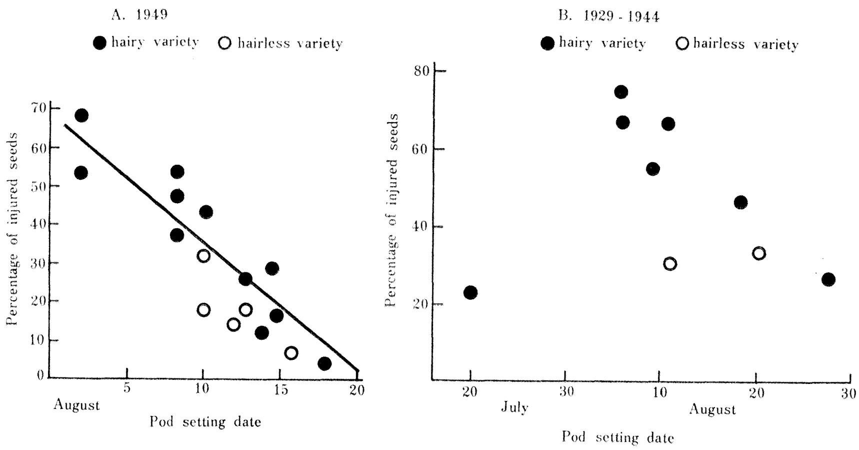


Fig. 8.

spp., and other legume plants.

Ecology:

The lima-bean pod borer occurs three times a year in Kanto District, and four times in Tokai and Shikoku Districts, hibernating in the larval stage in the ground or in various kinds of deposits. An adult female lays a few eggs on a pod, about 60 to 200 in total. The egg period is five to seven days in summer, and the hatched larvae bore into pods to feed on seeds. The larvae come to maturity during about 20 days and come out of the pods to pupate in the ground. The pupal period is ten days or so.

Control measures:

As the early podding varieties are apt to suffer heavy injury (Fig. 9), the late varieties and late sowing are recommended for decreasing the damage of the borer. It is also recommended to spray powder or emulsifiable insecticides of Baycid, Cyanox, EPN, etc. twice or so in the young pod period at the same rate as in the case of the stink bugs.

(3) Adzuki pod worm (*Matsumuraeses phaseoli* Matsumura)

Distribution:

Japan (whole land), Taiwan, India, etc.

Host plant:

Leguminosae like soybean, adzuki bean, pea, broad bean, kidney bean, etc.

Ecology:

This species has three or four generations a year in Shikoku district, and the young larvae sometimes sew young leaves of broad bean plants together to hibernate among them. On summer soybean and kidney bean plants, the worms first sew young leaves together to eat them, injure the young leaf, and then bore into the stems. Accordingly, the injured plant stops to grow, and suffers severe damage. On autumn soybean, they sew leaves, pods, and stems together, and injure the surface of pods, stems and seeds.

Control measures:

As the varieties cultured in early season are subject to receive severe damage,

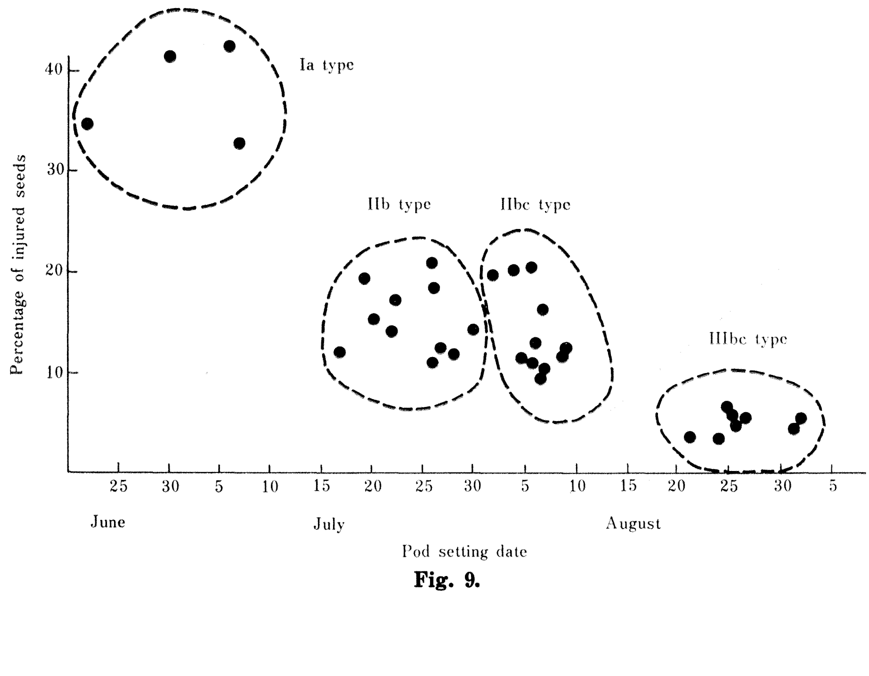


Fig. 9.

it is desired to culture the varieties which can be sown late in season. It is also recommended to spray the same insecticides as in the case of the lima-bean pod borers at the stage of injury.

Nematodes

Heterodera glycines Ichinohe, *Meloidogyne hapla* Chitwood, and *Pratylenchus penetrans* Cobb attack the roots. Here the most troublesome *Heterodera glycines* shall be described.

(1) Soybean cyst nematode (*Heterodera glycines* Ichinohe)

Distribution:

Japan (whole land), Korea, Northern part of China, North America, etc.

Host plant:

Soybean, *Glycine ussuriensis,* kidney bean, adzuki bean, etc.

Ecology:

Due to the rising temperature of the soil, the larvae of the second generation are hatched out from the cyst egg hibernated and get into the tissue of the root. The larvae molt three times to be adults. The male adults come out of the root tissue, while the female adults remain in the cortex of the roots and produce eggs in it, and accordingly disclose the most part of their grown body out of the roots. The thicken body skin become a cyst containing about 200 to 300 eggs. The nematodes have three generations or so a year. This nematode has two races, and the one distributed in Nagano Prefecture has strong parasitic ability than the other in any other area.

Damage:

The parasitized soybean plants discolor the leaves into light yellow and decrease growth and yield. The susceptible variety, and the soybean plants grown in soils suitable for multiplication of nematodes (light and somewhat dry soils characterized by well air permitability, such as volcanic ash ones), or in soil with few organic matters and poor nitrogen fertilizer tend to receive severe damage of this nematode.

Control measures:

Against the nematode, except one race in Nagano district, it is recommended to culture resistant varieties such as Horai, Toyosuzu, Raiko, Raiden, Nema-shirazu, etc. As a small number of cysts can survive as long as three to five years even in uncultivated soil, it is recommendable to improve the fertilizer application and to rotate crops longer than three to five year periods for the cultivation of susceptible varieties.

Discussion

P. P. Kurien, India: What is the estimated annual loss in grain legumes (including soybeans) as a result of insect infestation at the maturing stage (i.e. field infestation).

Answer: I don't know the annual loss in grain legumes. We have no statistics on the loss in Japan. But, the damaged seeds in percentage is about 20% in northern areas and about 30–50% in the southern areas in Japan. Please look at the Table 3 of my paper.

R. Bernard, USA: What percentage of soybean fields in Tohoku and elsewhere in Japan are treated with insecticides?

Answer: I guess 30% or so of soybean fields are treated with insecticides in Japan.

Arwooth N. L., Thailand: It has been observed that after spraying insecticide for legumes in certain areas for years, several insect pests occured. What is your opinion? Is it due to the resistance built in the insect itself or spraying insecticide depress the naturally occured enemies (parasite or predator) of the insects.

Answer: In geenrally, it has been considered as you have pointed out. But, in this case it is difficult to conclude simply.

From the experimental data, it is generally known, that repeated application of same insecticide in same area often result in building insect resistant to insecticide and increasing of minor insect pests which are tolerant to that chemicals.

I have heard that in your country, Malathion is used in general for pest control in the soybean field for years. Application of other effective chemicals should be considered. I may be able to recommend some effective insecticides such as Sumithion, Le Bycid and Cyanox.

As you have pointed out, usually we cannot minimize the effect of chemicals to the natural enemies. The chemicals which are less harmful to natural enemies should be adopted to protect them.

References

1) Chiku, T. and T. Miyashita: On the insect injuries causing the poor harvest of soybean in the Ina area, Nagano Prefecture. Bul. Nagano agr. Exp. Sta. 23: 1–61 (1957).
2) Ichihara, I.: Studies on the life cycle and damages of insect pests of soybean crop, with special reference to the insect attacking pods, in Chiba Prefecture. Bul. Chiba-ken Agr. Exp. Sta. 5: 80–93 (1964).
3) Ishikura, H., N. Nagaoka, T. Kobayashi and M. Fujita: Studies on insect pests of soybean crop. I. Pest insect fauna of soybean in Shikoku district. Bul. Chugoku-Shikoku Agr. Exp. Sta. A-1: 134–150 (1952).
4) Ishikura, H., N. Nagaoka, I Honda and M. Fujita: Studies on insect pests of soybean crop. II. Ecological studies on Lima bean pod borer, *Etiella zinckenella* Treitschke, in Shikoku district with experiment on its control. Bul. Shikoku Agr. Exp. Sta. 1: 186–216 (1953).
5) Ishikura, H., N. Nagaoka, T. Kobayashi and I. Tamura: Studies on insect pests of soybean crop. III. On the damages by stink bugs, their ecology and control measures against them. Bul. Shikoku Agr. Exp. Sta. 2: 147–195 (1955).
6) Kobayashi, T.: The developmental stages of some species of the Japanese Pentatomoidea (Hemiptera). VII. Developmental stages of *Nezara* and its allied genera (Pentatomidae s. str.). Japanese Jour. Appl. Ent. Zool. 3: 221–231 (1959).
7) Kuwayama, S. (Compiled): Survey on the fauna of soybean insect-pests in Japan. B 5. Tokyo. Yokendo. 129 pp (1953).
8) Matsumoto, S.: Studies on varietal differences of soybean with respect to the injury caused by the soybean pod borer, *Leguminivora glycinivorella* (Matsumura). Hokkaido Nat. Agr. Exp. Sta. Rep. 58: 1–58 (1962)
9) Nishijima, Y. and T. Kurosawa: Some factors affecting varietal differences of soybean to attack by the soybean pod borer, *Grapholitha glycinivorella* Matsumura (Lepidopt., Eucosmidae). Res. Bul. Hokkaido Nat. Agr. Exp. Sta. 65: 42–51 (1953).