1

AERIAL APPLICATION OF *Bacillus thuringiensis* AGAINST THE VELVETBEAN CATERPILLAR, *Anticarsia gemmatalis* Huebner, IN SOYBEAN FIELDS

M.E.M. Habib[1]
M.E.C. Amaral[2]

INTRODUCTION

Anticarsia gemmatalis Huebner is becoming a major threat to soybean production in the New World. The larva of this noctuid is commonly called the velvetbean caterpillar in the USA, "gusano terciopelo" in Mexico and "lagarta da soja" in Brazil. As the cultivated area and the economic value of soybeans have increased significantly in the New World tropical and subtropical regions, during the last 15 years, this foliage feeder has become recognized as a major soybean pest. In Brazil, it is frequent that soybean defoliation caused by *A. gemmatalis* reaches the injury economic level. Therefore, in this country as well as in other american ones, it is considered a key pest of this crop.

Chemical control is still considered the principal way to combat this insect pest (SARMENTO, 1958; FAGUNDES & BAUCKE, 1962; TURNIPSEED, 1967 and 1972; TOOD & CANERDAY, 1972; STRAYER & GREENE, 1974; PUIATTI & SALGADO, 1981). However, many authors have discussed the harmful effects of the chemical insecticides upon natural enemies and consequently the necessity to use selective components (BARTLETT, 1963; CROFT & BROWN, 1975; CARVALHO, 1978; CORSO & GAZZONI, 1980; MOROSINI & BERTOLDO, 1981).

In spite of the high susceptibility of the velvetbean caterpillar to *Bacillus thuringiensis*, little at-

[1] Universidade Estadual de Campinas, SP
[2] Universidade Federal de Mato Grosso do Sul, MS

tention was given to investigate the applicability of commercial products in soybean fields (TURNPSEED, 1972; SILVA, 1975; SILVA & HEINRICHS, 1975; AMARAL, 1982). The purpose of the present work, therefore, was to determine effective concentrations and flow rates of *B. thuringiensis* in addition to other aerial application criteria to control *A. gemmatalis* larvae in soybean fields.

MATERIAL AND METHODS

Two formulations, wettable powder (WP) and emulsified suspension (ES), of *B. thuringiensis* var. *kurstaki* (H:3a-3b) were tested in the field. Samples of these two formulations (DIPEL) were offered by Abbott Laboratories, Illinois, USA.

The experimental trials were undertaken in a soybean field in Dourados, State of Mato Grosso do Sul, Brazil. The area was divided in 40 units, 0.5 ha each. Two concentrations and two flow rates were evaluated for each of the two formulations mentioned above. The experimental design comprised completely randomized blocks (2 x 2 x 2), including 8 treatments with 4 replicates for each. The first one did not receive any treatment, while the second received conventional chemical insecticides. Concentrations and flow rates tested of both formulations (WP and ES) are shown in table I.

The aircraft used was an IPANEMA (Embraer, Brazil), with a flight speed of 115 miles/hour and altitude of 1.5 - 2.0 meters. The aircraft was equiped with micronair AU-3000 despersal rotatory units, and utilized according to the specifications shown in table II.

Basic aerial application criteria were based on MOTT et alii (1961), SMIRNOFF et alii (1962; 1973) and PREBBLE (1974). Normal assessment procedure of the deposit on Kromekote cards was undertaken to evaluate spray coverage in the different treatments. The drop density values for each card was determined by counting the number of spots per cm^2 and measuring the diameter of each. A specific tracer dye (Rhodamine) was added to the preparations (0.15 g/1) to facilitate the measuring procedure. To evaluate any possible effect of the dye on the pathogen, viability tests of *B. thuringiensis* (plate counting) and pathogenicity testes (utilizing *A. gemmatalis* larvae) were undertaken.

The HENDERSON & TILTON (1955) formula was utilized to correct mortality data. "F" test was applied for statistical comparisóns.

Table I - Tested flow rates and dosages of two formulations, WP and ES, of *B. thuringiensis*.

Treatment	Flow rate	Dosage	Formulation
T1	10 liters/ha	$4.8x10^9$ IU/ha	WP
T2	20 liters/ha	$4.8x10^9$ IU/ha	WP
T3	10 liters/ha	$8.0x10^9$ IU/ha	WP
T4	20 liters/ha	$8.0x10^9$ IU/ha	WP
T5	5 liters/ha	$4.8x10^9$ IU/ha	ES
T6	20 liters/ha	$4.8x10^9$ IU/ha	ES
T7	5 liters/ha	$8.0x10^9$ IU/ha	ES
T8	20 liters/ha	$8.0x10^9$ IU/ha	ES
C1	Control without any pesticide application.		
C2	An area treated conventionally with chemical insecticides		

Table II - Specifications of the micronair AU-3000 dispersing units.

Emission rate	VRU*	Pressure (psi)
5 liters/ha	9-7-7-9	30.5
10 liters/ha	13-11-11-13	25.0
20 liters/ha	shifted	30.0

* Variable Restriction Units.

RESULTS AND DISCUSSION

Efficiency of applications

The pathogen was applied when the infestation by *A. gemmatalis* reached an average of 25 larvae/m, using the drop-sheet shake method (TURNPSEED, 1974).

The laboratory tests indicated that the tracer dye had no significant effect on the viability of *B. thuringiensis* nor on its pathogenicity. Moreover, the dye had no effect on the food consumption of larvae when added to soybean leaves in the same concentration used in the field.

Field collected *A. gemmatalis* larvae lost their appetite, aproximately, 6 hours after field application of the pathogen. In the field, a significant mortality has begun 24 hours after treatments. Corrected mortalities in the different treatemtns, after 2, 4 and 7 days are presented in Table III. The results indicate that application of wettable powder (WP) with a flow rate of 20 liters/ha at a dose of 8.0 x 10^9 IU/ha (T4) was more efficient than the other treatments. Such a dose corresponds to 500 g/ha of the commercial product.

In small experimental plots (7.2 m2) and applied manually, SILVA (1975) and SILVA & HEINRICHS (1975) obtained satisfactory control of the same insect pest using, also, 500 g/ha of the same product (Dipel, WP).

The oil carrier of the emulsified formulation (ES) did not affect the viability or pathogenicity of *B. thuringiensis*. However, it did not permit a good uniformity of deposition under field conditions, resulting in lower mortality than that obtained by the WP formulation at the same dosage. HABIB (unpublished), during terrestrial applications, observed more efficiency of the emulsified suspension (with emission rate of 200 l/ha and 500 g/ha) than the wettable powder against the same insect. Therefore, it is possible that in terrestrial applications, more uniformity could be obtained using high volumes than in aerial applications, which are normally done with low volumes. On the other hand, the emulsified suspension could provide more protection to the pathogen against ultra-violet radiation and also more stability.

Table III - Corrected mortality in *A. gemmatalis* larvae 2, 4 and 7 days after aerial application of *B. thuringiensis*.

Treatment	Corrected mortality %		
	2 days	4 days	7 days
T1	28.2	23.1	62.6
T2	51.6	34.9	53.3
T3	43.3	41.7	59.9
T4	58.7	68.1	73.3
T5	41.4	27.3	65.0
T6	44.9	33.5	51.0
T7	49.6	42.1	67.0
T8	-	-	17.5

Our survey of the natural enemies (parasites and predators) in the treated plots, prior to and periodically after the aerial application of the pathogen, showed no effect caused on this entomofauna. *Macrocharops bimaculata* (Ashmead, 1895) (Hymenoptera, Ichneumonidae), was considered the key parasite, while *Calosoma granulatum* (Coleoptera, Carabidae) was the key predator. Moreover, the green stink bug, *Nezara viridula* , did not reach its economic injury level in these treated areas. Availability, maintainance and efficiency of the natural enemies may be the reason responsible for the suppression of *N. viridula* populations in these fields treated with the bacterium. On the other hand, in C2, which received 2 applications of Thiodan 35% (1.4 l/ha), the population density of the stink bug was much higher and in some locations reached 4 bugs/m, economically injurious. The role of natural enemies in soybean fields and their possible participation in IMP programs were discussed by some authors, such as TURNPSEED (1972) and AMARAL (1982).

Effect on soybean productivity

The last parameter used to evaluate the efficiency of *B. thuringiensis* was the soybean productivity. With this indicator, T4 also showed more satisfactory than the other treatments. Such a treatment was 30% higher in production per unit than the conventional one (details in table IV).

Table IV - Weight of grains obtained from 100 plants and weight of 1000 grains of each treatment.

Treatment	$\bar{x}$ Weight (g)			
	Grains of 100 plants *		1000 grains	**
T1	566.3	a	117.4	ef
T2	679.3	b	121.0	g
T3	732.1	c	117.7	ef
T4	877.3	d	123.4	h
T5	584.4	a	118.7	if
T6	754.3	c	119.7	gi
T7	545.4	a	113.9	j
T8	700.8	c	116.8	ef
C1	562.1	a	117.4	ef
C2	607.7	a	118.2	if

* F = 40.859; LSD = 65.2
** F = 63.462; LSD = 1.889
Same letters mean no significant differences.

It can be concluded that the aerial application of 8.0 x 10^9 IU of *B. thuringiensis* var. *kurstaki*/ha with a flow rate of 20 liters (drop density of 50 drops/cm2 and an average diameter of 215 µm) was the most adequate treatment. *A. gemmatalis* larvae showed to be highly susceptible to commercially produced *B. thuringiensis*, the pathogenicity was not affected by type of fomulation, and it is possible to apply a lethal deposit from aircraft. Also, the efficiency of aerial applications could be improved if it were possible to extend the viability of spores by protecting them against ultra-violet radiation and to reduce the clumping tendency of the suspensions.

SUMMARY

Aerial applications of 8 x 10^9 IU/ha of *Bacillus thuringiencis* var. *kurstaki* as wettable powder formulation were highly efficient against the velvetbean caterpillar, *Anticarsia gemmatalis*. The emulsified formulation did not permit an adequate uniformity of deposition, resulting in lower mortality than that obtained by the wettable powder.

The effectiveness of the pathogen as well as its safety to the natural enemies in addition to the high productivity of soybean, favour aerial applications of commercially produced *B. thuringiensis* in soybean monocultures.

RESUMO

A formulação pó molhável à base de *Bacillus thuringiensis* var. *kurstaki* demonstrou alta eficiência no controle da lagarta da soja, *Anticarsia gemmatalis*, em aplicações aéreas na dosagem 8 x 10^9 UI/ha com vazão de 20 l/ha.

A suspensão emulsionável não permitiu uma cobertura uniforme, nas vazões usadas, resultando em menor eficiência no controle da lagarta. O controle satisfatório obtido, a segurança para os inimigos naturais e a alta produtividade da soja favorecem recomendações de aplicações aéreas de produtos comerciais à base de *B. thuringiensis* (H:3a-3b), na formulação pó molhável, em monoculturas de soja.

LITERATURE CITED

AMARAL, M.E.C., 1982. **Controle biológico natural e aplicado de *Anticarsia gemmatalis* Huebner (Lepidoptera, Noctuidae) em campos de soja.** M.Sc. Thesis, UNICAMP, 198pp.

BARTLETT, B.R., 1963. The contact toxicity of some pesticide residues to hymenopterous parasites and coccinellid predators. **J. Econ. Entomol**. 56: 694-698.

CARVALHO, J.C.M., 1978. Entomologia e meio ambiente. **Memórias do II Cong. Latinoamer. Entomol.**, V. Cong. **Entomol.**, pp. 31-52.

CORSO, I.C. & D.L. GAZZONI, 1980. Efeito de inseticidas químicos sobre predadores do gênero *Geocoris* (Hem., Lygaeidae). **VI Cong. Bras. Entomol.**, Campinas-SP.

CROFT, B.A. & A.W.A. BROWN, 1975. Responses of arthropod natural enemies to insecticides. **Ann. Rev. Entomol**. 20: 285-335.

FAGUNDES, A.C. & O. BAUCKE, 1962. Ensaio de campo com polvilhação visando o controle à "lagarta da soja" *Anticarsia gemmatalis*. **Rev. Fac. Agron. & Veter.** Porto Alegre 5: 95-99.

HENDERSON, C.F. & E.W. TILTON, 1955. Tests with acaricides against the brown wheat mite. **J. Econ. Entomol**. 48: 157-161.

MOROSINI, S. & N.G. BERTOLDO, 1981. Efeito de alguns inseticidas no controle da lagarta da soja *Anticarsia gemmatalis* e seus inimigos naturais. **VII Cong. Bras. Entomol.**, Fortaleza, CE.

MOTT, D.G., T.A. ANGUS, A.M. HEIMPEL & R.A. FISHER, 1961. Aerial spraying of Thuricide against the spruce budworm in New Brunswick. **Can. Dept. For. Entomol. and Pathol. Br. Prog. Rept.**, 17, 2.

PREBBLE, M.L., 1974. Aerial control of forest insects in Canada. **Dept. Environ. Otawa, Canada**, 330pp.

PUIATTI, M. & L.O. SALGADO, 1981. Ensaio com inseticidas visando o controle das lagartas *Anticarsia gemmatalis* e *Pseudoplusia includens* na cultura da soja. **VII Cong. Bras. Entomol.**, Fortaleza, CE.

SARMENTO, A.A., 1958. Lagartas prejudiciais às nossas plantas cultivadas. **Bol. Agric. BH**, 7: 13-26.

SILVA, R.F.P., 1975. **Avaliação de produtos químicos e** *Bacillus thuringiensis* **no controle de** *Anticarsia gemmatalis* **em soja**, M.Sc. Thesis, UFRS, Fac. Agron., 95pp.

SILVA, R.F.R. & E.A. HEINRICHS, 1975. Influência no desfolhamento e rendimento da soja pelo ataque de *Anticarsia gemmatalis* e seu controle com *Bacillus thuringiensis* e clordimeform. **Anais da SEB** 4: 53-60.

SMIRNOFF, W.A., J.J. FETTES & W. HALIBURTON, 1962. A virus disease of Swaine's jach-pine sawfly *Neodiprion swainei* Midd. sprayed from an aircraft. **Can. Ent.** 94: 477-486.

SMIRNOFF, W.A., J.J. FETTES & R. DE-SAULNIERS, 1973. Aerial spraying of a *Bacillus thuringiensis* - chitinase formulation for control of the spruce budworm (Lepidoptera, Tortricidae). **Can. Ent.** 105: 1535-1544.

STRAYER, J. & G. GREENE, 1974. Soybean insect management. **Fla. Coop. Ext. Serv. IFAS UNIV. Florida Circ.** 395.

TODD, J.W. & T.D. CANERDAY, 1972. Control of soybean-insect pests with certain systemic insecticides. **J. Econ. Entomol.** 65: 501-504.

TURNIPSEED, S.G., 1967. Systemic insecticides for control of soybean insects in South Carolina. **J. Econ. Entomol.** 60: 1054-1056.

TURNIPSEED, S.G., 1972. Management of insect pests of soybeans. **Proc. Tall. Timbers. Conf. Ecol. Enim. Contr. Habitat Manage** 4: 187-203.

TURNIPSEED, S.G., 1974. Sampling soybean insects by various D-Vac, sweep, and ground cloth method. **Fla Entomol.** 57: 217-223.