FIELD TESTS OF TWO COMMERCIAL FORMULATIONS OF *BACILLUS THURINGIENSIS* SEROTYPE H-14 AGAINST *AEDES* MOSQUITO LARVAE IN MONTANA PASTURELAND[1]

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ABSTRACT. Two commercially formulated and registered *Bacillus thuringiensis* serotype H-14 (=*israelensis*) products, Vectobac® and Teknar® were tested against *Aedes* species mosquito larvae in flooded pastureland in Montana. Good control was achieved by both products at label dosages over the 16 and 40 hectare plots.

INTRODUCTION

The mosquito larval pathogen *Bacillus thuringiensis* serotype H-14 (de Barjac 1978) has developed rapidly from its initial discovery by Goldberg and Margalit (1977) to commercial registration by various industrial formulators in 1981.

During this 4-year interim a variety of research from basic to applied has been done on *Bti* and reported upon in the literature. A partial bibliography of this is available in World Health Organization VBC Mimeograph Document 79.750 (Anonymous 1979).

Medium to large scale field testing of this organism has not generally been reported and most of the small plot field testing that has been carried out has involved either riceland, tropical or neotropical mosquito species (Ali et al. 1981, Mulla, et al. 1980, Ramoska et al. 1981).

This report is on the series of field tests of commercially formulated *B. thuringiensis* H-14 *(Bti)* carried out in the high plains of Montana during the summer of 1981 utilizing treatment plots of from 16 to 40 hectares.

METHODS AND MATERIALS

TREATMENT SITE. Saco is a rural community in the northeast quadrant of Montana and lies in the Milk River flood plain. Fields surrounding Saco are extremely flat (ca. 10cm/km) graded pastureland in which the major crops are Bluejoint Reedgrass, *Calamagrostis canadenis* (Michx) Beauv. and alfalfa. The pastures are irrigated at least twice per growing year by means of flood gates that open up from a series of canals that lead to the Milk River. Upon opening the gates a typical section of land will be completely covered by 15 cm of water in 3–4 days. The composition of the soil is a heavy clay known as the Bowdoin series, which is very dense and allows little percolation of water. Land thus flooded provides ideal breeding beds for mosquitoes and indeed this area is renowned within the region for its mosquito production.

Experiments were carried out in June

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and July of 1981 following the irrigation schedules of the treatment sites. Site 'A' consisted of a 112 ha rectangular Bluejoint pasture. The grass was barely above the water surface and water depth ranged from 5–15 cm. Due to a late cold snap, the water temperature was 10–12°C.

Site 'B' was an 80 ha pasture. It contained Bluejoint grass that was 30–40 cm above the water surface some of which lodged across the water surface creating a canopy. It was treated with the *Bti* in July and the water temperature was 18°C in this site.

TARGET SPECIES. The mosquito assemblage most prevalent in this area was comprised of *Aedes* species: 25% *Ae. dorsalis* (Meigen), 45% *Ae. nigromaculis* (Ludlow), 20% *Ae. vexans* (Meigen) and 5% *Ae. melanimon* Dyar. Because of the 3–4 day period required to flood a pasture, 1st, 2nd, and 3rd instar larvae were present in both tests. Very few 4th instar larvae were present at treatment time.

TREATMENTS. The commercially formulated *Bti* utilized was San 402 WDC (Teknar®) produced by Sandoz, Inc., San Diego, CA and ABG 6108 II WP (Vectobac®) produced by Abbott Laboratories, North Chicago, IL. The Sandoz product was a flowable solution while Abbott's product was a wettable powder.

Treatment site 'A' was divided into 16 ha treatments consisting of 2 replicate treatments of San 402 at a rate of 1.1 liters/ha and 2 others at the rate of 0.5 liters/ha; 2 replicate treatments of ABG 6108 were applied at the rate of 1.6 kg/ha and the remaining site received ABG 6108 at 1.1 kg/ha rate. The higher rate for each formulation represents the recommended label rates. The treatments were aerially applied with using a Cessna 188 Agtruck equipped with a hydraulic spray system. Applications were made at 45 lbs nozzle pressure using either a # D6 or # D12 nozzle size. Airspeed was 115 to 120 mph and swath width was 15 m. Previous insecticidial materials had been flushed from the application equipment and it was cleaned with Crop Clean tank cleaner (Loveland Industries, Loveland, CO 80537). This material was determined to have no detrimental effects on *Bti* at residual levels (Ramoska 1981, unpublished). The application volume was 28 liters/ha through # D12 size nozzle. The applications were made between 0800–1000 hr.

Site 'B' was divided into 2 treatments of approximately 40 ha each. One treatment consisted of San 406 aerially applied at the rate of 1.1 liters/ha and spray volume of 9.4 liters/ha through a # D6 spray nozzle. ABG was applied at the rate of 1.6 kg/ha and spray volume of 28 liters/ha from a # D12 nozzle. Application was performed between 0700–0900 hr.

Standard dipper counts were made on the day prior to treatment and 1 day post-treatment in both tests. No less than 10 dips were made per replicate site and the mean number of insects per dip was calculated. In order to insure that all areas within the treatment sites were sampled dips were made in 2 diagonal transections across each site. The significances of differences between precount and postcount data were determined using paired "t" tests (Snedecor and Cochran 1976).

RESULTS AND DISCUSSION

Table 1 presents the data obtained from all applications. As illustrated in Table 1 both Abbott ABG and Sandoz 402 performed well at the recommended dosage levels in both sites.

It is significant to note that the second site (B) was one in which a vegetative canopy covered much of the water surface yet both products were capable of reaching the host at a dosage level sufficient to effect high mortality.

The variance of precount numbers exhibited in Table 1 is a consequence of 2 factors which are unavoidable in this type of site. First, water released from 'turnouts' into fields tends to set up a gradient of larval density incidence such that when the field is completely covered a higher

Table 1. Effect of 2 commercially prepared *B. thuringiensis* H-14 formulations on field populations of *Aedes* species mosquito larvae.

Test site	Formulation	Rate/AI	Mean number of larvae/dipper: 24 hr pre-treatment	24 hr post-treatment	% reduction
A	ABG 6108	1.6 kg/ha	23.6	4.9	80 (t^1=2.46,p=.015)
	ABG 6108	1.6 kg/ha	14.9	1.6	89 (t=2.53,p=.015)
	ABG 6108	1.1 kg/ha	1.9	0.5	74 (t=1.18,p=.200)
	San 402 wdc	1.1 liters/ha	7.1	1.0	86 (t=3.19,p=.010)
	San 402 wdc	1.1 liters/ha	19.5	0.6	97 (t=2.29,p=.050)
	San 402 wdc	0.5 liters/ha	9.6	0.9	91 (t=2.03,p=.065)
	San 402 wdc	0.5 liters/ha	2.7	1.4	48 (t=1.85,p=.100)
B	ABG 6108	1.6 kg/ha	16.0	0.4	98 (t^2=4.61,p=.0001)
	San 402 wdc	1.1 liters/ha	7.2	0.6	92 (t^3=4.89,p=.0001)

[1] d.f. = 9.
[2] d.f. = 18.
[3] d.f. = 19.

number of larvae occur at the end of the field furthest from the turnout gate. This is because many mosquitoes are literally carried along the front edge of the floodwater across the fields in preferred niches, or in pockets of water left standing in field. Upon closing the flood gates the flat nature of the plots, the disk furrows, and the vegetative growth inhibited any further movement of water across the field. Secondly, *Aedes* larvae tend to aggregate making for clumped rather than random distribution patterns.

In those samples that did permit pre- and postcount comparisons, however, the degree of mosquito suppression was significant (Table 1). At site 'A' both formulations effected 80% control within 18 hours after application at recommended applications rates. It should be noted that the water temperature at this site was between 10° and 12°C. An even higher mortality would likely have been found if 2 day postcounts had been taken, since this would have allowed more time for the relatively quiescent larvae to have consumed a lethal dose of the bacteria. Laboratory data comparing *Bti* efficacy at various water temperatures have indicated a metabolic increase in mosquito activity resulting in lower bacterial efficacy in lower water temperatures (Sinegre et al. 1980, Ramoska 1980 unpublished and Wraight et al. 1981).

At site 'B' which contained water temperatures more representative of mosquito breeding sites (ca 20°C) 1-day postcounts showed mortality to be greater than 90% for both products (Table 1).

In comparing aerial application of these 2 products we found that the Sandoz 402 could be adequately applied with 9.4 liters of water per ha through the smaller # D6 nozzle. ABG 6108 was applied with facility most effectively at 28 liters of water per ha through the larger # D12 nozzle.

CONCLUSIONS

Our experiments show that the commercial formulations of *Bti* tested are effective in reducing larval mosquito numbers in large flooded breeding sites. Successful larval control can be obtained even in breeding sites with a light vegetative canopy if proper spray nozzle size and spray volume are utilized in application.

Both products can be aerially applied using the spray equipment conventional pesticide applicators currently utilize.

ACKNOWLEDGMENTS

We wish to thank Dr. T. L. Couch,

Mayor Ralph Korman and Van C. Jamison for their expert technical assistance throughout the course of this study.

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