DESCRIPTION:	**Control of Codling Moth with Virosoft^{CP4} Bio-insecticide Containing *Cydia Pomonella* Granulovirus in Pears**
PROJECT LEADER:	**Rachel Elkins, UCCE Lake County** **Robert VanSteenwyk, UC Berkeley**
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CONTROL OF CODLING MOTH WITH VIROSOFT^{CP4} BIO-INSECTICIDE CONTAINING *CYDIA POMONELLA* GRANULOVIRUS IN PEARS

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ABSTRACT

There is a great need for effective, environmentally acceptable alternative insecticides to supplement codling moth mating disruption. Lack of suitable materials is especially acute for organic growers or those in transition to become organic. The biopesticide, granulosis virus (GV), was researched extensively in the 1980's by Dr. Louis Falcon of UC Berkeley. While commercial use of GV was never widely attained, growers who did use it report good results with frequent applications. A new commercial GV product, Virosoft$^{CP4®}$ (Biotepp, Inc., Quebec, Canada), was federally registered on pome fruit and walnuts in 2001. A set of trials was carried out in four California pear orchards under the auspices of IR-4 Minor Use Program and California Pear Advisory Board. In Mendocino County, applications were made according to label protocol, two per each hatch approximately 14 days apart for a total of eight applications. Treatments were compared to the insect growth regulator tebufenozide in one orchard and to horticultural oil in another. In Sacramento County, GV was applied weekly and was supplemented by horticultural oil. In all cases, Virosoft $^{CP4®}$ failed to show any significant control, whether used alone, with oil, or as a supplement to mating disruption, regardless of treatment protocol or combination. Possible suggested reasons for lack of efficacy include poor formulation, degradation by UV light and suppressed feeding response due to oil; however, GV was applied at night and without oil in Mendocino trials. GV should continue to be researched as a supplement to CM MD, however, the currently available product was shown to be non-effective for use in pears under California conditions.

INTRODUCTION

Codling moth mating disruption (CM MD) has become the standard practice in the California pear industry. It must, however, be supplemented by insecticides in at least some locations and years in order to maintain overall efficacy. The lack of effective supplements will likely render the technique ineffective over time due to CM population buildup in warm years or where sources of infestation exist.

Effective, environmentally acceptable alternative insecticides are desperately needed to replace or supplement currently available materials in MD programs. Current materials are mainly broad-spectrum organophosphates that are being increasingly restricted and are becoming less effective due to resistance. The problem is particularly acute for organic growers or those interested in transitioning to organic practices. Potential alternatives include certain IGR's (e.g. Confirm®, Success®) and biopesticides.

Dr. Louis Falcon of UC Berkeley isolated and developed a codling moth granulosis virus (GV) for use as a biopesticide. His work was partially funded by the pear industry during the late 1970's and early 1980's. The product was used by a few organic growers, but was never fully developed commercially and eventually faded from use several years ago.

A new commercial product obtained full federal registration on pome fruit, walnuts and plums in 2001. It is called VIROSOFT$^{CP4®}$ (CP4 refers to the strain of GV in the formulation) and is produced and sold by Biotepp, Inc. of Quebec, Canada. It first became available to apple growers in 2000 and was immediately in great demand. Biotepp's goal was to produce formulations using GV isolates specific to geographical locations and thus optimize efficacy, and collect CM from various areas in the U.S., including California.

Biotepp applied to the California Department of Pesticide Regulation (CalDPR) in 2001 to register Virosoft $^{CP4®}$ in California. CalDPR requires manufacturers to show efficacy before a label is granted registration. The only GV data on pears in California was that generated in the 1980's by Falcon (CTFA Research Reports 1981–1986). Trials were thus established and carried out in a multi-county research project for one year to determine the efficacy of the new GV product in order to provide an objective and thorough evaluation that would otherwise fail to be done. The project was funded both by the IR-4 Minor Use Program and California Pear Advisory Board.

PROCEDURES AND RESULTS

Two replicated trials were carried out in Mendocino County and three unreplicated trials were carried out in one orchard Sacramento County.

I. Mendocino County

Location 1: Todd Organic Orchards, Potter Valley
20' x 20' spacing, 108 trees per acre

Trial Design: RCBD, 5 replications per treatment; each plot 9 rows wide, 12 trees long = 1 acre except MD alone, 9 rows wide, 7 trees long = 0.5 acre

CM Pressure: very heavy

All timings were applied at 200 gpa by commercial engine-driven airblast sprayer. GV treatments consisted of 8 oz. Virsoft $^{CP4®}$ (Biotepp, Inc.) per hectare (2.5 acres) applied in the evening, twice per CM hatch period, 14 days apart. Oil treatments consisted of 3 gpa 415 oil (UAP) applied on approximately the same dates as the Virosoft $^{CP4®}$. The CM MD treatment consisted of Paramount Codling Moth Aerosol Pheromone Dispenser® ("puffers") applied at two per acre prior to biofix (April 23).

Treatments were:

1) **MD alone**
2) **MD plus 415 oil** applied May 9-14, May 23-June 1, June 6-18, June 22-30, July 5-16, and July 23-25.
3) **MD plus Virosoft**$^{CP4®}$ applied May 9, May 23, June 6, June 20, July 5-7, July 16-18, and July 23.
4) **untreated control** – one set of 4 upwind apple trees was used to obtain comparative trap and damage data for reference purposes only.

Evaluation

Degree-days and trap catches (reference only).

CM degree-days (base 50°F/88°F, single sine horizontal cut off) were calculated from a UCIPM-owned Adcon Telemetry weather station located within the test orchard. Trece 1x high and low and 10x high CM traps were hung in the orchard prior to biofix to track CM flight. OBLR (Western) traps were hung prior to OBLR biofix (May 22).

CM infestation

1) 300 clusters (150 top and bottom) were sampled for CM eggs on May 15 and June 15. 1000 fruit per replicate (25 top and 25 bottom fruit from each of 20 trees) were sampled on June 19-29 (908-1077°D, 1st generation larvae); 500 ground fruit on July 12 (1364°D, 1st generation larvae); 1000 fruit (25 top and 25 bottom from each of 20 trees) on August 1 (1751°D, late 1st and 2nd generation larvae).

2) A post-harvest sample of fruit remaining on trees (varying number per replicate depending on availability) was taken on September 18 (2095°D) to determine late 2nd and 3rd generation overwintering potential.

Results

Degree-day and trap catches: data shows there were three generations of CM and that MD kept catch relatively low compared to untreated controls. CM flight began April 23 and continued to August 28. OBLR catches are also shown (Figures 1 and 2).

Egg and Larval infestation: Damage was equal in all treatments throughout the sampling period (Tables 1 - 2).

Location 2: Hildreth Williams Orchard, Ukiah Valley, Talmage;
20 X 20 spacing, 109 trees per acre.

Trial design: RCBD, 4 replications per treatment; each plot 4 rows wide, 43 to 55 trees long, 2 acres each.

CM Pressure: moderate

CM MD was applied March 30, again on May 1 (MD alone plots) and June 23 on the entire trial, using 160 dispensers per acre (Checkmate®, Consep, Inc.).

All timings were applied at 250 gpa by commercial engine-driven air blast sprayer. GV treatments consisted of 8 oz. Virosoft$^{CP4®}$ per hectare (3.2 oz. per acre) applied twice per CM hatch period, 14 days apart (except as noted). Tebufenozide (Confirm 2F®, Rohm and Haas) was applied at 45 oz. per hectare (18 oz. per acre) with 20 oz. (0.0625% by volume) Latron B1956 spreader per hectare (8 oz. per acre). Treatments were:

1) **MD alone**
2) **MD plus Virosoft$^{CP4®}$** applied May 7, May 21, June 13, June 22, July 7, July 16, July 23, and July 30.
3) **MD plus Confirm 2F®** applied on the same dates as GV but ending after the July 16 spray.

There was no untreated control data collected for this site.

Evaluation

Degree-days and trap catches (reference only)

CM degree-day data was collected using a UCIPM-owned Adcon Telemetry weather station located less than one mile south of the test site. Traps were monitored by the pest control adviser and used to obtain biofix and discern flight pattern (Figure 3).

CM infestation

1) 300 clusters (150 top and 150 bottom) were sampled for CM eggs for the 1st generation on May 15-18 (362-406°D). Sampling protocol for larval infestation was the same as in Location 1. Sampling dates were July 3 (1259°D, 1st generation tree), July 13 (1475°D, 1st generation ground) and August 1 (1856°D, 2nd generation tree).

2) 300 fruit per replicate were sampled after harvest on September 18 (2792°D, 2nd and 3rd generation).

Results

CM injury was very low at this site due to low overwintering pressure and an unplanned second hanging of pheromone dispensers in the MD alone plots on May 1. There was no significant difference among treatments for any sampling event (Table 3).

II. Sacramento County

Location: Freeport, Sacramento County (organic)

Trial design: unreplicated, 10' x 16' spacing, 272 trees per acre

CM pressure: heavy

Three trials with three unreplicated treatments; plot size approximately 2 acres each.

Treatments were applied using PTO driven air blast sprayer operating at 2 mph and delivering 125 gpa. Treatments in trials one and two were: 1) 1% horticultural spray oil (Omni Supreme oil) by volume applied every week from April 23 until July 2, 2) 1% horticultural spray oil (Omni Supreme oil) by volume combined with 3.2 oz. per acre of VIROSOFT$^{CP4®}$ applied only twice per flight. Treatments in trial three were: 1) 3.2 oz. per acre of VIROSOFT$^{CP4®}$ APPLIED EVERY WEEK FROM April 23 until May 25, 2) 1% horticultural spray oil (Omni Supreme oil) by volume applied every week from April 23 until May 25 and combined with 3.2 oz. per acre of VIROSOFT$^{CP4®}$ applied only twice per flight. All treatments were applied from 7:00 a.m. to 3:00 p.m. In addition to these treatments, the entire orchard was treated with a 1% horticultural spray on the weeks of June 4, June 18, June 25, and July 2.

Evaluation

CM infestation and damage

The effectiveness of VIROSOFT$^{CP4®}$ was evaluated at mid-season on June 5 and again at harvest on July 12. Each treatment was divided into 3 replicates. At both the mid-season and harvest evaluations, 1500 fruit were inspected per treatment (500 fruit per replicate) for codling moth stings and infestation. Fruit was classified as infested if the CM larva was present or if an exit hole was visible. Fruit exhibiting only surface damage indicative of CM larval feeding, but with no CM larva present were identified as a sting.

Results and Discussion

The mid-season evaluation showed no consistent differences among the treatments. In trial 1, there was no significant difference among the treatments (Table 1). In trial 2, horticultural spray oil plus VIROSOFT$^{CP4®}$ applied every week had significantly less infestation than horticultural spray oil plus VIROSOFT$^{CP4®}$ applied twice per flight or horticultural spray oil alone applied every week. In trial 3, horticultural spray oil plus VIROSOFT$^{CP4®}$ applied every week and VIROSOFT$^{CP4®}$ applied every week showed significantly higher infestation than horticultural spray oil plus VIROSOFT$^{CP4®}$ applied twice per flight. Since the infestation had reached unacceptable levels (greater than 3%), Trial 3 was terminated and the trial was sprayed weekly with horticultural spray oil.

The harvest evaluation showed no significant differences among any of the treatments in Trial 1 or 2 (Table 2). In the VIROSOFT$^{CP4®}$ only treatment in Trial 3 that was terminated after the mid-season evaluation, the CM infestation exceeded 6%.

Table 1. Mean percent CM Damaged Pears at Mid-season Evaluation, Freeport, CA – 2001

			Mean[a] Percent CM Damaged Fruit		
Trial	Treatment	Timing	Stings	Infestation	Total
1	VIROSOFT$^{CP4®}$ + Oil	Twice/flight	0.13 a	0.80 a	0.93 a
	VIROSOFT$^{CP4®}$ + Oil	Weekly	0.17 a	1.70 a	1.87 a
	Oil Only	Weekly	0.00 a	1.40 a	1.40 a
2	VIROSOFT$^{CP4®}$ + Oil	Twice/Flight	0.13 a	2.40 c	2.53 c
	VIROSOFT$^{CP4®}$ + Oil	Weekly	0.00 a	0.73 a	0.73 a
	Oil Only	Weekly	0.03 a	1.30 b	1.33 b
3	VIROSOFT$^{CP4®}$ + Oil	Twice/Flight	0.07 a	1.27 a	1.33 a
	VIROSOFT$^{CP4®}$ + Oil	Weekly	0.07 a	3.27 b	3.33 b
	VIROSOFT$^{CP4®}$ Only	Weekly	0.00 a	3.80 b	3.80 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.

Table 2. Mean Percent CM Damaged Pears at Harvest Evaluation, Freeport, CA – 2001

			Mean[a] Percent CM Damaged Fruit		
Trial	Treatment	Timing	Stings	Infestation	Total
1	VIROSOFT$^{CP4®}$ + Oil	Twice/Flight	0.07 a	1.00 a	1.07 a
	VIROSOFT$^{CP4®}$ + Oil	Weekly	0.20 a	2.00 a	2.20 a
	Oil Only	Weekly	0.00 a	1.47 a	1.47 a
2	VIROSOFT$^{CP4®}$ + Oil	Twice/Flight	0.40 a	2.60 a	3.00 a
	VIROSOFT$^{CP4®}$ + Oil	Weekly	0.27 a	3.07 a	3.33 a
	Oil Only	Weekly	0.07 a	1.27 a	1.33 a

[a] Means followed by the same letter within a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.

CONCLUSIONS

The granulosis virus (GV) product VIROSOFT$^{CP4®}$ failed to exhibit any control of CM at any of the test locations. This was despite following, or even exceeding, the recommended number of treatments, as well as total amount applied.

There are several possible explanations for lack of efficacy. The first is degradation by UV light. However, in Mendocino Location 1, VIROSOFT$^{CP4®}$ was applied at night to avoid this. Second, horticultural oil applications may have suppressed feeding activity. However, VIROSOFT$^{CP4®}$ was applied alone to both Mendocino sites. Finally, there may have been a bad formulation, which may be the case.

While it is acknowledged that GV, in any form, will provide only partial control of CM in an economically-feasible program, successful use in California of the formulation developed at UC Berkeley indicates potential, particularly for organic growers. The concept of using GV is therefore a worthy goal; perhaps the manufacturer of VIROSOFT$^{CP4®}$ can work with researchers to improve the product efficacy.

ACKNOWLEDGEMENTS

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Thanks also to Biotepp, Inc., especially Jacques Drolet and Pierre Samson, for supplying VIROSOFT$^{CP4®}$ and Doug West of Rohm and Haas for supplying Confirm 2F$^{®}$.

Figure 1:

Codling Moth Trap Catches
Todd Organic Orchard, Potter Valley, Mendocino County
Mav 8 to September 13. 2001

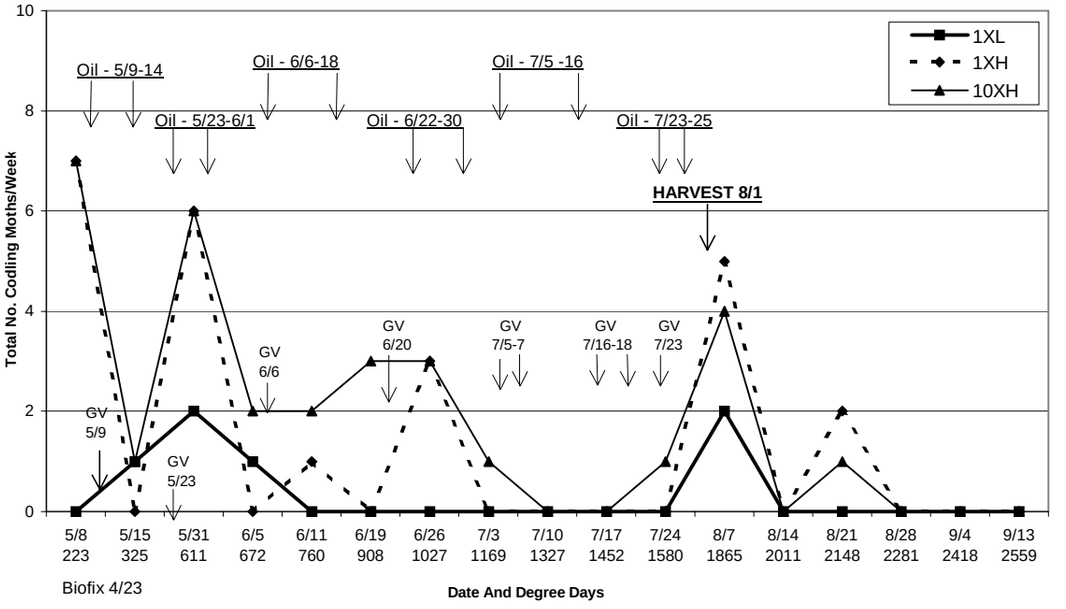

Figure 2:

OBLR Trap Catches
Todd Organic Orchard, Potter Valley, Mendocino County
May 31 to September 18, 2001

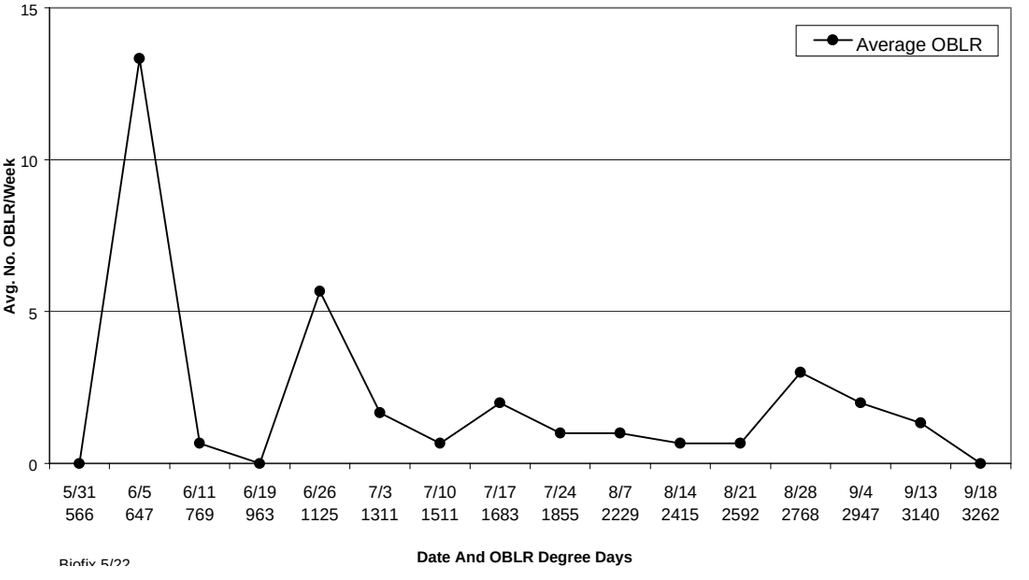

Figure 3:

Total Codling Moth Trap Catches
Williams Orchard, Talmage, Mendocino County
April 11, to September 28, 2001

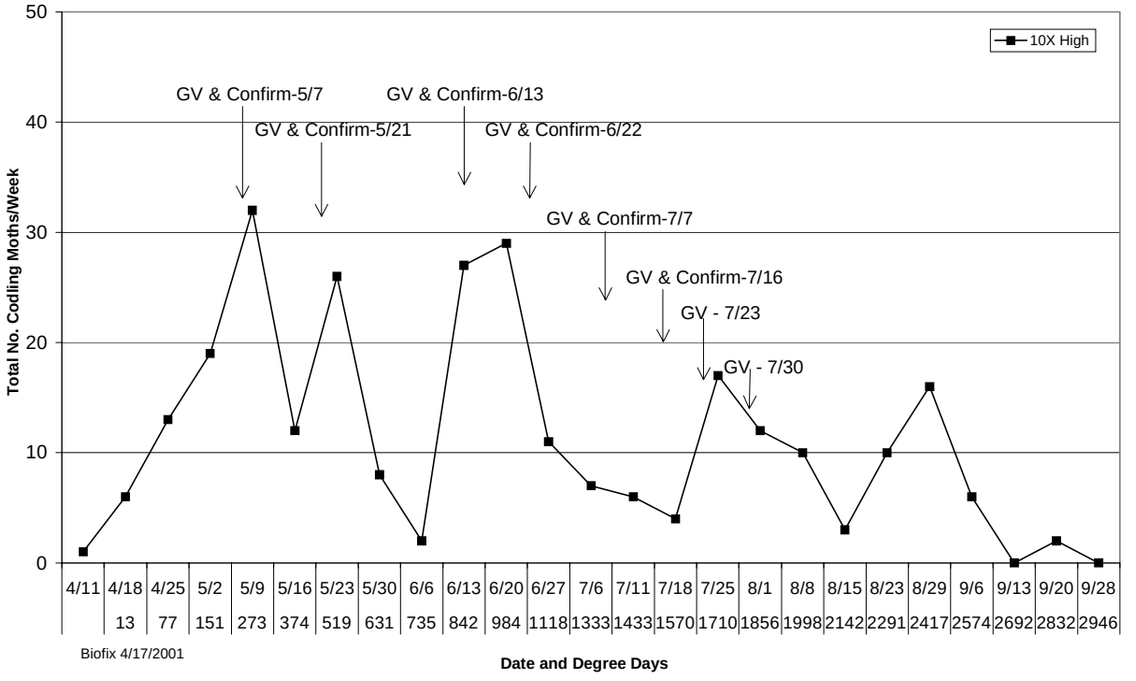

Table 1: **1st Generation Codling Moth Eggs and Worm Damage**

Todd Organic Orchards, Potter Valley, Mendocino County, California
Fruit Sample - %/1000 Fruit – June 19-29, 2001 (908°D)
Ground Fruit Sample - %/Fruit Found (100-500), July 12, 2001 (1364°D)

	Eggs			Worms/Damage			Ground
Treatment	**Top**	**Bottom**	**Avg.**	**Top**	**Bottom**	**Avg.**	**Damage**
Mating Disruption alone	2.8	5.4	**4.1**	0.4	0.8	**0.6**	**71.5**
Mating Disruption + oil	2.6	7.8	**5.3**	1.4	1.0	**1.2**	**75.7**
Mating Disruption + GV	2.6	4.0	**3.3**	1.2	1.2	**1.2**	**75.9**
ANOVA (P values)							
Treatment	0.987	0.350	0.401	0.535	0.904	0.664	0.539
Block	0.798	0.009	0.013	0.696	0.574	0.538	0.450
UNTREATED CONTROL							
Apples (40 fruit)	-	-	-	-	-	**50.0**	-

Treatment data not significant, P>0.05.

Table 2: **2nd and 3rd Generation Codling Moth Damage**

Todd Organic Orchards, Potter Valley, Mendocino County, California
Pre-harvest Fruit Sample - %/1000 Fruit, August 1, 2001 (1751°D)
Post-harvest Fruit Sample - % Fruit Found (range = 8-45 fruit),
August 1, 2001 (1751°D) and September 18, 2001 (2095°D)

Treatment	Top	Bottom	Average	Post-harvest
Mating Disruption alone	17.8	23.6	20.7	12.5
Mating Disruption + oil	10.5	9.40	9.90	19.2
Mating Disruption + GV	19.80	16.80	18.30	20.7
ANOVA (P values)				
Treatment	0.338	0.139	0.167	0.685
Block	0.968	0.73	0.966	0.705

Treatment data not significant, P.0.05

Table 3: **Codling Moth Trap Catches and Fruit Damage – Summary Table**
Williams Orchard, Talmage, Mendocino County
April – September 2001 (13 - 2946°D)
Egg Samples – Average %/50 shoots (top) & 100 shoots (bottom),
1st Generation Tree Fruit Samples – Average %/1000,
Ground Fruit Samples – Average %/500,
Pre-harvest Samples – Average %/2000, Post-harvest Samples – Average %/300

	Eggs		1st Generation	Ground Fruit	Pre-harvest	Post-harvest
Treatment	**Top**	**Bottom**	**Damage**	**Damage**	**Damage**	**Damage**
Mating Disruption + Confirm	0.0	0.0	0.03	0.1	0.0	0.0
Mating Disruption + GV	0.0	0.0	0.03	0.2	0.0	0.0
Mating Disruption alone	1.0	0.8	0.05	0.3	0.0	0.1
ANOVA (P values)						
Treatment	0.125	0.162	0.893	0.485	-	0.422
Block	0.455	0.455	0.800	0.248	-	0.455

Data transformed using sq. root of (x + 0.5) to accommodate large number of zeros.
Treatment data not significant, P>0.05.