INTEGRATED CONTROL OF THE BLACK MAIZE BEETLE, *HETERONYCHUS LICAS* (SCARABAEIDAE: DYNASTINAE), IN SUGARCANE IN THE SOUTH-EAST LOWVELD OF ZIMBABWE

R MAZODZE

Zimbabwe Sugar Association Experiment Station, Private Bag 7006, Chiredzi, Zimbabwe

Abstract

Chlorpyrifos, as controlled release suSCon Green granule formulation, significantly reduced the numbers of *Heteronychus licas* Klug (Scarabaeidae: Dynastinae) larvae in plant crop trials in the south-east lowveld of Zimbabwe (p<0,05). In insecticide trials on adults in late cut cane (September to November), Arriba (tebupirimfos) significantly reduced beetle activity and plant damage ('dead hearts'). The control strategy has recently been expanded to include (i) efficacy of chemicals applied to the soil surface against larvae early in the year; (ii) testing deep incorporation of insecticides into the soil, with a tractor drawn machine, after harvest; and (iii) efficacy of the entomopathogenic fungus *Metarhizium anisopliae*.

Keywords: Heteronychus licas, black maize beetle, integrated pest management, sugarcane, Zimbabwe.

Introduction

Heteronychus licas Klug (Scarabaeidae: Dynastinae), locally referred to as black maize beetle or BMB, is the major insect pest of sugarcane in the south-east lowveld of Zimbabwe (Cackett, 1992). Adult *H. licas* cause 'dead hearts' (shoot death) in regrowth from late harvested cane and are more serious than the larval stage, which feeds on roots from April to June. About 80 000 ha (20% of the area under cane) which is planted, or cut late (October to December), is vulnerable to attack by adults. Stools may be killed if compensatory tillers are repeatedly attacked, in which case replanting or gap filling is necessary. Yield losses in severely affected fields are estimated at about 40 to 50 tons cane/hectare.

The life cycle of *H. licas* in sugarcane under local conditions has been described by Cackett (1992) and Musikavanhu (1996). In the past this pest was more localised but, in the past two seasons, BMB has spread on Triangle (Musikavanhu, 1996) and Hippo Valley Estates and on to Mkwasine Estate. All three estates have initiated monitoring programmes for BMB. In 1990, no effective control measures were available against BMB. The formerly-used insecticide dieldrin was ineffective (Cackett, 1992) and was banned for environmental reasons. Consequently BMB populations increased. Recent research has consisted of screening alternative chemicals to apply at planting against larvae, or to apply on to the soil surface to target adults. Cackett (1992) illustrated the efficacy of organophosphate insecticides against adults.

This paper documents insecticide field trials, progress on application methods and biological control.

Methods

Trials on larvae in plant cane

In October 1994, a slow release suSCon Green (10%) formulation was evaluated in two field trials. These were replicated four times at three concentrations, *viz* 2, 3 and 4 kg a.i./ha. The insecticide was distributed in a 150 mm band across the base of the furrow. The seedcane was covered to a depth of about 100 mm. Dead hearts were assessed in November and December. Larvae were sampled from February through to June by digging pits beneath the stools (500 x 500 x 300 mm deep). Plot yields were recorded at harvest. Both the plant and first ratoon crops were assessed.

Adults in ratoon cane

Two replicated trials were carried out in November 1995 and 1996 to test several short term residual contact insecticides against adults in late cut (September to November) ratoons. Dursban (chlorpyrifos) 480EC (registered for use against BMB) was used as a standard for control. Insecticides were sprayed over the cane rows after harvest before the first irrigation, or between the second and third irrigation. Insecticides were covered with soil from the ridge, to reduce photodecomposition. Dead hearts were counted in two rows at the centre of each plot from November to December. Arriba (tebupirimfos) 5GR, a new organophosphate insecticide, was included in the 1996 trials. Cups were used to apply the granules along the cane lines covering a swathe of about 300 mm. The granules were covered with soil from the bottom and sides of the interrow ridge. Dead beetles on the soil surface and dead hearts were counted from two middle rows of each plot in November and December. Stalk heights were measured in January, 1997.

Bioassays to test the efficacy of tebupirimfos rates of 5, 10 and 20 ppm a.i. were conducted. Adults were placed in glass jars 15 mm high and insecticide was added to the soil. Residual activity was monitored for six weeks.

Bioassays with Metarhizium anisopliae *against adults*

M. anisopliae (Metschn) Sorokin (International Mycological Institute) was isolated from a diseased larva collected on Section 15 of Hippo Valley Estate. The fungal mycelia and spores (conidia) were suspended in distilled water. Ten millilitres of this suspension were poured into glass jars containing eight adults. Cross-cut sections of cane were provided as a food source. Excess water was removed through the perforated lids. As control, the process was replicated without the fungus. No attempt was made to determine the spore concentration nor the spore dose per insect, as the first objective was to determine pathogenicity. Beetle mortality was assessed every three days for 70 days following inoculation.

Statistical methods

A randomised complete block design was used in all field trials. Where treatments were compared, the LSD test at p=0,05 was used when analysis of variance indicated a significant treatment effect using MSTAT. Square root and logarithmic transformations were used for larvae and dead heart counts respectively.

Results and Discussion

Trials at planting

Results from only one trial are presented as the other site had a very low level of infestation. SuSCon Green applied at planting significantly reduced larvae numbers in the plant crop, even at a rate of 2 kg a.i./ha at p<0,05 (Table 1).

Average reduction in numbers of larvae in the suSCon Green treated plots was 50%. This confirms results obtained by Cackett (1992). There were no significant differences in numbers of dead hearts and cane yields at p=0,05. SuSCon Green had no effect on larval numbers, dead hearts or cane yield in the first ratoon crop (p=0,05). The lack of persistence of suSCon Green and the high cost of this insecticide (about US$300 per hectare), when applied at 3 kg a.i./ha, militates against its use. A number of farmers reported low *H. licas* activity where Regent (fipronil) had been applied at planting for termite control. Since this chemical remains active in the soil for about a year it may be effective against *H. licas* larvae; however, it is costly.

Adult control in young late-cut fields

Oftanol (isofenfos) 500EC, Mocap (ethoprofos) 720GEL and the standard treatment of Dursban (chlorpyrifos) 480EC had no effect on adult activity in the 1995 field trials (p=0,05) (Table 2). Insecticides have been screened in bioassays (Cackett, 1992).

Chemicals tested in the 1995 trials caused some beetle mortality in 1996, but adult activity remained high, i.e. dead heart counts differed little between treated and control plots (Table 3). Arriba (tebupirimfos) 5G tested in the 1996 trials was highly effective against adults. Arriba caused significantly higher beetle mortality than the standard Dursban treatment and the control. There were significantly fewer dead hearts in the Arriba treated plots (p<0,001). Plant heights appeared to be influenced by treatment p<0,001. Plants receiving the two rates of Arriba and the higher rate of Dursban were significantly taller than the control, and plants receiving either rate of Arriba were significantly taller than those receiving the higher rate of Dursban (p=0,05. Differences in plant height could be due to initial tiller losses causing younger tillers to arise later. The trials also showed that the chemicals killed more beetles when spraying was immediately followed by irrigation or rain. Arriba admixed with soil at 5, 10 and 20 ppm active ingredient in glass jars caused 100% mortality of adults up to six weeks from application.

Table 1

Larval counts, dead hearts and yield for the plant and ratoon crop after applying suSCon Green to the plant crop on 7 October 1994.

Treatment	Rate (kg a.i./ha)	Plant cane					First ratoon crop				
		Larvae/sample, February 1995		Cumulative dead hearts/10 m Nov - Feb		Cane yield at 13 mths (t/ha)	Larvae/sample, June 1996		Cululative dead hearts/10 m Jan - Dec		Cane yield at 11 mths (t/ha)
		x	sq rt x	x	log x		x	sq rt x	x	ln x	
Control	–	3,20	1,70b	10,80	1,01	103,82	5,50	2,33	68,39	4,21	79,96
suSCon Green 10% CRG	2	1,20	1,00a	10,44	1,01	117,25	6,05	2,35	69,72	4,22	75,97
suSCon Green 10% CRG	3	1,10	1,00a	10,55	1,00	126,38	5,35	2,22	73,47	4,29	84,00
suSCon Green 10% CRG	4	0,80	0,90a	10,39	0,99	131,91	6,25	2,34	66,65	4,14	73,27
Trial mean		1,9	1,24	10,59	1,00	116,64	5,80	2,31	69,56	4,22	78,30
Significance		5%		NS		NS	NS		NS		NS
LSD (p = 0,05)		0,61		–		–	–		–		–
SE of mean		0,28		0,05		9,38	0,27		0,14		2,54
CV%		31,73		10,49		16,10	23,56		6,45		6,49

Means in the same column, followed by the same letter, are not significantly different at p=0,05 (LSD test).
No letters indicate that the effect of the treatment is not significant in analysis of variance (p<0,05).

Table 2
Dead hearts resulting from use of organophosphates to control black maize beetle in late cut ratoon cane.

Treatment	Rate (kg a.i./ha)	Cumulative dead hearts/10 m Nov - Jan
Treatments applied 14 November 1995		
Control	–	284
Oftanol 500 EC	0,50	295
Oftanol 500 EC	1,00	314
Oftanol 500 EC	1,50	333
Dursban 480 EC	0,48	302
Significance		NS
SE of mean		21,70
CV%		15,80
Treatments applied 22 November 1995		
Control	–	157
Mocap 720 Gel	0,72	170
Mocap 720 Gel	1,44	220
Mocap 720 Gel	2,16	177
Mocap 200 EC	0,72	158
Mocap 200 EC	1,44	167
Mocap 200 EC	2,16	173
Dursban 480 EC	0,48	131
Significance		NS

Since most of the chemicals tested were largely ineffective against the adult beetle, it was indicated that the larval stage was likely to be most vulnerable to insecticides. Field trials in two month old ratoon cane to evaluate the larvicidal activity of these chemicals when applied to the soil surface, were established in January, 1997. The soil was moist and most larvae were found in the top 50 mm. Since most organophosphate insecticides are rapidly degraded when exposed to the sun, a prototype machine was designed for incorporation of insecticide into the soil in the dry season after cutting. The machine consists of two pairs of slant tines with adjustable nozzles fitted behind them, so that the chemical can be placed at various depths in the soil from both sides of the cane line (manufactured by HASTT and Agriquip). Preliminary trials on Triangle Estate have shown that, because of their curved nature, the tines tend to lift the stool and irrigation may be required to settle the stools back in position. Tines are curved to improve targeting of larvae near the roots. Carnegie (1988) indicated that insecticides are most conveniently and effectively applied at crop establishment.

Bioassays using M. anisopliae

There was up to 20% mortality in fungus inoculated jars two to three weeks from inoculation. Eight weeks later mortality in inoculated jars was 67% compared with 9% in uninoculated jars (Figure 1).

The LT_{50} in inoculated jars was five weeks (Figure 1), showing that *M. anisopliae* is slow acting, but effective. Eighty per cent of the cadavers from inoculated jars sporulated on incubation to produce the same fungus (visibly) as the original, and none from the control jars developed any fungus. Ultraviolet (UV) light trapping and cultural control strategies are practised in the industry. UV light trapping described by Musikavanhu (1996) is used as a means of monitoring adults.

Conclusions

The plant crop may be partially protected against *H. licas* with suSCon Green. However, due to its lack of persistence, the effects of the short term residual insecticide Dursban (also chlorpyriphos) applied at planting must be reconsidered. Dursban is less costly and does not leach readily. Results with Arriba show promise (for treatment of the ratoon crop) and this

Table 3
Results of Arriba and Dursban use on adults and dead hearts from a 1996 trial on Triangle Estate. Treatments applied 21 November 1996.

Treatment	Rate (kg a.i./ha)	Cumulative dead beetles/30 m 22.11.96 - 04.12.96		Cumulative dead hearts/10 m 28.11.96 - 04.12.96		Mean stalk height (cm)
		x	sqrt (x + 0,5)	x	ln x	
Control	–	0	0,97c	22,14	3,03a	53,86c
Arriba	1,50	109	10,24a	8,88	2,11b	69,18a
Arriba	2,00	136	11,56a	7,26	1,88b	72,00a
Dursban	0,48	39	6,13b	18,10	2,87a	59,70bc
Dursban	0,96	67	7,95b	22,50	3,05a	61,00b
Significance		0,1%	0,1%	0,1%	0,1%	0,1%
LSD (p = 0,05)		1,96		0,40		7,02
SE of mean		0,65		0,13		2,34
CV%		21,16		11,54		8,30

Means in the same column, followed by the same letter, are significantly different (p=0,05, LSD test).

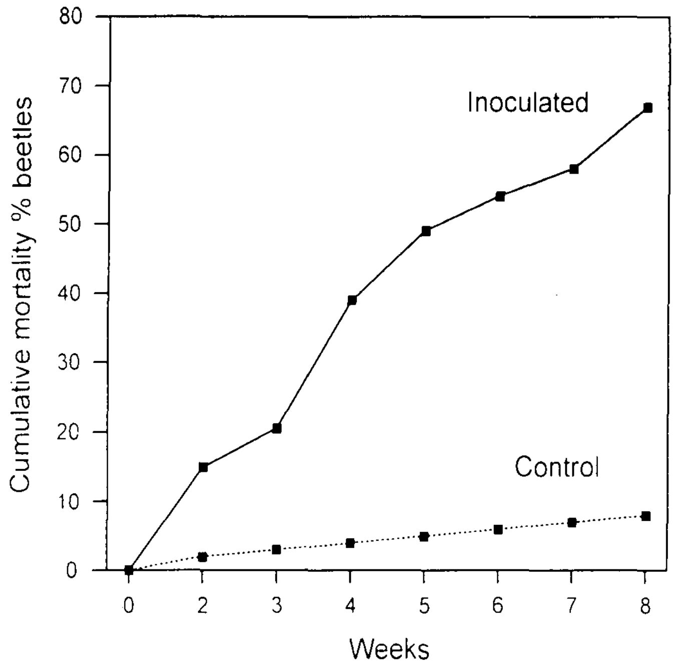

Figure 1. Effect of the fungus *Metarhizium anisopliae* on *Heteronychus licas* in bioassay trials.

chemical needs to be assessed on a plant crop. However, this product is not yet registered, and more information on rates and persistence is required. Preliminary bioassays using *Metarhizium anisopliae* show promise.

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