BLACK MAIZE BEETLE CONTROL STRATEGY AT TRIANGLE, ZIMBABWE

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Abstract

The need for a diversified and sustainable programme in the control of the black maize beetle, *Heteronychus licas* Klug (Scarabaeidae: Dynastinae) in sugarcane fields was highlighted in the late 1980s when the pest developed resistance to dieldrin insecticide. Triangle Limited has developed an integrated pest management strategy in response to this need. Emphasis is placed on knowledge of the pest's behaviour. Scouts are trained in all aspects of the pest's life cycle, identification features and field scouting recording procedures. Analysis of field records has shown that the use of insecticides both at planting and in the ratoon stages should be restricted to high infestation fields. Physical control can be achieved through the synchronisation of plough-out with the inactive pre-pupa stage of the pest. Soil disturbance at this stage exposes the pest to desiccation and predatory birds. Ultraviolet light traps have been used to reduce the numbers of breeding adults. The aim of this paper is to show how an integrated pest management programme has allowed management at Triangle to develop a focused approach in the control of *H. licas* following the withdrawal of dieldrin.

Keywords: Training, pest behaviour, integrated pest management, white grub, black maize beetle, sugarcane.

Introduction

H. licas is commonly known in Zimbabwe as the black maize beetle because it was first recorded in the country as a pest of maize (Symes, 1925). It should be noted that *H. licas* is not synonymous with *H. arator*, which shares the same common name (Cackett, 1992). The black maize beetle completes its life cycle under natural conditions in wet low lying areas that retain soil moisture and host plant populations throughout the dry period, which occurs in Zimbabwe from late April to late October. Soil moisture is essential to the insect for the prevention of egg and larva desiccation during the dry period. The introduction of large scale irrigated sugarcane operations in the south-eastern lowveld of Zimbabwe in the 1950s provided an ideal habitat for the black maize beetle. In addition, sugarcane provided an acceptable and abundant food source for both the beetles and larvae.

The adults cause damage to sugarcane shoots by feeding at or just below ground level (Sweeney, 1967). Sugarcane is vulnerable to attack at all stages of growth. The tender shoots of late planted or cut (October to December) crops are the most susceptible to damage, as the early stages of growth coincide with the period of peak adult activity. The damage to young shoots (less than four months old) destroys the growing point, thus creating typical 'dead heart' symptoms. Up to 100% of tillers can be destroyed within a matter of days. The second and third instar larvae cause damage to sugarcane by feeding on the plant's root system. Damage is concentrated in the period April to July and is recognised (under serious attack) by the wilting and yellowing of leaves. The mature (third instar) larvae also feed on underground shoots and setts (Sweeney, 1967).

The first recording of black maize beetle in the Zimbabwe lowveld sugarcane fields was made in 1966 (Cackett, 1978). The wet years from 1974 to 1978 led to a fast build-up in the beetle populations, with associated economic crop losses in the latter part of this period (Cackett, 1978). The pest succumbed to dieldrin applications from the late 1970s but, by 1986, evidence of resistance to this insecticide was being seen (Cackett, 1992). Persistence of dieldrin in the ecosystem combined with the beetle's resistance led to the withdrawal of the insecticide from the market between 1989 and 1990. It was at this time that the Zimbabwe Sugar Association Experiment Station intensified efforts to identify alternative insecticides (Cackett, 1992). Triangle Limited decided at the same time to develop a sustainable and cost effective integrated pest management programme in the control of *H. licas*. The components of the control strategy were influenced by the pest's behaviour. The high mobility of the adult (during mating flights) enables it to cause extensive damage in young cane. The larva has limited mobility and therefore only tends to cause economic damage under very serious infestation levels and/or in restricted niche areas. This is in direct contrast to the feeding habits of white grubs in other sugarcane growing countries where losses are associated more with the larvae of the prevalent white grub species (Sweeney, 1967; Allsopp and Chandler, 1989). Control measures at Triangle are therefore aimed at both the larvae and the adults through an integrated programme comprising, (1) understanding of the pest's behaviour, (2) use of ultra violetlight traps, (3) creation of unfavourable field conditions, (4) application of a slow release insecticide to high infestation fields at planting and (5) post-harvest application of a short residual insecticide on selected fields.

Strategy

Understanding the pest's behaviour

Understanding the life cycle of *H. licas* (Cackett, 1992) is an important facet of the control strategy (Table 1). Section Scouts are trained thoroughly in the following areas: (1) life cycle of the pest, (2) description and identification of the different stages of the pest, (3) scouting and recording methods used for the larvae, (4) scouting and recording methods used for the adult both in the field and in light traps, and (5) scouting and recording methods used for damage caused by the adult.

Table 1

The probable life cycle of *Heteronychus licas* in the lowveld of Zimbabwe

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eggs xx	xx	xx	x	x							x	xx
Larvae xx	xx	xx	xx	xx	xx	xx	xx	x			x	xx
Pre-pupae							x	xx	xx	x		
Pupae								x	xx	xx	x	
Adults xx	xx	xx	x	x	x				x	x	xx	xx

x – present in low numbers
xx – present in large numbers
NB: Variations in temperature and rainfall influence the numbers and distribution of the different life stages

Refresher courses are run by the Agronomy Department at appropriate times based on the pest's life cycle. Prior to 1990, the scouting emphasis was on counting dead hearts in the young ratoon crops during the late season, with limited surveys for larvae. The disadvantage of this method is that the control programme is reactive rather than proactive. Since 1990 the emphasis has shifted to scouting for larvae on all fields, irrespective of growth stage, during April to July when the larvae are large and relatively easy to identify. Heavily infested fields are therefore identified before the onset of the summer rains, and control measures can be put in place well in advance.

The sampling procedure used by scouts is based on work done in Swaziland by Williams (1985). The sampling holes are on a 70 x 70 m grid, which is equivalent to two holes/ha. Each hole is placed in the cane line and has surface dimensions of 60 x 60 cm. The depth of 20 cm is based on Sweeney's (1967) recommendation of nine inches adjusted to local observations. The position of each hole is marked on an auger map so that, where necessary, confirmatory adult scouting holes can be dug next to the larvae survey holes. Different white grub species are recorded separately, and site characteristics such as drainage, topography and soil type are noted. Pest pressure evaluation is based on the following in-house developed scale:

- Less than one larva/hole = low activity; no control.
- One to four larvae/hole = high activity; apply short residual insecticide if late cut, or spray the insecticide onto an adjacent late cut field if the survey field is not late cut.
- More than four larvae/hole = serious activity; consider plough-out after confirmatory adult scouting in October.

Interpretation places significance on individual hole counts and distribution of *H. licas* in the field in addition to field averages. Records of scouting results (Table 2a) have been kept since 1988. These records are referred to when making decisions on when to plough out fields, where to site light traps and in the evaluation of the effectiveness of control programmes.

Ultraviolet light traps

Trials were conducted in the summer of 1990-91 (Table 3) with four traps using different sources of light.

Table 3

Number of *Heteronychus licas* adults caught using different sources of light, and rainfall for 17 week period from 1 October 1990 to 26 January 1991

Amount	Ultraviolet tube 1,2 m	Mercury vapour tube	Fluorescent tube 0,5 m	Lightbulb 40 Watt	Rainfall (mm)
Total	64 669	1 768	249	15	155,5
Average/week	3 804	104	15	1	9,1
Average/day	543	15	2	0,1	

The tests showed that the 1 200 mm long, 40 watt ultraviolet tube was the most effective in attracting *H. licas* adults. Observations of beetle presence at isolated, out-of-field light sources, such as tower lights and pump stations, were used in estimating that the beetles could fly to a light source up to 1 000 m away. It was projected on the basis of this observation that a single light trap could command an area of 100 hectares. At present there is a network of 40 light traps throughout the estate. The objective is to have a density of one trap/70 ha, because the terrain and field layouts do not permit the calculated maximum coverage of one trap/100 ha. Each trap (Figure 1) comprises a vertically mounted tube on a 1,5 m stand, set up over the top of a 20 m wide and 30 cm deep brick, concrete stone and cement pond. The pond is filled with water to a depth of about 20 cm. The use of a wetting agent (Agral 90 at 1 ml/4 litres water) reduces the water's surface tension and ensures that beetles that fall into the trap will drown. The cost per trap, including electric fittings and

Table 2

Results of scouting for *Heteronychus licas* at Triangle Limited, Zimbabwe

(a) Results from seven years of scouting

Year	Average ha with cane*	Scouted area				Area with one or more larvae/hole				Area with four or more larvae/hole			
		Ha	Holes	Larvae/hole		Ha	Holes	Larvae/hole		Ha	Holes	Larvae/hole	
				Mean	Range			Mean	Range			Mean	Range
1988	12 461	2 306		1,15		936		2,44		93		6,99	
1989	12 197	3 475		0,54	0 – 11,40	565	838	2,70	1 – 11,40	105	119	6,10	4,6 – 11,40
1990	11 676	8 996	19 913	2,01	0 – 18,64	5 168	10 677	3,46	1 – 18,64	1 132	2 147	7,02	4,0 – 18,64
1991	11 308	10 377	20 476	1,94	0 – 21,30	6 312	12 518	2,97	1 – 21,30	1 094	2 165	6,74	4,0 – 21,30
1993	8 232	8 165	15 426	0,81	0 – 9,60	2 081	3 707	2,85	1 – 9,60	457	746	5,78	4,0 – 9,60
1994	12 033	8 602	16 874	0,49	0 – 10,40	1 442	2 522	1,72	1 – 10,40	80	147	6,23	4,5 – 10,40
1995	13 468	13 651	26 846	1,51	0 – 17,20	5 524	11 174	3,14	1 – 17,20	1 190	2 395	6,90	4,0 – 17,20
Mean	12 191	7 901		1,43		3 324		3,02		616		6,90	

(b) Results from confirmatory scouting for adults, October to December 1995

Year	Average ha with cane*	Scouted area				Area with one or more adults/hole				Area with four or more adults/hole			
		Ha	Holes	Adults/hole		Ha	Holes	Adults/hole		Ha	Holes	Adults/hole	
				Mean	Range			Mean	Range			Mean	Range
1995	11 314	5 165	9 863	0,53	0 – 5,71	317	691	2,37	0 – 5,71	55	103	2,37	4,37 – 5,71

* – Average area with sugarcane for the period April to July

** – Average area with sugarcane for the period October to December

NB: No scouting was carried in 1992 because labour had been lost to the drought retrenchment exercise.

construction labour, is currently estimated at Z$8 000. The cost/ha on a minimal light trap functional life of five years is Z$23 ($8 000/5/70).

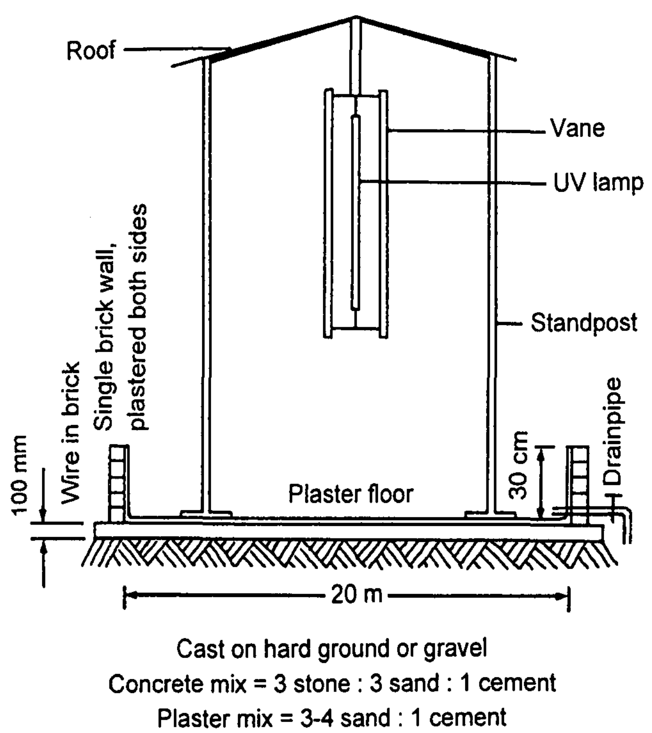

FIGURE 1: Ultraviolet light trap

Table 4

Black beetle catches from ultraviolet light trap October to January 1991-92 and 1993-94

Light trap location	Total beetle catch		% decline
	1991-92	1993-94	
Met station	383 247	464	99,9
Section 22 house	162 066	498	99,7
Section 1 store	241 974	1 688	99,3
Section 9 Edward dam	65 212	7 481	88,5
Section 9 Isaac dam	95 304	15 895	83,3
Section 9 Pokie dam	78 411	10 819	86,2
Section 9 Dr Wood dam	49 513	8 169	83,5
Section 10 Angella dam	30 290	4 004	86,8
Section 12 Batu dam	8 653	11 743	(35,7)
Cotton Gin ponds	20 851	1 546	92,6
Sectio 8 booster pump	58 667	12 277	79,1
Section 11 Mac dam	82 885	1 385	98,3
Section 62 booster pump	6 797	6 257	7,9
Total/mean	1 283 870	82 226	93,6

Peak adult flights have been observed from about 19h00 to 21h00. The light traps are therefore switched on at 17h00 and left operational overnight. High catches tend to occur one to two days after rain. Good, well-distributed rains, followed by windless and moonless nights, provide ideal conditions for good catches from September to February. The highest catch from a single night was 101 460 beetles at Section 22 Met station trap in the September 1991 to February 1992 flight season. This trap commands +/- 70 ha and had a total catch of 383 445 beetles in the 1991-92 season. Assuming all the 2 185 540 larvae (based on a mean larva/hole count of 2,81) found on this 70 ha block that year survived to adulthood, the catch would equate to 17,5% of the beetle population.

The light traps also provide useful information on beetle population dynamics. The devastating drought of 1991-92 led to complete withdrawal of irrigation from the estate of 13 870 ha from April to November of 1992. Only 12% of the estate (1 700 ha) survived the drought, in isolated pockets mainly along drainage lines. The effect of the drought on beetle numbers is shown in Table 4, which compares beetle catches from 13 core traps over the period October to January for the 1991-92 and 1993-94 seasons. A 94% decline in beetle catch was recorded despite the near normal rains received in 1992-93 and 1993-94.

Creation of unfavourable field conditions

The black maize beetle is known to prefer soft, moist soil with an adequate food supply for successfull breeding (Symes, 1925). Any factor negating these requirements may be useful in the control of this pest. Observations made from April to June 1993 following 'phase 1' of the post 1992 drought replanting programme (December 1992 to January 1993) showed marked differences in larval counts between fallow lands, plant and ratoon cane fields (Table 5).

Table 5

Heteronychus licas **larvae pressure on fallow, plant and ratoon cane lands April to June 1993**

Field category	Number of fields	Area (ha)	Holes		Larvae/hole	
			Total	% with larvae	Average	Range
Fallow	62	749	1 302	7	0,09	0 – 0,81
Plant	42	539	1 062	23	0,70	0 – 4,08
Ratoon*	37	376	1 034	37	3,05	0 – 9,60

* All older than fourth ratoon

Moisture during the peak egg laying period from December 1992 to February 1993 was not limiting, with 440 mm rain falling over the three month period against a long term mean of 326 mm. Eggs could therefore have been laid on either fallow or cropped land. The plant cane fields discussed here were only established after the rains and were in a fallow state during the period of peak oviposition. It would appear that excessive drying of the soil after the rains stopped in March 1993 and the absence of live cane stools (food source) in the fallow lands led to the large scale death of larvae. Irrigation of the plant and ratoon cane fields ensured that moisture was not a limiting factor to the survival of the larvae. The marked difference in larval pressure between plant fields (mean of 0,70 larvae/hole) and ratoon fields (3,05 larvae/hole) does, however, imply a measure of control on the former. Visual observations behind land preparation operations on former fallow lands in April/May 1993 showed larvae being exposed to the soil surface, where they were subject to damage by implements, desiccation and/or bird attack. Field observations have again shown that the *H. licas* larvae have a pre-pupal stage which is confined to earthen cells over the period July to September. Destruction of these cells by ploughing exposes the pre-pupae to desiccation, which is exacerbated by the low soil moisture levels at that time of the year.

Chemical control at planting

Chemical control at planting is achieved by placing suSCon Green, a 10% controlled release formulation of chlorpyrifos, into the open furrows at a rate of 30 kg/ha (Cackett, 1992). Two hoppers are mounted on a tractor tool bar to feed four cane lines. Accurate application (29,5 to 30,5 kg/ha) is ensured through a series of specific gears linked to each other by a chain, which is driven by a spiked land wheel positioned at the rear of the machine. The implement can support nine planting gangs (72 to 81 labour units), and can cover an area of 4,0 ha/day. No large scale work has yet been carried out on the estate to evaluate the success of this control method against *H. licas* larvae. Trials conducted by the Zimbabwe Sugar Association Experiement Station at Triangle, Hippo Valley Estates and at the Station itself have, however, shown significant levels of control (Cackett, 1992). suSCon Green is an expensive insecticide at Z$115/kg, which translates to Z$1 150/ha/year over three years. Selection of fields for suSCon Green application therefore requires careful consideration and is based on a combination of the following three criteria: (1) larval counts in the last ratoon crop before plough-out, with anything above four larvae/hole being considered serious, (2) correspondingly high adult populations from October confirmatory scouting and (3) the intended time of harvest for the next three years. Late harvest fields provide preferred breeding grounds for the adults and are therefore considered for suSCon Green application at planting, even if the previous ratoon crop had low pest activity. Based on these criteria, the first 285 ha were planted in 1994-95, starting from August 1994 and using the tractor mounted 'suSCon rig'.

Chemical control in ratoon cane

The average field at Triangle is cropped for eight to 10 years before plough-out. However, suSCon Green applied at planting is effective for only the first two ratoons. Such cane comprises about 30% of the cropped area, and *H. licas* control in the older ratoons is therefore a problem. Control programmes are tailored around the period of adult emergence (from October to February) and the residual activity period of the chemical in use. Fields having high larval counts are re-scouted in October prior to adult emergence. The final decision on whether or not to apply a chemical is based on the adult count from this second scouting.

Accurate identification at the larval stage requires patience and an experienced eye. The presence of other white grubs in the field can result in incorrect identification. Mortality between the larval and adult stages is also accounted for through re-scouting. Results from the larval scouting are therefore used primarily as an 'early warning' on the likely adult pressure in the following summer. The adult, which is easier to identify, provides a more accurate and reliable measure of the pest levels just before control measures are required on ratoon cane. On the 438 fields (5 165 ha) scouted from April to July 1995, a mean count of 2,85 larvae/hole was obtained. The same fields, re-scouted from October to early December 1995, showed a mean count of 0,53 beetles/hole (Table 2b). A threshold of one adult/hole is used for applying an insecticide. Using this threshold and the re-scouting results, the area requiring insecticide application in 1995 dropped from 2 765 ha to 870 ha and resulted in a saving of Z$240 000.

Dursban (a 48% emulsifiable concentrate of chlorpyrifos) is applied at one litre product/ha (Cackett, 1994) to all fields cut from October to December, with beetle counts of one or more/hole. If a field with a high count does not fall into the late season harvesting category, an adjacent (late cut) field is sprayed in anticipation of beetle flights from this cane. The chemical is applied when the field is dry enough for tractor movement following the first post-harvest 'field capacity' irrigation. Soil incorporation is achieved with a series of gang tillers mounted on a tractor drawn bar. The insecticide provides 'several weeks of control' (Thomson, 1992). The Zimbabwe Sugar Association Experiment Station is currently screening alternative short residual chemicals to reduce dependency on chlorpyrifos, the active ingredient of both Dursban and suSCon Green.

Conclusion

The behaviour of *H. licas* in the sugarcane fields at Triangle is now fairly well understood, mainly as a result of the ongoing training programmes, annual larvae and adult pest population assessments and analyses of catches from the ultraviolet light traps. Scouting for larvae has been carried out on at least 70% of the area under sugarcane in each year from 1990 to 1995 with the exclusion of 1992, when irrigation was withdrawn from the estate because of the serious drought of 1991-92. The 94% decline in adult catches in ultraviolet light traps between the 1991-92 and the 1993-94 seasons showed that adverse conditions (in this case restricted soil moisture) can be used to reduce *H. licas* populations. The need for rapid crop re-establishment following the droughts of 1992 and 1995 made it impossible to effectively implement the ploughout component of the strategy in controlling black maize beetle. Crops on fields with known high pest levels have not been eradicated because the main objective has been to recover productivity. The massive replanting programmes have, however, reduced the estate average ratoon stage from 7,2 in 1991 to 1,1 in 1995. The positive effect of this was shown in the relatively low count of 0,53 beetles/hole in the survey carried out on 5 165 ha (46% of the area under cane) from October to December 1995).

Control of the pest in ratoon crops through short residual insecticide applications appears to be the 'weak link' in the strategy in the long term. It may be necessary to review plough-out policies (aim for shorter ratooning cycles) depending on the pest's resurgence. The current cost of short residual insecticides, at over Z$100/ha for a few weeks of control, is another major consideration. Ultraviolet light traps appear to offer the most promising and cost effective long term solution to the control of *H. licas* on sugarcane fields in Zimbabwe's south-eastern lowveld.

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