

\* DIFFERENCES IN SUSCEPTIBILITY OF TEA CLONES  
IN CEYLON TO THE SHOT-HOLE BORER BEETLE,  
*XYLEBORUS FORNICATUS* EICHH.  
(COLEOPTERA: SCOLYTIDAE)<sup>1</sup>

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*Xyleborus fornicatus*, the shot-hole borer beetle of tea is a serious pest of the crop in Ceylon. However, tea plants raised vegetatively from various clones, show various degrees of susceptibility and/or tolerance to the borer beetle infestation. This has been investigated for the last five years and the results from five experiments, dealing with 77 different 'types' of tea plants, are reported here.

Tolerance to borer infestations is only one desirable quality of tea clones; and such tolerant clones have also to be high yielding clones, which are able to resist drought conditions as well and produce a manufactured tea of good quality. A list of the graded characteristics of the 77 'types' of tea plants is provided. It is shown, conclusively, that TRI 2023 and DG 39 are the best clones, and clone W 3 shows promise, in respect of their high degree of tolerance to the borer beetle, and also possess the other desirable characteristics, for their propagation in the mid-country tea districts of Ceylon.

## INTRODUCTION

### The crop

The tea plant, *Camellia sinensis*, is extensively cultivated in Ceylon, where the plantations have an interesting history of over hundred years (Forrest 1967). Eden (1958) gives a detailed scientific account of the cultivation of tea. At present, tea is mostly cultivated vegetatively, and plants raised from the various stocks are called 'clones'. The crop is subjected to a large number of insect pests (Cranham 1966), of which one of the most serious is the beetle stem borer, *Xyleborus fornicatus* Eichh. (Coleoptera: Scolytidae), commonly known as the Shot-hole Borer, so called because the openings to the galleries in tea stems appear like holes made with a shot-gun.

### The pest

*Xyleborus fornicatus*, the shot-hole borer beetle of tea is an ambrosia beetle and causes damage to the tea plant by the construction of galleries in tea stems to cultivate the fungus, *Monacrosporium ambrosium*. The construction of galleries primarily causes, the branches to break, affecting the yield. The more serious damage occurs secondarily when the damaged stems suffer from wood-rot, which ultimately

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<sup>1</sup> This paper was presented in commemoration of the sixty fifth Birthday of Prof. Dr. D. G. WELLENSTEIN.

\* Reprinted by courtesy of Zeitschrift für angewandte Entomologie, Verlag Paul Parey, Hamburg, West Germany. Sonderdruck aus Bd. 68 (1971) 3, 300-307.

results in the die-back of the affected branches, and finally the deterioration of the whole tea bush itself. Although research into this beetle pest has gone on for over 60 years, to-date, there appear to be no suitable control methods for the pest. Dieldrin at one time appeared to be the solution, but soon led to adverse effects of 'pest imbalances', in that, although it was useful in controlling the beetle pest, it resulted in the infestations of other caterpillar pests, by destroying the beneficial parasites of these pests (Danthanarayana 1966).

### Clonal selection

The screening of tea clones with the hope of finding plants resistance of the pest appeared at first discouraging, as most of the high yielding clones were very susceptible to the pest. Calnaido and Kanapathipillai (1967), working with 32 clones, were the first to show that there were high yielding clones that were resistant to the beetle. Thirugnanasuntharan and Calnaido (1968, 1969) followed up this work with additional clones and produced comparative lists of tea clones, in respect of their tolerance to the borer beetle and also the known characteristics of yield, manufactured quality of tea, and the drought resistance of the plants.

This paper deals with the overall picture of five years of investigations, where the results of five different experiments are evaluated together, in respect of 74 clones and 3 seedling plants (77 "types" of tea plants). The previous lists of clones, in order of their merits, have been revised and the best clones, for growing in the mid-country tea districts of Ceylon, are advocated.

## MATERIALS AND METHODS

Five experiments, on the randomized block design, including 74 clonal tea plants and 3 seed tea plants, listed in table I, were laid out at Kandy at the Mid-Country Station of the Tea Research Institute of Ceylon, at an elevation of about 800 metres. The experiments were labelled MVP 1 to 5, meaning Mid-Country Vegetative Propagation experiments. The plants were distributed in the experiments as follows:

Experiment No.	Year of Planting	Number of Clonal Types
MVP 1	1961	12
MVP 2	1962	16
MVP 3	1963	12
MVP 4	1964	16
MVP 5	1965	5

The four replicated plots in each experiment has 36 tea plants of one clonal type, planted in six rows at spacing 0.6 m in the row and 1.2 m between rows. Of the four replicated blocks two were planted with *Glicidia* shade trees and the other two were unshaded.

The degree of borer infestations in the plots of the different types of clonal plants were assessed by two methods, (a) branch breakages, *i.e.* the periodic observations on the number of branches that break, when they are bent, due to the borer galleries, and (b) the detailed examinations of 25 entire branches for borer galleries at pruning time, when once in three years the bushes are cut back to a height of 0.5 metre. The mean weights of all prunings per 10 bushes per plot, and the mean weights of samples of 25 branches per plot, were also recorded, and these values were used to make corrections for the variations in the number of branches per bush in the different clones.

TABLE 1 — *List of clones in MVP (1–5) Experiments*

Origin	Label of clone
Tea Research Institute	777, 1114, 1530, 2016, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2039, 2043, 2045, 2046, 2151
Balangoda	MT/BG, DG 39, BG (MT) 18, DG 3, DG 7
Cannavarella	CV4B1, CV5B1, MG3B1, NK4B29
Carolina	CAR7/10
Concordia	C 34
Craig	CR 4
Craighead	CH 13
Dambatenne	DA1408
Diyagama	DN, D, DG
Diyaniakelle	DK 17
Downside	DW 12
Drayton	DT 1
Endana	EN 31
Gonamotawa	GMT 9
Helbodde	H6A1, H 1/58
Karapincha	KP204
Kenilworth	KEN 15/7, KEN 16/3
Kirkoswald	K 136, K 150
Liddesdale	LD 999
Mincing Lane	ML 7
Mooloya	MO 114, MO 116, MO 146, MO 208, MO 241
Moray	MG
Nayabedde	N 3
Neluwa	NL 3/1, NL 4/2
Ottery	OT 5/8
Passara	MPA 1, PAS 22
Pitakande	W 2/145
Poonagala	PLLG 2, PCG 2
Poronuwa	PO 26
Queenstown	QT 1/5, QT 4/4
Talankande	TK 48
Tangakelle	CY 9, TGK 2, E 7/27
Thotalagala	T 5/3, T 5/35
Uva Highlands	UH 9/3
Wooton	W 3
<i>Seedlings</i>	
Tea Research Institute	Seed
Illuktenne	Seed ILL
Lansdowne	Seed LDC

## RESULTS

### Tolerance and susceptibility of clones to borer infestations

The inherent degrees of tolerance or susceptibility of the different types of clones to borer infestations were evident by the intensity of the galleries in the tea stems, and is shown in Table 2.

TABLE 2 — Shot-hole borer attack on 81 clones of the experiments MVP 1, MVP 2, MVP 3, MVP 4 and MVP 5 as measured by the total number of galleries in pruned branches

Clone	Experiment (MVP)	Total No. of galleries per 25 pruned branches per plot in prunings	Clone	Experiment (MVP)	Total No. of galleries per 25 pruned branches per plot in prunings
OT 1/5	1	13.75	CH 13	2	65.75
LD 999	5	19.25	CV4B1	1	68.50
TRI 2023	1	19.50	EN 31	1	68.75
NL 4/2	1	20.00	D	2	69.25
Seed ILL	4	21.50	TRI 2021	3	73.00
QT 4/4	4	22.50	TGK 2	3	76.50
MO 241	4	24.00	W 2/145	3	77.25
1530	4	26.75	Seed	1	78.75
MO 208	4	29.00	TRI 2046	3	83.25
PLLG 2	4	29.00	TRI 777	1	85.25
C 34	5	29.00	KEN 15/7	1	88.75
MO 146	4	30.00	TRI 2026	1	88.75
TRI 1114	4	30.25	DG	3	90.25
PCG 2	4	30.25	KP 204	2	90.75
DK 17	5	33.00	DG 7	3	91.25
MO 114	4	33.50	TRI 2020	2	91.50
DN	1	34.50	GMT 9	1	91.75
BG 18	1	36.00	PO 26	1	92.00
MO 116	4	36.75	CY 9	1	95.00
MT/BG	1	39.00	K 136	1	95.00
TRI 2024	4	39.50	KEN 16/3	1	96.75
DA 1408	5	39.50	TRI 2045	3	96.75
H 1/58	4	42.75	TRI 2022	2	104.50
ML 7	3	44.25	TRI 2024	3	106.50
T 5/35	1	44.50	TRI 2043	2	109.00
OT 5/8	2	45.50	N 3	2	115.25
MPA 1	2	50.00	TK 48	1	119.00
MG	2	51.25	TRI 2024	1	121.75
DW 12	4	51.25	CV5B1	1	122.50
TRI 2024	5	51.50	CR 4	1	127.50
W 3	3	54.50	TRI 2039	2	128.00
UH 9/3	1	55.25	TRI 2024	2	128.25
PAS 22	1	56.50	DT 1	1	134.75
DG 39	1	56.50	MG3B1	2	136.25
K 150	1	58.25	TRI 2151	1	136.50
DG 3	3	60.75	TRI 2027	1	138.25
Seed LDC	4	61.75	T 5/3	1	147.50
CAR 7/10	4	62.50	NL 3/1	1	174.00
NK4B29	2	63.75	TRI 2025	1	200.50
E 7/27	3	64.50	TRI 2016	2	204.50
			H6A1	2	—

LSD at P = 0.05 = 50.04  
P = 0.01 = 65.87  
P = 0.001 = 83.99

The intensity of infestation varied from a rate of one borer-gallery in two, branches, in clone QT 1/5, to 8 galleries in one branch, in TRI 2016 and TRI 2025 clones.

## The effect of shade on borer infestations

Conflicting evidence on the effect of shade on infestation was obtained from the different experiments, MVP 1 to MVP 5, and it is not clear whether shaded conditions in the crop do or do not encourage borer infestations (Table 3). Further, although the galleries made in tea stems healed, by the formation of a callus plug to the entrance of the galleries, at a constant rate in the different clones (Table 4), the evidence on the influence of shade on the healing of galleries in the same clones, was conflicting (Table 3).

TABLE 3—*The effect of shade (and no shade) on (a) yield (b) shot-hole borer infestations and (c) the ability of galleries to heal in clones*

Experiment	No. of Clones	Pruning Cycle	a. Yield (Kg made tea/ hectare/year)		b. No. of galleries/ 25 branches		c. % healed galleries	
			Shade	No Shade	Shade	No Shade	Shade %	No Shade %
MVP 1 (1)	32	1963-66	1529	1893**	97	78**	87***	81
MVP 1 (2)	32	1966-69	2178**	1943	53	52	86	89**
MVP 2 (1)	16	1964-67	1141**	862	84*	110	85	87
MVP 2(2)	16	1967-70	1738*	1511	39*	51	59	61
MVP 3	12	1965-68	1430**	1165	91	63***	79	78
MVP 4	16	1966-69	787	1244***	33	38	80	81
+ MVP 5	5	1967-70	—	656	—	35	—	72

+ - No difference of Shade and No Shade in MVP 5; all plots are unshaded

\*\*\* Significant at  $P < 0.001$

\*\* Significant at  $P < 0.01$

\* Significant at  $P < 0.05$

TABLE 4—*The levels of significant differences among clones of MVP experiments in (a) yields, (b) shot-hole borer infestations, (c) rate of healing and (d) drought resistance*

Experiment	No. of Clones	Pruning Cycle	a. Yield	b. Shot-hole borer infestation	c. Rate of healing	d. Drought resistance
MVP 1 (1)	32	1963-66	***	***	NS	***
MVP 1 (2)	32	1966-69	***	***	NS	***
MVP 2 (1)	16	1964-67	***	***	*	***
MVP 2 (2)	16	1967-70	***	***	NS	NS
MVP 3	12	1965-68	***	*	NS	***
MVP 4	16	1966-69	**	***	NS	*
MVP 5	5	1967-70	*	**	NS	NS

\*\*\* Significant at  $P < 0.001$

\*\* Significant at  $P < 0.01$

\* Significant at  $P < 0.05$

NS = Not significant

## The characteristics of clones

In the cultivation of tea clones, the degree of borer tolerance or resistance is only one desirable character; although an important one, and this has to be taken into account only in conjunction with the other characteristics of yield; the quality of the manufactured tea (Kirtisinghe *et al.* 1968 and Kirtisinghe 1969), and the ability of the clones to resist drought conditions, an important character in the climatic conditions prevailing in the Mid-Country of Ceylon, in Table 5 the clones are arranged

in order of merit of yields in kilograms/hectare in comparison with the characteristics of borer tolerance or resistance, drought resistance, and the quality of made teas of the different types of clones. This table reveals the several suitable clones for production in the mid-country districts of Ceylon. The best clones are TRI 2023 and DG 39, while clone W 3 appears to be a very promising one.

TABLE 5 — Characteristics of clones grown at the TRI Mid-Country Station — 1970

Clone (in order of merit of Yield)	Experiment No. MVP	Drought resistance	Shot-hole borer tolerance	Quality group after Kirtisinghe (1968-1969)
TRI 2023	1	*	****	3
TRI 2026	1	—	*	5
TRI 2025	1	***	—	4
DG 39	1	**	***	3
TRI 2151 (> 2500 Kg/ha)	1	*	—	3
KEN 16/3	1	*	*	3
TRI 2027	1	**	—	3
T 5/35	1	*	***	—
MT/BG	1	**	***	4
BG (MT 18)	1	**	***	4
NL 3/1 (> 2000 Kg/ha)	1	**	—	3
TRI 2024	1	*	—	3
TRI 2021	3	***	*	3
DG 7	3	****	—	3
DT 1	1	****	—	1
TRI 2024	3	**	—	3
K 136	1	*	**	3
KP 204	2	—	**	3
GMT 9	1	*	**	—
DN	1	****	***	3
PCG 2	4	**	***	—
MPA 1	2	**	***	2
W 3	3	****	**	1
TRI 2024	2	*	—	3
NK4B29	2	****	**	3
LDC Seed	4	**	**	—
QT 1/5	1	*	****	4
DG 3	3	***	**	—
PAS 22 (> 1500 Kg/ha)	1	—	**	5
POR 26	1	—	**	3
W 2/145	3	*	*	3
T 5/3	1	*	—	5
E 7/27	3	**	**	3
EN 31	1	**	**	3
H 1/58	4	**	***	—
MO 116	4	*	***	3
TRI 2024	4	**	***	3
TRI 2043	2	*	*	5
TK 48	1	***	**	3
KEN 15/7	1	***	**	3
DW 12	4	**	**	—
UH 9/3	1	—	***	4
Seed	1	*	**	5
TRI 2022	2	—	*	3
NL 4/2	1	—	****	1
TRI 1114	4	*	***	5
QT 4/4	4	**	****	4
TRI 2016	2	**	—	3
CY 9	1	***	**	5
TRI 2046	3	**	*	5
K 150	1	—	***	3
CH 13	2	***	***	3
MG3B1	2	*	*	3
DG	3	****	*	3
TRI 777	1	**	***	1

Continuation of Table 5

Clone (in order of merit of Yield)	Experiment No. MVP	Drought resistance	Shot-hole borer tolerance	Quality group after Kirtisinghe (1968-1969)
CV5B1 (> 1000 Kg/ha)	1	****	*	4
TRI 2024	5	—	**	3
TGK 2	3	****	*	—
TRI 2045	3	*	—	—
PLLG 2	4	***	***	—
CR 4	1	***	*	4
N 3	2	***	*	3
TRI 2039	2	***	*	—
MO 208	4	***	***	3
MO 241	4	**	****	2
ILL Seed	4	**	****	—
MG	2	*	***	—
LD 999	5	—	****	—
CAR 7/10	4	**	**	3
D	2	***	***	3
CV4B1	1	****	***	3
TRI 1530	4	*	****	3
DA 1408	5	**	***	—
C 34	5	*	***	4
DK 17 (> 500 Kg/ha)	5	*	***	2
MO 146	4	**	***	4
MO 114	4	**	****	3
ML 7	3	**	***	—
TRI 2020	2	****	***	3
OT 5/8	2	****	****	—
H6A1	2	**	—	—

	Score	Galleries
Excellent	****	> 80 %
Good	***	< 20 %
Moderate	**	< 40 %
Poor	*	< 60 %
Very Poor	—	< 80 %
		> 80 %

### Discussion

*Xyleborus fornicatus*, the shot-hole borer beetle of tea, appears to have adapted itself to live breed in the tea plant (Schedl 1959), and is a serious pest of tea in Ceylon, Taiwan and South India. It has however several alternate host plants, some of which belong to the group of shade trees grown in tea plantations, and Danthanarayana (1968) listed 99 host plants in all. Therefore, it is all the more interesting that even within the one species of host plant, tea, *Camellia sinensis*, of which the beetle borer is a serious pest, the beetle shows preference in the selection of the 'type' of tea plant or clone.

To-date, there is no explanation as to the cause of this selection of clonal tea by the borer. At first it was thought that all high yielding clones will have heavier borer infestation, on account of their rich vegetative growth, but now it is known that this is no longer generally applicable, and that a very high yielding clone like TRI 2023, is very resistant to the borer. Again, it was thought that high applications of nitrogen to tea increased borer infestations, and heavy doses of potassium diminished borer infestations, but results coming in from the Extension Experiments do not support this view (Calnaido 1971). Investigations are underway to determine the physiological or bio-chemical character or characters that make the tea clones susceptible or tolerant to the borer infestations, with the hope that this knowledge will be useful in the search for safe control measures for this beetle pest.

## ACKNOWLEDGMENTS

Work on this publication was partly completed, while I was a recipient of a Senior Research Fellowship by the Alexander Von Humboldt-Stiftung of Western Germany, at the "Institute für Pflanzenkrankheiten" of the University of Bonn and the "Forstzoologisches Institut" of the University of Freiburg. I wish to gratefully acknowledge the award from the Foundation and the facilities made available to me at these Institutes.

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