FEEDING, GROWTH AND SURVIVAL OF THE BLACK FIELD CRICKET, *TELEOGRYLLUS COMMODUS*, ON POTENTIAL MODEL PLANTS FOR GENETIC TRANSFORMATION

E.P.J. BURGESS¹, P.S. STEVENS¹, L.L. BEUNING²,
J.T. CHRISTELLER² and W.A. LAING²

¹DSIR Plant Protection, Private Bag, Auckland

²DSIR Fruit and Trees, Private Bag, Palmerston North

SUMMARY

A range of genetically transformable plants were tested for their suitability as model plants for determining resistance gene activity against the black field cricket (*Teleogryllus commodus*). Feeding, survival, growth, and development were measured for crickets fed on selected plants, an agar-based artificial diet containing casein, and a water-only control. Of the seven plant cultivars offered to crickets in this study, both white clover (cv. Grasslands Huia) and tomato (cv. Russian Red) allowed sufficient survival and growth to be useful as model plants although neither was as nutritious as the artificial diet.

INTRODUCTION

Research is under way to find protease inhibitors which have a toxic or anti-metabolic effect on the black field cricket, *Teleogryllus commodus* (Walker) (Orthoptera: Gryllidae) a significant pest of pasture in northern New Zealand (Blank 1982) and the southern states of Australia (Williams *et al* 1982). The genes for effective inhibitors will be isolated, cloned, and inserted into the genomes of pasture plants to confer resistance. Initially, potentially active protease inhibitors were identified by *in vitro* determination of their binding with gut enzymes (Christeller *et al* 1990). The effects of protease inhibitors on cricket growth were then determined by incorporating the inhibitors into artificial diet and allowing crickets to feed on this (Burgess *et al* in prep.). A genetic transformation system for white clover has been developed, but not yet refined (White and Greenwood 1987), and research on transforming ryegrass is still in the very early stages (T. Connor, D. White pers. comm.). As rapid transformation systems for these "target" pasture plants are not yet available, other, more readily transformed "model" plants provide the only system for testing and optimisation of the expression and activity of the resistance gene constructs inserted into plants. This paper reports a study designed to identify genetically transformable plants which could be used as models for cricket resistance.

METHODS AND MATERIALS

Three week old cricket nymphs were obtained from a laboratory-reared colony, and fed either tomato (*Lycopersicon esculentum* Mill., cv. Russian Red), *Arabidopsis thaliana* L. (cv. Columbia), *Petunia x hybrida* (cv. Fluffy Ruffles), *Petunia axillaris* x (*P. axillaris* x *P. hybrida*) (cv. Mitchell), pepino (*Solanum muricatum* Aiton, cv. El Camino), white clover (*Trifolium repens* L., cv. Grasslands Huia), tobacco (*Nicotiana tabacum* L., cv. Brazilian Blend), agar-based artificial diet containing 2% casein w/v (Malone and Wigley, in press) or water only. Each nymph was individually confined within a tissue culture dish, 85 mm diameter by 23 mm depth, and was fed exclusively with one type of food throughout the experiment. Each dish was lined with a water-sprayed 70 mm diameter filter paper disc (Whatman 2) and fresh plant leaf or artificial diet was placed on the disc, with the exception of the water-only control. Twenty-five crickets were tested for each treatment except where the supply of plant material was limited, i.e. arabidopsis (N = 10), petunia cv. Mitchell (N = 15) and pepino (N = 15).

Proc. 43rd N.Z. Weed and Pest Control Conf. 1990: 352-355

Survival and feeding level were recorded for each individual at 2-day intervals, and crickets were transferred to a clean dish with fresh food. An estimate of level of consumption of each type of leaf was obtained by providing crickets with approximately 60 mm² of leaf material and recording area eaten at the end of each 2-day interval on a scale from 0 to 5 as follows; 0 = 0%, 1 = 1 to 24%, 2 = 25 to 49%, 3 = 50 to 74%, 4 = 75 to 99%, 5 = 100%. As crickets feeding on clover grew so large that they were frequently consuming all leaf material, a further 30 mm² was provided after 22 days, and those eating more than 60 mm² were scored in category 5. Crickets were weighed initially and at 7 day intervals until death.

RESULTS

Fig. 1. shows, for each plant type, the frequency with which each consumption level was recorded throughout the experiment. The order of plant preference, based on amounts of leaf consumed, was; arabidopsis, clover, tomato, tobacco, pepino, petunia (cv. Mitchell), petunia (cv. Fluffy Ruffles).

Fig. 1: Cricket feeding on genetically transformable plants. Petunia (a) = cv. Fluffy Ruffles, Petunia (b) = cv. Mitchell.

Arabidopsis was most voraciously consumed, with 71% of scores at level 5. On clover, only 21% of scores were at level 5, but a further 48% occurred at levels 3 and 4. Feeding on tomato was moderate, with 38% of scores being at levels 3, 4 and 5. Tobacco and pepino were not particularly favoured with 27% and 21% of scores respectively, at levels 3, 4 and 5, and with only 1% and 0% at level 5. Petunias (both cultivars) were least favoured, with no scores at level 4 or 5, and most scores at levels 0 and 1.

Crickets provided with no food died within 14 days, and survival was not improved for crickets on pepino or either petunia cultivar (Fig. 2). Survival was little better on arabidopsis and tobacco, with crickets offered these plants surviving for a maximum of 22 and 26 days respectively, and severe mortality beginning after 14 days. On tomato, survival was high over a 7 week period, and some individuals were alive after 66 days.

Fig. 2: Cricket survival on a range of foods. Petunia (a) and (b) as for Figure 1.

Clover was the best host plant in terms of survival, with mortality beginning after 5 weeks, and continuing over the following 9 weeks. Artificial diet was nutritionally better than clover, resulting in high survival for 10 weeks, then rapid mortality over the following 3 weeks.

Nymphal growth rates were determined only for crickets provided with either clover, tomato or artificial diet as these were the only three foods which enabled a high level of survival beyond 3 weeks. On artificial diet, growth of nymphs was exponential, and slower weight gain continued in adults (Fig. 3). There was little difference between growth of crickets eating clover and those eating tomato. Growth on either plant was slower than on diet (Fig. 3).

Relative growth rate is the rate of change of weight relative to the weight at the beginning of a time period. This is the change in log weight (mg) divided by time (weeks), a term inversely related to the time taken for weight to double. The growth rate has units of $\text{g/g/week} = \text{week}^{-1}$. The relative growth rate for nymphs eating diet was 0.32 week^{-1} (s.d. = 0.011). Lower rates were found on both clover, with a rate of 0.18 week^{-1} (s.d. = 0.011), and tomato, on which the rate was 0.19 week^{-1} (s.d. = 0.016).

On diet, 95% of the 3-week old nymphs survived to become adults, taking a mean of 49 days (s.d. = 6.9). Development to adulthood on clover was slower ($P < 0.001$), taking 60 days (s.d. = 6.1), and only 29% of the crickets survived to this stage. On tomato only 9% of crickets survived to become adults, taking 56 days (s.d. = 5.7).

DISCUSSION

Of the genetically transformable plants offered to crickets in this study, both white clover and tomato enabled sufficient survival and growth to be useful as host plants for testing resistance gene activity. Cricket survival was not clearly related to the level of consumption of plant material, suggesting the operation of a number of interacting factors. Feeding level and survival were very low on both varieties of petunia, suggesting feeding deterrence and starvation or strong toxicity. On tobacco and pepino, feeding was low to moderate and survival low, possibly reflecting either the presence of a toxin or the absence of an essential nutrient. Feeding level was very high on arabidopsis while survival was low, indicating the presence of a feeding stimulant and either a toxin or a lack of an essential nutrient. Moderate to high levels of feeding on

Fig. 3: Cricket (nymphs and adults) weight gain on artificial diet, clover and tomato.

clover corresponded to good survival, while somewhat lower feeding on tomato resulted in reduced longevity. The low proportion of successful development to adulthood even on clover, a known host plant, may well reflect the fact that crickets in the field are able to fulfil their dietary requirements by feeding on a range of plants. Crickets are known to prefer ryegrass to white clover in the field (Blank *et al* 1980).

ACKNOWLEDGEMENTS

The authors wish to thank Ross Atkinson and Peter Workman for contributing plant material for this study.

REFERENCES

- Blank, R.H., 1982. The pest status of *Teleogryllus commodus* in New Zealand. (K.E. Lee, ed.) South Australian Government Printer, Adelaide. *Proc. 3rd Australasian Conf. Grassland Invert. Ecol.*
- Blank, R.H., Olson, M.H., Cox, N.R. and Bell, D.S., 1980. Black field cricket (*Teleogryllus commodus*) food preferences between sixteen pasture species. N.Z. J. Agric. Res. 23: 409-415.
- Christeller, J.T., Laing, W.A., Shaw, B.D., and Burgess, E.P.J., 1990. Characterisation and partial purification of the digestive proteases of the black field cricket, *Teleogryllus commodus* (Walker): Elastase is a major component. *Insect Biochemistry* 20: 157-164.
- Malone, L.A. and Wigley, P.J. A practical method for rearing Argentine Stem Weevil *Listronotus bonariensis* (Coleoptera: Curculionidae) in the laboratory. *New Zealand Entomologist*. In press.
- White, D.W.R. and Greenwood, D., 1987. Transformation of the forage legume *Trifolium repens* L. using *Agrobacterium* vectors. *Plant Molecular Biology* 8: 461-469.
- Williams, P., Stahle, P.P., Gagen, S.J. and Murphy, G.D. 1982. Strategies for control of the black field cricket, *Teleogryllus commodus* (Walker). (K.E. Lee, ed.) South Australian Government Printer, Adelaide. *Proc. 3rd Australasian Conf. Grassland Ecol.*