Growth of Koster's curse (*Clidemia hirta*) from seedlings to reproductive maturity and following mechanical damage

Michael F. Graham, Katie A. Patane and Stephen D. Setter
Biosecurity Queensland, Department of Primary Industries and Fisheries, PO Box 20, South Johnstone, Queensland 4859, Australia
Email: stephen.setter@dpi.qld.gov.au

Summary Koster's Curse (*Clidemia hirta* (L.) D. Don) is a highly invasive shrub which has the potential to become a major weed in many parts of Queensland and elsewhere in Australia. *C. hirta* is perennial, can grow to 5 m in height and mature plants are capable of producing in excess of 500 berries annually which are dispersed by birds and water. This study quantified growth, as well as the effects of damage on survival and time to reproduction of *C. hirta*, under environmental conditions experienced in the Wet Tropics of North Queensland. Studies were conducted under both field and shade house conditions. Following damage, plants were capable of setting seed in as few as 86 days and 194 days for plants cut at 10 cm and 0 cm respectively, by which stage they had recovered to the size at which they were prior to being cut.

Keywords *Clidemia hirta*, growth, north Queensland, damage.

INTRODUCTION

Clidemia hirta (L.) D. Don (Koster's curse) is a highly invasive perennial shrub which can grow to 5 m in height depending on the environment. Mature plants are capable of producing in excess of 500 berries annually (Smith 1993, DeWalt 2003) with individual fruit containing up to 900 seeds that remain viable for up to four years (DeWalt *et al*. 2004). When ripe, the berries are readily eaten and dispersed by birds (Smith 1993, Wagner *et al.* 1999, Department of Natural Resources, Mines and Energy 2004).

At present only one infestation of *C. hirta* is known to exist in Australia, near Julatten in far North Queensland. This species has the potential to become a major weed along the humid coastal areas of the Northern Territory, well-watered areas of the east coast of Queensland and the far north coast of New South Wales. If established in these areas *C. hirta* could form dense thickets that smother plantations, pastures and native vegetation and it has the potential to cause millions of dollars worth of damage to primary production (Peters 2001). *C. hirta* is a Class 1 Weed under the *Land Protection (Pest and Stock Route Management) Act 2002* and is subject to an eradication program managed by Biosecurity Queensland under the Four Tropical Weeds Eradication Program.

Seedling survival and age to reproduction are important management considerations, as are survival and recovery time following damage, since they determine the period between follow-up control activities to ensure re-infestation does not occur. This paper reports the results of a study which quantified the age and plant size at reproduction in the field and the shade house. It also reports the effect of damage (i.e. removal of above ground vegetative material, simulating incomplete hand removal) at reproductive maturity on plant survival, regrowth and time to reproduction.

MATERIALS AND METHODS

Field observations were made at Julatten (16°36'S, 145°20'E) which has an elevation of 426 m and an annual mean precipitation of 1442 mm. The shade house study was located at the DPI&F research station in South Johnstone (17°36'S, 145°59'E), elevation 25 m.

In order to determine growth and response to damage, 200 newly emerged seedlings were tagged in the field and 40 seedlings were transplanted into eight inch pots filled with garden soil for the shade house component of the study.

Field plants Field plants were visited monthly and measurements of height, basal diameter and initiation of flowering were recorded. During these visits any other weeds growing up and around the *C. hirta* were foliar sprayed with glyphosate. Plants were removed on the commencement of flowering so they would not fruit and add seed to the soil seed bank. Height, canopy diameter, basal diameter, number of flowers and leaves, and wet and dry weights were recorded for the removed material.

Shadehouse plants The shade house plants were watered to field capacity via an automated irrigation system twice a day and fertilised using 10 g of Osmocote® to provide optimum growing conditions. Once plants reached reproductive maturity, data was taken on height, canopy diameter, basal diameter and the number of leaves, flowers, immature fruit, and mature fruit. Subsequently half the plants were cut at ground level and the remainder at 10 cm from the soil surface,

simulating incomplete hand removal, so the response to damage could be observed. Wet weight and dry weights were taken for removed material.

Cut plants were kept under the same conditions as stated previously and were fertilised for a second time using 10 g of Osmocote. Plants were monitored, and measurements of survival, time to flowering and time for fruit to reach maturity were recorded. Once fruit had matured, measurements of height, width, basal diameter and the number of stems, leaves, flowers, immature and mature fruit were recorded. Plants were then cut at ground level and wet and dry weights were taken for the removed material, and the remainder of the plant was destroyed.

RESULTS

Growth of *C. hirta* from seedling to flowering at the Julatten infestation Both plant height and basal diameter were linearly related to plant age (Figures 1 and 2).

These relationships could also be expressed in a form whereby height and basal diameter could be utilised as predictors of plant age:

$$A = 6.0168 \times H$$

where A = age (in days) and H = height (in cm), and

$$A = 64.935 \times BD$$

where BD = basal diameter (in mm).

Growth, survival and time to reproduction of *C. hirta* under shade house conditions following cutting Survival rates were high post damage, averaging 95% and 89.5% for plants cut at 0 cm and 10 cm, respectively. Plants cut at both heights vigorously re-shot, displaying greater dry weight, height, canopy diameter and number of leaves than uncut plants (Table 1). The minimum time to flowering for plants cut at 10 cm was five days, and on average plants flowered after 176 days. The minimum time taken to produce mature fruit was 86 days, and the average 227 days. The minimum time to flowering for plants cut at 0 cm was 194 days, and on average plants flowered after 263 days. The minimum time taken to produce mature fruit was 294 days; an average time to produce mature fruit was not able to be calculated at time of writing, as some plants had not reached maturity.

DISCUSSION

The relationships between age and height and basal diameter provide eradication teams with a means to estimate the ages of plants present in the vicinity of the Julatten infestation. The ability to estimate a plant's

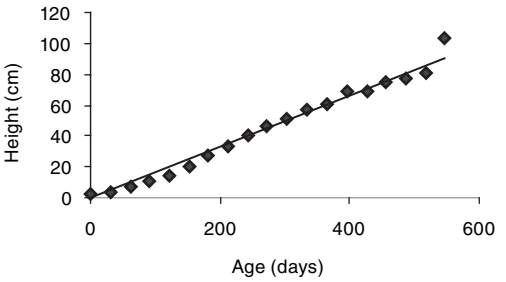

Figure 1. Relationship between average height and plant age, at Julatten.

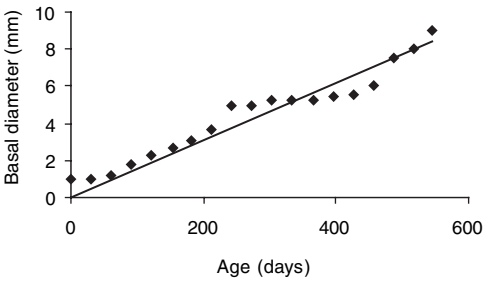

Figure 2. Relationship between average basal diameter and plant age at Julatten.

Table 1. Minimum time to fruiting and average plant size at time of fruiting before and after damage.

	Before damage	Cut at 0 cm	Cut at 10 cm
Minimum time to fruiting (days)	365	294	86
Basal diameter (mm)	8.34 ± 2.24	8.16 ± 1.09	12.7 ± 2.19
Height (cm)	44.7 ± 7.55	62.4 ± 4.16	52.8 ± 10.63
No. of leaves	116 ± 65.31	298 ± 77.15	199 ± 73.31
Canopy diameter (cm)	40.7 ± 11.82	58.8 ± 10.64	48.7 ± 10.23
No. of stems	1.00 ± 0	12.2 ± 3.34	8.27 ± 4.29
Dry weight (g)	39.6 ± 16.34	95.1 ± 42.44	50.8 ± 22.37

age with regard to reproductive maturity is critical as it allows the timing of follow-up control activities to prevent re-introduction of viable seed into the soil seed banks, thereby shortening the duration of eradication activities.

Previous studies have shown *C. hirta* exhibits high survival rates in shade house (97.5%) and field conditions (75%) (Graham and Setter 2007). This, along with the high survival rates following severe damage, further illustrate that once established in a favourable environment *C. hirta* will be a permanent part of the landscape unless removed.

The vigorous regrowth following cutting resulted in a much denser, leafier, multi-stemmed plant. This response is consistent with that reported for overseas populations of *C. hirta* (DeWalt 2003, DeWalt *et al.* 2004).

When grown under favourable shade house conditions, *C. hirta* was able to produce flowers in 266 days (mean ± SE of 382 ± 46.4 days) and fruit in 365 days (456 ± 40.7 days). This was slightly shorter than that recorded in the field, where flowering occurred after 275 days (477 ± 79.89 days), with fruiting at an estimated time of 374 days (Graham and Setter 2007). These figures were notably higher than those observed in Hawaii, where the exotic is thriving and plants have been observed bearing fruit in as few as 180 days (Tunison 1991). This, in turn, compares to the more rapid fruit set (86 days and 294 days for plants cut at 10 cm and 0 cm respectively) displayed following severe damage.

In Hawaii, fruiting has been described as seasonal (Smith 1993). However, opposing literature states that berries can be produced all year round (DeWalt 2003). Over the duration of this experiment in the Wet Tropics of North Queensland, plants were recorded flowering and fruiting for the duration of two years under shade house and field conditions, which indicates that there is little environmental influence on the reproduction patterns of *C. hirta.* This indicates that control teams will need to monitor infestations all year round in Queensland to prevent re-infestation.

Based on current literature, control teams should re-visit sites at least every 180 days. Presently, control teams have a re-visitation rate of 90 days to account for the possibility that some plants may be missed during visits (T. Sydes, personal communication). If mature plants are not treated correctly, i.e. removed fully intact, it is possible for damaged plants to rejuvenate and set seed before the next visitation. However the figure of 86 days was taken from plants grown under more optimal conditions in the shade house, and therefore the re-visitation rate of 90 days should be adequate to prevent re-infestation.

ACKNOWLEDGMENTS

The authors would like to thank Brodie Akacich for data collection, Travis Sydes for site selection and Melissa Setter and Wayne Vogler for reviewing the paper. Rebecca Breaden collated the *C. hirta* reference material.

REFERENCES

Department of Natural Resources, Mines and Energy (2004). Declared plants of Queensland, Pest Fact Series (QNRME01218) Koster's Curse. Land Protection, Brisbane.

DeWalt, S.J. (2003). The invasive tropical shrub *Clidemia hirta* (Melastomaceae) in its native and introduced ranges: tests of hypotheses of invasion. PhD thesis, Biological Sciences, Louisiana State University Louisiana.

DeWalt, S.J., Denslow, J.S. and Hamrick, J.L. (2004). Biomass allocation, growth, and photosynthesis of genotypes from native and introduced ranges of the tropical shrub *Clidemia hirta. Oecologia* 138, 521-31.

Graham, M.F. and Setter, S.D. (2007). The survival, growth and time to reproductive maturity of Koster's Curse (*Clidemia hirta* L.) seedlings under field and shadehouse conditions. Proceedings of the 9th Queensland Weed Symposium, eds C. Love and P. Maher, pp.159-63. (Queensland Weed Society Inc., Gold Coast).

Peters, H.A. (2001). *Clidemia hirta* invasion at the Pasoh Forest Reserve: an unexpected plant invasion in an undisturbed tropical forest. *Biotropica* 33, 60-8.

Smith, C.W. (1993). Distribution, status, phenology, rate of spread and management of *Clidemia* in Hawaii. *In* 'Alien plant invasions in native ecosystems of Hawaii: Management and research', eds C.W. Smith, C.P. Stone and J.T. Tunison, pp. 241-53. (University of Hawaii, Cooperative National Park Resources Studies Unit. Honolulu, Hawaii).

Tunison, T. (1991). Element stewardship abstract for *Clidemia hirta* – Koster's Curse. The Nature Conservancy, Arlington, Virginia USA.

Wagner, W.L., Herbst D.R. and Sohmer, S.H. (1999). 'Manual of the flowering plants of Hawaii', revised edition. Bishop Museum Special Publication 97, p. 1919. (University of Hawaii and Bishop Museum Press, Honolulu).