

## Frequency and density of *Mikania micrantha* and other weeds in taro and banana systems in eastern Viti Levu, Fiji

A.R. Macanawai<sup>1,2</sup>, M.D. Day<sup>3</sup>, T. Tumaneng-Diete<sup>4</sup> and S.W. Adkins<sup>1</sup>

<sup>1</sup>The University of Queensland, Tropical and Subtropical Weed Research Unit, School of Land, Crop and Food Sciences, St Lucia, Qld 4072, Australia

<sup>2</sup>Department of Agriculture, Plant Protection Section, Koronivia Research Station, Nausori, Fiji

<sup>3</sup>Department of Employment, Economic Development and Innovation, Biosecurity Queensland, Alan Fletcher Research Station, Sherwood, Qld 4075, Australia

<sup>4</sup>Water Allocation and Planning, Department of Environment and Resource Management, 41 George Street, Brisbane, Qld 4000, Australia

Corresponding author: [a.macanawai@uq.edu.au](mailto:a.macanawai@uq.edu.au)

**Summary** A survey was undertaken in June 2008 in the main production areas for taro and banana on Viti Levu, Fiji, to determine the frequency and density of *Mikania micrantha*. There were significant differences in the densities of the weed found in the different areas. Within the taro areas, the mechanised fields had the lowest densities ( $0.0$  to  $0.7 \pm 0.4$  plants  $m^{-2}$ ) of the weed while the traditionally farmed fields had the highest densities ( $0.9 \pm 0.3$  to  $6.8 \pm 2.8$  plants  $m^{-2}$ ). The banana areas had very high densities ( $3.0 \pm 0.4$  to  $16.3 \pm 2.0$  plants  $m^{-2}$ ) of the weed. The higher density of *M. micrantha* found in the traditional taro fields as compared to the mechanised fields suggests that the adoption of modern farming practices helps manage and reduce densities of *M. micrantha*. However, banana systems by their very nature, remain very susceptible to *M. micrantha* invasion. Under mechanised and traditional taro production, *Cuphea carthagenensis* and *Ageratum conyzoides* were the most frequently occurring weed species respectively. However, in banana cultivation, *M. micrantha* was the most common weed.

**Keywords** Population density, perennial, weed, frequency, herbicides.

### INTRODUCTION

*Mikania micrantha* Kunth ex H.B.K. (Asteraceae) is a fast growing and aggressive perennial vine, native to Central and South America (Ruas *et al.* 2000) and a major weed in Asia and many Pacific island countries, affecting production and food security. Its vegetative growth rate has been reported to be about  $7.0$  cm  $day^{-1}$  during the rainy season in China (Zhang *et al.* 2004),  $8.0$  to  $9.0$  cm  $day^{-1}$  in India (Choudhury 1972) and  $1.1$  to  $3.7$  cm  $day^{-1}$  in Fiji (M.D. Day, Biosecurity Queensland 2008, unpublished data). *Mikania micrantha* readily reproduces both by its windblown seeds and by its creeping vegetative stems that root at the nodes (Zhang *et al.* 2004).

*Mikania micrantha* is widespread in Fiji, invading both cropping and natural ecosystems. Control of mikania is mostly by slashing and hand-pulling, which is time-consuming and labour-intensive. Surveys were conducted in taro (*Colocasia esculenta* (L.) Schott) and banana (*Musa* spp.) (AAA group) production regions in Viti Levu to determine the distribution, frequency and density of *M. micrantha*, and the frequency of co-occurring weeds, in the two cropping systems. Such surveys are an integral component of weed management and will be useful in providing baseline information in relating crop losses to weeds and making cost-effective decisions for weed management and research.

### MATERIALS AND METHODS

**Taro and banana – survey area and procedure** Ten taro farms ( $>2000$   $m^2$  in size and crops 3–6 months old) from each of the three taro production areas of Viti Levu (Naitasiri, Tailevu and Serua) where both traditional and mechanical methods of cultivation are practiced and 10 farms ( $>2,000$   $m^2$ , with crops  $>6$  months old) from each of the two major banana production areas of Viti Levu (Tailevu and Naitasiri) were surveyed in June 2008 (Figure 1). These areas receive an average annual rainfall of *c.* 2900 mm with a minimum temperature of  $16^{\circ}C$  and a maximum of  $32^{\circ}C$  (Fiji Meteorological Service 2008).

All farms surveyed practiced semi-commercial taro and banana crop production, whereby the produce was for market and home consumption. The average size of the taro and banana farms surveyed was 1 acre ( $4047$   $m^2$ ), so the 10 quadrat samples taken on each farm, were relatively close to one another, giving a reduced level of sample variation (Legendre and Fortin 1989).

A zig-zag method of sampling plants (Figure 2) modified from (Mehdi *et al.* 2008) was used. Ten positions equal distance apart were marked with pegs along one long side of each plot. Each of the 10 quadrats was

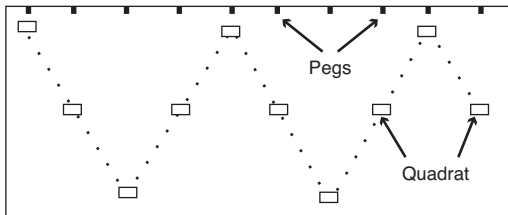
taken on a spot located along the zig-zag imaginary line perpendicular to the peg on the side of the plot. On each spot, a 1 × 1 m quadrat was placed and the number of *M. micrantha* plants was counted and the identity of other weeds was recorded.

In this study, a *M. micrantha* shoot is considered a ramet and was counted as an individual, as were *M. micrantha* seedlings. Images of weed species that could not be identified in the field were taken and specimens collected for later identification in the laboratory.

**Data analysis** *Mikania micrantha* densities were square root transformed to improve normality and variance homogeneity. Comparisons between provinces and farms were conducted using a two-way ANOVA while comparisons within farms were conducted using a one-way ANOVA. Genstat was used for analysis.



**Figure 1.** A map of Viti Levu, Fiji, showing *M. micrantha* infestations (each >4.0 m<sup>2</sup> in area) and areas (shaded) covered in the field study.



**Figure 2.** Zig-zag method used for sampling the *M. micrantha* populations growing in taro and banana plots.

The frequency (*F*) value indicates the percentage of quadrats in taro or banana fields that are infested by a particular weed species and is considered to be an estimate of the extent of infestation in a region (Mehdi *et al.* 2008).

$$F_b = \frac{\sum H_r}{n} \times 100$$

where *F<sub>b</sub>* is the frequency value for weed species *b*, *H<sub>r</sub>* is the presence of weed species *b* in a field *r*, and *n* is the total number of quadrats taken in field *r*.

**RESULTS**

Small plants and seedlings of *Ipomoea*, *Ludwigia* and *Christella* could not be identified to the species level.

**Frequency of weed species in taro** In total, 57 weed taxa belonging to 26 plant families were recorded in taro farms in Serua, Naitasiri and Tailevu provinces. The highest number of species belonged to the Asteraceae (11), followed by Poaceae (10), Fabaceae (4), Euphorbiaceae and Solanaceae (3 each), Cyperaceae, Convolvulaceae, Malvaceae, Melastomataceae and Rubiaceae (2 each). The remaining 16 plant families had one species each.

In Serua, 31 species were recorded in taro farms, with only 1% of quadrats infested with *M. micrantha*, while 40 species were recorded in Tailevu and 31 species were recorded in Naitasiri (Table 1).

**Frequency of weed species in banana** In total, 28 weed taxa, belonging to 16 plant families were recorded in banana farms in Tailevu and Naitasiri. The highest number of species belonged to the Poaceae (25), followed by Asteraceae (4), Cyperaceae, Convolvulaceae and Fabaceae (2 each). The remaining 11 plant families had one species each. About 57% (n = 16) of the weed species were common to both provinces. In Tailevu, 22 plant species were recorded in banana farms while in Naitasiri, 23 plant species

**Table 1.** The most frequently occurring plant species (% of quadrats infested) in taro farms in Serua, Tailevu and Naitasiri.

	Serua	Tailevu	Naitasiri
<i>Cuphea carthaginensis</i> (Jacq.) MacBr.	59	36	30
<i>Ludwigia</i> spp.	37	32	33
<i>Ageratum conyzoides</i> L.	46	59	
<i>Cyperus rotundus</i> L.	36	26	
<i>M. micrantha</i>		36	53
<i>Paspalum conjugatum</i> Bergius			72

were recorded. In both provinces, *M. micrantha* was the most frequent, with 100% of banana farms infested (Table 2).

**Density of *M. micrantha* in taro and banana** In Serua, *M. micrantha* was found on only one farm and the number of ramets found was small. All taro farms surveyed in this province practiced the mechanised method of cultivation where land was ploughed and taro planted into rows. In addition, herbicides are commonly used as part of the weed management programme.

In Tailevu, four farms practised mechanised taro cultivation and were all free of *M. micrantha*. *Mikania micrantha* was common in the remaining six farms, which employed traditional methods, using minimum soil tillage and weed control by hand-weeding and only the occasional herbicide application.

Overall, 80% of farms surveyed in Tailevu and Naitasiri practiced the traditional method of taro cultivation, with the density of *M. micrantha* in these two provinces ranging between 0.0 and 6.8 ramets m<sup>-2</sup> (Table 3). The difference in densities on farms between these two provinces was significant (P = 0.023). The density of *M. micrantha* on farms within both Naitasiri and Tailevu was significantly different (P <0.001).

In Naitasiri, the density of *M. micrantha* in banana fields ranged from 6.6 to 16.3 ramets m<sup>-2</sup>, which is about two times higher than the density range occurring in banana fields in Tailevu (Table 4). All banana farms surveyed in the two regions practiced the traditional method of minimum tillage, with hand-weeding as the main method for controlling weeds.

The density of *M. micrantha* on farms between the two provinces was significantly different (P <0.001). The density of *M. micrantha* on farms within both Naitasiri and Tailevu was significantly different (P <0.001).

DISCUSSION

The variations in the densities of *M. micrantha* in taro and banana farms across provinces may be attributed to the heterogeneity in environmental factors, such as soil type, fertility, moisture content, drainage or the uneven use of herbicides across the regions (Gold *et al.* 1996, Holst *et al.* 2007) and consequent variation in weed dispersal (seeds and ramets) (Holst *et al.* 2007). However, the variation in the density of *M. micrantha* in mechanised and traditional systems and between taro and banana cropping systems could also be due to the method of weed management employed by farmers in the two farming systems.

Mechanised taro farming is usually associated with the ploughing of fields between plantings and the

**Table 2.** The most frequently occurring plant species (% of quadrats infested) in banana farms in Tailevu and Naitasiri.

	Tailevu	Naitasiri
<i>Mikania micrantha</i>	100	99
<i>Brachiaria mutica</i> (Forsk.) Stapf	30	80
<i>Paspalum conjugatum</i>	42	43
<i>Blechnum pyramidatum</i> (Lam.) Urb.	40	37

**Table 3.** Mean (± SE) *M. micrantha* density (ramets/seedlings m<sup>-2</sup>) in taro plantations in Naitasiri, Tailevu and Serua provinces.

Farm	Naitasiri	Tailevu	Serua
1	1.5 ± 0.6	6.8 ± 2.8	0.0 ± 0.0
2	1.2 ± 0.5	0.9 ± 0.3	0.7 ± 0.4
3	2.0 ± 0.8	1.4 ± 0.8	0.0 ± 0.0
4	5.5 ± 0.7	1.3 ± 0.6	0.0 ± 0.0
5	4.3 ± 1.2	4.6 ± 2.0	0.0 ± 0.0
6	1.4 ± 0.6	1.0 ± 0.4	0.0 ± 0.0
7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
8	1.3 ± 0.7	0.0 ± 0.0	0.0 ± 0.0
9	2.6 ± 1.0	0.0 ± 0.0	0.0 ± 0.0
10	6.8 ± 1.8	0.0 ± 0.0	0.0 ± 0.0

**Table 4.** Mean (± SE) density (*M. micrantha* ramets/seedlings m<sup>-2</sup>) in banana plantations in Naitasiri and Tailevu provinces.

Farm	Naitasiri	Tailevu
1	13.6 ± 1.7	10.2 ± 1.8
2	10.0 ± 1.7	10.0 ± 1.6
3	14.7 ± 1.5	4.7 ± 0.6
4	14.6 ± 2.2	3.0 ± 0.4
5	16.3 ± 2.0	3.9 ± 0.6
6	13.6 ± 1.8	10.2 ± 1.9
7	9.5 ± 1.4	3.2 ± 0.6
8	6.0 ± 1.2	4.0 ± 0.4
9	6.6 ± 1.0	3.9 ± 0.3
10	8.7 ± 1.9	4.0 ± 0.6

use of herbicides for weed management (Lebot 2009), so weeds do not have time to establish into large populations. Traditionally cultivated taro plots are usually smaller than mechanised taro plots (Turagakula 2004), with manual control the most common form of weed management. In addition, banana is a perennial crop, so the soil is not ploughed between plantings and the use of herbicides is not desirable, as harvesting can be continuous within a plantation. Therefore, the only

option for weed management in banana crops is by slashing and hand-pulling.

The very low populations of *M. micrantha* on mechanised taro farms compared to the traditionally cultivated taro farms suggests that weed management and soil cultivation strategies practiced in mechanised taro production may have contributed to the successful control of *M. micrantha* in this system. The percentage of banana plots infested by *M. micrantha* in Tailevu and Naitasiri suggests that the current management practices used are largely ineffective against *M. micrantha* and that other options, such as ploughing around the perimeter of plots or providing a buffer zone between plots and/or non-cropping fields, may be beneficial.

The three most commonly represented plant families from this study, based on the number of taxa present, were the Poaceae, Asteraceae and Fabaceae. These three plant families are very species rich and so it is not surprising that they are dominant (Tamado and Milberg 2000). It is interesting to note that the 'fringed spiderflower' (*Cleome rutidosperma* DC., family Capparaceae), which was recorded in taro in Serua during this survey, has not been listed or mentioned in the Plants of the Fiji Islands (Parham 1972) and Flora Vitiensis Nova (Smith 1991).

This study has revealed that *M. micrantha* is not common in mechanised as compared to traditional taro cultivation. However, it is a major weed in banana cultivation. This study has also ranked, for the first time, the most frequent and troublesome weed species in flatland mechanised taro cultivation in Serua and Tailevu, traditional taro cultivation in Naitasiri and Tailevu, and banana cultivation in Tailevu and Naitasiri in Viti Levu. This information is essential for weed management and research.

#### ACKNOWLEDGMENTS

We thank the Australian Centre for International Agriculture Research (ACIAR) for funding parts of this research. We also thank the Plant Protection Section at Koronivia Research Station and the Agriculture Extension staff at Naitasiri, Tailevu and Serua/Namosi, Department of Agriculture, Ministry of Primary Industries, Fiji, for their assistance in the survey work.

#### REFERENCES

- Abraham, M. and Abraham, C.T. (2005). Biology of mile-a-minute weed (*Mikania micrantha* H.B.K.), an alien invasive weed in Kerala. *Indian Journal of Weed Science* 37 (1&2), 153-4.
- Holst, N., Rasmussen, I.A. and Bastiaans, L. (2007). Field weed population dynamics: a review of model approaches and applications. *Weed Research* 47 (1), 1-14.
- Choudhury, A.K. (1972). Controversial mikania (climber) – threat to the forests and agriculture. *Indian Forester* 98, 176-83.
- Fiji Meteorological Service (2008). Climate data and products. <http://www.met.gov.fj>.
- Gold, H.J., Bay, J. and Wilkerson, G.G. (1996). Scouting for weeds, based on the negative binomial distribution. *Weed Science* 44, 504-10.
- Lebot, V. (2009). 'Tropical root and tuber crops: cassava, sweet potato, yams and aroids'. (CABI, UK).
- Legendre, P. and Fortin, M.J. (1989). Spatial pattern and ecological analysis. *Vegetation* 80 (2), 107-38.
- Mehdi, M.M., Mohammad, A.B. and Hamid, R.M. (2008). Introducing an abundance index for assessing weed flora in survey studies. *Weed Biology and Management* 8 (3), 172-80.
- Parham, J.W. (1970). Plants of the Fiji Islands. (Government Printer, Suva, Fiji).
- Ruas, P.M., Ruas, C.F., Maffei, M.D., Marin-Morales, M.A. and Aguiar-Perecin, M.L.R. (2000). Chromosome studies in the genus mikania (Asteraceae). *Genetics and Molecular Biology* 23, 979-84.
- Smith, A.C. (1991). Flora Vitiensis Nova a new flora of Fiji. (National Tropical Botanical Garden, Lawai, Kauai, Hawaii).
- Tamado, T. and Milberg, P. (2000). Weed flora in arable fields of eastern Ethiopia with emphasis on the occurrence of *Parthenium hysterophorus*. *Weed Research* 40 (6), 507-21.
- Turagakula, A. (2004). Taro production in Fiji: constraints and future prospects. Proceedings of the Third Taro Symposium, eds L. Guarino, M. Taylor and T. Osborn. (Secretariat of the Pacific Community, Suva, Fiji).
- Zhang, L.Y., Ye, W.H., Cao, H.L. and Feng, H.L. (2004). *Mikania micrantha* H.B.K. in China – an overview. *Weed Research* 44 (1), 42-9.