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VEGETATIVE GROWTH AND DEVELOPMENT OF *Mikania micrantha* IN TARO AND CASSAVA PRODUCTION IN VITI LEVU, FIJI

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ABSTRACT

A growth analysis study was conducted on Mikania micrantha Kunth stem sections grown between crop rows and at the edges of taro (Colocasia esculenta (L.) Schott) and cassava (Manihot esculenta Crantz) fields at Koronivia Research Station, Viti Levu Fiji. The relative stem growth rate of the longest stem of mikania in the taro field was 3.4 and 2.7 cm cm^{-1} day^{-1} at the edges and in between crop rows, respectively. While in the cassava field, the relative stem growth rate was 2.7 and 3.8 cm cm^{-1} day^{-1} for between crop rows and at the edges, respectively. Mikania plants growing at the edges of the field had greater relative leaf, stem and root dry matter growth rates than plants growing in between crop rows of both crops. These differences in plant performance may be attributed to the photosynthetically active radiation (PAR) that was available for interception at the edges of the crop but less so within the crop as well as a greater nutrient availability at the edges compared to between the crop rows.

Keywords: *Mikania micrantha*, *Colocasia esculenta*, *Manihot esculenta*, relative growth rate

INTRODUCTION

Mikania micrantha Kunth (Asteraceae) was first recorded in Fiji in 1907 as *Mikania scandens* Willd (Knowles, 1907) and was later reported under its current name in 1942 by A.C Smith (Parham, 1959). According to Knowles (1907), mikania was mainly found along roadsides, climbing on trees, posts and forming dense mats on the ground and into *Saccharum officinarum* L. (sugarcane) crop in the high rainfall region of Viti Levu, suggesting that the weed was probably introduced well before this date. Its invasiveness is attributed to its

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ability to produce vast amounts of seed as well as reproduce vegetatively (Holm *et al*., 1991; Macanawai *et al*., 2010). Recently, mikania was reported to be infesting taro (*Colocasia esculenta* (L.) Schott) and cassava (*Manihot esculenta* Crantz; Macanawai *et al*., 2010), two of the most economically important food crops in Fiji (Ministry of Primary Industries, 2010). When mikania is growing in a cropping situation, various physical and environmental factors (such as the degree of shading, the levels of soil moisture and nutrients) may affect its vegetative growth (Kami *et al*., 2010; Sugiyama and Gotoh, 2010).

Several previous studies have documented the vegetative growth rate of mikania in non-cropping situations but measurement within crops is relatively unknown. In monoculture, the vegetative growth rate of mikania has been reported to be about 7.0 cm day^{-1} during the rainy season in China (Zhang *et al*., 2004). As there hasn't been any comparative studies on the vegetative growth rate of mikania within crops and at the edges of crops, the aim of this study was to gain an insight into how vegetative growth rates of mikania will differ in two cropping (taro and cassava) systems, and within a crop and at the edges of a crop. This will be undertaken with a view to better understanding its invasiveness and then to identify better management options for this weed in these cropping systems.

MATERIALS AND METHODS

Growth and development in crops

Stem section preparation

Eight hundred, 15 cm long stem sections of mikania, each with two nodes and of uniform diameter and of the same physiological state of development, were cut from a 12 m^2 mikania infested area at Koronivia Research Station (KRS), Viti Levu, Fiji. Each stem section was planted into a 200 mL pot (7 cm diameter), filled with a moistened Yates GroPlus multi-purpose potting mix (containing an organic-based compost and a full range of fertilizers) and placed onto a bench in a glasshouse. The pots were watered regularly to field capacity for three weeks, by which time new shoots had already formed at the upper node. Thirty of these plantlets, of uniform size were randomly selected and used for an initial dry weight determination. The leaves, stems and roots of each of these 30 plantlets were separated and dried in an oven at 70°C for 72 hours. From the remaining 770 plantlets, 600 were selected for uniform size and health, and transferred to a field site that was *c*. 1 KM away. Upon transplanting into the field (day 0), the initial morphological state of each plantlet was determined by measuring the length of the longest side shoot and counting the number of leaves, nodes, shoots and rooted nodes present.

Crop field description

The field site was prepared in April 2010 at the KRS farm, and consisted of two separate blocks of clay loam soil, with established taro or cassava crops. The cassava (800 m^2: 18° 02' 50.2" S, 178° 32' 10.0" E) and taro (600 m^2: 18° 02' 50.7" S, 178° 31' 53.3" E) fields had been prepared mechanically and the crops planted manually into rows (each *c*. 1.5 m apart). At the time of transplantation, the cassava and taro crops were both five months old and *c*. 1.5 m and 0.7 m in height, respectively. Both field sites were free from all other weeds at the commencement of the study. In each crop, two planting locations were selected, the first was between rows of the crop, in which 25 mikania plantlets were planted 50 cm apart in six rows. The second planting location was on the edges of the field, where six replications of 25 mikania stem sections were also planted 50 cm apart and *c*. 1.0 m away, parallel to the outside row of the field.

Eight soil cores (each 15 cm deep x 7 cm diameter) were randomly taken from each treatment (i.e. within and at the edges of each crop) at the time of transplantation. The soil samples collected were bulked together into polythene bags, air dried at room temperature and sieved with a 2 mm sieve. They were then analysed for their nutrient content at the Fiji Agricultural Chemistry Laboratory at KRS, using a standard soil testing approach. The soil pH was assessed from a 1:1 soil to water suspension. Carbon content was determined by the method of Walkley-Black which involves extraction with dichromate (Nelson and Sommers, 1982). The total N was analysed using the semi micro Kjedhal method. Exchangeable bases were determined from neutral 1M ammonium acetate (Blakemore *et al*., 1987). Soil phosphorus was extracted by using a sodium bicarbonate extraction. The level of the photosynthetically active radiation (PAR) perceived in the centre of the fields and at the edges of the field was measured on a number of clear days from (*c*. 12.00 to 1.00 pm) using a PAR light meter (PAR GASP-03 G11162). Sensors were placed 30 cm above the soil surface at about the same height as the mikania plants creeping on the soil surface and was conducted at four randomly selected places in each crop, within each treatment unit, and averaged for that crop.

Experimental Design and Statistical Analysis

The relative growth rate (RGR) data were log-transformed while the data sets on leaf number, nodes, shoot and rooted nodes were all square root-transformed prior to ANOVA to satisfy analysis requirements. The relative growth rate (fresh or dry matter) was calculated by using this formula (Radford, 1967):

$$RGR = \frac{F_2 - F_1}{t_2 - t_1}$$

Where F_2 is the final length of the stem or the final dry matter weight of the leaf, stem or root samples, F_1 is the initial length of the stem or initial dry matter weight of the leaf, stem or root at day 0 and t_2 is the final day of measurement when F_2 was taken and t_1 is the initial day of measurement at day 0. Data were analysed using Minitab® version 16, 2010 Minitab Inc.

RESULTS

Growth and development in crops

There was a significant difference in the relative stem growth rate (cm cm^{-1} day^{-1}) of mikania in between rows and at the edges of both taro ($F_{1,46} = 5.03$, $P < 0.05$) and cassava ($F_{1,46} = 8.78$, $P < 0.01$) fields. The relative stem growth rate of mikania was 3.4 and 2.7 cm cm^{-1} day^{-1} at the edges and in between rows of taro field, respectively while in cassava, the relative stem growth rate was 2.7 and 3.8 cm cm^{-1} day^{-1} at the edges and between the rows, respectively. There were significant differences in the relative whole plant dry matter growth rate of mikania plants in the between rows and at the edges of the taro crop ($F_{1,11} = 11.372$, $P < 0.01$) and at the cassava crop ($F_{1,11} = 5.128$, $P < 0.05$) fields. The dry matter growth rate of mikania at the edges of taro and cassava field were *c*. 150 and 100 mg g^{-1} day^{-1}, respectively where as in between the rows of the fields, it was 80 mg g^{-1} day^{-1} for taro and 50 mg g^{-1} for cassava.

Soil chemical properties and light intensity

The soil pH between the edges and in between rows of taro and cassava fields were similar. However, there were more macro nutrients at the edges than in the in between rows of the fields of both crops (Table-1). There was a significant difference between the three stages of crop growth in the PAR intercepted by mikania at the edges ($F_{2,9} = 272.36$, $P < 0.001$) and also in between rows of the cassava field ($F_{2,9} = 15.12$, $P < 0.01$; Table 2). There was also a significant difference between PAR intercepted by mikania at the edges and in between rows of the field ($F_{1,22} = 41.99$, $P < 0.01$; Table 2). In taro, there was also significant difference between the three stages of crop growth in the PAR intercepted by mikania at the edges ($F_{2,9} = 234.91$, $P < 0.001$) and in between rows of the field $F_{(2,9)} = 22.08$, $P < 0.001$; Table 2). There was also a significant difference between PAR intercepted by mikania at the edges and in between rows of the taro field ($F_{1,22} = 5.6$, $P < 0.05$; Table 2). For both crops and treatment areas there were greater PAR intercepted at days 0 to 18 than from days 19 to 56.

Furthermore, greater PAR was intercepted at the edges than in between rows of both crops (Table-2).

Table-1. The soil chemical properties found within crops rows and at the edges of taro and cassava fields. The measurements were taken before planting mikania plantlets.

Soil parameters ($mg\ kg^{-1}$ unless otherwise stated)	Taro		Cassava	
	In between rows	Edges	In between rows	Edges
pH	5.3	5.3	5.5	5.6
Total Carbon (%)	3	3	1	1
Total Nitrogen (%)	0.2	0.3	0.1	0.1
Available P	1	1	15	19
Ca^{2+}	2,570	2,658	2,334	2,365
Mg^{2+}	820	937	699	821
K^{+}	59	133	196	209
Na^{+}	46	48	51	43
Fe^{3+}	148	141	124	117
Mn^{2+}	19	13	50	55
Cu^{2+}	9	9	8	8
Zn^{2+}	3	3	3	4

Table-2. The photosynthetically active radiation (PAR) measured 30 cm above the soil surface at about the same height as the mikania plants in the in between rows and edges of taro and cassava fields. The PAR values were average values from four x 14 readings and ± two standard errors from the mean. Values within each crop and each treatment with same letters are not significantly different at $P < 0.05$.

Crop	Stages of crop growth (days)	PAR ($\mu mol\ m^{-2}s^{-1}$)	
		In between rows	Edges
Taro	0-18	899 ± 82 *a*	1,512 ± 58 *a*
	19-36	573 ± 20 *b*	837 ± 44 *b*
	37-56	374 ± 15 *c*	525 ± 20 *c*
	Overall (0-56)	618 ± 42	967 ± 63
Cassava	0-18	137 ± 10 *a*	1,239 ± 42 *a*
	19-36	98 ± 7 *b*	675 ± 41 *b*
	37-56	63 ± 4 *c*	419 ± 17 *c*
	Overall (0-56)	99 ± 6	785 ± 52

DISCUSSION

The relative stem growth rate of mikania at the edges was similar for both taro and cassava and also the relative stem growth rate of mikania between crop rows for both taro and cassava was the same. This indicates that mikania has the potential to compete successfully against. Although the relative growth rate of taro and cassava were not assessed, the growth rate of mikania from this study indicates the considerable growth potential of this weed to compete certain crop species both at the edges and in between crops including those of the present study in the Fiji cropping environment.

The higher levels of PAR recorded on the edges of both fields is reflected in the growth of mikania, with a larger number of leaves produced by mikania plants growing in between rows of both fields than at the edges. This suggests that mikania allocates more resources to produce more new leaves when it is under lower light conditions than when there is ample light. A similar response to low light is used by many plant species to enable them trap more light to sustain growth (Bazzaz *et al*., 1987). However, the significant differences in dry matter growth rate of mikania grown at the edges and those in between rows of both taro and cassava fields is likely to be due to the variation in the intensity of light intercepted by the plants in the two treatments, as light is a major determinant of plant growth (Kami *et al*., 2010; Nishimura *et al*., 2010). This study has also found that, as the number of rooted nodes increased, the number of shoots produced also increase, which indicates that an association exists between the rooted nodes and production of shoots in mikania*.* This response has also been observed in five stoloniferous species belonging to five different families including Asteraceae (Thomas and Hay, 2004).

The greater dry matter growth rate of mikania plants grown at the edges than those plants grown in between rows of both taro and cassava field, may also be attributed to the larger quantity of soil chemical nutrients present at the edges of the field as fertile soil produces more vigorous high yielding plants than poor soil (Sugiyama and Gotoh, 2010; Useche and Shipley, 2010).

The shading effect from crops and other weeds would explain the reduced light intensity within the crop and may have contributed to the reduction in biomass production of mikania*.* This study has also given some insights into the reason for the large occurrence of mikania at the edges, rather than within the crops (field observations). The assessment was conducted for only 56 days and some mikania vines were found scrambling on the canopy of both crops. This demonstrated that mikania can compete aggressively against the two crops for limited resources in soils similar to the current study and delay in its control may pose a real threat to the cost of crop production. The vigorous growth habit of mikania at the edges of the field shows its invasive potential and smothering habit if not managed and an ability to act as a reservoir for dispersal units including both stem sections and seeds.

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