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Growth and Mineral Content of *Mokara chark kuan* Pink Orchid as Affected by Allelopathic *Lantana camara* Weed

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***Abstract*—**Growth and mineral nutrient elemental content were studied in *Mokara chark kuan* pink terrestrial orchid and wild *Lantana camara* weed agroecosystem. The treated subplots were encircled with *L. camara* plants and sprayed weekly with *L. camara* 10% leaf aqueous extract. Allelopathic interactions were possible through extensive invading root of *L. camara* plants into the treated orchid subplots and weekly *L. camara* leaf aqueous extract sprayings. Orchid growth was not significantly different in between the control and treated plots, but chlorosis and yellowish patches of leaves were observed in control orchid leaves. Nitrogen content in *L. camara* leaf was significantly higher than in orchid leaf, the order of importance of mineral nutrient contents in *L. camara* leaf was K>Mg>Na>N. In treated orchid leaf, the order of importance was N>K>Mg>Na. Orchid leaf N content from the treated plot was higher than control, but Mg and Na contents were almost similar.

***Keywords*—**Growth, *Lantana camara,* mineral nutrient elements, *Mokara chark kuan* pink orchid.

I. INTRODUCTION

Lantana camara is a rapid-growing perennial woody shrub and a serious weed in orchards, rubber, and oil palm plantations in Malaysia [1]. It shows a wide distribution with a large range of cytotypes and ecotypes [2]. *Lantana camara*, locally called *bunga tahi ayam,* is also planted as ornamental plant with beautiful flower of various colors such as red, pink, purple, yellow, or white [3].

The effects of weeds on crops can be manifested in agroecosystems through dominant competitive position for growth prerequisites such as light, water, and mineral. On the other hand, allelopathic plants inhibit or suppress germination, growth, development or metabolism of crops due to secretion of allelochemicals to the rhizosphere of neighboring crop plants [4]–[6]. In tropical Malaysia, competition for nutrient and water is more severe than competition for light. Macronutrients nitrogen (N), phosphorus (P), sodium (S), potassium (K), calcium (Ca), magnesium (Mg), and iron (Fe) are required in large quantities by plant for growth. In agriculture, these elements are in greater need of replenishment and are normally supplied through fertilizer [7].

Lantana camara is known as one of the ten most toxic weeds in the world [8] that shows allelopathic effect or phytotoxicity to other plants [9]. *Lantana* weed debris is shown to reduce dry weight and emergence of rape, Chinese cabbage, and chili. At least some of phytotoxins present are water-soluble that can be leached to soil beneath *Lantana* plants. Aqueous extract of *L. camara* fresh leaf is shown to significantly reduce fresh weight of bioassay species such as spinach, rape, Chinese cabbage, chili, and cucumber at four weeks after planting in the greenhouse [1]. In the field, *L. camara* extract is comparatively effective with Carbaryl insecticide against *Oulema pectoralis* beetle [10]. This flower-eating yellow beetle is the most common pest of orchid. Several concentrations of water and ethanol extracts of *L. camara* fresh leaf were bioassayed [11] against similar beetle in the laboratory, and it was found that 10% water extract is the most effective.

This study was carried out in the field plot consisted of Bungor soil, wild *L. camara* plants, and *Mokara chark kuan* pink orchid. The first objective of this study was to compare the effect of *L. camara* plants *in situ* in combination with 10% leaf water extract spraying (in treated plot) with recommended agricultural practice of pesticide application (in control plot), on growth of this orchid at 17 months after orchid planting. The next objective was to measure the amounts of nitrogen, potassium, magnesium, and sodium, in orchid and *L. camara* plants, as affected by *L. camara* plants *in situ* in combination with 10% leaf water extract spraying (in treated plot) as compared to the control plot.

II. MATERIALS AND METHODS

A. Study Site and Planting

A field experiment was carried out on Bungor series sandy loam soil. Prior to experiment, *L. camara* cuttings were collected from the surrounding bushes and propagated. Approximately 60 established cuttings were then transferred into the field and planted in semi-circle around the treated plot. *Mokara chark kuan* pink terrestrial orchid was bought from nursery and transplanted in 5 control subplots and 5 treated subplots. Each subplot consisted of 12 plants arranged in three rows with four plants at each row. It was planted in

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the subplots after *L. camara* has established itself. Irrigation with tap water was applied regularly to orchid, and organic and foliar fertilizers were applied as recommended. Insecticide was applied as and when necessary.

B. Treatments

The treatments in this ornamental crop agroecosystem that consisted of Bungor soil, *Mokara chark kuan* pink orchid, and *Lantana camara* plants were; T1 = *Control plot* which was not surrounded by *L. camara* plant but followed the recommended pesticide application practice beginning 5 months after orchid planting, whereas T2 = *Treated plot* which was surrounded with *L. camara* bushes, in combination with weekly spraying of 10% *L. camara* aqueous extract beginning 10 months after orchid planting.

C. Preparation and Spraying of L. camara *Water Extract*

Spraying of fresh 10% *L. camara* aqueous extract to treated plot was carried out once a week by using a field sprayer, beginning 10 months after orchid planting. This aqueous extract was prepared in the laboratory by blending 500 g fresh weight of *L. camara* leaf in 5 L of tap water, followed by filtration through muslin cloth [11].

D.Soil Sampling and Preparation

The Bungor series soil was sampled at 17 months after planting. The characteristics of Bungor series soil were as previously mentioned [12].

Three replicate soil samples were randomly taken from three orchid subplots each from both the treated and control plots. Each replicate soil sample that consisted of three soil cores taken at 0-20 cm depth by using soil auger, was put into one plastic bag per subplot, combined, and agitated until homogenous, and transported to the laboratory. Twelve replicate soil samples from under *L. camara* bushes that encircled the orchid plot were also randomly sampled in a similar manner as the orchid sub-soils.

Prior to analysis, wet soil was sieved to separate the plant debris, oven dried at 105 ^{o}C, pounded using pestle and mortar followed by sieving using a 2 mm and 210 μm mesh sieves [13]. Moisture determinations of *Lantana* and orchid soils were also carried out in the laboratory [14].

E. Plant Sampling and Preparation

At 17 months after planting, one orchid plant was randomly harvested from three orchid subplots each, from both treated and control plots. Plant was pulled up carefully, washed clean under running tap water followed by separating it into flower, leaf (including the stem) and root. Plant parts was wiped dry with clean tissue in the laboratory, weighed, cut into small pieces with scissors and oven dried separately at 65 ^{o}C until constant weight. Following oven drying, plant sample was powdered using a grinder. Plant powder was sieved through a 40 μm mesh sieve [13]. Moisture determination of orchid was also carried out [14].

Up to 5 kg subsample of *L. camara* was harvested per plant. Twelve replicates were randomly sampled from *L. camara* bushes that encircled the orchid treated plot. At all sites, *L. camara* leaf was sampled concurrently with soil sampling. Fresh leaf was kept in plastic bags prior to transportation to the laboratory. Twelve *L. camara* leaf replicates were oven dried at 65 ^{o}C until constant weight, followed by grinding and sieving through a 40 μm mesh sieve [13].

F. Analysis of N by Using CHNS Analyzer

Sample was prepared by weighing 2.0 mg dried powder sample in tin capsule, followed by burning of sample at 950 ^{o}C and conversion to N_2 gas. Detection of N_2 was carried out by thermal conductivity using the Carbon Hydrogen Nitrogen and Sulfur (CHNS) Analyzer [15].

G.Analysis of K, Mg, and Na by Using INAA Techniques

Analysis of potassium, magnesium, and sodium in dried plant and soil samples were carried out using the Instrumental Neutron Activation Analysis (INAA) techniques. Two replicates of 0.15-0.20 g oven dried soil or plant powder, and 100 μl of standard solution, were each weighed into polyethylene vials and exposed to neutron irradiation in Triga MK-II reactor at the Malaysian Nuclear Agency.

The analysis of short-live radionuclide magnesium requires irradiation time of 1 min, followed by 20 min cooling and 5 min counting times. For radionuclides sodium and potassium, irradiation time of 1 min was followed by 24 hr cooling and 20 min counting times [13].

H.Statistical Analysis

Results were statistically analyzed by using the SPSS software: ANOVA (Analysis of Variance).

III. RESULTS AND DISCUSSION

A. Orchid Plant Growth

Mokara chark kuan pink terrestrial hybrid orchid has a monopodial growth type that allows it to grow upwards from a single point. It grows taller from a single stem in a single upward direction. It does not have a rhizome or pseudobulb, but adds a few leaves each year as well as flowers that generally come from in-between these leaves. In this study, the growth of *Mokara chark kuan* pink terrestrial orchid in Bungor soil was shown in terms of wet weight (ww) and dry weight (dw) of leaf (that include also the stem), root, and flower (Table I).

TABLE I
GROWTH OF *MOKARA CHARK KUAN* PINK ORCHID IN BUNGOR SOIL

Plant Parts	Whole Plant Weight (g)		
	Wet weight (ww)	Dry weight (dw)	Total weight
		Control (T1)	
Leaf	559.38 ± 90.87	131.40 ± 17.66	1087.57 ± 170.36 (ww)
Root	497. 33 ± 95.52	129.33 ± 12.26	267.90 ± 25.00 (dw)
Flower	30.87 ± 8.27	7.18 ± 1.64	
		Treated (T2)	
Leaf	409.33 ± 82.63	100.69 ± 24.30	847.56 ± 116.72 (ww)
Root	421.85 ± 30.58	93.02 ± 4.55	196.59 ± 29.68 (dw)
Flower	16.39 ± 8.31	2.88 ± 2.22	

Note: Mean ± standard deviation

It was found that growth of leaf, root, and flower was not significantly different in control plot as compared to treated plot. These results suggested that growing orchid not

surrounded by *L. camara* plants in the recommended pesticide application practice was not much better than growing orchid adjacent to *L. camara* plants that was combined with weekly spraying of *L. camara* 10% leaf water extract. However, the control orchid was also observed to develop chlorosis and yellow patches on the older leaves indicating nitrogen and potassium deficiency, respectively.

B. Moisture Content of Soil and Plant

Orchid was irrigated continuously whilst *L. camara* depended solely on rainfall for irrigation as in the wild. Moisture contents of soil as well as *L. camara* and orchid plants measured were as shown in Table II.

TABLE II
MOISTURE CONTENT OF *MOKARA CHARK KUAN* PINK ORCHID FLOWER, LEAF AND ROOT (%)

	Moisture Content (%)		
	Orchid Plant Parts	Soil (0-20 cm depth)	
	Control (T1)	Orchid	*Lantana*
Leaf	72.69 ± 4.03	15.94 + 3.55	5.11 + 1.80
Root	75.13 ± 3.80		
Flower	86.01 ± 1.62		
	Treated (T2)		
Leaf	71.31 ± 7.00		
Root	73.02 ± 2.63		
Flower	81.64 ± 5.29		

Note: Mean ± standard deviation

It was found that *L. camara* soil at 0-20 cm depth has significantly less moisture content, measured at 5.11 ± 1.80% of water, than orchid soil that has 15.94 ± 3.55% of water. Low soil moisture content measured at this soil depth might affect *L. camara* because even though it has extensive lateral roots system that can tap nutrients near the surface [7], the sinker roots system for tapping water resources far and deeper below the sub-soil depth was limited. Lateral roots of *L. camara* were visibly seen to encroach into treated orchid subplots few meters away. Thus, it was possible that these roots were poaching nutrients as well as water [7], and provisioning active allelochemical root excretion. Nevertheless, allelochemical excretion and possible water poaching by *L. camara* might not give adverse effect on physiological growth and biomass of orchid because its growth and moisture contents of leaf, root, and flower were almost similar in both treated and control plots.

C. Nutrient Element in Orchid Soil

Nitrogen, potassium, magnesium, and potassium mineral nutrient elements in the orchid growing Bungor soil were analyzed at 17 months after planting (Table III).

The order of importance of nutrient element in soil from the control plot of orchid was magnesium > potassium > sodium > nitrogen (Table III). In treated plot, the order of importance has shifted slightly to magnesium > potassium > nitrogen > sodium. Nitrogen and potassium contents were higher in control plot whereas, magnesium and sodium contents were higher in treated plot. However, these differences were not significant.

TABLE III
MINERAL CONTENT OF ORCHID SOIL (%)

Soil Depth	Mineral content (%)			
	N	K	Mg	Na
		Control (T1)		
0-20 cm	0.39 ± 0.06	2.40 ± 0.99	6.24 ± 6.66	0.35 + 0.12
		Treated (T2)		
0-20 cm	0.21 ± 0.04	1.85 ± 0.51	8.36 ± 8.65	0.43 ± 0.25

Note: Mean ± standard deviation

D. Nutrient Element in L. camara Soil

Four mineral nutrient elements in Bungor soil underneath the *L. camara* bushes were also analyzed, from soil sampled at 17 months after planting (Table IV).

TABLE IV
MINERAL CONTENT OF *LANTANA CAMARA* SOIL AT 0-20 CM SOIL DEPTH (%)

Sample Number	Mineral content (%)			
	N	K	Mg	Na
A	0.40	7.11	17.71	1.74
B	0.42	3.68	14.98	0.385
C	0.68	2.14	13.25	0.221
D	0.64	2.25	15.29	0.27
E	0.63	2.59	15.59	0.25
F	0.48	5.57	14.00	1.45
G	0.49	6.14	13.11	1.72
H	0.10	5.95	14.79	1.60
I	0.65	7.03	13.77	1.89
J	0.14	9.75	1.32	0.78
K	0.47	11.53	1.92	1.15
L	0.14	12.52	2.35	2.82
Mean	0.44 ± 0.21	6.35 ± 3.49	11.50± 5.95	1.19 ± 0.82

Note: Mean ± standard deviation

The order of importance of nutrient elements in *L. camara* soil was magnesium > potassium > sodium > nitrogen (Table IV); following a similar trend as in the soil from control plots of orchid. The contents of magnesium, potassium, sodium, and nitrogen in the *L. camara* soil were higher than in the orchid soil (Tables III & IV) however, these differences were not significant.

E. Nutrient Element in Mokara chark kuan *Pink Orchid*

Nitrogen, potassium, and magnesium are important mineral nutrients of plant. Nitrogen is essential for producing proteins, chlorophyll, and nucleic acids; potassium is required as a cation in enzyme function; and magnesium is required as an activator to photosynthetic enzymes [16]. Nitrogen, potassium, magnesium, and potassium contents analyzed in orchid flower, leaf, and root were as shown in Table V.

The order of importance of nutrient elements in control plot was potassium > magnesium > nitrogen > sodium in the orchid leaf, root, and flower. In treated plot, the order of importance was potassium > nitrogen > magnesium > sodium

in leaf and flower, and potassium > magnesium > nitrogen > sodium in root.

TABLE V
MINERAL CONTENT AND DISTRIBUTION IN LEAF, ROOT AND FLOWER OF *MOKARA CHARK KUAN* PINK ORCHID IN CONTROL AND TREATED PLOTS (%)

Plant Parts	Mineral content (%)			
	N	K	Mg	Na
		Control (T1)		
Leaf	0.64 ± 0.13	11.77 ± 7.27	1.43 ± 1.24	0.07 + 0.01
Root	0.80 ± 0.08	3.65 ± 0.62	1.26 ± 0.17	0.69 ± 0.11
Flower	1.48 ± 0.21	16.41 + 0.26	1.57 ± 0.16	0.03 ± 0.01
		Treated (T2)		
Leaf	1.26 ± 0.05	5.73 ± 0.33	1.23 ± 1.08	0.08 ± 0.01
Root	1.23 ± 0.16	3.25 ± 0.24	1.34 ± 0.52	0.51 ± 0.07
Flower	1.67 ± 0.12	14.01 ± 2.69	1.25 ± 0.19	0.03 ± 0.01

Note: Mean ± standard deviation

Potassium plays important role in many cellular processes [16] necessary for the formation of starches, carbohydrates, sugars, protein synthesis, and cell division in roots and other plant parts. It is important for water balance adjustment, stem rigidity and cold hardiness improvements, flavor and color enhancements in fruit and vegetable crops, and for increasing the oil content of fruits. It is also important for leafy crops. Potassium content was higher in flower whilst sodium content was higher in the root (Table V), but the differences were not significant. Potassium content was significantly higher in the control plant as compared to the treated plant (Table V), however deficiency symptoms such as curled and scorched leaves or retarded growth was not observed in the treated plants.

Nitrogen content was higher in the leaf, root, and flower of treated orchid (Table V). The higher nitrogen content of treated orchid plant may contribute to its growth because nitrogen metabolism is a major factor in vegetative growth of plant in the leaf and stem. Furthermore, nitrogen is a major component of proteins, hormones, chlorophyll, vitamins, and enzymes that are essential for plant life [16]. The treated orchid plant also did not show symptoms of N deficiencies such as leaf yellowing and stunted growth.

In this study, magnesium content was almost similar from both treatments; in all plant parts studied. Magnesium is a critical structural component of the chlorophyll molecule and is necessary for plant enzyme functioning; to produce carbohydrate, sugar, and fat. It is used for fruit and nut formation, and essentials for seed germination. Magnesium is leached by watering and must be supplied by applying fertilizer in a foliar spray to correct deficiencies. Deficient plant begins to appear chlorotic on the oldest leaves which then progressing to the younger leaves as deficiency worsens, displaying yellowing between veins of older leaves, and leaf drooping [16].

Even though less than 0.1% of sodium was measured in orchid (Table V), sodium is involved in osmotic (water movement) and ionic balance [16].

F. Nutrient Element in L. camara *Plant*

The order of importance of mineral nutrients in *L. camara* leaf was potassium > magnesium > sodium > nitrogen (Table VI); the trend being different from nutrient in orchid from both control and treated plots.

TABLE VI
MINERAL CONTENT OF *LANTANA CAMARA* LEAF (%)

Sample Number	Mineral content (%)			
	N	K	Mg	Na
AL	3.42	24.65	3.46	0.04
BL	3.73	30.87	4.53	0.07
CL	3.22	23.02	4.60	0.09
DL	3.22	25.18	3.54	0.08
EL	2.66	18.34	4.57	0.10
FL	2.89	18.83	2.34	0.05
GL	3.02	16.95	2.33	0.06
HL	2.90	20.63	2.89	0.07
IL	3.03	18.40	2.81	0.07
JL	3.01	18.66	3.70	0.07
KL	2.77	19.23	3.09	0.07
LL	2.80	18.77	2.96	0.07
Mean	3.06 ± 0.30	21.13 ± 4.05	3.40 ± 0.82	0.07 ± 0.02

Note: Mean ± standard deviation

Nitrogen content in *L. camara* leaf was significantly higher than in orchid leaf (Tables V & VI). Since nitrogen deficiency results in plant of poor color and quality, higher nitrogen content in *L. camara* leaves was displayed by deep- green coloration as compared to a yellowish-green color of orchid leaves.

Continuous spraying of aqueous *L. camara* leaf extract was shown to eventually increase the nitrogen content in the leaf, root, and flower of treated orchid (Table V). Similar to nitrogen, magnesium and potassium contents were also higher in *L. camara* leaf. Less chlorosis and yellowish patches observed on treated *Mokara chark kuan* pink terrestrial orchid leaves were thus attributed to continuous spraying of *L. camara* aqueous leaf extract, despite them being surrounded by allelopathic *L. camara* plants.

Accumulation, degradation and leaching of *L. camara* leaf debris also increases the nitrogen, magnesium, potassium, and sodium contents of *L. camara* soil as compared to the treated and control orchid soils (Tables III & IV), however the concentration differences between both soils were not significant.

Less than 0.1% of sodium was measured in both *Lantana camara* and *Mokara chark kuan* pink plants (Tables V & VI), which presumably has little effect on plant growth.

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