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CONTENTS

SOME STUDIES ON ALLELOPHATIC POTENTIAL OF *CYPERUS ROTUNDUS* L

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ABSTRACT *Cyperus rotundus* (sedge weed) that exhibit allelophatic behaviour represent potential options for sustainable weed management. Previous study has shown that application of mulch from the weed suppressed broadleaved weed. Hence, in this study we carried out a series of experiments to elaborate whether the weed has an allelophatic potential for broadleaved weed control. Consistent with the previous study, the result of a field experiment in this study show that biomass aplication of *C. rotundus* as mulch, compost and soil ameliorant suppressed broad leved weed in soybean cultivation. However, a green house experiment show that biomass aplication had no negative effect on the growth and biomass production of 3 common broadleaved weeds, *Asystasia ganggetica*, *Mimosa pigra* and *Borreria alata*, and soybean. Study on the effect of the concentration of water extract of *C. rotundus* (0.5 – 4.5 kg/L) show that up to 1.0 kg/l concentration significantly decreased (more than 60%) seed germination of the three common broadleaf weeds in upland; but had no effect on seed germination of soybean. Analysis of allelochemical componds indicated that phenolic compounds from *C. rotundus*, cyperene and culmorin were specific compounds that only found in fresh *C. rotundus* with aquadest sovent. The study indicates that *C. rotundus* may be used as an option for seed germination control of broad leaf weeds.

Keywords: Allelochemicals, bioherbicide, weed management, *Asystasia gangetica, Borreriaalata, Mimosa pigra, Cyperus rotundus*

INTRODUCTION

There is a growing interest in allelophatic study especially on their potential ability to support sustainable agriculture system (Junaedi *et al* 2006). Commonly, allelophaty form as secondary metabolites on several plant organs such as roots, stems, leaves, flowers and seeds. Allelophaty of crops and weeds can be expressed in the form of exudates from roots, pollens, decomposition of plant organs, volatiles from leaf, stem and root, and also through the leaching of plant organs.

Nut sedge *(Cyperusrotundus* L.) is important weed in the world that distributed widely in all tropical and sub-tropical area. Holm*et al.* (1977) reported that *C. rotundus* is the member of the worst weeds, had become a serious problem in 90 countries on more than 50 kind of crops. This weed can cause serious problem because of its ability to suppress several crop production significantly and its difficulty to be controlled. This suppression is caused by the high competition to get resources, allelochemical of *C. rotundus*, and the combination of both factor.

Allelophaty of *C. rotundus* is not only to suppress crop growth and production, but also to suppress several weeds growth. Some literatures reported that allelophaty of *C. rotundus* is able to suppress the growth of crop or other plant including weeds (Izah, 2009;; Elrokiek, 2010; Palapa, 2009). However, specific and systematic studies regarding the use of allophaty of *C. rotundus* as agent for controllong weeds growth in an environmentally friendly agricultural system is still lacking.

This study was aimed at studying the potency of allelophaty of *C. rotundus* as biological controll of weeds in environmentally friendly crops production system.

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MATERIALS AND METHODS

In order toassess the potency and prospective of *C. rotundus* allelophaty in weed control, a series of studies was done at Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University, Bogor, Indonesia, including field trials, greenhouse trials and laboratorium experiments.

Experiment 1. This experiment was a preliminary study that has been carried out in the field to identify several important prospective candidates that can be used to suppress weed growth and development in soybean production. The experiment was designed block design. The treatment was different mulches developed from several kind of weed that was applied in soybean production. The mulches were developed from paddy (*Oryza sativa*), cogongrass (*Imperatacylindrica*), nut sedge (*C. rotundus*), and waterhyacinth (*Eichorniacrassipes*). Black plastic mulch and no-mulch were used as control. Vegetation analysis was done at three and sixth week after planting to determine the growing weeds species and their growth and development.

Experiment 2. This field experiment was to know the effects of teki as organic material to weed growth and development on soybean field. The experiment was designed in a block design using three replications. The treatment was the formula of organic matter from C. rotundus as follow: (1) fresh of *C. rotundus* as mulch (2) dried *C. rotundus* as mulch, (3) fresh of *C. rotundus* incorporated with soil, (4) dried *C. rotundus* incorporated with soil, (5) composted *C. rotundus*. In addition (6) manuallyweeding and (7) non-weeding beds were used as controls. Vegetation analysis was done using quadran methods at fourth and eight weeks after planting.

Experiment 3. This experiment was a greenhouse experiment that was aimed at determining the effects of teki organic matter to growth and development of weeds, and to biomass production of several broad leaf weeds. This experiment was designed using complete randomized design. The treatment was several forms of organic materials from C. rotundus applied to three kind of broad leaf weeds and soybean planted in a polybag under greenhouse condition. The organic matters from *C. rotundus*(CR) were: (1) fresh CR incorporated with soil , (2) dried CR incorporatedwith soil, (3) fresh CR as mulch, (4) dried CR as mulch, (5) composted CR (6) powder of CR (7) extract of CR, (8) control. Three important weeds species were used as trial plant, those were ***Asystasia gangetica*, *Borreria alata*, *Mimosa pigra***, dan soybean (*Glycine max*). Growth and development of plant were observed until generative stage, then were harvested to measure the biomass of each plant sample.

Experiment 4. This experiment was conducted at laboratory to study the effect of C. rotundus extract to the germination rate of broad leaf weeds and soybean seeds. The experiment was conducted using a complete randomized design with three replications. The treatment used in this experiment was the concentration of C. rotundus extract (using water as the solvent) ranging from 0.0 – 4.5 kg fresh teki/liter water with interval of 0.5 kg/liter. *Asystasia gangetica*, *Borreria alata*, *Mimosa pigra*, dan soybean (*Glycine max*) were used as object plants. Teki extract treatment was done to the 50 seeds of weeds, which have already broken for their dormancy and soybean on petridish in an incubator. The observation was made on the number of germinating seeds, plumule length, radicule length, and speed of germination periodically until 30 days old.

Experiment 5. This experiment is to analyze the allelochemical content of *C. rotundus*. The analysis was conducted on fresh and dried of *C. rotundus*, *C. rotundus* powder and *C. rotundus* compost. Analysis was done at Health Laboratorium using GC-MS analysis. Every sample was analyzed duplo.

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RESULTS AND DISCUSSION

Experiment 1. The effect of weed mulches to the growth and development of weeds in a soybean field

This experiment showed that generally the weed mulches able to increase the growth and production of soybean. Besides that, all mulches can suppress the growth of weeds significantly. There was an indication that *C. rotundus* mulch can suppress broad leaf weeds more effectively than paddy mulches, waterhyacinth mulches, and cogongrass mulches (Table 1). At second time of observation (six week after transplanting), weed biomass on teki mulch treatment was 16.18 g, the lowest compare to that of paddy mulch (45.55g), waterhyacinth mulch (34.35g) and cogongrass mulch (26.25 g). From this study, it is known that the production of soybean using weed mulches is lower than that using black plastic mulch (data not shown). The production of soybean using C. rotundus mulch was 158.90 g/plot, significantly lower than that of black plastic mulch (1023.00 g/plot), but still higher compare to that of control (without mulch/no weeding) (99.23 g/plot).

This results strengthen the hypothesis that teki has allelophatic effects to broad leaf plant. Negative effects of teki to broad leaf plants has been reported before (Izah, 2009; Fitria*et al.* 2011).

Experiment 2. The effects of several organic matter of *C. rotundus* to the growth of weeds in a soybean cultivation

Weed biomass of *C. rotundus* can be used as mulch, compost, or soil ameliorant material in crops productions. This also has been shown in Experiment 2. The result of this experiment shows that *C. rotundus* that was applied in different formulas can be used to suppress the growth and development of broad leaf weeds. Table 2 show that weeds biomass in several treatments of *C. rotundus* were significantly lower than that in control beds. At 8 weeks after planting, broad leaf weeds biomass harvested inboth fresh and dried *C. rotundus* as mulches, both fresh and dried *C. rotundus* as soil amelorant and compost were 8.7, 6.7, 2.6, 10.5 and 4.4 g per plot, respectively, in which significantly lower than that on control (302.3 g/plot).

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Table 1. Weed growth on several weed organic mulch treatments

Mulch resources	Time (WAT)	Number of weed species			Summed Dominance Ratio (SDR) (%)			Biomass (gram)			Total biomass (gram)
		S	G	BL	S	G	BL	S	G	BL	
Rice straw	3	1	8	15	1.49	59.04	39.46	0.50	73.91	29.21	103.61
	6	1	6	9	6.54	50.35	43.11	7.40	42.09	45.44	95.04
Waterhyacinth	3	0	5	9	7.81	58.46	33.73	11.10	41.88	32.05	85.03
	6	1	6	8	6.30	72.65	21.04	4.70	91.96	34.35	113.25
Black polythylene	3	1	4	3	0.00	60.94	39.06	0.00	6.63	5.87	12.50
	6	0	4	4	0.00	69.44	30.56	0.00	32.85	21.80	54.65
Cogongrass	3	0	5	8	0.00	67.76	32.23	0.00	40.94	20.73	61.67
	6	1	7	9	6.87	70.46	22.66	3.40	92.18	26.25	121.83
Cyperus rotundus	3	1	5	9	3.17	67.96	28.86	0.90	69.48	22.13	92.51
	6	1	7	6	4.88	72.18	22.92	1.28	53.68	16.18	71.14
No mulch	3	1	5	9	2.56	67.31	30.03	1.70	72.08	34.35	108.13
	6	0	5	8	0.00	65.78	34.21	0.00	137.30	33.00	170.30

Notes
S : Sedges
G : Grasses
BL : Broadleave

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However, contrary with Experiment 1 and other studies, the result of this study showed that the addition of teki organic matter did not produce significant effects on vegetative development of soybean, except at early growth stages. The highest increase was found on fresh teki plots. The possible explanation of this is that organic material treatment as full coverage can function optimally as mulches.

The result of this experiment strengthen the hypothesis that *C. rotundus* has allelophatic potential to suppress the growth of broad leaf weeds. In its application, teki can be applied through several formulas, such as as mulches and compost.

Experiment 3. The effects of organic materials from teki to the growth of broad leaf weeds and soybean (under greenhouse condition)

There was no negative effect of *C. rotundus* to the growth of weeds, except the application of *C. rotundus* extract 1 kg/L that can suppress *Borreriaalata* (Table 3). Even the application of *C. rotundus*organic materials or extract of *C. rotundus*can increase the growth and biomass of soybean.

Table 2. Growth of weeds on several treatment of *C. rotundus* organic matter

Treatment of CR organic matter	Time (WAT)	Number of weed species			Summed Dominance Ratio (SDR) (%)			Biomass (g/0.25 m^2)			Total biomass (g/0.25 m^2)
		S	G	BL	S	G	BL	T	R	BL	
Manual weeding	4	1	4	6	18.90	27.60	53.50	34.30	43.50	174.50	252.50
	8	1	1	8	4.50	6.70	88.90	1.00	1.20	28.20	30.40
No weeding	4	1	3	6	9.50	13.20	77.40	11.60	20.80	239.70	272.00
	8	0	1	5	0.00	4.70	95.30	0.00	3.20	302.40	305.60
Fresh of CR as mulch	4	1	6	7	20.10	26.50	53.40	35.40	57.80	104.50	197.70
	8	1	2	7	8.60	24.10	67.40	0.60	4.10	8.70	13.40
Dry of CR as mulch	4	0	5	10	0.00	37.10	63.00	0.00	36.10	103.60	139.70
	8	1	4	6	4.90	40.90	54.30	0.20	7.40	6.70	13.40
Fresh of CR incorporated in soil	4	1	4	7	45.10	23.50	31.40	125.50	69.00	77.20	271.70
	8	1	2	3	22.00	47.60	30.40	0.90	6.60	2.60	10.10
Dry of CR incorporated in soil	4	1	5	8	41.00	21.60	37.40	120.30	44.10	54.30	218.70
	8	1	3	5	4.50	32.40	67.60	0.50	5.00	10.50	16.00
Composted CR	4	0	3	7	0.00	31.50	68.50	0.00	96.50	172.20	268.70
	8	0	3	4	0.00	53.20	46.80	0.00	6.00	4.40	10.40

Notes CR : *C. rotundus*
S : Sedges
G : Grasses
BL : Broadleaves

These results are in line with the result of Experiment 2 that show that organic matter from *C. rotundus* does not have negative effect to the seedling. The low population of broad leaf weeds in soybean cultivation (Experiment 1 and 2) probably caused by the effects of *C. rotundus* allelophaty to their germination. Therefore, the mechanism of *C. rotundus* suppression to the broad leaf weeds might be expressed during germination periods.

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Table 3. Biomass of weeds *A. gangetica, B. alata, M. pigra* and soybean on different organic matter treatment of C. Rotundus*

	Biomass (g)			
Organic matter treatment of *C. rotundus*	*A.gangetica*	*M. pigra*	*B. alata*	Soybean
Control	34.41a	10.53a	12.28dc	19.23d
Extract of C. rotundus (1kg/1L)	46.38a	8.28a	6.85d	30.72bc
Fresh CR incorporated with soil	41.66a	8.11a	22.07ab	37.19ab
Dried CR incorporated with soil	44.35a	13.97a	14.78bc	25.71cd
Fresh CR as mulch	48.24a	13.04a	29.15a	39.60a
Dried CR as mulch	51.88a	8.71a	18.57bc	30.66bc
Composted CR	32.12a	15.86a	22.31ab	25.68cd
Powder of CR	53.96a	15.58a	21.19b	23.58cd

Notes: CR: *C. rotundus*

*Value with different letters in each column indicate significant differenceamong sectors by DMRT $p< 0,05$

Experiment 4. The effect of *Cyperusrotundus*extract to the germination of broad leaf weeds and soybean

Extract of *C. rotundus* treatment, concentration 0 – 4.5 kg/l, significantly affected seed germination, speed of germination, plumule length, radicule length of broad leaf weeds: *Asystasia gigangtea, Mimosa pigra dan Boreria alata*, but does not affect soybean. The effect of teki extract to the germination of *Asystasia gigangtea*and*Boreria alata* can be seen on Table 4 and Table 5.

Table 4 shows that the *C. rotundus* extract, concentration 0.5 kg/l, can suppress the germination percentage as 42.67% and germination speed as 12.53%, but does not significantly decrease the length of its plumule and radicule. On higher concentration (1 kg/l), teki extract can suppress the germination rate as 69.33%, while on concentration 1.5 kg/l, it can decrease the germination rate as 92.67%. The increase of extract concentration from 2 kg/l to 4.5 kg/l can caused the seed of weed failed to germinate.

Table 4. Effects of *Cyperus rotundus* extract to the germination percentage (%), speed of germination (% normal seedling/etmal), length of plumule (cm) and length of radicule of *A. gangetica*

Cyperus rotundus extract (kg/L)	Germination Percentage	Speed of germination	Length of plumule	Length of radicule
0 (kontrol)	97.33a	18.26a	1.50a	1.76a
0.5	54.66b	5.73b	1.36ab	1.83a
1.0	28.00c	2.36c	1.13ab	2.33a
1.5	6.66d	0.43d	0.83bc	0.76ab
2.0	0.00d	0.00d	0.00d	0.00b
2.5	0.00d	0.00d	0.00d	0.00b
3.0	6.66d	0.33d	0.43dc	0.86b
3.5	0.00d	0.00d	0.00d	0.00b
4.0	0.00d	0.00d	0.00d	0.00b
4.5	0.00d	0.00d	0.00d	0.00b

Notes: value with different letters in each column indicate significant differenceamong sectors by DMRT $p<0.05$

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Table 5 shows that the responses of *Boreria alata*seed to the teki extract treatment are similar with those of *A.gangetica*. The number of *B. alata* that successfully germinated on concentration 0.5 kg/l and 1 kg/l are 52.00% and 32.00%. Different with *A.gangetica*,plumule and radicule length of *B. alata* were significantly decreased by application of C. rotundus extract. Plumule length of this species on *C. rotundus* extract concentration 1 kg/l was 0.86 cm, significantly different with control (1.63 cm); while its radicule length, on concentration 1 kg/L was 0.86 cm, significantly lower than that of control (2.33 cm). Although *C. rotundus* extract significantly suppress the germination of those three species of broad leaf weeds, there was no effect on seed germination of soybean. On all treatment (0.0 – 4.5 kg/l), the number of soybean seed that germinated were not-significantly ranging from 78.66 – 96.00%.It is known from this experiment that in line with the result of experiment 3 that the hypothesis that suppression mechanism of teki to broad leaf weeds (*A. gangetica, B. alata, M. pigra*) is operated on the germination stages. Another information from this experiment, similar with Weston (1996), is that allelophaty has specific or selective effects.

Table 5. The effects of *Cyperusrotundus* extract on the germination percentage (%), speed of germination (% normal seedling/etmal), length of plumule (cm) and length of radicule of *Borreria alata**.

	Germination Percentage	Speed of germination	Length of plumule	Length of radicule
0 (control)	96.00a	15.63a	1.63a	2.33a
0.5	52.00b	6.33b	0.96b	0.60c
1.0	32.00c	2.73c	0.86b	0.86b
1.5	14.66d	1.06d	1.03b	0.7bc
2.0	0.00f	0.00e	0.00d	0.00d
2.5	1.33ef	0.03e	0.10d	0.13d
3.0	5.33ef	0.23e	0.56c	0.53c
3.5	0.00f	0.00e	0.00d	0.00d
4.0	5.33ef	0.23e	1.06b	0.76cd
4.5	9.33ed	0.40e	1.03b	0.53c

*Notes: Value with different letters in each column indicate significant difference among sectors by DMRT $p<0.05$

Experiment 5. Analysis of allelochemical componds of *C. rotundus*

GC-MS analysis using aquadest as solvent was able to detect 16 compoundson fresh *C. rotundus*, while using etanol as solvent was able to detect 10 compouds on fresh *C. rotundus*, 12 compounds on dried *C. rotundus*, 19 compounds on compost of *C. rotundus*, and 3 compounds on *C. rotundus*powder. The difference of the number of compounds detected might be caused by the difference in the processing of the sample. The processing step such as drying and powdering could possible cause the loss and formation of some compounds.

Table 6. Analysis of allelochemical componds of *C. rotundus*

	Aquadest	etanol 96 %			
	fresh	fresh	dried	compost	powder
Content of*C. Rotundus*	.... %.................................				
4-vinyl-2-methoxy-phenol	1.88	1.39	-	-	-
Cedranone	-	-	-	1.61	-
Choles-5-en-3-ol (3.beta)-, propanoate(CAS)	-	-	-	-	2.91

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Culmorin	1.81	-	-	-	-
Cyperene	0.73	-	-	-	-
Furanmethanol (CAS) fulfuryl alcohol	-	3.06	-	-	-
Ethylcholest-5-en-3.beta,-ol, Cholest-5-en	5.7	-	-	12.69	-
Hexadecanoic acid	29.53	-	6.31	12.13	-
Total number of identified compounds	16	10	12	19	3

From this analysis, it is known that cyperene and culmorin only can be identified on fresh *C. rotundus* using aquadest as solvent, and cannot be detected on other formula of *C. rotundus*.Lawal&Oyedeji (2009); Elrokiek (2010) have reported that *C. rotundus* contains phenolic compounds such as cyperene and culmorin. Phenolic compounds with high solubility in water have reported to have low allelophaty activities (Seigler 1996). Therefore, although teki extract could be very effective to suppress broad leaf weeds germination, for its application in the field as bioherbicide, further studies to solve these issues are needed.

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