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Plant Growth Inhibitory Activity of *Goniothalamus andersonii* Bark Incorporated with Soil on Selected Plants

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Abstract

Phytotoxic effects of soil incorporation with *Goniothalamus andersonii* bark powder against *Cucumis sativus* (cucumber), *Trifolium repens* (white clover), *Lactuca sativa* (lettuce) and *Lolium perenne* (perennial ryegrass) were evaluated under the greenhouse condition for possible utilization as weed suppression. The growth of tested plants was reduced significantly after 14 days of incorporation where the degree of inhibition was dose dependent. A monocotyledonous plant, *L. perenne* was greatly inhibited by 94.8% when exposed to the bark powder concentration of 2% (w/w). After 21 days of incorporation, the length and fresh weight of both root and shoot part of tested plants were decreased significantly. These results indicate that *G. andersonii* bark has great inhibitory activity against various tested plants, suggesting that the bark powder is very beneficial as a natural herbicide in weed control management.

Keywords: Phytotoxic effects; Soil incorporation; *Goniothalamus andersonii*; *Lolium perenne*; Weed control

Introduction

Allelopathy is defined as the interaction between plants, including microorganisms which have detrimental or beneficial effects through the release of chemical compounds into the environment [1]. The liberation of secondary metabolites into the environment by living or dead plant tissue occurs through several ways namely volatilization, root exudation, leaching and decomposition of plant residues in soil [1,2]. This will interfere with the growth and development of neighboring plants or other organisms.

Excessive use of synthetic herbicides has been negatively affected human health and the environment as well as rapid development on herbicide-resistant weeds [3,4]. The application of herbicides is being prevented due to the effect of its residue, non-target toxicity and long-term perseverance in soil [5]. Therefore, the demand for natural herbicide is increasing as it is ecologically friendly and easily biodegradable.

The use of plant residue with allelopathic properties incorporated into soil known as one of the alternatives in weed management. The weed germination and growth can be inhibited by various applications of allelopathic crops and allelochemicals as extracts, mulches and residues [6]. The retardation of seed germination and individual plant growth inhibition are adversely affected by soil incorporation or surface application, such as mulch of allelopathic crop residues. This phenomenon resulted in the reduction of weed community density and vigor as a whole [7]. The effective and success use of cover crops as mulches or incorporated into soil to control weeds has been reported in several literatures. For example, the density and biomass of some weeds were significantly decreased as affected by the mulching or incorporation of legumes or cereals [8-10].

Goniothalamus andersonii J. Sinclair, from the family Annonaceae is an aromatic medicinal plant, endemic to Sarawak. This plant is widely used in traditional medicines by natives especially for abortion and post-partum treatment. Our previous study indicated a great allelopathic activity of the bark part of this plant. Goniothalamin was isolated and identified as its predominant plant growth inhibitor [11]. However, the phytotoxic effects of this plant residue in soil have not yet been investigated. Therefore, current research was conducted to evaluate the plant growth inhibitory activity of *G. andersonii* bark residue incorporated into soil against *C. sativus*, *T. repens*, *L. sativa* and *L. perenne* as tested plants for possible application as a bioherbicide.

Materials and Methods

Plant materials

The bark of *Goniothalamus andersonii* was collected in Lundu, Sarawak and oven-dried at 60˚C for 48 hours. The bark samples

(100 g) were chopped into small pieces and grounded into powder by using a traditional grinder. The seeds of *Cucumis sativus* L. cv. Ora 2 were purchased from Kurume Vegetable Breeding Co., Ltd., *Trifolium repens* L. cv. Fia from Snow Brand Seed Co., Ltd., *Lactuca sativa* L. cv. Legacy from Takii and Co., Ltd. and *Lolium perenne* L. from Fukuokaen Seedling Co., Ltd.

Pot experiment

The phytotoxic effects of bark powder from *G. andersonii* incorporated with soil on the growth of selected plants were evaluated in the greenhouse. The environmental conditions were 11h/13h day/night photoperiod, average day/night temperature of 36/14˚C and humidity of 78%. This pot experiment was conducted by integrating bark powder with soil (Kumiai Engei-Baido, Zen-no, Japan) at different bark concentrations of 0.1, 0.5, 1 and 2% (w/w). These treatments were prepared in three replications by using the pot of dimensions 55 mm diameter, 65 mm height (Agripot, BBJ High-Tech) as well as control treatment devoid of bark powder. One pre-germinated seed of tested plants was sowed in each pot and all those treatments were irrigated with an adequate amount of water to keep them in moisture condition.

The height of tested plants was measured on the 7th, 14th and 21st day after incorporation. The inhibition (%) was calculated compared to the control treatment as follow:

Inhibition(%)=100-[(Average height for residue treatment/ Average height for control) × 100]

On the day 21st after incorporation, the length and fresh weight of both roots and shoots of tested plants were measured. For control treatment, the length (mm) of roots of *C. sativus*, *T. repens*, *L. sativa* and *L. perenne* were 122, 125, 84.0 and 135 while their shoot length was 118, 56.7, 96.7 and 168, respectively. In terms of fresh weight (g), the root weight of *C. sativus*, *T. repens*, *L. sativa* and *L. perenne* were 0.57, 0.08, 0.02 and 0.05 while their shoot weight was 2.17, 0.18, 0.37 and 0.24, respectively. The inhibition (%) was calculated compared to those values based on the above formula. EC_{50} values (%) which are the concentrations of bark powder that inhibit 50% growth were determined based on those results.

Statistical analysis

The data gathered were analyzed by using Analysis of Variance (ANOVA). Tukey's HSD test was used to compare between treatments at 0.05 probability level. The statistical software employed was Statistics 10 Analytical Software, Tallahassee, FL, USA. The EC_{50} values were determined by Probit analysis.

Results

The effects of soil incorporated with *G. andersonii* bark powder on the growth of tested plants over time

The bark powder of *G. andersonii* incorporated with soil was tested against *C. sativus*, *T. repens*, *L. sativa* and *L. perenne* in order to evaluate its phytotoxic effects on those plants under the greenhouse condition. The growth of tested plants was decreased with the increasing concentration of *G. andersonii* bark powder on the 7th, 14th and 21st day after incorporation. The results showed a various degree of inhibition based on the species tested as well as the treatment period.

Throughout the weeks, the inhibition rate trend was significantly inclined after 14 days followed by a slight decreased after 21 days of incorporation in most cases. On the contrary, the inhibition rate of cucumber was declined through time except for the application of 2% bark residue. Similar tendency exhibited by lettuce only at the lowest rate of 0.1%.

The growth of *L. perenne* exposed to 2% bark powder was strongly inhibited by 94.8% from week 2 followed by white clover with 93.9%. This shows the high sensitivity of both plants towards inhibitory substances from *G. andersonii* bark powder.

The effective concentration (EC_{50}) which induced 50% inhibition was ranging from 0.23 to 0.81% **(Table 1)**. The values were varied depending on recipient species and period of incorporation. The application of 0.31% bark powder incorporated into soil could reduce 50% growth of *C. sativus*. This was the lowest EC_{50} value as compared with other plants tested after 7 days of incorporation. After 14 days of incorporation, *T. repens* recorded the lowest EC_{50} value (0.23%) followed by *C. sativus*, *L. sativa* and *L. perenne* in an ascending order. Intriguingly, this result showed that the application of bark powder at 0.6% or less vigorously retarding 50% growth of tested plants.

Table 1: Effective concentration (EC_{50}) for growth of tested plants over time.

Tested plants	EC_{50} values (%)		
	Day 7th	Day 14th	Day 21st
Cucumis sativus	0.31	0.46	0.61
Trifolium repens	0.64	0.23	0.39
Lactuca sativa	0.74	0.53	0.49
Lolium perenne	0.81	0.6	0.61

The effects of soil incorporated with *G. andersonii* bark powder on the growth and biomass of tested plants 21 days after incorporation

The growth of both roots and shoots of tested plants as well as their fresh biomass after 21 days of incorporation are shown in **Figure 1**. The inhibition rate (%) of roots and shoots of all tested plants increased parallel with the increasing concentration of bark powder incorporated into soil. There was a slight stimulation effect exhibited by *C. sativus* root and *L. sativa* shoot at the lowest concentration of bark powder (0.1%) with -15.3% and -2.8%, respectively. The sensitivity of root and shoot part of all plants varied depending on the species and concentration applied.

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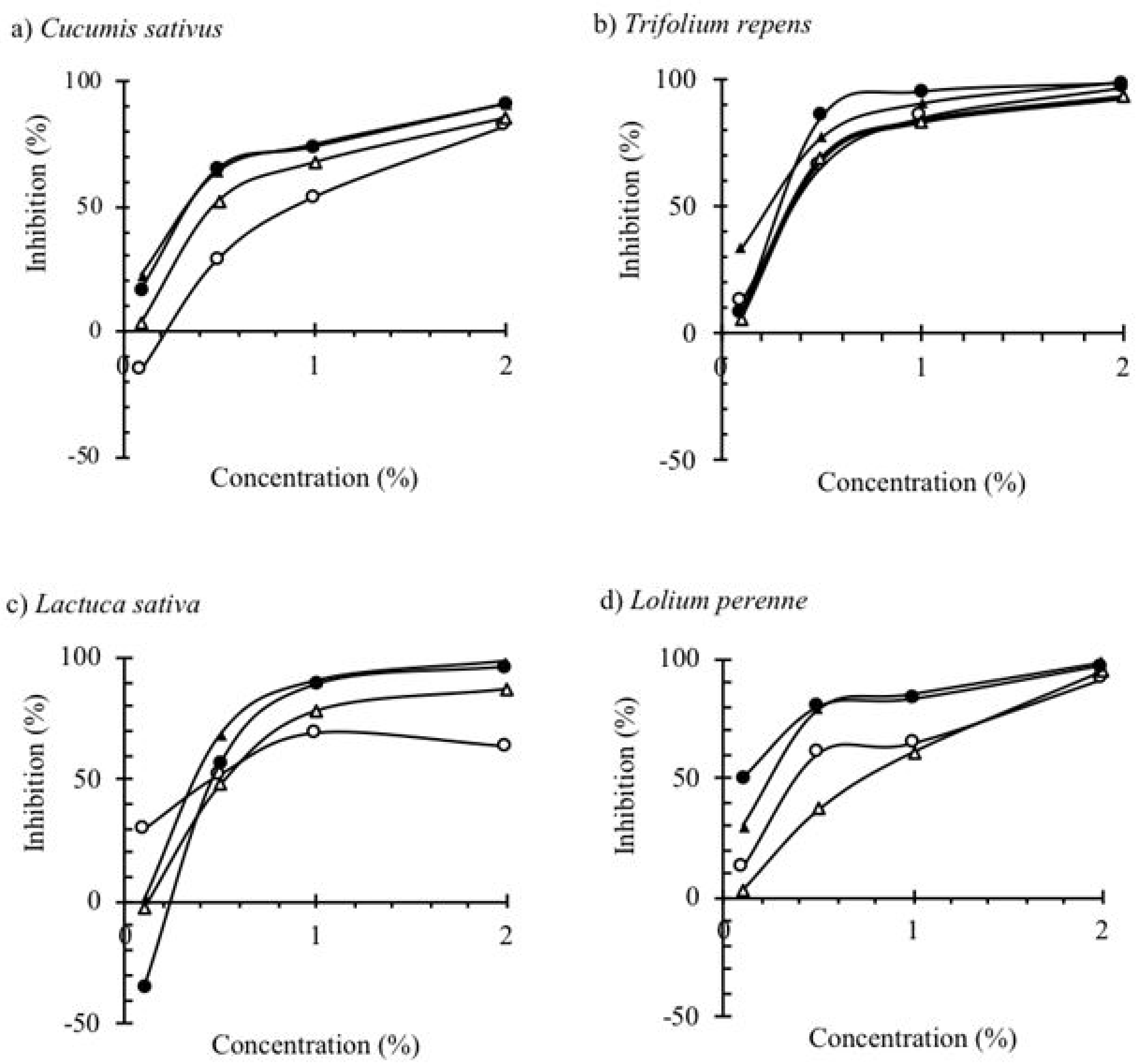

Figure 1: The effects of soil incorporated with different concentrations of *G. andersonii* bark powder on the growth and fresh weight (FW) of roots and shoots of tested plants: a) *Cucumis sativus*, b) *Trifolium repens*, c) *Lactuca sativa* and d) *Lolium perenne* on day 21st after incorporation (○: root length, •: root FW, △: shoot length, ▲: shoot FW).

Among all species tested, *T. repens* and *L. perenne* were the most sensitive towards bark powder of *G. andersonii* at the rate of 2% (w/w) in terms of root and shoot growth, respectively. Apparently, the root growth of T. repens was inhibited by 97.3% while 94.5% inhibition was recorded by *L. perenne* shoot.

Based on the EC_{50} analysis, *T. repens* recorded the lowest EC_{50} value in terms of root and shoot growth **(Table 2)**. The soil incorporation with 0.32% and 0.39% bark powder could inhibit 50% growth of root and shoot, respectively. The results indicate that incorporation of bark powder at the rate less than 1% could retard 50% growth of all tested plants three weeks after application.

Table 2: Effective concentration (EC_{50}) for the growth and fresh weight of tested plants on day 21st after incorporation.

Tested plants	EC_{50} values (%)			
	Growth		Fresh weight	
	Root	Shoot	Root	Shoot
Cucumis sativus	0.87	0.61	0.35	0.32
Trifolium repens	0.32	0.39	0.27	0.18
Lactuca sativa	0.44	0.49	0.4	0.33
Lolium perenne	0.43	0.61	0.11	0.2

The significant reduction in root and shoot biomass was in line with the decline of their length. The exposure of tested plants to the highest concentration of 2% bark powder greatly reduced *T. repens* root and shoot as well as *L. perenne* root fresh weight the most by the equal rate of 99%.

The effective concentration which can induce 50% fresh weight of all tested plants was ranging from 0.11% to 0.40%. Among all plants tested, *L. perenne* was the most sensitive for the root biomass while for shoot biomass, *T. repens* was the most sensitive.

Discussion

The bark powder of *G. andersonii* incorporated into soil found to possess phytotoxic effects against *C. sativus*, *T. repens*, *L. sativa* and *L. perenne*. This was attributed to the allelochemicals including goniothalamin released by this plant residue into soil hampering the growth and biomass of tested plants. However, their inhibition rates were different depending on the species tested, the dosage of bark powder applied as well as the period of incorporation.

The application of plant powder from various plant parts of plant including leaf, root, shoot and flower incorporated into soil are known to have a potent suppression effect on the growth of tested plants [12-15]. Different rate of inhibition was exhibited by *C. sativus*, *T. repens*, *L. sativa* and *L. perenne*. A similar trend was indicated by the exposure of various plants to Mexican sunflower leaf residue [12].

The increasing of inhibitory rate was consonant with the increase of the dose applied. There are a plethora of studies in line with this [16-18]. The greatest phytotoxic effects displayed after 14 days of treatment was parallel with the previous report [13] which stated that the phytotoxic activity of soil incorporation with itchgrass powder was effective up to 14 days after incorporation.

Ecological and physiological aspects of plants were one of the key factors affecting the sensitivity of plants towards plant growth inhibitory substances [19]. The susceptibility of seeds towards allelochemicals was contingent on their size, where large-sized seeds display a lower sensitivity in contrast to small-sized seeds [20] as well as the permeability of seed coat [21]. The present study was supported by those finding where a small-seeded plant, *T. repens* was the most sensitive towards plant growth inhibitory substances released by *G. andersonii* bark powder. In a laboratory bioassay conducted, this plant also reported to have a high sensitivity towards goniothalamin with the EC_{50} value of 40 µM on the radicle growth [11]. The allelopathic potential demonstrated indicates that this plant not only has phytotoxic effects in laboratory condition, but also in nature.

A potent deleterious effect was presented by a monocotyledonous plant, *L. perenne* treated with *G. andersonii* bark powder at the highest dose. This was uncommon since dicotyledonous plants are usually more susceptible to plant growth inhibitory substances in comparison with monocotyledonous plants [22]. Therefore, this interesting finding indicates the possible utilization of *G. andersonii* bark as a bioherbicide to control weeds.

The application of *G. andersonii* bark powder at the lowest rate slightly promoted the growth of cucumber root and lettuce shoot after 21 days of incorporation. Similar results exhibited promotion effects on the shoot growth and dry biomass of *Trifolium alexandrium* as exposed to the lowest concentration of *Sonchus oleracues* shoot residue [23,24]. Most organic compounds which possess suppression effects at some concentrations also stimulate at low concentrations [1].

Conclusion

Phytotoxic substances exuded from *G. andersonii* bark through the incorporation with soil significantly reduced the growth and biomass of *C. sativus*, *T. repens*, *L. sativa* and *L. perenne*. The suppression effect proved that this plant has great potential as a bioherbicide for weed management. However, the target species, the dose of residue applied as well as the treatment period should be taken into consideration. Further research in the field is required in order to demonstrate this effect in natural condition.

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References

1. Rice EL (1984) Allelopathy 2nd Edn. Academic Press Orlando Florida USA. 368.
2. Putnam AR (1985) Weed allelopathy. In: S.O. Duke (ed.). Weed physiology: Reproduction and Ecophysiology. CRC Press 1: 131-155.
3. Kropff MJ, Walter H (2000) EWRS and the challenges for weed research at the start of a new millennium. Weed Res 40: 7-10.
4. Macias FA (1995) Allelopathy in the search for natural herbicide models. In Allelopathy: Organisms, Process and Applications; Inderjit, Dakshini KMM and Einhellig FA, Eds.; ACS Symposium Series 582; American Chemical Society: Washington DC 310-329.
5. Hussain I, Singh NB, Singh A, Singh H (2017) Allelopathic potential of sesame plant leachate against Cyperus rotundus L. Ann Agrar Sci 15: 141-147.
6. Singh HP, Batish DR, Kohli RK (2003) Allelopathic interactions and allelochemicals: New possibilities for sustainable weed management. Crit Rev Plant Sci 22: 239-311.
7. Gallandt ER, Liebman M, Huggins DR (1999) Improving soil quality: implications for weed management. J Crop Prod 2: 95-121.
8. Nagabhushana GG, Worsham AD, Yenish JP (2001) Allelopathic cover crops to reduce herbicide use in sustainable agricultural systems. Allelopathy J 8: 133-146.
9. Ngouajio N, Mennan H (2005) Weed populations and pickling cucumber (Cucumis sativus) yield under summer and winter cover crop systems. Crop Prot 24: 521-526.
10. Dhima KV, Vasilakoglou IB, Eleftherohorinos IG, Lithourgidis AS (2006) Allelopathic potential of winter cereals and their cover crop mulch effect on grass weed suppression and corn development. Crop Sci 46: 345-352.
11. Takemura T, Kamo T, Raihan I, Baki B, Wasano N (2012) Plant growth inhibitor from the Malaysian medicinal plant Goniothalamus andersonii and related species. Nat Prod Commun 7: 1197-1198.

12. Tongma S, Kobayashi K, Usui K (1998) Allelopathic activity of Mexican sunflower (Tithonia diversifolia) in soil. Weed Sci 46: 432-437.

13. Kobayashi K, Itaya D, Mahatamnuchoke P, Pornprom T (2008) Allelopathic potential of itchgrass (Rottboellia exaltata L.f.) powder incorporated into soil. Weed Biol Manag 8: 64-68.

14. Omezzine F, Ladhari A, Rinez A, Haouala R (2011) Potent herbicidal activity of Inula crithmoides L. Sci Hortic 130: 853-861.

15. Han X, Cheng ZH, Meng HW, Yang XL, Ahmad I (2013) Allelopathic effect of decomposed garlic (Allium sativum L.) stalk on lettuce (L. sativa var. crispa L.). Pak J Bot 45: 225-233.

16. Batish DR, Lavanya K, Singh HP, Kohli PK (2007) Phenolic allelochemicals released by Chenopodium murale affect growth, nodulation and macromolecule content in chickpea and pea. Plant Growth Regul 51: 119-128.

17. Dhima KV, Vasilakoglou IB, Gatsis ThD, Panou-Philotheou E, Eleftherohorinos IG (2009) Effects of aromatic plants incorporated as green manure on weed and maize development. Field Crop Res 110: 235-241.

18. Bundit A, Thongjoo C, Chompoo J, Pornprom T (2015). Allelopathic activity of icthgrass (Rottboelli cochinchinensis) and its phytotoxicity in soil. Thai J Agric Sci 48: 73-80.

19. Kobayashi K (2004) Factors affecting phytotoxic activity of allelochemicals in soil. Weed Biol Manag 4: 1-7.

20. Adler JM, Chase AC (2007) Comparison of the allelopathic potential of leguminous summer cover crops: cowpea, sunn hemp and velvetbean. HortScience 42: 289-293.

21. Gange AC, Brown VK, Farmer LM (1992) Effects of pesticides on the germination of weed species: implications for manipulative experiments. J Appl Ecol 29: 303-310.

22. Soltys D, Krasuska U, Bogatek R, Gniazdowska A (2013) Allelochemicals as bioherbicides - Present and Perspectives. In: Herbicides-Current Research and Case Studies in Use. Price AJ, JA Kelton, (eds.), CC BY 517-542.

23. Hassan MO, Gomaa NH, Fahmy GM, Gonzalez L, Hammouda O et al. (2014) Influence of Sonchus oleraceus L. residue on soil properties and growth of some plants. Philipp Agric Sci 97: 368-376.