MANUSCRIPT HISTORY Published in Research on Crops (Q3)

Publisher: Gaurav Society of Agricultural Research Information Centre

https://www.scopus.com/sourceid/19900191751

+ c	Contraction and a second second		क्र	
Source o	taga.	Q Author Search Sources	2 B Connessee	
	aarst - Trom 2008 to Present / Secrety of Agricultural Research Information	s Cunn	Cheffone 372 1.7 3,6722	3 3
	na a da di dagadi sana (garanga di ng karan) Kal	(Agram a dia di A dagado) meta katikan a	0.277 swr.801 1.056	*
OpSo: Op	core rank & trend Scopus corners coverag	87		

https://www.scimagojr.com/journalsearch.php?q=19900191751&tip=sid&clean=0

🖬 vanan in ne saanne saat 🐘 🗐	Penerd Vetran 👘 🐻 Penerd Vetran					
+ e 0 u i	the construction of a support of which	for data agricult			0.2	*
снино Сонтахана						
			1.000	(141) - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	III. Standard institution	CHE BANK K
SJR: samage.com	al & Coammy (Sect			Sectored	True 3880 (rink the store -	
	Lorne Journal Sankings	Country Ferridage	vie Tasle – Hels	About Us		
12 8	55N					
Research o	n Crops					
128 B4155	oo.	analysis and a second	Direct.	4.8710		
CONFINA	STRUKT APPO ANT I	ATHODAY ALA	D94-4F	+ 6010	54	
	Agricultural and Si	elegical Sik	gy Society of Agricult	4.267.2		
baka.	Agricultural and Sector and Sector and Frequency Program (Sector and Sector and Sector and Sector)	ulapical sia Rea		. 15		
	Agricultural and Scheroter Scheroter Agronotive and Scherote	ulapical sia Rea	gy Society of Agricult And Finder and Arrived	. 15		
baka.	Agricultural and Sector and Sector and Frequency Program (Sector and Sector and Sector and Sector)	ulapical sia Rea	gy Society of Agricult And Finder and Arrived	. 15		
baka .	Agricultural and S Solentee Agricultural Solence Solence Solence	ulapasi sin Sin IQmp	gy Society of Agricult And Finder and Arrived	. 15	5	

IFICACOR.

11 👗 🛄 🛤 🥺 🛅 🕫

......

2 2 toebio newrit

21160121

ноперали

🕈 Harachang 🕗 🛛 🖻 🕄 ita 💡

111

https://indianjournals.com/ijor.aspx?target=ijor:rcr&type=for_authors

		Contraction of the second s			
Q.1	C E Heward and a Straphy at the state	191		3.0	
ter al biter vers	d. —				_
1.51	and some			200712-000	
Contraction of the local division of the loc	1715-000			land a AG	1
Land appartur	The Average Appropriation is not better and the average Average and	and internation connector down		L MORE HOLDING	
Ensagerch an Comp				Let a	
Senations I		RDC Author Guidalines		1000	
	A CONTRACT OF				
Autor Change	Manuseriois:				
southing I	to a standard the second				
Forest alloc	and the second second				
Constraint Const	The Millional supervise of a supervise of the Alexandra State of the Alexandra	we is able to the formation from its to	17-1-18-18-12-12-12-16-16-1	(004) 2040-7542; The attacked to and	
Constraint Constraint		wela ablwia tifa Ganacter Gyr In ta	177 - 1 72 4 6373 (2060) also (668 3343 7588 . The advances of the l	
Sound States Convertion Convertion Convertion States Convertion States Convertion	The Millional supervision stars a device the relation Depicture on the	जनाव अधिकाल । विंग विज्ञास्त्रा स्वार्थ के वि	177 - 1 884 (1973-1886) (1986)	ion destates to started in the	
Constraint Constraint	The Million of Automatic and Automatic on Automatics During as Au- Region of Later Carp	ne la solaria da Rospone (in s	177 <mark>-1</mark> 72,46953-12860 (inc.)	KARSHATHE THE MANNET TH	
Norski Alan Roseli Marka Anari Marka Socol Natar Californe	The Millional supervision stars a device the relation Depicture on the	we in addimine of a Bassacier (1993) in the	17 = 724092-226C (m.)	KARSHOTHE THE MANNED IN I	
Count Value C. count :: Policity - Room States - California Chillion - Room - California Chillion - Room - California Chillion - Room - California Chillion - Count - Count - California Chillion - Count - Count - California Chillion - Count - Chillion - Chillion - Chillion - Chillion - Chillion - Chillion - C	The Million of Automatic and Automatic on Automatics During as Au- Region of Later Carp	weinendwise ihn Gemacies (frys in sa	17) - 52 4 6973 (206 C ales)	KARSASTAS Teatheradi ind	
Constitution Co	Ta Minut sections are acted and the Date are Information of a				
Count Value C. count :: Policity - Room States - California Chillion - Room - California Chillion - Room - California Chillion - Room - California Chillion - Count - Count - California Chillion - Count - Count - California Chillion - Count - Chillion - Chillion - Chillion - Chillion - Chillion - Chillion - C	Te Millional subschede son school on which Doubles we Te justed - Te - Cap Arms and Scope: Te Minned a Ca (Capital Scope)	cyberhingting fan af bekennet in okte finsam en se fergere	ras, all riting alcono in	hika aka mana	
Kanahinin Carentis Halaya Rusei Katelo Katel	To Millional subschede son sideout resident inDuct as we have all the Gay Almo and Scope: To Network that the the spectroscophic subschede the shadding of spectrum by againment as proceeded and set to shadding a	cylectionstatics at task and spatialized as a subgroup any garanty it goes areas of post-source at the	nas alterniturg almanitur Katologi almanitur pedro	telle gegin die al with the operation	
Constitution Co	The Mill and is set of point over a device on electric Druck as we a high and - The Drug Alime and Scope: The Neural of Tarch open converted and on the only allong a spectrum by gradenics and an electric product on equipped	cylectionstatics at task and spatialized as a subgroup any garanty it goes areas of post-source at the	nas alterniturg almanitur Katologi almanitur pedro	telle gegin die al with the operation	
Constraint Constraint	The Millional subscription place is device the relation in Drack as we a high and the Drack age Almost and Scope: The Networks for the spon decremental modern is not publicly affecting a spontaneous partners, and an advanced publicly are appreciated as the publicly age above, and managements of the spontaneous age of the set are the articles are	n giordinatari na di sek nari ngala di kan isa ingan aray garaka la pasi anan ng na tanana aka tan araw garaka inganaran na isi aray ang ang ang ang	ning, salt mitting sakuna tan Katinanggi sakun attan pisan se usanca ang activation, pan	t de grapie de sé velocitaria para arrectaria por esta de conceptaria campana actorica de tecorrecta etc.	
Constitution Co	The Millional subscription size is deviation which is Doubt as the Indonesian The Corp. Arms and Scorps: The Remarker Corp. (Second Scorps and Scorps) The Remarker Corp. (Second Scorps) and the second scorp additional approximately approximately and solid and provide in capacity of access to be provided in the solid and provide in the solid addition of the first and provided provided in the solid addition of a solid additional of the first additional additional additional additional of the first additional additional additional additional of the first additional addit	n gina functional and a stand and a guide distance as a fungement and a spanning in the stand and a spanning in the stand and a st and a stand and a stand a stand and a Stand and a stand a Stand and a stand a	e es alle entreg alman de Kathalog sere attan pol- to mens en entre alman. mengis direktionigan mikk	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Constraint Constraint	The Millional subscription place is device the relation in Drack as we a high and the Drack age Almost and Scope: The Networks for the spon decremental modern is not publicly affecting a spontaneous partners, and an advanced publicly are appreciated as the publicly age above, and managements of the spontaneous age of the set are the articles are	n gina functional and a stand and a guide distance as a fungement and a spanning in the stand and a spanning in the stand and a st and a stand and a stand a stand and a Stand and a stand a Stand and a stand a	e es alle entreg alman de Kathalog sere attan pol- to mens en entre alman. mengis direktionigan mikk	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Constitution Co	To bill and watch part over a deviation when in Doubling watch To be and the tag. Anne and Scope: To Bernaline fair the spectration be address to only all large agreementation games are evaluated or publicles capacity as a factors, to immediate and publicles are publicles are address and a factors are to approximate and sectors are address and the bill of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and the tagent of the sector publicles are address and the tagent of the sector publicle and the tagent of the sector publicles are address and the tagent of the sector publicle and the tagent of the sector publicle and the tagent of the tagent of the sector publicle and the tagent of the sector publicle and the tagent of the sector tagent of the tagent of the tagent of the sector publicle and the tagent of the sector tagent of the tagent of the tagent of the tagent of the sector publicle and the tagent of tagent	ogiochina anti occitaria nel spalio bizano se fogore ana garade i spaci ana og notestara se a traj ana ne navasanarat te teres, notestaras se tra og spalinen grift an org, teresti teres ti o na anang nela tara tat bezegage, estara garada	e es alle entreg alman de Kathalog sere attan pol- to mens en entre alman. mengis direktionigan mikk	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Vorank Mar Portentia Portentia Portentia Portentia Portentia Portentia Machinetta Machinetta Portenti	The Millional subscription size is deviation which is Doubt as the Indonesian The Corp. Arms and Scorps: The Remarker Corp. (Second Scorps and Scorps) The Remarker Corp. (Second Scorps) and the second scorp additional approximately approximately and solid and provide in capacity of access to be provided in the solid and provide in the solid addition of the first and provided provided in the solid addition of a solid additional of the first additional additional additional additional of the first additional additional additional additional of the first additional addit	ogiochina anti occitaria nel spalio bizano se fogore ana garade i spaci ana og notestara se a traj ana ne navasanarat te teres, notestaras se tra og spalinen grift an org, teresti teres ti o na anang nela tara tat bezegage, estara garada	e es alle entreg alman de Kathalog sere attan pol- to mens en entre alman. mengis direktionigan mikk	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Constitution Co	To bill and watch part over a deviation when in Doubling watch To be and the tag. Anne and Scope: To Bernaline fair the spectration be address to only all large agreementation games are evaluated or publicles capacity as a factors, to immediate and publicles are publicles are address and a factors are to approximate and sectors are address and the bill of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and publicles are address and the tagent of the sector publicle and the tagent of the sector publicles are address and the tagent of the sector publicle and the tagent of the sector publicles are address and the tagent of the sector publicle and the tagent of the sector publicle and the tagent of the tagent of the sector publicle and the tagent of the sector publicle and the tagent of the sector tagent of the tagent of the tagent of the sector publicle and the tagent of the sector tagent of the tagent of the tagent of the tagent of the sector publicle and the tagent of tagent	cylonferster for all site and spatio fiscal as a forger and yarabet is part and by rotherary, and that an art is investment to inclusion and the so inclusion of the state of the source of the source inclusion of the state of the source of the source analogic of the state of the spages of the source of the source of the state of the spages of the source of the source of the space of the state of the source of the source of the source of the source of the source	nos, alle ortrig alcuni en estatogo escontratoro por contento and econocos, an escondo de la terratoro por en egune de las constantes ta	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Vorank Harr Porter Porter Market Scott Porter Zahrone Marchander M	The Millimod is also thread size is depending which is Database et al. The Millimod of the Database Almost and Scoppe: The Mercondructure of the open dependent of probability of algorithmitizy agriculture and exceeded and the only allefung of algorithmitizy agriculture and exceeded and the only allefung of algorithmitizy agriculture and exceeded and the only allefung of algorithmitize agric of the open dependent of probability of the open dependent of the open open dependent of the open algorithmitized open dependent of the open open dependent of the open algorithmitized open dependent of the open open dependent of the open algorithmitized open dependent of the open open open dependent open algorithmitized open dependent open open open algorithmitized of the open of the open open open open open open of the open open open open open open open ope	e globilitation de ale contrapale datas est legen any ganales legent anno globilitationes de tra anvantes investmentationes, consectores de la seguinar globilitati d'an angli entertationes d'una entergender trais 135,500 pages estatorigitation d anno de trais trais 2,500 pages estatorigitations d	n og stille omforig saktand om hadriskog saktar af for god se mensen and ermoslos, som nængi et det konges er KR mengi et skal konges er KR ne gode stør se set senaet af s	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Vorank Harr Porter Porter Market Scott Porter Zahrone Marchander M	The Mill and is also thread along a device or provident in Database of a light and other day. Almost and Scorpes: The Nermatine for eth open devices the analysis of public group appendiculation for eth open devices the analysis of public group above, non-management of the sector and the test, tertained and the formula of a sector open devices and the test, tertained and the test of the sector open devices and the test, tertained and the test of the sector open devices and the test and test open of the test.	e globilitation de ale contrapale datas est legen any ganales legent anno globilitationes de tra anvantes investmentationes, consectores de la seguinar globilitati d'an angli entertationes d'una entergender trais 135,500 pages estatorigitation d anno de trais trais 2,500 pages estatorigitations d	n og stille omforig saktand om hadriskog saktar af for god se mensen and ermoslos, som nængi et det konges er KR mengi et skal konges er KR ne gode stør se set senaet af s	hillige ger flast with range of a and range of the state and a state and state of the state and a state and state of the state of the	
Vorank Harr Porter Porter Market Scott Porter Zahrone Marchander M	To black a sector part over a device resident in Drack as we a region of the Corporation of the Sector of	e glosfensterine, et olsk om hypikelistaanse fogen men ganaar it glost onder gjosterinen, at stea men ganaar it glost onder gjosterinen. At stea men geden meg då at, orgjosterine hære formet i men geden men fot betrigt geget och om gjosterine men geden for 2 gest och at beset och staat	n eg selle en brog selvene me kontraktyg sener af fan goed de menne and en moleten selv mengig sen ste tet somet en ta ne gjane ste tet somet en ta n gif nyst ja mel	hillige professively reaction of the second se	
Vorank Harr Porter Porter Market Scott Porter Zahrone Marchander M	The Millimod is also thread size is depending which is Database et al. The Millimod of the Database Almost and Scoppe: The Mercondructure of the open dependent of probability of algorithmitizy agriculture and exceeded and the only allefung of algorithmitizy agriculture and exceeded and the only allefung of algorithmitizy agriculture and exceeded and the only allefung of algorithmitize agric of the open dependent of probability of the open dependent of the open open dependent of the open algorithmitized open dependent of the open open dependent of the open algorithmitized open dependent of the open open dependent of the open algorithmitized open dependent of the open open open dependent open algorithmitized open dependent open open open algorithmitized of the open of the open open open open open open of the open open open open open open open ope	e glosfensterine, et olsk om hypikelistaanse fogen men ganaar it glost onder gjosterinen, at stea men ganaar it glost onder gjosterinen. At stea men geden meg då at, orgjosterine hære formet i men geden men fot betrigt geget och om gjosterine men geden for 2 gest och at beset och staat	n eg selle en brog selvene me kontraktyg sener af fan goed de menne and en moleten selv mengig sen ste tet somet en ta ne gjane ste tet somet en ta n gif nyst ja mel	hillige professively reaction of the second se	



Manuscript submission : 3 Oktober 2022

COVER LETTER

To Research on Crops

Dear Editor,

I would like to send an original article entitled: "**The Role of Biochar Amendments in Improving the Properties of Acid Sulphate Soil**" for Research on Crops to consider. I confirm that this work is genuine and has not been published elsewhere, nor is it considered for publication elsewhere. We believe and hope that this manuscript is worthy of publication by Research on Crops. We are interested in publishing articles in this journal because it has an excellent reputation, so it is a matter of pride if published in Research on Crops. Here I attach the manuscript.

Thank you Best regards,

Agusalim Masulili Panca Bhakti University, Pontianak, West Kalimantan, Indonesia

The Role of Biochar Amendments in Improving the Properties of Acid Sulphate Soil

AGUSALIM MASULILI^{1,*}, SUTIKARINI², RINI SURYANI³, IDA AYU SUCI⁴, ISMAIL ASTAR⁵, HARDI DOMINIKUS BANCIN⁶, AND PAIMAN⁷

¹Department of Agrotechnology, Faculty of Agriculture, Universitas Panca Bhakti, Pontianak 78113, West Kalimantan, Indonesia

²Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia

Author email:

¹agusalim@upb.ac.id,

²<u>sutikarini@upb.ac.id</u>,

³<u>rini.suryani@upb.ac.id</u>, ⁴idaayusuci@upb.ac.id,

⁵ismailastar@upb.ac.id, ⁶hdbancin14@upb.ac.id,

⁷⁾paiman@upy.ac.id

*Corresponding author: Agusalim Masulili, Tilp: +628125631353, fax : 056177442, email: agusalim@upb.ac.id

ABSTRACT

Acid sulphate soil has the potential for agricultural development. Nevertheless, this soil has various soil properties problems that can inhibit plant growth. The granting of amendments can improve the properties of the soil. The study aimed to know the role of rice husk biochar combined with amendments to *Chromolaena odorata*, rice straw, and rice husk ash to improve the properties of acid sulphate soil. The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely: without amendments (control), *Chromolaena odorata* (10 t/ha), rice straw (10 t/ha), rice husk biochar (1

ash (10 t/ha), *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha), rice straw (10 t/ha) + rice husk biochar (5 t/ha), *Chromolaena odorata* (10 t/ha) + rice husk ash (5 t/ha), and rice straw (10 t/ha) + rice husk ash (5 t/ha). The results showed that the amendment of rice husk biochar combined with amendments to *Chromolaena odorata* and rice straw, respectively, had a good effect on improving soil physical properties, namely total soil pores, reducing soil content weight and soil strength. Its effect on soil chemical properties is that it can increase pH, C-organic, P-available, cation exchange capacity (CEC), and lower Al-dd and Fe soluble. The research findings show that applying biochar and organic amendments to *Chromolaena odorata* and rice straw can potentially improve the properties of acid sulphate soil. In future research, we recommend increasing the carrying capacity of acid sulphate soil against plant growth, and it can be done by improving soil properties through the organic amendments application of *Chromolaena odorata* or straw enriched with rice husk biochar.

Key words: *Chromolaena odorata*, rice husk ash, rice husk biochar, rice straw, soil properties **Running headline:** Improving the properties of acid sulphate soil

INTRODUCTION

Acidic sulphate soils are the common name for soils and sediments containing iron sulfide, namely pyrite (Das and Das, 2015). In agricultural development, efforts to reclaim acid sulphate soils do not always result in soil productivity since improvements in soil properties after reclamation are not achieved. So far, efforts have been encouraged to overcome existing obstacles after reclamation, including inorganic fertilizers (urea, TSP, KCl) and liming (dolomite). However, rice crop productivity in this field has not been optimal.

Inorganic fertilizers increase over time and can even decrease land quality if inputs are high and intensive. Liming can only cope with short-term pH and is often done repeatedly. As a result, high costs are needed, which becomes a burden for farmers and will threaten the sustainability of land productivity. Therefore, it is necessary to manage land based on land amendments that can improve the nature of sustainable soils.

Reclamation can result in changes in soil properties and is related to the potential for pyrite oxidation, affecting the increase in soil packaging and the solubility of ions such as Al, Fe, Mn, and sulphate. On the other hand, this soil has a high clay content which affects the increased weight of the contents. Therefore, the development of acid sulphate soil for agriculture after reclamation requires proper management of soil amendments to achieve the formation of steady cultivated land and sustainable farming. Das and Das (2015) suggested that acid sulphate soil having a high pH can inhibit plant growth. In addition, when this soil is drained, it can affect an increase in sulfuric acid and the release of iron, aluminum, and other heavy metals. Shamshuddin *et al.* (2014), stated that plants grown in acidic sulphate soils could not grow well due to low pH and high Al content.

Biochar is one of the soil amendment materials with the long-term potential to maintain soil fertility. The results of experts' investigations into the phenomenon of terra preta show that soil fertility is stable in the Amazon basin due to the presence of black carbon, the result of the management of the Amerindian nation 500–2,500 years ago. This carbon black is nothing but biochar immersed in the soil. Murtaza *et al.* (2021) found that 4.0 t/ha cotton biochar improves physical, chemical, soil biological, and soil fertility properties and peanut productivity in Alfisol. Zhang *et al.* (2022) have proven that biochar provides effects such as liming and providing nutrients that lead to soil improvement. Kocsis *et al.* (2022) stated that biochar has a high porosity and can improve the physicochemical and biological properties of the soil. In line, Sovova *et al.* (2021) found biochar had a good influence on improving the soil properties of regosol. Further afield, Das *et al.* (2021) suggest the application of biochar to the soil can provide agronomic benefits, support crop yield improvement, and improve soil quality and health. In addition, biochar has been shown to act as a fertilizer and soil conditioner.

Nutrient retention and higher nutrient availability were found in the soil after biochar addition, associated with higher CEC, surface acreage, and direct nutrient addition (Glaser *et al.*, 2002). In line with opinions, Murtaza *et al.* (2021) suggested that biochar is a recalcitrant carbon product of

biomass produced through the pyrolysis process. The recalcitrant properties of biochar are distinctive and important to the long-term improvement of soil properties through the effects of their residues that can persist for a long time in the soil. Beusch (2021), biochar can contribute to soil fertility and crop productivity, and Kalu *et al.* (2021) increase water availability and lower soil BD.

Applying biochar can improve soil properties and long-term crop productivity compared to other organic amendments. In other organic amendments, research results by Suri and Yudono (2020) showed that giving *Cromolaena odorata* as compost can increase plants' nutrition and nutrient uptake. Agustina *et al.* (2019) argued that using *Chromolaena odorata* and rice straw can maintain soil quality. Mahmoud *et al.* (2009) also showed rice straw compost could improve soil quality. The same was discovered by Gewaily (2019), that straw compost can increase potassium availability.

Furthermore, the results of the study by Yin *et al.* (2022) showed the weight of the soil contents decreased, and the water-holding capacity and total porosity increased in the soil with rising rice husk ash. Adding rice husk ash neutralizes soil acidity and increases plant nutrient availability. Research by Lestari and Rachmawati (2020) showed that applying rice husk ash (4 t/ha) can increase rice growth and reduce salinity stress.

Previously, several studies on the effect of biochar singularly have been carried out, including on the P-availability (Zhang *et al.*, 2022), improvement of soil physical properties (Aslam *et al.*, 2014), chemical properties of the soil (Bista *et al.*, 2019), and some soil characteristics (Yadav *et al.*, 2018), soil aggregate stability (Ebido *et al.*, 2021), and to the development of rice roots (Kartika *et al.*, 2021). However, no research has been found on how the role of biochar was given together with other organic amendments in acid sulphate soil. Therefore, it is necessary to study how the effect of biochar is given together with organic amendments to *Chromolaena odorata* and rice straw. This research is expected to contribute to improving the nature of acid sulphate soil in West Kalimantan, which has been one of the types of soil widely used as an agricultural activity for rice crops. In connection with this hah, this study aimed to know the role of rice husk biochar combined with amendments to *Chromolaena odorata*, rice straw, and rice husk ash in improving the properties of acid sulphate soil.

MATERIALS AND METHODS

Study Area

This research was conducted from September to November 2021. The research site was carried out at the Laboratory of the Faculty of Agriculture, Universitas Panca Bhakti, Pontianak, West Kalimantan Province, Indonesia. The height of the study site is one m from above sea level, with an average temperature and humidity of 27.6 °C and 82.8%, respectively. The research position is located at a latitude of 2°05' N–3° 05' S and longitude of 108°30' E–144°10' W.

Experimental Design

The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely: without amendments (control), *Chromolaena odorata* (10 t/ha), rice straw (10 t/ha), rice husk biochar (10 t/ha), rice husk ash (10 t/ha), *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha), rice straw (10 t/ha) + rice husk biochar (5 t/ha), rice straw (10 t/ha) + rice husk biochar (5 t/ha). In all, 27 polybags are needed.

Research Procedures

The material in this study used acid sulphate soil taken on the experimental land of the West Kalimantan, Sungai Kakap, Agricultural Technology Assessment Center, and land farmers' work on rice crops. This area included the development of swampland agriculture which has built irrigation canals since 1980 and was currently designated as an Integrated Farmer Business Area. Soil picking

was carried out randomly at a soil depth of 0-20 cm, then mixed, air-dried, and cleaned. Then put in polybags was as much as 8 kg.

Biochar was made by taking rice husk from grain harvested from rice plants grown directly in the acid sulphate soil of the Kakap River, West Kalimantan, Indonesia. First, the rice mill was taken the grain to obtain rice husk. Furthermore, the rice husk was placed on the pyrolysis device to be processed into biochar by incomplete combustion (limited air) in a reactor made of Pertamina drums.

Organic amendments to *Chromolaena odorata* were taken from around the field, then chopped to a size of 1-2 cm. Rice straw was taken from waste harvested rice grown and grown by farmers in acid sulphate soil and chopped within 1-2 cm. Rice husks were taken from waste from rice milling, then used as ash through burning in open areas to produce grayish-white ash.

Prepared acid sulphate soil introduced into 27 polybags until it reached 8 kg. Further, the dose of soil amendment was calculated based on the soil weight in the polybag area, mixed with the soil in each polybag to a soil depth of 20 cm, after which it was incubated with moisture content until it was closed to the field capacity for 30 days.

At 30 days after incubation, from each study unit, soil sampling of about 50 g was undisturbed to determine the weight of the soil moisture content accident. In addition, a disturbed soil sample of 100 g was taken from each research unit for analysis of chemical properties.

Observation parameters

The soil bulk density (BD) was determined by the clod method described by Blake & Harke. The total pore was calculated from the soil moisture content (v/v) at the matrix potential of 0 kPa. The available groundwater was estimated by reducing the soil moisture content in the matrix potential by -33 kPa (field capacity) with the soil moisture content in the matrix potential, which was -15 Mpa (wilting point). The soil moisture content at this potential matrix was determined using a pressure plate device. The strength of the soil was measured with a hand penetrometer (Daikie) at a soil depth of 15 cm.

The pH level was measured in a soil solution at a ratio of 1:2.5 (with deionized water), using a pH meter (Jenway 3305). Walkley and Black's wet oxidation method was used to determining organic C levels (Soil Survey Laboratory Staff). Total N levels were measured by the Kjeldhal (Bremner and Mulvaney) method. Al₃ + and Fe₂+ were extracted with 1 M KCl (Barnhisel and Bertsch). CEC was extracted with 1 M NH₄Oac (buffer at pH 7.0), and the concentration of alkaline cations was measured using AAS (Shimadzu), P-available with Bray I.

Statistical Analysis

Statistical analysis was carried out on each observation parameter data to determine the effect of the amendments on the nature of acid sulphate soil. The data obtained were analyzed by analysis of variance (ANOVA) at 5% significant level. In addition, the test of least significant difference (LSD) at 5% significant level was used to determine the average value between treatments.

RESULTS AND DISCUSSION

Effect of various soil amendments on some physical soil properties

Applying biochar improved the soil's physical properties (Aslam *et al.*, 2014). Applying biochar and organic amendments influenced the changes in some of the observed soil physical properties. The statistical test is shown in Table 1. The soil BD was lower on all amendments granted. For example, in soils fed a single rice husk biochar (10 t/ha), soil BD decreased from 1.27 mg/m³ in the control soil to 1.15 mg/cm³. However, not significantly different from soils was given straw (10 t/ha) and a combination of straw + biochar, *Chromolaena odorata* + rice husk ash, and straw + rice husk

ash. Furthermore, in the combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha), a BD of 1.13 mg/m³ was obtained and was the lowest soil BD. Still, it was not significantly different from the soil, given a combination of straw (10 t/ha) + rice husk biochar 5 (t/ha) produced soil BD of 1.14 mg/m³. These results indicate an improvement in the physical soil properties if biochar was given together with organic amendments to *Chromolaena odorata*.

	BD	Total	Penetratio	on resistance (N	V/cm^2)
Soil amendments	(mg/m^3)	pores (%)	pF 0	pF 2	pF 2.5
Control	1.24 e	44.43 a	36.67 b	310.00 e	500.00 d
C. odorata (10 t/ha)	1.16 c	52.17 e	20.00 a	230.00 abc	403.33 bc
Rice straw (10 t/ha)	1.17 bc	53.27 f	16.67 a	243.33 bc	393.33 b
Rice husk biochar (10 t/ha)	1.15 b	54.21 g	14.33 a	223.33 ab	390.00 b
Rice husk ash (10 t/ha)	1.19 d	47.30 b	20.00 a	270.00 d	403.33 bc
C. odorata (10 t/ha) +	1.13 a	56.73 i	10.00 a	220.00 a	340.00 a
biochar (5 t/ha)					
Rice straw (10 t/ha) + rice	1.14 ab	55.57 h	13.33 a	223.00 ab	360.00 a
husk biochar (5 t/ha)					
C. odorata (10 t/ha) + rice	1.15 b	48.90 c	16.67 a	240.00 bc	420.00 c
husk ash (5 t/ha)					
Rice straw (10 t/ha) + rice	1.16 bc	50.30 d	20.00 a	246.67 c	403.33 bc
husk ash (5 t/ha)					

Table 1. Effect of rice husk biochar with soil amendments on some physical properties of acid sulphate soil at one month after incubation

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Applying various biochar amendments and their combinations increased the soil's total pore. The statistical test results are shown in Table 1. There was a significant difference in the total pore of the soil between the various amendments. Control soils had the lowest total pore (44.43%), contrasting with soils that provided various amendments. On soils fed with rice husk biochar (10 t/ha), the total soil pore increased to 54.21%, significantly different from other single amendments. Furthermore, a combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) caused the total pore to increase to 56.73% and was the highest total pore.

The application of various amendments, both single and combined, affected the decrease in soil strength as measured as soil penetration resistance (N/cm²) at conditions of pF 0, pF 2, and pF 2.5, where the higher the soil matric suction (pF), the higher the soil penetration resistance. The results of statistical tests (Table 1) show that under saturated conditions (pF 0), the various soil amendments do not offer a noticeable difference. In pF 2 shows that the application of rice husk biochar (10 t/ha) can reduce soil penetration resistance from 310.00 N/cm² (control soil) to 223.33 N/cm². No significant difference between soils fed with *Chromolaena odorata* and rice straw or a combination of straw (10 t/ha) + rice husk biochar (5 t/ha). Furthermore, soils given a combination of *Cromolaena odorata* (10 t/ha) + biochar (5 t/ha) obtained the lowest penetration resistance (220.00 N/cm²). Still, it was not significantly different from soils have given *Chromolaena odorata* (10 t/ha), rice husk biochar (10 t/ha) + biochar (5 t/ha).

Similarly, at pF 2.5, the application of rice husk biochar (10 t/ha) was single. It could reduce the value of soil penetration resistance from 500.00 N/cm² on control soil to 390.00 N/cm². Still, it was not significantly different from soils have given *Chromolaena odorata* (10 t/ha), straw (10 t/ha), rice husk ash (10 t/ha), and a combination of rice straw (10 t/ha) + rice husk ash (5 t/ha). Furthermore, the combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) achieved the lowest penetration resistance (340.00 N/cm²). Still, it was not significantly different from the combination

of rice straw (10 t/ha) + biochar (5 t/ha) (360.00 N/cm²). It indicated that rice husk biochar had the potential to control soil strength. In line with Das *et al.* (2021), applying biochar into the soil could reduce soil strength.

Effect of rice husk biochar on some soil chemical properties

The application of several soil amendments and their combinations could influence some chemical properties of acid sulphate soil. The results of statistical tests in Table 2 show that soil reaction (pH) of the soil increased in all treatments given compared to controls. For example, in the application of rice husk biochar showed an increase in pH from 3.36 (control soil) to 4.40 on soils given biochar (10 t/ha) but did not significantly different from other single amendments. Furthermore, the combined application of *Cromolaena odorata* (10 t/ha) + biochar (5 t/ha) obtained the highest increase in soil pH (4.58), in marked contrast to soils given rice husk ash but not significantly different from single amendments or other combinations.

Applying single and combined soil amendments affected to increase in soil C-organics. The statistical test results in Table 2 show that the control soil had the lowest C-organic (1.94%), in stark contrast to other amended soils, except that the soils have given rice husk ash (10 t/ha) was not significantly different. The soil given a single amendment of rice straw (10 t/ha) obtained 4.58% C-organic, in stark contrast to the control soil and the soil given rice husk ash, but not significantly different from other soil amendments. Similarly, soils given a combination of *Chromolaena odorata* (10 t/ha) + biochar husk (5 t/ha) achieved the highest soil C-organic (4.93%) in marked contrast to control soils and soils fed with rice husk ash but did not significantly different from other soil amendments.

Soil amendments	pH H ₂ O	C- organic (%)	P- available (%)	Al-dd (me/100 g)	Soluble Fe (%)	CEC (me/100 g)
Control	3.36 a	1.94 a	0.21 a	3.84 e	3.61 d	6.64 a
C. odorata (10 t/ha)	4.06 bc	4.22 b	0.29 bc	3.31 c	3.28 c	7.15 ab
Rice straw (10 t/ha)	4.28 bc	4.58 b	0.30 bc	3.42 cd	3.34 cd	7.32 abc
Rice husk biochar (10 t/ha)	4.40 bc	4.09 b	0.32 cd	3.16 b	3.10 abc	8.03 c
Rice husk ash (10 t/ha)	3.98 b	2.78 a	0.28 b	3.51 d	3.34 cd	7.76 bc
C. odorata (10 t/ha) + biochar (5 t/ha)	4.58 c	4.93 b	0.34 d	3.02 a	2.94 ab	10.04 e
Rice straw (10 t/ha) + rice husk biochar (5 t/ha)	4.48 bc	4.75 b	0.33 d	3.08 ab	2.91 a	9.67 de
<i>C. odorata</i> (10 t/ha) + rice husk ash (5 t/ha)	4.26 bc	4.70 b	0.31 cd	3.37 c	3.25 c	9.17 d
Rice straw (10 t/ha) + rice husk ash (5 t/ha)	4.26 bc	4.73 b	0.31 cd	3.47 d	3.22 bc	9.20 d

Table 2. Effect of rice husk biochar with soil amendments on some chemical properties of acid sulphate soil at one month after incubation

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Applying various amendments and combinations to acid sulphate soil generally affected the increase in P-available. The results of statistical tests (Table 2) showed that control soils had the lowest P-available content (0.21%), significantly different from soils given various amendments. In soils fed with a rice husk biochar (10 t/ha), the P-available increased to 0.32%. Still, it was not significantly different from other combined or single-amended soils, except with soils that were given rice husk ash with a lower P-available (0.27%). The highest P-available was obtained on soils given a combination of *Chromolaena odorata* (10 t/ha) + biochar (5 t/ha) (0.34%), in stark contrast to control soils and those topped with rice husk ash but not significantly different from single amendments or other combinations.

The decrease in Al-dd and Fe-dissolve in acid sulphate soil also occurs due to applying various soil amendments and their combinations. Statistical tests (Table 2) show that the highest Al-dd was obtained on control soils (3.84%), further decreasing and differing markedly from soils given various single and combined amendments. On single-amendment soils of rice husk biochar (10 t/ha), Al-dd decreased to 3.16%, significantly different from other single-amended soils. Furthermore, the soil given the combination of *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) obtained the lowest Al-dd content (3.02%). It was not significantly different from the soil given a combination of rice husk biochar (10 t/ha) + biochar (5 t/ha), but it was significantly different from other amended soils. In soluble Fe content, the application of rice husk biochar (10 t/ha) could reduce soluble Fe from 3.61% on control soils to 3.10% and was significantly different from other single amendments. And when the soil was given a combination of rice straw (10 t/ha) + rice husk biochar (5 t/ha) caused the lowest decrease in Al-dd (2.91%). Still, it was not significantly different from soil that was given a combination of *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) caused the lowest decrease in Al-dd (2.91%). Still, it was not significantly different from soil that was given a combination of *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha).

The CEC of land has also increased due to the application of various land amendments and their combinations. The statistical test is shown in Table 2 show that the control soil had the lowest CEC (6.64 Cmol/kg), not significantly different from soils fed with *Chromolaena odorata* and rice straw. On the other hand, on soils provided with rice husk biochar (10 t/ha), the soil CEC increased to 8.03 Cmol/kg, but it was not significantly different from soil given rice straw and rice husk ash.

In line with the results that have been put forward, Yamato *et al.* (2006) found that the application of biochar from *Acacia mangium* bark into the soil in Sumatra led to changes in soil chemical properties through increased pH, N-total and P-available, CEC, and lowered interchangeable Al. Liang *et al.* (2006) found that two mechanisms could create a larger CEC. First, a higher charged density per unit of surface acreage means a higher degree of oxidation of soil organic matter. Second, the presence of a higher surface area for cation absorption or the combined effect of both. Glaser *et al.* (2002) posit that oxidation of aromatic C and carboxyl formation are the main reasons for the high CEC. Liang *et al.* (2006) also found that the CEC per unit C was higher, and the load density was higher in carbon-black-rich Anthrosol compared to soils that were poor in carbon black. In addition, Anthrosol showed a higher surface acreage due to its higher carbon black concentration.

From the results, the great potential of rice husk biochar against improving soil properties increased when given together with the biomass *Chromolaena odorata*. It could happen because *Chromolaena odorata* contains higher humate and fulvic organic acids, so that it could encourage the complex mechanisms of organo-mineral organs and soil aggregation. In addition, *Chromolaena odorata* can highly suppress Al and Fe, thereby increasing the P availability in the soil due to the presence of organic acids released during decomposition. Research results by Suri and Yudono (2020) also found that using *Chromolaena odorata* compost could improve soil quality and nutrient uptake of lettuce plants.

Chromolaena odorata can contribute to the care of soil C-organic and physical properties due to a reasonably high polyphenol content that could inhibit the decomposition and mineralization of N organic matter, even though it had a low C/N ratio.

CONCLUSIONS

In conclusion, the amendment of rice husk biochar combined with amendments to *Chromolaena* odorata and rice straw improved soil physical properties, namely total soil pores, reducing soil

content weight and strength. Its impact on soil chemical properties was that it could increase pH, Corganic, P-available, CEC, lower Al-dd, and Fe soluble. Therefore, applying biochar and organic amendments to *Chromolaena odorata* and rice straw could improve the properties of acid sulphate soil. Consequently, we recommend increasing the carrying capacity of acid sulphate soil against plant growth. It can be done by enhancing soil properties through the organic amendments application of *Chromolaena odorata* or straw enriched with rice husk biochar.

ACKNOWLEDGEMENTS

We thank the Institute for Research and Community Service, Universitas Panca Bhakti, which has given support for research funds. In addition, we thank the Faculty of Agriculture, Universitas Panca Bhakti, which has provided loans for facilities in the form of equipment for research.

REFERENCES

- Agustina, R., Jumadi, R., Firmani, U. and Abdul Faisal, R. H. (2019). Effects of decomposition rate of *Chromolaena odorata* and straw rice in fresh and compost form to the growth and yield of rice. *IOP Conf Ser Earth Environ Sci.* 250(1): 1–5. <u>https://doi.org/10.1088/1755-1315/250/1/012078</u>
- Aslam, Z., M. Khalid, M. and Aon, M. (2014). Impact of biochar on soil physical properties. Sch J Agric Sci. 4(5): 280–84.
- Beusch, C. (2021). Biochar as a soil ameliorant: How biochar properties benefit soil fertility A review. J Geosci Environ Prot. 9(10): 28–46. https://doi.org/10.4236/gep.2021.910003
- Bista, P., Ghimire, R., Machado, S. and Pritchett, L. (2019). Biochar effects on soil properties and wheat biomass vary with fertility management. *Agronomy*. **9**(10): 1-10. https://doi.org/10.3390/agronomy9100623
- Das, S. K. and Das, S. K. (2015). Acid sulphate soil: Management strategy for soil health and productivity. *Pop. Kheti.* **3**(2), 3–8.
- Das, S., Mohanty, S., Sahu, G., Rana, M. and Pilli, K. (2021). Biochar: A sustainable approach for improving soil health and environment. In: Soil Erosion - Current Challenges and Future Perspectives in a Changing World, (April). https://doi.org/10.5772/intechopen.97136
- Ebido, N. E., Edeh, I. G., Unagwu, B. O., Nnadi, A. L., Ozongwu, O. V., Obalum, S. E. and Igwe, C. A. (2021). Rice-husk biochar effects on organic carbon, aggregate stability and nitrogenfertility of coarse-textured Ultisols evaluated using *Celosia argentea* growth. *Sains Tanah*. 18(2): 177–87. https://doi.org/10.20961/stjssa.v18i2.56330
- Gewaily, E. (2019). Impact of compost rice straw and rice straw as organic fertilizer with potassium treatments on yield and some grain quality of Giza 179 rice variety. *J Plant Prod.* **10**(2): 143–151. https://doi.org/10.21608/jpp.2019.36244
- Glaser, B., Lehmann, J. and Zech, W. (2002). Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal - A review. *Biol Fertil Soils*. 35(4): 219–30. <u>https://doi.org/10.1007/s00374-002-0466-4</u>
- Kalu, S., Simojoki, A., Karhu, K. and Tammeorg, P. (2021). Long-term effects of softwood biochar on soil physical properties, greenhouse gas emissions and crop nutrient uptake in two contrasting boreal soils. *Agric Ecosyst Environ.* 316: 107454. https://doi.org/10.1016/j.agee.2021.107454
- Kartika, K., Sakagami, J. I., Lakitan, B., Yabuta, S., Akagi, I., Widuri, L. I., Siaga, E., Iwanaga, H. and Nurrahma, A. H. I. (2021). Rice husk biochar effects on improving soil properties and root development in rice (*Oryza glaberrima* Steud.) exposed to drought stress during early reproductive stage. *AIMS Agric Food*. 6(2): 737–751. https://doi.org/10.3934/AGRFOOD.2021043
- Kocsis, T., Ringer, M. and Biró, B. (2022). Characteristics and applications of biochar in soil-plant systems: A short review of benefits and potential drawbacks. *Appl Sci.* **12**(8): 1–16. https://doi.org/10.3390/app12084051
- Lestari, M. F. and Rachmawati, D. (2020). The effect of rice husk ash on growth of rice (Oryza sativa

L. 'Sembada Merah') on salinity stress. *AIP Conf Proc.* **2260**: 1–6. https://doi.org/10.1063/5.0015860

- Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J. O., Thies, J., Luizão, F. J., Petersen, J. and Neves, E. G. (2006). Black carbon increases cation exchange capacity in soils. *Soil Sci Soc Am J.* **70**(5): 1719–30. https://doi.org/10.2136/sssaj2005.0383
- Mahmoud, E., Ibrahim, M., Robin, P., Akkal-Corfini, N. and El-Saka, M. (2009). Rice straw composting and its effect on soil properties. *Compost Sci Util.* **17**(3): 146–50. <u>https://doi.org/10.1080/1065657X.2009.10702415</u>
- Murtaza, G., Ahmed, Z., Usman, M., Tariq, W., Ullah, Z., Shareef, M., Iqbal, H., Waqas, M., Tariq, A., Wu, Y., Zhang, Z. and Ditta, A. (2021). Biochar induced modifications in soil properties and its impacts on crop growth and production. *J Plant Nutr.* 44(11): 1677–91. https://doi.org/10.1080/01904167.2021.1871746
- Shamshuddin, J., Elisa Azura, A., Shazana, M. A. R. S., Fauziah, C. I., Panhwar, Q. A. and Naher, U. A. (2014). Properties and management of acid sulfate soils in Southeast Asia for sustainable cultivation of rice, oil palm, and cocoa. Advances in Agronomy (1st ed., Vol. 124). Elsevier Inc. https://doi.org/10.1016/B978-0-12-800138-7.00003-6
- Sovova, S., Enev, V., Smilek, J., Kubikova, L., Trudicova, M., Hajzler, J. and Kalina, M. (2021). The effect of biochar application on soil properties and growth of the model plant Zea mays. *Ecocycles*. 7(2): 46–54. https://doi.org/10.19040/ecocycles.v7i2.201
- Suri, A. M. and Yudono, P. (2020). Effects of Chromolaena odorata compost on soil and nutrient uptake of lettuce (Lactuca sativa). Planta Trop J Agro Sci. 8(1): 33–8. <u>https://doi.org/10.18196/pt.2020.111.33-38</u>
- Yadav, N. K., Kumar, V., Sharma, K. R., Choudhary, R. S., Butter, T. S., Singh, G., Kumar, M. and Kumar, R. (2018). Biochar and their impacts on soil properties and crop productivity: A review. *J Pharmacogn Phytochem Harpole*. 7(4): 49–54.
- Yamato, M., Okimori, Y., Wibowo, I. F., Anshori, S. and Ogawa, M. (2006). Effects of the application of charred bark of *Acacia mangium* on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Sci Plant Nutr.* 52(4): 489–95. https://doi.org/10.1111/j.1747-0765.2006.00065.x
- Yin, M., Li, X., Liu, Q. and Tang, F. (2022). Rice husk ash addition to acid red soil improves the soil property and cotton seedling growth. *Sci Rep.* 12(1): 1–9. https://doi.org/10.1038/s41598-022-05199-7
- Zhang, Y., Chen, H., Xiang, J., Xiong, J., Wang, Y., Wang, Z. and Zhang, Y. (2022). Effect of ricestraw biochar application on the acquisition of rhizosphere phosphorus in acidified paddy Soil. *Agronomy*. 12: 1-13.

Online manuscript submission : 3 Oktober 2022

-	M Gmail		R. anter last	x # •++++ \$\$ #	- UPB	18
9	It is		1111 =) (12.50 m/p =) (analandean } (milange a - in na approx.) taan milanan		
	E Steves	S 1465	D - 0 1	- E. Arrit	100	
	- Selman		🖂 🧉 Yangi Sali Kora	Bill Maria and a characteristic term in Security (19) and 10 mm in April 70 per provide the security of the sector by [1]	100	
***	Fr. Nextern		E - web	manager Softwarks & Newyard Tel Packer (9600012). The lattice provident of Tel pro-		
¥.2	D car	+	ri fala ala	company Pro Med and PPA and also in the first second of the case for from Merch 4 while a	10.0m	
	B Arran		= 0.5 Parameters	Statistics: "A located (Filler for sides, inclusion (Filler) and a formulation are point attack and the set."	Safes (
	B www.scool		III - Annala-	Statistical: One of any point and a secondary. For Sector Work 2022 - Pain Works (Web 2022 - Budy to a man-	C Rise:	
	C an		A 10 10 10 10 10 10 10 10 10 10 10 10 10	Sampling Alas. Worder Resident to be a four and sector residence.	11.1.10	
	 Constant 		C service and	manatile suspenses and the second	Million	
	· Delatert		II	Constant (Const) many and the second to the	7175.1	í.
	+ failurth	8	C Arthesister	manufacti (Antal Devano Internetintin deva es acopadates relativas problem de que a	+ + + + +	
	lidered	40	12 il defenda	management of the second state of the second s	1.110	
			Charles and the	manifest POPULA a Dearwork and their Charles in Residence has a last of Palace.		







		lan.	□· ⊂ ±	1-50 das 32 (1
1	 Contractory Optimization 	1311	📋 🚊 Gal 7, 1995	And Mark Peter Mippellor Report 2408 - The Market
	() (L112			🔂 Dig al (1997) - 🔯 Helin al Tépia. 🛛 🔂 1930 Secondar. 19
	j⊳ Twa n		📋 🚊 Geb vestander;	Public Perinter Science Les explorations et Sale all programme Refere Sciences (Science)
ē	0.24	(\mathbf{f})		
2	->-04 x		T a bebyeaterder:	willing by blue Schole war a local war Schole scheme in dure Grant monol (C)
	3 Aris		11.2000.00000000	T : 5079544
	is thank			S March
	🖸 Sasta		🔲 🗇 Acceptoriaen (+	Willing Omaal husbaat a dork da ab Vohjar adolben verant (1805 u
	() span		Li 😄 Velana Bria	Weit Mark Repairs Freques (Felancelon, 17, 20, Repairs Pare, 17, 1978; Scholar Pate double 190
	র ওবর ।০ মর্মা		□ ± Newood Safety ,	weiting Frenz (Billein an adamin'diginisitie a swadenfant dass Tauf 2013a
	 Exclosion 		🗆 🕂 čranstv sligita	Notified Was to be appeared for the evidence for an analysis of the
			- Bocalias 30/S/Ck.	Continue Reads - CO regenerant Ward? H. Accur for a CD regenerative of a content of
	Jabel	1	R. Marson	
			📋 😑 Bernada s Hosca Daliga	Honorade Bernariae Hesta Dungan Hapitabak menganiertan bilik keri 17 - Hel Agetalin Esnado Histor Tur



Role of biochar amendments in improving the properties of acid sulphate soil AGUSALIM MASULILI^{1,*}, SUTIKARINI¹, RINI SURYANI¹, IDA AYU SUCI¹, ISMAIL ASTAR¹, HARDI DOMINIKUS BANCIN¹ AND PAIMAN²

¹Department of Agrotechnology, Faculty of Agriculture Panca Bhakti University, Pontianak 78113, West Kalimantan, Indonesia *(e-mail: <u>agusalim@upb.ac.id</u>) ²Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia

ABSTRACT

Acid sulfate soils have potential for agricultural development. However, this soil has various properties problems that can inhibit plant growth. One way to improve soil properties is through the application of biochar amendments. The study aimed to know the role of rice husk biochar combined with amendments to *Chromolaena odorata*, rice straw, and rice husk ash to improve the properties of acid sulphate soil. The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely: without amendments (control), *Chromolaena odorata* (10 t/ha), rice straw (10 t/ha), rice husk biochar (5 t/ha), rice

straw (10 t/ha) + rice husk biochar (5 t/ha), *Chromolaena odorata* (10 t/ha) + rice husk ash (5 t/ha), and rice straw (10 t/ha) + rice husk ash (5 t/ha). The results showed that the amendment of rice husk biochar combined with amendments to *Chromolaena odorata* and rice straw, respectively, had a good effect on improving soil physical properties, namely total soil pores, reducing soil content weight and soil strength. Its effect on soil chemical properties is that it can increase pH, C-organic, P-available, cation exchange capacity (CEC), and lower Al-dd and Fe soluble. The research findings show that applying biochar and organic amendments to *Chromolaena odorata* and rice straw can potentially improve the properties of acid sulphate soil. In future research, we recommend increasing the carrying capacity of acid sulphate soil against plant growth, and it can be done by improving soil properties through the organic amendments application of *Chromolaena odorata* or straw enriched with rice husk biochar.

Key words: Chromolaena odorata, rice husk ash, rice husk biochar, rice straw, soil properties

INTRODUCTION

Acidic sulphate soils are the common name for soils and sediments containing iron sulfide, namely pyrite (Das and Das, 2015). In agricultural development, efforts to reclaim acid sulphate soils do not always result in soil productivity since improvements in soil properties after reclamation are not achieved. So far, efforts have been encouraged to overcome existing obstacles after reclamation, including inorganic fertilizers (urea, TSP, KCl) and liming (dolomite). However, rice crop productivity in this field has not been optimal.

Inorganic fertilizers increase over time and can even decrease land quality if inputs are high and intensive. Liming can only cope with short-term pH and is often done repeatedly. As a result, high costs are needed, which becomes a burden for farmers and will threaten the sustainability of land productivity. Therefore, it is necessary to manage land based on land amendments that can improve the nature of sustainable soils.

Reclamation can result in changes in soil properties and is related to the potential for pyrite oxidation, affecting the increase in soil packaging and the solubility of ions such as Al, Fe, Mn, and sulphate. On the other hand, this soil has a high clay content which affects the increased weight of the contents. Therefore, the development of acid sulphate soil for agriculture after reclamation requires proper management of soil amendments to achieve the formation of steady cultivated land and sustainable farming. Das and Das (2015) suggested that acid sulphate soil having a high pH can inhibit plant growth. In addition, when this soil is drained, it can affect an increase in sulfuric acid and the release of iron, aluminum, and other heavy metals. Shamshuddin *et al.* (2014), stated that plants grown in acidic sulphate soils could not grow well due to low pH and high Al content.

Biochar is one of the soil amendment materials with the long-term potential to maintain soil fertility. The results of experts' investigations into the phenomenon of terra preta show that soil

fertility is stable in the Amazon basin due to the presence of black carbon, the result of the management of the Amerindian nation 500–2,500 years ago. This carbon black is nothing but biochar immersed in the soil. Murtaza *et al.* (2021) found that 4.0 t/ha cotton biochar improves physical, chemical, soil biological, and soil fertility properties and peanut productivity in Alfisol. Zhang *et al.* (2022) have proven that biochar provides effects such as liming and providing nutrients that lead to soil improvement. Kocsis *et al.* (2022) stated that biochar has a high porosity and can improve the physicochemical and biological properties of the soil. In line, Sovova *et al.* (2021) found biochar had a good influence on improving the soil properties of regosol. Further afield, Das *et al.* (2021) suggest the application of biochar to the soil can provide agronomic benefits, support crop yield improvement, and improve soil quality and health. In addition, biochar has been shown to act as a fertilizer and soil conditioner.

Nutrient retention and higher nutrient availability were found in the soil after biochar addition, associated with higher CEC, surface acreage, and direct nutrient addition (Glaser *et al.*, 2002). In line with opinions, Murtaza *et al.* (2021) suggested that biochar is a recalcitrant carbon product of biomass produced through the pyrolysis process. The recalcitrant properties of biochar are distinctive and important to the long-term improvement of soil properties through the effects of their residues that can persist for a long time in the soil. Beusch (2021), biochar can contribute to soil fertility and crop productivity, and Kalu *et al.* (2021) increase water availability and lower soil BD.

Applying biochar can improve soil properties and long-term crop productivity compared to other organic amendments. In other organic amendments, research results by Suri and Yudono (2020) showed that giving *Cromolaena odorata* as compost can increase plants' nutrition and nutrient uptake. Agustina *et al.* (2019) argued that using *Chromolaena odorata* and rice straw can maintain soil quality. Mahmoud *et al.* (2009) also showed rice straw compost could improve soil quality. The same was discovered by Gewaily (2019), that straw compost can increase plantsium availability.

Furthermore, the results of the study by Yin *et al.* (2022) showed the weight of the soil contents decreased, and the water-holding capacity and total porosity increased in the soil with rising rice husk ash. Adding rice husk ash neutralizes soil acidity and increases plant nutrient availability. Research by Lestari and Rachmawati (2020) showed that applying rice husk ash (4 t/ha) can increase rice growth and reduce salinity stress.

Previously, several studies on the effect of biochar singularly have been carried out, including on the P-availability (Zhang *et al.*, 2022), improvement of soil physical properties (Aslam *et al.*, 2014), chemical properties of the soil (Bista *et al.*, 2019), and some soil characteristics (Yadav *et al.*, 2018), soil aggregate stability (Ebido *et al.*, 2021), and to the development of rice roots (Kartika *et al.*, 2021). However, no research has been found on

how the role of biochar was given together with other organic amendments in acid sulphate soil. Therefore, it is necessary to study how the effect of biochar is given together with organic amendments to *Chromolaena odorata* and rice straw. This research is expected to contribute to improving the nature of acid sulphate soil in West Kalimantan, which has been one of the types of soil widely used as an agricultural activity for rice crops. In connection with this background and literature review above, this study aimed to know the role of rice husk biochar combined with amendments to *Chromolaena odorata*, rice straw, and rice husk ash in improving the properties of acid sulphate soil.

MATERIALS AND METHODS

Study Area

This research was conducted from September to November, 2021. The research site was carried out at the Laboratory of the Faculty of Agriculture, Universitas Panca Bhakti, Pontianak, West Kalimantan Province, Indonesia. The height of the study site is one m from above sea level, with an average temperature and humidity of 27.6 °C and 82.8%, respectively. The research position is located at a latitude of 2°05' N–3° 05' S and longitude of 108°30' E–144°10' W.

Experimental Design

The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely: without amendments (control), *Chromolaena odorata* (10 t/ha), rice straw (10 t/ha), rice husk biochar (10 t/ha), rice husk ash (10 t/ha), *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha), rice straw (10 t/ha) + rice husk biochar (5 t/ha), rice straw (10 t/ha) + rice husk biochar (5 t/ha). In all, 27 polybags are needed.

Research Procedures

The material in this study used acid sulphate soil taken on the experimental land of the West Kalimantan, Sungai Kakap, Agricultural Technology Assessment Center, and land farmers' work on rice crops. This area included the development of swampland agriculture which has built irrigation canals since 1980 and was currently designated as an Integrated Farmer Business Area. Soil picking was carried out randomly at a soil depth of 0-20 cm, then mixed, air-dried, and cleaned. Then put in polybags was as much as 8 kg.

Biochar was made by taking rice husk from grain harvested from rice plants grown directly in the acid sulphate soil of the Kakap River, West Kalimantan, Indonesia. First, the rice mill was taken the grain to obtain rice husk. Furthermore, the rice husk was placed on the pyrolysis device to be processed into biochar by incomplete combustion (limited air) in a reactor made of Pertamina drums.

Organic amendments to *Chromolaena odorata* were taken from around the field, then chopped to a size of 1-2 cm. Rice straw was taken from waste harvested rice grown and grown by farmers in acid sulphate soil and chopped within 1–2 cm. Rice husks were taken from waste from rice milling, then used as ash through burning in open areas to produce grayish-white ash.

Prepared acid sulphate soil introduced into 27 polybags until it reached 8 kg. Further, the dose of soil amendment was calculated based on the soil weight in the polybag area, mixed with the soil in each polybag to a soil depth of 20 cm, after which it was incubated with moisture content until it was closed to the field capacity for 30 days.

At 30 days after incubation, from each study unit, soil sampling of about 50 g was undisturbed to determine the weight of the soil moisture content accident. In addition, a disturbed soil sample of 100 g was taken from each research unit for analysis of chemical properties.

Observation parameters

The soil bulk density (BD) was determined by the clod method described by Blake & Harke. The total pore was calculated from the soil moisture content (v/v) at the matrix potential of 0 kPa. The available groundwater was estimated by reducing the soil moisture content in the matrix potential by -33 kPa (field capacity) with the soil moisture content in the matrix potential, which was -15 Mpa (wilting point). The soil moisture content at this potential matrix was determined using a pressure plate device. The strength of the soil was measured with a hand penetrometer (Daikie) at a soil depth of 15 cm.

The pH level was measured in a soil solution at a ratio of 1:2.5 (with deionized water), using a pH meter (Jenway 3305). Walkley and Black's wet oxidation method was used to determining organic C levels (Soil Survey Laboratory Staff). Total N levels were measured by the Kjeldhal (Bremner and Mulvaney) method. Al₃ + and Fe₂+ were extracted with 1 M KCl (Barnhisel and Bertsch). CEC was extracted with 1 M NH₄Oac (buffer at pH 7.0), and the concentration of alkaline cations was measured using AAS (Shimadzu), P-available with Bray I.

Statistical Analysis

Statistical analysis was carried out on each observation parameter data to determine the effect of the amendments on the nature of acid sulphate soil. The data obtained were analyzed by analysis of variance (ANOVA) at 5% significant level. In addition, the test of least significant difference (LSD) at 5% significant level was used to determine the average value between treatments.

RESULTS AND DISCUSSION

Effect of various soil amendments on some physical soil properties

Applying biochar improved the soil's physical properties (Aslam *et al.*, 2014). Applying biochar and organic amendments influenced the changes in some of the observed soil physical properties. The statistical test is shown in Table 1. The soil BD was lower on all amendments granted. For example, in soils fed a single rice husk biochar (10 t/ha), soil BD decreased from 1.27 mg/m³ in the control soil to 1.15 mg/cm³. However, not significantly different from soils was given straw (10 t/ha) and a combination of straw + biochar, *Chromolaena odorata* + rice husk ash, and straw + rice husk ash. Furthermore, in the combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha), a BD of 1.13 mg/m³ was obtained and was the lowest soil BD. Still, it was not significantly different from the soil, given a combination of straw (10 t/ha) + rice husk biochar 5 (t/ha) produced soil BD of 1.14 mg/m³. These results indicate an improvement in the physical soil properties if biochar was given together with organic amendments to *Chromolaena odorata*.

Applying various biochar amendments and their combinations increased the soil's total pore. The statistical test results are shown in Table 1. There was a significant difference in the total pore of the soil between the various amendments. Control soils had the lowest total pore (44.43%), contrasting with soils that provided various amendments. On soils with rice husk biochar (10 t/ha), the total soil pore increased to 54.21%, significantly different from other single amendments. Furthermore, a combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) caused the total pore to increase to 56.73% and was the highest total pore.

The application of various amendments, both single and combined, affected the decrease in soil strength as measured as soil penetration resistance (N/cm²) at conditions of pF 0, pF 2, and pF 2.5, where the higher the soil matric suction (pF), the higher the soil penetration resistance. The that under saturated conditions (pF 0), the various soil amendments do not offer a noticeable difference. In pF 2 showed that the application of rice husk biochar (10 t/ha) can reduce soil penetration resistance from 310.00 N/cm² (control soil) to 223.33 N/cm², but not significant difference between *Chromolaena odorata* (10 t/ha) + rice straw or a combination of straw (10 t/ha) + rice husk biochar (5 t/ha). Furthermore, soils given a combination of *Cromolaena odorata* (10 t/ha) + biochar (5 t/ha) obtained the lowest penetration resistance (220.00 N/cm²), and this treatment was not significantly different from soils have given *Chromolaena odorata* (10 t/ha), rice husk biochar (10 t/ha), and a combination of rice straw (10 t/ha) + rice husk biochar (5 t/ha).

Similarly, in pF 2.5, the application of rice husk biochar (10 t/ha) could reduce the value of soil penetration resistance from 500.00 N/cm² (control soil) to 390.00 N/cm², and this treatment not significantly different from soils have given *Chromolaena odorata* (10 t/ha), rice straw (10 t/ha), rice husk ash (10 t/ha), and a combination of rice straw (10 t/ha) + rice husk ash (5 t/ha). Furthermore, the combination of *Cromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) achieved the lowest

penetration resistance (340.00 N/cm²). Also, it was not significantly different from the combination of rice straw (10 t/ha) + biochar (5 t/ha) (360.00 N/cm²). It indicated that rice husk biochar had the potential to control soil strength. In line with Das *et al.* (2021), applying biochar into the soil could reduce soil strength.

Effect of rice husk biochar on some soil chemical properties

The application of several soil amendments and their combinations could influence some chemical properties of acid sulphate soil. The results of statistical tests in Table 2 showed that soil reaction (pH) of the soil increased in all treatments given compared to controls. For example, in the application of rice husk biochar showed an increase in pH from 3.36 (control soil) to 4.40 on soils given biochar (10 t/ha) but did not significantly different from other single amendments. Furthermore, the combined application of *Cromolaena odorata* (10 t/ha) + biochar (5 t/ha) obtained the highest increase in soil pH (4.58), in marked contrast to soils given rice husk ash but not significantly different from single amendments or other combinations.

Applying single and combined soil amendments affected to increase in soil C-organics. The statistical test results in Table 2 showed that the control soil had the lowest C-organic (1.94%), in stark contrast to other amended soils, except that the soils have given rice husk ash (10 t/ha) was not significantly different. The soil given a single amendment of rice straw (10 t/ha) obtained 4.58% C-organic, in stark contrast to the control soil and the soil given rice husk ash, but not significantly different from other soil amendments. Similarly, soils given a combination of *Chromolaena odorata* (10 t/ha) + biochar husk (5 t/ha) achieved the highest soil C-organic (4.93%) in marked contrast to control soils and soils fed with rice husk ash but did not significantly different from other soil amendments.

Applying various amendments and combinations to acid sulphate soil generally affected the increase in P-available. The results of statistical tests (Table 2) showed that control soils had the lowest P-available content (0.21%), significantly different from soils given various amendments. In soils fed with a rice husk biochar (10 t/ha), the P-available increased to 0.32%. Still, it was not significantly different from other combined or single-amended soils, except with soils that were given rice husk ash with a lower P-available (0.27%). The highest P-available was obtained on soils given a combination of *Chromolaena odorata* (10 t/ha) + biochar (5 t/ha) (0.34%), in stark contrast to control soils and those topped with rice husk ash but not significantly different from single amendments or other combinations.

The decrease in Al-dd and Fe-dissolve in acid sulphate soil also occurs due to applying various soil amendments and their combinations. Statistical tests (Table 2) showed that the highest Al-dd was obtained on control soil (3.84%), further decreasing and differing markedly from soils given various single and combined amendments. On single-amendment soils of rice husk biochar (10 t/ha),

Al-dd decreased to 3.16%, significantly different from other single-amended soils. Furthermore, the soil given the combination of *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha) obtained the lowest Al-dd content (3.02%). It was not significantly different from the soil given a combination of rice straw (10 t/ha) + rice husk biochar (5 t/ha), but it was significantly different from other amended soils. In soluble Fe content, the application of rice husk biochar (10 t/ha) could reduce soluble Fe from 3.61% on control soil to 3.10% and was significantly different from other single amendments. And when the soil was given a combination of rice straw (10 t/ha) + rice husk biochar (5 t/ha). Still, it was not significantly different from soil that was given a combination of *Chromolaena odorata* (10 t/ha) + rice husk biochar (5 t/ha).

The CEC of land has also increased due to the application of various land amendments and their combinations. The statistical test is shown in Table 2 show that the control soil had the lowest CEC (6.64 Cmol/kg), not significantly different from soils fed with *Chromolaena odorata* and rice straw. On the other hand, on soils provided with rice husk biochar (10 t/ha), the soil CEC increased to 8.03 Cmol/kg, but it was not significantly different from soil given rice straw and rice husk ash.

In line with the results that have been put forward, Yamato *et al.* (2006) found that the application of biochar from *Acacia mangium* bark into the soil in Sumatra led to changes in soil chemical properties through increased pH, N-total and P-available, CEC, and lowered interchangeable Al. Liang *et al.* (2006) found that two mechanisms could create a larger CEC. First, a higher charged density per unit of surface acreage means a higher degree of oxidation of soil organic matter. Second, the presence of a higher surface area for cation absorption or the combined effect of both. Glaser *et al.* (2002) posit that oxidation of aromatic C and carboxyl formation are the main reasons for the high CEC. Liang *et al.* (2006) also found that the CEC per unit C was higher, and the load density was higher in carbon-black-rich Anthrosol compared to soils that were poor in carbon black. In addition, Anthrosol showed a higher surface acreage due to its higher carbon black concentration.

From the results, the great potential of rice husk biochar against improving soil properties increased when given together with the biomass *Chromolaena odorata*. It could happen because *Chromolaena odorata* contains higher humate and fulvic organic acids, so that it could encourage the complex mechanisms of organo-mineral organs and soil aggregation. In addition, *Chromolaena odorata* can highly suppress Al and Fe, thereby increasing the P availability in the soil due to the presence of organic acids released during decomposition. Research results by Suri and Yudono (2020) also found that using *Chromolaena odorata* compost could improve soil quality and nutrient uptake of lettuce plants.

Chromolaena odorata can contribute to the care of soil C-organic and physical properties due to a reasonably high polyphenol content that could inhibit the decomposition and mineralization of N organic matter, even though it had a low C/N ratio.

CONCLUSIONS

In conclusion, the amendment of rice husk biochar combined with amendments to *Chromolaena odorata* and rice straw improved soil physical properties, namely total soil pores, reducing soil content weight and strength. Its impact on soil chemical properties was that it could increase pH, C-organic, P-available, CEC, lower Al-dd, and Fe soluble. Therefore, applying biochar and organic amendments to *Chromolaena odorata* and rice straw could improve the properties of acid sulphate soil. Consequently, we recommend increasing the carrying capacity of acid sulphate soil against plant growth. It can be done by enhancing soil properties through the organic amendments application of *Chromolaena odorata* or straw enriched with rice husk biochar.

ACKNOWLEDGEMENTS

We thank the Institute for Research and Community Service, Universitas Panca Bhakti, which has given support for research funds. In addition, we thank the Faculty of Agriculture, Universitas Panca Bhakti, which has provided loans for facilities in the form of equipment for research.

REFERENCES

- Agustina, R., Jumadi, R., Firmani, U. and Abdul Faisal, R. H. (2019). Effects of decomposition rate of *Chromolaena odorata* and straw rice in fresh and compost form to the growth and yield of rice. *IOP Conf Ser Earth Environ Sci.* **250**: 1–5.
- Aslam, Z., Khalid, M. and Aon, M. (2014). Impact of biochar on soil physical properties. *Sch J Agric Sci.* **4**: 280–4.
- Beusch, C. (2021). Biochar as a soil ameliorant: How biochar properties benefit soil fertility A review. J Geosci Environ Prot. 9: 28–46.
- Bista, P., Ghimire, R., Machado, S. and Pritchett, L. (2019). Biochar effects on soil properties and wheat biomass vary with fertility management. *Agronomy*. **9**: 1-10.
- Das, S. K. and Das, S. K. (2015). Acid sulphate soil: Management strategy for soil health and productivity. *Pop. Kheti.* **3**: 3–8.
- Das, S., Mohanty, S., Sahu, G., Rana, M. and Pilli, K. (2021). Biochar: A sustainable approach for improving soil health and environment. In: Soil Erosion - Current Challenges and Future Perspectives in a Changing World. pp. 1-18.
- Ebido, N. E., Edeh, I. G., Unagwu, B. O., Nnadi, A. L., Ozongwu, O. V., Obalum, S. E. and Igwe, C. A. (2021). Rice-husk biochar effects on organic carbon, aggregate stability and nitrogen-fertility of coarse-textured Ultisols evaluated using *Celosia argentea* growth. *Sains Tanah.* 18: 177–87.
- Gewaily, E. (2019). Impact of compost rice straw and rice straw as organic fertilizer with potassium treatments on yield and some grain quality of Giza 179 rice variety. *J Plant Prod.* **10**: 143–51.
- Glaser, B., Lehmann, J. and Zech, W. (2002). Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal A review. *Biol Fertil Soils*. **35**: 219–30.

- Kalu, S., Simojoki, A., Karhu, K. and Tammeorg, P. (2021). Long-term effects of softwood biochar on soil physical properties, greenhouse gas emissions and crop nutrient uptake in two contrasting boreal soils. *Agric Ecosyst Environ.* **316**: 107454.
- Kartika, K., Sakagami, J. I., Lakitan, B., Yabuta, S., Akagi, I., Widuri, L. I., Siaga, E., Iwanaga, H. and Nurrahma, A. H. I. (2021). Rice husk biochar effects on improving soil properties and root development in rice (*Oryza glaberrima* Steud.) exposed to drought stress during early reproductive stage. *AIMS Agric Food.* 6: 737–51.
- Kocsis, T., Ringer, M. and Biró, B. (2022). Characteristics and applications of biochar in soil–plant systems: A short review of benefits and potential drawbacks. *Appl Sci.* **12**: 1–16.
- Lestari, M. F. and Rachmawati, D. (2020). The effect of rice husk ash on growth of rice (*Oryza sativa* L. 'Sembada Merah') on salinity stress. *AIP Conf Proc.* **2260**: 1–6.
- Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J. O., Thies, J., Luizão, F. J., Petersen, J. and Neves, E. G. (2006). Black carbon increases cation exchange capacity in soils. *Soil Sci Soc Am J.* **70**: 1719–30.
- Mahmoud, E., Ibrahim, M., Robin, P., Akkal-Corfini, N. and El-Saka, M. (2009). Rice straw composting and its effect on soil properties. *Compost Sci Util.* **17**: 146–50.
- Murtaza, G., Ahmed, Z., Usman, M., Tariq, W., Ullah, Z., Shareef, M., Iqbal, H., Waqas, M., Tariq, A., Wu, Y., Zhang, Z. and Ditta, A. (2021). Biochar induced modifications in soil properties and its impacts on crop growth and production. *J Plant Nutr.* 44: 1677–91.
- Shamshuddin, J., Elisa Azura, A., Shazana, M. A. R. S., Fauziah, C. I., Panhwar, Q. A. and Naher, U. A. (2014). Properties and management of acid sulfate soils in Southeast Asia for sustainable cultivation of rice, oil palm, and cocoa. *Advances in Agronomy*. **124**: 91-142
- Sovova, S., Enev, V., Smilek, J., Kubikova, L., Trudicova, M., Hajzler, J. and Kalina, M. (2021). The effect of biochar application on soil properties and growth of the model plant *Zea mays*. *Ecocycles*. 7: 46–54.
- Suri, A. M. and Yudono, P. (2020). Effects of Chromolaena odorata compost on soil and nutrient uptake of lettuce (Lactuca sativa). Planta Trop J Agro Sci. 8: 33–8.
- Yadav, N. K., Kumar, V., Sharma, K. R., Choudhary, R. S., Butter, T. S., Singh, G., Kumar, M. and Kumar, R. (2018). Biochar and their impacts on soil properties and crop productivity: A review. *J Pharmacogn Phytochem Harpole*. 7: 49–54.
- Yamato, M., Okimori, Y., Wibowo, I. F., Anshori, S. and Ogawa, M. (2006). Effects of the application of charred bark of *Acacia mangium* on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Sci Plant Nutr.* 52: 489–95.
- Yin, M., Li, X., Liu, Q. and Tang, F. (2022). Rice husk ash addition to acid red soil improves the soil property and cotton seedling growth. *Sci Rep.* 12: 1–9.

Zhang, Y., Chen, H., Xiang, J., Xiong, J., Wang, Y., Wang, Z. and Zhang, Y. (2022). Effect of ricestraw biochar application on the acquisition of rhizosphere phosphorus in acidified paddy Soil. *Agronomy*. 12: 1-13.

Table 1. Effect of rice husk biochar with soil amendments on some physical properties of acid sulphate soil at one month after incubation.

Soil amendments	BD	Total	Penet	ration resistanc	$e (N/cm^2)$
Soll amendments	(mg/m^3)	pores (%)	pF 0	pF 2	pF 2.5
Control	1.24 e	44.43 a	36.67 b	310.00 e	500.00 d
C. odorata (10 t/ha)	1.16 c	52.17 e	20.00 a	230.00 abc	403.33 bc
Rice straw (10 t/ha)	1.17 bc	53.27 f	16.67 a	243.33 bc	393.33 b
Rice husk biochar (10 t/ha)	1.15 b	54.21 g	14.33 a	223.33 ab	390.00 b
Rice husk ash (10 t/ha)	1.19 d	47.30 b	20.00 a	270.00 d	403.33 bc
C. odorata (10 t/ha) +	1.13 a	56.73 i	10.00 a	220.00 a	340.00 a
biochar (5 t/ha)					

Rice straw (10 t/ha) + rice	1.14 ab	55.57 h	13.33 a	223.00 ab	360.00 a
husk biochar (5 t/ha)					
C. odorata (10 t/ha) + rice	1.15 b	48.90 c	16.67 a	240.00 bc	420.00 c
husk ash (5 t/ha)					
Rice straw (10 t/ha) + rice	1.16 bc	50.30 d	20.00 a	246.67 c	403.33 bc
husk ash (5 t/ha)					

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Table 2. Effect of rice husk biochar with soil amendments on some chemical properties of acid sulphate soil at one month after incubation.

-		C-	Р-	Al-dd	Soluble	CEC
Soil amendments	pH H ₂ O	organic	available	(me/100	Fe	(me/100
		(%)	(%)	g)	(%)	g)
Control	3.36 a	1.94 a	0.21 a	3.84 e	3.61 d	6.64 a
C. odorata (10 t/ha)	4.06 bc	4.22 b	0.29 bc	3.31 c	3.28 c	7.15 ab
Rice straw (10 t/ha)	4.28 bc	4.58 b	0.30 bc	3.42 cd	3.34 cd	7.32 abc
Rice husk biochar (10 t/ha)	4.40 bc	4.09 b	0.32 cd	3.16 b	3.10 abc	8.03 c
Rice husk ash (10 t/ha)	3.98 b	2.78 a	0.28 b	3.51 d	3.34 cd	7.76 bc
C. odorata (10 t/ha) + rice husk biochar (5 t/ha)	4.58 c	4.93 b	0.34 d	3.02 a	2.94 ab	10.04 e
Rice straw (10 t/ha) + rice husk biochar (5 t/ha)	4.48 bc	4.75 b	0.33 d	3.08 ab	2.91 a	9.67 de
<i>C. odorata</i> (10 t/ha) + rice husk ash (5 t/ha)	4.26 bc	4.70 b	0.31 cd	3.37 c	3.25 c	9.17 d
Rice straw (10 t/ha) + rice husk ash (5 t/ha)	4.26 bc	4.73 b	0.31 cd	3.47 d	3.22 bc	9.20 d

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Manuscipt acceptance : 29 Oktober 2022





Pembayaran : 31 Oktober 2022

=	M Gmail		Q. 1	tient.									×	81	• sat-	1	2 0	01	-	UPB	-
0	1 741		+	Ð	φ.	e	n	U	8	8	D	ŧ.						санта		,	1
1 #	 Sole Veran Octomera 	655	1	Rector Deal	- Sick	3							 I	nieszei koles	the set of the		into int National		т. т. т.		
	C Contra Toban D Cont	-		Sas : Lass Geals	arnal A Vol. Ajurda,	rik ur	to Denie	and a	echara	PNIM V			01-01-0					1.0000		200	
PP	united			Parrow	T-ult	Gryen	h, Part	tat :	der sold											ĥ	ł
								2.6.0	- Ser al .	a										*	
			0		n Pag		u -ree	eliperi.	121010	dino-						10	100219-	\$	н.	5	
					701 3001		k da	100	- le fe	others	ei)						HE WAR	metik	120		,

Bukti pembayaran:

🗧 tarafa. Aya déning a (Opdi	Dor e	114 + I O	161
	∫an Rasi setaran transferiki hagi inkaso dan bandar tang barkar panakar tang	mandiri	
	August Procession Control of Cont	Constraints Constrain	
		Mar	

Pemberitahuan penerimaan pembayaran biaya publikasi: 31 Oktober 2022

	Pro Circuit		12 19 west 20 19 19	* **** @ S = SPUTO SO
	tel cara			and the second s
-	1		+ 0 A F # 0 3 F 0 I	E
		0140		-
-	0		Construction and a second seco	- 10.000 mm - 10 - 44 - 1
2	11 Post	- 54	An approx is a second of approximately and	
	udad	(a)	Beach and the costs of the program with the second state of the se	•
			Define can brain Chief Brain	
			a sector for the sector part of the sector part of the sector of the sec	
			(make) (manual)	

Galley copy of paper for publication (10.11147) : 8 Desember 2022

	· · · · · · · · · · · · · · · · · · ·	CARLES AND	E. PROOFFE PA				** n D	
-	M Omai		Q. Television real	r:	8 and +	<i>∞</i> ⊛ ∷	QUP	n 🧐
100	1 360		0-00 = m	of GL ni mi i		Clinitati		
11	E States	120	11 - 11:000, incr	Guine stored same to underline 75, "DHI - There is no use of 20 (5, 10) Sectors	1	e alcan-	+*	
241	n hines		1.1 - Januar Bria Parlan	1991 New well according to a detail line Welter and eveness - Scaling		and a second to the		
100	() C = = = = = = = = = = = = = = = = = =							
	to Telles 13 Col	- 22	11 - Vanish afferten	1891 New York as a control of a matter of the last end was made in the form			900	
0	- house		11 - Wale alto an Wa	Non-weath, while - cale and as dots, 2019, 1919 - Non-year is provide the			the second	
	Contraction of the second		11 = kawye	Not iterative as a - Loge Data & Medices massime Diack as 25a	an analysis and raise in	Card Nor May 2005	2.00	
	abel			a 13 All supervision of the proceeding to be a supervision with the	constitution in the Real Property lies	second the second	1.04	
			() - resconser	CPATHannood Reset can be about 2000 we received a machine	and the many old TAV		2.50	
			1.1 de Accelhia refer	(2.4) Here of a law content the formula induction of	a stand and a fight-	denter and set of the set of the	5.50	
			a new widden.	Dependent was explorate or Report Published Automatical automatical	speciele call for Kasara Notic	NO-MERCHANNER.	1	Т
			A Restor	The Mathematical Society and an environment of the second states of the			7.9-	
			The Second visitio	Aid for your This work (shift) - you (Saber Months of a - unit			-	ч
				그는 말 같은 것을 하는 것 같은 것이 가지 않는 것이 많이 많이 많이 많이 했다.				1
			. Boothchartthe	Tellaribet 2 Annalysis, "Topic take resurce maters", Aurige Kon-	- In Marine Decision	aper the rord	(25.m)	
p -	upparante sance		A Sector Ches	Terlander 7 An ander Trope bei reserverenden 5. Kongerber Terlander 7 An ander Trope bei Tergen verbei 1. Kongerber Terlander 7 An ander Trope bei Tergen verbei 1. Kongerber Terlander 7 An ander Trope bei Tergen verbei 1. Kongerber 1. State 1. State 1. State 1. State 1. State 1. State 1. State 1. St	 Outrigonal contracts Outrigonal contracts 		-	
- 10-	et an anticipation of the static of X		III - AS SAMES, CALLS	Terlerker (* 6. voor "toge dat tergen veter), borge ber Terlerker (* 6. voor "toge dat tergen veter), borge ber	 Outrigonal contracts Outrigonal contracts 	- donors rep . Sea marcara Gaussia A. Dan	-	
- 14-	et an anticipation of the static of X		at spens, and a second state of the second sta	Terlerker (* 6. voor "toge dat tergen veter), borge ber Terlerker (* 6. voor "toge dat tergen veter), borge ber	 Outrigonal contracts Outrigonal contracts 	- donors rep . Sea marcara Gaussia A. Dan	rike rike na Jaire	-
	in a state of the state. X		at spens, and a second state of the second sta	Terlerker (* 6. voor "toge dat tergen veter), borge ber Terlerker (* 6. voor "toge dat tergen veter), borge ber	 Outrigonal contracts Outrigonal contracts 	- donors rep . Sea marcara Gaussia A. Dan	entre entre tre derive	-
-	1 and 1 and 2 a				- 10 49 140 4 1 10 4 10 - 10 4 2 10 1 10 1 10 10 - 11 4 1 10 1 10 1 10 10 10 10 - 11 10	- 000 000 000 (1999) - 000 (1999) - 000 *		-
- 1.0m 	ti ak ne podene 19 sec M Graat			Televisi 7 6. von Tuge del Televisi del Longe del . Televisi del sono Televisi del Contenue del 1 10. Contenue del 1 20. Contenue del 1. Contenue del 1. C	- 10 49 140 4 1 10 4 10 - 10 4 2 10 1 10 1 10 10 - 11 4 1 10 1 10 1 10 10 10 10 - 11 10	00000000000 karnet 0000 karnet 0000 00000000000000000000000000000000		-
- 2.4m 	B and M Creat		Carky copy of pac	Teteritet of Annous Huge bat Reported to Longe te Teteritet of Annous Huge bat Report ester and the Teteritet of Annous Huge bat Report ester and the Teteri	• 10 49 1944 41 195 19 • 14 49 1944 4 199 19 • 14 49 1944 4 199 19 • 14 49 • 14 49 • 14 49	(3), (3), (3), (3), (3), (3), (3), (3),	ана на мара мара мара мара мара мара мар	-
	E ver			Teteritet of Annous Huge bat Reported to Longe te Teteritet of Annous Huge bat Report ester and the Teteritet of Annous Huge bat Report ester and the Teteri	• 10 49 1944 41 195 19 • 14 49 1944 4 199 19 • 14 49 1944 4 199 19 • 14 49 • 14 49 • 14 49	00000000000 karnet 0000 karnet 0000 00000000000000000000000000000000	ана на мара мара мара мара мара мара мар	-
	M Croat D Second M Croat M		Carley copy of page Carley copy of page Carley copy of page Carley copy of page Vignaming 1:	Teteritet of Annous Huge bat Reported to Longe te Teteritet of Annous Huge bat Report ester and the Teteritet of Annous Huge bat Report ester and the Teteri	• 10 49 1944 41 195 19 • 14 49 1944 4 199 19 • 14 49 1944 4 199 19 • 14 49 • 14 49 • 14 49	(3), (3), (3), (3), (3), (3), (3), (3),		-
	Crast Const		Carley copy of page Carley copy of page Carley copy of page Carley copy of page Vignaming 1:	Television in our many data television and the second of t	• 10 49 1944 41 195 19 • 14 49 1944 4 199 19 • 14 49 1944 4 199 19 • 14 49 • 1	(0.000 mp) (0.000 m) (0.000 m) (0.00		-
	Constant Constant Const	250	Alternative points Alternative point	Television in our many data television and the second of t	• 10 49 1940 41 195 19	(0.000 mp) (0.000 m) (0.000 m) (0.00		-
	Crast Const	250	Carloy and a Control of Cont	Technologi de verser frager des langes verten 1, konge kan Technologi de verser frager des langes verser en den 1, tec 100 State de verser frager des langes verser en den 1, tec 100 State de verser de verser de verser en de verser en de verser		(0.000 mp) (0.000 m) (0.000 m) (0.00		-
	Constant Constant Const	250	Carloy and a Control of Cont	Television of Annuals Traje but Report which Large but in Television of Annuals Traje but Report of a second of the Television of Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Annuals and Ann		(0.000 mp) (0.000 m) (0.000 m) (0.00		-

Improving the properties of acid sulphate soil

- 221 Causes - - 2 dd Rol, 7084

Res. Crop. **23** (4): (2022) *Printed in India*

an A April and a sector

Role of biochar amendments in improving the properties of acid sulphate soil

AGUSALIM MASULILI*, SUTIKARINI, RINI SURYANI, IDA AYU SUCI, ISMAIL ASTAR, HARDI DOMINIKUS BANCIN AND PAIMAN¹

Department of Agrotechnology, Faculty of Agriculture Panca Bhakti University, Pontianak 78113, West Kalimantan, Indonesia *(e-mail: <u>agusalim@upb.ac.id</u>) (Received: October 03, 2022 / Accepted: November 28, 2022)

ABSTRACT

Acid sulfate soils have potential for agricultural development. However, this soil has various properties problems that can inhibit plant growth. One way to improve soil properties is through the application of biochar amendments. The study aimed at knowing the role of rice husk biochar combined with amendments to Chromolaena odorata, rice straw, and rice husk ash to improve the properties of acid sulphate soil. The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely, without amendments (control), C. odorata (10 t/ha), rice straw (10 t/ha), rice husk biochar (10 t/ha), rice husk ash (10 t/ha), C. odorata (10 t/ha)+rice husk biochar (5 t/ha), rice straw (10 t/ha)+rice husk biochar (5 t/ha), C. odorata (10 t/ha)+rice husk ash (5 t/ha), and rice straw (10 t/ha)+rice husk ash (5 t/ha). The results showed that the amendment of rice husk biochar combined with amendments to C. odorata and rice straw, respectively, had a good effect on improving soil physical properties, namely, total soil pores, reducing soil content weight and soil strength. Its effect on soil chemical properties was that it could increase pH, C-organic, P-available, cation exchange capacity (CEC), lower Al-dd and Fe soluble. The research findings showed that applying biochar and organic amendments to Chromolaena odorata and rice straw could potentially improve the

¹Department of Agrotechnology, Faculty of Agriculture, Universitas PGRI Yogyakarta, Yogyakarta 55182, Indonesia.

properties of acid sulphate soil. In future research, we recommend increasing the carrying capacity of acid sulphate soil against plant growth, and it can be done by improving soil properties through the organic amendments application of *C. odorata* or straw enriched with rice husk biochar.

Key words: Chromolaena odorata, rice husk ash, rice husk biochar, rice straw, soil properties

INTRODUCTION

Acidic sulphate soils are the common name for soils and sediments containing iron sulfide, namely, pyrite (Das and Das, 2015). In agricultural development, efforts to reclaim acid sulphate soils do not always result in soil productivity since improvements in soil properties after reclamation are not achieved. So far, efforts have been encouraged to overcome existing obstacles after reclamation, including inorganic fertilizers (urea, TSP and KCl) and liming (dolomite). However, rice crop productivity in this field has not been optimal.

Inorganic fertilizers increase over time and can even decrease land quality if inputs are high and intensive. Liming can only cope with short-term pH and is often done repeatedly. As a result, high costs are needed, which becomes a burden for farmers and will threaten the sustainability of land productivity. Therefore, it is necessary to manage land based on land amendments that can improve the nature of sustainable soils.

Reclamation can result in changes in soil properties and is related to the potential for pyrite oxidation, affecting the increase in soil packaging and the solubility of ions such as Al, Fe, Mn and sulphate. On the other hand, this soil has a high clay content which affects the increased weight of the contents. Therefore, the development of acid sulphate soil for agriculture after reclamation requires proper management of soil amendments to achieve the formation of steady cultivated land and sustainable farming. Das and Das (2015) suggested that acid sulphate soil having a high pH could inhibit plant growth. In addition, when this soil is drained, it can affect an increase in sulfuric acid and the release of iron, aluminum, and other heavy metals. Shamshuddin *et al.* (2014) stated that plants grown in acidic sulphate soils could not grow well due to low pH and high Al content.

Biochar is one of the soil amendment materials with the long-term potential to maintain soil fertility (Ogunleye *et al.*, 2019; Jaswal *et al.*, 2022). The results of experts' investigations into the phenomenon of terra preta show that soil fertility is stable in the Amazon basin due to the presence of black carbon, the result of the management of the Amerindian nation 500-2,500 years ago. This carbon black is nothing but biochar immersed in the soil. Murtaza *et al.* (2021) found that 4.0 t/ha cotton biochar improved physical, chemical, soil biological soil fertility properties and peanut productivity in Alfisol. Zhang *et al.* (2022) have proven that biochar provides effects such as liming and providing nutrients that lead to soil improvement. Kocsis *et al.* (2022) stated that biochar had a high porosity and could improve the physico-chemical and biological properties of the soil. In line, Sovova *et al.* (2021) found that biochar had a good influence on improving the soil properties of regosol. Further, Das *et al.* (2021) suggest the application of biochar to the soil can provide agronomic benefits, support crop yield improvement, and improve soil quality and health. In addition, biochar has been shown to act as a fertilizer and soil conditioner.

Nutrient retention and higher nutrient availability were found in the soil after biochar addition, associated with higher CEC, surface acreage and direct nutrient addition (Glaser *et al.*, 2002). In line with opinions, Murtaza *et al.* (2021) suggested that biochar was a recalcitrant carbon product of biomass produced through the pyrolysis process. The recalcitrant properties of biochar are distinctive and important to the long-term improvement of soil properties through the effects of their residues that can persist for a long time in the soil. Beusch (2021), biochar can contribute to soil fertility and crop productivity, and Kalu *et al.* (2021) increase water availability and lower soil BD.

Applying biochar can improve soil properties and long-term crop productivity compared to other organic amendments. In other organic amendments, research results by Suri and Yudono (2020) showed that giving *C. odorata* as compost can increase plants' nutrition and nutrient uptake. Agustina *et al.* (2019) argued that using *C. odorata* and rice straw could maintain soil quality. Mahmoud *et al.*

(2009) also showed rice straw compost could improve soil quality. The same was discovered by Gewaily (2019), that straw compost can increase potassium availability.

Furthermore, the results of the study by Yin *et al.* (2022) showed the weight of the soil contents decreased, and the water-holding capacity and total porosity increased in the soil with rising rice husk ash. Adding rice husk ash neutralizes soil acidity and increases plant nutrient availability. Research by Lestari and Rachmawati (2020) showed that applying rice husk ash (4 t/ha) could increase rice growth and reduce salinity stress.

Previously, several studies on the effect of biochar singularly have been carried out, including on the P-availability (Zhang *et al.*, 2022), improvement of soil physical properties (Aslam *et al.*, 2014; Yin *et al.*, 2018), chemical properties of the soil (Bista *et al.*, 2019), some soil characteristics (Yadav *et al.*, 2018), soil aggregate stability (Ebido *et al.*, 2021) and to the development of rice roots (Kartika *et al.*, 2021). However, no research has been found on how the role of biochar was given together with other organic amendments in acid sulphate soil. Therefore, it is necessary to study how the effect of biochar is given together with organic amendments to *C. odorata* and rice straw. This research is expected to contribute to improving the nature of acid sulphate soil in West Kalimantan, which has been one of the types of soil widely used as an agricultural activity for rice crop. In connection with this background and literature review above, this study aimed at knowing the role of rice husk biochar combined with amendments to *C. odorata*, rice straw and rice husk ash in improving the properties of acid sulphate soil.

MATERIALS AND METHODS

Study Area

This research was conducted from September to November 2021. The research site was carried out at the Laboratory of the Faculty of Agriculture, Universitas Panca Bhakti, Pontianak, West Kalimantan Province, Indonesia. The height of the study site is one m from above sea level, with an average temperature and humidity of 27.6°C and 82.8%, respectively. The research position is located at a latitude of 2°05' N-3° 05'S and longitude of 108°30' E-144°10' W.

Experimental Design

The study was conducted in a greenhouse and arranged in a complete randomized design (CRD) with three replications. Biochar amendments consisted of nine kinds, namely, without amendments (control), *C. odorata* (10 t/ha), rice straw (10 t/ha), rice husk biochar (10 t/ha), rice husk ash (10 t/ha), *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha), rice straw (10 t/ha)+rice husk biochar (5 t/ha), *C. odorata* (10 t/ha)+rice husk ash (5 t/ha), and rice straw (10 t/ha)+rice husk ash (5 t/ha). In all, 27 polybags were needed.

Research Procedures

The material in this study used acid sulphate soil taken on the experimental land of the West Kalimantan, Sungai Kakap, Agricultural Technology Assessment Center, and land farmers' work on rice crops. This area included the development of swampland agriculture which had built irrigation canals since 1980 and was currently designated as an Integrated Farmer Business Area. Soil picking was carried out randomly at a soil depth of 0-20 cm, then mixed, air-dried, and cleaned. Then put in polybags was as much as 8 kg.

Biochar was made by taking rice husk from grain harvested from rice plants grown directly in the acid sulphate soil of the Kakap River, West Kalimantan, Indonesia. First, the rice mill was taken the grain to obtain rice husk. Furthermore, the rice husk was placed on the pyrolysis device to be processed into biochar by incomplete combustion (limited air) in a reactor made of Pertamina drums.

Organic amendments to *C. odorata* were taken from around the field, then chopped to a size of 1-2 cm. Rice straw was taken from waste harvested rice grown and grown by farmers in acid sulphate soil and chopped within 1-2 cm. Rice husks were taken from waste from rice milling, then used as ash through burning in open areas to produce grayish-white ash.

Prepared acid sulphate soil introduced into 27 polybags until it reached 8 kg. Further, the dose of soil amendment was calculated based on the soil weight in the polybag area, mixed with the soil in each polybag to a soil depth of 20 cm, after which it was incubated with moisture content until it was closed to the field capacity for 30 days.

At 30 days after incubation, from each study unit, soil sampling of about 50 g was undisturbed to determine the weight of the soil moisture content accident. In addition, a disturbed soil sample of 100 g was taken from each research unit for analysis of chemical properties.

Observation Parameters

The soil bulk density (BD) was determined by the clod method described by Blake & Harke. The total pore was calculated from the soil moisture content (v/v) at the matrix potential of 0 kPa. The available groundwater was estimated by reducing the soil moisture content in the matrix potential by -33 kPa (field capacity) with the soil moisture content in the matrix potential, which was -15 Mpa (wilting point). The soil moisture content at this potential matrix was determined using a pressure plate device. The strength of the soil was measured with a hand penetrometer (Daikie) at a soil depth of 15 cm.

The pH level was measured in a soil solution at a ratio of 1 : 2.5 (with deionized water), using a pH meter (Jenway 3305). Walkley and Black's wet oxidation method was used to determine organic C levels (Soil Survey Laboratory Staff). Total N levels were measured by the Kjeldhal (Bremner and Mulvaney) method. Al₃+and Fe₂+were extracted with 1 M

KCl (Barnhisel and Bertsch). CEC was extracted with 1 M NH₄Oac (buffer at pH 7.0), and the concentration of alkaline cations was measured using AAS (Shimadzu), P-available with Bray I.

Statistical Analysis

Statistical analysis was carried out on each observation parameter data to determine the effect of the amendments on the nature of acid sulphate soil. The data obtained were analyzed by analysis of variance (ANOVA) at 5% significant level. In addition, the test of least significant difference (LSD) at 5% significant level was used to determine the average value between treatments.

RESULTS AND DISCUSSION

Effect of Various Soil Amendments on Some Physical Soil Properties

Applying biochar improved the soil's physical properties (Aslam *et al.*, 2014). Applying biochar and organic amendments influenced the changes in some of the observed soil physical properties. The statistical test is shown in Table 1. The soil BD was lower on all amendments granted. For example, in soils fed a single rice husk biochar (10 t/ha), soil BD decreased from 1.27 mg/m³ in the control soil to 1.15 mg/cm^3 . However, not significantly different from soils was given straw (10 t/ha) and a combination of straw+biochar, *C. odorata*+rice husk ash, and straw+rice husk ash. Furthermore, in the combination of *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha), a BD of 1.13 mg/m^3 was obtained and was the lowest soil BD. Still, it was not significantly different from the soil, given a combination of straw (10 t/ha) + rice husk biochar (5 t/ha) produced soil BD of 1.14 mg/m^3 . These results indicated an improvement in the physical soil properties if biochar was given together with organic amendments to *C. odorata*.

Applying various biochar amendments and their combinations increased the soil's total pore. The statistical test results are shown in Table 1. There was a significant difference in the total pore of the soil between the various amendments. Control soils had the lowest total pore (44.43%), contrasting with soils that provided various amendments. On soils with rice husk biochar (10 t/ha), the total soil pore increased to 54.21%, significantly different from other single amendments. Furthermore, a combination of *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha) caused the total pore to increase to 56.73% and was the highest total pore.

The application of various amendments, both single and combined, affected the decrease in soil strength as measured as soil penetration resistance (N/cm²) at conditions of pF 0, pF 2 and pF 2.5, where the higher the soil matric suction (pF), the higher the soil penetration resistance. The under saturated conditions (pF 0), the various soil amendments did not offer a noticeable difference. In pF 2 showed that the application of rice husk biochar (10 t/ha) could reduce soil penetration resistance from 310.00 N/cm² (control soil) to 223.33 N/cm², but not significant difference between *C. odorata* (10 t/ha)+rice straw or a combination of straw (10 t/ha)+rice husk biochar (5 t/ha). Furthermore, soils

given a combination of *Cromolaena odorata* (10 t/ha)+biochar (5 t/ha) obtained the lowest penetration resistance (220.00 N/cm²), and this treatment was not significantly different from soils have given *C. odorata* (10 t/ha), rice husk biochar (10 t/ha), and a combination of rice straw (10 t/ha)+rice husk biochar (5 t/ha).

Similarly, in pF 2.5, the application of rice husk biochar (10 t/ha) could reduce the value of soil penetration resistance from 500.00 N/cm² (control soil) to 390.00 N/cm², and this treatment not significantly different from soils had given *C. odorata* (10 t/ha), rice straw (10 t/ha), rice husk ash (10 t/ha), and a combination of rice straw (10 t/ha)+rice husk ash (5 t/ha). Furthermore, the combination of *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha) achieved the lowest penetration resistance (340.00 N/cm²). Also, it was not significantly different from the combination of rice straw (10 t/ha)+biochar (5 t/ha) (360.00 N/cm²). It indicated that rice husk biochar had the potential to control soil strength. In line with Das *et al.* (2021), applying biochar into the soil could reduce soil strength.

Effect of Rice Husk Biochar on Some Soil Chemical Properties

The application of several soil amendments and their combinations could influence some chemical properties of acid sulphate soil. The results of statistical tests in Table 2 show that soil reaction (pH) of the soil increased in all treatments given compared to controls. For example, in the application of rice husk biochar showed an increase in pH from 3.36 (control soil) to 4.40 on soils given biochar (10 t/ha) but did not significantly differ from other single amendments. Furthermore, the combined application of *C. odorata* (10 t/ha)+biochar (5 t/ha) obtained the highest increase in soil pH (4.58), in marked contrast to soils given rice husk ash but not significantly different from single amendments or other combinations.

Applying single and combined soil amendments affected the increase in soil C-organics. The statistical test results in Table 2 show that the control soil had the lowest C-organic (1.94%), in stark contrast to other amended soils, except that the soil had given rice husk ash (10 t/ha) was not significantly different. The soil given a single amendment of rice straw (10 t/ha) obtained 4.58% C-organic, in stark contrast to the control soil and the soil given rice husk ash, but not significantly different from other soil amendments. Similarly, soils given a combination of *C. odorata* (10 t/ha)+biochar husk (5 t/ha) achieved the highest soil C-organic (4.93%) in marked contrast to control soils and soils fed with rice husk ash but did not significantly differ from other soil amendments.

Applying various amendments and combinations to acid sulphate soil generally affected the increase in P-available. The results of statistical tests (Table 2) show that control soils had the lowest P-available content (0.21%), significantly different from soils given various amendments. In soils fed with a rice husk biochar (10 t/ha), the P-available increased to 0.32%. Still, it was not significantly different from other combined or single-amended soils, except with soils that were given rice husk

ash with a lower P-available (0.27%). The highest P-available was obtained on soils given a combination of *C. odorata* (10 t/ha)+biochar (5 t/ha) (0.34\%), in stark contrast to control soils and those topped with rice husk ash but not significantly different from single amendments or other combinations.

The decrease in Al-dd and Fe-dissolve in acid sulphate soil also occured due to applying various soil amendments and their combinations. Statistical tests (Table 2) showed that the highest Al-dd was obtained on control soil (3.84%), further decreasing and differing markedly from soils given various single and combined amendments. On single-amendment soils of rice husk biochar (10 t/ha), Al-dd decreased to 3.16%, significantly different from other single-amended soils. Furthermore, the soil given the combination of *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha) obtained the lowest Al-dd content (3.02%). It was not significantly different from the soil given a combination of rice straw (10 t/ha)+rice husk biochar (5 t/ha), but it was significantly different from other single amended soils. In soluble Fe content, the application of rice husk biochar (10 t/ha) could reduce soluble Fe from 3.61% on control soil to 3.10% and was significantly different from other single amendments. And when the soil was given a combination of rice straw (10 t/ha)+rice husk biochar (5 t/ha) caused the lowest decrease in Al-dd (2.91%). Still, it was not significantly different from soil that was given a combination of *C. odorata* (10 t/ha)+rice husk biochar (5 t/ha).

The CEC of land has also increased due to the application of various land amendments and their combinations. The statistical test shown in Table 2 shows that the control soil had the lowest CEC (6.64 Cmol/kg), not significantly different from soils fed with *C. odorata* and rice straw. On the other hand, on soils provided with rice husk biochar (10 t/ha), the soil CEC increased to 8.03 Cmol/kg, but it was not significantly different from soil given rice straw and rice husk ash.

In line with the results that have been put forward, Yamato *et al.* (2006) found that the application of biochar from *Acacia mangium* bark into the soil in Sumatra led to changes in soil chemical properties through increased pH, N-total and P-available, CEC and lowered interchangeable Al. Liang *et al.* (2006) found that two mechanisms could create a larger CEC. First, a higher charged density per unit of surface acreage means a higher degree of oxidation of soil organic matter. Second, the presence of a higher surface area for cation absorption or the combined effect of both. Glaser *et al.* (2002) posit that oxidation of aromatic C and carboxyl formation were the main reasons for the high CEC. Liang *et al.* (2006) also found that the CEC per unit C was higher, and the load density was higher in carbon-black-rich Anthrosol compared to soils that were poor in carbon black. In addition, Anthrosol showed a higher surface acreage due to its higher carbon black concentration.

From the results, the great potential of rice husk biochar against improving soil properties increased when given together with the biomass *C. odorata*. It could happen because *C. odorata* contained higher humate and fulvic organic acids, so that it could encourage the complex mechanisms

of organo-mineral organs and soil aggregation. In addition, *C. odorata* can highly suppress Al and Fe, thereby increasing the P availability in the soil due to the presence of organic acids released during decomposition. Research results by Suri and Yudono (2020) also found that using *C. odorata* compost could improve soil quality and nutrient uptake of lettuce plants.

C. odorata can contribute to the care of soil C-organic and physical properties due to a reasonably high polyphenol content that could inhibit the decomposition and mineralization of N organic matter, even though it had a low C/N ratio.

CONCLUSION

In conclusion, the amendment of rice husk biochar combined with amendments to *C. odorata* and rice straw improved soil physical properties, namely, total soil pores, reducing soil content weight and strength. Its impact on soil chemical properties was that it could increase pH, C-organic, P-available, CEC, lower Al-dd and Fe soluble. Therefore, applying biochar and organic amendments to *C. odorata* and rice straw could improve the properties of acid sulphate soil. Consequently, we recommend increasing the carrying capacity of acid sulphate soil against plant growth. It can be done by enhancing soil properties through the organic amendments application of *C. odorata* or straw enriched with rice husk biochar.

ACKNOWLEDGEMENTS

The authors thank the Institute for Research and Community Service, Universitas Panca Bhakti, which has given support for research funds. In addition, they thank the Faculty of Agriculture, Universitas Panca Bhakti, which has provided loans for facilities in the form of equipment for research.

REFERENCES

- Agustina, R., Jumadi, R., Firmani, U. and Abdul Faisal, R. H. (2019). Effects of decomposition rate of *Chromolaena odorata* and straw rice in fresh and compost form to the growth and yield of rice. *IOP Conf. Ser. Earth Environ. Sci.* **250** : 1-5.
- Aslam, Z., Khalid, M. and Aon, M. (2014). Impact of biochar on soil physical properties. Sch. J. Agric. Sci. 4: 280-84.
- Beusch, C. (2021). Biochar as a soil ameliorant : How biochar properties benefit soil fertility–A review. J. Geosci. Environ. Prot. 9 : 28-46.
- Bista, P., Ghimire, R., Machado, S. and Pritchett, L. (2019). Biochar effects on soil properties and wheat biomass vary with fertility management. *Agronomy* **9** : 1-10.
- Das, S. K. and Das, S. K. (2015). Acid sulphate soil : Management strategy for soil health and productivity. *Pop. Kheti* **3** : 3-8.

- Das, S., Mohanty, S., Sahu, G., Rana, M. and Pilli, K. (2021). Biochar : A sustainable approach for improving soil health and environment. In : Soil Erosion–Current Challenges and Future Perspectives in a Changing World. pp. 1-18.
- Ebido, N. E., Edeh, I. G., Unagwu, B. O., Nnadi, A. L., Ozongwu, O. V., Obalum, S. E. and Igwe, C. A. (2021). Rice-husk biochar effects on organic carbon, aggregate stability and nitrogen fertility of coarse-textured Ultisols evaluated using *Celosia argentea* growth. *Sains. Tanah.* 18 : 177-87.
- Gewaily, E. (2019). Impact of compost rice straw and rice straw as organic fertilizer with potassium treatments on yield and some grain quality of Giza 179 rice variety. *J. Plant Prod.* **10** : 143-51.
- Glaser, B., Lehmann, J. and Zech, W. (2002). Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal–A review. *Biol. Fertil. Soils* **35** : 219-30.
- Jaswal, A., Mehta, C. M. and Singh, A. (2022). Probing the impact of biochar combined with organic and inorganic amendments on soil carbon pools of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Res. Crop* 23 : 508-15.
- Kalu, S., Simojoki, A., Karhu, K. and Tammeorg, P. (2021). Long-term effects of softwood biochar on soil physical properties, greenhouse gas emissions and crop nutrient uptake in two contrasting boreal soils. *Agric. Ecosyst. Environ.* **316** : doi.org/10.1016/j.agee.2021.107454.
- Kartika, K., Sakagami, J. I., Lakitan, B., Yabuta, S., Akagi, I., Widuri, L. I., Siaga, E., Iwanaga, H. and Nurrahma, A. H. I. (2021). Rice husk biochar effects on improving soil properties and root development in rice (*Oryza glaberrima* Steud.) exposed to drought stress during early reproductive stage. *AIMS Agric. Food* 6 : 737-51.
- Kocsis, T., Ringer, M. and Biró, B. (2022). Characteristics and applications of biochar in soil-plant systems : A short review of benefits and potential drawbacks. *Appl. Sci.* **12** : 1-16.
- Lestari, M. F. and Rachmawati, D. (2020). The effect of rice husk ash on growth of rice (*Oryza sativa* (L.) 'Sembada Merah') on salinity stress. *AIP Conf. Proc.* **2260** : 1-6.
- Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J. O., Thies, J., Luizão, F. J., Petersen, J. and Neves, E. G. (2006). Black carbon increases cation exchange capacity in soils. *Soil Sci. Soc. Am. J.* **70** : 1719-30.
- Mahmoud, E., Ibrahim, M., Robin, P., Akkal-Corfini, N. and El-Saka, M. (2009). Rice straw composting and its effect on soil properties. *Compost Sci. Util.* **17** : 146-50.
- Murtaza, G., Ahmed, Z., Usman, M., Tariq, W., Ullah, Z., Shareef, M., Iqbal, H., Waqas, M., Tariq, A., Wu, Y., Zhang, Z. and Ditta, A. (2021). Biochar induced modifications in soil properties and its impacts on crop growth and production. *J. Plant Nutr.* 44 : 1677-91.
- Ogunleye, K. S., Okeke, O. S., Umego, M. O. and Ogbonnaya, O. U. (2019). Extraction behaviour of cadmium in biochar amended soils. *Crop Res.* **54** : 59-64.

Shamshuddin, J., Elisa Azura, A., Shazana, M. A. R. S., Fauziah, C. I., Panhwar, Q. A. and Naher,

U. A. (2014). Properties and management of acid sulfate soils in South-east Asia for sustainable cultivation of rice, oil palm and cocoa. *Adv. Agron.* **124** : 91-142.

- Sovova, S., Enev, V., Smilek, J., Kubikova, L., Trudicova, M., Hajzler, J. and Kalina, M. (2021). The effect of biochar application on soil properties and growth of the model plant *Zea mays*. *Ecocycles* **7** : 46-54.
- Suri, A. M. and Yudono, P. (2020). Effects of *Chromolaena odorata* compost on soil and nutrient uptake of lettuce (*Lactuca sativa*). *Planta Trop. J. Agro. Sci.* **8** : 33-38.
- Yadav, N. K., Kumar, V., Sharma, K. R., Choudhary, R. S., Butter, T. S., Singh, G., Kumar, M. and Kumar, R. (2018). Biochar and their impacts on soil properties and crop productivity : A review. *J. Pharmacogn. Phytochem.* 7 : 49-54.
- Yamato, M., Okimori, Y., Wibowo, I. F., Anshori, S. and Ogawa, M. (2006). Effects of the application of charred bark of *Acacia mangium* on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Sci. Plant Nutr.* 52 : 489-95.
- Yin, M., Li, X., Liu, Q. and Tang, F. (2022). Rice husk ash addition to acid red soil improves the soil property and cotton seedling growth. *Sci. Rep.* **12** : 1-9.
- Yin, X., Huang, M. and Zou, Y. (2018). Potential use of biochar in raising machine-transplanted rice seedlings. *Farm. Manage.* 3 : 87-92.
- Zhang, Y., Chen, H., Xiang, J., Xiong, J., Wang, Y., Wang, Z. and Zhang, Y. (2022). Effect of ricestraw biochar application on the acquisition of rhizosphere phosphorus in acidified paddy soil. *Agronomy* 12 : 1-13.

Table 1. Effect of rice husk biochar with soil amendments on some physical properties of acid sulphate soil at one month after incubation.

Soil amendments	BD	Total	Penet	ration resistanc	$e (N/cm^2)$
Soli amendments	(mg/m^3)	pores (%)	pF 0	pF 2	pF 2.5
Control	1.24 e	44.43 a	36.67 b	310.00 e	500.00 d
C. odorata (10 t/ha)	1.16 c	52.17 e	20.00 a	230.00 abc	403.33 bc
Rice straw (10 t/ha)	1.17 bc	53.27 f	16.67 a	243.33 bc	393.33 b
Rice husk biochar (10 t/ha)	1.15 b	54.21 g	14.33 a	223.33 ab	390.00 b
Rice husk ash (10 t/ha)	1.19 d	47.30 b	20.00 a	270.00 d	403.33 bc
C. odorata (10 t/ha) +	1.13 a	56.73 i	10.00 a	220.00 a	340.00 a
biochar (5 t/ha)					

Rice straw (10 t/ha) + rice	1.14 ab	55.57 h	13.33 a	223.00 ab	360.00 a
husk biochar (5 t/ha)					
C. odorata (10 t/ha) + rice	1.15 b	48.90 c	16.67 a	240.00 bc	420.00 c
husk ash (5 t/ha)					
Rice straw (10 t/ha) + rice	1.16 bc	50.30 d	20.00 a	246.67 с	403.33 bc
husk ash (5 t/ha)					

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Table 2. Effect of rice husk biochar with soil amendments on some chemical properties of acid sulphate soil at one month after incubation.

		C-	Р-	Al-dd	Soluble	CEC
Soil amendments	pH H ₂ O	organic	available	(me/100	Fe	(me/100
		(%)	(%)	g)	(%)	g)
Control	3.36 a	1.94 a	0.21 a	3.84 e	3.61 d	6.64 a
C. odorata (10 t/ha)	4.06 bc	4.22 b	0.29 bc	3.31 c	3.28 c	7.15 ab
Rice straw (10 t/ha)	4.28 bc	4.58 b	0.30 bc	3.42 cd	3.34 cd	7.32 abc
Rice husk biochar (10 t/ha)	4.40 bc	4.09 b	0.32 cd	3.16 b	3.10 abc	8.03 c
Rice husk ash (10 t/ha)	3.98 b	2.78 a	0.28 b	3.51 d	3.34 cd	7.76 bc
C. odorata (10 t/ha) + rice	4.58 c	4.93 b	0.34 d	3.02 a	2.94 ab	10.04 e
husk biochar (5 t/ha)	4 40 1 -	4751	0.22.1	2 00 -1	2.01	0(7.1)
Rice straw (10 t/ha) + rice husk biochar (5 t/ha)	4.48 bc	4.75 b	0.33 d	3.08 ab	2.91 a	9.67 de
C. odorata (10 t/ha) + rice	4.26 bc	4.70 b	0.31 cd	3.37 c	3.25 c	9.17 d
husk ash (5 t/ha)						
Rice straw (10 t/ha) + rice husk ash (5 t/ha)	4.26 bc	4.73 b	0.31 cd	3.47 d	3.22 bc	9.20 d
nusk asn (5 1/11a)						

Remarks: The average numbers followed by the same letter in the same column show no significant difference in the LSD test at 5% significant level.

Persetujuan artikel untuk dipublikasi : 8 Desember 2022



Online publication : 16 Desember 2022

		N. S. Water and State									10 - 10 T
	0.0	a se prokrive	estimate.	alla eskocittine :							2 WE D 4
a code		Mage:									
-	M	Gmail		PL IS YOU THE			× 22	. 40.6 -	30 8	p 111	CPB (
P	1	Tates		(Aut +) (Reaming +))		foresting (
11		And all Marcan	100	10 · 4 ·					-	N) Jac 44	1.1
-		tert-mark.		[1] = -2.6 m mov-	minister (strategies	on of later origination	and of Procession	and a state of the state of the	Property of		ALC: N
		Telitie Sed Calue		🖂 🚖 WDN2, agest	Contract Color way of	renter a dealer (d	Liall. Ibersteyer		19.9.9	4 ¹	4100
0			+								1999
		Perda		() - Jacobia Station	monthly of the New York	concrete Arrestaria	National Accession		1.00	10.0	100
	Te	for access		(i) a series a series	USERSE (PC issued)	Solider implications of	mental and the former of the	(w) (***************************	- br + +	#÷.	4.100
	10	CREACE CREAT		🖄 😸 Schue Anderner	staniana (and longer)	Overcation is	i han malan grapa	a a company provide		and a	4.000
	2	Automatic Sector		TO the Manadia	maniforms 171 - Abet and 4	are many at all the	- norpidation of the	a la di uantaka	interior a		100.00
	16			11	Southing Tecordation	and in the prototypes	- supercharacter		hil many		44
		Post street		()	MARINE I SHOTHER	rentanine Juwa I uw	0Atp-51-6(10.)7.	45.000 (* 45.00°C)	1.44 mil	199.	46%
	-	alaritoataes a		(1) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2		erenderes i sec con El 1920,040-9	a 2128-23 - 16 (16 - 16		• • = + •	-	89.56
				11 = ses Jece*	manifolding the set in the	The Robert Mercenne	ken in her we have a	والما الحديد ورود ورق		- 40	Rha
P.	type or	a manini.		111 III III III		12 3		Here (Later		10.00	No. an or



https://gauravpublications.com/journal/research-on-crops/ROC-907



Final copy of final published paper (ID 11147) :19 Desember 2022.

Per la	o e	May 1							
-	M	Genat		G. ministera	× 🕫 🔹 ++++ 🕲 🛞 11	TUP	1		
e 1	10.1		Ref =] [Room 600 +]]	Add presses { Press (+) Press dense } Press are pressed +					
		NAME AND A	1.400	1.1 + 2 1	- 60 (to b)	1.0			
in: In	0.0	dersiziona Clarica		FF = VERM. HVHT	Settimation control with division over \$2.1975. Descionality with a control field that an in the factors. = 1.18750.004	BUD	ľ		
2		tean tea Cate	÷	D = Generation La = constance	The second	8.7m 8100	1		
		ining					2 C THE SHOP		
	14	Reaches		11 m. were briefpille	Statistic LPA has not creative the development with part for the second states of the development.	1000			
	40	In station		1.1	International CPP, New and present the Antonian Partner for any start of the series and the series of the series o	Seller-			
	12	(anal)		11 m Chie Fotory	mailing 189 Passwellers (Annual Studies reasons Constants) and Alta Scheller and -	100			
	+=	Kelman				U Shabaad	maniane (API Reserved Parcel Conference) - Vertical memory a memory of reserves a barrow of the stretters of	4100	
		File alcost		C - levels.	manager Pre-bestellaries agree when a warding where their constants more when	and the			
		Lanoscher.		C = limb was	management for resolution particular management for any state. The second state of the second state range				
	3-64	ul.	+	C	Interface, a give memory and press and other states of the restriction of a president all belows	0.01			
				La province start t	statistical states of second these two two two two two in all the particular second and	Mile-			



Complete Publication of manuscript no. ROC-907 entitled Role of biochar amendments in improving the properties of acid sulphate soil.

Publication : 25 Desember 2022.

https://gauravpublications.com/journal/research-on-crops/ROC-907

		Aller a cost action		4.4.41		6 # II		
2	Mi Gn	lien		 kinosrani 	× 左 • • • • • • • • •	TUPE	1	
P	1 24			We - Rectruck -]	Restaurune respective paramiditera remaining standard		1	
			1.400	n+ a ;	1 Cancell	- B.		
*	TOALS	19973		🗋 📄 Rose Nobel Av	For the Design of Parks and a second of the Work in Action in the Second State of	1228		
-	10- 10-1	in .		Distantistes.	mentioned \$100 (Amount counterparts in the field on chain was should be as were also and the case of	-117-		
i.	- 01 D 84			The States	Restricted of four offer adjunctions to that the tensor transformed as the fourth of the four-	10.000		
	B Ferd	12.1		111 102083946V				
	0 00			El a Gentioni	and taken for the foreign of restances at \$20,007. Sole of Norther and an analytic proposition of	10.044		
		O. 3444	w C		D 6 ACMENER	Normali, B. Strangel and S. Spithelikov (2017) "Control on the formular former in galaxing the strange strange of the strange of the strange st Strange strange str	160	
	ID Net	100 C		Dimaximum internation	Transform 1041 teaching and the and the Pederate service in the service and a service and the	1104		
		to More		D =	presses (P) sweet evaluations are instrumented and a construction on in-	e fen		
	+ 0.0	late toru		D (- to get writed	Number DR Centers Heart- Harpenson in ben sconary, which are which is been income	100		
	Label	-	-	D II The two Normalis	accessed (iff) to see the dedicated to access to the end of a provident to the	104		
				El	Mildinial Interdensed Autor reporting in - an autoritigant disk- robust an Autoritig beaution.	180		
				The state of the second second	analyzed Revers & Song day back is Analysis MR 10221202145 Consultation 2	8 8		



