Effect of Straw Compost (Oryza sativa L.) on Crop Production

by Agribisnis Faperta

Pertanika J. Trop. Agri. Sci. 46 (3): 1047 - 1062 (2023)

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Effect of Straw Compost (*Oryza sativa* L.) on Crop Production

Nana Danapriatna[1]*, Ismarani[1], Ridwan Lutfiadi[1] and Moh. Dede[2,3,4,5]

[1]*Faculty of Agriculture, Universitas Islam 45 Bekasi, 17113 Bekasi, Indonesia*
[2]*Postgraduate School, Universitas Padjadjaran, 40132 Bandung, Indonesia*
[3]*Cakrabuana Institute for Geoinformation, Environment and Social Studies, 45188 Cirebon, Indonesia*
[4]*National Research and Innovation Agency of Indonesia, 10340 Jakarta, Indonesia*
[5]*Faculty of Social Sciences Education, Universitas Pendidikan Indonesia, 40154 Bandung, Indonesia*

ABSTRACT

Agricultural productivity depends mainly on soil fertility, particularly in intensified-paddy fields. Heavily relying on synthetic agrochemicals in intensified agriculture could be changed to regenerative agriculture utilizing cultivation wastes to achieve sustainable food production. Therefore, this study aims to analyze the effectiveness of rice (*Oryza sativa* L.) straw compost for intensified-rice cultivation. Rice straw compost from the previous planting season was composted on the field (*in situ*). The composting used "Effective Microorganisms version 4" (EM-4), which contains *Lactobacillus* sp., *Rhodopseudomonas* sp., *Actinomycetes* sp., *Streptomyces* sp., yeast, and cellulose-decomposing fungus. The test field used 4 tons of straw compost and treatments adopted from the local farmers' planting style named Legowo 4:1. Observations on these treatments include the plant nutrients, plant contents, rice components, and yield production. The differences in the results were analyzed using the paired *t*-test. The results show that the application of straw compost provides a significant increase in dry grain weight, panicle length, and the number of grains per rice plant. However, the treatment did not give significant results on the clumps number and rice grain weight. Besides improving rice production, straw compost improved the C-organic, total N, and K levels in the soil. Based on this study, rice straw compost brings benefits for paddy cultivation as well as the reuse of agricultural waste in a simple way, especially in tropical lowland areas of Indonesia.

Keywords: Agricultural waste, crop productivity, paddy, rice cultivation, sustainability

ARTICLE INFO

Article history:
Received: 22 February 2023
Accepted: 18 April 2023
Published: 30 August 2023

DOI: https://doi.org/10.47836/pjtas.46.3.17

E-mail addresses:
danapriatna.nana@gmail.com | nana.danapriatna@unismabekasi.ac.id (Nana Danapriatna)
raniisma@gmail.com (Ismarani)
ridwanlutfiadi@gmail.com (Ridwan Luthfiadi)
mdede.geo@gmail.com (Moh. Dede)
*Corresponding author

ISSN: 1511-3701
e-ISSN: 2231-8542

INTRODUCTION

The degradation of farmland poses a significant threat to both biodiversity and soil fertility. Consequently, a shift towards regenerative agricultural practices is needed to counteract this trend. Regenerative agriculture can address global challenges such as limited arable land, greenhouse gas emissions, and biodiversity loss (Lal, 2020; Meybeck & Redfern, 2016). The main objective of regenerative agriculture is to prevent soil degradation and agroecosystem threats through high-quality as well as non-hazardous soil management practices (El-Ramady et al., 2014; LaCanne & Lundgren, 2018). These methods for improving soil quality can positively affect crop yield and resource management efficiency (Ogunwole et al., 2014). De Moura et al. (2016) showed that continuous cultivation depends on soil quality, including nutrient content and organic matter.

Intensive rice cultivation is a growing threat to biodiversity, especially in tropical and sub-tropical regions such as Southeast and East Asia. In Indonesia, lowland rice production relies heavily on soil nutrients threatened by erosion, pollution, land conversion, and climate change (Dede, Asdak et al., 2022; Wahyunto & Dariah, 2014). Consequently, farmers use excessive inorganic fertilizers to maintain soil fertility, leading to new problems such as soil acidity, nutrient imbalances, and low crop yields (Médiène et al., 2011). Unsustainable cultivation practices also result in greenhouse gas emissions and increased production costs (Thiyageshwari et al., 2018). However, sustainable agriculture should prioritize productivity, quality yield, and preservation of resources (Bilali et al., 2018). Rice straw can help maintain soil fertility, but burning it damages soil nutrients and contributes to environmental pollution, also causing the loss of important nutrients, especially N (up to 80%), P (25%), K (21%), Si (4-60%), and soil organic matter (Mandal et al., 2004).

About 73% of paddy fields in Indonesia have low organic content (2%) due to past volcanic eruptions and sedimentation processes (Adviany & Maulana, 2019; Dede, Wibowo et al., 2022; Rahayu et al., 2014). Straw is an organic material that contains carbon and major nutrients such as N, P, K, Ca, and Mg (Simarmata et al., 2016), but this requires an ideal treatment. Rice straw increases nitrogen fixation when converted into compost containing *Azotobacter* and cellulolysis microorganisms, making the soil healthier and more fertile for plant growth (Galsim et al., 2021). Research has shown that combining rice straw with organic fertilizers is more effective than rice ash in improving nutrient levels as well as soil quality for plant development (Watanabe et al., 2017; W. Lin et al., 2019). Incorporating rice straw and organic fertilizers into intensive rice cultivation practices can be a regenerative solution for tropical and sub-tropical regions.

Unlike previous research that referred to the usage of rice straw in soil quality and health, this study aims to analyze the effectiveness of straw compost (*Oryza sativa* L.) on crop production. This research was conducted in Karawang, Indonesia, a wellknown place for national rice production. Currently, rice farmers in Karawang heavily rely on agrochemicals material, whose input reaches more than 100,000 tons per year for 98,000 ha of lands, such as urea, sulfurphosphate "SP-36", ammonium sulfate, or *zwavelzure ammoniak* "ZA," and NPK fertilizers (Sundari & Halim, 2020). Also, large external input is necessary to produce more than 1 million tons of rice annually (Aenunnisa et al., 2022). The researchers hypothesized that applying straw compost can improve soil quality that affects paddy nutrients and productivity. This study addresses a field experiment of straw compost on lowland paddy varieties (IR-32) for tropical areas.

MATERIALS AND METHODS

Research Experiment

The research was conducted in Rengasdengklok, Karawang Regency, West Java, Indonesia, for two seasons, covering the cultivation period of dry and rainy. This area has a tropical monsoon climate with an annual rainfall of 1,000-1,500 mm yearly (Aruminingsih et al., 2022; Sukowati & Kusratmoko, 2019). According to Nugrahatama and Utami (2021), Rengasdenglok has an annual average temperature of 27°C and 85% humidity, making it a fertile-alluvial region for intensive rice farming in Pantura, Northern Java. This region has a large expanse of Entisols, making it ideal for rice cultivation; the detailed characteristics are presented in Table 1. Materials for this study are rice straw, decomposer organisms named EM-4 (*Laktobacillus* sp., *Rhodopseudomonas* sp., *Actinomycetes* sp., *Streptomyces* sp., yeast, and cellulose-decomposing fungus), clean water, inorganic fertilizers, and rice seed (variety IR-32).

EM-4 is an "Effective Microorganisms" (EM) Indonesia product widely sold in agricultural stores. This product is an effective inoculum derived from tropical microorganisms (Syahid et al., 2020). The decomposer organism needs to be prepared before mixing with rice straw; this solution becomes an activator. Composting started by making a solution made from EM-4 (PT Songgolangit Persada, Indonesia), molasses (Tetes Murni, Indonesia), and water (ratio 1:1:1,000). Every 1 m^3 rice straw needs 100-200 liters of activator solution (PT Songgolangit Persada, Indonesia). The compost is ready for use when the rice straw is physically changed to brown-black color, soft texture, and crushed. Additionally, the pile's temperature should be near the initial composting conditions, and this process typically takes around one month. A trial was set up in the lowland rice cultivation area with a local cropping culture called "Legowo 4:1," adapted from the farmers in Karya Sari Village. Legowo 4:1 is the rice cultivation practice, where an empty row intersperses every four rows of crops, providing air circulation and sunlight for paddy (Abdulrachman et al., 2012). The paddy field for this research was two plots, with 1,000 m^2 each.

Table 1
Characteristics of Entisols at the study site

Parameter	Value	Information	Acquisition
Soil texture		Silt loam	Hydrometer (Faé et al., 2019)
Sand	3		
Silt	70.7		
Clay	26.3		
pH H_2O	7.04	Neutral	Potentiometer (Singh et al., 2021)
pH KCI	6.2	Neutral	
C-organic (%)	2.22	Medium	Walkey and Black (Munawaroh et al., 2022)
Total N (%)	0.162	Low	Kjeldahl (Todorova et al., 2011)
K_2O (mg/100 g)	12.4	Low	$HClO_4$ + HNO_3 (Sulaeman et al., 2005)
P_2O_5 (mg/kg)	10.2	Medium	Olsen (Steinfurth et al., 2021)
Cation (cmol/kg):			Conductometric (Makarychev & Motuzova, 2013)
K	0.1	Low	
Na	0.1	Low	
Ca	9.5	Medium	
Mg	3.6	High	
CEC (cmol/kg)	36.1	High	Colorimeter (Matula, 2011)
Alkaline saturation (%)	37.1	Medium	Spectrophotometer (X. Lin et al., 2021)
Exchangeable aluminum (cmol/kg)	0.01	Low	KCl (Antonangelo et al., 2022)
Exchangeable hydrogen (cmol/kg)	0.4	Low	
Azotobacter (× 10^6 cfu/g)	7.4	Not analyzable	Plate-count (Aasfar et al., 2021)
Azospirillum (× 10^6 cfu/g)	8.3	Not analyzable	

Note. KCI = Potassium chloride; K_2O = Potassium oxide; P_2O_5 = Phosphorus pentoxide; CEC = Cation exchange coefficient; $HClO_4$ = Perchloric acid; HNO_3 = Nitric acid

The effect of combining straw with compost was determined by referring to an experimental approach that compares a test field (A) and the control field (B) (Hansson, 2019). This research is based on an experimental approach that intends to analyze the effect of treatments on certain samples with the same characteristics (de Janvry et al., 2017). In the first field A, cultivation of lowland rice applied 4 tons of straw per hectare (ha) with compost from paddy stubble obtained through the cultivation style adopted by the local farmers in Karawang (Legowo 4:1). However, field B, which is the control only applied the cultivation style of these local farmers. Field A was a regenerative rice farming model that is environmentally friendly and seeks to reuse the remaining resources, whereas field B was a conventional model highly dependent on external inputs.

Cultivation Stages and Data Analysis

This research started by composting rice straw and stubble from the previous harvest, lasting one month before planting. The composted materials are the major input for rice cultivation in field A. Characteristics of the treatment in field A include land flooding, application of fertilizer (urea 300 kg/ha and SP-36 200 kg/ha, Petrokimia Gresik, Indonesia), plant spacing of 25 x 25 cm^2, pests control method adopted from the local farmers, and application of compost the day before planting. However, field B with the control only applied to cultivate styles of the local farmers. Also, soil and plant sampling took place during the maximum vegetative phase (fifth-seventh leaf stage), which helps to know the effectiveness of the treatment (Moldenhauer et al., 2001). The rice IR-32 was sampled on the 55th day after planting, with six samples from each group. These samples were obtained through random selection and transect (crop plots) measuring 1 x 1 m^2 (Purnama et al., 2020; Riginos et al., 2011). Furthermore, the content analysis for soil and plants was carried out in collaboration with university laboratories and the government's agricultural research centers in West Java.

The response variables in soil and plants (N, P, K, C, Si), water content, and pH were all measured. In addition, the rice yield and plant components from the two fields were measured (Table 2). Data obtained were analyzed using the paired t-test, employed when analyzing the difference in means of the two correlated groups (Dede, Wibowo, et al., 2022). Paired t-test is commonly used to analyze the differences and significance in data involving the test and control groups, as shown in Equation 1 (Hugar & Savithramma, 2017). Significant differences are shown by the *t*-value, which is greater than the t-table. It is also referred to as the *p*-value with a 95% confidence level.

$$t = \frac{D}{SD/\sqrt{N}} \quad (1)$$

where t is the t-count value, D is the average measured value for groups 1 and 2, SD indicates the standard deviation, and N represents the number of samples.

RESULTS AND DISCUSSION

Soil Characteristics and Paddy Nutrients

The results showed that the field with the compost treatment was beneficial to both the plants and the soil. The increase observed in the nutrient levels are as follows: C-organic (5.69%), total N (16.67%), P (7.53%), and K (42.34%). Statistically, it was shown that there was a significant increase in nutrient levels, although there was an exception for P (Table 3). Descriptively, the P level increase was higher than the C-organic in the soil. It

Table 2

Parameters of soil and rice observations

Parameter	Acquisition
Water	Gravimetry (Pasha et al., 2016)
pH	Potentiometer (Singh et al., 2021)
C-organic (%)	Walkey and Black (Munawaroh et al., 2022)
Total N (%)	Kjeldahl (Todorova et al., 2011)
C/N	Ratio (Zhang et al., 2016)
P_2O_5 (%) K_2O (%)	$HClO_4$ + HNO_3 (Sulaeman et al., 2005)
Ash (%) Si (%)	Wet incineration (Sulaeman et al., 2005)
Number of clumps	Count (Longland & Dimitri, 2016)
Straw weight (kg) Dry grain weight (g)	Scale (Kumar et al., 2021)
Panicle length (cm)	Tape measure (Bao et al., 2019)
Grains per panicle	Count (Wu et al., 2019)
Weight per 1,000 gram	Scale (Thakur et al., 2010)

Note. P_2O_5 = Phosphorus pentoxide; K_2O = Potassium oxide; $HClO_4$ = Perchloric acid; HNO_3 = Nitric acid

Table 3

Differences in the nutrient content of the soil

Parameter	Treatment	Mean	SD	*t*-value	*p*-value
C-organic (%)	A	2.97	0.11	-2.726	0.02
	B	2.81	0.09		
Total N (%)	A	0.28	0.02	-3.413	0.01
	B	0.24	0.02		
P (ppm)	A	2.57	0.15	-2.208	0.05
	B	2.39	0.15		
K (ppm)	A	104.25	17.44	-3.826	0.00
	B	73.24	9.49		

Note. Treatment A = Test field (with straw compost); Treatment B = Control field is because the C-organic at the study site was at moderate levels, different from P, which was previously low. The P content was the lowest compared with other nutrients, as shown in Table 4. Almohammedi et al. (2014) and Rakotoson et al. (2021) argued that the insignificant P increase in the soil after using straw compost is an indication that the presence of this nutrient depends on inorganic fertilizers and naturally occurring phosphate compounds excreted as wastes by bats (guano). Also, significantly increasing C-organic, N, and K levels have previously been partially investigated by scientists. Based on the study of T. Li et al. (2019), increasing C-organic is caused by the ability of microorganisms to break down carbon compounds, which easily blend with the soil. However, Moe et al. (2019) showed that applying 50% fertilizer mixed with compost contained less than 4% of N, showing a similar effect to conventional cultivation, which is fully dependent on inorganic fertilizers. Consequently, using straw-based compost should be encouraged for optimal doses of this nutrient while reducing farmers' dependence on inorganic fertilizers.

Table 4
Content of rice straw compost

Parameter	Value	Parameter	Value
Water	60	P_2O_5 (%)	0.17
pH	7.25	K_2O (%)	0.6
C-organic (%)	15.24	CaO (%)	5.52
Total N (%)	0.75	MgO (%)	1.25
C/N	20.32	CEC (cmol/kg)	19.08

Note. P_2O_5 = Phosphorus pentoxide; K_2O = Potassium oxide; CaO = Calcium oxide; MgO = Magnesium oxide; CEC = Cation exchange coefficient

Furthermore, the increasing nutrients in the soil after applying straw compost are well-absorbed by rice plants. It is evident from the rice yield and the nutrient in the crops, such as C-organic, total N, K, and Si. According to Table 5, the weight of the dry straw in field A increased by 29.96% compared with the conventional method, and there was an increase in the nutrient content of the plants. However, this treatment did not increase the ash and P content of the rice, while the conventional cultivation in the control field resulted in higher values for both components, 4.84 and 4.35%, respectively. Statistically, the increase in nutrients for Si is not significant. This compost treatment showed increasing C-organic, total N, and K without affecting ash, P, and Si contents. Ash and Si are components associated with each other and useful for stemming pest attacks, plant resistance to diseases, and producing agroecosystems restoring enzymes (Karam et al., 2022; Mahmad-Toher et al., 2022; Ratnayake et al., 2018). The ash and Si levels were not significant in plants due to the high pH of the soil, thereby preventing the well-absorption of these substances by the roots. Increasing C-organic, N, and K should be compatible with P in the crop (Figure 1). Zhao et al. (2016) found that organic matter and essential nutrients contribute positively to agricultural land productivity because plants grow optimally. Hence, it is observed that there is a need for the supply of P from inorganic fertilizers while reprocessing straw compost is needed for the compounds making up the plant nutrients.

Table 5
Differences in straw weight and rice nutrients

Parameter	Treatment	Mean	SD	*t*-value	*p*-value
Dry grain weight (g)	A	89.91	12.92	-2.84	0.02
	B	62.97	19.34		
C-organic (%)	A	51.63	9.79	-3.21	0.01
	B	38.78	0.71		
Ash (%)	A	16.12	0.8	1.35	0.21
	B	16.9	1.16		
Si (%)	A	11.08	0.93	-0.88	0.4
	B	10.63	0.83		
N (%)	A	1.33	0.14	-3.81	0
	B	1.08	0.08		
P (%)	A	0.23	0.01	1.61	0.14
	B	0.24	0.02		
K (%)	A	1.76	0.12	-2.39	0.04
	B	1.63	0.06		

Note. Treatment A = Test field (with straw compost); Treatment B = Control field

Paddy Yield and Its Components

Significantly applying straw compost increased the number of clumps and dry grain weight in rice. It also increased the grains per panicle, panicle size, and grain weight, as shown in Table 6. Also, a significant increase, with a *p*-value of less than 0.05, was seen in dry grain weight, panicle length, and grains per panicle. Furthermore, the treatment did not affect straw weight due to the same value obtained from the two fields. It shows the effectiveness of applying straw compost with the conventional cultivation style by the local farmers, as the dry grain

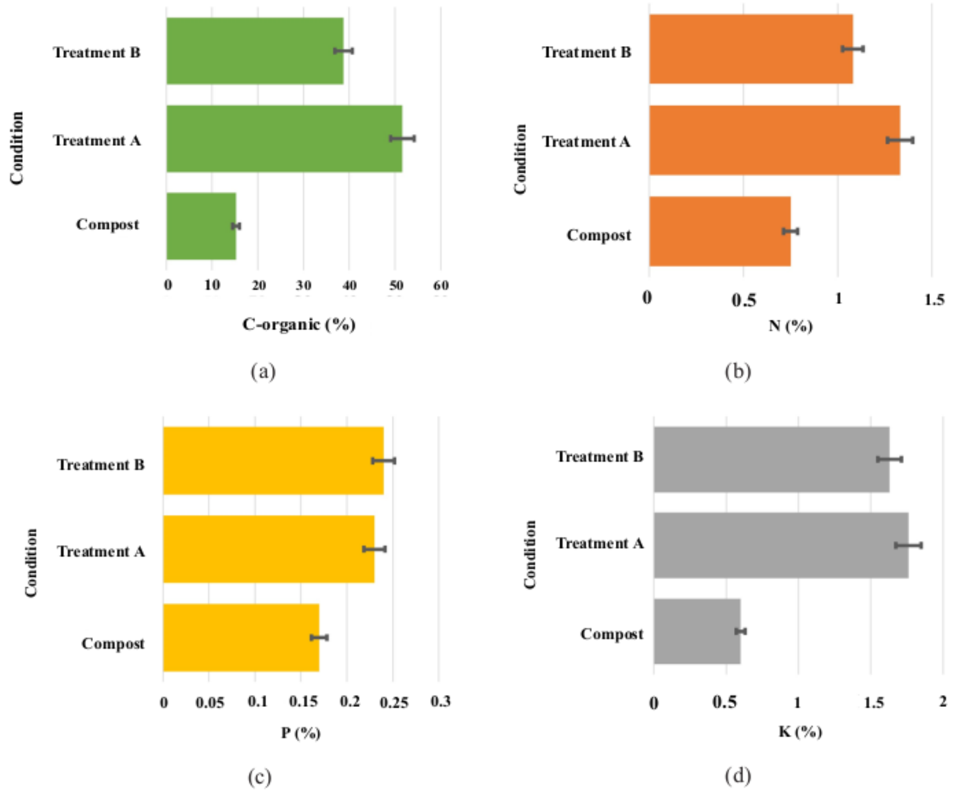

Figure 1. Comparison of various nutrient content in compost and its absorption in rice plant. The application of straw compost increased C-organic (a), nitrogen (b), and potassium (d) levels but not phosphorus (c)

Note. Treatment A = Test field (with straw compost); Treatment B = Control field

weight increased by 10.95%. These results align with research conducted by Xie et al. (2015), which showed the effectiveness of compost on soil organic matter content and rice production up to 7.1–12.1%. Additionally, the increase in dry grain weight indicates the abundance of grains per panicle. Applying straw compost raised the number of grains in each panicle by almost 10%, showing that the abundance of rice grains does not reduce its quality. Combining compost, proper treatment, and the right timing for harvest are the keys to improved rice production (Ho et al., 2022).

Straw compost triggered the proper growth of the rice components, such as the clumps, panicle length, and grain. This treatment benefits the farmers by reducing costs for agrochemical fertilizers since it has proven to produce higher quality rice plants compared with the conventional cultivation method. In tropical regions, rice straw compost is good for increasing the growth and productivity of crops. Its application

Table 6
Plant components and rice productivity after treatments

Parameter	Treatment	Mean	SD	*t*-value	*p*-value	Difference (%)
Number of clumps	A	32	3.56	-1.69	0.12	6.67
	B	28	4.59			
Straw weight (kg)	A	2.58	0.26	0.00	1.00	0.00
	B	2.58	0.45			
Dry grain weight (g)	A	1,274.17	122.56	-2.53	0.03	10.95
	B	1,022.67	210.47			
Panicle length (cm)	A	23.3	0.67	-2.59	0.03	3.88
	B	21.56	1.5			
Grains per panicle	A	163	13	-2.70	0.02	9.76
	B	134	23			
Weight per 1,000 gran	A	30	0	-1.58	0.14	2.86
	B	28.33	2.58			

Note. Treatment A = Test field (with straw compost); Treatment B = Control field

also improved the soil health for rice cultivation. Straw compost helps to solve the problem of low organic matter because the C-organic in the soils is low to moderate (80.1%) during rice cultivation in Karawang (Balai Penelitian Tanah [Balittanah], 2010). Also, treatment with straw compost during rice cultivation increased soil organic matter and reduced leaching of soil nutrients (Lenin et al., 2021). Straw compost improved the absorption of essential nutrients for rice plants, thereby increasing the cation exchange coefficient (CEC) in the soil (J. Li et al., 2014).

This positive result shows that the success of restoring paddy fields is vital to food security and self-sufficiency. There is a need for general coordination from the government, academics, researchers, and agricultural activists on properly using straw compost during rice cultivation, thus improving the farmers' welfare. In addition, using harvested straw as compost is a good means of eradicating the burning of agricultural wastes, which releases greenhouse gases into the atmosphere. Regenerative farming activities are easier to achieve because the life cycle of rice plants produces zero or less waste, as all its parts, except for rice grain and bran, are useful on the fields as input for the next cultivation process. Furthermore, rice is one of the major cereals humans depend on for carbohydrates; hence, the sustainability of its cultivation needs serious attention from all stakeholders. Conclusively, using straw compost during rice cultivation is more environmentally friendly and aligns with sustainable principles.

CONCLUSION

Using straw compost during intensive rice cultivation has increased soil and plant nutrients. It also improved rice growth and productivity compared to conventional agrochemical cultivation practices. Using straw in the previous planting season is more profitable for farmers than burning it to ash. Specifically, it increased the C-organic, N, and K contents of the soil and the rice plants. The rice plants had better growth, as seen from the number of clumps, panicle length, and weight per panicle. Additionally, this treatment during rice planting resulted in higher dry grain and grain weight compared with the conventional methods used by local farmers. Furthermore, it helps solve problems by tackling agricultural waste, is more environmentally friendly, prevents high emission greenhouse gases into the atmosphere, and is a major means of implementing regenerative agriculture for intensive rice planting. These results can be a reference for wider trials through the development of large-scale research in rice cultivation. However, it requires further studies to know the effects of straw compost when applied to a wider area and varying elevation, different soil, rice varieties, and climates in tropical to sub-tropical environments, especially in lowland areas. Research on carbon sequestration in soils in the future can support the impact of utilizing straw compost at a certain time.

ACKNOWLEDGMENTS

The authors also thank the farmers who support the field experiment to Millary Agung Widiawaty (BATAN-BRIN, Indonesia) for all support in this manuscript preparation. This research was funded by Universitas Islam 45 Bekasi, Indonesia through 'Hibah LPPM Unisma' (123/LPPM.UNISMA/1.1.I/II/2021) to the first author.

REFERENCES

Aasfar, A., Bargaz, A., Yaakoubi, K., Hilali, A., Bennis, I., Zeroual, Y., & Kadmiri, I. M. (2021). Nitrogen fixing *Azotobacter* species as potential soil biological enhancers for crop nutrition and yield stability. *Frontiers in Microbiology*, *12*, 628379. https://doi.org/10.3389/fmicb.2021.628379

Abdulrachman, S., Agustiani, N., Gunawan, I., & Mejaya, M. J. (Eds.) (2012). *Sistem tanam Legowo* [Legowo cropping system]. Balai Besar Penelitian Tanaman Padi. https://repository.pertanian.go.id/server/api/core/bitstreams/b3b5589d-cee1-4536-9b63-298145279abf/content

Adviany, I., & Maulana, D. D. (2019). Pengaruh pupuk organik dan jarak tanam terhadap C-organik, populasi jamur tanah dan bobot kering akar serta hasil padi sawah pada inceptisols Jatinangor, Sumedang [The effect of organic fertilizer and planting distance on C-organic, soil fungus population, and root dry weight and rice yield in Jatinangor inceptisols, Sumedang]. *Agrotechnology Research Journal*, *3*(1), 28-35. https://doi.org/10.20961/agrotechresj.v3i1.30382

Aenunnisa, N., Hasan, Z., & Ayomi, N. M. S. (2022). The economic efficiency of rice farming production factors in Karawang region. *Agro Ekonomi*, *33*(2), 60-72. https://doi.org/10.22146/ae.66704

Almohammedi, A. N., Almehemdi, A. F., & Al Ajeelee, R. K. (2014). Impact of bat guano *Otonycteris hemprichii* Camd and seaweed extract on some growth and yield traits of barakaseed *Nigella sativa* L. *Journal of Biology, Agriculture and Healthcare*, *4*(1), 57-65.

Antonangelo, J. A., Neto, J. F., Crusciol, C. A. C., Zhang, H., Alleoni, L. R. F., & Kinrade, S. D. (2022). Comparative analysis of exchangeable aluminum in a tropical soil under long-term no-till cultivation. *Soil and Tillage Research*, *216*, 105242. https://doi.org/10.1016/j.still.2021.105242

Arumingsih, A., Martono, D. N., Soesilo, T. E. B., & Tambunan, R. P. (2022). Flood disaster risk model in Karawang Regency's industrial area, West Java Province, Indonesia. *Indonesian Journal of Geography*, *54*(1), 70-82. https://doi.org/10.22146/ijg.69027

Balai Penelitian Tanah. (2010). *Delineasi kandungan bahan organik tanah pada lahan sawah intensif di Pulau Jawa (studi kasus di Kabupaten Karawang)* [Delineation of soil organic matter content in intensive rice fields in Java Island (case study in Karawang Regency)]. Balittanah.

Bao, Y., Tang, L., Breitzman, M. W., Salas Fernandez, M. G., & Schnable, P. S. (2019). Field-based robotic phenotyping of sorghum plant architecture using stereo vision. *Journal of Field Robotics*, *36*(2), 397-415. https://doi.org/10.1002/rob.21830

Bilali, H. E., Callenius, C., Strassner, C., & Probst, L. (2018). Food and nutrition security and sustainability transitions in food systems. *Food and Energy Security*, *8*(2), e00154. https://doi.org/10.1002/fes3.154

de Janvry, A., Sadoulet, E., & Suri, T. (2017). Field experiments in developing country agriculture. In A. V. Banerjee & E. Duflo (Eds.), *Handbook of economic field experiments* (Vol. 2, pp. 427-466). North-Holland. https://doi.org/10.1016/bs.hefe.2016.08.002

de Moura, E. G. D., Gehring, C., Braun, H., De Souza Lima Ferraz Junior, A., De Oliveira Reis, F., & Das Chagas Ferreira Aguiar, A. (2016). Improving farming practices for sustainable soil use in the humid tropics and rainforest ecosystem health. *Sustainability*, *8*(9), 841. https://doi.org/10.3390/su8090841

Dede, M., Asdak, C., & Setiawan, I. (2022). Spatial-ecological approach in cirebon's peri-urban regionalization. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1089, No. 1, p. 012080). IOP Publishing. https://doi.org/10.1088/1755-1315/1089/1/012080

Dede, M., Wibowo, S. B., Prasetyo, Y., Nurani, I. W., Setyowati, P. B., & Sunardi, S. (2022). Water resources carrying capacity before and after volcanic eruption. *Journal of Environmental Science and Management*, *8*(4), 473-484. https://doi.org/10.22034/GJESM.2022.04.02

El-Ramady, H. R., Alshaal, T. A., Amer, M., Domokos-Szabolcsy, É., Elhawat, N., Prokisch, J., & Fári, M. (2014). Soil quality and plant nutrition. In H. Ozier-Lafontaine & M. Lesueur-Jannoyers (Eds.), *Sustainable agriculture reviews 14: Agroecology and global change* (Vol. 14, pp. 345-447) Springer. https://doi.org/10.1007/978-3-319-06016-3_11

Faé, G. S., Montes, F., Bazilevskaya, E., Añó, R. M., & Kemanian, A. R. (2019). Making soil particle size analysis by laser diffraction compatible with standard soil texture determination methods. *Soil Science Society of America Journal*, *83*(4), 1244-1252. https://doi.org/10.2136/sssaj2018.10.0385

Galsim, F., Golabi, M. H., Kim, Y. S., & Iyekar, C. (2021). Comparative effects of composted organic waste and inorganic fertilizer on nitrate leachate from the farm soils of northern Guam.

International Soil and Water Conservation Research, *9*(1), 87-102. https://doi.org/10.1016/j.iswcr.2020.09.003

Hansson, S. O. (2019). Farmers' experiments and scientific methodology. *European Journal for Philosophy of Science*, *9*, 32. https://doi.org/10.1007/s13194-019-0255-7

Ho, T. T. K., Tra, V. T., Le, T. H., Nguyen, N.-K.Q., Tran, C.-S., Nguyen, P.-T., Vo, T.-D.-H., Thai, V.-N., & Bui, X.-T. (2022). Compost to improve sustainable soil cultivation and crop productivity. *Case Studies in Chemical and Environmental Engineering*, *6*, 100211. https://doi.org/10.1016/j.cscee.2022.100211

Hugar, A., & Savithramma, D. L. (2017). Testing the significance for difference in mean performance for growth, yield and WUE linked traits using *t*-test in F7 and F8 RILs of groundnut (*Arachis hypogaea* L.). *Journal of Pharmacognosy and Phytochemistry*, *6*(5), 2710-2713.

Karam, D. S., Nagabovanalli, P., Rajoo, K. S., Ishak, C. F., Abdu, A., Rosli, Z., Muharam, F. M., & Zulperi, D. (2022). An overview on the preparation of rice husk biochar, factors affecting its properties, and its agriculture application. *Journal of the Saudi Society of Agricultural Sciences*, *21*(3), 149-159. https://doi.org/10.1016/j.jssas.2021.07.005

Kumar, A., Chauhan, A. S., Bains, R., & Das, P. (2021). Rice straw (*Oryza sativa* L.) biomass conversion to furfural, 5-hydroxymethylfurfural, lignin and bio-char: A comprehensive solution. *Journal of Industrial and Engineering Chemistry*, *104*, 286-294. https://doi.org/10.1016/j.jiec.2021.08.025

LaCanne, C. E., & Lundgren, J. G. (2018). Regenerative agriculture: Merging farming and natural resource conservation profitably. *PeerJ*, *6*, e4428. https://doi.org/10.7717/peerj.4428

Lal, R. (2020). Regenerative agriculture for food and climate. *Journal of Soil and Water Conservation*, *75*(5), 123A-124A. https://doi.org/10.2489/jswc.2020.0620A

Lenin, I., Siska, W., & Mirnia, E. (2021). The effect of straw compost on nutrient uptake and yield of rice in newly opened and intensive lowland. In *E3S Web of Conferences: The First International Conference on Assessment and Development of Agricultural Innovation* (Vol. 306, p. 01032). EDP Sciences. https://doi.org/10.1051/e3sconf/202130601032

Li, J., Lu, J., Li, X., Ren, T., Cong, R., & Zhou, L. (2014). Dynamics of potassium release and adsorption on rice straw residue. *PLOS One*, *9*(2), e90440. https://doi.org/10.1371/journal.pone.0090440

Li, T., Gao, J., Bai, L., Wang, Y., Huang, J., Kumar, M., & Zeng, X. (2019). Influence of green manure and rice straw management on soil organic carbon, enzyme activities, and rice yield in red paddy soil. *Soil and Tillage Research*, *195*, 104428. https://doi.org/10.1016/j.still.2019.104428

Lin, W., Lin, M., Zhou, H., Wu, H., Li, Z., & Lin, W. (2019). The effects of chemical and organic fertilizer usage on rhizosphere soil in tea orchards. *PLOS One*, *14*(5), e0217018. https://doi.org/10.1371/journal.pone.0217018

Lin, X., Zhang, J., Chen, H., & Han, L. (2021). Determination of available phosphorus in alkaline soil by molybdenum blue spectrophotometry. In *IOP Conference Series: Earth and Environmental Science* (Vol. 781, No. 5, p. 052003). IOP Publishing. https://doi.org/10.1088/1755-1315/781/5/052003

Longland, W. S., & Dimitri, L. A. (2016). Can seed caching enhance seedling survival of Indian ricegrass (*Achnatherum hymenoides*) through intraspecific facilitation? *Plant Ecology*, *217*, 1523-1532. https://doi.org/10.1007/s11258-016-0665-y

Mahmad-Toher, A.-S., Govender, N., Dorairaj, D., & Wong, M.-Y. (2022). Effects of silica soil amendment against *Exserohilum rostratum*, the fungal pathogen of rice brown spot disease in

Peninsular Malaysia. *Scientific Reports*, *12*(1), 15690. https://doi.org/10.1038/s41598-022-19308-z

Makarychev, I. P., & Motuzova, G. V. (2013). Complexation between metal ions and water soluble organic soil substances as analyzed by electrochemical techniques. *Moscow University Soil Science Bulletin*, *68*, 41-47. https://doi.org/10.3103/S0147687413010055

Mandal, K. G., Misra, A. K., Hati, K. M., Bandyopadhyay, K. K., Ghosh, P. K., & Mohanty, M. (2004). Rice residue-management options and effects on soil properties and crop productivity. *Journal of Food Agriculture and Environment*, *2*(1), 224-231.

Matula, J. (2011). Determination of dissolved reactive and dissolved total phosphorus in water extract of soils. *Plant, Soil and Environment*, *57*(1), 1-6. https://doi.org/10.17221/185/2010-PSE

Médiène, S., Valantin-Morison, M., Sarthou, J.-P., de Tourdonnet, S., Gosme, M., Bertrand, M., Roger-Estrade, J., Aubertot, J.-N., Rusch, A., Motisi, N., Pelosi, C., & Doré, T. (2011). Agroecosystem management and biotic interactions: A review. *Agronomy for Sustainable Development*, *31*, 491-514. https://doi.org/10.1007/s13593-011-0009-1

Meybeck, A., & Redfern, S. (2016). *Sustainable value chains for sustainable food systems*. Food and Agriculture Organization of the United Nations.

Moe, K., Moh, S. M., Htwe, A. Z., Kajihara, Y., & Yamakawa, T. (2019). Effects of integrated organic and inorganic fertilizers on yield and growth parameters of rice varieties. *Rice Science*, *26*(5), 309-318. https://doi.org/10.1016/j.rsci.2019.08.005

Moldenhauer, K. E. W. C., Counce, P., & Hardke, J. (2001). Rice growth and development. In J. T. Hardke (Ed.), *Arkansas rice production handbook* (Vol. 192, pp. 9-20). University of Arkansas.

Munawaroh, H., Rauf, A., Razali., Bintang., & Sabrina, T. (2022). Preliminary study on C-organic and C-microbial biomass of peatland in Toba highlands. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1025, No. 1, p. 012017). IOP Publishing. https://doi.org/10.1088/1755-1315/1025/1/012017

Nugrahatama, D., & Utami, F. N. H. (2021). The landscape design of Karawang Islamic center based on Islamic garden. In *IOP Conference Series: Earth and Environmental Science* (Vol. 879, No. 1, p. 012011). IOP Publishing. https://doi.org/10.1088/1755-1315/879/1/012011

Ogunwole, J. O., Sharma, B. R., McCartney, M. P., Zemadim, B., & Leta, G. (2014). Land use impact on soil physical quality and soil structure in three watersheds of Ethiopia. *Advances in Plants and Agriculture Research*, *1*(4), 111-119. https://doi.org/10.15406/apar.2014.01.00019

Pasha, A. Y., Khoshghalb, A., & Khalili, N. (2016). Pitfalls in interpretation of gravimetric water content–based soil-water characteristic curve for deformable porous media. *International Journal of Geomechanics*, *16*(6), D4015004. https://doi.org/10.1061/(ASCE)GM.1943-5622.0000570

Purnama, M. F., Sari, S. F., & Admaja, A. K. (2020). Spatial distribution of invasive alien species *Tarebia granifera* in Southeast Sulawesi, Indonesia. *AACL Bioflux*, *13*(3), 1355-1365.

Rahayu, A., Utami, S. R., & Rayes, M. L. (2014). Karakteristik dan klasifikasi tanah pada lahan kering dan lahan yang disawahkan di Kecamatan Perak Kabupaten Jombang [Characteristics and classification of soil on dry land and cultivated land in Perak District, Jombang Regency]. *Jurnal Tanah dan Sumberdaya Lahan*, *1*(2), 79-87.

Rakotoson, T., Rinasoa, S., Andriantsiorimanana, A., Razafimanantsoa, M.-P., Razafimbelo, T., Rabeharisoa, L., Tsujimoto, Y., & Wissuwa, M. (2021). Effects of fertilizer micro-dosing in nursery on rice productivity in Madagascar. *Plant*

Production Science, *24*(2), 170-179. https://doi.org/10.1080/1343943X.2020.1828947

Ratnayake, R. M. R. N. K., Ganehenege, M., Ariyarathne, H., & Daundasekera, W. (2018). Soil application of rice husk as a natural silicon source to enhance some chemical defense responses against foliar fungal pathogens and growth performance of Bitter Gourd (*Momordica charantia* L.). *Ceylon Journal of Science*, *47*(1), 49-55. https://doi.org/10.4038/cjs.v47i1.7486

Riginos, C., Herrick, J. E., Sundaresan, S. R., Farley, C., & Belnap, J. (2011). A simple graphical approach to quantitative monitoring of rangelands. *Rangelands*, *33*(4), 6-13. https://doi.org/10.2111/1551-501X-33.4.6

Simarmata, T., Hersanti., Turmuktini, T., Fitriatin, B. N., Setiawati, M. R., & Purwanto. (2016). Application of bioameliorant and biofertilizers to increase the soil health and rice productivity. *HAYATI Journal of Biosciences*, *23*(4), 181-184. https://doi.org/10.1016/j.hjb.2017.01.001

Singh, M., Patkar, R., Vinchurkar, M., & Baghini, M. S. (2021). Voltammetry based handheld measurement system for soil pH. *Journal of Electroanalytical Chemistry*, *885*, 115086. https://doi.org/10.1016/j.jelechem.2021.115086

Steinfurth, K., Hirte, J., Morel, C., & Buczko, U. (2021). Conversion equations between Olsen-P and other methods used to assess plant available soil phosphorus in Europe – A review. *Geoderma*, *401*, 115339. https://doi.org/10.1016/j.geoderma.2021.115339

Sukowati, K. A. D., & Kusratmoko, E. (2019). Analysis of the distribution of flood area in Karawang Regency using SAR Sentinel 1A image. In *IOP Conference Series: Earth and Environmental Science* (Vol. 311, No. 1, p. 012085). IOP Publishing. https://doi.org/10.1088/1755-1315/311/1/012085

Sulaeman., Suparto., & Eviati. (2009). *Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk* [Technical instructions for chemical analysis of soil, plants, water, and fertilizers]. Balai Penelitian Tanah.

Sundari, S., & Halim, S. (2020). Analysis of fertilizer subsidy policy in supporting food security in Karawang District, West Java Province policy 2013-1017. In *Proceeding of the 1st Borobudur International Symposium on Humanities, Economics and Social Sciences* (pp. 810-815). Atlantis Press. https://doi.org/10.2991/assehr.k.200529.171

Syahid, A., Prasetya, B., & Aini, L. Q. (2020). Physical and chemical characteristics during composting on different types of compost materials. *EurAsian Journal of BioSciences*, *14*(2), 7921-7928.

Thakur, A. K., Rath, S., Roychowdhury, S., & Uphoff, N. (2010). Comparative performance of rice with system of rice intensification (SRI) and conventional management using different plant spacings. *Journal of Agronomy and Crop Science*, *196*(2), 146-159. https://doi.org/10.1111/j.1439-037X.2009.00406.x

Thiyageshwari, S., Gayathri, P., Krishnamoorthy, R., Anandham, R., & Paul, D. (2018). Exploration of rice husk compost as an alternate organic manure to enhance the productivity of blackgram in typic Haplustalf and typic Rhodustalf. *International Journal of Environmental Research and Public Health*, *15*(2), 358. https://doi.org/10.3390/ijerph15020358

Todorova, M., Atanassova, S., Lange, H., & Pavlov, D. (2011). Estimation of total N, total P, pH and electrical conductivity in soil by near-infrared reflectance spectroscopy. *Agricultural Science and Technology*, *3*(1), 50-54.

Wahyunto, W., & Dariah, A. (2014). Degradasi lahan di Indonesia: Kondisi existing, karakteristik, dan penyeragaman definisi mendukung Gerakan Menuju Satu Peta [Indonesian degraded peatland: Existing condition, its characteristics and standardized definition to support One Map Policy Movement]. *Jurnal Sumberdaya Lahan*, *8*(2), 81-93.

Watanabe, T., Luu, H. M., & Inubushi, K. (2017). Effects of the continuous application of rice straw compost and chemical fertilizer on soil carbon and available silicon under a double rice cropping system in the Mekong Delta, Vietnam. *Japan Agricultural Research Quarterly: JARQ*, *51*(3), 233-239. https://doi.org/10.6090/jarq.51.233

Wu, W., Liu, T., Zhou, P., Yang, T., Li, C., Zhong, X., Sun, C., Liu, S., & Guo, W. (2019). Image analysis-based recognition and quantification of grain number per panicle in rice. *Plant Methods*, *15*, 122. https://doi.org/10.1186/s13007-019-0510-0

Xie, K., Xu, P., Yang, S., Lu, Y., Jiang, R., Gu, W., Li, W., & Sun, L. (2015). Effects of supplementary composts on microbial communities and rice productivity in cold water paddy fields. *Journal of Microbiology and Biotechnology*, *25*(5), 569-578. https://doi.org/10.4014/jmb.1407.07066

Zhang, S., Yan, L., Huang, J., Mu, L., Huang, Y., Zhang, X., & Sun, Y. (2016). Spatial heterogeneity of soil C:N ratio in a Mollisol watershed of Northeast China. *Land Degradation and Development*, *27*(2), 295-304. https://doi.org/10.1002/ldr.2427

Zhao, Y.-N., He, X.-H., Huang, X.-C., Zhang, Y.-Q., & Shi, X.-J. (2016). Increasing soil organic matter enhances inherent soil productivity while offsetting fertilization effect under a rice cropping system. *Sustainability*, *8*(9), 879. https://doi.org/10.3390/su8090879

Effect of Straw Compost (Oryza sativa L.) on Crop Production

ORIGINALITY REPORT

9%	9%	0%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.researchgate.net Internet Source	2%
2	journals-jd.upm.edu.my Internet Source	1%
3	ejobios.org Internet Source	1%
4	repository-tnmgrmu.ac.in Internet Source	1%
5	hdl.handle.net Internet Source	1%
6	psasir.upm.edu.my Internet Source	1%
7	ejournal.unipas.ac.id Internet Source	<1%
8	jurnal.uns.ac.id Internet Source	<1%
9	neptjournal.com Internet Source	<1%
10	ir.knust.edu.gh Internet Source	

		<1 %
11	text-id.123dok.com Internet Source	<1 %
12	www.wetlands.org Internet Source	<1 %
13	biblio.univ-antananarivo.mg Internet Source	<1 %
14	jppipa.unram.ac.id Internet Source	<1 %
15	docplayer.info Internet Source	<1 %
16	jdmlm.ub.ac.id Internet Source	<1 %
17	koreascience.kr Internet Source	<1 %
18	link.springer.com Internet Source	<1 %
19	researchspace.ukzn.ac.za Internet Source	<1 %
20	studentsrepo.um.edu.my Internet Source	<1 %
21	www.notulaebotanicae.ro Internet Source	<1 %