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THE EFFECT OF A COMBINATION OF SOIL IMPROVEMENT AND N, P, K FERTILIZER ON K-POTENTIAL, K-dd, K-UPTAKE, AND YIELD OF LOWLAND RICE (Oryza sativa L.) IN INCEPTISOLS FROM JATINANGOR

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Abstract

Low fertility is one of the issues in Inceptisols. One solution to solve this issue by provide a combination of soil conditioners containing organic matter and N, P, and K fertilizers as available nutrient elements to optimize soil fertility, thus improving the quality and quantity of rice. This experiment aims to determine the best dosage of the combination of soil improvement and N, P, and K fertilizers for K-potential, K-uptake, and rice crop results on Inceptisols from Jatinangor. The experiment was conducted from July to December 2023 at the Soil Chemistry and Plant Nutrition Laboratory Experiment Garden, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang. The research design used was Completely Randomized Block Design (CRBD) consisting of eight treatments and four replications, namely: control; N, P, K dose recommendation; soil improver; ½ soil improver+ ¾ dose of N, P, K; ¾ soil improver+ ¾ dose of N, P, K; 1 soil improver+ ¾ dose of N, P, K; 1½ soil improver+ ¾ dose of N, P, K; and 1 soil improver+ 1 dose of N, P, K. The results of the experiment indicate that the treatment of 1½ soil improver+ ¾ dose of N, P, K can provide the best influence in increasing K-potential content, K-dd, K-uptake, and rice crop result (number of grains per panicle, 100-grain weight, and milled rice weight) in Inceptisols from Jatinangor.

Keywords

Rice; Inceptisols; Organic Matters; Potassium; N, P, K Fertilizers.

INTRODUCTION

Lowland rice (*Oryza sativa* L.) is included in the main food crops because its production produces rice. Rice is used as an ingredient to make the staple food of Indonesian people, and rice is even a source of energy and nutrition for some of the world's population. Rice contains carbohydrates, protein, fat, vitamins, and other nutrients needed by the human body (Fitriyah et al., 2020).

As the population in Indonesia increases, the demand for rice increases every year (Sukmawati et al., 2016). Based on data from (BPS, 2023), rice production in 2023 will be around 53.63 million t GKG (Grinded Dried Grain), this figure has decreased by 1.12 million t or 2.05 percent compared to rice production in 2022, namely reached 54.75 million t GKG. A decrease in rice production can occur due to a decrease in rice harvested area caused by a decrease in soil quality and fertility due to the long dry season, land conversion, and intensive use of inorganic fertilizers. The rice harvest area in 2023 will decrease by 255.79 thousand hectares or 2.45 percent compared to the harvest area in 2022 which reached 10.45 million hectares (BPS, 2023).

The impact of intensive use of inorganic fertilizers stimulates a decrease in soil organic matter content thereby disrupting soil fertility and quality (Simanungkalit et al., 2006). Ruminta (2016) explains that the danger of decreasing lowland rice production, especially in the Bandung district area, has an average of 6,706 t in 2030. If this danger occurs, it will affect the decline in rice supply which will result in disruption of food security and balance. The solution to this problem can be done in various ways, one of which is the use of superior varieties, that have high yield potential, are resistant to pests and diseases, and have good grain and rice quality (Arianti et al., 2020). The Inpari 32 HDB rice variety has the main advantage, namely its abundant harvest, which has a potential yield of up to 8.42 t ha-1 Milled Dry Grain (GKG). Farmers in Indonesia generally like this variety because it has high production, good grain shape and rice taste, and a high level of resistance to Bacterial Leaf Blight (HDB) and tungro (Nurwahyuni and Arianti, 2022).

This food problem must be taken into account so it is necessary to implement a rice planting intensification program as an effort to increase rice production by providing fertilizer based on government recommendations and extensification of Inceptisols (Yuniarti et al., 2020).

Indonesia has Inceptisols land which has a wide coverage, namely around 70.52 million hectares or reaching 37.5% of Indonesia's land area (Setyastika and Suntari, 2019). Inceptisols have quite prospective potential in the future, however, cultivation carried out on Inceptisols has obstacles, namely chemical properties that are less fertile, including having a slightly acidic soil pH level, moderate C-organic levels, and the nutrients N, P, and K low (Mulyani et al., 2017). Fertilization according to recommendations can be carried out to improve soil quality and fertility so that rice plant productivity can increase.

Soil K elements in food crop agricultural land are very diverse, in general watery rice fields contain more K nutrients than dry land, however the area of rice fields with low and medium K levels is relatively high, especially on the island of Java, namely 45% (Subandi, 2013). In food crop farming in Indonesia, the provision of the K nutrient is relatively lower compared to the provision of the N and P nutrients. This occurs because the price of K fertilizer is quite high and farmers lack understanding regarding the importance of the K nutrient for plants (Yuniarti et al., 2020). The non-exchangeable form of K is the form of K that is slow to become available so it is called K-potential. All K nutrients cannot be absorbed directly by plants, so K uptake by plants is influenced by potential K-levels and soil K-dd (Nursyamsi, 2012). Element K in soil has an important role in the breakdown and formation of starch (Havlin et al., 2005). Potassium is one of the macronutrients that are important for plant growth, including activating enzymes that are important in the processes of photosynthesis and respiration (Salisbury et al., 1995).

Cultivation of plants that will be carried out on Inceptisols requires fertilization so that the plants can grow well and maintain the balance of nutrients in the soil, however continuous fertilization using inorganic fertilizers will result in a decrease in land productivity, one of the efforts to reduce the impacts arising from the application of inorganic fertilizers excessively or continuously is the provision of organic material which acts as a soil conditioner.

One of the concepts of soil improvement is to increase the soil's ability to hold nutrients by increasing the Cation Exchange Capacity (CEC). Soil improvers are also used to improve soil chemical properties such as improving soil reaction (pH) and neutralizing toxic compounds. Soil amendments also often contain nutrients, but are not classified as fertilizers because their nutrient content is relatively low (Dariah et al., 2015). Therefore, it is necessary to combine organic materials to create an organic soil improver that contains higher nutrients than a single soil amendment.

Water hyacinth (*Eichhornia crassipes* (Mart.) is a weed that can grow at a fairly high speed which can pollute the aquatic environment (Prasetyo et al., 2021). (Prasetyo et al., 2021). Water hyacinth can be used as a soil conditioner because it can add nutrients such as N, P, and K. Apart from that, water hyacinth can also increase humus levels in the soil, thereby increasing the porosity and ability of the soil to store water (Remona et al., 2020). Based on research by Remona (2020), the results of the analysis of fresh water hyacinth contain 39.95% C-Organic; C/N 25; water content 48.9%; N-total 1.57%; P_2O5-total 0.59%; K_2O-total is 1.64%, while water hyacinth that has been composted has a relatively high content of organic matter and nutrients, namely N content of 1.68%, P of 3.69%, K of 2.50%, C-organic 31 .92%, C/N ratio of 19 and S reaching 900 mg/kg.

Another organic material that can be combined to become an organic soil conditioner is humic acid. Humic acid can help loosen the soil and spread the transfer of nutrients from the soil to the plants, increase water retention, and stimulate microbial growth in the soil (Suwahyono, 2016).

Biochar is a soil improver that can be used to improve soil quality, including increasing soil pH and increasing nutrients (Prasetiyo et al., 2020). Biochar can be made from various materials, one of which is rice straw. The results of research conducted by Prasetiyo et al. (2020) it can be concluded that rice straw can be used as a source of biochar, biochar derived from rice straw contains sufficient nutrients to increase plant nutrients, including C-organic, and N-total so that it has a C/N ratio of 17 and has a level of The neutral pH is 6.25.

It cannot be denied that giving organic soil improvers to plants is not a substitute for inorganic fertilizers and is not classified as fertilizer because the nutrient content is relatively low, so it cannot meet the needs of plants, but organic soil improvers act as a complement to increase soil and plant productivity sustainably. Therefore, it is necessary to combine organic soil improvers with inorganic fertilizers N, P, and K to improve soil quality and lowland rice production (Subandi, 2013).

Based on the description of the effect of the combination of soil improver and N, P, K fertilizer on lowland rice plants, the problem can be formulated as follows: (1) is there an effect of soil improver and N, P, K fertilizer on increasing K-potential, K-dd, K uptake, and rice yield in Inceptisols from Jatinangor; (2) Which treatment dose of soil improver and N, P, K fertilizer gives the highest yield of lowland rice (*Oryza sativa* L.) in Inceptisols from Jatinangor.

The research objective of the results of this research is to provide information about the benefits of a combination of soil improver and N, P, K fertilizers on K-potential, K-dd, plant K-uptake, and lowland rice yields as a support for the development of Agro-industry. Apart from that, this research is expected to increase the use of water hyacinth which is a weed, and rice straw which is still considered waste.

MATERIALS AND METHODS

This experiment was carried out in July-December 2023 and was carried out at the Soil Fertility and Plant Nutrition Laboratory Experiment Field, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor District, Sumedang Regency. Soil and plant analysis was carried out at the Soil Fertility and Plant Nutrition Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java.

The materials used in this experiment were planting media in the form of Inceptisols order soil from Jatinangor, and Inpari 32 HDB variety lowland rice seeds from CV Seed Producers. Fiona Benih Mandiri, goat manure as a mixture for planting seedbeds, water hyacinth compost-based soil conditioner enriched with humic acid and straw biochar, Urea, SP-36, and KCl fertilizers in various doses according to the treatment.

Laboratory equipment for analyzing soil and plants; Other supporting equipment: bucket with a volume of 22 L with a diameter of 30 cm and a height of 25 cm, analytical balance, seedling tray, shovel, moisture meter, zip plastic, brown envelope, and writing utensils.

This experiment used a Completely Randomized Block Design (CRBD), which consisted of 8 treatments, namely 1 control treatment, 1 treatment with recommended doses of N, P, and K fertilizer, 1 treatment with doses of soil improver, and 5 treatments with a combination of soil improver and N, P fertilizer. , K. Each treatment has 4 replications. There are 2 experimental plots (maximum vegetative and generative) so the total number is 32 x 2 = 64 buckets. The combination of treatments can be structured as follows:

A. Control
B. N, P, K recommendations
C. 1 Soil improver
D. ½ Soil Improver + ¾ recommended dose of N, P, K
E. ¾ Soil Improver + ¾ recommended dose of N, P, K
F. 1 Soil Improver + ¾ recommended dose of N, P, K
G. 1 ½ Soil Improver + ¾ recommended dose of N, P, K
H. 1 Soil Improver + 1 recommended dose of N, P, K

RESULTS AND DISCUSSION

1. Preliminary Analysis

1.1 Land

Initial soil analysis results show that this soil has a dusty clay loam texture. The reaction of this soil is slightly acidic, the organic C content of this soil is in the low category, the total N is medium, and the C/N ratio is low. These Inceptisols also have moderate CEC values, medium base saturation, P2O5 which is relatively low, and K_2O HCl 25% which is classified as medium. Based on the description of the soil characteristics above, it is suitable for lowland rice plants, but there are obstacles to soil fertility such as the availability of N, P, and K elements being low to moderate, the soil reaction being slightly acidic, so it requires a combination of soil amendments so that the soil can provide nutrient availability, and other soil properties for plants.

1.2 Combination of Soil Improvers

The results of the analysis of the nutrient content of the water hyacinth compost showed the availability of the elements N (1.74%), P_2O_5 (0.22%), K_2O (2.19%), and C-organic 32.58%. The straw biochar used in this research contains 31.73% C-organic, 0.56% N, has a pH of 7.28, and meets SNI for soil improver. The results of the elemental analysis of humic acid show that the humic acid used contains 97.02% humic compounds and has a pH of 4.68. The combination of soil improver is expected to be able to increase K-potential, K-dd, and K-uptake. In addition, it is hoped that it can increase the efficiency of using N, P, and K fertilizers.

2. Potassium Levels in Soil

2.1 K-potential level

The results of the research on the effect of combined application of soil amendment and N, P, K fertilizer on soil K-potential in Inceptisols from Jatinangor are presented in Table

Table 1. Effect of Combination Application of Soil Improver and N, P, K Fertilizer on Soil K-potential in Inceptisols from Jatinangor

	Treatments	K-potensial (mg100 g^{-1})
A	Control	6,33 a
B	N, P, K dose recommendation	7,17 a
C	Soil Improver	10,51 b
D	½ Soil Improver + ¾ dose N, P, K	12,25 b
E	¾ Soil Improver + ¾ dose N, P, K	17,62 cd
F	¾ Soil Improver + ¾ dose N, P, K	19,04 d
G	**1** ½ Soil Improver **+ ¾ dose N, P, K**	**24,07 e**
H	1 Soil Improver + 1 dose N, P, K	16,78 c

Note: Numbers followed by the same letter do not show significant differences according to Duncan's Multiple Range Test at the 5% level.

Based on the results of statistical tests that have been carried out, it can be seen that the combination of soil improver and N, P, and K fertilizers has a significant effect on the Kpotential of the soil. In general, each treatment can increase soil K-potential when compared with control treatments and N, P, and K recommendations (Table 1).

This increase in K-potential cannot yet illustrate that lowland rice production will increase, this is because K-potential is a form of K that cannot be directly utilized by plants. K-potential is a non-exchangeable form of K which is included in the slowly available K. Non-exchangeable potassium has several forms, namely fixed K and mineral K, although the K release process occurs very slowly and relatively cannot be used directly by plants, it is still considered a soil K reserve (Mulyani et al., 2017).

Based on the results of statistical tests in Table 1, the control treatment shows the lowest K-potential value compared to other treatments. This can be caused by the K element in the soil not receiving additional K elements either from a combination of soil improver or N, P, K fertilizer. Meanwhile, the treatment of 1 ½ soil improver + ¾ dose of N, P, K shows the highest K-potential value compared to other treatments. This occurs due to the provision of a combination of soil improver consisting of water hyacinth compost which contains K nutrients and organic material that is not easily leached, then straw biochar has a buffering capacity that can increase K retention in the soil so that it can suppress the K leaching process in the soil (Oktaviani et al., 2018). Apart from that, there is humic acid which can stimulate and activate the biological and physiological processes of organisms in the soil and increase the availability of the nutrient K (Lestari et al., 2023).

2.2 Exchangeable K rate (K-dd)

The results of research on the effect of a combination of application of soil improver and N, P, K fertilizer on soil K-dd on Inceptisols from Jatinangor are presented in Table 2.

Table 2. Effect of Combination Application of Soil Improver and N, P, K Fertilizer on Soil K-dd in Inceptisols from Jatinangor

	Treatments	K-dd (Cmolkg^{-1})
A	Control	0,14 a
B	N, P, K dose recommendation	0,17 a
C	Soil Improver	0,23 b
D	½ Soil Improver + ¾ dose N, P, K	0,27 b
E	¾ Soil Improver + ¾ dose N, P, K	0,43 c
F	¾ Soil Improver + ¾ dose N, P, K	0,51 d
G	**1** ½ Soil Improver **+ ¾ dose N, P, K**	**0,60 e**
H	1 Soil Improver + 1 dose N, P, K	0,45 c

Note: Numbers followed by the same letter do not show significant differences according to Duncan's Multiple Range Test at the 5% level.

Based on the results of statistical tests, it can be seen in Table 2 that the application of a combination of soil improver and N, P, K fertilizer has a significant effect on K-dd in each treatment compared to the control treatment and recommended N, P, K.

Table 2 shows that the control treatment had the smallest amount of K-dd because there was no fertilizer application and was not significantly different from the recommended N, P, and K treatments so K-dd was slowly available to the plants. Apart from that, the nutrient K is an element that is often lost due to washing, so it requires organic material that can hold or support it (Wulansari et al., 2022). The combination treatment of soil improver and inorganic fertilizer, namely 1 ½ soil improver+ ¾ dose of N, P, K, had the highest soil K-dd analysis results compared to other treatments, namely 0.60 Cmolkg^{-1}. This is because the organic materials contained in the combination of soil improverssuch as water hyacinth compost which provides more available K nutrients, biochar which has nutrient buffering capacity and a fairly high pH, and humic acid which stimulates the growth of microorganisms that can dissolve K elements. so it is available to plants (El-atbany & Byan, (2019), Chintala et al., (2014).

The K-dd value in this experiment is in line with the K-potential. The highest K-dd value resulted from treatment G (1 ½ soil improver+ ¾ dose of N, P, K). The ionization process of the KCl fertilizer applied causes an increase in the K concentration in the soil solution and K ions are absorbed by negative soil colloids (Al Mu'min et al., 2016).

2.3 Plant K-Uptake

Plant K uptake is the result of the K concentration in the plant multiplied by the dry weight of the plant. The plant parts used to measure the K uptake value are all parts of the plant starting from the leaves, stems, and roots. Based on the results of statistical tests on plant K uptake (Table 3), the combination treatment of soil improver and inorganic fertilizer had a significant effect on the control treatment and recommended N, P, and K in increasing plant K-uptake.

Table 3. Effect of the Combination of Soil Improvers and N, P, K Fertilizers on Plant K-Uptake in Inceptisols from Jatinangor

Treatments		Plant K-Uptake (mg plant^{-1})
A	Control	96,87 a
B	N, P, K dose recommendation	287,21 b
C	Soil Improver	132,46 a
D	½ Soil Improver + ¾ dose N, P, K	406,87 c
E	¾ Soil Improver + ¾ dose N, P, K	392,15 c
F	¾ Soil Improver + ¾ dose N, P, K	370,90 c
G	**1** ½ Soil Improver **+ ¾ dose N, P, K**	**501,11 d**
H	1 Soil Improver + 1 dose N, P, K	409,91 c

Note: Numbers followed by the same letter do not show significant differences according to Duncan's Multiple Range Test at the 5% level.

Based on Table 5, the control treatment shows the lowest K-uptake value, namely 96.87 mgplant^{-1}. This can happen because in this treatment there is no application of any fertilizer to the soil so the plants only absorb the nutrients contained in the soil. Meanwhile, the treatment of 1 ½ soil improver + ¾ dose of N, P, K produced the highest K uptake value compared to other treatments, namely 501.11 mgplant^{-1}.

The N, P, and K fertilizers given are Urea, SP-36, and KCl which are artificial chemical fertilizers that dissolve quickly. KCl fertilizer is a fertilizer that contains K with a K_2O content of 60% so that it can provide sufficient and quickly available K2O nutrients (Gunadi, 2009). The amount of K absorbed by plants is influenced by the concentration of K in the soil solution, the higher the K in the soil, the higher the K-uptake of the plants (Mulyani et al., 2017).

The combination of soil improvercontaining water hyacinth compost has a role in providing element K for plants, namely through mineralization of organic material it will increase element K in the soil (Mashavira et al., 2015), and the content of negatively charged organic colloids will temporarily bind element K so that The K element provided is protected from leaching and fixation by clay minerals (Hartati et al., 2013).

3. Components of Crop Results

Based on the results of statistical tests, the application of a combination of soil improver and N, P, K fertilizers had a real influence on the variable number of grains per panicle, but was not significantly different from the recommended N, P, K treatments, apart from that it had a real influence on the variable weight of 100 grains. dry, all combination treatments of soil improver and N, P, K fertilizer were significantly different from the control treatment but not significantly different from the recommended N, P, K treatment and the soil improver treatment alone. On the variable weight of milled dry grain, the treatment dose of a combination of soil improver and N, P, K fertilizer had a significant effect but was not significantly different from the recommended N, P, K treatment. On the variable percentage of grain content per panicle, the application of a combination of soil improver and N, P, K fertilizer did not have a significant effect.

Table 4. Effect of Combination of Soil Improver and N, P, K Fertilizer on Crop Yield Components in Inceptisols from Jatinangor

	Treatments	Number of Grains per Panicle (seed)	Percentage of Grain Contents per Panicle (%)	Weight of 100 Dry Grains (g)	Weight of Milled Dry Grain
A	Control	42 a	**98,2 b**	2,50 a	4,78 a
B	N, P, K dose recommendation	82 de	86,8 a	2,68 b	22,38 b
C	Soil Improver	56 b	93,5 ab	2,66 b	5,49 a
D	½ Soil Improver + ¾ dose N, P, K	81 de	90,7 ab	2,65 b	20,64 b
E	¾ Soil Improver + ¾ dose N, P, K	71 cd	93,4 ab	2,64 b	22,27 b
F	¾ Soil Improver + ¾ dose N, P, K	67 c	90,6 ab	**2,72 b**	23,23 bc
G	**1** ½ Soil Improver **+ ¾ dose N, P, K**	78 cde	97,3 b	2,70 b	**25,93 c**
H	1 Soil Improver + 1 dose N, P, K	**83 e**	93,2 ab	2,68 b	22,33 b

Note: Numbers followed by the same letter do not show significant differences according to Duncan's Multiple Range Test at the 5% level.

Treatment H (soil improver + 1 dose of N, P, K) had the highest value of grain number per panicle, namely 83 seeds. This is thought to be because plants treated with various doses of a combination of soil improver+ N, P, K fertilizer have better plant nutrients and nutrition, and the use of humic acid as a soil improverhas a good effect on the number of panicles, resulting in more filled grain production (Nuraini and Zahro, 2020). Organic materials and N, P, and K fertilizers applied to the soil have an impact on the availability of nutrients for plants so that plants get enough nutrients needed to produce grain (Kaya, 2014).

The control treatment showed the highest value of the percentage of filled grain per panicle, namely 98.2%, so based on the results of statistical tests, giving a combination dose of soil improverdid not have a significant effect on the percentage of filled grain per panicle. This happens because the percentage of filled grain per panicle is assessed by how much filled grain and empty grain is from the total number of grains per panicle produced. The control treatment produced a low number of grains, namely 42 grains per panicle, but there were only 4 empty grains so the total grain content was 38 seeds, whereas in treatment G (1 ½ soil improver+ ¾ dose of N, P, K) showed a percentage of filled grains per panicle of 97.3% with an average number of grains per panicle of 78, empty grains were 9 seeds so that the grain content was 69 seeds.

Treatment F (1 soil improver+ ¾ dose of N, P, K) showed the highest weight value for 100 dry grains, namely 2.72 grams, this treatment was not significantly different from the treatment of soil improver+ N, P, K fertilizer with various other doses. Dry grain is a grain that has been dried to a moisture content of 12%. The weight of dry grain per hill is influenced by the total number of tillers, the number of productive tillers, the number of grains per panicle the percentage of filled grain, and the weight of 100 dry grains. Therefore, the greater the weight of 100 dry grains, the greater the weight of the dry grain. According to Azalika et al. (2018), providing organic materials can significantly improve growth and increase rice yields.

Treatment G (1 ½ soil improver+ ¾ dose of N, P, K) showed the highest weight of milled dry grain compared to other treatments, namely 25.93 g but was not significantly different from treatment F (¾ soil improver+ ¾ dose of N, P, K) namely 23.23 g. Meanwhile, the control treatment showed the lowest weight of milled dry grain, namely 4.78 g. This allegedly occurs because the application of organic fertilizer and inorganic fertilizer can affect the yield of rice plants, especially the weight of milled dry grain, which is related to the increase in the availability of nutrients in the soil, one of which is the element K and the K-uptake by plants (Table 4), as well as the availability of the element Other macroelements are N and P elements in the soil. These three macroelements are needed by plants to support good rice growth and yields (Kaya, 2014).

CONCLUSION

A treatment dose of 8 t ha-1 combination of soil improverand ¾ dose of N, P, K fertilizer (262.5 kg Urea, 37.5 kg SP-36, and 37.5 kg KCl) gave the highest results on the variable weight of 100 grains. A treatment dose of 12 Mg ha^{-1} combination of soil improverand ¾ dose of N, P, K fertilizer (262.5 kg Urea, 37.5 kg SP-36, and 37.5 kg KCl) gave the best effect on increasing K-potential, K-dd, and K-uptake. But not in lowland rice yields.

BIBLIOGRAPHY

Al Mu'min, M. I., Joy, B., & Yuniarti, A. (2016). Dynamics of Soil Potassium and Rice Yield (Oryza sativa L.) due to Compound NPK Application and Flooding in Fluvaquentic Epiaquepts. SoilREns, 14(1), 11–15. https://doi.org/10.24198/soilrens.v14i1.9269

Arianti, F. D., Nurlaily, R., &iapermas, M. N. (2020). Increasing Rice Productivity Through the Use of New Superior Varieties and Fertilization in Rainfed Rice Fields. Proceedings of the National Seminar on Agricultural Resource Readiness and Location-Specific Innovation Entering the Industrial Era 4.0, 191–196.

Azalika, R. P., Sumardi, S., & Sukisno, S. (2018). Growth and Yield of Sirantau Rice When Providing Several Types and Doses of Manure. Indonesian Journal of Agricultural Sciences, 20(1), 26–32. https://doi.org/10.31186/jipi.20.1.26-32

BPS. (2023). Harvest Area and Rice Production in Indonesia 2023 (Fixed Figures). [BPS] Indonesian Central Bureau of Statistics, 21, 1–20.

Chintala, R., Mollinedo, J., Schumacher, T. E., Malo, D. D., & Julson, J. L. (2014). Effect of biochar on chemical properties of acidic soil. Agron Soil Sci, 60, 393–404.

Dariah, Sutono, S., & Nurida, N. L. (2015). Soil Improvement to Increase Agricultural Land Productivity. Journal of Land Resources Vol. 9 No. 2, December 2015; 67-84 Opened, 9 No.2(December 2015), 67–84.

El-atbany, S. A., & Byan, A. I. (2019). Effect of Using Water Hyacinth Compost Comparing with Some Organic Fertilizers and Mineral Fertilizer Levels on Growth and Yield of Sweet Pepper. Journal of Horticultural Science and Ornamental Plants, 11(3), 204–213. https://doi.org/10.5829/idosi.jhsop.2019.204.213

Gunadi, N. (2009). Potassium sulfate and potassium chloride as a source of potassium fertilizer for shallot plants. Hort, 19(2), 174–185.

Hartati, S., Minardi, S., & Ariyanto, D. P. (2013). Zero Point Charge Of Various Organic Materials, Its Effect On Cation Exchange Capacity In Degraded Lands. Journal of Soil Science and Agroclimatology, 10(1).

Havlin, J. L., Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (2005). Production of Compost From Rice Straw Under Prototype Condition (event). Pearson Education Inc.

Rich, E. (2014). The Effect of Organic Fertilizer and Npk Fertilizer on Soil Ph and K-Availability as well as K-Uptake, Growth and Yield of Lowland Rice (Oryza SATIVA L). Buana Science, 14(2), 113–122.

Lestari, S. U., Sari, V. I., & Hidayat, M. W. (2023). The Role Of Humic Acid And Treatment Of KCL On The Growth And Production Of Cherry Tomato (*Solanum lycopersicum* var. cerasiforme) PLANT ON PMK SOIL. Indragiri Agro Journal, 9(2), 49–57. https://doi.org/10.32520/jai.v9i2.2559.

Mashavira, M., Chitata, T., Mhindu, R. L., Muzemu, S., Kapenzi, A., & Manjeru, P. (2015). The Effect of Water Hyacinth (<i>Eichhornia crassipes</i>) Compost on Tomato (<i>Lycopersicon esculentum</i>) Growth Attributes, Yield Potential and Heavy Metal Levels. American Journal of Plant Sciences, 06(04), 545–553. https://doi.org/10.4236/ajps.2015.64059

Mulyani, O., Salim, E. H., Yuniarti, A., Machfud, Y., Sandrawati, A., & Dewi, M. P. (2017). Study of Changes in Potassium Elements Due to Fertilization and Their Effect on Plant Yields. SoilREns, 15(1), 53–61. https://doi.org/10.24198/soilrens.v15i1.13348

Nuraini, Y., & Zahro, A. (2020). Effect of Application of Humic Acid and Npk Phonska 15-15-15 Fertilizer on Nitrogen Uptake and Growth of Rice Plants and Nitrogen Residue in Paddy Fields. Journal of Soils and Land Resources, 7(2), 195–200. https://doi.org/10.21776/ub.jtsl.2020.007.2.2

Nursyamsi, D. (2012). Technology for Increasing the Efficiency of K Fertilization on Soils Dominated by Smectite. Journal of Land Resources, 6(1), 9–22.

Nurwahyuni, E., & Arianti, F. D. (2022). Application of Agrimeth in Inpari 32 Planting Season II Rice Cultivation in Pemalang Regency. Proceedings of the National Seminar on Agribusiness Research Results VI, 6(1), 223–227.

Oktaviani, L., Aspan, A., & Nusantara, R. W. (2018). The Effect of Biochar and Compost on Potassium Retention in Land Used by Unlicensed Gold Mining (PETI) in Central Singkawang District, Singkawang City. Equator Journal of Agricultural Science, 7, 3.

Prasetiyo, Y., Hidayat, B., & Bintang, S. (2020). Chemical Characteristics of Biochar From Several Biomasses and Pyrolysis Methods. Agrium, 23(1), 17–21. https://jurnal.umsu.ac.id/index.php/agrium/article/view/5653

Prasetyo, S., Anggoro, S., & Soeprobowati, T. R. (2021). Reducing the Density of Water Hyacinth (Eichhornia crassipes (Mart.) Solms) in Rawapening Lake by Using It as a Compost Base Material. Biomes: Biological Scientific Periodicals, 23(1), 57–62. https://doi.org/10.14710/bioma.23.1.57-62

Remona, R., Trinurani Sofyan, E., Joy, B., Sudirja, R., Yuniarti, A., & Sauman Hamdani, J. (2020). Quantity and Quality of Shallot (^{*Allium ascalonicum*} L.) as Influenced by Water Hyacinth Compost on Fluventic Eutrudepts. American Journal of Biological and Environmental Statistics, 6(3), 50. https://doi.org/10.11648/j.ajbes.20200603.13

Ruminta, R. (2016). Analysis of the decline in rice production due to climate change in Bandung Regency, West Java. Cultivation, 15(1), 37–45. https://doi.org/10.24198/kultivasi.v15i1.12006

Salisbury, Frank, B., Ross, & Cleon, W. (1995). Plant Physiology. Bandung Institute of Technology.

Setyastika, U. S., & Suntari, R. (2019). The Effect of Bokashi Application on the Dynamics of N, P, and S Availability in Karangploso Inceptisol, Malang. Journal of Soils and Land Resources, 6(2), 1291–1299. https://doi.org/10.21776/ub.jtsl.2019.006.2.10

Simanungkalit, R. D. ., Suriadikarta, D. A., Saraswari, R., Setyorini, D., & Hartatik, W. (2006). Organic Fertilizer and Biological Fertilizer. Center for Agricultural Land Resources R&D, Agricultural Research and Development Agency.

Subandi. (2013). Role and Management of Potassium Nutrient for Food Production in Indonesia. Agricultural Innovation Development, 6(1), 1–10.

Sukmawati, F. N., Zein, Z., Handayati, W., Hijau, P., Hamawi, M., Sebayar, H. T., Tyasmoro, Y., Amiroh, A., Timing, D., Laila, A., &Waluyo , S. (2016). Science Journal. 2(2).

Suwahyono, U. (2016). Prospects of Critical Land Remediation Technology with Humic Acids. Journal of Environmental Technology, 12(1), 55. https://doi.org/10.29122/jtl.v12i1.1262

Wulansari, R., Maryono, M., Darmawan, D. A., Athallah, F. N. F., & Hakim, F. K. (2022). Bio-organic mineral effect on soil fertility, nutrient uptake, and sweet corn (*Zea mays* L. saccharata) growth planted in inceptisols soils. Indonesian Mining Journal, 25(1), 49–58. https://doi.org/10.30556/imj.vol25.no1.2022.1282

Yuniarti, A., Machfud, Y., & Falma, Y. D. (2020). Application of Various Organic Fertilizers and N, P, K Fertilizers on pH, K-dd, K-Potential, and Yield of Black Rice (*Oryza sativa* L. Indica) in Inceptisols. Innovative Rice Technology Supports Sustainable And Agriculture, 207–222.

Yuniarti, A., Solihin, E., & Arief Putri, A. T. (2020). Application of organic fertilizer and N, P, K on soil pH, available P, P uptake, and yield of black rice (*Oryza sativa* L.) on inceptisol. Cultivation, 19(1), 1040. https://doi.org/10.24198/kultivasi.v19i1.24563