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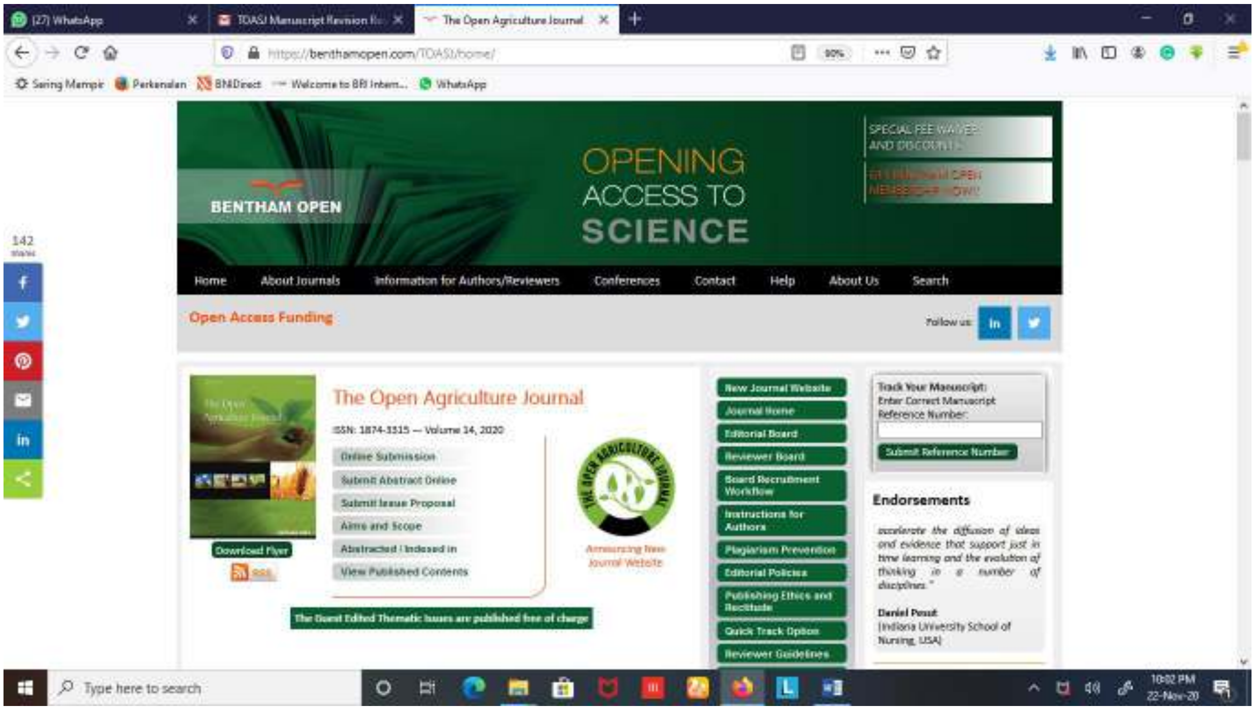

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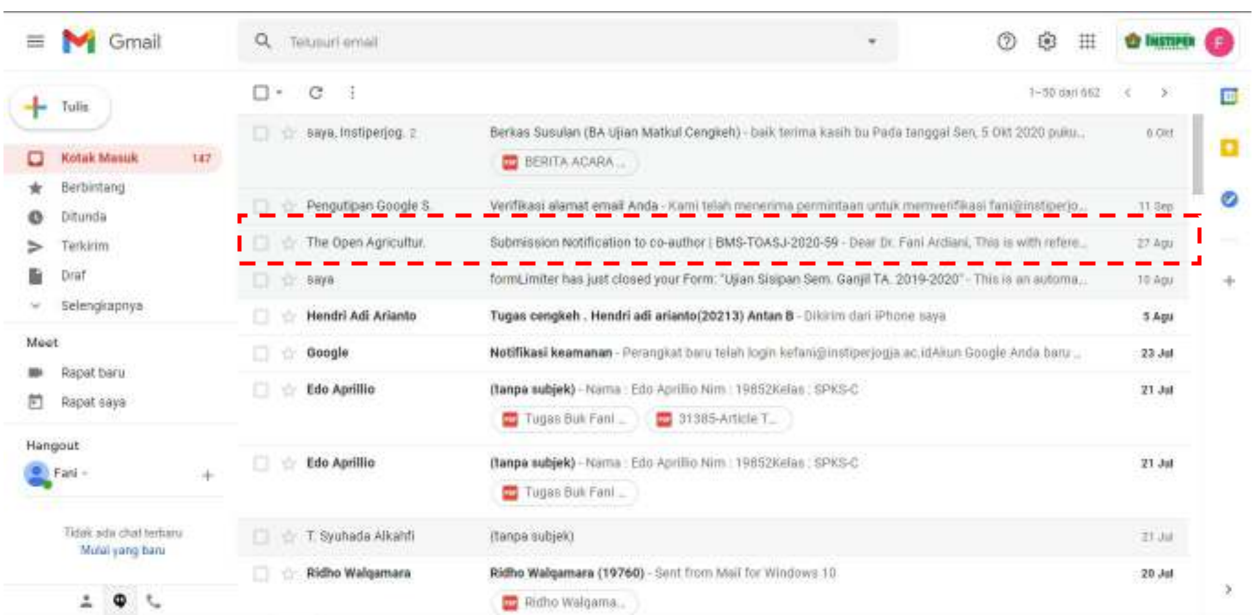

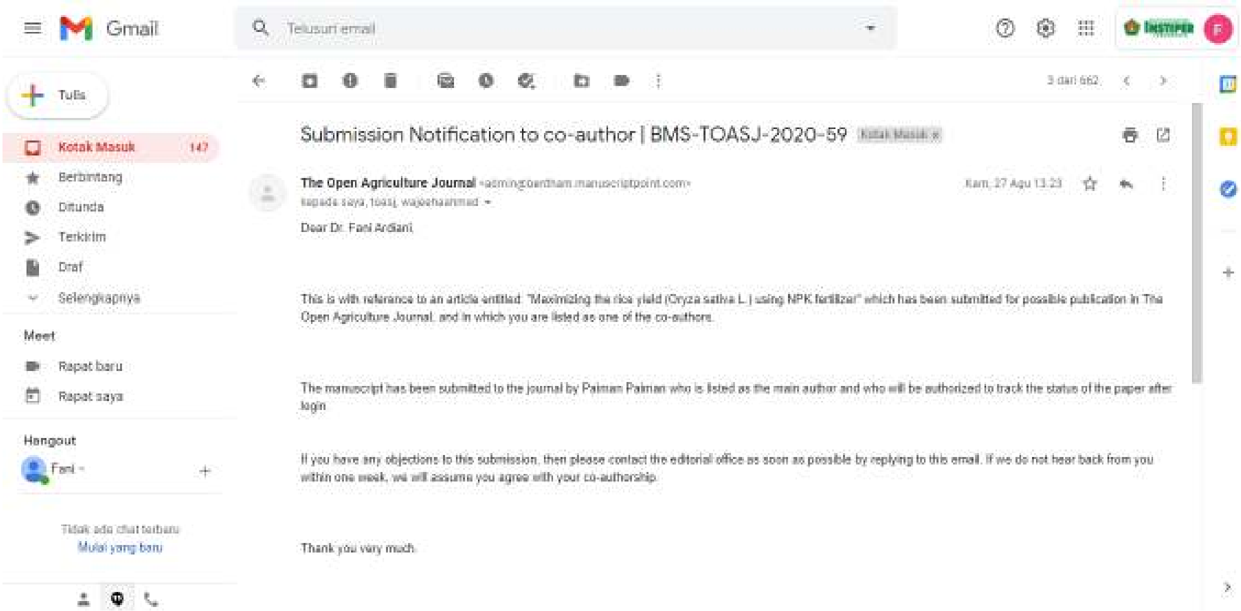

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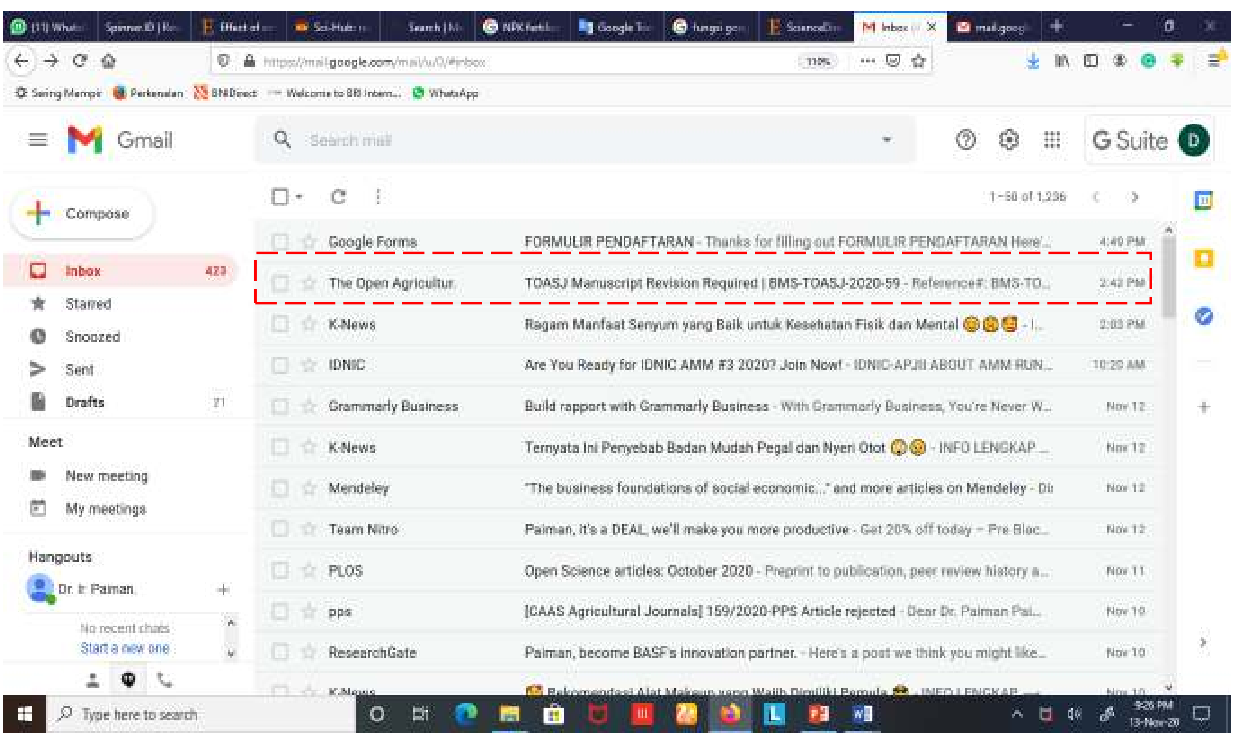

Gmail Dr. Ir. Paiman, M.P. - UPY <paiman@upy.ac.id>

TOASJ Manuscript Revision Required | BMS-TOASJ-2020-59

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Submission Title: Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer

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Referee 2:
The manuscript entitled, "Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer". The present research article is well prepared and having good and useful information about the about NPK fertilizer use for rice yield. I believe this article will be a unique in this area. This research article may be accepted for publication after minor

revision as below: 1. Minimum keywords should be five. 2. In 2.2 section replace x by × in 4 x 3 x 5 = 60 polybags. 3. Follow the pattern of the journal for reference.

Referee 3:

English is to be improved. Avois senceless sentences like 'Nitrogen can absorb plants in the form of and ions'. or "The seedling was done in several plastic tubes germination' or 'NPK fertlizer was significantly effected on tillers..... except not significant effect on shoot....' Introduction. Some references (8, 14-16) to Indonesian works are strange as the material is basics known widely, published in text-books. Bacterial leaf blight is mentioned twice. Statements that NPK is smth that 'large amounts of crops are needed' are not correct as all plants need NPK. There is too many not needed detailed information in the introduction (refs to the results on day 35, 45, 90). What is the novelty of the work? If application of NPK to alluvial soil, then whu there is no a word about application of NPK to other soil types or alluvial soil? Methods: What does it mean 'less soil'? How harvest index is calculated? (it must be in Methods, not in the Discussion) What exactly was used as a control? Results: In the descriptions of the data in tables 1 and 2 we read ' ... application of NPK fertilizers can increase the growth .... compared to plants only given a single N fertilizer' The question therefore the same - what was used as a control? Discussion: There are too many data on NPK effects, but no discussion on what do you know now that you did not know from the literature (that you cited in the Discussion) and wouldn't have guessed doing this work? Did you find different results than others who have investigated the same things? What about similar research on other types of soil?

Referee 4:

Manuscript Number: BMS-TOASJ-2020-59 Title: Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer Content: Rice has become a primary daily necessity for most Indonesian population. The upsurge of national rice production can be done by agricultural intensification through the application of compound fertilizer.The optimal dose of NPK fertilizer and can maximizing the rice yields. Increasing rice production can be done with the program agricultural of intensification with the use of superior seeds and proper use of fertilizer. The N element in crop functions as a leaf-forming substance (chlorophyll), and protein-forming elements. The P element functions as energy storage, and transfer constitute an essential component in nucleic acids, coenzymes, nucleotides, phosphoprotein, phospholipid, and sugar-phosphate. The K element works in starch formation, activating enzymes, and catalysts storage of photosynthesis results. The excessive application of NPK fertilizer in rice cultivation will cause environmental pollution, especially nitrates and nutrient imbalance occurs in the soil. It is very useful to study the maximum yield of nitrogen, phosphorus and potassium fertilizer to local rice varieties. This manuscript has clear ideas, proper methods, credible results and clear language. It is recommended that the manuscript be published after revised. 1. INTRODUCTION --By 2060, the global population is expected to reach 10 billion. "By 2060" What do you mean ? --Nitrogen can absorb plants in the form of and ions. Grammatical error, correct. -- Fig. (1). Fig. (2). Do not mark the vertical axis title in the picture as yellow.

Referee 5:

This greenhouse study examines the influence of different rates of compound fertilizer application on growth and yield of Ciherang rice variety. The results of the study indicate that application of 656 kg ha -1 NPK fertilizer resulted in maximum growth and yield of rice. Although these results are interesting, it lacks novelty as there are many studies in literature where such a response has been examined. Further, the results of the present study have little practical value as it is well known that results from studies conducted under controlled conditions could substantially differ from those conducted under realistic field conditions. Moreover, the study suffers from several inherent shortfalls and poor presentation making reading extremely difficult. I suggest the authors to seek the help of a colleague with good proficiency in English while revising the manuscript. Almost all sections of the manuscript especially the discussion section require reworking. The discussion is totally unfocused and wavered. The results of the present study should be compared with the previous studies to see how they agree or disagree and the reasons for these should be discussed. As the comments are too many to list here I had marked my comments directly on the annotated manuscript appended herewith.

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RESPOND TO REFEREES COMMENTS

Comments	Addressed Y/N	Reply / Action taken
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Referee 2:		
The manuscript entitled, "Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer". The present research article is well prepared and having good and useful information about the about NPK fertilizer use for rice yield. I believe this article will be a unique in this area.		
This research article may be accepted for publication after minor revision as below: 1. Minimum keywords should be five.	Y	1. The number of keywods in the manuscript is six words so that it enough for the requirements.
2. In 2.2 section replace x by × in 4 x 3 x 5 = 60 polybags.	Y	2. We have replaced the letter 'x' with '×', namely: 4 × 3 × 5 = 60.
3. Follow the pattern of the journal for reference.	Y	3. We have adjusted the journal pattern for reference with the journal template
Referee 3:		
1. English is to be improved.	Y	1. We have leveled the quality of English with the help of native speakers
2. Avois senceless sentences like 'Nitrogen can absorb plants in the form of and ions'. or ''The seedling was done in several plastic tubes germination' or 'NPK fertlizer was significantly effected on tillers..... except not significant effect on shoot....'	Y	2. We have corrected the sentence to be: 'Nitrogen can be absorbed by plants in the form of ions'. 'The nursery is carried out in a plastic germination tub'. 'NPK fertilizer was significantly effected on tillers number, leaf area, shoot dry weight, roots dry weight, and dry weight of crop stover, except shoot root ratio'.
Introduction:		**Introduction:**
1. Some references (8, 14-16) to Indonesian works are strange as the material is basics known widely, published in text-books.	Y	1. We have been replaced several references to Indonesian works with higher quality literartures.
2. Bacterial leaf blight is mentioned twice.	Y	2. Double words of Bacterial leaf blight we have corrected.
3. Statements that NPK is smth that 'large amounts of crops are needed' are not correct as all plants need NPK.	Y	3. We have corrected the statement to 'The nutrients element of N, P, and K are macronutrients needed by all plants.
4. There is too many not needed detailed information in the introduction (refs to the results on day 35, 45, 90).	Y	4. Detailed information that is not needed we have deleted.
5. What is the novelty of the work? If application of NPK to alluvial soil, then	Y	5. Optimization of the use of NPK in rice plants in allluvial soils has not been widely

whu there is no a word about application of NPK to other soil types or alluvial soil? **Methods:** 1. What does it mean 'less soil'? 2. How harvest index is calculated? (it must be in Methods, not in the Discussion) 3. What exactly was used as a control? **Results:** In the descriptions of the data in tables 1 and 2 we read ' ... application of NPK fertilizers can increase the growth .... compared to plants only given a single N fertilizer' The question therefore the same - what was used as a control? **Discussion:** 1. There are too many data on NPK effects, but no discussion on what do you know now that you did not know from the literature (that you cited in the Discussion) and wouldn't have guessed doing this work? 2. Did you find different results than others who have investigated the same things? What about similar research on other types of soil?	 Y Y Y Y Y Y	used by previous researchers, especially in Indonesia, as well as for other soil types. Optimization rate of use of NPK fertilizer depends on climate and soil conditions. **Methods:** 1. Less soil means using a small amount of soil media (a thin soil layer) to cover the seeds that are spread on the surface of the media to maintain field capacity and free from disturbing organisms. 2. We have been entered the harvest index calculated in the methods section. 3. As a control, namely rice plants without NPK fertilizer treatment (treatment of 0 kg. ha^{-1} NPK) **Results:** In the description of Tables 1 and 2 there is a misunderstanding. We have revised the error. … Given a single N fertilizer replaced… control (treatment of NPK of 0 kg ha^{-1}). **Discussion:** 1. We have added about the discussion of what we know from the results of this research with existing research in the excerpt in the introduction to the introduction. 2. We have not found research results from the same study. However, we have found similar studies but different types of soil. Based on the results of the study, it was shown that rice cultivation on allluvial soils required higher NPK nutrients than in Inceptisols.
<u>Referee 4:</u>		
Manuscript Number: BMS-TOASJ-2020-59 Title: Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer **Content:** Rice has become a primary daily necessity for most Indonesian population. The upsurge of national rice production can be done by agricultural intensification through the application of compound fertilizer.The optimal dose of NPK fertilizer and can maximizing the rice yields. Increasing rice production can be done with the program		

agricultural of intensification with the use of superior seeds and proper use of fertilizer. The N element in crop functions as a leaf-forming substance (chlorophyll), and protein-forming elements. The P element functions as energy storage, and transfer constitute an essential component in nucleic acids, coenzymes, nucleotides, phosphoprotein, phospholipid, and sugar-phosphate. The K element works in starch formation, activating enzymes, and catalysts storage of photosynthesis results. The excessive application of NPK fertilizer in rice cultivation will cause environmental pollution, especially nitrates and nutrient imbalance occurs in the soil. It is very useful to study the maximum yield of nitrogen, phosphorus and potassium fertilizer to local rice varieties. This manuscript has clear ideas, proper methods, credible results and clear language. It is recommended that the manuscript be published after revised. 1. INTRODUCTION --By 2060, the global population is expected to reach 10 billion. "By 2060" What do you mean ? 2. Nitrogen can absorb plants in the form of and ions. Grammatical error, correct. 3. Fig. (1). Fig. (2). Do not mark the vertical axis title in the picture as yellow.	Y Y Y	1. The word 'by 2060', which means the year of 2060. So as not to confuse, we have fixed it to: 'In 2060' 2. We have corrected the sentence to be correct, namely: 'Nitrogen can be absorbed by plants in the form of ions'. 3. We've changed it.
Referee 5:		
1. This greenhouse study examines the influence of different rates of compound fertilizer application on growth and yield of Ciherang rice variety. The results of the study indicate that application of 656 kg ha -1 NPK fertilizer resulted in maximum growth and yield of rice. Although these results are interesting, it lacks novelty as there are many studies in literature where such a response has been examined. Further, the results of the present study have little practical value as it is well known that results from studies conducted under controlled conditions could substantially differ from those conducted under realistic field conditions.	Y Y Y	1. We conduct research in greenhouses in the hope that environmental conditions are under control. The results of this research, in the future, will be developed in the field and tested on various types of soil. With the hope that the information is more complete. 2. The quality of English is still low. We have improved the quality with the help of proofread from native speakers. 3. We have made improvements and added research results from previous references or the like in the discussion section with sentences colored red in both the introduction and discussion sections.

2. Moreover, the study suffers from several inherent shortfalls and poor presentation making reading extremely difficult. I suggest the authors to seek the help of a colleague with good proficiency in English while revising the manuscript. 3. Almost all sections of the manuscript especially the discussion section require reworking. The discussion is totally unfocused and wavered. The results of the present study should be compared with the previous studies to see how they agree or disagree and the reasons for these should be discussed. As the comments are too many to list here I had marked my comments directly on the annotated manuscript appended herewith.		

A revised paper with the highlights

Maximizing the rice yield (Oriza sativa L.) using NPK fertilizer

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Abstract:

Background:

Rice has become a primary daily necessity for most Indonesian population. The upsurge of national rice production can be done by agricultural intensification through the application of compound fertilizer.

Objective:

This study aims to determine the optimum dose of NPK fertilizer, which can provide the highest rice yield of Ciherang varieties in Alluvial soil.

Methods:

This experiment was a single factor arranged in a completely randomized design and three times replications. The treatment of NPK fertilizer consisted of four doses, i.e., 0, 160, 320, and 480 kg ha^{-1}. The data observations were analyzed by using analysis of variance at 5% significance levels. The difference between the averages of the treatment was compared using Duncan′s new multiple range test at 5% significance levels.

Results:

The results of the research showed that the application of NPK fertilizer could increase the growth and yield of rice plants compared to only providing urea fertilizer. The optimum dose of compound NPK was obtained at 656 kg ha^{-1} and was given the maximum dry weight of grains of 4.26 tons ha^{-1} milled dry grain.

Conclusion:

The study indicated that the NPK fertilizer interval is still low. Therefore, it is necessary to conduct further research on a higher doses interval.

Keywords: Optimum dose, NPK fertilizer, Growth, Yield, Rice, Ciherang variety.

Running title: Maximizing the rice yield using NPK fertilizer

1. INTRODUCTION

In 2060, the global population is expected to reach 10 billion. Grain production relies heavily on chemical fertilizers to meet the food demands of the increasing population [1]. Rice is the primary daily staple food that is widely consumed and it is a source of calories [2]. Rice is a type of crop production consumed by nearly half of the world population. Likewise, In Indonesia, rice is a staple food for most the Indonesian population. The demand on rice by the Indonesian community from year to year is always increasing. The rice harvest area in Indonesia from the period of January to September 2018 was 9.54 million hectares and by December 2018, the harvest area was 10.90 million hectares. In December 2018, the total production of rice was 56.54 million tons of dry weight of grain. Meanwhile, the rice production from January to September 2020 was 49.65 tons of dry weight grain. In December 2018, the total production of rice was 56.54 million tons of dry weight of grain. In 2008, rice production was equivalent to 32.42 million tones using the conversion rate of the dry weight of unhulled to rice [3].

The Indonesia′s rice import volume in the period of January-November 2018 surged 2.2 million tons compared to January-December 2017, which only reached 305.75 thousand tons. The value of rice imports in the first 11 months of the previous year increased to US$ 1.02 billion over the whole year 2017, which only amounted to US$ 143.65 million [4]. Rice of Ciherang is a new superior variety which is adaptable to the Indonesian environment, producing profitable crop growth, high yield, good quality, and it hastaste accepted by the market. The potential productivity of Ciherang is 6.0 to 8.5 tons ha^{-1} of the dry weight of grain, and crop age is 116 to 125 days after planting (DAP). This type of rice is resistant to brown planthopper biotype 3, bacterial left blight resistance, brown planthopper biotype 2, and slightly resistant to brown planthopper biotype 3. The taste of rice is fluffier [5]. The rice production can be increased with the program agricultural of intensification using superior seeds and proper use of NPK fertilizer.

Estimating crop nutrient requirements are essential for informing decisions of optimal nutrient management. However, the nutrient requirements often vary depending on climates and soil conditions [6]. Nitrogen, phosphorus, and potassium are important macronutrients for plant growth and development [1]. Fertilizer as sources nutrients is a material of production which plays an important role in improving rice productivity. NPK Mutiara fertilizer is one type of compound fertilizer with at least five elements nutrients of macro and micro. The fertilizer is granular in a faded blue color contains of 16% N (nitrogen), 16% P_2O_5 (phosphate), 16% K_2O (potassium), 0.5% MgO (magnesium), and 6% CaO (calcium). Henceforth the fertilizer is called NPK (16-16-16). The nutrients element of N, P, and K are macronutrients needed by plants. The N element in crop functions as a leaf-forming substance (chlorophyll) and protein-forming elements. The P element functions as energy storage and transfer constitute an essential component in nucleic acids, coenzymes, nucleotides, phosphoprotein, phospholipid, and sugar-phosphate. The K element works in starch formation, activating enzymes, and catalysts storage of photosynthesis products [7].

The N element has a vital role for rice crops, i.e., encourage faster crop growth, improve grain yield and quality by increasing the number of tillers, leaf area development, grain formation, grain failing, and protein synthesis. Rice plants that are deficient in N have fewer tillers, have stunted growth, have yellowish-green leaves, and begin to die from the top and then spread to the middle of the leaf blade. If the N element is excessively given, it will result in detriment, such as weakening straw, causing the crop fall, and decreasing the rice yield quality [8]. The combination of a dose of nitrogen (90 kg ha^{-1}), farmyard manure (5 tons ha^{-1}), and blue-green algae (9 kg ha^{-1}) contributes to higher plant height (96.13 cm), effective tiller per square meter (345.6), filled grain per panicle (180.9), grain yield (4.787 tons ha^{-1}), and straw yield (9.07 tons ha^{-1}) [9]. Nitrogen can absorb plants in the form of NO_3^- and NH_4^+ ions.

The P element function in the crop plays a role in the process of photosynthesis, respiration, transfer and energy storage, cell division and enlargement, and internal operation of other crops. The plant absorbs the big section of the P element in the form of primary orthophosphate ion (H_2PO_4) and the small number in secondary orthophosphate ion (HPO_4^{-2}). The P element is essential in seed formation, helps accelerate root development and germination, improves water efficiency, and increases power resistance to diseases that ultimately enhance the quality of the harvest. The deficiency of the P element potentially causes maturity delay and reduce seed filling [10]. The P element is a constituent of adenosine triphosphate (ATP). The P element directly plays a role in the process of energy storage and transfer and activities involved in crop metabolism. The P element is highly required by rice, especially at the beginning of the growth, because it can support the root formation and additives' number and accelerate flowering and grain maturity [11].

The K element is the third essential nutrient after N and P. Crops absorb the K element in the soil in the form of K^+ ions. This element performs as an activator of many enzymes participating in several crop metabolism processes, including photosynthesis. If the nutrient of K deficiency occurs, it will cause a decrement in photosynthesis, and respiratory disorders. This occurrence eventually dampens the carbohydrate production. The K element function is essential in protein synthesis, solving carbohydrates, the process of energizing crops, translocation of heavy metals such as Fe, resistance to disease disorders, fruit formation, and regulates the opening and closing of guards cell in leaf stomata [12]. K element deficiency symptoms are indicated by the sign of the burning of leaves starting from the edges, necrotic patches brown on old leaves and stems.

NPK fertilization has a significant effect on crop height, the tillers number, panicle number per clumps, total grain per panicle, percentage of the empty and filled with grain per panicle, the weight of 1,000 grain, and the potential yield of grain per hectare (Waty et al., 2014). The increasing element tends to improve rice yields. The use of NPKS (15-15-15-5) with a dose of 600 kg ha^{-1} effectively increases the grain dry weight from 3.63 to 4.67 tons ha^{-1} in the Inceptisols soil. The optimum rate of NPK Phonska fertilizer (15-15-15) was 440 kg/ha, as shown with the production performance of 4.12 tons ha^{-1}. The NPK fertilizer (15-15-15) effectively elevates the growth and grain dry weight, equivalent to standard NPK at the dose of 300-750 kg ha^{-1} [7]. The estimated N, P, and K requirements of rice were 15.3, 6.0, and 19.9 kg mg^{-1} grain in Northern China and 21.0, 4.4, and 22.1 kg mg^{-1} grain in Southern China, respectively [6]. The application of a fertilizer dose of 550 kg ha^{-1} NPK Phonska gave the highest yield on the total number of grain (174.58 seeds), number of filled grains (144.67 seeds), and grain yield (85.33 g) per rice clump [15].

The excessive application of NPK fertilizer in rice cultivation will also bring about environmental pollution, especially nitrates and nutrient imbalance occurs in the soil. NPK fertilizer (20-10-10) with at the dose of 200 kg ha^{-1} makes the plant less sensitive to rice blast at all its phases of growth and improves the output compared with NPK (23-10-05). NPK fertilizer (23-10-05) at the maturation phase influences the panicle rice blast by making the plant susceptible and depreciating the quality of the production and lowland rice as upland rice [16]. The application of NPKSZn (80-18-28-6-1) fertilizers is economically profitable for Binadhan-7 rice and higher yield [17]. The impact of fertilizers on grain yields was 2NPK > NPK > NP > NK > N. The P fertilizer application not only increased the rice yield but also improved yield stability. The trend of agronomic use efficiency of applied P element was significantly positive only for the first rice crop, suggesting that P fertilizer plays a less critical role in the second rice season than in the early rice season [18].

Referring to the existing literature, knowledge about NPK fertilizer has significant implications in increasing rice crops' growth and yield. Therefore, this study intends to determine the optimum dose of NPK fertilizer, which can provide the highest rice yield of Ciherang varieties in Alluvial soils.

2. MATERIALS AND METHODS

2.1. Study Site

The research was conducted from February to June 2019. This research was located in a greenhouse facility, Faculty of Agriculture, Universitas PGRI Yogyakarta, Indonesia. The particular territory of Yogyakarta having an elevation of 118 m above means sea levels in the position S 7° 33′ – 8° 12′ and E 110° 00′ – 110° 50′.

2.2. Experiment Design

This experiment was s single factor and arranged in a completely randomized design (CRD), replicated three times. The NPK fertilizer treatments have consisted of four levels, i.e., 0, 160, 320, and 480 kg ha^{-1}. Each replication consisted of five samples and needed $4 \times 3 \times 5 = 60$ polybags.

2.3. Research Procedures

The soil type used in this research was Alluvial soil. The media planting was made from the soil of 15 kg and cow manure of 1.5 kg or the ratio of 15:1.5. An addition of NPK (16-16-16) fertilizer was applicably suitable for the treatments. The combination of soil, manure, and NPK were mixed into one media before putting into polybag in size of 40 cm × 40 cm. The Ciherang rice variety was used in this research. The seedlings were done in plastic tubs germination. The seeds of rice were spread on the media surface and covered with a thin soil layer. Watering the media was done to keep the field capacity. Ten days after seedling, the rice sprouts were planted in the soil as deep as 3 cm. Each planting hole was planted with two rice sprouts. Plant spacing between polybag wass 25 cm × 25 cm measured from the midpoint polybags. There were 160.000 clumps ha^{-1}. The application of water in the polybags was until waterlogging. The urea fertilizer was given as many as 160 kg ha^{-1} in twice age, namely, 14 and 42 DAP. The anticipation of pest attacks of brown planthopper had been done by applying Temin pesticides.

2.4. Parameters

The observation was done on the rice growth, including the tillers per clumps, leaf area, shoot dry weight, roots dry weight, stover dry weight, and shoot-root ratio. The rice yield was observed, including panicle length, grain dry weight of grain, and harvest index. Harvest index is grain dry weight (economic yield) divided by overall crop dry weight (biological yield, including the dry weight of grains).

2.5. Statistical Analysis

The data were analyzed using variance (ANOVA) analysis at 5% significance levels [19] with IBM SPSS Statistic 23. The treatment means were compared using Duncan′s new multiple range test (DMRT) at 5% significance levels.

3. RESULTS

3.1. Component of the Rice Growth

The ANOVA showed that NPK fertilizer was significantly affected on tillers number, leaf area, shoot dry weight, roots dry weight, and stover dry weight, except shoot root ratio. The results of DMRT at a 5% significant level on the component of rice growth are presented in Table 1.

Table 1. The effect of NPK on the component of rice growth.

Parameters	Doses of NPK fertilizer (kg ha^{-1})			
	0	160	320	480
Tillers number (stem clump^{-1})	29,0 c	34,3 bc	42,5 ab	44,7 a
Leaf area (cm^{2} Clump^{-1})	825.3 b	1,173.5 a	1,320.2 a	1,405.1 a
Shoot dry weight (g clump^{-1})	10.59 c	13.02 bc	15.33 ab	16.85 a
Root dry weight (g clump^{-1})	3.2 c	4.52 bc	5.35 ab	6.29 a
Shoot root ratio	3,30 a	2,89 a	2,86 a	2,69 a
Stover dry weight (g clump^{-1})	13.8 c	17.55 bc	20.76 ab	22.76 a

Remarks: The numbers in the same row having the same characters are not significantly different at 5% significance levels ($p < 0.005$) based on Duncan's new multiple range test (DMRT).

Table 1 shows that compound NPK fertilizers' application could increase rice plants' growth compared to control (treatment of 0 kg ha^{-1} NPK Phonska), except for the shoot root ratio. The dose of NPK fertilizer of 480 kg ha^{-1} produced the highest number of tillers and significantly different from 160 kg ha^{-1} and control, but not significant with 320 kg ha^{-1}. There was a decrease of tillers number in the 160 kg ha^{-1} and the lower in 0 kg ha^{-1}. There was no significant difference in leaf area between the dose of 160, 320, and 480 kg ha^{-1}, but all three treatments significantly different from the control. The use of NPK fertilizer in the dose of 480 kg ha^{-1} produced the highest root dry weight, and significantly different from 160 and 0 kg ha^{-1}, but not significant with 320 kg ha^{-1}. Table 1 also explains that The highest dry weight of shoots, roots, and stover was achieved in applying NPK fertilizer at a dose of 480 kg ha^{-1}.

3.2. Component of the Rice yield

The ANOVA shows that the NPK fertilizer significantly affects the grains dry weight and harvest index, except panicle length. The results of DMRT at a 5% significant level on grain dry weight and harvest index are presented in Table 2.

Table 2. The effect of NPK fertilizer on the component of rice yield.

Parameters	Doses of NPK fertilizer (kg ha^{-1})			
	0	160	320	480
Panicle lenght (cm)	20.2 a	20.4 a	21.5 a	21.8 A
Grains dry weight (ton ha^{-1})	1.69 c	2.68 b	3.68 a	4.04 A

Harvest index (g)	0.43 b	0.48 ab	0.53 a	0.53 A

Remarks: The numbers in the same row having the same characters are not significantly different at 5% significance levels ($p < 0.005$) based on Duncan's new multiple range test (DMRT).

The application of NPK fertilizers can increase rice yields compared to control (0 kg ha^{-1}), except for panicle length. The dose of 320 and 480 kg ha^{-1} produced higher grains dry weight and significantly different from 160 kg ha^{-1} and control. The grains dry weight was lower in the dose of 160 and 0 kg ha^{-1}. The application of more from 480 kg ha^{-1} still could increase the grain dry weight.

The quadratic regression analysis result shows that the effect of NPK fertilizer on grain dry weight has obtained $y = -6E\text{-}06\ x^2 + 0.0079\ x + 1.6635$, and coefficient of determination (R^2) of 0.99. The first derivative of the quadratic regression obtained the optimum dose of NPK fertilizer of 656 kg ha-1 and given the grains dry weight of 4.26 tons ha^{-1}. The quadratic regression curve is made from the NPK fertilizer effect on the grain dry weight (Fig. **1**).

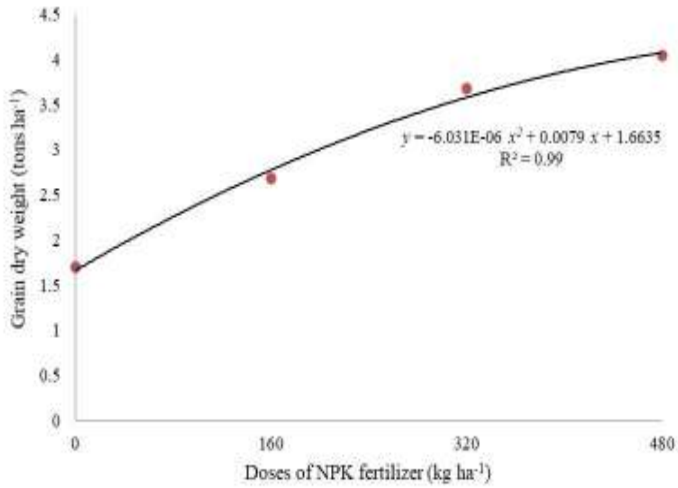

Fig. (1). The effect of NPK fertilizer on the dry weight of grains.

The highest harvest index occurs in NPK fertilizer at a dose of 480 kg ha^{-1}. It was significant from other treatments, except with a dose of 320 kg ha^{-1}. The harvest index was lower in control. The quadratic regression result showed that NPK fertilizer effect on harvest index was obtained $y = -4.8E\text{-}07\ x^2 + 0.00043\ x + 0.4337$, and coefficient of determination (R^2) of 0.99. The first derivative of quadratic regression obtained the optimum dose of NPK at 445.7 kg ha^{-1}, and resulted in the harvest index of 0.53. The quadratic regression curve ismade from the NPK fertilizer effect on the harvest index (Fig. **2**).

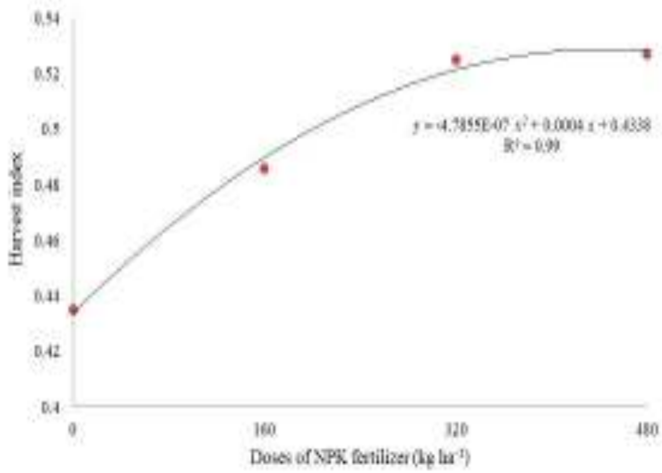

Fig. (2). The effect of NPK fertilizer on harvest index.

4. DISCUSSION

4.1. Component of the Rice Growth

The dose of 480 kg ha^{-1} NPK fertilizer could increase the tillers' number compared to control. The P element's content in the compound NPK fertilizer plays an important role when forming the rice tillers. The P element for the plant functions is as a developmental material of nucleoprotein in every cell core. Thus, it plays a role in forming new cells, including the formatting of prospective rice tillers. The P element is available in the soil; accordingly, it will be more absorbed by the roots. Hence, it results in higher rice tillers. This study's results are supported by Ginting [20] the highest number of tillers was obtained in the NPK fertilizer 400 kg ha^{-1}. The number of tillers is one of the determining components in achieving rice production in rice plants per hectare.

The application of compound NPK fertilizer in the soil will increase the N content in the soil. N addition frequently stimulates plant growth more than long-term N effect. Legacy of N tends to be only beneficial for non-N fixing plants in medium-aged soils [21]. N element is needed in large quantities for the shoot and vegetative growth of rice. The N element plays a significant role in forming meristem tissue, stimulates branch, leaf, and shoots. The availability of sufficient N nutrients by applying the proper NPK fertilizer will produce a better crop growth phase. The N element sufficient causes leaf growth of rice wider, then the leaf area more full for the capture of sunlight in the photosynthesis process [22]. Leaves are the site of photosynthesis and describe the actual production capacity of the crop. Subsequently, carbohydrates could affect the growth, yield, and economic value of the plant. The more full leaves of the plant, followed by increasing chlorophyll content, the moresupports to the photosynthesis process. The optimum leaf area produces maximum carbohydrate. The N element application sufficiently caused by the increase of shoot growth hence endorses the development of tillers number, stem, and leaf to the maximum. This growth will produce higher shoot dry weight.

It was clearly explained that the application of higher NPK could increase the root dry weight. NPK fertilizer could accelerate, multiply, strengthen, and extend crop root so that roots will easily absorb nutrients to the soil. The content of the K element in NPK fertilizer is capable of spurring root development and affecting the absorption of ingredients other nutrients. The P element is part of the cell core. Therefore, it is essential in cell division and development meristem networks to stimulate rice crops' root growth, especially lateral roots, and hair roots, to absorb a higher amount of nutrients. The existence of K and P elements in the soil can control root formation, cleavage, and meristem culture, which maximize the root growth. Table 1 shows that NPK fertilizer application at a dose of 480 kg ha^{-1} causes higher root dry weight.

Stover dry weight of rice crop is the amount from dry shoot weight (including panicle without grain) and root dry weight. The dry weight material is the ingredients crop (besides economic yield) after the water container was removed. Stover dry weight is very dependent on the results of the photosynthesis process, which is determined by the ability of crop in nutrients absorption, sunlight capture, and uptake of CO_2 and H_2O.

4.2. Component of the Rice Yield

The application of NPK Phonska fertilizer can increase the production of dry grain weight per hectare. The application of NPK Phonska fertilizer at a dose of 480 kg ha-1 can give a yield of 4.04 tonnes ha-1 in Ciherang rice varieties on Alluvial soil. The estimation results show that the highest production of milled dry grain weight is 4.26 tons ha-1 and the optimum dose of NPK fertilizer is 656 kg ha-1. However, the type of paddy soil will also determine the production of Ciherang rice varieties. This research results by Hartatik [7] showed the NPKS optimum dose of 440 kg ha-1 produced milled dry grain weight of 4.12 tons ha-1 on Inceptisols soil. According to Shanti [23], the dose of NPK Phonska of 300 kg ha-1 could produce 6.18 tons ha-1 in Ultisols soil. Therefore, it indicates that Alluvial soil is marginal soil with lower fertility than Inceptisols and Ultisols soil. Consequently, it requires more NPK nutrient additions. The evidence presented thus far supports the idea that the increase of nutrients in Alluvial soil can augment the dry weight of grain compared to control.

Plant reproduction and growth are processes that require energy from photosynthetic products [24]. NPK fertilizer can reduce the possibility of flower fall and seedloss due to increasing the crop yield. In addition, NPK fertilizer can intensify the photosynthesis of crops result in higher carbohydrate formation. The P element performs as an element of protein compilers is needed for the support of flowers, fruit, and seeds. Potassium fertilizer minimize rice growth, physiology, and biochemical changes under cyclic water stress conditions. High potassium rates reduce water stress effects by having a high transpiration rate. A high transpiration increases the nutrient uptake that would repair the damaged tissue under water stress to minimize oxidative stress [25].

The K element plays a role in metabolic processes, namely photosynthesis and respiration in crop growth. The K element regulates the balance of ions in the cell which sets various metabolic mechanisms like photosynthesis, metabolism carbohydrates, and translocation. Synthetic protein plays a role in the respiration process. In most soil, P fractions decreased with time due to continuous depletion by rice plants, while they generally increased with time in the fertilizer due to the supply of P to soils [26]. The K element is necessary at thepaddy flowering stage.. However, the P element is urgently needed by crop when panicle formation, activating seed filling, and accelerate fruit ripening. The P element has the function to accelerate flowering and ripening of fruit and seeds or grain. The P element enables growth crop, flower growth, stimulates fruit ripening , and plant. On paddy crop, the P element is essential when accelerating the maturity of the grain filling. The P element is a necessary constituent of adenosine diphosphate (ADP). It plays a role in the energy transfer process, and adenosine triphosphate (ATP) directly plays a role in the energy storage process. The explanations above confirm the importance of the P Element of the paddy corp which accelerates the process of flower formation and grain ripening.

The N and K requirements increased with increasing daily average temperature, solar radiation, N and K fertilizer rate, soil total N, Exchanged-K and organic matter content, total rainfall, and potential evapotranspiration the rice-growing season and decreased with increasing growth duration and harvest index [6]. K application promoted early flowering by 1–3 days. The higher the application rates of K fertilizer, the earlierthe flowering starts. The use of P and K fertilizers had no significant effects on the duration of rice flowering. The above evidence indicated that fertilization was vital to regulating flowering in rice production [27]. Higher corp harvest index leads to the increased dry weight of grains of each clump of paddy crop. More over, the carbohydrate formatted in photosynthesis, the more organic metabolic stored in the seeds. Food reserves (carbohydrate) can be stored in organ crops, namely leaves, stem, and root, in a vegetative phase. In the generative phase, this carbohydrate will move to seeds filling (grain). The K element can stimulate carbohydrate translocation from leaf to the other organ crop.

The use of a dose of 320 kg ha-1 NPK Phonska can produce a harvest index of 0.53 and is not significantly different from a dose of 480 kg ha-1. The proper application of NPK nutrients can help translocation and storage of carbohydrates so that the harvest index can reach a maximum. The fruit filling is needed during the generative phase. Therefore, it requires the stored carbohydrate from photosynthesis during the production phase. Seeds filling period requires higher organic metabolic that occurrs at the maximum process of photosynthesis. The NPK fertilizer influences the number of carbohydrates stored by crop (stored capacity).

CONCLUSIONS

1. NPK fertilizer was significantly affected on tillers number, leaf area, shoot dry weight, roots dry weight, and dry weight of crop stover, except for the shoot root ratio. The application of NPK fertilizer on paddy of Ciherang variety could increase the tiller numbers, leaf area, shoot dry weight, roots dry weight, dry weight of crop stover, grain dry weight, and harvest index.
2. NPK fertilizer has a significant effect on the dry weight of grains and harvest index, except for panicle length. The optimum dose of NPK fertilizer on the grains dry weight was at 656 kg ha^{-1} and given the maximum of the dry weight of grains was 4.26 tons ha^{-1} milled dry grain.
3. In the future, the research results can be applied by farmers to Alluvial soil by using a compound NPK fertilizer dose of around 656 kg ha^{-1} to obtain maximum rice yields of Ciherang variety in Alluvial soil.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No human or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

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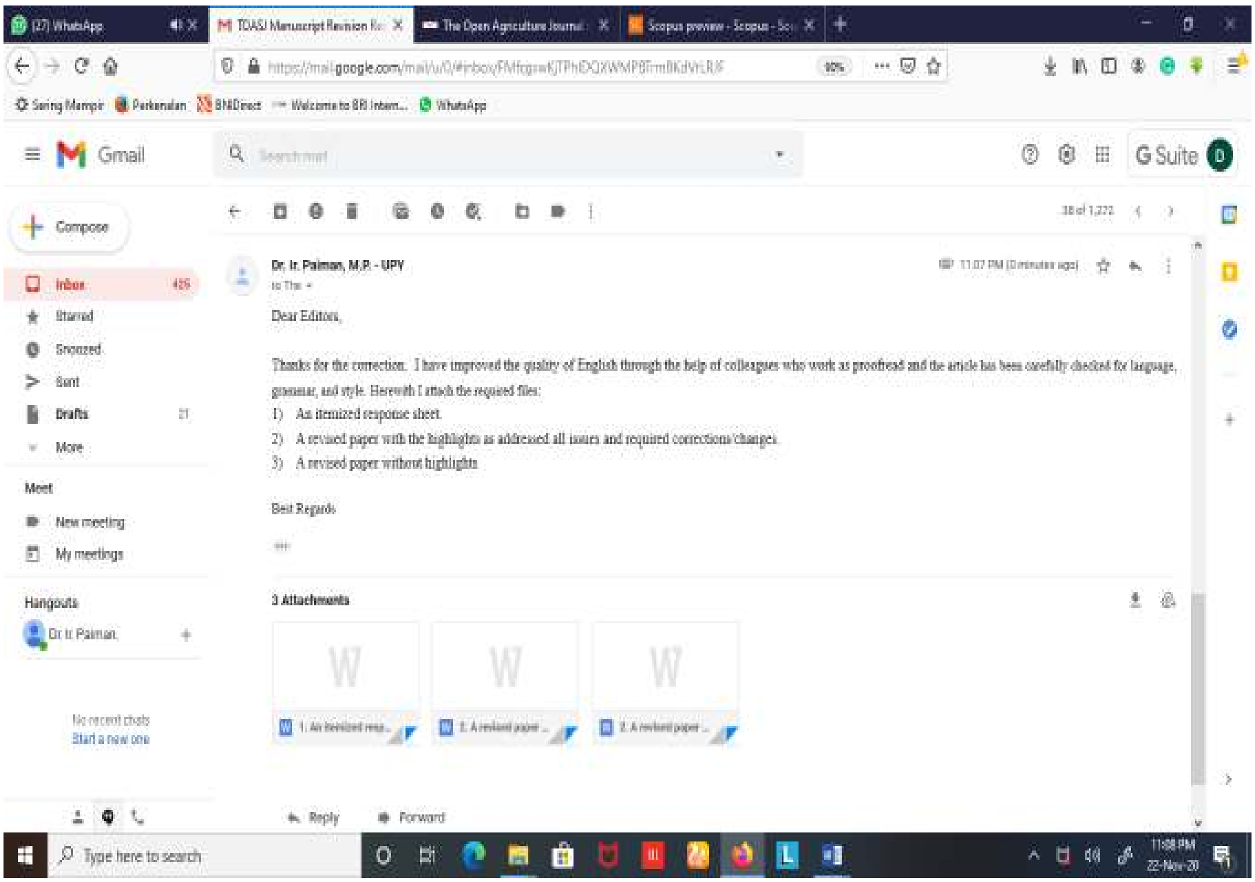

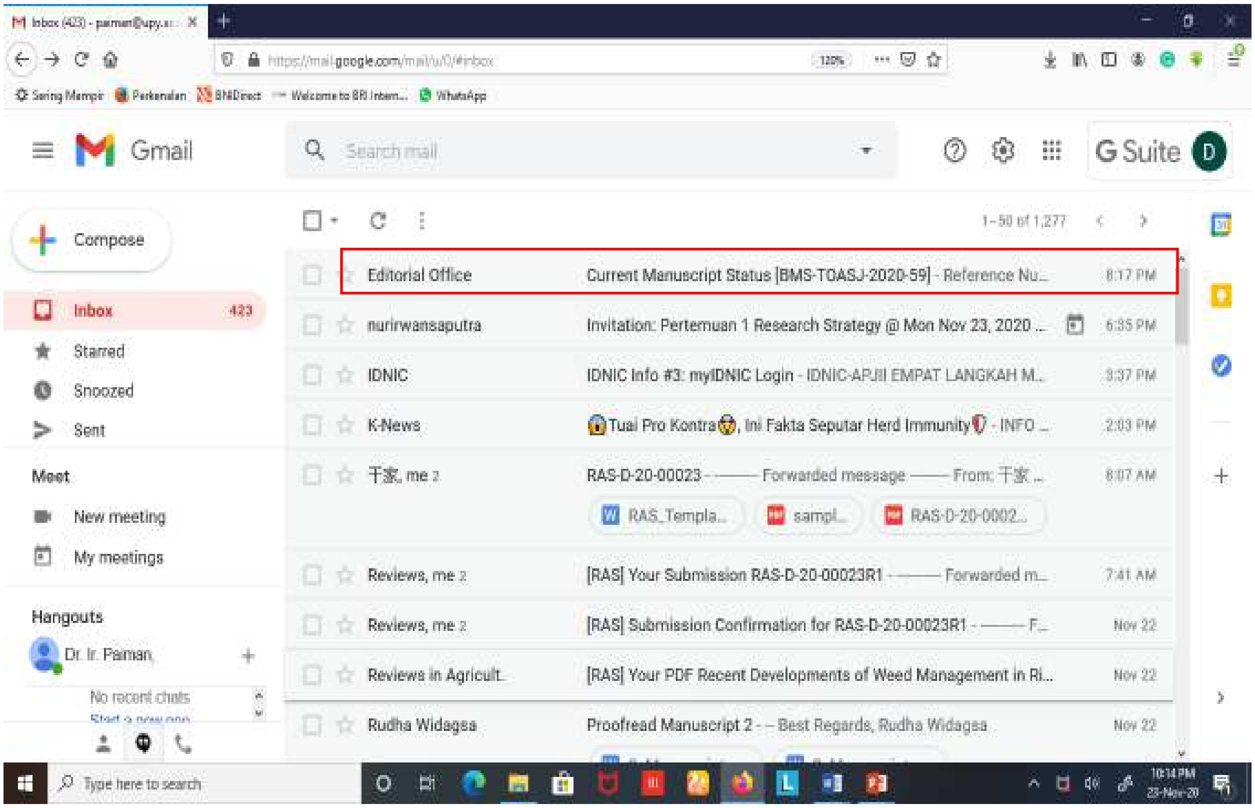

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Dear Dr. **Paiman Paiman**

This is to update you about your manuscript entitled **"Maximizing The Rice Yield (Oryza Sativa L.) Using NPK Fertilizer"** submitted to the journal **"The Open Agriculture Journal"**. Your manuscript is currently in **"REVISION REQUIRED"** stage.

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Thank you very much for submitting your revised manuscript, BMS-TOASJ-2020-59. We hope to successfully collaborate with you in the future as well. Please do let us know if you face any issues.

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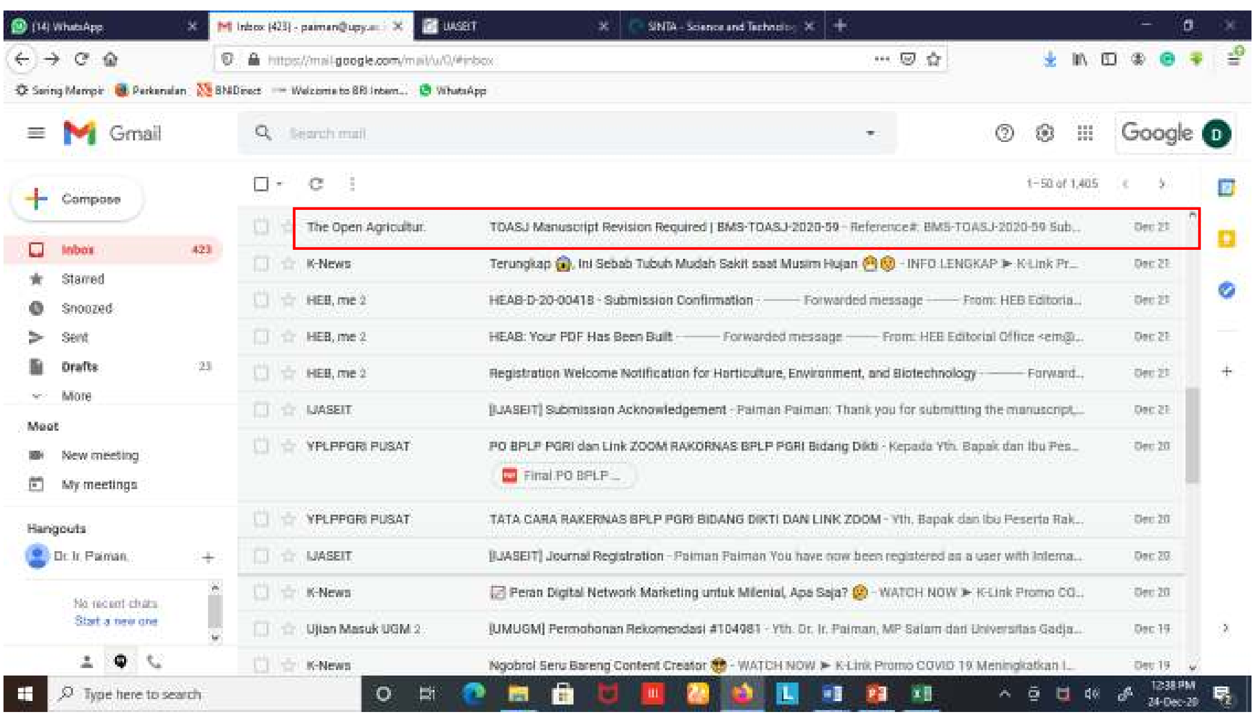

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Submission Title: Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer

Dear Dr. Paiman Paiman,

Thanks for submitting the manuscript to "The Open Agriculture Journal". Your manuscript has been reviewed by experts in the field, and it needs substantial revision (comments given below/ attached). You are encouraged to carefully revise the manuscript, highlighting the exact changes made.

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Reviewer Comments:

The article entitled "Maximizing the rice yield (Oryza

sativa L.) using NPK fertilizer" suggested for publication in "The Open

Agriculture Journal"

can not be recommended for publication in its present state.

1.The introduction is too long and contains a lot of unnessesary and

well-known information about the role of NPK in plant life. The novelty

is still poorly stated.

2. English is substantially improved, bit not throughot the whole text.

For example in the conclusion: "NPK fertilizer was significantly

affected on tillers number, leaf area..."

3. Conclusion is made that "The optimum dose of NPK fertilizer on the

grains dry weight was at 656 kg ha-1...", but tested doses were 0, 160,

320, and 480 kg ha-1. Such extrapolations are not accepted in this type

of research.

4. Again it is not clear was was used as a control. If it was NPK dose 0

kg per ha, then why we read in the abstract "The results of the research

showed thatthe application of NPK fertilizer could increase the growth

and yield of rice plants COMPARED TO ONLY PROVIDING UREA FERTILIZER".

5. Discussion is too long and partly repeat the Introduction.

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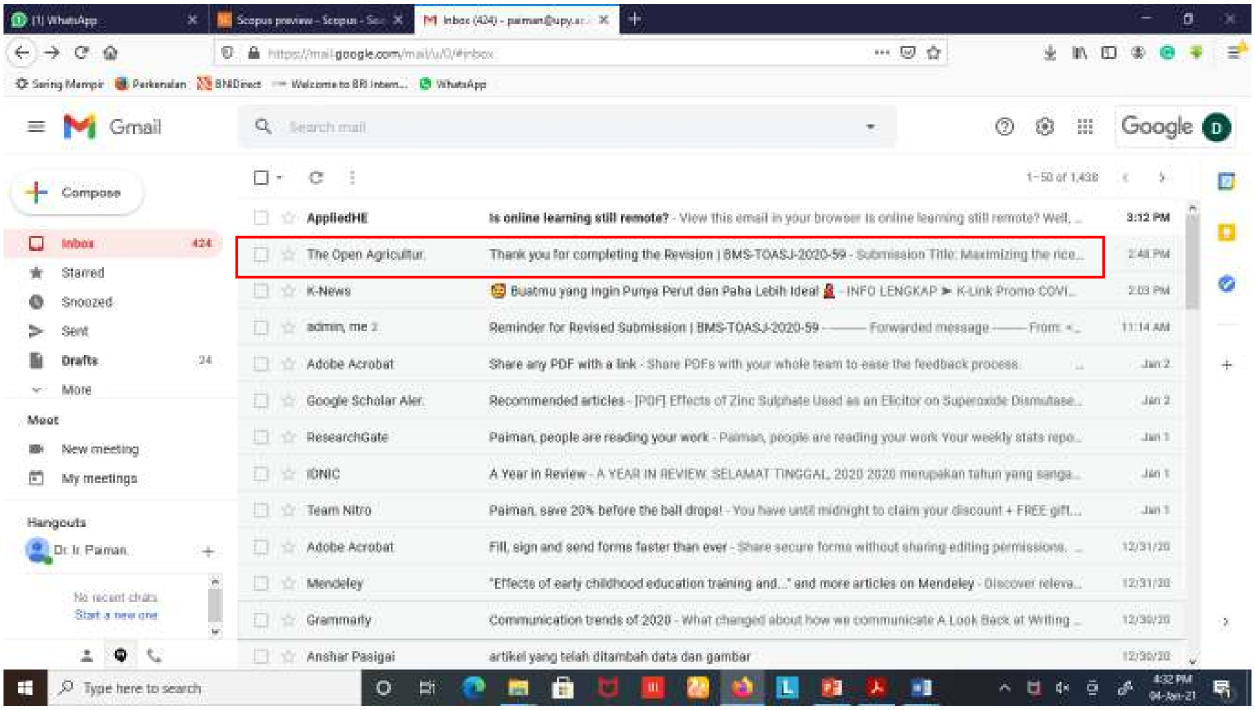
AN ITEMIZED RESPONSE SHEET (2)
To Reviewer Comment

We have revised the manuscript according to reviewer suggestions and highlighted changes that were added. We've enlisted the help of native English speakers to check the language, grammar and style of this article. In the following, we attach responses to article improvements based on suggestions from reviewers.

Reviewer Comments: The article entitled "Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer" suggested for publication in "The Open Agriculture Journal" can not be recommended for publication in its present state.		
1. The introduction is too long and contains a lot of unnessesary and well-known information about the role of NPK in plant life. The novelty is still poorly stated.	Y	• We have improved the introduction by eliminating insignificant information. NPK Mutiara fertilizer is a new compound fertilizer that has not been widely studied for its use on marginal soils.
2. English is substantially improved, bit not throughot the whole text. For example in the conclusion: "NPK fertilizer was significantly affected on tillers number, leaf area..."	Y	• We have fixed the conclusion. The application of a dose of NPK Mutiara fertilizer in Alluvial soil could increase the growth and yield of the Ciherang rice. In this study, higher grain dry weight results were achieved at NPK Mutiara fertilizer dose of 480 kg ha.
3. Conclusion is made that "The optimum dose of NPK fertilizer on the grains dry weight was at 656 kg ha-1...", but tested doses were 0, 160, 320, and 480 kg ha-1. Such extrapolations are not accepted in this type of research.	Y	• Thank you for your input. We have corrected the conclusion and removed the extrapolated results. We replace it with the conclusion. In this study, higher grain dry weight results were achieved at NPK Mutiara fertilizer dose of 480 kg ha. In this study, optimum NPK fertilizer has not been found, so the next research needs to use a higher dose treatment, especially rice cultivation in alluvial soils.
4. Again it is not clear was was used as a control. If it was NPK dose 0 kg per ha, then why we read in the abstract "The results of the esearch showed thatthe application of NPK fertilizer could increase the growth and yield of rice plants COMPARED TO ONLY PROVIDING UREA FERTILIZER".	N	• Urea was not a treatment, because all plants in the experiment were treated or given urea fertilizer at the same dose. The control we mean is without the application of NPK Mutiara fertilizer.
5. Discussion is too long and partly repeat the Introduction.	Y	• Thank you for the input. We have reduced the irrelevant discussion in this section. We have omitted some repetitions of the discussion from the introduction.



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Submission Title: Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer.

Dear Dr. Paiman,

Thank you very much for submitting your revised manuscript, BMS-TOASJ-2020-59. We hope to successfully collaborate with you in the future as well. Please do let us know if you face any issues.

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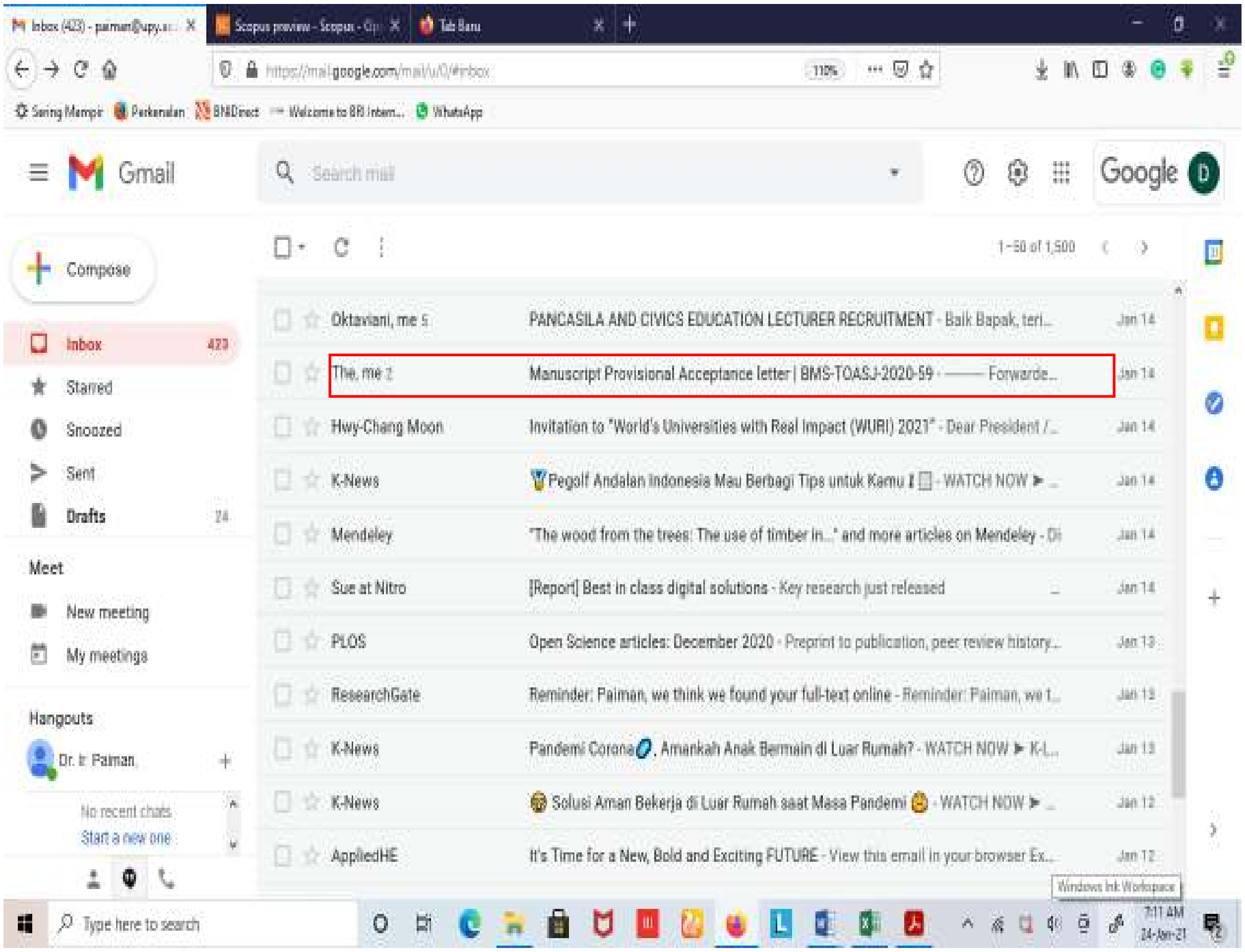

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Dear Dr. Paiman Paiman,

I am pleased to inform you that your article Reference No. BMS-TOASJ-2020-59, entitled **"Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer"** has been provisionally approved for publication in "**The Open Agriculture Journal**" journal.

You will now need to pay the processing fee, either via the online payment link in the invoice sent to you or, via a bank transfer (evidence of which would need to be sent to us), before your article is published.

Please note that the final acceptance of your article is subject to a detailed scrutiny and approval of the following:

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b. "IMRAD" Structure: Headings such as Introduction/background, Methods and Materials, Experimental, Result and Discussion are mandatory for research articles.

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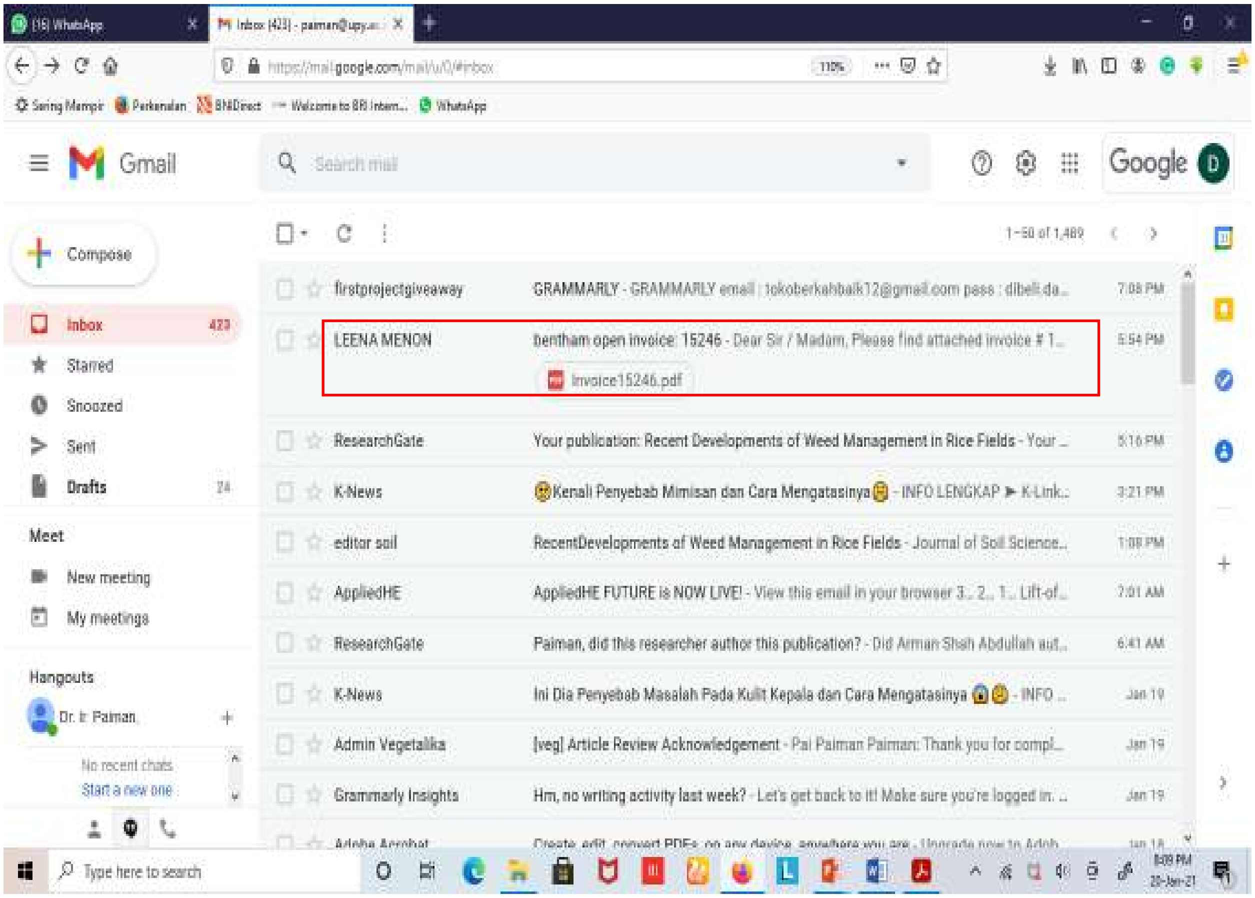

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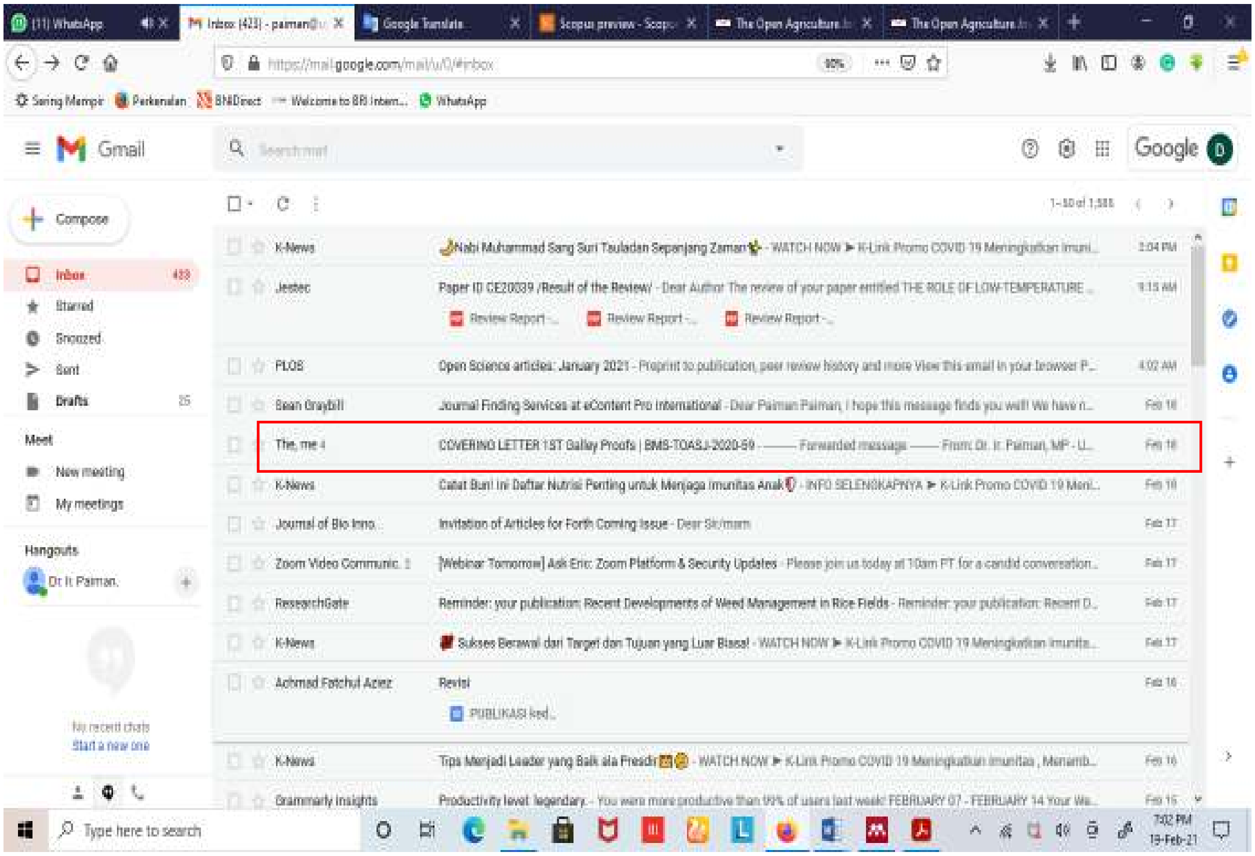

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Final revision of manuscript:

Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer

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Abstract:

Background:

Rice has become a primary daily necessity for mostly Indonesian population. The upsurge of national rice production can be done by agricultural intensification through the application of NPK fertilizer.

Objective:

This study aimed to determine the optimum dose of NPK Mutiara fertilizer, which could provide the highest rice yield of Ciherang variety in Alluvial soil.

Methods:

This study was a single factor arranged in a completely randomized design (CRD) with three replications. The NPK Mutiara fertilizer treatment consisted of four doses, i.e., 0, 160, 320, and 480 kg ha^{-1}. The data observations were analyzed by using analysis of variance (ANOVA) at 5% significance levels. The difference between the averages of the treatment was compared using Duncan′s new multiple range test (DMRT) at 5% significance levels.

Results:

The results of the research showed that the application of NPK Mutiara fertilizer could increase the growth and yield of the Ciherang variety in Alluvial soil. The quadratic regression analysis revealed that the optimum dose of NPK Mutiata was obtained at 656 kg ha^{-1} and was given the maximum grains dry weight of 4.26 tons ha^{-1}. The application of NPK Mutiara fertilizer could not affect the shoot root ratio and panicle length.

Conclusion:

The findings of the study suggest that the application of NPK fertilizer interval has not reached the optimum dose in Alluvial soils for Ciherang variety. Therefore, application of NPK Mutiara fertilizer with doses higher than 480 kg ha^{-1} is required for alluvial soils.

Keywords: Optimum dose, NPK fertilizer, Growth, Yield, Rice, Ciherang variety.

Running title: Maximizing the rice yield using NPK fertilizer

1. INTRODUCTION

In 2060, the global population is expected to reach 10 billion, and the demand for staple food supplies particularly rice increases accordingly. On the other side, rice production relies heavily on chemical fertilizers to meet the food demands of the increasing population [1]. Rice is widely consumed as source of calories and a veritable source of calories [2], and it was consumed by nearly half of the world population. Likewise, In Indonesia, rice is a staple food for most of the Indonesian population. The demand for rice by the Indonesian population continues to grow from year to year [3]. Indonesia′s rice import volume in January-November 2018 surged 2.2 million tons compared to January-December 2017, which only reached 305.75 thousand tons [4]. The data illustrates that the national rice production has not been able to meet the needs of the Indonesian population. Considering all of this evidence, it seems that the rice cultivation in Indonesia should be optimized through the use of superior rice varieties.

One of the Indonesian superior rice varieties is Ciherang. It is a new superior variety that is adaptable to the Indonesian environment. Ciherang varieties have advantages over other varieties. This rice variety has a profitable high yield and a taste that meets the demand of the market. The potential productivity of Ciherang is 6.0 to 8.5 tons ha^{-1} of the dry weight of grain, and crop age is 116 to 125 days after planting (DAP). In addition, this rice crop is resistant to brown planthopper biotype 3, bacterial left blight resistance, and brown planthopper biotype 2 [5]. However, to obtain high yields, this rice variety requires the fulfillment of macro fertilizer such as NPK. Many choices of NPK fertilizers are available in the farmer's environment.

Estimating crop nutrient requirements are essential for informing decisions of optimal nutrient management. However, the nutrient requirements often vary depending on climates and soil conditions [6]. Nitrogen, phosphorus, and potassium are important macronutrients for plant growth and development [1]. The fertilizer as source nutrients is a material of production which plays an important role in improving rice productivity. There are many fertilizers on (in) the market. However, farmers prefer NPK Mutiara fertilizer. NPK Mutiara fertilizer is one type of compound fertilizer with at least five elements nutrients of macro and micro. The fertilizer is granular in a faded blue color contains of 16% N (nitrogen), 16% P_2O_5 (phosphate), 16% K_2O (potassium), 0.5% MgO (magnesium), and 6% CaO (calcium). Henceforth the fertilizer is called NPK Mutiara (16-16-16) fertilizer. The nutrients element of N, P, and K are macronutrients needed by plants. The N element in the crop functions as a leaf-forming substance (chlorophyll) and protein-forming elements. The P element functions as energy storage and transfer constitute an essential component in nucleic acids, coenzymes, nucleotides, phosphoprotein, phospholipid, and sugar-phosphate. The K element works in starch formation, activating enzymes, and catalyst storage of photosynthesis products [7]. Nitrogen could absorb plants in the form of NO_3^- and NH_4^+ ions.

The N element has a vital role on (role for) rice crops, i.e., it encourages faster crop growth, improves grain yield and quality by increasing tillers number, leaf area development, grain formation, grain failing, and protein synthesis. Rice plants that are deficient in N have fewer tillers, have stunted growth, have yellowish-green leaves, and begin to die from the top and then spread to the middle of the leaf blade. If the N element is excessively given, it will result in detriment, such as weakening straw, causing the crop fall, and decreasing the rice yield quality [8].

The P element function in the crop plays a role in photosynthesis, respiration, transfer and energy storage, cell division and enlargement, and internal operation of other crops. The plant absorbs the big section of the P element in the form of primary orthophosphate ion (H_2PO_4) and the small number in secondary orthophosphate ion (HPO_4^{-2}). The P element is essential in seed formation, helps accelerate root development and germination, improves water efficiency, and increases power resistance to diseases that ultimately enhance the harvest quality. The deficiency of the P element potentially causes maturity delay and ~~reduces~~ (reduced) seed filling [9]. The P element is a constituent of adenosine triphosphate (ATP). The P element directly plays a role in energy storage and transfer and activities involved in crop metabolism. The P element is highly required by rice, especially at the beginning of the growth, because it can support the root formation and additives' number and accelerate flowering and grain maturity [10].

The K element is the third essential nutrient after N and P. Crops absorb the K element in the soil in the form of K^+ ions. This element performs as an activator of many enzymes participating in several crop metabolism processes, including photosynthesis. If the nutrient of K deficiency occurs, it will cause a decrement in photosynthesis and respiratory disorders. This occurrence eventually dampens carbohydrate production. The K element function is essential in protein synthesis, solving carbohydrates, the process of energizing crops, translocation of heavy metals such as Fe, resistance to disease disorders, fruit formation, and regulates the opening and closing of guards cell in leaf stomata [11]. K element deficiency symptoms are indicated by the burning of leaves from the edges, necrotic patches brown on old leaves and stems.

NPK fertilization has a significant effect on crop height, the tillers number, panicle number per clumps, total grain per panicle, percentage of the empty and filled with grain per panicle, the weight of 1,000 grain, and the potential yield of grain per hectare [12]. The optimum rate of NPK Phonska (15-15-15) fertilizer was 440 kg/ha, as shown with the production performance of 4.12 tons ha^{-1}. The NPK Phonska (15-15-15) fertilizer effectively elevates the growth and grain dry weight, equivalent to standard NPK at the dose of 300-750 kg ha^{-1} [7]. The application dose of 550 kg ha^{-1} NPK Phonska fertilizer gave the highest yield on the total number of grains (174.58 seeds), number of filled grains (144.67 seeds), and grain yield (85.33 g) per rice clump [13].

Rice cultivation can be done in various of soil types. Alluvial soil is land that can be utilized, but it needs to add higher fertilizer input than fertile soil types. According to Bullinger-Weber and Gobat [14], alluvial soil(s) ~~is~~ are ~~the~~ land plains resulting from the process of deposition and erosion due to flooding so that its characteristics will reflect the composition and properties of the material transported.

Referring to the existing literature, knowledge about NPK fertilizer has significant implications in increasing the growth and yield of rice. Therefore, this study intends to determine the optimum dose of NPK Mutiara fertilizer, which can provide the highest rice yield of Ciherang variety in Alluvial soil.

2. MATERIALS AND METHODS

2.1. Study Area

The study was conducted from February to June 2019. This research was located in a greenhouse facility, Faculty of Agriculture, Universitas PGRI Yogyakarta, Indonesia. The particular territory of Yogyakarta having an elevation of 118 m above means sea levels in the position S 7° 33′ – 8° 12′ and E 110° 00′ – 110° 50′.

2.2. Experiment Design

This study was s single factor and arranged in CRD with three replications. The NPK Mutiara fertilizer treatments have consisted of four levels, i.e., 0, 160, 320, and 480 kg ha^{-1}. Each replication consisted of five samples and needed $4 \times 3 \times 5 = 60$ polybags.

2.3. Research Procedures

The soil type used in this research was Alluvial soil. The media planting was made from the soil of 15 kg and cow manure of 1.5 kg or the ratio of 15:1.5. The combination of soil and manure were mixed into one media before putting into a polybag in size of 40 cm × 40 cm. The Ciherang variety was used in this research. The seedlings were done in plastic tubs germination. The seeds of rice were spread on the media surface and covered with a thin soil layer. Watering the media was done to keep the field capacity. Two weeks after seeding, the rice seedlings were planted in the soil as deep as 3 cm. Each planting hole was planted with two rice seedlings. Plant spacing between polybag was

25 cm × 25 cm measured from the midpoint polybags, then the plants' number is 160.000 clumps ha^{-1}. The water ~~was~~ is supplied in the polybags until waterlogging. The urea fertilizer was applied for all treatments as many as 160 kg ha^{-1} in the age of 14 DAP. An addition of NPK Mutiara (16-16-16) fertilizer was applicably suitable for the treatments in the age of 42 DAP. The anticipation of pest attacks of brown ~~plant-thoppers was~~ planthopper is done by applying Temin pesticides.

2.4. Parameters

The observation was done on the rice growth, including the tillers per clumps, leaf area, shoot dry weight, roots dry weight, stover dry weight, and shoot-root ratio. The rice yield was observed, including panicle length, grain dry weight of grain, and harvest index. Harvest index is grain dry weight (economic yield) divided by overall crop dry weight (biological yield, including the dry weight of grains).

2.5. **Statistical Analysis**

The data were analyzed using ANOVA at 5% significance levels [15] with IBM SPSS Statistic 23. The treatment means were compared using DMRT at 5% significance levels.

3. RESULTS

3.1. Component of the Rice Growth

The ANOVA showed that NPK fertilizer was significantly affected on tillers number, leaf area, shoot dry weight, roots dry weight, and stover dry weight, except shoot root ratio. The results of DMRT at a 5% significant level on the component of rice growth are presented in Table 1.

Table 1. The effect of NPK on the component of rice growth.

Parameters	**Doses of NPK fertilizer (kg ha^{-1})**			
	0	**160**	**320**	**480**
Tillers number (stem clump^{-1})	29,0 c	34,3 bc	42,5 ab	44,7 a
Leaf area (cm^2 Clump^{-1})	825.3 b	1,173.5 a	1,320.2 a	1,405.1 a
Shoot dry weight (g clump^{-1})	10.59 c	13.02 bc	15.33 ab	16.85 a
Root dry weight (g clump^{-1})	3.2 c	4.52 bc	5.35 ab	6.29 a
Shoot root ratio	3,30 a	2,89 a	2,86 a	2,69 a
Stover dry weight (g clump^{-1})	13.8 c	17.55 bc	20.76 ab	22.76 a

Remarks: The numbers tailed by the same characters in the same row are not significantly different at 5% significance levels ($p < 0.005$) based on DMRT.

Table 1 shows that compound NPK fertilizer application could increase rice growth compared to control (treatment of 0 kg ha^{-1} NPK), except for the shoot root ratio. The dose of NPK fertilizer of 480 kg ha^{-1} produced the highest number of tillers and ~~it was~~ significantly different from 160 kg ha^{-1} and control, but not significant with 320 kg ha^{-1}. There was a decrease of tillers number in the 160 kg ha^{-1} and the lower in 0 kg ha^{-1}. There was no significant difference in leaf area between the dose of 160, 320, and 480 kg ha^{-1}, but all three treatments significantly different from the control. The use of NPK fertilizer in the dose of 480 kg ha^{-1} produced the highest root dry weight, ~~which was~~ and significantly different from 160 and 0 kg ha^{-1}, but not significant with 320 kg ha^{-1}. Table 1 also explains that the highest dry weight of shoots, roots, and stover was achieved in applying NPK fertilizer at a dose of 480 kg ha^{-1}.

3.2. Component of the Rice yield

The ANOVA showed that the NPK fertilizer significantly affects the grains dry weight and harvest index, except panicle length. The results of DMRT at a 5% significant level on grain dry weight and harvest index are presented in Table 2.

Table 2. The effect of NPK fertilizer on the component of rice yield.

Parameters	Doses of NPK fertilizer (kg ha^{-1})			
	0	**160**	**320**	**480**
Panicle lenght (cm)	20.2 a	20.4 a	21.5 a	21.8 a
Grains dry weight (ton ha^{-1})	1.69 c	2.68 b	3.68 a	4.04 a
Harvest index	0.43 b	0.48 ab	0.53 a	0.53 a

Remarks: The numbers tailed by the same characters in the same row are not significantly different at 5% significance levels ($p < 0.005$) based on DMRT.

The application of NPK fertilizers was able to increase rice yields, except for panicle length. The dose of 320 and 480 kg ha^{-1} produced higher grains dry weight, and ~~it was~~ significantly different from 160 kg ha^{-1} and control 0 kg ha^{-1}. The grains dry weight was lower in the dose of 160 and 0 kg ha^{-1}. The application of more from 480 kg ha^{-1} could also increase the grain dry weight. From the correlation between NPK fertilizer and grain dry weight, the optimum NPK dose can be determined based on quadratic regression. The optimum NPK is obtained from the first derivative of the quadratic regression equation.

The quadratic regression analysis result shows that the effect of NPK fertilizer ~~effected~~ on grain dry weight has obtained $y = -6E\text{-}06\ x^2 + 0.0079\ x + 1.6635$, and the coefficient of determination (R^2) of 0.99. The first derivative of the quadratic regression obtained the optimum dose of NPK fertilizer of 656 kg ha^{-1} and given the grains dry weight of 4.26 tons ha^{-1}. The quadratic regression curve is made from the NPK fertilizer effects on the grain dry weight (Fig. **1**).

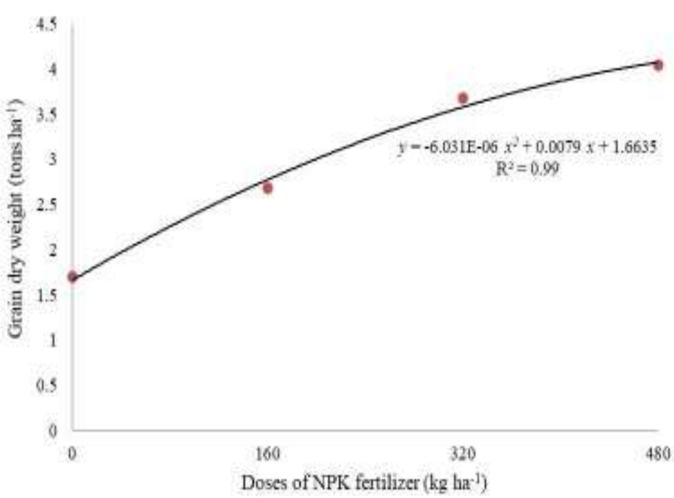

Fig. (1). The effect of NPK fertilizer on the dry weight of grains.

The highest harvest index was obtained ~~by~~ at NPK fertilizer at a dose of 480 kg ha^{-1}. It was significant from other treatments, except with a dose of 320 kg ha^{-1}. The harvest index was lower in control. The quadratic regression result showed that NPK fertilizer effect on harvest index was obtained $y = -4.8E\text{-}07\ x^2 + 0.00043\ x + 0.4337$, and coefficient of determination (R^2) of 0.99. The first derivative of quadratic regression obtained the optimum dose of NPK at 445.7

kg ha⁻¹ and resulted in the harvest index of 0.53. The quadratic regression curve is made from the NPK fertilizer effect on the harvest index (Fig. **2**).

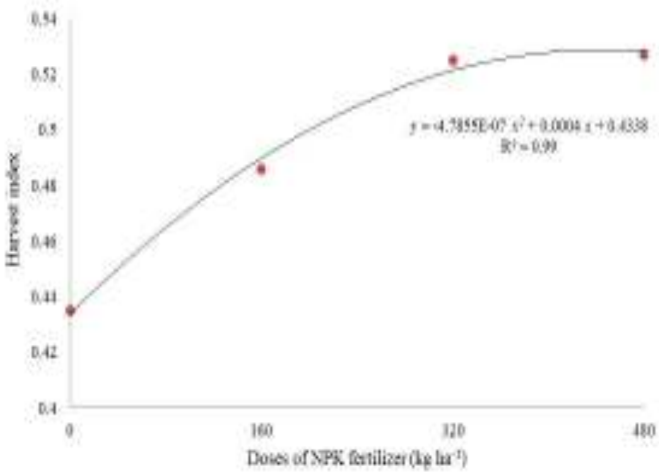

Fig. (2). The effect of NPK fertilizer on harvest index.

4. DISCUSSION

4.1. Components of Rice Growth

It was clearly explained that the dose of 480 kg ha⁻¹ NPK Mutiara fertilizer could increase rice growth of the leaf area, tillers' number, shoot dry weight, root dry weight, and strove dry weight, although it is not significantly different from the application of a dose of 320 kg ha⁻¹. The results of this study indicate that NPK fertilizer doses of more than 480 kg ha⁻¹ can still increase rice growth. Rice cultivation in Alluvial soils requires the addition of a higher dose of NPK fertilizer due to the low fertility of the soil. The maximum rice growth requires high NPK fertilizer input compared to the previous studies. These findings are in line with Ginting [16], the highest number of tillers was obtained in the NPK fertilizer 400 kg ha⁻¹.

The application of NPK fertilizer in the soil will ~~increased~~ increases the N content in the soil. N addition frequently stimulates plant growth more than the long-term N effect. Legacy of N tends to be only beneficial for non-N fixing plants in medium-aged soils [17]. N element is needed in large quantities for the shoot and vegetative growth of rice. The N element plays a significant role in forming meristem tissue, stimulates branch, leaf, and shoots. The availability of sufficient N nutrients by applying the proper NPK fertilizer will produce a better crop growth phase. The N element ~~supported~~ supports the leaf growth wider, then the leaf area more full for the capture of sunlight in the photosynthesis process [18]. Leaves are the site of photosynthesis and describe the actual production capacity of the crop. Subsequently, carbohydrates could affect the growth, yield, and economic value of the plant. The more full leaves of the plant, followed by increasing chlorophyll content, support the photosynthesis process. The optimum leaf area produces maximum carbohydrate. The N element application sufficiently caused by the increase of shoot growth hence endorses the development of tillers number, stem, and leaf to the maximum. This optimal growth of the rice will automatically produce higher shoot dry weight.

NPK fertilizer could accelerate, multiply, strengthen, and extend crop roots so that roots will easily absorb nutrients to the soil. The content of the K element in NPK fertilizer is capable of spurring root development and affecting the absorption of ingredients other nutrients. The existence of K and P elements in the soil can control root formation, cleavage, and meristem culture, which maximize the root growth. The P element content plays an important role when forming rice tillers. The P element for the plant functions is as a developmental material of nucleoprotein in every cell core. Thus, it plays a role in forming new cells, including the formatting of prospective rice tillers. The P element is available in the soil. The roots will more absorb it. The P element is part of the cell core. Therefore, it is essential in cell division and development meristem networks to stimulate crop roots growth, especially lateral roots, and hair roots, to absorb a higher amount of nutrients. Hence, it results in higher rice tillers. The number of tillers is one of the determining components in rice production per hectare.

4.2. Components of Rice Yield

Based on the results of this study, the application of NPK Mutiara fertilizer can increase the production of dry grain weight per hectare. The application of NPK fertilizer at a dose of 480 kg ha^{-1} can give a yield of 4.04 tons ha^{-1} in Ciherang rice varieties on Alluvial soil. The estimation results show that the highest production of milled dry grain weight is 4.26 tons ha^{-1}, and the optimum dose of NPK fertilizer is 656 kg ha^{-1}. However, the soil type will also determine the production of Ciherang rice varieties. Therefore, a higher dose of NPK fertilizer on marginal soils is highly required. It is proven that the maximum of milled grain dry weight was obtained at 656 kg ha^{-1} and higher than the previous studies. The optimum dosage for the NPK fertilizer is also determined by the soil types where the rice is cultivated. Hartatik's study [7] showed the NPKS optimum dose of 440 kg ha^{-1} produced milled dry grains weight of 4.12 tons ha^{-1} in Inceptisols soil and Shanti's work [19] provided the data that the dose of 300 kg ha^{-1} could produce 6.18 tons ha^{-1} in Ultisols soil. However, those previous studies were implemented in Inceptisols and Ultisols which have different characteristics from Alluvial soil. Alluvial soil is marginal soil with lower fertility than Inceptisols and Ultisols soil. Consequently, it requires more NPK fertilizer doses. The evidence presented thus far supports the idea that the increase of nutrients in Alluvial soil augments the dry weight of grain. In addition, the N, P, and K nutrients also support the soil metabolic process, which eventually affects the plant growth.

Plant reproduction and growth are processes that require energy from photosynthetic products [20]. NPK fertilizer can reduce the possibility of flower fall and seed loss due to increasing crop yield. Also, NPK fertilizer can intensify the photosynthesis of crops ~~wich~~ so result in higher carbohydrate formation. The P element performs as an element of protein compilers is needed for the support of flowers, fruit, and seeds [21]. The P element has the function to accelerate flowering and ripening of fruit and seeds or grain. The P element is a necessary constituent of adenosine diphosphate (ADP). It plays a role in the energy transfer process, and adenosine triphosphate (ATP) directly plays a role in the energy storage process. The explanations above confirm the importance of the rice crop's P element, which accelerates flower formation and grain ripening.

In accordance with the present results, some previous studies have demonstrated that the K element plays a role in metabolic processes, namely photosynthesis and respiration in crop growth. The K element regulates the balance of ions in the cell, which sets various metabolic mechanisms like photosynthesis, metabolism carbohydrates, and translocation. Synthetic protein plays a role in the respiration process [22]. The K application promoted early flowering by 1–3 days and regulating flowering in rice production [23]. A higher crop harvest index leads to the increased dry weight of grains of each clump of rice crop. More carbohydrate formatted in photosynthesis, the more organic metabolic stored in the seeds. Food reserves (carbohydrate) can be stored in organ crops, namely leaves, stem, and root, in a vegetative phase. In the generative phase, this carbohydrate ~~transfers~~ are transferred to seeds filling (grain). The K element can stimulate carbohydrate translocation from the leaf to the other organ crop.

By providing optimal NPK, the results of photosynthesis will be directed to fill seeds. The proper application of NPK nutrients can help translocation and storage of carbohydrates so that the harvest index can reach a maximum. The seed filling is needed during the generative phase. Therefore, it requires the ~~stored carbohydrate~~ carbohydrate storage from photosynthesis during the production phase. The seed filling period requires higher ~~organic metabolic~~ carbohydrate that occurs at the maximum process of photosynthesis. The NPK fertilizer influences the number of carbohydrates stored by the crop (stored capacity).

This section has attempted to provide a brief summary of the literature and the present study relating to the application of NPK Mutiara fertilizer in rice cultivation, different doses of NPK have been proposed to provide solutions ~~to~~ for increasing rice production. The present study was designed to determine the optimum dose of NPK Mutiara fertilizer on Ciherang rice variety.

CONCLUSIONS

Based on the research results and the discussion above, the conclusions derived from this study were as follows. The application of dose of NPK Mutiara fertilizer in Alluvial soil could increase the growth and yield of the Ciherang rice. In this study, higher grain dry weight results were achieved at a NPK Mutiara fertilizer dose of 480 kg ha. In this study, the use of optimum NPK fertilizer has not been found, so the next research needs to use a higher dose treatment, especially rice cultivation in alluvial soils.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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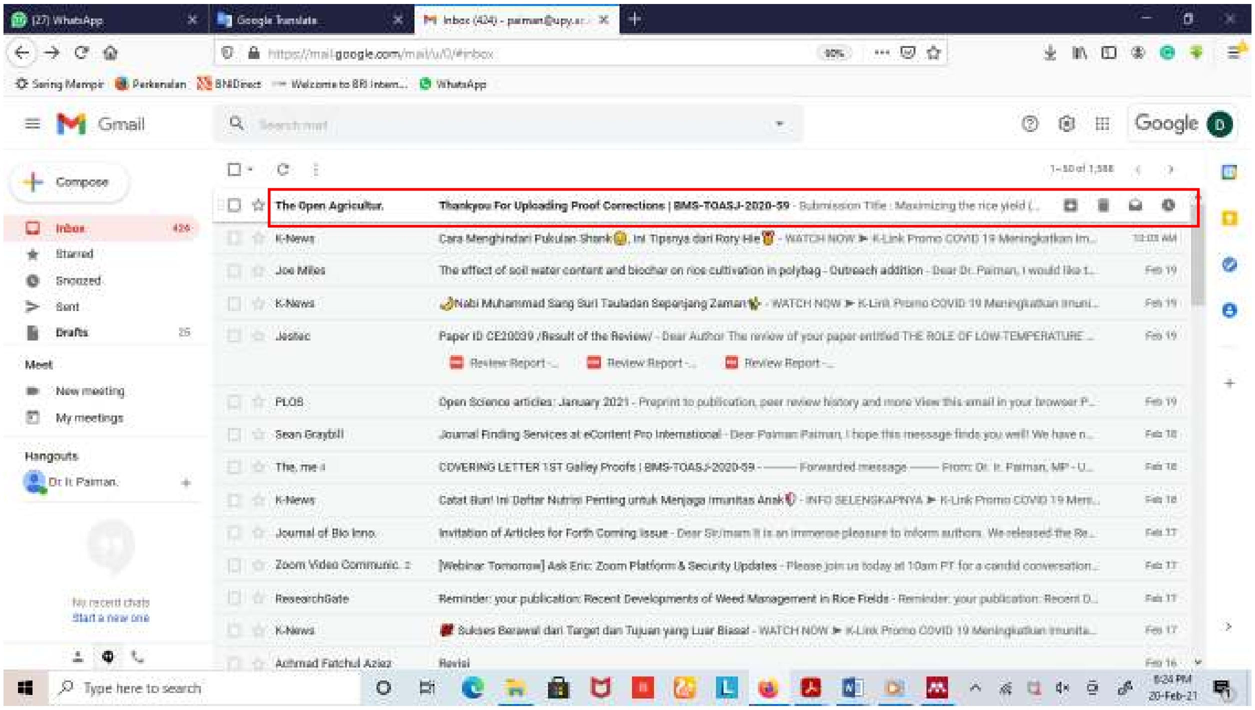

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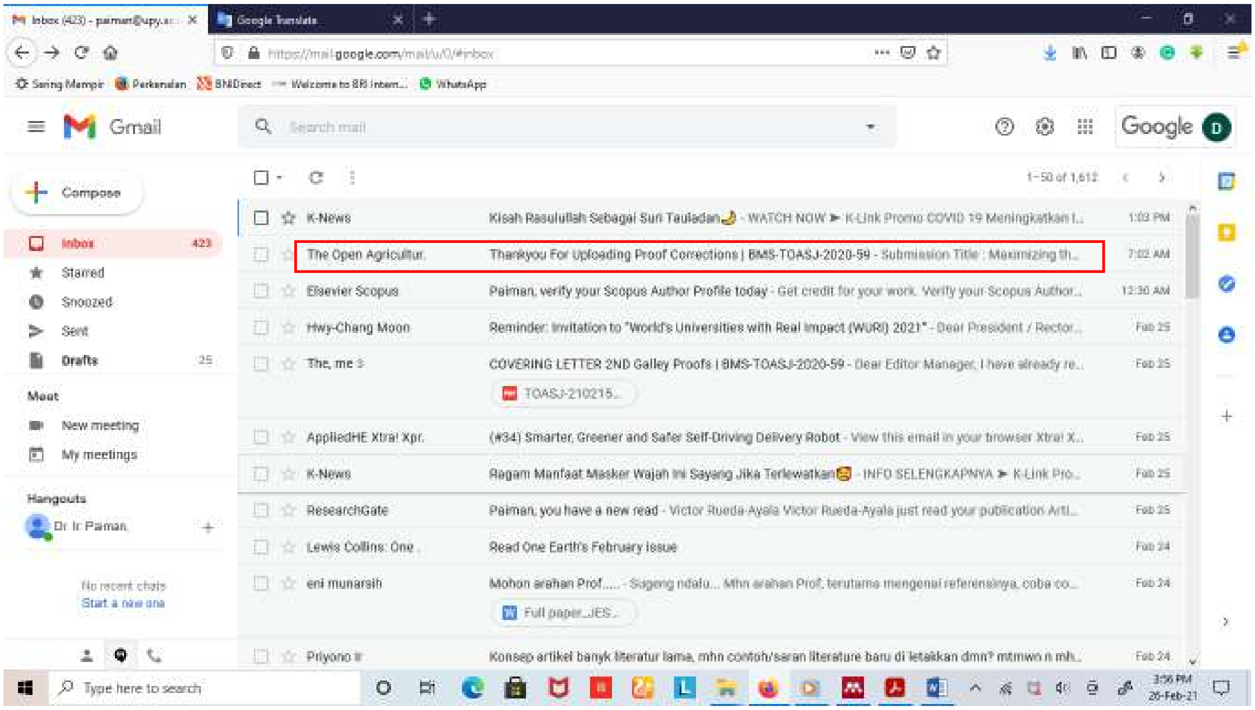

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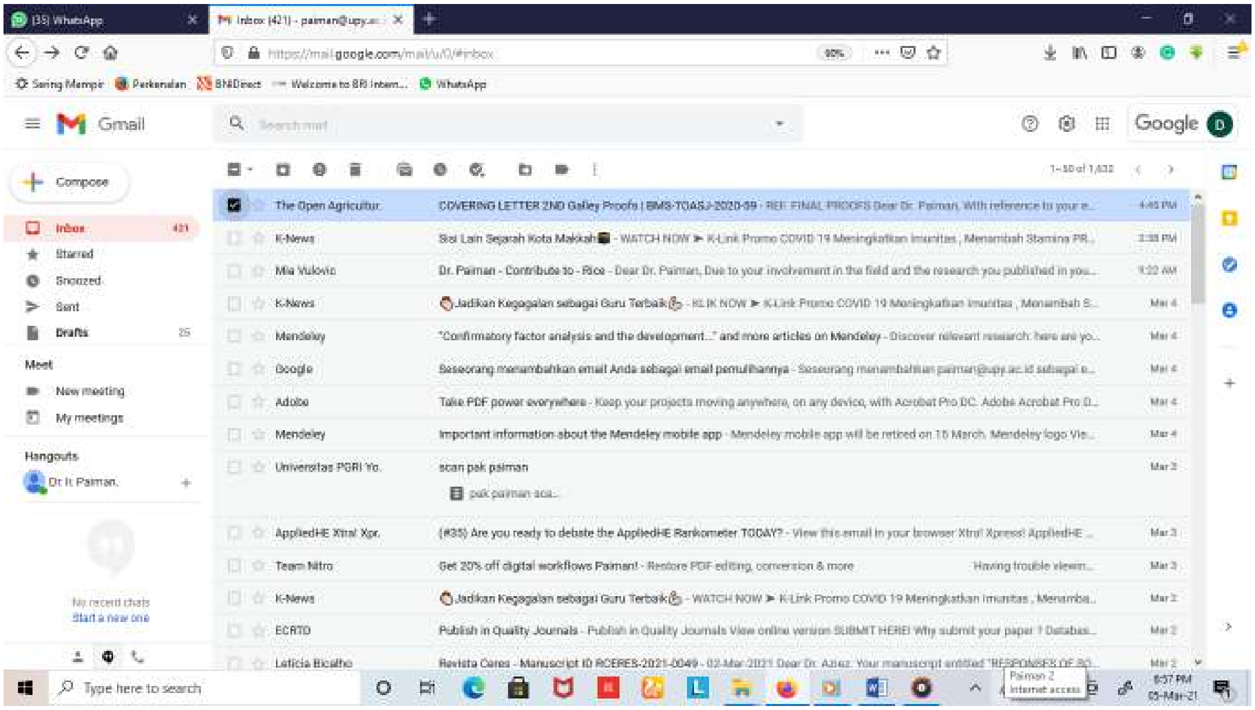

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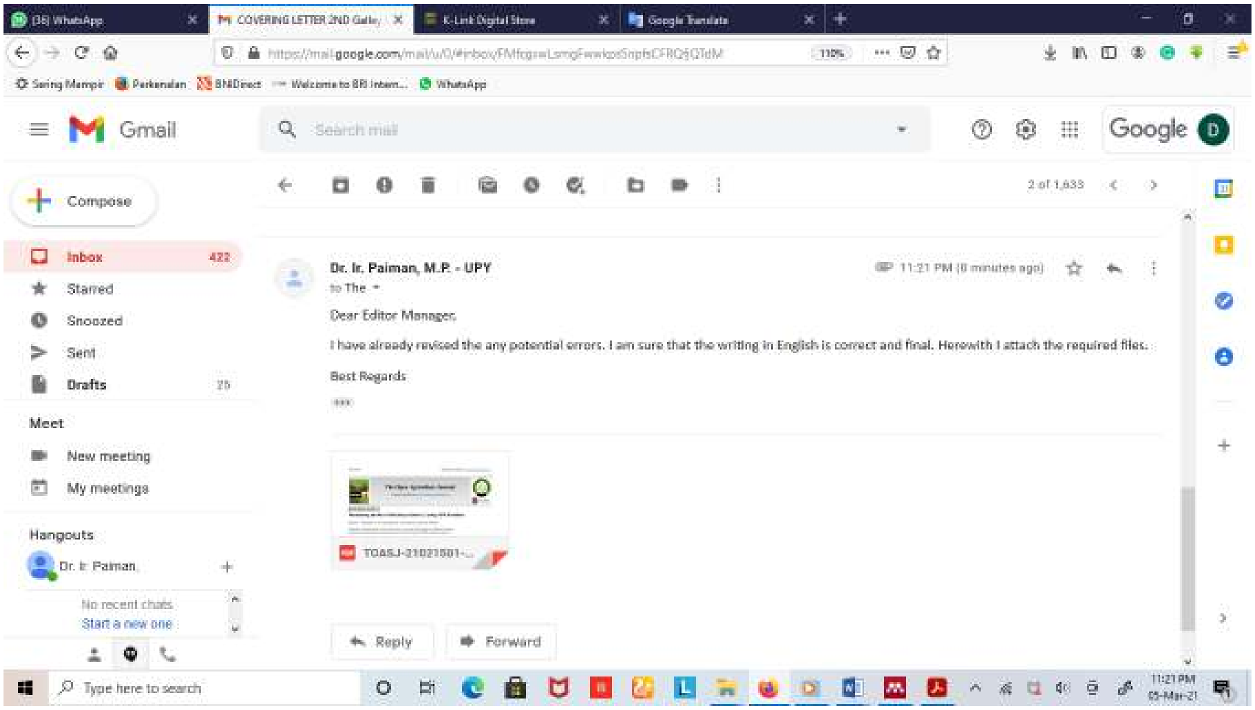

Maximizing the rice yield (Oryza sativa L.) using NPK fertilizer

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Abstract:

Background:

Rice has become a primary daily necessity for mostly Indonesian population. The upsurge of national rice production can be done by agricultural intensification through the application of NPK fertilizer.

Objective:

This study aimed to determine the optimum dose of NPK Mutiara fertilizer, which could provide the highest rice yield of Ciherang variety in Alluvial soil.

Methods:

This study was a single factor arranged in a completely randomized design (CRD) with three replications. The NPK Mutiara fertilizer treatment consisted of four doses, i.e., 0, 160, 320, and 480 kg ha^{-1}. The data observations were analyzed by using analysis of variance (ANOVA) at 5% significance levels. The difference between the averages of the treatment was compared using Duncan's new multiple range test (DMRT) at 5% significance levels.

Results:

The results of the research showed that the application of NPK Mutiara fertilizer could increase the growth and yield of the Ciherang variety in Alluvial soil. The quadratic regression analysis revealed that the optimum dose of NPK Mutiata was obtained at 656 kg ha^{-1} and was given the maximum grains dry weight of 4.26 tons ha^{-1}. The application of NPK Mutiara fertilizer could not affect the shoot root ratio and panicle length.

Conclusion:

The findings of the study suggest that the application of NPK fertilizer interval has not reached the optimum dose in Alluvial soils for Ciherang variety. Therefore, application of NPK Mutiara fertilizer with doses higher than 480 kg ha^{-1} is required for alluvial soils.

Keywords: Optimum dose, NPK fertilizer, Growth, Yield, Rice, Ciherang variety.

Running title: Maximizing the rice yield using NPK fertilizer

5. INTRODUCTION

In 2060, the global population is expected to reach 10 billion, and the demand for staple food supplies particularly rice increases accordingly. On the other side, rice production relies heavily on chemical fertilizers to meet the food demands of the increasing population [1]. Rice is widely consumed ~~as source of calories~~ as a veritable source of calories [2], and it was consumed by nearly half of the world population. Likewise, In Indonesia, rice is a staple food for most of the Indonesian population. The demand for rice by the Indonesian population continues to grow from year to year [3]. Indonesia's rice import volume in January-November 2018 surged 2.2 million tons compared to January-December 2017, which only reached 305.75 thousand tons [4]. The data illustrates that the national rice production has not been able to meet the needs of the Indonesian population. Considering all of this evidence, it seems that the rice cultivation in Indonesia should be optimized through the use of superior rice varieties.

One of the Indonesian superior rice varieties is Ciherang. It is a new superior variety that is adaptable to the Indonesian environment. Ciherang varieties have advantages over other varieties. This rice variety has a profitable high yield and a taste that meets the demand of the market. The potential productivity of Ciherang is 6.0 to 8.5 tons ha^{-1} of the dry weight of grain, and crop age is 116 to 125 days after planting (DAP). In addition, this rice crop is resistant to brown planthopper biotype 3, bacterial left blight resistance, and brown planthopper biotype 2 [5]. However, to obtain high yields, this rice variety requires the fulfillment of macro fertilizer such as NPK. Many choices of NPK fertilizers are available in the farmer's environment.

Estimating crop nutrient requirements are essential for informing decisions of optimal nutrient management. However, the nutrient requirements often vary depending on climates and soil conditions [6]. Nitrogen, phosphorus, and potassium are important macronutrients for plant growth and development [1]. The fertilizer as source nutrients is a material of production which plays an important role in improving rice productivity. There are many fertilizers on the market. However, farmers prefer NPK Mutiara fertilizer. NPK Mutiara fertilizer is one type of compound fertilizer with at least five elements nutrients of macro and micro. The fertilizer is granular in a faded blue color contains of 16% N (nitrogen), 16% P_2O_5 (phosphate), 16% K_2O (potassium), 0.5% MgO (magnesium), and 6% CaO (calcium). Henceforth the fertilizer is called NPK Mutiara (16-16-16) fertilizer. The nutrients element of N, P, and K are macronutrients needed by plants. The N element in the crop functions as a leaf-forming substance (chlorophyll) and protein-forming elements. The P element functions as energy storage and transfer constitute an essential component in nucleic acids, coenzymes, nucleotides, phosphoprotein, phospholipid, and sugar-phosphate. The K element works in starch formation, activating enzymes, and catalyst storage of photosynthesis products [7]. Nitrogen could absorb plants in the form of NO_3^- and NH_4^+ ions.

The N element has a vital ~~role on~~ role for rice crops, i.e., it encourages faster crop growth, improves grain yield and quality by increasing tillers number, leaf area development, grain formation, grain failing, and protein synthesis. Rice plants that are deficient in N have fewer tillers, have stunted growth, have yellowish-green leaves, and begin to die from the top and then spread to the middle of the leaf blade. If the N element is excessively given, it will result in detriment, such as weakening straw, causing the crop fall, and decreasing the rice yield quality [8].

The P element function in the crop plays a role in photosynthesis, respiration, transfer and energy storage, cell division and enlargement, and internal operation of other crops. The plant absorbs the big section of the P element in the form of primary orthophosphate ion (H_2PO_4) and the small number in secondary orthophosphate ion (HPO_4^{-2}). The P element is essential in seed formation, helps accelerate root development and germination, improves water efficiency, and increases power resistance to diseases that ultimately enhance the harvest quality. The deficiency of the P element potentially causes maturity delay and ~~reduced~~ reducees seed filling [9]. The P element is a constituent of adenosine triphosphate (ATP). The P element directly plays a role in energy storage and transfer and activities involved in crop metabolism. The P element is highly required by rice, especially at the beginning of the growth, because it can support the root formation and additives' number and accelerate flowering and grain maturity [10].

The K element is the third essential nutrient after N and P. Crops absorb the K element in the soil in the form of K^+ ions. This element performs as an activator of many enzymes participating in several crop metabolism processes, including photosynthesis. If the nutrient of K deficiency occurs, it will cause a decrement in photosynthesis and respiratory disorders. This occurrence eventually dampens carbohydrate production. The K element function is essential in protein synthesis, solving carbohydrates, the process of energizing crops, translocation of heavy metals such as Fe, resistance to disease disorders, fruit formation, and regulates the opening and closing of guards cell in leaf stomata [11]. K element deficiency symptoms are indicated by the burning of leaves from the edges, necrotic patches brown on old leaves and stems.

NPK fertilization has a significant effect on crop height, the tillers number, panicle number per clumps, total grain per panicle, percentage of the empty and filled with grain per panicle, the weight of 1,000 grain, and the potential yield of grain per hectare [12]. The optimum rate of NPK Phonska (15-15-15) fertilizer was 440 kg/ha, as shown with the production performance of 4.12 tons ha^{-1}. The NPK Phonska (15-15-15) fertilizer effectively elevates the growth and grain dry weight, equivalent to standard NPK at the dose of 300-750 kg ha^{-1} [7]. The application dose of 550 kg ha^{-1} NPK Phonska fertilizer gave the highest yield on the total number of grains (174.58 seeds), number of filled grains (144.67 seeds), and grain yield (85.33 g) per rice clump [13].

Rice cultivation can be done in various of soil types. Alluvial soil is land that can be utilized, but it needs to add higher fertilizer input than fertile soil types. According to Bullinger-Weber and Gobat [14], alluvial soil(s) ~~is~~ are ~~the~~ land plains resulting from the process of deposition and erosion due to flooding so that its characteristics will reflect the composition and properties of the material transported.

Referring to the existing literature, knowledge about NPK fertilizer has significant implications in increasing the growth and yield of rice. Therefore, this study intends to determine the optimum dose of NPK Mutiara fertilizer, which can provide the highest rice yield of Ciherang variety in Alluvial soil.

6. MATERIALS AND METHODS

6.1. Study Area

The study was conducted from February to June 2019. This research was located in a greenhouse facility, Faculty of Agriculture, Universitas PGRI Yogyakarta, Indonesia. The particular territory of Yogyakarta having an elevation of 118 m above means sea levels in the position S 7° 33′ – 8° 12′ and E 110° 00′ – 110° 50′.

6.2. Experiment Design

This study was s single factor and arranged in CRD with three replications. The NPK Mutiara fertilizer treatments have consisted of four levels, i.e., 0, 160, 320, and 480 kg ha^{-1}. Each replication consisted of five samples and needed $4 \times 3 \times 5 = 60$ polybags.

6.3. Research Procedures

The soil type used in this research was Alluvial soil. The media planting was made from the soil of 15 kg and cow manure of 1.5 kg or the ratio of 15:1.5. The combination of soil and manure were mixed into one media before putting into a polybag in size of 40 cm × 40 cm. The Ciherang variety was used in this research. The seedlings were done in plastic tubs germination. The seeds of rice were spread on the media surface and covered with a thin soil layer. Watering the media was done to keep the field capacity. Two weeks after seeding, the rice seedlings were planted in the soil as deep as 3 cm. Each planting hole was planted with two rice seedlings. Plant spacing between polybag was 25 cm × 25 cm measured from the midpoint polybags, then the plants' number is 160.000 clumps ha^{-1}. The water ~~was~~ is filled ~~supplied~~ in the polybags until waterlogging. The urea fertilizer was applied for all treatments as many as 160 kg ha^{-1} in the age of 14 DAP. An addition of NPK Mutiara (16-16-16) fertilizer was applicably suitable for the treatments in the age of 42 DAP. The anticipation of pest attacks of brown ~~plant-thoppers was~~ planthopper is done by applying Temin pesticides.

6.4. Parameters

The observation was done on the rice growth, including the tillers per clumps, leaf area, shoot dry weight, roots dry weight, stover dry weight, and shoot-root ratio. The rice yield was observed, including panicle length, grain dry weight of grain, and harvest index. Harvest index is grain dry weight (economic yield) divided by overall crop dry weight (biological yield, including the dry weight of grains).

6.5. Statistical Analysis

The data were analyzed using ANOVA at 5% significance levels [15] with IBM SPSS Statistic 23. The treatment means were compared using DMRT at 5% significance levels.

7. RESULTS

7.1. Component of the Rice Growth

The ANOVA showed that NPK fertilizer was significantly affected on tillers number, leaf area, shoot dry weight, roots dry weight, and stover dry weight, except shoot root ratio. The results of DMRT at a 5% significant level on the component of rice growth are presented in Table 1.

Table 1. The effect of NPK on the component of rice growth.

Parameters	Doses of NPK fertilizer (kg ha^{-1})			
	0	160	320	480
Tillers number (stem clump^{-1})	29,0 c	34,3 bc	42,5 ab	44,7 a
Leaf area (cm^2 Clump^{-1})	825.3 b	1,173.5 a	1,320.2 a	1,405.1 a
Shoot dry weight (g clump^{-1})	10.59 c	13.02 bc	15.33 ab	16.85 a
Root dry weight (g clump^{-1})	3.2 c	4.52 bc	5.35 ab	6.29 a
Shoot root ratio	3,30 a	2,89 a	2,86 a	2,69 a
Stover dry weight (g clump^{-1})	13.8 c	17.55 bc	20.76 ab	22.76 a

Remarks: The numbers tailed by the same characters in the same row are not significantly different at 5% significance levels ($p < 0.005$) based on DMRT.

Table 1 shows that compound NPK fertilizer application could increase rice growth compared to control (treatment of 0 kg ha^{-1} NPK), except for the shoot root ratio. The dose of NPK fertilizer of 480 kg ha^{-1} produced the highest number of tillers and ~~it was~~ significantly different from 160 kg ha^{-1} and control, but not significant with 320 kg ha^{-1}. There was a decrease of tillers number in the 160 kg ha^{-1} and the lower in 0 kg ha^{-1}. There was no significant difference in leaf area between the dose of 160, 320, and 480 kg ha^{-1}, but all three treatments significantly different from the control. The use of NPK fertilizer in the dose of 480 kg ha^{-1} produced the highest root dry weight, ~~which was~~ and significantly different from 160 and 0 kg ha^{-1}, but not significant with 320 kg ha^{-1}. Table 1 also explains that the highest dry weight of shoots, roots, and stover was achieved in applying NPK fertilizer at a dose of 480 kg ha^{-1}.

7.2. Component of the Rice yield

The ANOVA showed that the NPK fertilizer significantly affects the grains dry weight and harvest index, except panicle length. The results of DMRT at a 5% significant level on grain dry weight and harvest index are presented in Table 2.

Table 2. The effect of NPK fertilizer on the component of rice yield.

Parameters	Doses of NPK fertilizer (kg ha^{-1})			
	0	160	320	480
Panicle lenght (cm)	20.2 a	20.4 a	21.5 a	21.8 a
Grains dry weight (ton ha^{-1})	1.69 c	2.68 b	3.68 a	4.04 a
Harvest index	0.43 b	0.48 ab	0.53 a	0.53 a

Remarks: The numbers tailed by the same characters in the same row are not significantly different at 5% significance levels ($p < 0.005$) based on DMRT.

The application of NPK fertilizers was able to increase rice yields, except for panicle length. The dose of 320 and 480 kg ha^{-1} produced higher grains dry weight, and ~~it was~~ significantly different from 160 kg ha^{-1} and control 0 kg ha^{-1}. The grains dry weight was lower in the dose of 160 and 0 kg ha^{-1}. The application of more from 480 kg ha^{-1} could also increase the grain dry weight. From the correlation between NPK fertilizer and grain dry weight, the optimum NPK dose can be determined based on quadratic regression. The optimum NPK is obtained from the first derivative of the quadratic regression equation.

The quadratic regression analysis result shows that NPK fertilizer has an effect ~~effected~~ on grain dry weight has obtained y = -6E-06 x^2 + 0.0079 x + 1.6635, and the coefficient of determination (R^2) of 0.99. The first derivative of the quadratic regression obtained the optimum dose of NPK fertilizer of 656 kg ha^{-1} and given the grains dry weight of 4.26 tons ha^{-1}. The quadratic regression curve is made from the NPK fertilizer effects on the grain dry weight (Fig. **1**).

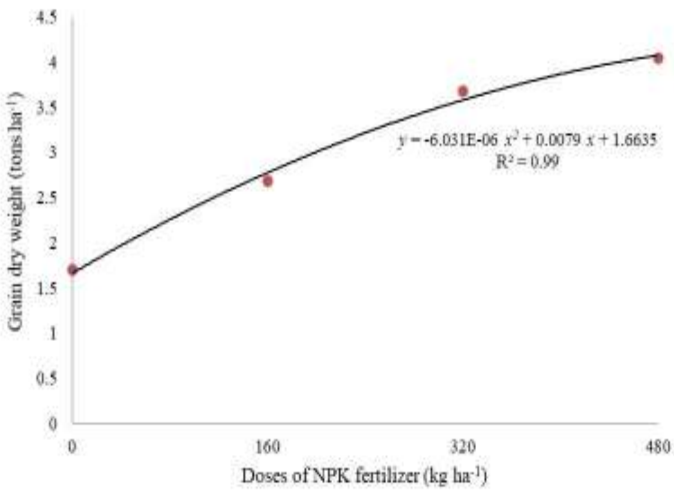

Fig. (1). The effect of NPK fertilizer on the dry weight of grains.

The highest harvest index was obtained ~~at~~ from NPK fertilizer at a dose of 480 kg ha^{-1}. It was significant from other treatments, except with a dose of 320 kg ha^{-1}. The harvest index was lower in control. The quadratic regression result showed that NPK fertilizer effect on harvest index was obtained y = -4.8E-07 x^2 + 0.00043 x + 0.4337, and coefficient of determination (R^2) of 0.99. The first derivative of quadratic regression obtained the optimum dose of NPK at 445.7 kg ha^{-1} and resulted in the harvest index of 0.53. The quadratic regression curve is made from the NPK fertilizer effect on the harvest index (Fig. **2**).

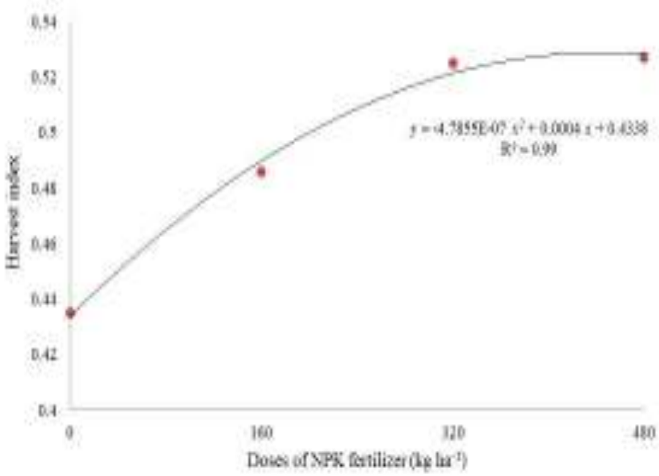

Fig. (2). The effect of NPK fertilizer on harvest index.

8. DISCUSSION

8.1. Components of Rice Growth

It was clearly explained that the dose of 480 kg ha^{-1} NPK Mutiara fertilizer could increase rice growth of the leaf area, tillers' number, shoot dry weight, root dry weight, and strove dry weight, although it is not significantly different from the application of a dose of 320 kg ha^{-1}. The results of this study indicate that NPK fertilizer doses of more than 480 kg ha^{-1} can still increase rice growth. Rice cultivation in Alluvial soils requires the addition of a higher dose of NPK fertilizer due to the low fertility of the soil. The maximum rice growth requires high NPK fertilizer input compared to the previous studies. These findings are in line with Ginting [16], the highest number of tillers was obtained in the NPK fertilizer 400 kg ha^{-1}.

The application of NPK fertilizer in the soil will ~~increased~~ increases the N content in the soil. N addition frequently stimulates plant growth more than the long-term N effect. Legacy of N tends to be only beneficial for non-N fixing plants in medium-aged soils [17]. N element is needed in large quantities for the shoot and vegetative growth of rice. The N element plays a significant role in forming meristem tissue, stimulates branch, leaf, and shoots. The availability of sufficient N nutrients by applying the proper NPK fertilizer will produce a better crop growth phase. The N element ~~supported~~ supports the leaf growth wider, then the leaf area more full for the capture of sunlight in the photosynthesis process [18]. Leaves are the site of photosynthesis and describe the actual production capacity of the crop. Subsequently, carbohydrates could affect the growth, yield, and economic value of the plant. The more full leaves of the plant, followed by increasing chlorophyll content, support the photosynthesis process. The optimum leaf area produces maximum carbohydrate. The N element application sufficiently caused by the increase of shoot growth hence endorses the development of tillers number, stem, and leaf to the maximum. This optimal growth of the rice will automatically produce higher shoot dry weight.

NPK fertilizer could accelerate, multiply, strengthen, and extend crop roots so that roots will easily absorb nutrients to the soil. The content of the K element in NPK fertilizer is capable of spurring root development and affecting the absorption of ingredients other nutrients. The existence of K and P elements in the soil can control root formation, cleavage, and meristem culture, which maximize the root growth. The P element content plays an important role when forming rice tillers. The P element for the plant functions is as a developmental material of nucleoprotein in every cell core. Thus, it plays a role in forming new cells, including the formatting of prospective rice tillers. The P element is available in the soil. The roots will more absorb it. The P element is part of the cell core. Therefore, it is essential in cell division and development meristem networks to stimulate crop roots growth, especially lateral roots, and hair roots, to absorb a higher amount of nutrients. Hence, it results in higher rice tillers. The number of tillers is one of the determining components in rice production per hectare.

8.2. Components of Rice Yield

Based on the results of this study, the application of NPK Mutiara fertilizer can increase the production of dry grain weight per hectare. The application of NPK fertilizer at a dose of 480 kg ha^{-1} can give a yield of 4.04 tons ha^{-1} in Ciherang rice varieties on Alluvial soil. The estimation results show that the highest production of milled dry grain weight is 4.26 tons ha^{-1}, and the optimum dose of NPK fertilizer is 656 kg ha^{-1}. However, the soil type will also determine the production of Ciherang rice varieties. Therefore, a higher dose of NPK fertilizer on marginal soils is highly required. It is proven that the maximum of milled grain dry weight was obtained at 656 kg ha^{-1} and higher than the previous studies. The optimum dosage for the NPK fertilizer is also determined by the soil types where the rice is cultivated. Hartatik's study [7] showed the NPKS optimum dose of 440 kg ha^{-1} produced milled dry grains weight of 4.12 tons ha^{-1} in Inceptisols soil and Shanti's work [19] provided the data that the dose of 300 kg ha^{-1} could produce 6.18 tons ha^{-1} in Ultisols soil. However, those previous studies were implemented in Inceptisols and Ultisols which have different characteristics from Alluvial soil. Alluvial soil is marginal soil with lower fertility than Inceptisols and Ultisols soil. Consequently, it requires more doses of NPK fertilizer. The evidence presented thus far supports the idea that the increase of nutrients in Alluvial soil augments the dry weight of grain. In addition, the N, P, and K nutrients also support the soil metabolic process, which eventually affects the plant growth.

Plant reproduction and growth are processes that require energy from photosynthetic products [20]. NPK fertilizer can reduce the possibility of flower fall and seed loss due to increasing crop yield. Also, NPK fertilizer can intensify the photosynthesis of crops, ~~wich~~ ~~so~~ therefore it results in higher carbohydrate formation. The P element performs as an element of protein compilers is needed for the support of flowers, fruit, and seeds [21]. The P element has the function to accelerate flowering and ripening of fruit and seeds or grain. The P element is a necessary constituent of adenosine diphosphate (ADP). It plays a role in the energy transfer process, and adenosine triphosphate (ATP) directly plays a role in the energy storage process. The explanations above confirm the importance of the rice crop's P element, which accelerates flower formation and grain ripening.

In accordance with the present results, some previous studies have demonstrated that the K element plays a role in metabolic processes, namely photosynthesis and respiration in crop growth. The K element regulates the balance of ions in the cell, which sets various metabolic mechanisms like photosynthesis, metabolism carbohydrates, and translocation. Synthetic protein plays a role in the respiration process [22]. The K application promoted early flowering by 1–3 days and regulating flowering in rice production [23]. A higher crop harvest index leads to the increased dry weight of grains of each clump of rice crop. More carbohydrate formatted in photosynthesis, the more organic metabolic stored in the seeds. Food reserves (carbohydrate) can be stored in organ crops, namely leaves, stem, and root, in a vegetative phase. In the generative phase, this carbohydrate ~~transfers~~ is transferred to seeds filling (grain). The K element can stimulate carbohydrate translocation from the leaf to the other organ crop.

By providing optimal NPK, the results of photosynthesis will be directed to fill seeds. The proper application of NPK nutrients can help translocation and storage of carbohydrates so that the harvest index can reach a maximum. The seed filling is needed during the generative phase. Therefore, it requires the ~~stored carbohydrate~~ storage of carbohydrate from photosynthesis during the production phase. The seed filling period requires higher ~~organic metabolic~~ carbohydrate that occurs at the maximum process of photosynthesis. The NPK fertilizer influences the number of carbohydrates stored by the crop (stored capacity).

This section has attempted to provide a brief summary of the literature and the present study relating to the application of NPK Mutiara fertilizer in rice cultivation, different doses of NPK have been proposed to provide solutions ~~to~~ for increasing rice production. The present study was designed to determine the optimum dose of NPK Mutiara fertilizer on Ciherang rice variety.

CONCLUSIONS

Based on the research results and the discussion above, the conclusions derived from this study were as follows. The application of dose of NPK Mutiara fertilizer in Alluvial soil could increase the growth and yield of the Ciherang rice. In this study, higher grain dry weight results were achieved at a NPK Mutiara fertilizer dose of 480 kg ha. In this study, the use of optimum NPK fertilizer has not been found, so the next research needs to use a higher dose treatment, especially rice cultivation in alluvial soils.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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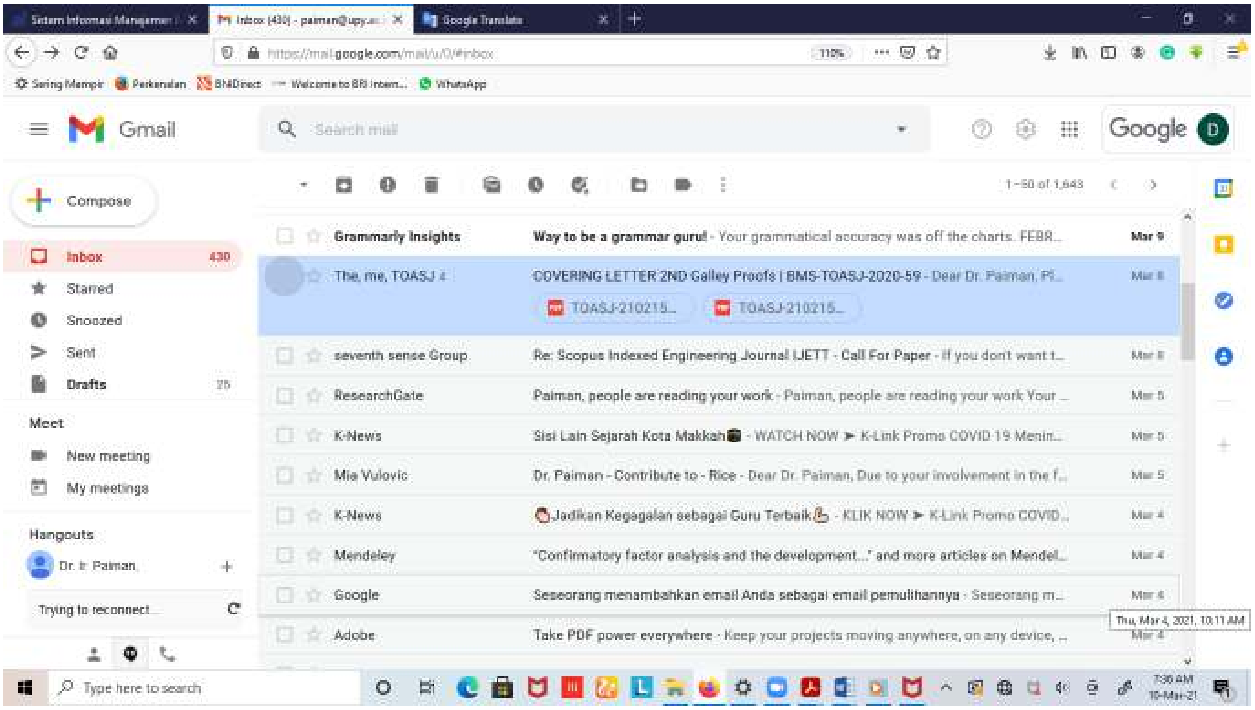

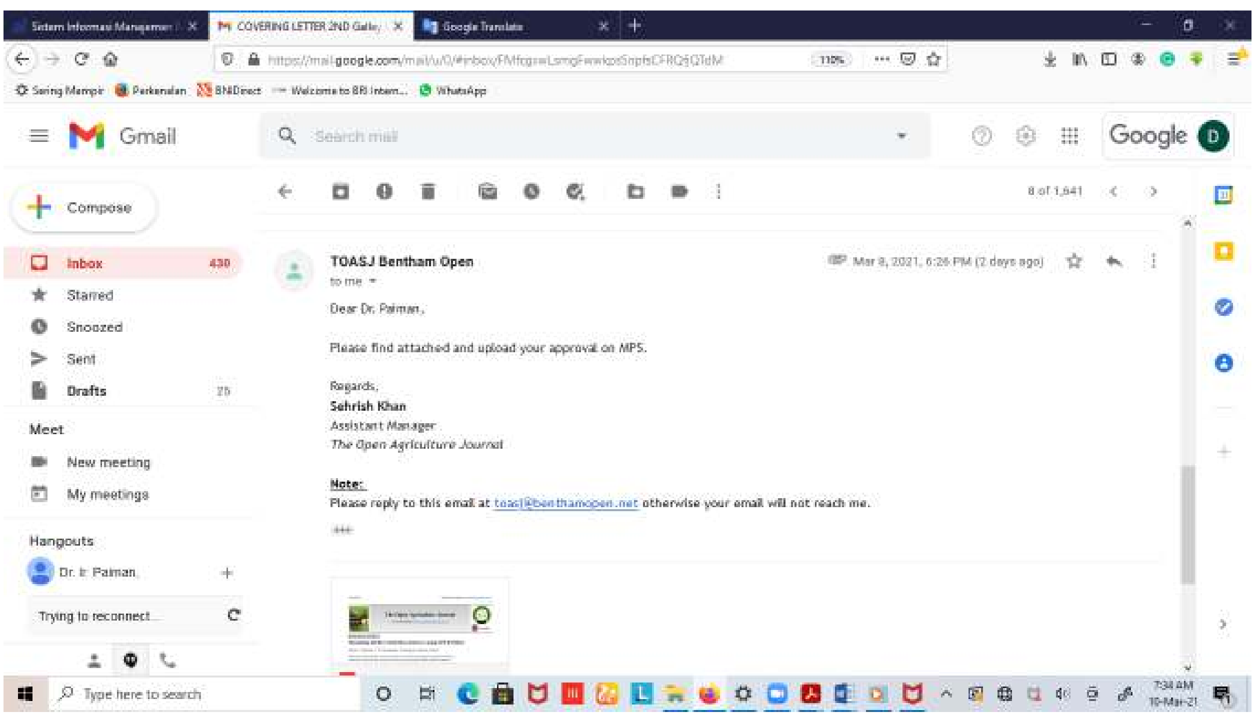

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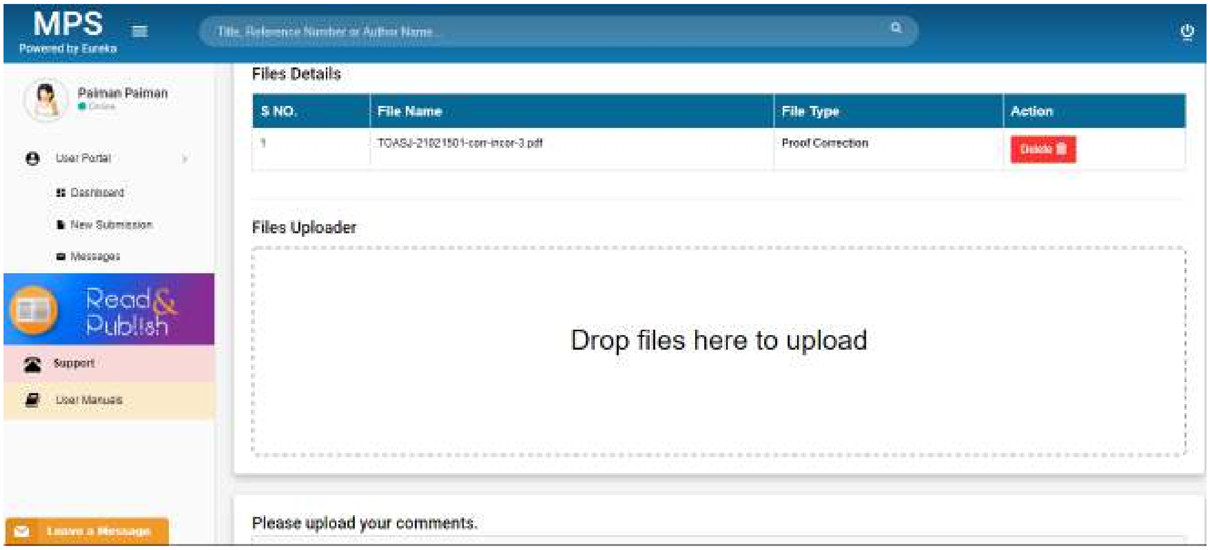

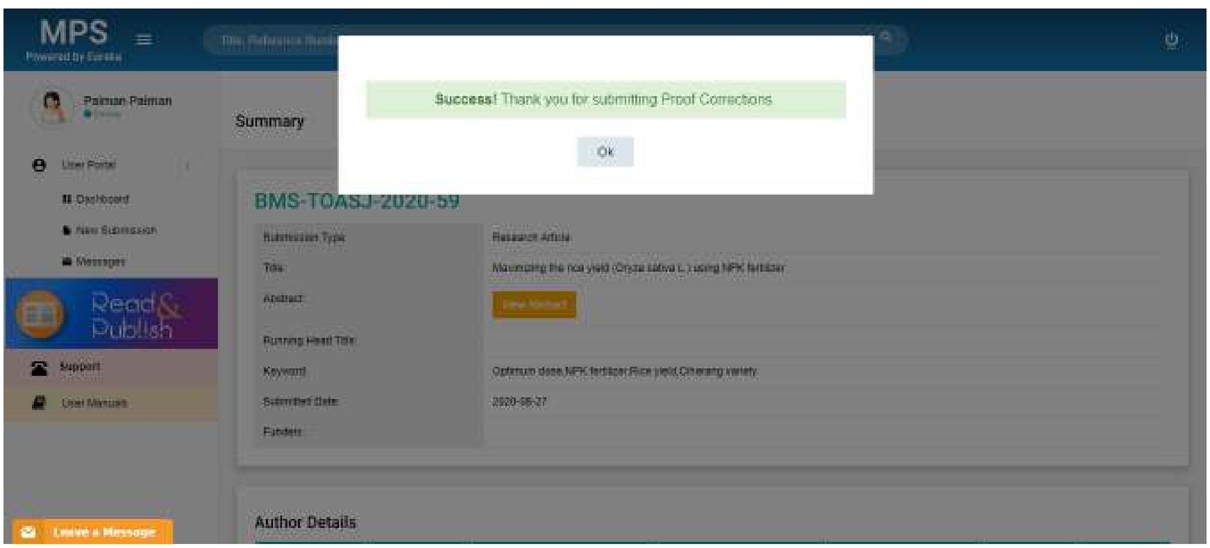

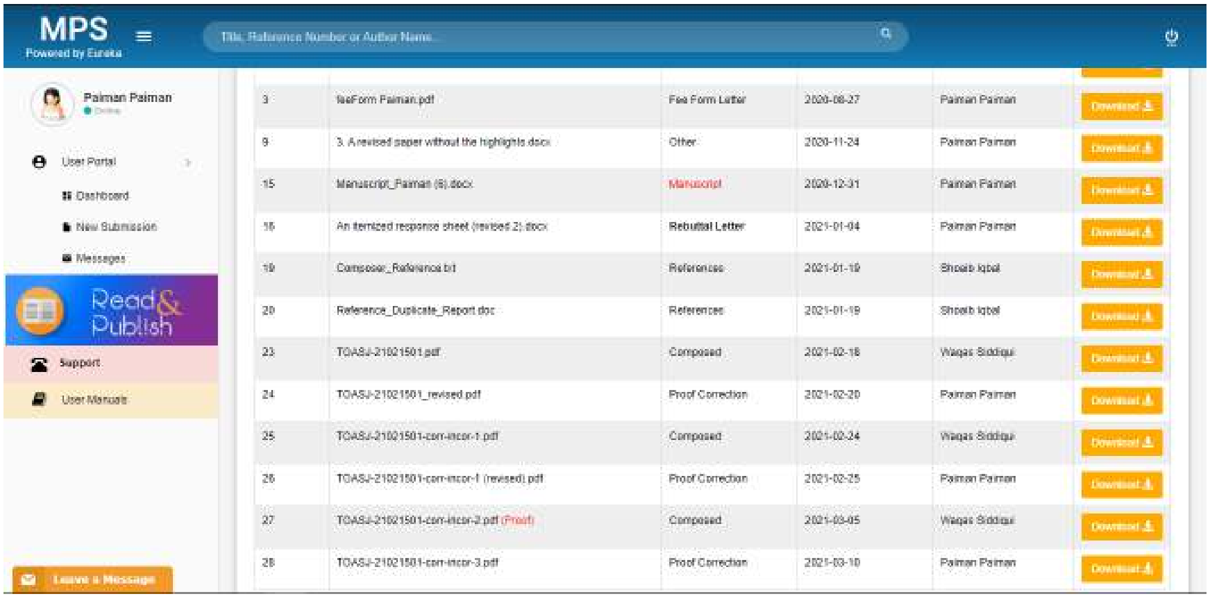

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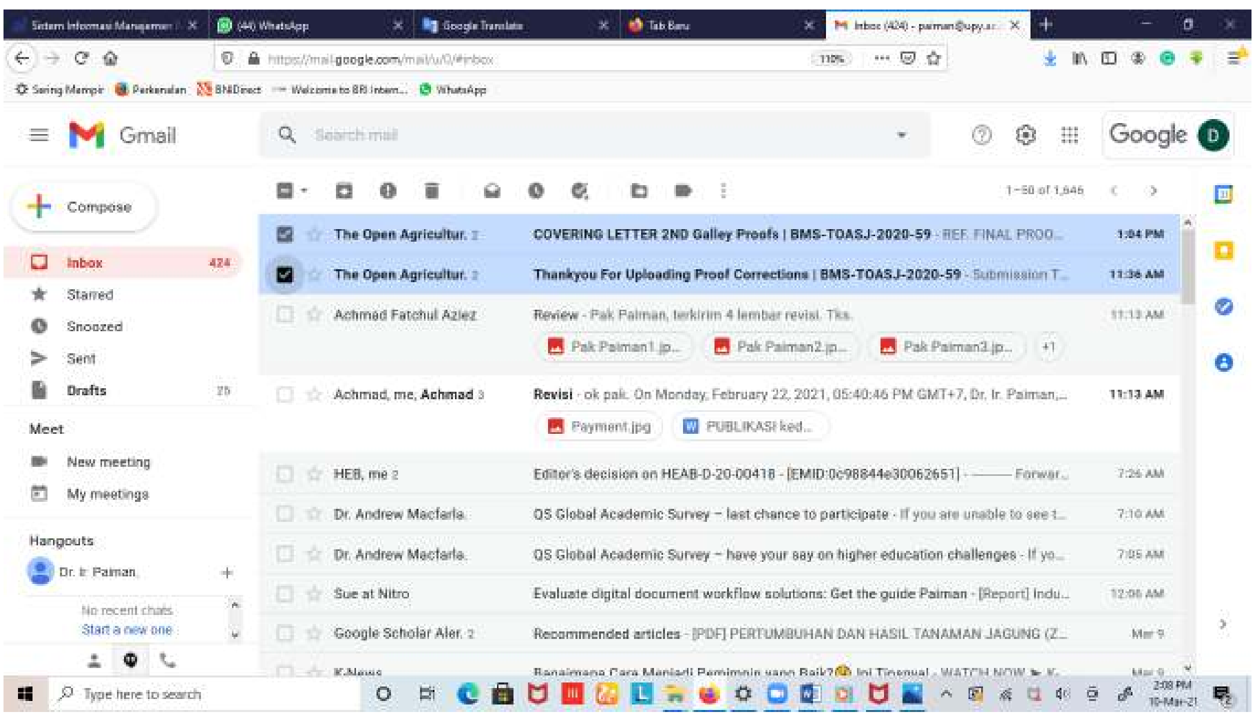

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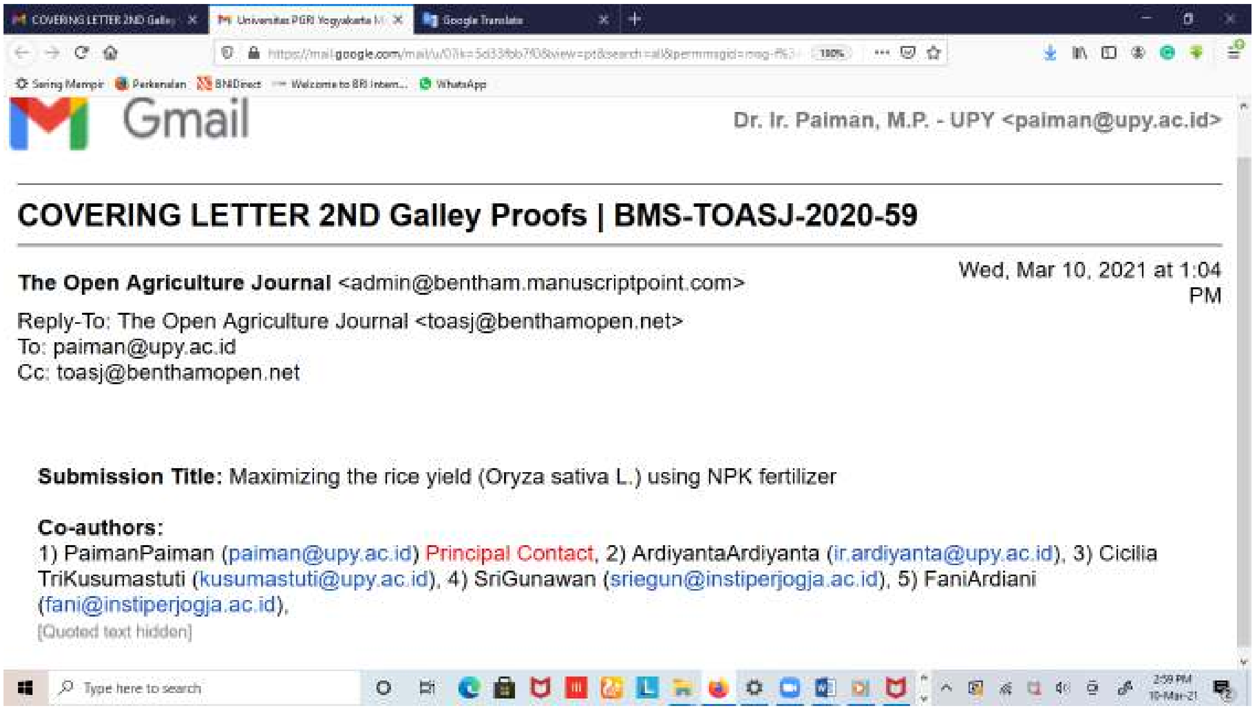

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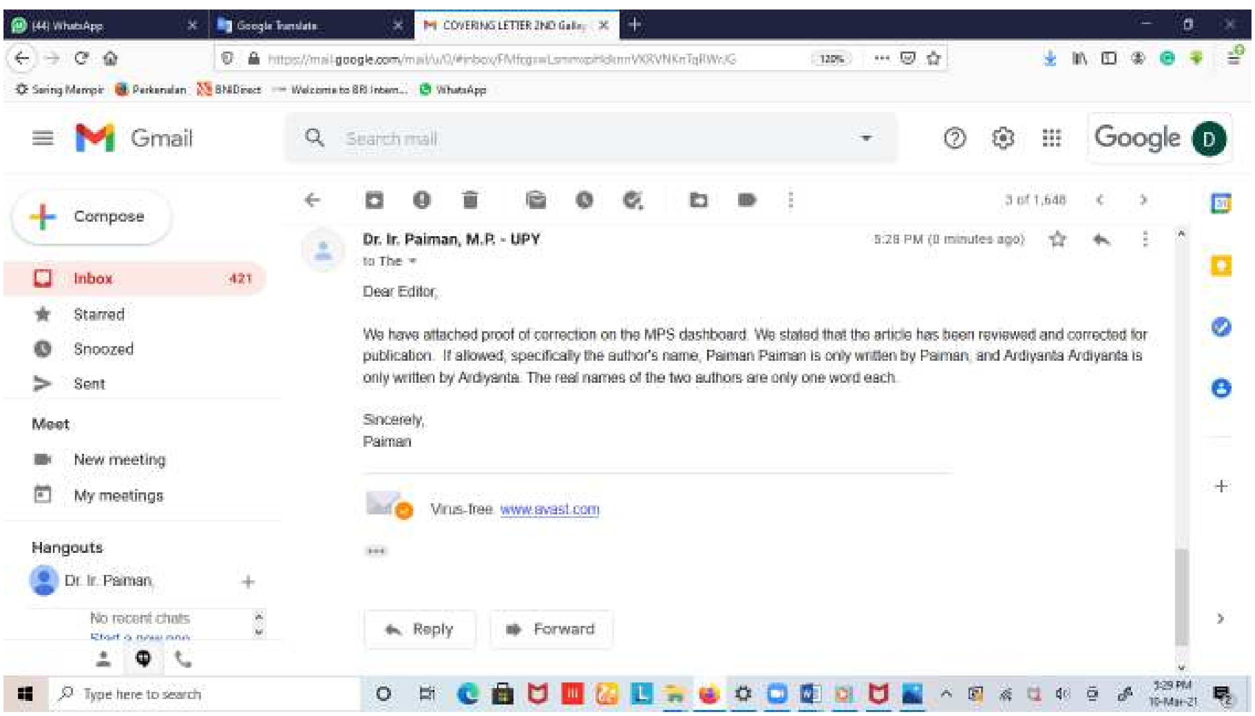

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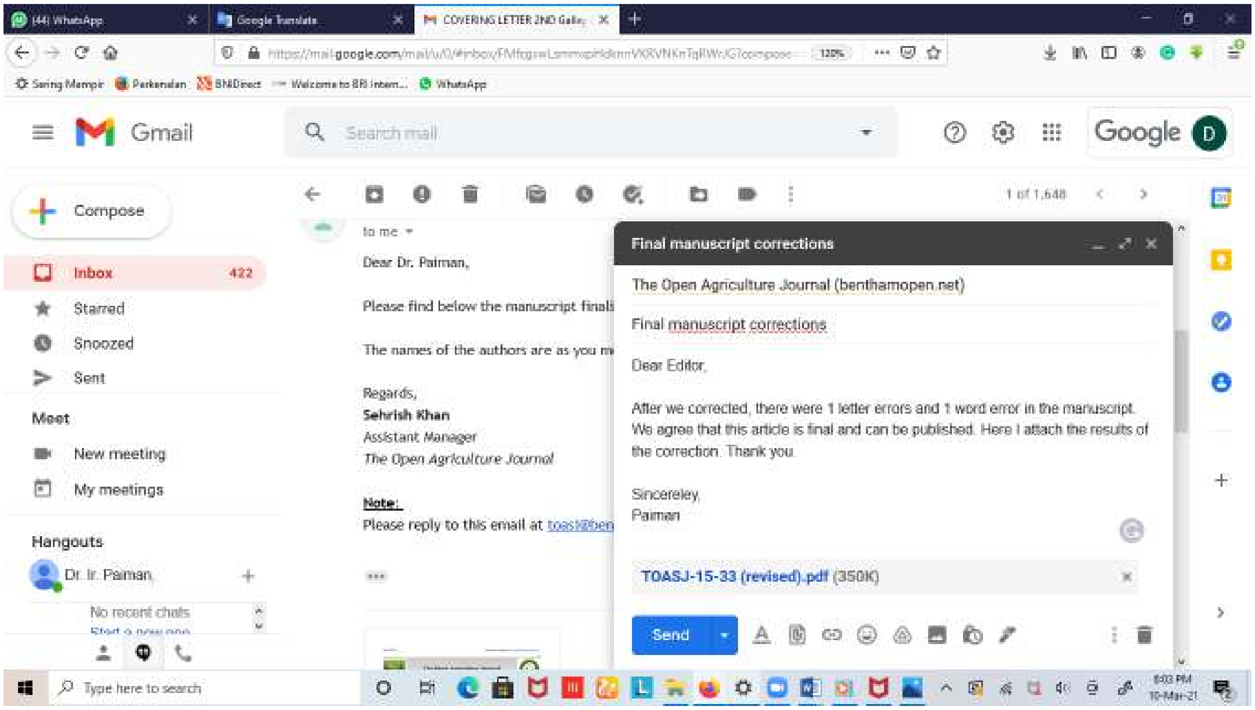

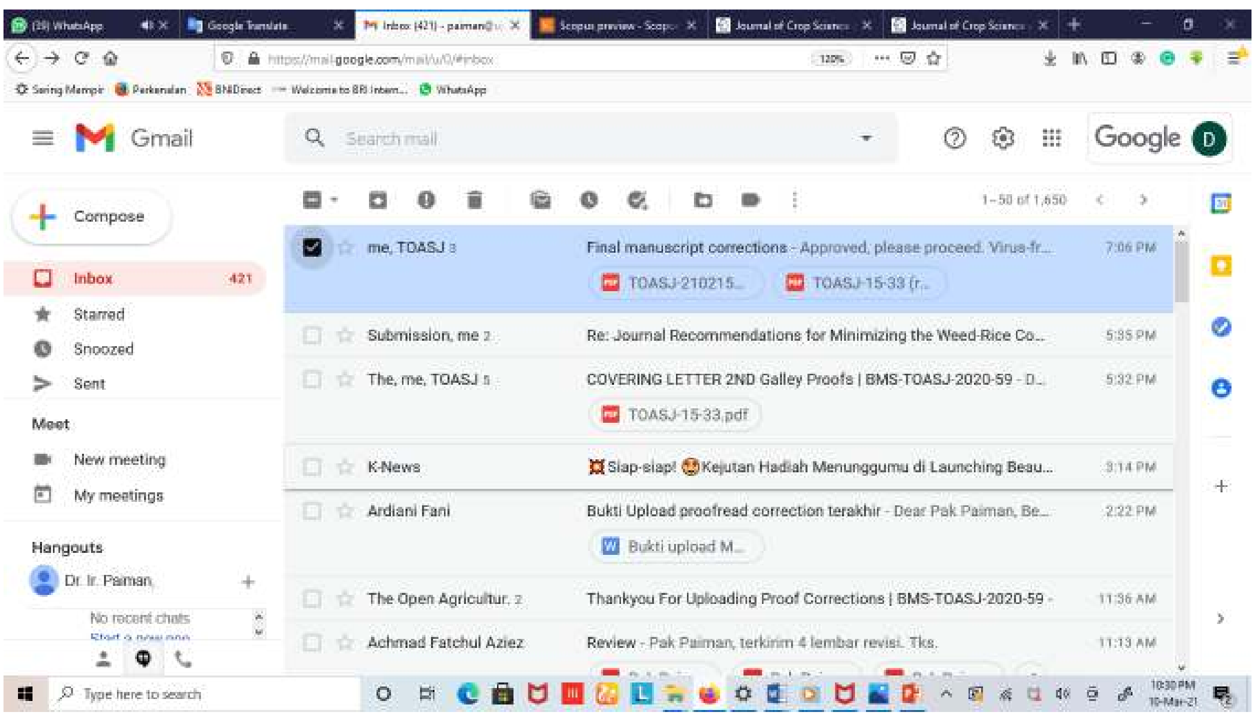

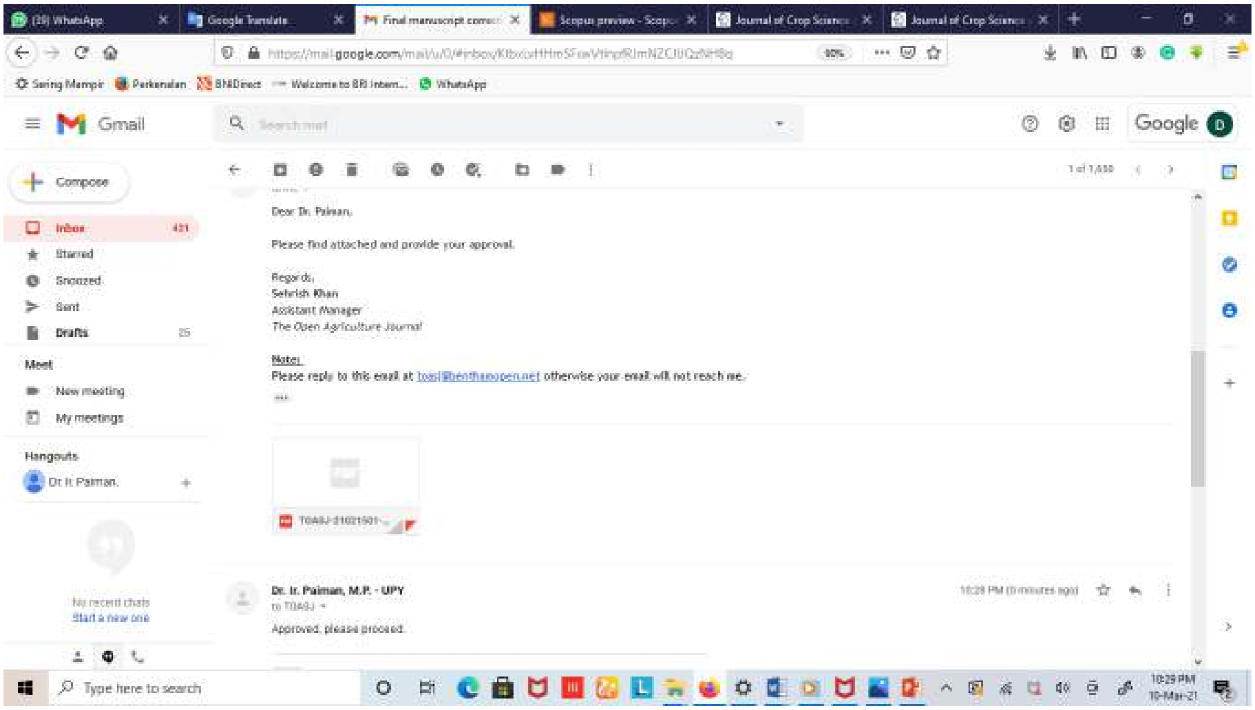

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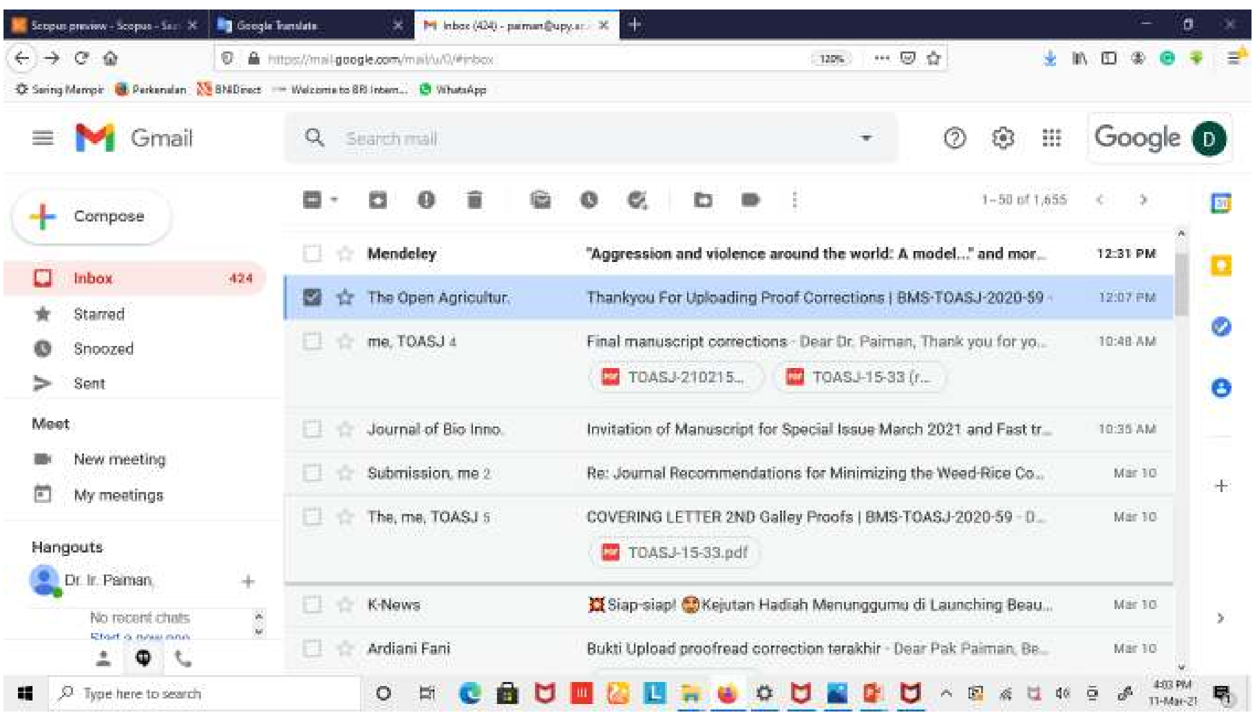

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