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Improving the Performance of Oil Palm NPK Fertilization Using Risk Management and Analytic Hierarchy Process

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Abstract

Purpose: This study aims to improve the performance of oil palm fertilization by analyzing the fertilizer procurement process, particularly in addressing inefficiencies and mismatches between planned and applied fertilizers.
Research Methodology: The study employs a descriptive analysis approach based on identified problems. Priority risks are evaluated using Failure Mode and Effects Analysis (FMEA), while mitigation strategies are formulated using the Analytic Hierarchy Process (AHP). Data are collected through observations and questionnaires involving stakeholders with relevant expertise at the research site.
Results: The findings indicate that key risks occur across procurement stages. In planning, the main risk is budget availability not aligned with recommendations (RPN 27). In supplier selection, delays in tender announcements are identified (RPN 18). In delivery, delays are caused by late contract signing (RPN 18), while in acceptance, fertilizers are often received beyond the scheduled time (RPN 18). Procurement planning is the most important criterion (0.575), followed by supplier selection (0.214), delivery (0.134), and acceptance (0.077).
Conclusions: Fertilizer procurement performance can be improved through strengthening the budgeting system, improving procurement documentation, and optimizing supplier selection processes.
Limitations: This study is limited to a single research site and focuses only on procurement-related factors, which may not fully represent broader operational conditions.
Contributions: This study contributes by integrating FMEA and AHP to identify risk priorities and develop practical strategies for improving fertilizer procurement performance in oil palm plantations.

Keywords: *Analytic Hierarchy Process, Fertilizer, NPK, Performance Oil Palm, Risk Management*

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1. Introduction

Plantation is one of the agricultural sub-sectors that contribute to the state. According to data from the Central Statistics Agency for 2020, the contribution of the plantation sub-sector in 2019 was 3.27 percent (517,507.80 billion rupiah) to total GDP (15,833,943.40 billion rupiah) and 25.71 percent to the Agriculture, Forestry and Fisheries sector. (2,013,626.90 billion rupiah) or is the first in the sector (Direktorat Jenderal Perkebunan, 2019). Oil palm is one of the most widely cultivated plantation crops by large plantation companies. Large plantations are commercially organized or managed by a company that is a legal entity. Large plantations consist of State Large Plantations (PBN) and National/Foreign

Large Private Plantations (PBS) plantations. Based on data from the Central Bureau of Statistics (2020), from 2017 to 2019, oil palm plants were mostly cultivated by large plantations, followed by rubber and coconut plants. In 2017, oil palm plantations were cultivated by 1695 large plantation companies, in 2018 there were 2165 large plantation companies, and in 2019 (temporary figures) were cultivated by 2165 large plantation companies.

The more large plantation companies that are engaged in oil palm plantations, the tougher the competition between these large plantations. The moratorium on oil palm plantation permits, as stipulated in Presidential Instruction No. 8 of 2018 (Secretariat of the Republic of Indonesia Cabinet, 2018) dated September 19, 2018, concerning the Suspension and Evaluation of Oil Palm Plantation Licensing and Increasing Productivity of Oil Palm Plantations, which is valid for 3 (three) years, prevents coconut plantation companies from obtaining permission to add new land, making it difficult for oil palm plantation companies to expand. This encourages oil palm plantation companies to increase the productivity of oil palm plantations on plantation lands that are currently under their control.

Fertilizers greatly affect the productivity of oil palm plants. According to Pranata and Afrianti (2020) based on research results in Afdeling I Kebun Adolina PT Perkebunan Nusantara IV partially or simultaneously, labor, rainfall, rainy days, and fertilizer factors have a positive effect on oil palm productivity, while the theft of fruit bunches has a negative effect on oil palm productivity. In line with this research, Sari et al. (2020) conducted a study on rainfall and fertilization on oil palm productivity at a company and obtained the results that annual oil palm productivity is not affected by the amount of rainfall, but is influenced by fertilization in the same year.

Procurement of fertilizers starts from the decline in fertilizer recommendations from research institutions, namely, the Palm Oil Research Center (PPKS). Fertilizer recommendations issued by PPKS are based on the results of leaf or soil analyses. Recommendations are provided in the form of alternative types and doses of fertilizers to be applied to oil palm plants. Based on the results of these recommendations, each PT XYZ, which has oil palm commodities, determines the type of fertilizer to be used for oil palm plants, including determining the amount of fertilizer needed. PT XYZ is a state-owned enterprise engaged in plantations with the main commodities of oil palm and rubber plants, paying great attention to fertilization to achieve optimal performance. One of the obstacles experienced by PT XYZ in NPK fertilization of Palm Oil plants on mature plants is the incompatibility of the fertilizer applied to the plan. This discrepancy can be seen in Figure 1, the realization from 2016 to 2019 on oil palm producing plants at PT XYZ as follows:

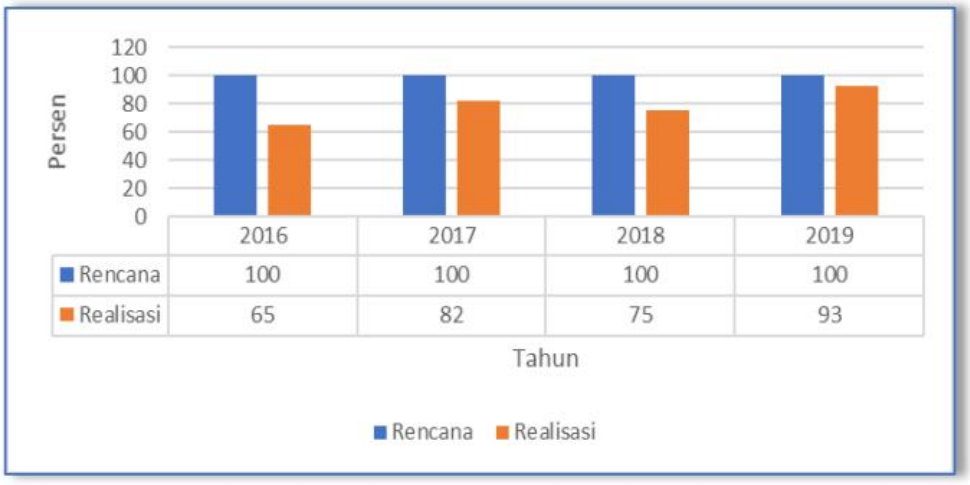

Figure 1. Realization of NPK Fertilization for Palm Oil Produced Plants

The type and amount of fertilizer needed is then sent by each company to Plantation Holding for a recapitulation of all types and needs of PT XYZ, after which the supplier selection process is carried out. The selection of suppliers is carried out by an Ad Hoc Committee formed by the Self Estimated Price Adhoc Committee, whose task is to determine the technical specifications and own estimated price (HPS), which will be used as a reference in the implementation of the tender. The Procurement Committee is tasked with determining suppliers based on the tender conducted. The resulting tender product is a Letter of Appointment for Goods and Services Providers (SPPBJ), which is then sent to the Supplier and to PT. XYZ will be followed up with the issuance of contracts by each company.

Based on the contract, the supplier followed up by dropping/delivering fertilizer to each PT XYZ that needed it. Dropping begins by sending fertilizer samples to PT. XYZ is accompanied by a certificate of fertilizer analysis from an accredited laboratory. If the fertilizer sample sent is declared appropriate by PT. XYZ, the supplier, then started dropping fertilizer to each unit/garden warehouse at PT.XYZ. Fertilizers that have been dropped by the supplier before being applied to oil palm plantations were analyzed for proper use. Sampling for usable analysis was conducted by taking samples from one of the plantation units carried out by PT. XYZ, suppliers, and officers from accredited laboratories.

The results of this usable analysis were used as a basis for PT. XYZ to determine whether the dropping fertilizer is in accordance with the required quality specifications. If the fertilizer specifications are in accordance with the quality requirements that have been determined, then the fertilizer can be applied to the plants, and the supplier can continue dropping the fertilizer. Meanwhile, if based on the results of the appropriate use analysis, it is stated that the fertilizer is not in accordance with the quality standards that have been set, the supplier can submit a re-analysis where the costs for this re-analysis are the burden of the supplier. The results of this re-analysis are a reference for both PT.XYZ and the supplier. If the results of the re-analysis are suitable for use and the fertilizer is in accordance with the required quality, then the fertilizer can be immediately applied to the plant. However, if based on the results of the re-analysis, it is still suitable for use and does not meet the required quality standards, the PT should be rejected. XYZ will refuse delivery and/or delivery of fertilizers so that the supplier is obliged to replace all the fertilizers that have been sent with substitute fertilizers in accordance with the required quality standards.

Fertilization of oil palm plantations that is not in accordance with the plan is caused by the risk of the procurement process of goods and services, including delays in dropping fertilizer by fertilizer suppliers, supplier selection process, recommendations, collecting recapitulation of fertilizer needs from subsidiaries, signing contracts, and agreement methods. payments, delays in the results of proper use analysis, fertilizers by an accredited laboratory, or other factors. The main problem in fertilization performance at PT.XYZ is the mismatch between planning and realization. This discrepancy affects the achievement of the production targets. The activity that greatly affects the realization of fertilizer is the procurement process. Thus, risk management in the fertilizer procurement process must be implemented. The risk management methods used in this study is the FMEA (Failure Modes and Effects Analysis (FMEA) and Analytic Hierarchy Process (AHP).

According to Cavique et al. (2019) and Zhang et al. (2019), FMEA is a method used to evaluate failures that occur in a system, design, process, or service. Potential failures are identified by assigning a score or score for each failure mode based on the occurrence, severity, and detection level. Identification of the failure of the fertilizer procurement process is carried out following the identification method carried out by (Hassan et al., 2020), by assigning a score of 1-10 for each criterion. The first step in the risk management process is to identify risk events that occur in the fertilizer procurement process. After identifying the risk, a risk analysis was conducted. Risk analysis can be performed using the Analytic Hierarchy Process (AHP). AHP is a quantitative technique developed for cases with various levels (hierarchies) of analysis (Hambali & Rivai, 2017). This method is a practical way to deal with

various functional relationships in complex networks. This method uses pairwise comparisons, calculates the weighting factor, and analyzes it to produce a relative priority among the alternatives. AHP is a simple and flexible method that can accommodate creativity in problem-solving.

Risk management is carried out from the planning process until the fertilizer supply process is completed. Good risk management is risk management starting from the planning process. This action can minimize the occurrence of unpredictable risks during the project implementation. Risk management in the fertilizer procurement process at the company using the FMEA and AHP methods results in mitigation that can be implemented to overcome the identified risks. The stages of risk management are risk identification, giving priority ratings to risk prioritization, and risk mitigation. This result is a very important recommendation for improving the future fertilizer procurement process at PT.XYZ.

Based on the description of the background above, the following problems can be identified: 1) Based on Figure 1 Realization of fertilization cannot be carried out according to the plan that has been set by the company, namely the realization of fertilization is lower than the plan., 2) The risks of the fertilizer procurement process starting from planning to receiving fertilizer include delays in recommendations, delays in the supplier selection process, delays in signing contracts, delays in dropping fertilizers by fertilizer suppliers, or other factors affecting the realization of fertilization for oil palm plants. This research is structured based on several problems, which are formulated as follows: 1) What are the priority risk in fertilizer procurement planning? 2) What are the priority risks in the process of selecting fertilizer suppliers?; 3) What are the priority risks in the risk of dropping/delivery of fertilizer from suppliers to the company?; 4) What are the priority risks in the fertilizer acceptance process at the company?5) What is the strategy in the fertilizer procurement process to improve fertilization performance?

2. Literature Review & Hypothesis Development

2.1 Oil Palm

Oil palm (*Elaeis guineensis* Jacq.) is a tropical plant that produces the world's largest vegetable oil. One hectare of oil palm plantation produces between 10 and 35 tons of fresh fruit bunches (FFB) per year. FFB can generally be harvested after three years of planting, and the optimal amount is 10 years after planting. In its life cycle, the economic age of oil palm is between 20-25 years with the first 11-15 months of seedling. The first harvest usually occurs 32–38 months after planting, and maximum yields are achieved 5–10 years after planting. Normally, oil palm grows in tropical lowlands, 15○N–15○S with an even rainfall of 1800–5000 mm/year (Beaudry et al., 2018; Nuraeni et al., 2022). The world's need for vegetable oil continues to increase along with the increase in population (Hernawan et al., 2022; Juliansyah & Supijatno, 2018). The area of oil palm plantations in Indonesia has continued to increase over the last 3 (three) years. According to data from the Central Statistics Agency for 2020, the area of large plantation oil palm plantations in 2017 was 6.685.2 thousand hectares, in 2018 it was 8.507.4 thousand hectares and in 2019 it was 8.688.9 thousand hectares (temporary figures). Meanwhile, the area of smallholder oil palm plantations in 2017 was 5.697.90 thousand hectares, in 2018 it was 5.818.90 thousand hectares and in 2019 it was 6.035.70 thousand hectares (temporary figures) (Direktorat Jenderal Perkebunan, 2019).

Oil palms are monocotyledonous plants with fibrous roots. which can grow under various soil conditions. Oil palm is able to adapt to various types of soil and conditions of low pH and water content (Abidin et al., 2022; Hambali & Rivai, 2017). Oil palm cultivation is influenced by environmental factors such as soil, temperature, and climate. In addition, the presence of water and social activities in the plantation environment affect the growth of oil palm plants (Khatun, 2017). Compatibility is the extent to which an innovation is in accordance with the current values and needs of an organization (Woittiez, 2018).

2.2 Fertilizer

Fertilizer is an important factor in oil palm cultivation. The application of fertilizer to oil palm plants is necessary to promote their growth of oil palm plants (Lumi & Yosef, 2022; Sinulingga et al., 2015). The application of fertilizers increases the production of oil palm fresh fruit bunches (FFB). The main elements needed by oil palm plants for growth are nitrogen, phosphorus, and potassium in the soil. Therefore, in oil palm planting, fertilizer application, especially NPK, is carried out from the nursery to the garden (Izzati et al., 2015; Ko et al., 2020). It also aids tissue development, reproduction (flowering), and fruit production. It also increases plant resistance to pests and diseases (Siallagan et al., 2014; Warsito et al., 2017). According to Hidayat et al. (2017), fertilizer application can increase plant growth rate which can be seen from plant height and stem diameter in oil palm plants in nurseries.

The application of single fertilizer with a maximum dose of 9 kg urea + 6 kg SP-36 + 9 kg KCl + 50 g Borate + 50 g CuSO4.5H2O per plant per year can increase productivity by 260.64% (26.94 tons/ha) compared to the control (7.47 tons/ha). The application of compound fertilizer with a dose of 12 kg NPK compound + 50g Borate + 50 g CuSO4.5H2O per plant per year can increase productivity by 237.08% (25.18 tons/ha) compared to control. Providing 6 kg urea + 4 kg SP36 + 6 kg KCl + 100 kg organic fertilizer per plant per year increased productivity by 265.59% (Sukmawan, 2016). According to Panggabean (2017) and Parmenas (2022), the application of NPK and organic fertilizers can increase the rate of plant growth. The optimum dose of organic fertilizer is the corresponding values for compound NPK fertilizer were 40.7 kg of plants and 1.9 kg of plants on one-year-old immature oil palm plantations of one year. One of the most widely used organic fertilizers in oil palm plantations is empty fruit bunches (Sakiah et al., 2020).

Fertilization is a key factor influencing oil palm growth and productivity. Fertilization is the provision of nutrients to the soil to maintain the balance of nutrients needed by plants and replace nutrients lost during harvest (Panggabean, 2017). Fertilization is carried out throughout the planting period, from the nursery to fruit production (Ariyanti et al., 2017; Juliansyah & Supijatno, 2018).

In addition to providing nutrients for plants, fertilizer application can help improve soil physical and chemical properties and increase nutrient levels in the soil (Effendy & Jalal, 2019; Warsito et al., 2017). Fertilizer application also affects the development of root-associated microbes in the soil. The application of different types of fertilizers and fertilizer application techniques affects the growth and activity of soil microbes, thereby increasing soil pores and improving soil structure (Murugan et al., 2020). Risk is the possibility of loss in a management system. Risk events can occur in various fields of work, such as education (Aleksandrova & Novikova, 2019), trading business (Oguzhan & Erol, 2016), construction (Chatterjee et al., 2018), health (Moreno et al., 2020), and agriculture (Supriyanto et al., 2019). In general, the agricultural sector has the greatest risk. Some of the risks that may occur in agriculture include water factors, energy availability, workers, cultivation factors and plant pests and natural disasters (Zandi et al., 2020). In the palm oil supply chain management process, it is known that there are 5 risk aspects, namely aspects of raw material supply, quality aspects of supply FFB, FFB price aspects, management aspects and social aspects (Thaheer & Hasibuan, 2019).

To overcome the occurrence of risk events, a risk mitigation strategy is required and should be determined during the planning stage. This allows risk events to be addressed more quickly and reduces waste (Lin et al., 2018). Risk mitigation actions for short-duration activities can be implemented more quickly than those for long-duration activities; therefore, different mitigation strategies are required for long-duration activities. The implementation of mitigation efforts can prevent companies from incurring losses caused by risks (Aranti & Oktaufanus, 2015). Methods such as the Analytic Hierarchy Process (AHP) and Failure Mode and Effects Analysis (FMEA) are widely used to analyze risk in various fields (Aranti & Oktaufanus, 2015; Yahman et al., 2020).

Risk analysis is conducted by classifying identified risk factors into high- and low-risk groups. Priority risk assessment may differ across fields of work. Risk management must be based on resilience (Zandi et al., 2020). Risk management is defined as a comprehensive set of policies and procedures used to manage, monitor, and control organizational exposure to risk. Risk itself is defined as uncertainty caused by changes (Hidayat, 2019). Risk management is conducted from planning to implementation stages, where early-stage management can reduce unidentified risks during execution (Ulfah et al., 2018). The main stages of risk management include risk identification, assessment, prioritization and response planning, and monitoring (Hartuliyoso et al., 2018).

Fertilizer application significantly affects oil palm yield. Excessive fertilization can damage crops, harm the environment, and increase costs. Therefore, soil and leaf analyses are required before fertilization planning (Khatun, 2017; Sanputawong et al., 2017; Woittiez, 2018). Fertilization management follows standard operating procedures based on the 6T principle (right type, dose, time, method, place, and tools) to ensure effectiveness and efficiency (Khalida & Lontoh, 2019; Pranata & Afrianti, 2020). Fertilizer procurement in oil palm companies involves several stages, including cost estimation, procurement documentation, online tendering, announcement of winners, and contract signing (Kurniawan & Riyanto, n.d.). Supplier selection is conducted using e-procurement systems and can be supported by AHP (Rianti, 2018; Ridwan et al., 2019). Delivery challenges include high costs and unclear contracts (Msuku et al., 2020), making contract clarity essential (Khalida & Lontoh, 2019).

2.3 FMEA

Coordination between suppliers and users is essential to reduce delivery risks (Ulfah et al., 2018). Mitigation planning documents, such as disaster recovery plans, are also important (Supriyanto et al., 2019). Quality inspection and proper storage are necessary to maintain fertilizer quality and reduce losses (Amanah & Tjitropranoto, 2018; Ulfah et al., 2018). FMEA is a structured method used to identify failure modes based on severity, occurrence, and detection, resulting in a Risk Priority Number (RPN) (Zandi et al., 2020). The highest RPN values indicate priority risks requiring mitigation. AHP is then used to determine the most appropriate mitigation strategies (Huang et al., 2020; Shi & Fei, 2019). AHP, developed by Saaty (2016), is a decision-making method that structures complex problems into hierarchical levels.

Several mitigation strategies include ensuring budget adequacy (Borkovskaya et al., 2018), increasing the number of suppliers (Rianti, 2018), improving quality inspection (Ume et al., 2020), utilizing information technology in procurement (Msuku et al., 2020), optimizing fertilization timing (Dawi et al., 2017), and enhancing communication between suppliers and users (Ward et al., 2019).

Risk management in the fertilizer procurement process at PT XYZ is performed using the FMEA method. Primary and secondary data obtained from interviews and company data were grouped by entering them into the FMEA table as follows:

Table 1. Table of FMEA

Number	Failure Type	Severity	Occurance	Detection	RPN
1	The length of the procurement planning process				
2	The length of the document preparation process				
3	The length of the supplier selection				
4	The length of the contract agreement process				
5	Fertilizer delivery time				

The data are given a score between 1-10 based on the level of conformity with severity, occurrence, and detection. The scores obtained are then summed to obtain the RPN value, which can be used to determine the risk of failure. Decision-making problems can be complex because of the existence of multiple objectives and criteria. One of the tools that is suitable for candidate selection or priority sequencing is the Analytic Hierarchy Process (AHP) (Saaty, 2016). Specifically, AHP is suitable for candidate selection or priority ordering problems with the following characteristics (Hassan et al., 2020).

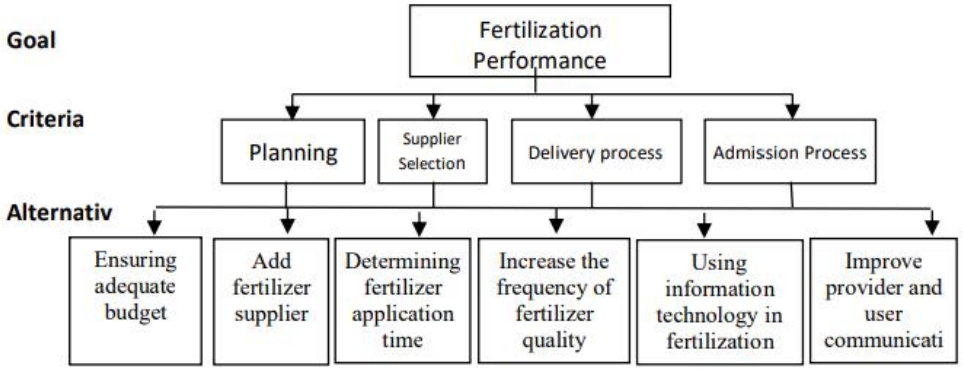

Figure 2. AHP Model of Fertilizer Performance Improvement

2.4 Hypothesis Development

Based on the research findings, which emphasize the key risk factors in the fertilizer procurement process (planning, supplier selection, and delivery–acceptance integration), the hypotheses are formulated as follows:

H_1: Fertilizer procurement planning has a significant effect on improving oil palm fertilization performance.

H_2: Supplier selection processes have a significant effect on improving oil palm fertilization performance.

H_3: Delivery and acceptance processes have a significant effect on improving oil palm fertilization performance.

3. Methodology

The research design that will be carried out in this study is based on the problems studied using descriptive analysis methods. Measurement of priority risk using FMEA and formulation of mitigation strategies using AHP (Analytic Hierarchy Process) by collecting data through observation, questionnaires with stakeholders who have expertise in their respective fields at the research site.

3.1 Research Design

This study employs a quantitative descriptive research design aimed at identifying, analyzing, and prioritizing risks in the fertilizer procurement process. The research integrates two main analytical methods:

1) Failure Mode and Effect Analysis (FMEA) to identify and assess risks.
2) Analytic Hierarchy Process (AHP) to determine priority mitigation strategies

This design is suitable for analyzing complex systems involving multiple stages, from planning to fertilizer acceptance

3.2 Data Collection

Data were collected through multiple methods, including direct observation of the fertilizer procurement process, the distribution of questionnaires to expert respondents, and in-depth interviews with key stakeholders. In addition, secondary data were obtained from company reports and procurement-related documents to support the analysis. The respondents in this study consisted of 27 expert employees drawn from the Plant/Division Section, the HPS Ad Hoc Committee, and the Procurement Ad Hoc Committee. All respondents hold managerial positions and possess extensive experience and expertise in procurement activities, ensuring the reliability and relevance of the data collected.

3.3 Data Analysis

The data analysis was conducted in several systematic stages. First, risk identification was carried out using the Failure Mode and Effect Analysis (FMEA) method by assigning scores for Severity (S), Occurrence (O), and Detection (D), followed by calculating the Risk Priority Number (RPN = S × O × D). The identified risks were then prioritized by ranking them based on their RPN values. Furthermore, decision analysis was performed using the Analytic Hierarchy Process (AHP) by developing a hierarchical model consisting of goals, criteria, and alternatives, conducting pairwise comparisons, and calculating priority weights to determine the most appropriate mitigation strategies. The results of the analysis indicate that the highest priority risks include budget mismatch, delayed tender announcements, delayed contract signing, and delays in fertilizer delivery or receipt.

4. Results and Discussion

The respondents in this study were expert employees who had experience and deep insight into the fertilizer procurement process and were in leadership positions at the managerial level. Researchers grouped the respondents' profiles based on the function of the work division, gender, and age. The following are the results of grouping the respondents' profiles. The composition of respondents for each division of work was 33.3 percent. This proportional number of respondents produced a more objective assessment. The composition of the respondents is shown in the following table:

Table 2. Respondent Work Section

Work Section	**Amount**	**Percentage**
Plant Division/Section	9	33.3
HPS Ad Hoc Committee	9	33.3
Procurement Ad Hoc Committee	9	33.3
Total	27	100%

Source: Proccesed Data, 2022

Based on Table 2, the respondents in this study were employees who were directly involved and experienced in the process of procuring goods and services, especially fertilizer procurement, namely the Division/Plant Division for fertilization as many as nine (9) people, the HPS Ad Hoc Committee as many as nine (nine) people, and the Ad Hoc Procurement Committee. as many as 9 (nine) people.

The majority of the respondents in this study were male. Employees at PT XYZ are dominated by male gender. Although the majority of respondents were male, this did not affect the assessment because there was no assessment regarding aspects of gender. The composition of respondents by gender is as follows.

Table 3. Gender

Gender	Amount	Percentage
Male	2	7.4
Female	25	92.6
Total	27	100%

Source: Proccesed Data, 2022

From the Table 3, it can be seen that the respondents in this study were 25 (twenty five) men (92.6%), while the female respondents were 2 (two) (7.4%). The respondents were in their productive age. In general, leadership employees are expected to work at the age of 24 to 25 years. Thus, the respondents were employees who had worked for a long time and had experience related to their field of work.

Table 4. Age

Age	Amount	Percentage
20 -< 30 years	1	3.7
30 -< 40 years	10	37.0
40 -< 50 years	16	59.3
Total	27	100%

Source: Proccesed Data, 2022

From Table 4, it can be seen that respondents aged 20 - < 30 years amounted to 1 (one) person or (3.7%), those aged 30 - < 40 years amounted to 10 (ten people) or (37%) and those aged 40 - < 50 years old totaling 16 (sixteen) people or (59.3%). The results of this study showed that increasing the performance of NPK fertilization is very important and important for PT XYZ. Improved NPK fertilization performance will increase the productivity of oil palm plants, because NPK fertilizer is the main fertilizer used in oil palm production. The planning criteria for the procurement of NPK fertilizer, selection of NPK fertilizer suppliers, delivery process for NPK fertilizer, and process for receiving NPK fertilizer are very important and important for improving the performance of oil palm fertilization, because these criteria are a series of fertilizer procurement processes.

Table 5. Criteria

Criteria	Amount	Percentage
Improving Palm Oil NPK Fertilization Performance		
- Very Unimportant	0	0.0
- Not Important	0	0.0
- Ordinary	0	0.0
- Important	5	18.5
- Very Important	22	81.5
Total	27	
Planning for Procurement of Palm Oil NPK Fertilizer		
- Very Unimportant	0	0.0
- Not Important	0	0.0
- Ordinary	0	0.0
- Important	3	11.1
- Very Important	24	88.9
Total	27	
Selection of NPK Fertilizer Supplier		
- Very Unimportant	0	0.0
- Not Important	0	0.0
- Ordinary	0	0.0
- Important	8	29.6
- Very Important	19	70.4
Total	27	
NPK Fertilizer Delivery Process		
- Very Unimportan t	0	0.0
- Not Important	0	0.0
- Ordinary	0	0.0
- Important	5	18.5
- Very Important	22	81.5
Total	27	
NPK Fertilizer Acceptance Process		
- Very Unimportant	0	0.0
- Not Important	0	0.0
- Ordinary	0	0.0
- Important	10	37.0
- Very Important	17	63.0
Total	27	

Source: Proccesed Data, 2022

Based on Table 5 the results of the study above show that of the 27 (twenty seven) respondents, the majority of the respondents amounted to 22 (twenty two) people or (81.50%) stated that improving the performance of NPK fertilization has a very important role, while as many as 5 (five) respondents or (18.5%) stated that improving the performance of NPK fertilization has an important role. Furthermore, in the planning criteria for the procurement of NPK fertilizer, as many as 24 (twenty-four) people (88.9%) stated it was very important, and three (three) people (11.1%) stated it was important. In the selection criteria for NPK fertilizer suppliers, 19 (nineteen) people or (70.4%) stated it was very important, and 8 (eight) people or (29.6) stated it was important. On the criteria for sending NPK fertilizer, 22 (twenty

two) people or (81.5%) stated it was very important and 5 (five) people or (18.5%) stated it was important. Regarding the criteria for receiving fertilizer, 17 (seventeen) farmers (63%) stated that it was very important, and 10 (ten) farmers (3%) stated that it was important.

Risk identification is performed using the Failure Mode and Effects Analysis (FMEA) method. According to Alijoyo et al. (2020) when compiling the criteria for parameters Severity (S), Occurrence (O) and Detection (D) is the criterion for the three parameters having the same scale. The scale used can be determined by consensus and agreement by the team.

In this study, the scale for measuring Severity, Occurrence and Detection was based on expert opinions from the division in charge of corporate risk management and was agreed upon by the team involved in the joint fertilizer procurement process as follows:

Table 6. Severity (S), Occurance (O), and Detection (D0 Rating Sale

Scale	**Information**
Severity (S)	
1	Not severe, NPK fertilizer application >90% & 37.0
2	Slightly severe, NPK fertilizer application >50% and <90%
3	Severe, application of NPK fertilizer is less than 50%
4	Very bad, no NPK fertilizer application at all
Occurence (O)	
1	Never happen
2	Very rare (1 time in 1 year)
3	Frequent (<9 times in 1 year)
4	Very common (>9 times in 1 year)
Detection (D)	
1	Very easy to detect (failure does not occur because it has been prevented by the controller
2	Easy to detect (high probability of controller to detect failure)
3	Difficult to detect (the controller's probability of detecting a failure is very low)
4	Not detected (controller cannot detect failure)

Source: Proccesed Data, 2022

Based on the rating scale in Table 4 and 5 , the Risk Priority Number (RPN) can be calculated, which is the result of the multiplication of severity (S), occurrence (O), and detection (D). The results of the Risk Priority Number (RPN) assessment are presented in Table 6.

Table 7. Result of Risk Priority Number (RPN) Assessment

Risk	Reason	Occurance	Severity	Detection	RPN
Fertilizer Planning					
- Fertilizer recommendation late	Sampling and analysis of old leaves	2	2	3	12
- The type of fertilizer used for a long time is determined	Need consideration from cross section	2	3	2	12
- Availability of funds/budget is not in accordance with fertilizer recommendations	Fertilizer prices according to high recommendations	3	3	3	27
- The volume of fertilizer needed by the garden was received late	The garden is late in calculating needs	3	2	2	12
Supplier Selection Process					
- Determination of old HPS	Price surveys are hard to come by	3	2	3	12
- Announcement of the old tender carried out	procurement packages enter at the same time	3	2	3	18
Supplier bids on HPS	The price on HPS does not match the price conditions	2	2	3	12
- The supplier does not meet the procurement criteria	Supplier unable to meet tender requirements (other than HPS)	2	2	3	12
Delivery Procces					
- Late contract signed	Company and supplier renegotiation	3	2	3	18
- The supplier is late in producing fertilizer	Supplier internal constraints	2	3	2	12
- Fertilizer delivery late	There is a shortage of fuel	2	2	3	12
- Fertilizer quality is not suitable	The quality of the fertilizer sample does not meet requirements	2	2	3	12
Admission Process					
- Fertilizer quality is not suitable	The quality of the fertilizer does not match the sample sent	2	2	3	12
- The amount of fertilizer received not appropiate	Fertilizer is reduced during the trip	2	2	3	12
- Fertilizer received past the time period	The supplier's production capability does not match	2	3	3	18

Source: Proccesed Data, 2022

Risk	Reason	Occurance	Severity	Detection	RPN
- Incomplete shipping documents	Documents are still incomplete	2	2	3	12
- There is damage to goods or packaging due to transportation	Damaged goods due to improper treatment	2	2	3	12
- Different types of fertilizers accepted	Fertilizers are replaced with other brands with the same ingredients	2	2	3	12
Competence					
- Lack of personnel knowledge	The assigned personnel is still new	2	2	3	12
- Lack of personnel skills	Inexperienced personnel	2	2	3	12
- The number of personnel is less	Personnel handling less in number	2	2	3	12
Fertilizer Quality					
- Fertilizer quality is reduced due to storage conditions	Moist warehouse	2	2	3	12
- Fertilizer packaging is not up to standard	Open packaging due to transportation	2	2	3	12
- The method of sowing fertilizer is not up to standard	Unprepared applicator	2	2	3	12

Source: Proccesed Data, 2022

Based on Table 7, the risk priority (Risk Priority Number) in the fertilizer procurement planning criteria is the risk of the availability of funds/budget not in accordance with the fertilizer recommendation with an RPN value of 27. Furthermore, the risk priority supplier selection criteria are the announcement of the old tender carried out with an RPN value. 18. Next on the risk priority fertilizer delivery criteria are late contracts signed with an RPN of 18. The risk priority fertilizer acceptance process criteria are fertilizers received past the time period with an RPN value of 18.

Budget availability is the main factor in the procurement process. The current condition of fertilizer prices is very high due to, among other things, the war between Russia, where one of the main sources of making NPK is element K (potassium), which is obtained from Belarus. While the preparation of the budget for fertilization was conducted in the previous year. The old fertilizer packages were announced/tendered because the current condition was that all fertilizer packages for all commodities were carried out simultaneously, so the NPK fertilizer packages were waiting for the announcement to be made. The old contract was signed because of the length of negotiations between the PT. XYZ in question and the selected fertilizer provider because the procurement document and technical specifications have unclear points that must be negotiated between the two parties, namely the article on payment and the article on the period of execution of the work. Meanwhile, fertilizer has passed the time period because currently the pawnshop method used for one procurement package is a single winner. Therefore, if the winner experiences problems, it will disrupt the process of sending fertilizer to the PT. XYZ.

Joint procurement is carried out to meet mutual needs for goods and services or production supporting materials of the same type and certain for the parent company and/or subsidiaries. Joint procurement is carried out to ensure that the price of goods, services, or production-supporting materials is more

efficient and that the availability of goods, services, or production-supporting materials is guaranteed. One of the goods carried out by joint procurement is fertilizer.

Based on the understanding of the procurement of goods and services, where the process starts from planning the needs to the handover of the results of the work in accordance with the results of the study, several things become priority risks. The priority risks of pawning NPK fertilizer according to the results of this study are as follows:

1) In the risk priority planning process, the availability of funds/budget is not in accordance with fertilize recommendations, with an RPN value of 27
   At this time, the price of fertilizer has increased significantly compared to the previous fertilizer price, so that the fertilizer budget according to the recommendations is no longer sufficient to meet purchases as needed. To proceed to the next process, the volume must be reduced or diverted from another budget, which is not short.
2) In the risk priority supplier selection process, the announcement of the old tender was carried out with an RPN value of 18
   The joint procurement of fertilizer at Holding Perkebunan Nusantara was carried out simultaneously for all commodities in PT XYZ. This causes the number of fertilizer procurement packages to enter the Ad Hoc Procurement Committee simultaneously at a certain time, so that the packages that enter the Ad Hoc Procurement Committee cannot be immediately announced at that time.
3) In the fertilizer delivery process, the risk priority is the late contract signing with the RPN value of 18
   In the procurement document sourced from the technical specifications compiled by the HPS Ad Hoc Committee, there are several points that still do not provide certainty, namely payment points. In the Procurement Document CHAPTER IV letter E Article 1 reads, "Payment for Fertilizer is made through Giro, and/or based on an agreement between the selected fertilizer provider and the relevant PT.XYZ. This led to long negotiations between the PT. XYZ and the provider, which caused delays in signing the contract.
4) In the process of receiving fertilizer, the risk priority is that the fertilizer is received past the time period with an RPN value of 18
   At this time, joint fertilizer procurement uses one (1) winner for 1 (one) procurement package. With In this system, if there are obstacles during the work process, it will cause the fertilizer received by PT.XYZ to pass the time period. At this time, the period of work for the procurement of NPK fertilizer is 90 (ninety) calendar days.

Based on the results of this study, there are several alternatives to mitigate these risks that aim to improve the performance of NPK fertilization for Palm Oil, namely:

1) Ensure sufficient funds/budget
   Adequacy of funds/budget is the main alternative choice for improving the performance of NPK Palm Oil fertilization, with a value of 0.432. Budgeting is carried out a year before the implementation of the work. Therefore, when preparing the budget, the company must consider the potential for price increases and other factors that will affect NPK fertilizer. The majority of NPK fertilizer raw materials are raw materials obtained through imported, such as Phosphate and Potassium. At the time of budgeting the Company's Work Budget Plan (RKAP), which was carried out in the year prior to the implementation of procurement, thus requiring more precise pricing accuracy.
2) Adding fertilizer suppliers
   The second alternative, adding suppliers, has a value of 0.208. At this time, the Regulation of the Procurement of Goods and Services Directors of PT Perkebunan Nusantara III (Persero) has

adopted the existence of multiple winners in one procurement package; therefore, it is possible to have more than 1 (one) provider in one procurement package. With more than 1 (one) winner, these providers will be more competitive in completing their work in fertilizer procurement.

3) Improve communication between fertilizer providers and users 0.188
The third main alternative for improving the performance of NPK fertilizer procurement is to improve communication between fertilizer providers and users, with a value of 0.188. With more intensive communication, it is hoped that negotiations on unclear matters will reach an agreement more quickly. To reduce negotiations related to the payment of Procurement Documents, it is necessary to strictly stipulate how the payment will be applied so that it will close the door to negotiations regarding payments with the provider.

5. Conclusions

Based on the data analysis and discussion, the following conclusions can be drawn:

1) The priority risk in the fertilizer procurement planning process is the availability of funds/budget that is not in accordance with the fertilizer recommendation with risk priority number (f Rof PNPN 27, the risk priority in the fertilizer supplier selection process is the announcement of the old tender being carried out with anuRPof PNPN 18, the risk priority in the fertilizer dropping/delivery process is contract signing with anuRPof PNPN 18d, the priority risk in the process of receiving fertilizer is that fertilizer is received past the time period with anuRPof PNPN 18.
2) Criteria in improving the performance of the procurement of NPK Palm Oil fertilizer at PT XYZ is the criteria for planning fertilizer procurement had the first order with a value of 0.575. The second criterion was the selection of suppliers, with a value of 0.214. The third criterion was the delivery of fertilizer, with a value of 0.134. The fourth criterion was fertilizer acceptance, with a value of 0.077.
3) Alternatives for improving the performance of palm oil NPK fertilizer procurement at PT XYZ are alternatives to ensure the adequacy of the budget, which has the first order with a value of 0.432. The second alternative was to add fertilizer suppliers, with a value of 0.208. The third alternative is to improve communication between fertilizer providers and users, with a value of 0.188. The fourth alternative was to determine the time of fertilizer application with a value of 0.070. The fifth alternative is to increase the frequency of fertilizer quality inspection, with a value of 0.055. The sixth alternative is the use of information technology in fertilization, with a value of 0.047.

5.1 Research Limitations

This study has several limitations:

1) The number of respondents is relatively small (27), limiting generalizability.
2) Data rely on subjective assessments from expert judgment.
3) The study is limited to a single company (PT XYZ).
4) External factors such as global fertilizer price fluctuations are not deeply analyzed.

5.2 Suggestions and Directions for Future Research

Future research is recommended to:

1) Expand the study to multiple plantation companies for broader generalization.
2) Apply advanced quantitative methods such as SEM to test causal relationships.
3) Incorporate external variables such as global supply chain dynamics and policy factors.

4) Develop digital-based risk management systems for procurement processes.

5) Combine FMEA with other decision-making methods such as TOPSIS or ANP.

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Author Contributions

RK contributed to conceptualization, formal analysis, writing—review and editing, and final approval of the manuscript. AH contributed to study design, data collection, and writing of the original draft.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this study. The research was conducted independently without any external influence that could affect the results.

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