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Effect of NBPT-DCD (Urease and Nitrification Inhibitor) on Nitrogen Loss, N Uptake and Oil Palm Yields (*Elaeis guineensis* Jacq.) bn Typic Dystrudepts Soil

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ABSTRACT

Incorporating N-(n-butyl) thiophosphoric triamide (NBPT) as a urease inhibitor and Dicyandiamide (DCD) as a nitrification inhibitor can enhance the efficiency of nitrogen (N) fertilization. The main aim of the study was to evaluate the impact of urease and nitrification inhibitors (NBPT and DCD) on N loss in urea fertilizer, N absorption, and oil palm (*Elaeis guineensis* Jacq.) yield. Researchers conducted the field trial using a single-factor, completely randomized design (CRD) with three replications. The experimental treatments included nitrogen (N) fertilization with 5 different levels. The levels were: 100% urea (2.75 kg/plant/year: 1.50 kg/plant in rotation 1 and 1.25 kg/plant in rotation 2) (N0), 80% urea + NBPT-DCD (2.20 kg/plant/year: 1.20 kg/plant in rotation 1 and 1.0 kg/plant in rotation 2) (N1), 60% urea + NBPT-DCD (1.65 kg/plant/year: 0.90 kg/plant in rotation 1 and 0.75 kg/plant in rotation 2) (N2), Urea dosage of 80% (2.20 kg/year: 1.20 kg/plant in rotation 1 and 1.00 kg/plant in rotation 2) (N3), and Urea dosage of 60% (1.65 kg/plant/year: 0.90 kg/plant in rotation 1 and 0.75 kg/plant in rotation 2) (N4). The findings revealed that the application of Urea in combination with NBPT-DCD (inhibitors of urease and nitrification) led to a reduction in N loss by 30.33-37.48% and an increase in N absorption compared to Urea without NBPT-DCD. Oil palm trees grew on Typic Dystrudept soil. The plants received 2.20 kg of urea treatment per plant. The researchers combined Urea with NBPT-DCD. These trees had better outcomes than others. They had less N volatilization and better N absorption. They also had higher fresh fruit bunch productivity. The others received N fertilization but not NBPT-DCD.

Keywords: *N fertilizer (Urea), NBPT-DCD, urease inhibitor, nitrification inhibitor, oil palm.*

1. INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a highly productive plantation commodity for vegetable oil production, surpassing other vegetable oil-producing commodities. Consequently, it has been extensively cultivated on a large scale. Indonesia holds the distinction of being the largest oil palm grower and crude palm oil (CPO) producer globally. In 2018, the country had a planted area of 14.3 million hectares, yielding a CPO production of 42.9 million tons (Direktorat Jenderal Perkebunan 2019). As per PASPI (2016), Indonesia's CPO production has experienced rapid growth, positioning it as the world's leading CPO producer. In 2015, Indonesia accounted for approximately 53% of global CPO production, with Malaysia following at 33%. The export value of CPO and its products rose, reaching USD 15.4 billion in 2008 and USD 21.6 billion in 2011. Then, it fell to USD 18.6 billion in 2015 due to lower CPO prices. As a result, the palm oil industry greatly adds to the country's foreign exchange earnings. They come from the non-oil and gas sector.

To achieve maximum oil palm productivity, it is crucial to take into account all the characteristics and critical factors involved in the cultivation process. According to Jannah et al. (2012), by implementing suitable cultivation technology, we can significantly enhance oil palm production and bring it closer to its full potential. However, it is important to note that the productivity of oil palm plantations currently varies greatly. This diversity primarily stems from the differences in soil and land characteristics across these plantations. Therefore, it becomes essential to have objective information about the fertility of each soil type in order to provide accurate agronomic recommendations.

Oil palm plantations in Indonesia are predominantly grown on acidic mineral soil. The country has a vast expanse of 107.36 million hectares of such land (BBSDPL, 2014), with one example being the Typic Dystrudepts soil. These soils are characterized by their low fertility, which is evident in their acidic to slightly acidic soil reactions (pH 4.5-5.6). The content of organic carbon, cation exchange capacity (CEC), and aluminium (Al) saturation varies significantly, ranging from very low to very high. Available nutrients, such as phosphorus (P), are generally low to very low, while potassium (KB) levels are very low. To enhance the agricultural potential of Typic Dystrudepts soils, it is crucial to improve their chemical properties through the application of organic and inorganic fertilizers, as well as lime, to adjust the pH and reduce Al saturation (Busyra et al., 2010).

Fertilization plays a crucial role in determining the productivity of oil palm. In fact, more than half of the production costs in oil palm cultivation are allocated to fertilization activities, as stated by Hakim in 2007. The currently developed oil palm hybrids have shown positive responses to fertilization, as highlighted by Nurjaya in 2009. Fertilizer holds immense significance as a limiting factor that influences the growth of oil palm plants, as mentioned by Corley and Tinker in 2016. However, the global price hike and reduced availability of fertilizer have posed challenges. Therefore, it is essential to enhance fertilizer efficiency and explore alternative fertilizers with high efficacy. For a long time, the application of inorganic fertilizers has been a key method to boost productivity and replenish soil nutrients in oil palm crops, as emphasized by Soh et al. in 2017. Nevertheless, improper fertilization practices can lead to inefficiencies in oil palm cultivation, especially with the rising fertilizer prices.

Nitrogen represents a crucial macronutrient for oil palm cultivation. Nevertheless, its mobility in the soil makes it susceptible to loss through leaching, volatilization, and binding into unavailable compounds for plant uptake.

The primary mechanisms responsible for nitrogen loss in soil include denitrification, volatilization, decomposition, leaching, and plant absorption (Sanchez, 1979). According to Hardjowigeno (2003), strategies aimed at delaying nitrogen release from urea fertilizer can help mitigate environmental pollution, as nitrate contamination from nitrogen entering water bodies serves as a significant source of water pollution. Inorganic nitrogen forms such as nitrate, nitrite, and ammonia serve as key indicators of water pollution. Nitrification poses a threat to water quality by converting NH4+ into soluble NO3-, leading to elevated nitrate levels in groundwater that can stimulate the growth of microbes, algae, plankton, water hyacinth, and other aquatic plants through water fertilization by nitrates.

Urea ($CO[NH_2]2$) is the most commonly utilized nitrogen (N) fertilizer in the cultivation of oil palm. However, its effectiveness is compromised due to its hygroscopic and volatile nature, as well as its rapid decomposition. According to Abdul Rachman and Pahim (2000), the consumption of domestic Urea has increased significantly over the past three decades, rising from 372,260 tons in 1969 to 4,288,648 tons in 1998, marking a tenfold increase. The World Bank has reported that Indonesia's fertilizer usage surpasses that of other Asian countries. In 2014, Hidayani's research findings revealed that in West Sumatra alone, on an area spanning 381,754 hectares, a staggering 163,772,466 kg of N fertilizer was applied to oil palm plants. However, the actual amount of N fertilizer absorbed by the plants was only 73,697,609.70 kg, resulting in a wastage of 90,074,856.30 kg. These figures indicate that the N uptake efficiency stands at a mere 45%.

The rapid loss of NH_3 in urea fertilization applications is primarily due to the quick release of NH_3 from Urea after application, which does not correspond proportionally to the rate of uptake by the roots. This rapid release of NH_3 from Urea is attributed to its hygroscopic nature, leading to the immediate activation of urease upon dissolution in water. The heightened urease activity expedites the release of NH_4+ from Urea, which then reacts with OH- at pH≥7 to form H_2O and NH_3, resulting in the easy loss of NH_3 through volatilization.

To mitigate NH_3 loss through volatilization, inhibiting urease activity can be effective in slowing down the release of NH_4+ from Urea, allowing plants to absorb more N in the form of NH_4+. Moreover, the gradual release of NH_4+ from Urea leads to a lesser conversion to NH_3, thereby reducing the rate of N loss in the form of NH_3. This controlled release of NH_4+ from Urea has the potential to enhance the efficiency of N uptake by oil palm plants when Urea is utilized as a fertilizer.

In addition to inhibiting urease activity, the suppression of nitrogen loss can also be achieved by inhibiting nitrification. The utilization of nitrification inhibitors can effectively decrease the conversion of ammonium (NH_4+) to nitrate (NO_3-) and the production of N_2O gas during the nitrification and denitrification processes. According to Nainggolan et al. (2009), the application of nitrogen fertilizer to the soil can enhance the nitrification reaction by releasing hydrogen ions, thereby reducing soil pH and promoting the formation of nitrate. The activity of nitrosamine and nitrobacteria, which are obligate autotrophic bacteria, leads to an increase in nitrate levels in the soil during the nitrification process when ammonium nitrate is converted. The concentration of nitrate in the soil is closely associated with the ammonium concentration. As the ammonium concentration increases, the nitrate concentration in the soil tends to rise as well. The process of nitrate formation, known as nitrification, is carried out by Nitrosomonas, which converts ammonium to nitrite, and nitrobacteria, which convert nitrite to nitrate.

There are multiple approaches to enhance the efficiency of fertilizers, and these include improving the techniques of fertilizer application, enhancing the physical and chemical characteristics of fertilizers, altering the shape and size of fertilizers, and regulating nutrient levels to match the specific requirements of plants. By implementing these methods, the aim is to ensure that plants can utilize the nutrients provided by fertilizers most optimally. One strategy to specifically enhance the efficiency of nitrogen (N) fertilization involves improving the chemical properties of urea fertilizer. This can be achieved by coating urea with N-(n-butyl) thiophosphoric triamide (NBPT/C4H14N3PS), which acts as a urease inhibitor in urea fertilizer (CO[NH2]2). Additionally, dicyandiamide compounds (DCD/C2H4N4) are commonly used as nitrification inhibitors in urea fertilizer (CO[NH2]2) to enhance their effectiveness further. The utilization of these two substances helps to prevent nitrogen loss in the soil. However, it is important to conduct tests to determine the efficacy of these materials in inhibiting urease activity and nitrification. Hence, it is imperative to conduct a research study to evaluate the efficacy of NBPT and DCD in suppressing urease activity and N nitrification in oil palm farming. The significant effectiveness of NBPT and DCD in inhibiting urease and nitrification processes can lead to a decrease in the loss of N fertilizer in oil palm cultivation. From an economic perspective, this could result in potential cost savings due to the reduced application of N fertilizer. Moreover, from an ecological standpoint, the utilization of urease and nitrification inhibitors has the potential to mitigate the risk of N contamination in both soil and the atmosphere. The risk of N contamination is particularly high in oil palm cultivation compared to other crops, given the high N requirements per plant and the extensive cultivation area. This risk is exacerbated when the efficiency of N uptake from applied fertilizers is low. Incorporating NBPT and DCD into urea application could not only lower fertilizer expenses related to N fertilizers but also ensure the long-term viability of oil palm plantations and promote environmental sustainability by reducing N loss rates.

2. MATERIAL AND METHODS

The study was carried out between January 2021 and December 2022 at an oil palm plantation situated in Kubang Jaya Village, Siak Hulu District, Kampar Regency, Riau Province. The precise geographical coordinates of the site are 0.4219958 latitude and 101.3918895 longitude. The soil condition in the research area is classified as Typic Dystrudept. The temperature at the research location ranges from 25 to 30 degrees Celsius, while the annual rainfall varies from 2,000 to 2,500 mm.

The field trial was conducted using a single-factor, completely randomized design (CRD) with three replications. The experiment focused on nitrogen (N) fertilization, which included 5 different treatments: 100% Urea (2.75 kg/plant/year: 1.50 kg/plant in rotation 1 and 1.25 kg/plant in rotation 2) (N0), 80% urea + NBPT-DCD (2.20 kg/plant/year: 1.20 kg/plant in rotation 1 and 1.0 kg/plant in rotation 2) (N1), 60% urea + NBPT-DCD (1. 65 kg/plant/year: 0.90 kg/plant in rotation 1 and 0.75 kg/plant in rotation 2) (N2), Urea dose 80% (2.20 kg/year: 1.20 kg/plant in rotation 1 and 1.00 kg/plant in rotation 2) (N3), and Urea dose 60% (1.65 kg/plant/year: 0.90 kg/plant in rotation 1 and 0.75 kg/plant in rotation 2) (N4). Additionally, Rock Phosphate fertilizer (28% P2O5) at 1.75 kg/plant, KCl fertilizer (60% K2O) at 3.25 kg/plant, Kiserite fertilizer (25% MgO) at 1.75 kg/plant, and HGFB fertilizer (45% B2O5) at 0.10 kg/plant were also administered. The fertilizers were spread on the oil palm plant disk (Ring Placement). The experiment comprised 5 treatments with 3 replications, resulting in a total of 15 experimental units. Each experimental unit consisted of 36 plants, thus requiring a total of 540 oil palm trees for the study.

The parameters of environmental observation are climatic observations to determine the environmental conditions at the research site, namely rainfall, sunshine, humidity, and temperature of the research site. Other observation parameters are: (1) observation of evaporation of N applied to the oil palm disk, NH_3 loss analysis was carried out using the foam method (Cantarella et al., 2003), carried out in the second and fourth weeks after the application of N fertilizer. Each treatment per plot installed one tube (pipe) to capture NH_3 lost through evaporation, and the NH_3 came from the N fertilizer applied per oil palm stand. Therefore, overall, this study will use 15 units of cylindrical tubes (pipes) to capture vaporized NH_3. (2) Analysis of N in plant tissues (leaves). The plant tissue analysis carried out is the analysis of N levels in the leaves of oil palm plants. This analysis was conducted in the laboratory. Leaf sampling is done by taking the leaves on the 17th midrib, and then the leaves are taken from the flat endpoint in the middle position of the midrib. Sampling was done 6 times during the experiment, namely months 3, 6, 12, 15, 18 and 24. (3) Observation of fresh fruit bunch (FFB) production. Production observations were made for every harvest rotation, starting from the beginning of the experiment, including the weight of fresh fruit bunches per bunch (kg), per stand (kg), and hectare (kg). Observations were made for 24 months (2 years).

The collected data was subsequently subjected to Analysis of Variance (ANOVA) with a significance level (α) of 5%. If the ANOVA results indicate that the obtained F-value is greater than the critical F-value, it signifies the presence of significant differences between the treatments. In such cases, the analysis proceeds with the application of the Duncan Multiple Range Test.

3. RESULT AND DISCUSSION.

Table 1. Treatment of Various Doses of N Fertilization and Combination with NBPT-DCD in Oil Palm Crops.

No	Treatment	Code	Fertilizing Method
1	Urea 2.75 kg/plant	N0	*Ring Placement*
2	Urea +NBPT-DCD 2.20 kg/ plant	N1	*Ring Placement*
3	Urea +NBPT-DCD 1.65 kg/ plant	N2	*Ring Placement*
4	Urea 2.20 kg/ plant	N3	*Ring Placement*
5	Urea 1.65 kg/ plant	N4	*Ring Placement*

Environmental Conditions of the Research Area.

The average rainfall recorded in the environmental observations is 2,694.5 mm, while the average temperature is 26.91ºC. These rainfall and temperature conditions align with the optimal growth requirements for oil palm plants. According to Pahan (2010), oil palm thrives in regions with an annual rainfall of at least 2000 mm, which remains consistent throughout the year, and where the dry months have a rainfall of less than 100 mm and do not exceed three months. The ideal temperature range for oil palm cultivation is between 29ºC and 33ºC during the day and 22ºC to 24ºC at night. Furthermore, Sunarko (2007) highlights the correlation between rainfall, duration of sunshine, and variation in palm oil production. Extended periods of consecutive dry months can adversely impact flower production, including both the quantity and sex ratio, for the subsequent two years.

In relation to humidity, it can be stated that the mean humidity at the research location aligns with the ideal humidity range for oil palm plants, which is approximately 81.43%. The optimal humidity for oil palm plants falls within the range of 80-90 degrees, accompanied by a wind speed of 5-6 km/hour, which facilitates pollination (Kiswanto et al., 2008). The duration of sunlight is solely measured between 08:00 and 16:00 at the weather stations managed by BMKG. Consequently, if the area receives sunlight for 8 hours, the duration of sun exposure amounts to 100%. The average solar irradiation recorded at the study site was 50.58%, indicating an irradiation time of approximately 4.05 hours per day. This indicates that during the study period, the sunlight was not optimal for oil palm plants, which typically require 5-7 hours of sunlight per day (Kiswanto et al., 2008).

N Loss on Urea Fertilizer.

Nitrogen availability in the soil plays a crucial role in agricultural production and tillage systems, given that plants have a higher demand for this nutrient compared to others. Moreover, nitrogen can be depleted from agricultural ecosystems through a variety of means, including natural processes and agricultural activities.

The findings presented in Table 2 demonstrate that the inclusion of urease and nitrification inhibitors in urea fertilizers can lead to a substantial reduction in volatilization and nitrogen loss compared to standard urea fertilizers that lack the NBPT-DCD coating. Specifically, when comparing the percentage of urea volatilization between NBPT-coated and non-coated fertilizers at the same dosage, there is a difference of 30.33% between N1 (26.03%) and N3 (56.36%) and a difference of 37.48% between N2 (25.07%) and N4 (62.55%). The application of regular urea fertilizer resulted in higher rates of evaporation and nitrogen loss, which were significantly different from the application of urease fertilizer with an inhibitor at the same dosage. Furthermore, the results also indicate that as the fertilizer dosage increases, the amount of evaporated and lost nitrogen from the fertilizer also increases, and this difference is statistically significant.

The findings of this investigation align with the study conducted by Riyadi et al. in 2020, which demonstrated that the application of NBPT treatment to Urea can result in a 30-50% reduction in ammonia loss compared to untreated Urea. Furthermore, research by Bastos et al. in 2015 indicated that urease inhibitors have the potential to decrease N loss levels by approximately 21-43% when compared to fertilizers lacking urease inhibitors. Moreover, Roberts et al. (2016) proposed that nitrification inhibitors are substances that impede or slow down the transformation of ammonium to nitrate, influencing the activity of Nitrosomonas bacteria and offering possibilities for minimizing nitrate leaching and denitrification losses.

Table 2. NH_3 Volatilization of Urea under Various Doses of N Fertilization and Combination with NBPT-DCD in Oil Palm Crops

Treatment	Total NH_3 Evaporation of N Fertilizer Day 1-7 (ppm)			N volatilization in Urea
	Days 1-7	Days 8-14	Days 1-14	(%)
N0	1,090.17 ± 171.71 c	79.40 ± 57.74 a	1,169.57±121.65c	50.96 ± 2.44 b
N1	259.10 ± 116.75 a	218.83 ± 180.49 a	477.93 ± 294.54 a	26.03 ± 7.38 a
N2	246.42 ± 100.03 a	98.80 ± 38.42 a	345.22 ± 72.36 a	25.07 ± 2.42 a
N3	988.70 ± 50.06 bc	46.10 ± 7.44 a	1,034.8 ± 47.74 bc	56.36 ± 1.20 b
N4	796.10 ± 86.48 b	65.30 ± 16.21 a	861.40 ± 102.16 b	62.55 ± 3.41 b

Note: Numbers followed by the same letter in the same column indicate results that are not significantly different based on DMRT at α = 5%.

Plant Tissue Analysis

Table 3. N Levels in Leaves of Oil Palm Plants at 3-24 Months of N Fertilizer Experiments in Treatments with Various N Fertilization Doses and Combinations with NBPT-DCD on Oil Palm Plants

Treatment	N Levels in Leaves (%)					
	3 BSP	6 BSP	12 BSP	18 BSP	24 BSP	Mean
N0	2.61 ± 0.15 a	2.37 ± 0.05 a	2.52 ± 0.02 a	2.87 ± 0.19 a	2.75 ± 0.12 a	2.63 ± 0.11 a
N1	2.82 ± 0.02 a	2.46 ± 0.02 a	2.63 ± 0.05 a	2.55 ± 0.74 b	2.79 ± 0.14 a	2.68 ± 0.06 a
N2	2.80 ± 0.10 a	2.42 ± 0.08 a	2.56 ± 0.06 a	2.49 ± 0.05 b	2.76 ± 0.08 a	2.64 ± 0.07 a
N3	2.76 ± 0.09 a	2.34 ± 0.10 a	2.68 ± 0.16 a	2.42 ± 0.12 b	2.29 ± 0.08 b	2.54 ± 0.11 b
N4	2.69 ± 0.07 a	2.35 ± 0.09 a	2.62 ± 0.11 a	2.43 ± 0.10 b	2.25 ± 0.08 b	2.53 ± 0.09 b

Note: Numbers followed by the same letter in the same column indicate results that are not significantly different based on DMRT at α = 5%.

Based on the examination of leaf N levels in oil palm plants (Table 3), it is evident that N fertilization, with or without urease and nitrification inhibitors, does not have a significant impact on leaf N levels in oil palm plants at 3, 6, and 12 months post-N fertilization. Varied N fertilizer doses resulted in fluctuations in leaf N levels but did not exhibit statistically significant variances. Notably, the average results at 24 months displayed significant distinctions among treatments. The data indicates that the highest leaf N content was observed in the urea+NBPT-DCD treatment with a fertilizer dose of 2.20 kg/tree/year, which was notably different from the same dose treatment lacking NBPT-DCD. Furthermore, the average outcomes revealed that the N treatment utilizing NBPT-DCD exhibited a higher N nutrient value compared to treatments without NBPT-DCD at equivalent doses. Oil palm plants fix nitrogen in the forms of NH4 and NO3, derived from nitrogen-containing fertilizers and soil organic matter. Leiwakabessy (1988) highlighted that the quantity of these ions is contingent upon the fertilizer dosage administered and the rate of organic matter decomposition in the soil. The nitrogen released from soil organic matter is influenced by the equilibrium between factors affecting the mineralization and immobilization of elemental nitrogen, as well as its loss from the soil layers. Bonner and Vanner (1976) proposed that light plays a crucial role in the nitrogen reduction process within the amino acid composition of proteins. Nitrogen reduction is intricately linked to photosynthesis, where proteins generate ATP through photophosphorylation, converting organic nitrogen for the breakdown of accumulated nitrogen.

Production Results of Fresh Fruit Bunches (TBS)

Table 4. Production of FFB (Fresh Fruit Bunches) N Fertilizer Trial on Various N Fertilizer Doses and Combinations with NBPT-DCD on Oil Palm Plants.

Treatment	***Yield 2021***			***Yield 2022***		
	FFB (Ton/Ha/Yr)	**Total Kernel /Pkk**	**BJR (Kg)**	**FFB (Ton/Ha/Yr)**	**Total Kernel/Pkk**	**BJR (Kg)**
N0	34.48 ± 1.45 a	17.11 ± 0.34 a	14.84 ± 1.11 a	31.25 ± 0.94 a	14.17 + 0.06 a	16.21 ± 0.37 a
N1	31.23 ± 1.76 a	15.67 ± 0.88 a	14.71 ± 1.63 a	33.95 ± 0.67 a	15.79 ± 0.92 a	15.84 ± 0.84 a
N2	30.12 ± 4.37 a	14.72 ± 0.74 a	15.04 ± 1.89 a	33.09 ± 1.28 a	15.03 ± 1.05 a	16.25 ± 1.40 a
N3	29.67 ± 3.13 a	14.76 ± 0.30 a	14.79 ± 1.57 a	32.98 ± 2.49 a	14.29 ± 0.68 a	16.99 ± 1.22 a
N4	30.19 ± 1.46 a	14.05 ± 1.40 a	15.85 ± 0.81 a	30.98 ± 0.45 a	13.67 ± 0.78 a	16.69 ± 0.66 a

Note: Numbers followed by the same letter in the same column indicate results that are not significantly different based on DMRT at $\alpha = 5\%$.

The productivity of oil palm plants is determined by a variety of factors, including environmental conditions, genetic characteristics, and breeding methods. Environmental factors, such as rainfall, soil quality, and topography, as well as biotic factors like pests and weeds, play a crucial role in influencing oil palm productivity. Genetic factors, such as the selection of seeds and the age of the plant, also contribute to productivity. Additionally, agricultural techniques, including fertilization, soil and water management, weed and pest control, and overall plant maintenance, are important factors that impact oil palm productivity. These factors interconnect and mutually influence each other (Pahan 2010).

Corley (2003) explains that as the oil palm plant ages, the weight of the bunches it produces increases. Initially, at the age of 3 years, the average bunch weight is approximately 4 kg per bunch. This weight continues to rise, reaching 25 kg per bunch when the plant is 15 years old or older. The author further notes that oil palm productivity experiences a rapid growth phase, peaking between 8 and 12 years of age. Subsequently, productivity gradually declines with increasing plant age, eventually becoming uneconomical after 25 years. Well-managed oil palm plantations in Indonesia and Malaysia can achieve a maximum yield of fresh fruit bunches ranging from 24 to 32 tons per hectare per year.

The research plantation contains a range of oil palm plants, specifically the Damimas variety. In the experimental plots, the DxP (Damimas) variety exhibited an average bunch weight of 14-15 kg and an average fresh fruit bunches (FFB) of 29-32 tons/ha/year. Data presented in Table 4 includes an analysis of variance of production parameters such as tons/ha, number of baskets/stocks, and average basket weight (BJR). Results from observations in 2022 (12-24 months) indicated that N fertilization treatment, with or without the use of urease and nitrification inhibitors, did not have a significant impact on all parameters. However, a comparison between urea dose treatments coated with NBPT-DCD (N1 and N2) and those not coated with NBPT-DCD (N3 and N4) revealed that ton/ha and number of baskets/stalk were higher in the former group at the same dose.

The observation of plant responsiveness in terms of yield has not yielded significant results. This result could be due to the fact that the previous experimental area had a history of good fertilization, following recommended guidelines and routine practices. As a result, it requires a longer time to observe the effects of the treatment given. This extended timeframe is because of the various stages involved in the growth and development of the plant. For example, the formation of Primordia takes around 36 months before harvest, while sex determination occurs approximately 24 months before harvest. Additionally, the period from flower blooming (anthesis) to fruit ripening lasts about 6 months. Analysis of the production trend shows that the N1 treatment demonstrates higher FFB (tons/ha/year) and a greater number of baskets/staples compared to the other treatments.

4. CONCLUSION

Using Urea in conjunction with NBPT-DCD, which acts as a urease and nitrification inhibitor, significantly reduces N loss by 30.33-37.48% compared to using Urea alone. Furthermore, the utilization of Urea combined with NBPT-DCD has demonstrated the ability to enhance the absorption of N nutrients in plants. Notably, when oil palm plants cultivated on Typic Dystrudept soil were treated with Urea at a rate of 2.20 kg/plant in combination with NBPT-DCD, they exhibited the most favorable outcomes in terms of reducing N volatilization, increasing N uptake, and ultimately yielding higher fresh fruit bunch productivity, surpassing the results observed in plants that solely received N fertilization without NBPT-DCD.

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