Australian Journal of Crop Science AJCS

Aust J Crop Sci. 18(12):871-877 (2024) | https://doi.org/10.21475/ajcs.24.18.12.p166

ISSN:1835-2707

Fruit maturity and production of oil palm *(Elaeis guineensis* Jacq.) subjected to cow bio-urine and NPKMg fertilizer

M Amrul Khoiri*[1], Syafrinal[1], Gian Juliano[1,2], M Guna Setiawan[1,3], Aan Royfan[1]

[1]Department of Agrotechnology, Faculty of Agriculture, University of Riau, Bina Widya Campus, Pekanbaru 28293, Riau, Indonesia
[2]Department of Soil Science and Land Resources, Faculty of Agriculture, IPB University, IPB Darmaga Campus, Bogor 16680, West Java, Indonesia
[3]Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, IPB Darmaga Campus, Bogor 16680, West Java, Indonesia

***Corresponding author: M Amrul Khoiri** ✉

Received: 07/04/2024

Revised: 06/08/2024

Accepted: 06/09/2024

Abstract: Oil palm (*Elaeis guineensis* Jacq.) is a valuable commodity that contributes significantly to the Indonesian economy. The current decrease in oil palm production is partly attributed to the substandard quality of fresh fruit bunches (FFB) and the duration of fruit maturation. Therefore, appropriate fertilization is essential to enhance oil palm production. One potential solution involves the utilization of cow bio-urine in conjunction with NPKMg fertilizer. Both bio-urine and NPKMg fertilizer contain essential nutrients that promote increased oil palm production. This study was conducted in an oil palm plantation in Riau province, situated at an altitude of 34 meters above sea level, on Inceptisol soil with a flat topography. The region experiences a wet tropical climate with an annual rainfall ranging from 2,000 to 3,000 mm and is classified as type B in the Schmidt-Ferguson classification. The research was conducted experimentally in a 3x3 factorial design using a completely randomized design (CRD). Factor I, cow bio-urine, comprised of 3 levels (0, 2.5, and 5 liters per plant), while Factor II, NPKMg fertilizer, consisted of 3 levels (0, 1.5, and 3 kg per plant). The oil palm variety used was DxP PPKS SP 540, which was 48 months old after being planted in the field. The study results revealed that the application of 5 liters of cow bio-urine per plant, in combination with a 3 kg dose of NPKMg fertilizer, accelerated oil palm fruit maturation by 10 days compared to plants that did not receive this combination. Providing 2.5 liters of cow bio-urine per plant with a 3 kg dose of NPKMg fertilizer increased the number of FFB by 33% and the weight of FFB by 36% compared to plants that did not receive fertilization.

Keywords: cow bio-urine, NPKMg fertilizer, oil palm.
Abbreviations: Ca_Calcium; CEC_Cation exchange capacity; CPO_Crude palm oil; Cu_Copper; Fe_Iron; FFB_Fresh fruit bunches; K_Potassium; Mg_Magnesium; Mn_Manganese; N_Nitrogen; P_phosphorus; pH_Potential of hydrogen; Zn_Zinc.

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a leading commodity supporting the economy and is Indonesia's largest non-oil and gas foreign exchange contributor. Oil palm development also aims to reduce dependence on fossil fuels and create new targets for biodiesel blends (Putrasari et al., 2016). Global demand for oil palm will continue to increase in the next decade (OECD/FAO, 2015). In response to these conditions, it is necessary to develop the oil palm industry through a significant increase in crop production.

Indonesia is the largest oil palm exporting country in the world, with details of export distribution to Asia (64.72%), Europe (16.29%), Africa (13.59%), America (5.30%), and Oceania (0.07%) (Bogheiri et al., 2023). The area of oil palm plantations in Indonesia until 2020 reached 14.85 million ha (Directorate General of Plantations, 2021). In 2020, Riau province had the largest oil palm plantation area in Indonesia, namely 2.85 million ha, with an oil palm production of 9.98 million tons of CPO. However, in 2021, there has been a decline in production, namely only 8.62 million tons of CPO, with a plantation area of 2.86 million ha.

The productivity of oil palm plantations in Indonesia must continue to be increased through improvements in cultivation activities (Boafo et al., 2020). The low production of oil palm is due to the low quality of FFB and the relatively long maturity of the fruit. Oil palm production is closely related to flowering, pollination, and fruiting. According to Sujadi and Supena (2020), the development duration of oil palm flowers and fruit from the formation of female flowers to harvest is around 222 days. The length of the fruit ripening process is caused by environmental, technical, and cultural factors that must be carried out correctly. One of the technical cultural factors that requires management is fertilization (Tounkara et al., 2020). Effective and efficient fertilization methods can increase plant growth (Cui et al., 2020). The right type and dose also affect growth and production (Setyawan et al., 2020). This impacts increasing of leaves' area, thickness, and chlorophyll content (Emmanuel et al., 2020). If vegetative growth is good, generative development will also be good, especially the productivity of FFB. An increase in FFB will positively correlate with the CPO produced (Moreno-Sader et al., 2020).

Low levels of macronutrients such as N, P, K, and Mg in oil palm can harm plant growth and quality (Adib and Daliman, 2021). Fertilization must be carried out to meet the oil palm's need for these nutrients. Nutrients provided through fertilization must pay attention to the principle of balanced fertilization and according to needs to achieve optimal plant growth and production (Rahhutami, 2015).

Fertilization is the most crucial component in maintaining oil palm plantations. Fertilization costs up to 30–35% of total production or 40–60% of total plant maintenance costs (CPOPC, 2021). One way that plant nutrient needs can be met is by providing NPKMg inorganic fertilizer. NPKMg fertilizer is a compound fertilizer consisting of N, P, K, and Mg elements. The nutrients contained in NPKMg fertilizer will help in the process of fruiting oil palms, primarily the P and K nutrients. Hasputri et al. (2017) report that administering compound NPKMg fertilizer at a dose of 6 kg per plant per year can increase the number of tuber rings, the addition of fronds, leaf area, leaf N nutrient and leaf P nutrient content, FFB weight, and productivity of oil palm plants producing four years of age. Considering the high demand for NPKMg fertilizer and the increasing price of fertilizer on the market, other alternatives are needed to meet the nutrient needs of oil palm plants. One solution can be implemented by using organic materials, namely liquid cow bio-urine fertilizer.

So far, cow bio-urine has only been an agricultural waste, even though cow bio-urine contains N, P, K, Mg, and other nutrients that are important for plants (Wati et al., 2014), as well as organic substrates containing auxin and gibberellin (Mulyani et al., 2018). Bovine bio-urine contains N 1.67%, P 2.59%, K 22.30%, Mg 1.80%, Ca 0.47%, Cu 72.12 ppm, Mn 16.68 ppm, Zn 31.57 ppm, Fe 372.90 ppm from total solids (3.56%), and pH 8.35 (Agricultural Technology Assessment Center, 2018). Therefore, it is necessary to carry out research examining the combination of NPKMg fertilizer and cow bio-urine to support the increased production of oil palm plants. Specifically, this research aims to study the effect of NPKMg fertilizer and cow bio-urine and their interaction on fruit maturity and oil palm (*Elaeis guineensis* Jacq.) production.

Results and discussion

Female flower sheath rupture time

Table 1 shows that the combination of cow bio-urine with NPKMg fertilizer at each different dose did not significantly affect the time of female flower sheath rupture, as did the single factor of cow bio-urine and NPKMg fertilizer. This is due to nutrients not yet available and can be absorbed optimally by a combination of cow bio-urine with NPKMg fertilizer. Apart from that, genotype and environmental factors also have an impact on the flower formation process, so that they influence when the female flower breaks the sheath. According to research by Arifin et al. (2022), the nutrient requirements of oil palm plants are determined by potential yields which vary according to genotype, soil, age of the palm, and environmental factors. According to research by Sujadi and Supena (2020), the time required for peat soil is faster than for mineral soil. On mineral soil, flower sheaths break approximately 64 days after flower emergence.

Table 1 shows that the combination of cow bio-urine with NPKMg fertilizer at each different dose did not significantly affect the time of female flower sheath rupture, as did the single factor of cow bio-urine and NPKMg fertilizer. This is due to nutrients that are not yet available and can be absorbed optimally by a combination of cow bio-urine with NPKMg fertilizer. Apart from that, genotype and environmental factors also have an impact on the flower formation process, so they influence when the female flower breaks the sheath. According to research by Arifin et al. (2022), the nutrient requirements of oil palm plants are determined by potential yields, which vary according to genotype, soil, age of the palm, and environmental factors. According to research by Sujadi and Supena (2020), the time required for peat soil is faster than for mineral soil. On mineral soil, flower sheaths break approximately 64 days after flower emergence.

P-nutrient has a positive influence on flower and fruit growth. N and Mg nutrients influence leaf growth, and K catalyzes photosynthesis. Therefore, the presence of NPK is necessary for all forms of overall plant growth (Loh et al., 2013). P nutrients not absorbed optimally cause delays in the flowering process. This delay in flower development is due to metabolism not running well; this can be seen from the study results, where all the treatments given did not affect when the female flowers broke the sheath.

The sheath rupture time phase requires the P nutrient as an energy source in flower formation metabolism. This is in line with Purba et al. (2021), which state that more P nutrients are needed in parts that have high metabolic activity and rapid cell division, such as during flower initiation, flower formation, and development. The need for P elements is very necessary in the flower development process because it will help speed up the flowering process. This is in line with Napitupulu and Winarno (2010), who stated that the nutrient P will encourage the flowering process to be faster.

Anthesis male flower time

Table 2 shows that the observations of anthesis male flowers on all sample plants were only found on 6 plants, and the time interval for male anthesis flowers was not significantly different. The production of male flower clusters is generally less than that of female flowers. Young oil palm plants produce 4–6 clusters of male flowers per year (Hidayat et al., 2012).

The average time required from the ovary flower measuring approximately 10 cm to the anthesis of the male flower in this study was 16 days. Sujadi and Supena (2020) also reported that the time required from the male flower sheath breaking to anthesis is approximately 16 to 18 days. This is in line with Mubarok (2022), which states that the anthesis period for male flowers lasts 18 days.

P nutrients that are not yet available and absorbed optimally cause plant metabolism in the flower formation phase to not run well, so that the development of anthesis male flowers is hampered. This can be seen from the research results, which show that each treatment does not affect the time of the anthesis male flower. In line with Gardner et al. (1991), the delay in the flowering process was due to the suboptimal provision of the P nutrient as a structural component, which plays an important role in the metabolism of energy sources in the form of ATP and ADP.

P nutrient plays an important role in the production of chemical energy such as ADP and ATP; this energy is needed in the photosynthesis process. The nutrient P can stimulate an increase in plant metabolic processes, especially photosynthesis and plant regeneration. Increasing metabolic processes will affect the amount of assimilation produced. Phosphorus plays a role in the processes of photosynthesis, burning carbohydrates, and compounds related to glycolysis.

The increasing availability of male flowers will increase the population of *E. camerinicus* beetles, thereby increasing the value of the oil palm fruitset (Prasetyo and Susanto, 2014). Male flowers also act as a place to lay *E. camerinicus* beetle eggs, which help in the pollination process. One way to increase the appearance of male flower clusters is by carrying out heavy shoots.

Fruit maturity time

The combination of cow bio-urine at a dose of 5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant significantly accelerated the maturity of oil palm fruit by 10 days compared to without fertilization. And the single factor of cow bio-urine at a dose of 5 liters per plant significantly accelerates the maturity of oil palm fruit compared to without cow bio-urine, but the difference is not significant when given a dose of 2.5 liters per plant. The cow bio-urine and NPKMg fertilizer provided contain the nutrients N, P, and K, which help in the formation and ripening of oil palm fruit. Viegas et al. (2023) stated that the P, K, and Mg nutrients help assimilation and accelerate flowering, seed ripening, and fruit formation. Fruit ripening is also related to the availability of the N nutrient, which functions as a building block for amino acids, proteins, and chlorophyll, which are essential in photosynthesis. An adequate supply of nutrients, especially N, is essential in oil palm production (Diyana et al., 2017).

Table 1. Female flower sheath rupture time subjected to cow bio-urine and NPKMg fertilizer

Cow bio-urine dosage (liters per plant)	NPKMG fertilizer dosage (kg per plant)			Average
	0	1.5	3	
	......day......			
0	60.50 a	60.67 a	60.50 a	60.56 a
2.5	60.33 a	60.33 a	60.50 a	60.39 a
5	60.67 a	60.17 a	60.17 a	60.33 a
Average	60.50 a	60.39 a	60.39 a	

Note: Numbers in the same row and column followed by the same letter are not significantly different according to the DNMRT test at the 5% level.

Table 2. Anthesis male flower oil palm subjected to cow bio-urine and NPKMg fertilizer

Treatment combination	Repetition to-	Sample Plants	
		1	2
		......days......	
B0P1	3	16 a	-
B0P2	3	17 a	-
B1P1	2	16 a	-
B1P2	3	-	15 a
B2P0	3	-	18 a
B2P1	3	15 a	-

Note: Numbers in the same row and column followed by the same letter are not significantly different according to the DNMRT test at the 5% level. Dose of cow bio-urine B0 = 0.0 liter per plant; B1 = 2.5 liter per plant; and B2 = 5.0 liter per plant. Dose of NPKMg fertilizer P0 = 0.0 kg per plant; P1 = 1.5 kg per plant; P2 = 3.0 kg per plant

According to Razali et al. (2012), fruit ripening occurs when the maximum accumulation of chemicals in the fruit occurs, where fat is the main constituent of the fruit and has reached 45%. Potassium helps transport carbohydrates and plays a vital role in cell division, influencing the formation and growth of fruit until it matures.

Adequate need for the nutrients N, P, and K, which play a role in fruit formation, will improve the quality of oil palm FFB. Azahari and Sukarman (2023) stated that oil palms require moderate to high amounts of nutrients for fruit formation, and increasing the amount of fertilizer as a source of nutrients can increase the weight and number of FFB. Wati et al. (2014) reported that cow bio-urine contain nutrients such as N, P, and K that are essential for plant growth and development.

Providing cow bio-urine can add nutrients to the soil (Ramirez-Sandova et al., 2023), increase humus, improve soil structure, and encourage microorganisms in the soil (Comadran-Casas et al., 2022; Bertram, 2009). Fitrah (2022) states that with organic fertilizer, the soil can hold a lot of water, making it easier for the roots to absorb nutrients.

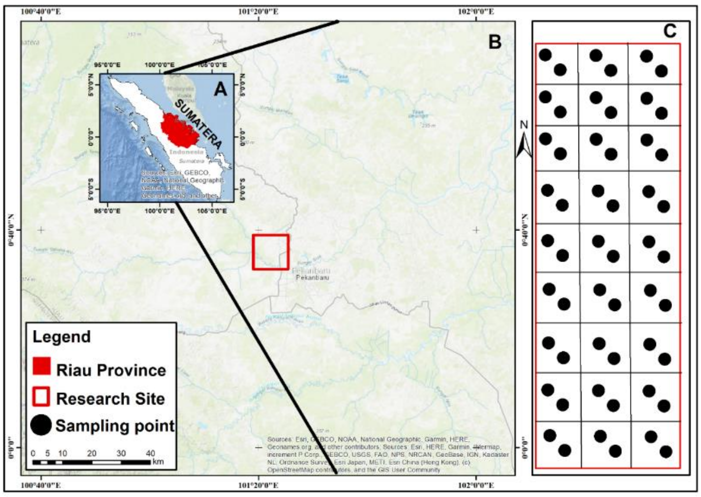

Figure 1. A (inset): Riau Province. B: Location of oil palm plantation. C: Plant sampling distribution scheme.

Number of FFB per month per plant

Table 4 shows that the combination of cow bio-urine at a dose of 5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant produces the highest amount of FFB, but it is not significantly different from the combination of cow bio-urine at a dose of 2.5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant. The combination of cow bio-urine at a dose of 2.5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant significantly increased the amount of FFB by 33% more than without fertilization.

The single factor of cow bio-urine at a dose of 5 liters per plant increased the number of FFB for oil palm compared to those without cow bio-urine. However, the difference was not significant when given a dose of 2.5 liters per plant. The single factor of NPKMg fertilizer at a dose of 3 kg per plant significantly increased the number of FFB for oil palm compared to those without NPKMg fertilizer and a dose of 1.5 kg per plant. This is likely because the availability of K nutrient in cow bio-urine and NPKMg fertilizer is sufficient for the needs of oil palm plants to produce FFB. The general impact of K fertilization on increasing oil palm yields is caused by several factors, namely, increasing stomatal conductance and photosynthesis in leaves, thereby stimulating net carbon assimilation (Mirande-Ney et al., 2020), stimulation of phloem transport and allocation of assimilate from leaves and stems to fruit (Lamade et al., 2014; Cui et al., 2020), an increase in the number and size of bunches (Imogie et al., 2012; Mirande-Ney et al., 2020), and an increase in the total surface area of the canopy (Tiemann et al., 2018).

Fruit formation is a phase that requires a lot of nutrients, including K. Imogie (2012) reports that adding the K nutrient can increase the quality of oil palm FFB. K-nutrient plays a role in carbohydrate metabolism (formation, breakdown, and translocation of starch) by maintaining the balance of electrical charge at the site of ATP production. K plays a role in translocating photosynthesis (sugar) for plant growth or storage in fruit, and together with the N element, the K element plays a role in protein synthesis (Purba et al., 2021).

Giving cow bio-urine, apart from contributing as a source of element K, also produces natural growth regulators containing auxin group hormones, namely indole acetic acid (IAA), to encourage root growth (Karimah et al., 2013). Increased root growth causes more optimal absorption of nutrients in the soil. Research by Viegas et al. (2023) showed that the increase in oil palm production aligns with the increase in P and K nutrients, especially until the plants are eight years old.

Table 3. Maturity time of oil palm fruit subjected to cow bio-urine and NPKMg fertilizer.

Cow bio-urine dosage (liters per plant)	NPKMG fertilizer dosage (kg per plant)			Average
	0	1.5	3	
	......days......			
0	144.67 a	142.17 ab	141.83 abc	142.89 a
2.5	142.83 ab	141.00 abc	139.83 bc	141.22 ab
5	142.17 ab	141.17 abc	134.00 c	140.39 b
Average	143.22 a	141.44 ab	139.83 b	

Note: Numbers in the same row and column followed by the same letter are not significantly different according to the DNMRT test at the 5% level.

Table 4. The number of FFB per month per oil palm plant subjected to cow bio-urine and NPKMg fertilizer.

Cow bio-urine dosage (liters per plant)	NPKMG fertilizer dosage (kg per plant)			Average
	0	1.5	3	
	......bunch......			
0	1.40 c	1.57 bc	1.70 bc	1.58 b
2.5	1.53 bc	1.83 ab	1.87 ab	1.76 a
5	1.80 ab	1.87 ab	2.13 a	1.90 a
Average	1.56 c	1.74 b	1.93 a	

Note: Numbers in the same row and column followed by the same letter are not significantly different according to the DNMRT test at the 5% level.

The nutrient content sufficient for photosynthesis causes more photosynthete to be produced and the number of FFB produced to increase. The research results of Efendi and Ramon (2019) show that the application of 80 kg of compost fertilizer per tree and 5 liters of cow bio-urine per tree increases the trend of oil palm fruit production compared to oil palms that are not given fertilizer and only given compost.

The development and generative growth of oil palms, especially the number of FFB, is greatly influenced by the application of fertilizer and the availability of nutrients in the soil. Fertilizer added to the soil replaces nutrients lost through leaching and transported through the production of FFB. According to Sukmawan et al. (2015), compound fertilizer application began to become apparent four months after treatment. Providing NPKMg fertilizer in this research can increase the number of oil palm bunches in the transition phase from immature plants to mature plants.

Weight of FFB per plant

Table 5 shows that the combination of cow bio-urine at a dose of 5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant produces the highest FFB weight for oil palm, but this is not significantly different from the combination of cow bio-urine at a dose of 2.5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant. The combination of cow bio-urine at a dose of 2.5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant significantly increased the weight of FFB by 36% more than without fertilization.

The single factor of cow bio-urine at a dose of 5 liters per plant increased the weight of FFB compared to without cow bio-urine, but this was not significant at a dose of 2.5 liters per plant. The single factor of NPKMg fertilizer at a dose of 3 kg per plant increased the weight of FFB compared to those without NPKMg fertilizer and those given a dose of 1.5 kg per plant. This is closely related to the role of cow bio-urine and NPKMg fertilizer, which provide the K and Mg nutrients that help the fruit formation process of oil palm plants.

Applying cow bio-urine can improve the spread of roots so that the absorption of nutrients in plants is more optimal. Using cow bio-urine liquid organic fertilizer could increase the growth and spread of the root system. Organic fertilizer improves soil structure and fertility, provides various nutrients, and adds beneficial microorganisms to the soil (Brar et al., 2015; Maltas et al., 2018; Diacono and Montemurro, 2010). Organic fertilization practices can increase crop yields and soil quality, and combining organic and inorganic fertilizers is considered an effective solution for maintaining the sustainability of plant ecosystems (Gentile et al., 2008). Many studies show that applying organic fertilizer to the soil surface can provide a rich food source for microorganisms and significantly increase the composition and diversity of microbial communities compared to no fertilizer application (Chang et al., 2007; Diacono and Montemurro, 2010). In addition, applying organic fertilizer significantly increases CEC and soil water content, thereby causing changes in the structure and composition of soil fauna communities in acid soils (Zelles et al., 1992). Therefore, combining treatment with organic cow bio-urine fertilizer can increase the weight of FFB (Table 5). The NPKMg fertilizer used in this research has a higher K content than other nutrients, with a composition of (N 12%, P 6%, K 22%, and Mg 3%), so it can meet the needs of oil palm plants in increasing the weight of FFB. Imogie (2012) reported that adding K nutrients can increase the quality of FFB. In particular, due to K fertilization, there are changes in sugars, amino acids, and organic acids, which indicate modifications of photosynthetic and catabolic capacity (Krebs cycle). Therefore, K availability causes rapid changes in leaf primary metabolism and the resulting photosynthate (Mirande-Ney et al., 2020). Oil palm plants require moderate to high amounts of the K element to produce a good number and size of bunches.

An increase in magnesium nutrients will stimulate plant physiological processes. Marschner (2012) stated that Mg plays a role as a constituent of chlorophyll and protein synthesis. In addition, magnesium nutrients regulate the distribution of carbohydrates throughout plant tissues and protein synthesis (Hartatik and Widowati, 2010). Viegas et al. (2023) reported that the availability of Mg can increase the average weight of FFB. Application of N and K fertilizer without Mg fertilizer can cause Mg deficiency (Ningsih et al., 2015). Mg is a secondary macronutrient needed in manageable quantities, but its availability is critical to supporting oil palm production.

Materials and methods

Place and time

This research was carried out in an oil palm plantation in Riau province, Indonesia (Figure 1), with an altitude of 34 meters above sea level, on Inceptisol soil and flat topographic conditions. According to Rahmanto et al. (2022), the area has a wet tropical climate with rainfall of 2,000–3,000 mm yr^{-1} and is classified as type B in the Schmidt-Ferguson classification. The research was conducted from January to August 2023.

Material and tool

The materials used in this research were oil palm plants that had produced the DxP PPKS SP 540 variety, aged 48 months after planting in the field, cow bio-urine, and NPKMg fertilizer

Table 5. The weight of FFB per oil palm plant subjected to cow bio-urine and NPKMg fertilizer.

Cow bio-urine dosage (liters per plant)	NPKMG fertilizer dosage (kg per plant)			Average
	0	1.5	3	
	......kg......			
0	3.98 d	4.20 cd	4.87 bc	4.35 b
2.5	4.17 cd	4.80 bc	5.43 ab	4.80 a
5	4.37 cd	5.08 b	5.93 a	5.11 a
Average	4.16 c	4.69 b	5.41 a	

Note: Numbers in the same row and column followed by the same letter are not significantly different according to the DNMRT test at the 5% level.

(12:6:22:3). The tools used include hoes, machetes, rickshaws, palm harvest tools, colored paint, scissors, tarpaulins, jerry cans, large buckets, labels, scales, stationery, calipers, and documentation tools.

Conduction of study and experimental design

The research was carried out experimentally in 3x3 factorial form using a completely randomized design (CRD). Factor I is cow bio-urine (B) consisting of 3 levels, namely: B0 = 0.0 liter per plant (without giving cow bio-urine); B1 = 2.5 liter per plant; and B2 = 5.0 liter per plant. Factor II is NPKMg fertilizer (P), consisting of 3 levels, namely: P0 = 0.0 kg per plant (without NPKMg fertilizer); P1 = 1.5 kg per plant; and P2 = 3.0 kg per plant. The two factors combined resulted in nine treatment combinations with three repetitions, resulting in 27 experimental units. Each experimental unit consisted of two oil palm plants, so the number of plants used was 54, and all plants were sampled. A chart of experiments according to a factorial completely randomized design (CRD) was presented in Figure 2.

NPKMg fertilizer is applied using a single system by making four holes in the plant's east, north, west, and south directions. The depth and diameter of the hole are 20 cm by 20 cm, at a radius of 1 m from the base of the trunk. Meanwhile, cow bio-urine is applied by pouring it around the area of the oil palm plant plate. Fertilization was carried out at the beginning of the research.

Preparation of fermentation cow urine

The steps for making cow bio-urine to be used as fertilizer are (Agricultural Technology Assessment Center, 2018):

1. Prepare the tools and materials that will be used in making cow bio-urine. The tools used were a machete, bucket, jerry can with capacity of 30 liters, tarpaulin, and barrel with a capacity of 180 liters. Meanwhile, the ingredients used are EM_4, 160 liter cow urine, 10 liter water, and a 10 kg mixture of turmeric, ginger, galangal, and ginger.
2. Grind the brown sugar, then dissolve it in water.
3. Grind the mixture of turmeric, ginger, and galangal.
4. Prepare 10 liter of water.
5. Add the mixture of turmeric ginger, galangal, and EM_4 to the water until it becomes a solution.
6. Mix the solution into a cow urine drum and stir until smooth.
7. Cover the urine with a tarpaulin to avoid direct sunlight and free air. This step is important for maintaining the right conditions for fermentation and preventing any potential health hazards.
8. Fermented for approximately 3-4 weeks
9. Check and stir the mixture once a week to ensure the fermentation is progressing as expected.

Observation parameter and statistical analysis

The parameters observed were the time the female flower sheath rupture time, anthesis male flower time, fruit maturity time, the number of FFB per plant, and the weight of FFB per plant.

The observation data were analyzed using analysis of variance and the Duncan New Multiple Range Test (DNMRT) at the 5% level. The linear model used:

$Yijk = \mu + Bi + Pj + (BP)ij + \varepsilon ijk$

Yijk= Observation data on each sample of oil palm plants

μ = Common mean value

Bi = Effect of cow bio-urine dose

Pj = Effect of NPKMg fertilizer dose

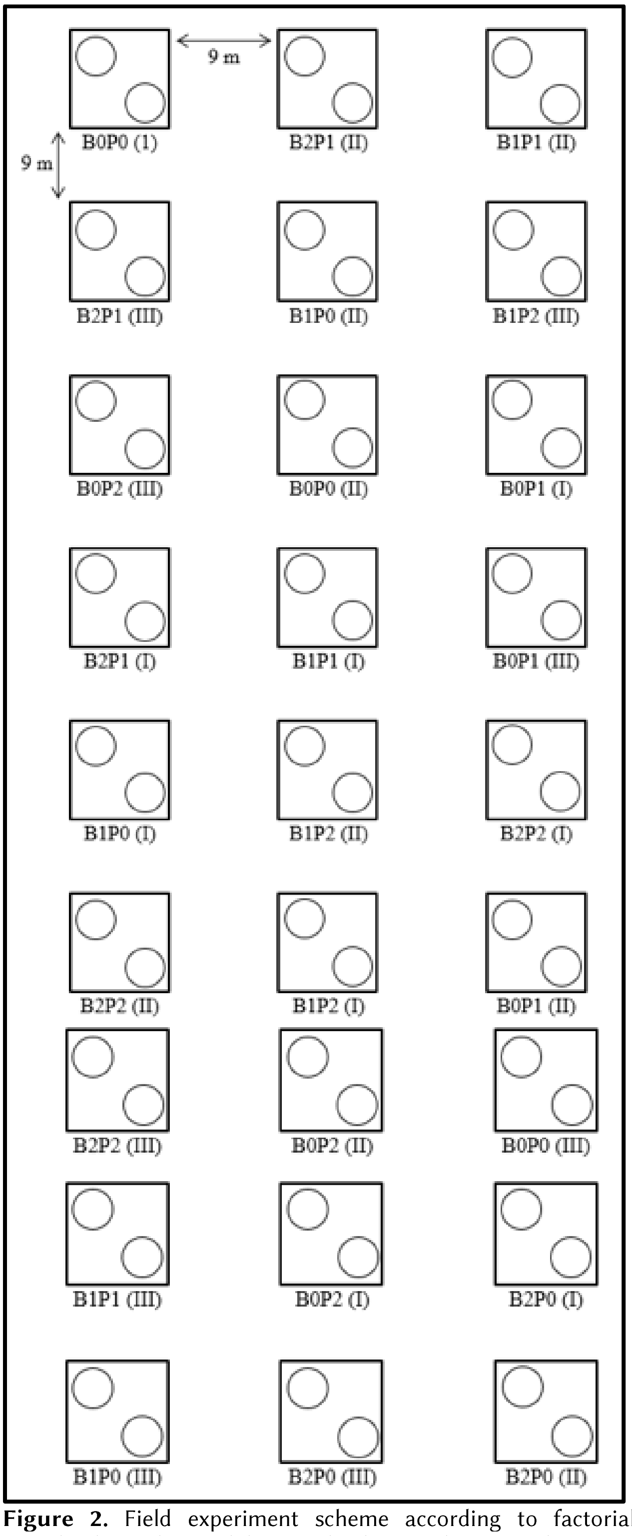

Figure 2. Field experiment scheme according to factorial completely randomized design. The distance between plants was 9 m and the distance between experimental units was 9 m.

(BP)ij = interaction effect of giving cow bio-urine and NPKMg fertilizer

εijk = Experimental error on observation data on oil palm plants

Conclusion

The research showed that 5 liters of cow bio-urine per plant dose with a dose of NPKMg fertilizer of 3 kg per plant produces oil palm fruit maturity that is 10 days faster when compared to without cow bio-urine and NPKMg fertilizer. Giving cow bio-urine at a dose of 2.5 liters per plant with NPKMg fertilizer at a dose of 3 kg per plant increased the number of FFB by 33% and the weight of FFB by 36% when compared to without giving cow bio-urine and NPKMg fertilizer.

References

Adib NAN, Daliman S (2021) Conceptual framework of smart fertilization management for oil palm tree based on IOT and deep learning. 3rd International Conference on Tropical Resources and Sustainable Sciences. IOP Conference Series: Earth and Environmental Science 842: 1-9.

Agricultural Technology Assessment Center (2018) Making bio-urine from cow urine. Agricultural Technology Assessment Center of Bangka Belitung. Ministry of Agriculture of the Republic of Indonesia

Arifin I, Hanafi MM, Roslan I, Ubaydah MU, Karim YA, Tui LC, Hamzah S (2022) Responses of irrigated oil palm to nitrogen, phosphorus, and potassium fertilizers on clayey soil. Jurnal Agricultural Water Management. 74: 107922.

Azahari DH, Sukarman (2023) Impact of chemical fertilizer on soil fertility of oil palm plantations in relation to productivity and environment. IOP Conference Series: Earth and Environmental Science. 1243: 1-12.

Bertram J (2009) Effects of cow urine and its constituents on soil microbial populations and nitrous oxide emissions. Lincoln University. [Thesis].

Boafo DK, Kraisornpornson B, Panphon S, Owusu BE, Amaniampong PN (2020) Effect of organic soil amendments on soil quality in oil palm production. Applied Soil Ecology. 147: 1-9.

Bogheiri A, Thaha M, Rahmah L (2023) Global dependence analysis on indonesian palm oil production and its effect on environmental security using the copenhagen school approach. Journal of World Science. 2(3): 466-482.

Brar BS, Singh J, Singh G, Kaur G (2015) Effects of long term application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize-wheat rotation. Agron. 5(2):220-238.

Chang EH, Chung RS, Tsai YH (2007) Effect of different application rates of organic fertilizer on soil enzyme activity and microbial population. Soil Science and Plant Nutrition. 53(2): 132-140.

Comadran-Casas C, Schaschke CJ, Akunna JC, Jorat ME (2022) Cow urine as a source of nutrients for Microbial-Induced Calcite Precipitation in sandy soil. Journal of Environmental Management. 304: 114307.

CPOPC (2021) Palm oil supply and demand outlook report 2022. Retrieved from https://www.cpopc.org/wp-content/uploads/2021/12/CPOPC-OUTLOOK-2022.pdf

Cui J, Lamade E, Tcherkez G (2020) Potassium deficiency reconfigures sugar export and induces catecholamine accumulation in oil palm leaves. Plant Science. 300: 1-10.

Diacono M, Montemurro F (2010) Long-term effects of organic amendments on soil fertility. A review. Agronomy For Sustainable Development. 30(2): 401-422.

Directorate General of Plantations (2020) Indonesian Plantation Statistics. Ministry of Agriculture of the Republic of Indonesia, Jakarta.

Diyana A, Muharam FM, Paing TN, Yusoff MM, Karam DS (2017) Nitrogen effects on growth and spectral characteristics of immature and mature oil palms. Asian Journal of Plant Sciences. 16(4): 1-11.

Efendi Z, Ramon E (2019) Peningkatan produktivitas kelapa sawit dengan pemberian pupuk kompos dan bio-urine sapi di desa Margo Mulyo Kabupaten Bengkulu Tengah. AGRITEPA: Jurnal Ilmu dan Teknologi Pertanian. 6(2): 29-36.

Emmanuel OC, Akintola OA, Tetteh FM, Babalola OO (2020) Data on the vegetative response of cowpea to fertilizer application on three selected benchmark soils of the Upper West region of Ghana. Data in Brief. 30: 105590.

Fitrah H (2022) Benefits of using organic fertilizer for soil fertility. Sinomics Journal. 1(1): 257-266.

Gardner FP, Pearce RB, Mitchell RL (1991) Physiology of Crop Plants. Iowa State University Press.

Gentile R, Vanlauwe B, Chivenge P, Six J (2008) Interactive effects from combining fertilizer and organic residue inputs on nitrogen transformations. Soil Biology and Biochemistry. 40(9): 2375-2384.

Hasputri R, Sudradjat, Sugiyanta (2017) The roles of organic and NPK compound fertilizers for four year old mature oil palm (*Elaeis guineensis* Jacq.). International Journal of Science: Basic and Applied Research (IJSBAR). 36(1): 213-225.

Hidayat TC, Harahap IY, Pangaribuan Y, Fauzi WR, Hasrsanto WA (2012) Bunga, Buah, dan Produksi Kelapa Sawit. Medan, Indonesia.

Imogie AE, Oviasogie PO, Ejedegba BO, Udosen CV (2012) Effect of potassium (K) source on oil palm yield at Okomu Oil Palm Plc, Ovia North East L.G.A. of Edo State. International Journal of Plant Research. 2(1): 35-38.

Karimah AS, Purwanti, Rogomulyo R (2013) Kajian perendaman rimpang temulawak (*Curcuma xanthorriza* Roxb.) dalam urin sapi dan air kelapa untuk mempercepat pertunasan. Vegetalika 2(2): 1-6.

Lamade E, Ollivier J, Rozier-Abouab T, Gerardeaux E (2014) Occurrence of potassium location in oil palm tissues with reserve sugars; Consequences for oil palm K status determination. Paper presented at the International Oil Palm Conference, Bali, Indonesia.

Loh SK, James S, Ngatiman M, Cheong KY, Choo YM, Lim WS (2013) Enhancement of palm oil refinery waste – Spent bleaching earth (SBE) into bio-organic fertilizer and their effects on crop biomass growth. Jurnal Industrial Crops and Products. 49: 775-781.

Maltas A, Kebli H, Oberholzer HR, Weisskopf P, Sinaj S (2018) The effects of organic and mineral fertilizers on carbon sequestration, soil properties, and crop yields from a long-term field experiment under a Swiss conventional farming system. Land Degradation and Development. 29(4): 926-938.

Mirande-Ney C, Tcherkez G, Balliau T, Zivy M, Gilard F, Cui J, Ghashghaie J, Lamade E (2020) Metabolic leaf responses to potassium availability in oil palm (*Elaeis guineensis* Jacq.) trees grown in the field. Environmental and Experimental Botany. 175(104062): 1-10.

Moreno-Sader K, Alarcón-Suesca C, González-Delgado AD (2020) Application of environmental and hazard assessment methodologies towards the sustainable production of crude palm oil in North-Colombia. Sustainable Chemistry and Pharmacy. 15: 1-10.

Mubarok H, Ahmad F, Tambusai MN, Hidayat AN, Harahap IA (2022) Fenologi kelapa sawit dan hubunganya dengan curah hujan dan kedalaman muka air di lahan gambut. Jurnal Penelitian Agronomi. 24(2): 111-118.

Mulyani IS, Fatmawaty AA, Ritawati S (2018) Pengaruh pemberian tingkat konsentrasi larutan fermentasi urine sapi dan lama perendaman terhadap perkecambahan benih trembesi (*Samanea saman*). Jurnal Agroekotek. 10(2): 73-80.

Napitupulu D, Winarno L (2010) Pengaruh pemberian pupuk P dan K terhadap pertumbuhan dan produksi bawang merah. Jurnal Hortikultura. 20(1): 27-35

OECD/FAO (2015) OECD-FAO agricultural outlook 2015. OECD Publishing, Paris

Prasetyo AE, Purba WO, Susanto A (2014) Elaeidobius kamerunicus: application of hatch and carry technique for increasing oil palm fruit set. Journal of Oil Palm Research. 26 (3): 195- 202.
Purba T, Ningsih H, Junaedi PAS, Junairiah BG, Firgiyanto R, Arsi (2021) Tanah dan Nutrisi Tanaman. Yayasan Kita Menulis, Medan.
Putrasari Y, Praptijanto A, Santoso WB, Lim O (2016) Resources, policy, and research activities of biofuel in Indonesia: A review. Energy Reports. 2: 237-245.
Rahhutami R (2015) Optimization and effect of N, P and K single fertilizer package rate on two years old immature oil palm (*Elaeis guineensis* Jacq.). Bogor. IPB University. [Thesis].
Rahmanto E, Rahmabudhi S, Kustia T (2022) Analisis spasial penentuan tipe iklim menurut klasifikasi Schmidt-Ferguson menggunakan metode Thiessen-Polygon di Provinsi Riau. Buletin GAW Bariri. 3: 35-42.
Ramirez-Sandoval, Magdalena, Pinochet D, Rivero MJ, Cardenas LM (2023) Effect of cow urine nitrogen rates and moisture conditions on nitrogen mineralization in andisol from Southern Chile. Agronomy. 13(1): 1-19.
Razali MH, Somad A, Roslan S (2012) A review on crop plant production and ripeness forecasting. International Journal of Agricultural and Crop Sciences. 4(2): 54–63.
Setyawan H, Rohmiyati SM, Purba JH (2020) Application of cow manure, urea and NPK fertilizer combination on the growth of palm oil (E*laeis guineensis* Jacq) in pre-nursery. Agro Bali Agricultural Journal. 3(1): 74-83.
Sujadi, Supena N (2020) Tahap perkembangan bunga dan buah tanaman kelapa sawit. Warta Pusat Penelitian Kelapa Sawit 25(2): 64-71.
Sukmawan Y, Sudradjat, Sugiyanta (2015) Peranan pupuk organik dan NPK majemuk terhadap pertumbuhan kelapa sawit TBM 1 di lahan marjinal. Jurnal Agronomi Indonesia 43(3): 242-249.
Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T (2018) Chapter Four - Feeding the Palm: A Review of Oil Palm Nutrition. Advances in Agronomy. 152: 149-243.
Tounkara A, Clermont-Dauphin C, Affholder F, Ndiaye S, Masse D, Cournac L (2020) Inorganic fertilizer use efficiency of millet crop increased with organic fertilizer application in rainfed agriculture on smallholdings in central Senegal. Agriculture, Ecosystems and Environment. 294: 1-11
Viegas IdJM, dos Santos LD, Costa MG, de Oliveira Ferreira EV, da Silva Barata H, Silva DAS (2023) Production of oil palm under phosporus, potassium and magnesium fertilization. Revista Ceres. 70(2): 112-123.
Wati YT, Nurlaelih EE, Santosa M (2014) Pengaruh aplikasi biourin pada pertumbuhan dan hasil tanaman bawang merah (*Allium ascalonicum* L.). Jurnal Produksi Tanaman 2(8): 613-619.
Zelles L, Bai QY, Beck T, Beese F (1992) Signature fatty acids in phospholipids and lipopolysaccharides as indicators of microbial biomass and community structure in agricultural soils. Soil Biology and Biochemistry. 24(4): 317-323.