International Journal of Agricultural Technology 2023 Vol. 19(6):2727-2740
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Influence of irrigation water quantity and fertilizer applied together with mulch on the growth and yield of oil palm cv. Deli x Nigeria (*Elaeis guineensis* Jacq.)

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Wiangsamut, B. (2023). Influence of irrigation water quantity and fertilizer applied together with mulch on the growth and yield of oil palm cv. Deli x Nigeria (*Elaeis guineensis* Jacq.). International Journal of Agricultural Technology 19(6):2727-2740.

Abstract The result showed that only the irrigation water quantity of 200 L palm/day (IQ200) promoted better growth and quality of oil palm cv. Deli x Nigeria as compared with those of irrigation water quantity of 100 L/palm/day (IQ100) and no irrigation (IQ0). IQ200 helped in increasing significant fruit pulp thickness by 32.79% as well as reduced the palm kernel diameter by 4.76% as compared with IQ0. Through correlation analysis, pulp thickness was negatively associated with palm kernel diameter (r= - 0.74). Nevertheless, a sufficient irrigation of IQ200 led to obtain high values of the fruit diameter, fruit height, twenty-five fruits weight, number of bunch per palm, and fresh weight of bunch per palm, as compared with those under IQ100 and IQ0. The application of fertilizer together with mulch derived from byproducts of oil palm (FM) contributed to significant values of fruit diameter (14.36%), pulp thickness (17.91%), twenty-five fruits weight (20.28%), and yield (71.49%; fresh weight of bunch per palm) higher than those of no application of fertilizer and mulch (NFM). Therefore, the irrigation water quantity of 200 L/palm/day and application of fertilizer together with mulch derived from byproducts of oil palm could better determine the growth and yield of oil palm cv. Deli x Nigeria during the dry season period, than the other irrigation methods of water quantity of 100 L/palm/day, no irrigation, and no application of fertilizer and mulch.

Keywords: Irrigation, Oil palm, Pulp thickness, Yield, Fertilizer

Introduction

Oil palm (*Elaeis Guineensis* Jacq.) is a perennial and an important economic crop of the world, which is suitable to grow in the tropical climate of South-East Asia especially Indonesia, Malaysia and Thailand (Malinee *et al*., 2021; Aksornniam *et al*., 2012). Oil palm globally produces an annual 81 million tonnes (Mt) of oil from about 19 million hectares (Mha) (Murphy *et al*., 2021), and is a highly productive perennial with a 25-year life cycle. Palm oil is

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a widely attractive ingredient due to its texture, taste, odour, consistency, and shelf life (Ritchie and Roser, 2020; WWF, 2022). About 25% of the world's vegetable oil production comes from this crop. The oil palm gives 10 times more oil than any other crop. In 2021, the world's major palm oil producers were Indonesia (59.7%), Malaysia (24.5%), and Thailand (3.8%) (Sowcharoensuk, 2022). In 2020, the total oil palm plantations in Thailand was 0.99 Mha but yielding area was only 0.94 Mha with a productivity of 16.2 Mt and with an average yield of 0.442 tons per hectare (t/ha) (OAE, 2023). Biodiesel is also mostly produced from palm oil (Tunpaiboon, 2021). The suitable soil types for oil palm plantations are clay loam and sandy loam soil (Abubakar *et al*., 2022). Oil palm acquires water from precipitation and irrigation (Chantaraniyom, 2007, Sapjareonwongse *et al*., 2001). The fertilizer application rates depend on the specific requirements of each type of oil palm planting material (Dassou *et al*., 2022). The precipitation (rainfall) use per ton of fresh fruit bunch is approximately 6,200 m^3 as reported by Akram *et al*. (2022), and the high value of rainwater indicates that the site is suitable for oil palm production (Santosa *et al.*, 2018). On the other hand, Pongpinyopap *et al*. (2014) argues that precipitation use per ton of fresh fruit bunch is 5,714 m^3 as indicated by the value of weighted average of the total water footprint which has a mean annual precipitation of 1,905 mm per year. While the irrigation water use per ton of fresh fruit bunch required is about 8,800 m^3 (Akram *et al*., 2022). Low amount of irrigation water use indicates that the oil palm extracts low amount of ground water indicating that oil palm production is more sustaintable on reference to ground water conservation (Santosa *et al.*, 2018). Every year, there is a 2-5 months, between November and May, with precipitation less than 50 mm; such as in the years of 2015-2021 in which this particular dry season period in Chanthaburi province of Thailand, oil palms utilized ground water for growing (MD, 2015-2021). Fertilization is just one of the productivity factors that determine oil palm yields, and the major nutrients [Nitrogen (N), phosphorus (P), potassium (K)] that need to be regularly provided to maintain yields (Dubos *et al*., 2022). Mulch is one of those factors that determine oil palm yields. Some of the byproducts derivable from the waste of oil palm when appropriately managed are energy, mulch, compost or organic fertilizer from empty fruit bunch (Sridhar and AdeOluwa, 2009). Mulching of oil palm with empty fruit bunch, dried leaves, palm bunch ash, sludge, is essential to conserve moisture as well as to control weed. This management practice can also maintains soil temperature and adding organic matter and nutrients mainly K to improve the physical, chemical, and biological properties of the soils (Directorate of Agriculture, 2009; Sridhar and AdeOluwa, 2009). Juntarumporn *et al*. (2013) described that the oil palm cv.

Deli x Nigeria had a fast growth, short palm height, and it bore a productive fruit bunch at 3-4 years old. The rapid gowth and fast yielding oil palm like Deli x Nigeria cultivar can enable the growers a capital return, especially small-scale oil palm growers. The total oil palm plantation area has increased from 0.04% in 2000 to 6.84% in 2016, due to a policy introduced by the government of Thailand that promotes the use of biodiesel and increases capacity of palm oil production. Paddy field, evergreen forest, wetlands, and peatlands were the main areas replaced. The clearance of natural forest greatly increased in the period of 2000-2009 (Srisunthon and Chawchai, 2020). Oil palm growers in Chanthaburi, a province in the eastern region of Thailand, obtain low yield due to inadequate irrigation water supply and no application of fertilizer during the dry season from November to May. This resulted in an increased and high farm gate price of oil palm in Thailand in 2022, which was 7.9 Thai baht/kilogram (Statista Research Department, 2023). Consequently, a large number of oil palm plantations had tended to expand their areas therefore producing more oil palm waste derived from palm oil extract industries. To solve these problems, palm oil waste were used as mulch in oil palm plantations together with proper irrigation water and fertilizer. The study aimed to assess the growth and yield of oil palm cv. Deli x Nigeria under different irrigation methods and fertilizer with mulch that is derived from byproducts of oil palm.

Materials and methods

The experiment was conducted in an oil palm plantation with sandy loam soil type, 49 meters sea level elevation, at the Department of Plant Production Technology and Landscape, Rajamangala University of Technology Chanthaburi Campus in Chanthaburi, Thailand from November 2015 to May 2016 during the dry season. The precipitation in November-December of 2015 and January-May 2016 was low at 186.5, 26.4, 43.9, 11.8, 42.4, 42.4, and 261.5 mm, respectively. The relative humidity ranged from 71.1-86.4%. Temperature at day ranged from 34.8-37.2 °C while it ranged from 14-20.8 °C at night. The evaporation rate of water was between 3.6-4.8 mm/day (MD, 2015-2016). In this oil palm plantation, the chemical properties of the sandy loam soil comprised of soil pH 6.10, electrical conductivity of 0.01 mS/cm, organic matter of 2.17%, 74 mg P/kg, 90.39 mg K/kg, 882.17 mg Ca/kg, and 59.34 mg Mg/kg (OARDR, 2015). There were 24 oil palms of seven years old cv. Deli Nigeria with similar size and a planting distance of 9.0 m x 9.0 m x 9.0 m were selected and used in the experiment.

The preparation of mulch derived from residues in oil palm plantations and palm oil extract industries consisted of empty fruit bunch (with a ratio of 300 kg), palm leaves (15 kg), palm bunch ash (5 kg), and sludge (5 kg). Empty fruit bunch and palm leaves were chopped and ground with an electric chopper separately. They were then weighed: 7,200 kg of finely ground empty bunch, 360 kg of finely palm leaves, 120 kg of palm ash, and 120 kg of sludge, and mixed together. The total weight of the mulch from the mixture was 7,800 kg (or 7.8 t); this was then left for about a month to decompose prior to be used as mulch in the experimental palm fields. A month of decomposition later, the weight of the mulch had lost 50% of the total weight due to water loss. The prepared mulch totaled to 3,900 kg (or 3.9 t) was then ready to be used in the experiment.

The next step was the installation of a sprinkler water system in the selected oil palm plantations, this along with placing the water main pipe in the between rows of oil palm to ensure regular flow of water. There were 2 sprinkler heads per palm used and provided water in the amount specified in each treatment by an electric water pump of 2 HP.

The experiment was laid out in a split-plot design. The mainplot treatment comprised of three irrigation water quantities (IQ): 1) IQ0, or no-irrigation; 2) IQ100, or irrigation with 100 L of water/palm/day and; 3) IQ200, or irrigation with 200 L of water/palm/day. Whereas the subplot treatment comprised of two fertilizer management methods (FMM): 1) NFM, or no application of fertilizer and together with mulch derived from byproducts of oil palm) and; 2) FM, or application of fertilizer together with mulch derived from byproducts of oil palm [6 kg of 13-6-27 (13% N, 6% P_2O_5, and 27 K_2O) fertilizer formula/palm/year + 500 g of magnesium sulphate (MgO 25% and 15%S) fertilizer formula/palm/year + 300 g of boron (20.9%) fertilizer formula/palm/year] together with 325 kg of prepared mulch/palm/year. The combination treatments of irrigation quantity and fertilizer management method are presented in Table 1. The experiment used a total of 24 oil palms in the total area of 1,900 m^2, 4 palms per combination treatment, 4 replicates, 1 palm per replication.

Table 1. Six combination treatments (T1, T2, T3, T4, T5, and T6) of irrigation water quantity and fertilizer management method

Irrigation water quantity (IQ)	**Fertilizer management method (FMM)**	
	No application of fertilizer and mulch (NFM)	**Application of fertilizer together with mulch from oil palm residues (FM)**
IQ0	IQ0 x NFM (T1)	IQ0 x FM (T2)
IQ100	IQ100 x NFM (T3)	IQ100 x FM (T4)
IQ200	IQ200 x NFM (T5)	IQ200 x FM (T6)

The fertilizers were not applied to the three combination treatments T1, T3, and T5. Meanwhile, fertilizer application was split into three times during the dry season (November 2015-April 2016) in T2, T4, and T6 treatments fields. The 1st, 2nd, and 3rd split-apply of fertilizer were made with 50%, 25%, and 25% of the total amount of fertilizers on November 1, 2015, January 1, 2016, and March 1, 2016, respectively, when the soil was moist by sprinkler in both T4 and T6, except in T2 (the applied fertilizer absorbed moist from its atmosphere). Fertilizer was applied by sowing it around the base of the oil palm, a meter from the base to the end of the leaf canopy of oil palm.

The prepared mulch was sown evenly at a meter away from the base of the palm, within the leaf canopy, at the rate of 325 kg per palm per year. This mulch was applied just once after the first application of irrigation and fertilizer in the three combination treatments fields (T2, T4, and T6).

Fresh fruit bunch per palm were harvested when the green color of fruits had turned into orange color with more than 80% (the unripe fruit is green and turns into orange color when it ripens). The cycle of oil palm harvest ranges from 10-20 days, with an average of 15 days per harvest. Data were gathered in each time within 24 hours from harvest to keep both fruit weight and quality of the fruits.

Data gathered

Random sampling of the fruits was done at the ripening stage taken in the center area of oil bunch (13 fruits) and on the tip of oil bunch (12 fruits). A total of 25 fruits per bunch were used to determine the parameters of fruit diameter, fruit height parameter, fruit pulp thickness, twenty-five fruits weight, palm shell thickness, and palm kernel diameter. The crosswise fruit diameter was measured by a vernier caliper and was recorded in a unit of centimeter (cm). The same samples were used to measure the fruit height parameter. This parameter was measured along the length of the fruit, from the upper part to the bottom also by a vernier caliper, and was recorded in a unit of centimeter. Fruit pulp thickness was measured by a ruler in a unit of centimeter (cm) from the inner edge of the fruit that is attached to the palm shell to the outer edge of the fruit that is attached to the shell of the palm fruit. Twenty-five fruits weight was determined from the total fresh weight of 25 fruits and recorded in a unit of gram (g). Palm shell thickness was measured from the inner edge of the shell to the outer edge by a ruler and was recorded in a unit of centimeter. Palm kernel diameter along the transverse direction of the fruit was measured and recorded in a unit of centimeter. Number of bunch per palm was counted from each oil palm in the 4-month harvest period from December 2015 to March 2016 and recorded in a unit of number per palm (no/palm). Fresh weight of bunch per palm was determined from the sum of weight of fresh fruit bunch derived from the oil palm in the 4-month harvest cycle from December 2015 to March 2016 and were weighed and recorded in a unit of kilogram per palm (kg/palm).

Data analysis

Data on growth and yield of oil palm cv. Deli x Nigeria were statistically analyzed through Statistix 10 (SXW) software. The treatments mean comparison were performed using Duncan's multiple range test (DMRT) at the 0.05 probability level. The relationship of all growth parameters was performed through correlation analysis.

Results

The irrigation water quantity (IQ) and fertilizer management method (FMM) had no significant interactive effect (P>0.05) on growth parameters of oil palm cv. Deli x Nigeria such as fruit diameter, fruit height, pulp (pulp) thickness and twenty-five fruits weight, palm shell thickness, palm kernel diameter, number of bunch per palm, and fresh weight of bunch per palm (Tables 2-9).

The significantly highest fruit pulp thickness of the oil palm (P≤0.05) was under IQ200 (irrigation with 200 L of water/palm/day) followed by IQ100 (irrigation with 100 L water/palm/day) and IQ0 (no-irrigation), respectively (Table 4). The highest values of the fruit diameter, fruit height, twenty-five fruits, number of bunch per palm, and fresh weight of bunch per palm were under IQ200, followed by IQ100 and IQ0, respectively (Tables 2-5 and Tables 8-9). A slightly thicker shell with its narrower shell diameter was found under IQ200 compared with those under IQ100 and IQ0 (Tables 6-7).

Table 2. Fruit diameter (cm)

Irrigation water quantity (IQ)	**Fertilizer management method (FMM)**		**Mean/2**
	No application of fertilizer and mulch (NFM)	**Application of fertilizer together with mulch from oil palm residues (FM)**	
IQ0	1.70a/1	2.06a	1.88a
IQ100	1.88a	2.17a	2.02a
IQ200	2.04a	2.24a	2.14a
Mean/3	1.88b	2.15a	

1/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), 2/ in the column of IQ means with the same letter is not significantly different (P>0.05), 3/ in the row of FMM means with the different letter is significantly different (P≤0.05)

Table 3. Fruit height (cm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	3.19a[/1]	3.59a	3.39a
IQ100	3.34a	3.64a	3.48a
IQ200	3.62a	3.83a	3.72a
Mean[/3]	3.39a	3.68a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the same letter is not significantly different (P>0.05)

Table 4. Fruit pulp thickness (cm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	0.52a[/1]	0.69a	0.61b
IQ100	0.72a	0.81a	0.76ab
IQ200	0.76a	0.87a	0.81a
Mean[/3]	0.67b	0.79a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the different letter is significantly different (P≤0.05), [3]/ in the row of FMM means with the different letter is significantly different (P≤0.05)

Table 5. Twenty-five fruits weight (g)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	231.75a[/1]	327.25a	279.50a
IQ100	280.00a	323.25a	301.63a
IQ200	305.50a	332.50a	319.00a
Mean[/3]	272.42b	327.67a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the same letter is not significantly different (P>0.05)

The values of fruit diameter, pulp thickness, twenty-five fruits weight, and fresh weight of bunch per palm under FM (application of fertilizer together with mulch from byproducts of oil palm) were significantly higher than those under NFM (no application of fertilizer and mulch or natural condition) (Tables 2, 4, 5, and 9). Moreover, fruit height and number of bunch per palm under FM were higher than those under NFM (Tables 3 and 8). The lower values of palm shell thickness and palm kernel diameter were under FM compared with those under NFM (Tables 6-7).

Table 6. Palm shell thickness (cm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	0.21a[/1]	0.19a	0.20a
IQ100	0.22a	0.17a	0.20a
IQ200	0.25a	0.18a	0.22a
Mean[/3]	0.22a	0.18a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the same letter is not significantly different (P>0.05)

Table 7. Palm kernel diameter (cm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	1.22a[/1]	1.31a	1.26a
IQ100	1.43a	1.29a	1.36a
IQ200	1.21a	1.20a	1.20a
Mean[/3]	1.28a	1.26a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the same letter is not significantly different (P>0.05)

Table 8. Number of bunchs per palm (no/palm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[/2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	2.50a[/1]	2.00a	2.25a
IQ100	3.00a	3.00a	3.00a
IQ200	4.50a	5.50a	5.00a
Mean[/3]	3.33a	3.50a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the same letter is not significantly different (P>0.05)

Table 9. Fresh weight of bunchs per palm (kg/palm)

Irrigation water quantity (IQ)	Fertilizer management method (FMM)		Mean[2]
	No application of fertilizer and mulch (NFM)	Application of fertilizer together with mulch from oil palm residues (FM)	
IQ0	23.40a[1]	39.60a	31.50a
IQ100	37.35a	51.43a	44.39a
IQ200	43.40a	87.60a	65.50a
Mean[3]	34.72b	59.54a	

[1]/ In the table of IQ x FMM means with the same letter is not significantly different (P>0.05), [2]/ in the column of IQ means with the same letter is not significantly different (P>0.05), [3]/ in the row of FMM means with the different letter is significantly different (P≤0.05)

Discussion

Pe *et al*. (2014) reported that the parameters of growth and yield of oil palm cv. Deli x Nigeria were bunch weight of 1.40 kg, fruit to bunch ratio of 71.41%, average fruit weight of 10.04 g, mesocarp to fruit ratio of 66.43%, shell to fruit ratio of 11%, kernel to fruit ratio of 21.60%, shell thickness of 1 mm, and yield of 13.58 kg/palm. This cultivar produced a high oil yield due to ratios of a high mesocarp to fruit, low shell to fruit, high fruit to bunch (Noh *et al*., 2014). Irrigation with 200 L/palm/day (IQ200) to the oil palm cv. Deli x Nigeria resulted in a significantly (P≤0.05) increased fruit pulp thickness by 32.79% while its palm kernel diameter of the fruit was reduced by 4.76% as compared with IQ0 (no-irrigation). Whereas the pulp thickness and the palm kernel diameter of the fruit under IQ100 (irrigation with 100 L/palm/day) appreciably increased by 24.59% and 7.94%, respectively as compared with that under IQ0. Through correlation analysis, pulp thickness was negatively associated with palm kernel diameter (r=- 0.74). This means that by increasing the pulp thickness of the oil palm fruit, the palm kernel diameter of the fruit reduces. Nevertheless, an adequate irrigation with 200 L of water/palm/day (IQ200) contributed to have a better growth and fruit quality as indicated by the higher values of the fruit diameter, fruit height, twenty-five fruits, number of bunch per palm, and fresh weight of bunch per palm compared with those under IQ100 and IQ0. The growth and yield of Deli x Nigeria cultivar in terms of its fruit components that have a thicker pulp with narrower palm kernel diameter of the fruit are classified to be good characteristics of the oil palm that its fruit can be extracted for high amount of oil. In Serting Hilir, Malaysia, Afandi *et al*. (2022) reveals that the yield response from irrigated palms was 12 t/ha/year or 56% higher than the non-irrigated palms. He adds that the furrow irrigation system is recommended in areas with unlimited water. Through feasibility analysis on irrigation implementation economics, irrigation is therefore able to increase the yield by 5-6 t/ha/year. The drip irrigation system is then selected to irrigate areas but with sufficient nutrient inputs, in particular to areas with limited water.

To accelerate the mineralization process, Sung (2016) believes that empty fruit bunches (EFB) and oil palm fronds decomposition would become much faster if N and P fertilizers were added to the soil. Fifty percent of EFB weight was lost just within the first month when additional N and P fertilizers were applied with EFB (Caliman *et al*., 2001).) Empty fruit bunches and palm kernel shells were successfully converted into compost fortified with goat manure according to Sridhar and AdeOluwa (2009). Based on the results, the application of fertilizer together with mulch from byproducts of oil palm (FM) contributed to have significantly higher values of fruit diameter, pulp thickness, twenty-five fruits weight, and fresh weight of bunch per palm as compared with those of NF (no application of fertilizer and mulch). Through correlation analysis, fruit diameter was positively associated with twenty-five fruits weight (r=0.64). This means that by increasing the fruit diameter, the fruits weight also increases. Moreover, FM contributed to have higher values of fruit height and number of bunch per palm as compared with that of NPM. Nevertheless, the oil palm cv. Deli x Nigeria responded to the application of fertilizer together with mulch derived from byproducts of oil palm (FM) by lowering the palm shell thickness and by narrowing the palm kernel diameter as compared with those under NPM. Thus, wider fruit diameter, more pulp thickness, heavier twenty-five fruits weight, and heavy fresh weight of bunch per palm are good characteristics of the oil palm to produce oil for commercial use. As Chang *et al*. (2022) claims that fertilization is crucial to sustaining optimum vegetative growth and yield performance of oil palm in high-density planting. In their study, the fresh fruit bunch yield significantly improved by increasing the application of nitrogen (N) up to 6 kg of ammonium sulphate/palm/year on six years old palms planted at 180 palms per hectare. Its yield performance, however, was less responsive to potassium fertilizer mainly due to the high potassium reserve in their study site. There were no significant interaction effects reported between nitrogen and potassium on the yield performance. Dubos *et al*. (2022) describes that the major nutrients that need to be regularly provided to maintain yields can be classed in the following decreasing order of importance: Potassium (K), Nitrogen (N), Magnesium (Mg), Phosphorus (P), respectively, due to K is the main nutrient exported by bunches. Sanputawong *et al.* (2017) points out that the fertilizer application of urea, ammonium phosphate, potassium chloride, kieserite and borate based on the soil and leaf analysis are at the rate of 2040, 1050, 3792, 1500, and 56 g/palm, respectively, which contributes to have the best response on the vegetative growth of oil palm as measured by the value of average leaf area that is 4.37 m^2 and the leaf dry weight is 3.06 kg. This also responded to having a high yield of oil palm as measured by the number of bunches (2.65 no/palm/month) and fresh weight of bunch (23.22 kg/palm/month). The fertilizer application based on the soil and leaf analysis reduced the amount of fertilizer applied to the palm and consequently earned net income of 3,873 USD/ha. Morgan (2005) claims that at least 70% ground cover is considered sufficient for full soil protection and by applying biomass in the form of crop residues or wastes as a soil mulch is an effective method to protect the soil against degradation and to conserve or increase soil fertility. Covering the soil surface with organic materials, the surface is physically protected against water erosion, and reducing soil and nutrient losses. By covering the soil surface with mulch, it also reduces weed growth, particularly soil water loss by evaporation. Palm oil waste contributes to greenhouse gases (GHG) and conversion to energy is a good means of obtaining carbon credit facility for sustainable management as suggested by Sridhar and AdeOluwa (2009) as well as increased crop water use efficiency (WUE) as this value expressed in cubic meters of water per ton dry matter (m^3/kg) (Ludwig *et al*., 2011).

It is therefore concluded that the irrigation water quantity of 200 L/palm/day (IQ200) could promote better growth and quality of oil palm cv. Deli x Nigeria compared with those of irrigation water quantity of 100 L/palm/day (IQ100) and no-irrigation (IQ0)during the dry season period. IQ200 had significantly ($P \leq 0.05$) increased fruit pulp thickness and reduced the palm kernel diameter as compared with IQ0. A sufficient irrigation of IQ200, nonetheless, led to obtain the high values of the fruit diameter, fruit height, twenty-five fruits, number of bunch per palm, and fresh weight of bunch per palm compared with those under IQ100 and IQ0. The application of fertilizer together with mulch derived from byproducts of oil palm (FM) contributed to have significantly ($P \leq 0.05$) wider fruit diameter (14.36%), thicker pulp of the fruit (17.91%), heavier fruit weight (20.28%), and higher yield (71.49%; fresh weight of bunch per palm) than those of no application of fertilizer and mulch (NFM). FM also contributed to higher values of fruit height and number of bunch per palm as compared with that of NPM, and lowering the palm shell thickness and narrowing the palm kernel diameter as compared with those under NPM.

Acknowledgements

The author would like to thank Rajamangala University of Technology Tawan-ok for the financial support. Further gratitude is extended to Associate Professor Manoch Koolpluksee and Assistant Professor Dr. Chaiwat Makornpas for providing the necessary information during the conduct of this study.

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(Received: 30 September 2023, Revised: 15 November 2023, Accepted: 17 November 2023)