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Research Article
Growth Palm Oil Seedling (*Elaeis guineensis* Jacq.) via NPK Fertilization and Different Frequency of Watering

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Abstract

Background and Objective: The problem of fertilization in Indonesia is indeed complex, especially on palm oil seedling. This study aimed to observe the effect of NPK treatment and frequency of watering to growth and proline of palm oil seedlings in pre-nursery. **Materials and Methods:** The experiment was done in June-September 2019. This experiment uses the RCBD Factorial method consisting of 2 treatment factors: NPK consists of 3 levels, namely, $N_1 = 5.0$ g planting per media, $N_2 = 10.0$ g planting per media, $N_3 = 15.0$ g planting per media, Frequency of watering consisting of 4 levels namely $L_0 = 200$ mL water planting per media day^{-1}, $L_1 = 200$ mL water planting per media days^{-3}, $L_2 = 200$ mL water planting per media days^{-5}, $L_3 = 200$ mL water planting per media days^{-7}. The observation variables which reflect plant growth namely plant height, stem diameter, number of leaves, leaf area and one of the characteristics lack of water namely leaf proline. **Results:** Fertilizer NPK up to 15 g planting per media has a trend increase plant growth of palm oil seedlings in pre-nursery, frequency of watering significantly decreases plant growth, on treatment 200 mL water planting per media days^{-7} increases the proline content about 3.26 mM g^{-1}. The combination of NPK fertilizer and frequency of watering has no significant effect. **Conclusion:** Hence it was concluded that NPK has no significant effect to the growth of seedlings, the frequency of watering which is rarely caused the growth of seedling decreased but the proline content increased in leaves.

Key words: NPK, frequency of watering, plant growth, seedling, proline

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

NPK fertilizers are so important to investigate because lately there are a lot of NPK fertilizers on the market and generally the legal group received a recommendation from the government of the Republic of Indonesia because NPK nutrients are very essential for palm oil seedlings[1], smallholder plantations rarely know to provide NPK fertilizer is more suitable so that until now, seedling growth in pre nurseries is not optimal. Through this research, there is a results of NPK fertilization are needed, especially for small holders and the negative impact due to the lack of watering will enrich scientific information as an important basis for policy making[2,3].

Recent progress in general understanding reveals that good seedling will produce high yield on palm oil, and one of the determinants of oil palm plant productivity is to use quality seedling and good agricultural practices, especially proper watering and NPK fertilization every 2 weeks so that the total dose required each seedling up to 8 months old is 158 g with optimal provision of water (personal communication). The NPK as a compound fertilizer is the choice of farmers because it is more efficient and cheap, while the price of other compound fertilizers such as NPK mg and Rock Phosphate is quite expensive and relatively difficult to obtain by Indonesian farmers (personal communication). Therefore, an alternative source of fertilizer that is more affordable and easy to obtain is needed, one of which is compound fertilizer NPK 15-15-15. Apart from fertilizing, watering needs to be given in the pre-nursery. Water is the most important requirement for oil palm plants in their physiological processes. Watering that is not perfect will cause abnormalities and can even lead to death of the oil palm seedlings in the pre-nursery[1-4].

Previous studied was reported the influence of Vedagro fertilizer for palm oil seedlings which have composition N = 11-12%, P_2O_5 = 0.4-0.6%, K_2O = 4.5-6.0%, Ca = 1.1% and Mg = 1.9-2.2%, enriched with iron, manganese, cuprum, zinc, boron and molybdenum and aspartic acid, glutamic acid, alanine, valine, isoleucine, leucine, tyrosine, lysine and arginine is able significantly to increase plant height of oil palm seedlings in the pre nursery[1]. From the results of previous studies it was observed that in the second year of immature palm oil plantations, it was revealed that compound fertilizer N, P, K significantly affected plant height, trunk girth, leaf area, NAR, Chlorophyll, nutrient N, P, K in leaf content[2]. Imperfect watering will cause abnormalities and can even lead to death for oil palm seedlings in the pre-nursery, even though the seeds used are superior[4]. Due to the desire for big profits, Smallholder oil palm plantations in Indonesia continue to expand without technical assistances and agricultural inputs especially for seedling oil palm cultivation[3,4] and The problem of smallholder plantations in Indonesia is indeed complicated, from upstream to downstream. This is what makes smallholder plantations income per unit area much lower than that of those managed by the foreign private sector or state plantations.

Drought is a significant obstacle for palm oil plantations in many areas dependent on rainfall including in Indonesia. Besides, Indonesia must overcome its own problems, one of which has not been separated harvesting of palm oil from various superior varieties[5]. To answer this, it is not possible to have a onetime research, still it must be repeatedly started information from the morphological and physiological aspect in nurseries, one of which is at various levels of lack of watering. Palm oil of Tenera-Simalungun variety is a superior variety produced in North Sumatra and planted in multiple agro climate in Indonesia[1,2]. Indonesia has many areas for palm oil plantations with low rainfall, moderate and high rainfall, finally, the correlation of this research will be to low rainfall. In this case, morphological and physiological characterizations need to be prior to molecular markers. The characteristic of this fertilizer is that it dissolves easily and reacts quickly so that plants rapidly absorb it. The need for water for palm oil seedlings in the pre-nursery is 200 mL planting per media day^{-1}, below 200 mL planting per media day^{-1} is considered to be lack of watering[6-9].

This study determined the optimal dose of NPK fertilizer for palm oil seedlings in the pre-nursery and frequency of watering whether the results are the same watering every day with watering once every three days or once 5 days or once a week to get better seedling. This will advance new knowledge, mainly from the agronomic aspect, namely what the NPK relationship is like and the frequency of water application on the growth and proline content of oil palm seedlings.

MATERIALS AND METHODS

Study area: This research uses Tenera of variety of Simalungun, from PPKS (The Indonesia Palm oil Research Institute), experiment was carried out in a plastic house to see some morphological growth and leaf proline content.

Methodology: The experiment was done in June-September, 2019. This research uses the RCBD Factorial method consisting of 2 treatment factors. The first factor of NPK Fertilizer Dose consists of 3 levels, namely, N_1 = 5.0 g planting per media,

N_2 = 10.0 g planting per media, N_3 = 15.0 g planting per media, while the second factor is lack of watering consisting of 4 levels namely L_0 = 200 mL water planting per media days^{-1} (control), L_1 = 200 mL water planting per media days^{-3}, L_2 = 200 mL water planting per media days^{-5} and L_3 = 200 mL water planting per media days^{-7}. According to applicable standards, soil weight in plant media that is baby polybag 1 kg. The observation variable was observed at ages 4-12 weeks after the plant which reflects plant growth namely plant height, stem diameter, number of leaves, leaf area and one of the characteristics when palm oil seedling lack water namely leaf proline content.

Statistical analysis: Statistical data processing using analysis of variance source, and if the effect of NPK or and lack of watering treatment is significant, followed by the LSD test at the level of $p<0.05$. Proline content was carried out at the Laboratory of the Institute of Research and Development of Agriculture-Center for Research and Development of Agriculture Biotechnology and Genetic Resources of Agriculture, Bogor-West Java. Data processing in statistical only at 12 Weeks after Planting (WAP).

RESULTS

Plant height: Table 1 shows a trend that the higher the dose of NPK the more increased the plant height (16.80 cm) although is not significant, the less watering the more depressed the growth of seedlings, Watering 200 mL planting per media days^{-7} significantly reduces plant height of palm oil seedlings highest to only 10.10 cm at ages 12 weeks after planting, meanwhile, if normally the seedling growth which is represented by plant height has far exceeded this numbers.

Figure 1 shows relationship between plant height and frequency of watering at ages 12 WAP, following the regression Eq.:

$$\hat{Y} = 30.50\text{-}5.23X$$

this can be interpreted in the agronomic approach that each decreased of 1 L in watering will decrease plant height 5.23 cm, with r value 0.87.

Stem diameter: The diameter of seedlings continue to increase with increasing ages (Table 2). Table 2 shows a trend

Table 1: Plant height of palm oil seedling due to NPK fertilizer and frequency of watering at ages 4-12 WAP

	Plant height (cm)				
Treatments NPK	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP
N_1	9.13	10.68	13.30	14.36	15.54
N_2	9.85	11.53	13.32	14.58	16.61
N_3	9.49	11.99	14.99	15.91	16.80
Frequency of watering					
L_0	9.62	13.18	16.19	20.40	23.86^{a}
L_1	9.60	13.33	15.99	19.82	23.37^{a}
L_2	9.33	12.07	12.19	12.29	12.35^{ab}
L_3	9.17	10.02	10.09	10.99	10.10^{b}

Numbers followed by the same letter in the same column are not different from the LSD test at the 5% level, N_1: 5.0 g planting per media, N_2: 10.0 g planting per media, N_3: 15.0 g planting per media, L_0: 200 mL water planting per media day^{-1}; L_1: 200 mL water planting per media days^{-3}, L_2: 200 mL water planting per media days^{-5}, L_3: 200 mL water planting per media days^{-7} , WAP: Weeks after planting

Table 2: Stem diameter of palm oil seedling plant due to NPK fertilizer and frequency of watering at ages 4-12 WAP

	Stem diameter (mm)				
Treatments NPK	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP
N_1	3.15	4.35	4.48	4.82	5.42
N_2	3.18	4.39	4.52	5.16	5.64
N_3	3.32	4.43	4.78	5.35	5.76
Frequency of watering					
L_0	3.19	4.38	4.85	5.24	6.10^{a}
L_1	3.16	4.25	4.81	5.19	5.81^{a}
L_2	3.13	4.14	4.34	4.42	4.46^{ab}
L_3	2.10	2.14	2.19	2.26	2.29^{b}

Numbers followed by the same letter in the same column are not different from the LSD test at the 5% level, N_1: 5.0 g planting per media, N_2: 10.0 g planting per media, N_3: 15.0 g planting per media,L_0: 200 mL water planting per media day^{-1}; L_1: 200 mL water planting per media days^{-3}, L_2: 200 mL water planting per media days^{-5}, L_3: 200 mL water planting per media days^{-7} , WAP: Weeks after planting

Table 3: Number of leaves of palm oil seedling plant due to NPK fertilizer and frequency of watering at ages 4-12 WAP

	Number of leaves (leaf)				
Treatments NPK	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP
N_1	2.61	3.52	4.49	5.57	5.60
N_2	2.64	3.57	4.52	5.68	6.19
N_3	2.67	3.63	4.66	5.78	6.20
Frequency of watering					
L_0	2.67	3.65	4.67	5.87	6.50^{a}
L_1	2.65	3.11	3.67	5.61	6.42^{a}
L_2	2.65	3.01	3.41	3.82	4.11^{ab}
L_3	2.56	2.64	3.19	3.25	3.26^{b}

N_1: 5.0 g planting per media, N_2: 10.0 g planting per media, N_3: 15.0 g planting per media,L_0: 200 mL water planting per media day^{-1}; L_1: 200 mL water planting per media days^{-3}, L_2: 200 mL water planting per media days^{-5}, L_3: 200 mL water planting per media days^{-7}, WAP: Weeks after planting

Table 4: Leaf area palm oil seedling due to NPK fertilizer and frequency of watering treatment at ages 12 Weeks After Planting (WAP)

	Frequency of watering				
Treatments NPK	L_0	L_1	L_2	L_3	Average
N_1	32.11	27.24	18.27	12.12	22.43
N_2	32.27	27.16	18.13	12.11	22.41
N_3	32.87	26.50	17.80	11.32	22.12
Average	32.41^{a}	26.96^{ab}	18.06^{ab}	11.85^{b}	-

Numbers followed by the same letter in the same row are not different significant from the LSD test at the 5% level, N_1: 5.0 g planting per media, N_2: 10.0 g planting per media, N_3: 15.0 g planting per media

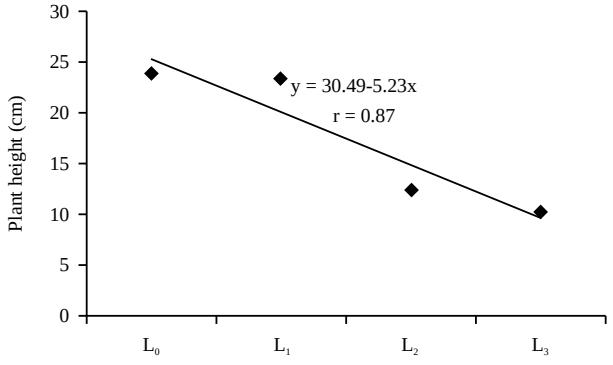

Fig. 1: Relationship between plant height and frequency of watering at ages 12 WAP

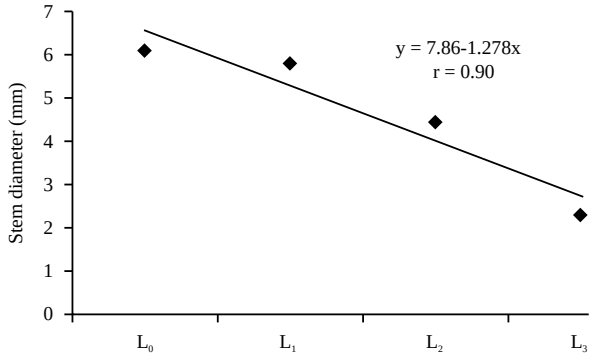

Fig. 2: Relationship between stem diameter and frequency of watering at ages 12 WAP

that the higher the dose of NPK fertilizer the higher the stem diameter is found though is not significant, on the other hand the less watering the more depressed the stem diameter of seedlings, watering 200 mL planting per media days^{-7} significantly reduces stem diameter of palm oil seedlings to only 2.29 mm at ages 12 weeks after planting (Table 2).

Figure 2 shows relationship between stem diameter and frequency of watering at ages 12 WAP, following the regression Eq.:

$$\hat{Y} = 7.86\text{-}1.27X$$

this can be interpreted in the agronomic approach that each decreased of 1 L in watering will decrease stem diameter 1.27 mm, with r value 0.90.

Number of leaves: Number of leaves continues to increase with increasing ages (Table 3), effect of NPK fertilizer is not significant. The effect of frequency of watering is significant on the number of leaves, for more details can be seen in Fig. 3, relationship between number of leaves with frequency of watering at ages 12 WAP following the regression Eq.:

$$Y = 8.08\text{-}1.203x,\ r = 0.90$$

Leaf area: Due to NPK fertilizer and frequency of watering treatment at ages 12 weeks after planting (WAP) on Table 4. Effect of NPK fertilizer is not significant while watering 200 mL

Table 5: Experiment matrix at age of 12 WAP with frequency of watering

Treatments	Plant height (cm)	Stem diameter (mm)	Number of leaves (leaf)	Leaf area (cm^2)	Proline (mM g^{-1})
L_0	23.86[a]	6.10[a]	6.50[a]	32.41[a]	1.65[b]
L_1	23.37[a]	5.81[a]	6.42[a]	26.96[ab]	2.24[b]
L_2	12.35[ab]	4.46[ab]	4.11[ab]	18.06[ab]	3.93[ab]
L_3	10.10[b]	2.29[b]	3.26[b]	11.85[b]	4.91[a]

Numbers followed by the same letter in the same column are not different from the LSD test at the 5% level, L_1: 200 mL water planting per media $days^{-3}$, L_2: 200 mL water planting per media $days^{-5}$, L_3: 200 mL water planting per media $days^{-7}$, WAP: Weeks after planting

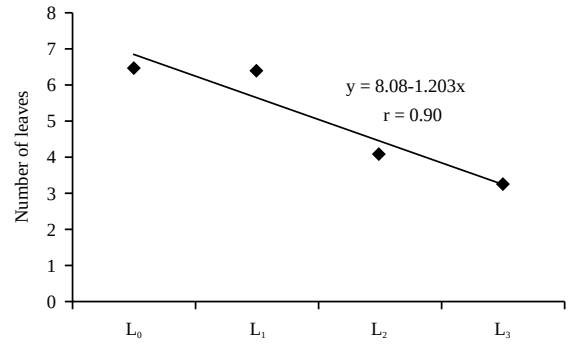

Fig. 3: Relationship between number of leaves and frequency of watering at ages 12 WAP

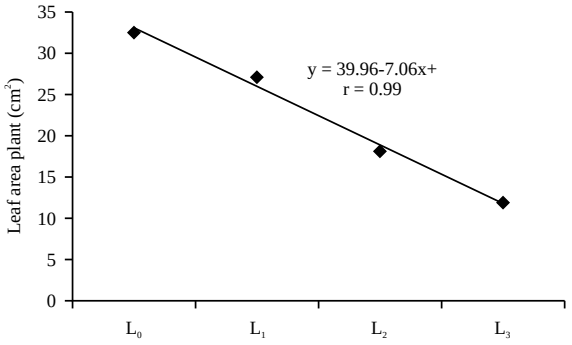

Fig. 4: Relationship between leaf area and frequency of watering at ages 12 WAP

planting per media $days^{-7}$ significantly reduces leaf area of palm oil seedlings to only 11.85 cm^2 at 12 weeks after planting, with the regression equation as in Fig. 4.

From regression Eq.:

$$\hat{Y} = 39.96-7.06X$$

can be interpreted that each decrease of 1 L watering will decrease 7.06 cm^2 leaf area.

Proline content: Proline content in Leaf area due to frequency of watering treatment at ages 12 Weeks after Planting (WAP) shown in Table 5 and Fig. 5. Watering 200 mL planting per media $days^{-7}$ significantly increases proline to 4,91 mM g^{-1} at 12 weeks after planting.

Relationship between proline and Frequency of Watering at ages 12 WAP is shown in Fig. 5. The Fig. 5 shows relationship between proline and frequency of watering at ages 12 WAP follows regression Eq.:

$$Y = 0.31+1.15x$$

means that each decrease of 1 L in watering will increase Proline in leaf 1.15 mM g^{-1}.

DISCUSSION

The NPK only contains nutrients N, P, K, meaning this is in accordance with the theory that applying NPK fertilizer will produce optimal seedling growth but in this study the effect is not significant. Fertilizer NPK up to 15 g planting $media^{-1}$ has a trend increase in plant growth of palm oil seedlings in pre-nursery, seen from plant height, stem diameter, number of leaves, leaf area. According to nursery experts that NPK fertilization every 2 weeks so that the total dose required each seedling up to 3 months old is 59.25 g with optimal provision of water, in this study, the total NPK fertilizer given is not the same with 59.25 g, maybe this is the reason why NPK fertilizer had no effect significantly. On the other hand, applying only NPK fertilizer can cause soil to become hard because it can accumulate residues in the soil. The results of the previous study show that the application of 25% NPK and 75% organic matter gave the best results such as root length, root area, leaf area, the number of leaves, plant height, and dry matter plant[10,11]. This conditions, presumably, palm oil form osmoprotectant to maintain the stability of cell to deficit water. This is not much different from the results of previous studies that the average dry matter yields of palm oil from all stressed environments did not differ significantly from each other but significantly lower than those that were not stressed[6].

The results of the regression analysis from previous studied showed that 72% of the compost and topsoil mixture planting media determined the growth performance of palm oil seedlings in the pre-nursery phase which was supported by leaf or N, P, K supplemented with micro nutrients through the leaves[12].

Application fortified organic fertilizer in the main nursery at 200 g rate can increase growth and soil fertility, it is the best alternative to replace Fertilizer NPK, which is used in nursery stage[13], a combination of 50% NPK+OPEFB compost gives the best effect on the parameters of increasing the height of oil palm seedlings, stem diameter, number of leaves and dry weight of seedlings[14]. Other researchers found that the use of 25% NPK substituted with 75% organic material contributes to the best results in increasing the growth performance of oil palm seedlings in pre-nursery and main nursery[15]. In other crops, NPK fertilizer has a significant effect on plant height, number of leaves, total fruit count and total fruit weight of tomato plants[16]. In contrast to oil palm plants, compared with NPK fertilizer (300 kg ha^{-1}), poultry manure is more improved the performance of tomato and its nutrient status[17], moderate rates of NPK fertilizer (100 or 200 kg ha^{-1}) can be applied to boost soya bean production[18]. Apart from NPK, other nutrients are often added to make the results more satisfactory, for example, NPK 2,600+25 g boric acid +25 g $CuSO_{4.5}H_2O$ (P3) per palm oil significantly increased the growth of palm oil linearly as shown by plant height, leaf number, leaf area of frond number nine, chlorophyll content, N and P content of the leaves[19].

One of the characteristics of oil palm seedling due to lack of water is the increase in leaf proline content as a form of adaptation. Furthermore, proline accumulation in the leaves of water-stressed palm oil seedlings plays an essential role in maintaining turgor, so that proline accumulation is the common response of plant to drought stress, also palm oil plantation with water scarcity significantly reduces growth and oil yield and an increase in stomatal resistance[4,20], also palm oil plantation with water scarcity significantly reduces growth and oil yield[20,21]. This results inform the significance of water. Also, the aeration of palm oil seedlings and pore space is crucial to note[12], based on lipid peroxidation, glycine betaine and proline contents, found in some drought tolerant sugarcane genotypes[22]. Proline is an excellent osmolyte as well as a metal chelator, an antioxidative defense molecule and a signaling molecule[23]. Proline accumulation is caused by the activation of proline biosynthesis and inactivation of proline degradation although it is still not fully understood[24]. Low temperature and lack of watering inhibited the growth of palm oil seedlings. The relative conductivity, injury index, malondialdehyde and proline content in the leaves increased to different degrees of low temperature and drought stress[23,24]. Also, the activity of superoxide dismutase and peroxidase also increases[25], although using superabsorbent, is still increases superoxide dismutase activity when the irrigation deficit is 80% compared to full irrigation[26].

Proline is the most suitable osmolytes for plants experiencing lack of watering[26]. Glutamate appears to be the primary precursor of proline, why elevated proline levels lead to enhanced osmotolerance are still discussed. A lot of evidence shows that a positive correlation exists between proline accumulation and plant stress tolerance[27,28]. Some researchers induce resistance of palm oil seedlings but have not been success as expected, for example, the optimal dose of Si to induce resistance of palm oil seedlings to drought stress has a linear trend[29]. One thing to remember is that proline accumulation in plants is not only in the condition of lack of watering but also as plant signaling[30].

The implication of this experiment is NPK fertilization is needed, especially for smallholders and negative impact due to the lack of watering will enrich scientific information as an important basis for policy making. Watering should be according to the recommendation of 200 mL of water planting per media day^{-1}. Limitation of this study, not yet known whether the results of this experiment in nurseries are strongly correlated when planted in different places in Indonesia include now on land that produce crude palm oil.

CONCLUSION

Fertilizer NPK up to 15 g planting per media has a trend to increase the growth of palm oil seedlings in pre-nursery. Frequency of watering that rarely or lack of watering significantly decreases plant growth seedlings of palm oil but increases proline content. Frequency of watering (200 mL water planting per media $days^{-7}$) can increase the proline content 3.26 mM g^{-1}. The combination of doses of NPK fertilizer and frequency of watering has no significant effect on all observation experiment.

SIGNIFICANCE STATEMENT

This study discovers the effect of NPK fertilizer to produce growth of palm oil seedlings and the effect of frequency of watering on seedling growth. This study will help researchers, farmers, seed industry to uncover the critical point on a nursery in various places in Indonesia, especially in NPK fertilization and frequency of watering. Thus, a new theory is found that on the frequency of watering 200 mL water planting per media $days^{-7}$ can be predicted proline content formed may be arrived at.

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REFERENCES

1. Sirait, B., A.I. Manurung, E. Panjaitan and L. Siregar, 2020. ABA content of palm oil seedlings (*Elaeis guineensis* Jacq.) With vedagro treatment on water stress. Asian J. Crop Sci., 12: 147-151.
2. Ubara, U.E., C.A. Agho, A.I. Aye, M. Yakubu, C.R. Eke and O. Asemota, 2017. Identification of drought tolerant progenies in oil palm (*Elaeis guineensis* Jacq.) Int. J. Adv. Res. Biol. Sci., 4: 120-127.
3. Erniwati, E., E.A.M. Zuhud, I. Anas, A. Sunkar and Y. Santosa, 2017. Independent Smallholder oil palm expansion and its impact on deforestation: Case study in kampar district, riau provice Indonesia. J. Manajemen Hutan Tropika, 23: 119-127.
4. Harun, M.H., 1997. Proline accumulation in the leaves of water stressed oil palm (*Elaeis guineensis* Jacq.) Seedlings. Elaeis, 9: 93-99.
5. Duangpan, S., P. Buapet, S. Sujitto and T. Eksomtramage 2018. Early assessment of drought tolerance in oil palm D×P progenies using growth and physiological characters in seedling stage. Plant Genet. Resour., 16: 544-554.
6. Osakabe, Y., K. Osakabe, K. Shinozaki and L.S.P. Tran, 2014. Response of plants to water stress. Front. Plant Sci., Vol. 5. 10.3389/fpls.2014.00086.
7. Najihah, T.S., M.H. Ibrahim, A.A. Razak, R. Nulit and P.E.M. Wahab, 2019. Effects of water stress on the growth, physiology and biochemical properties of oil palm seedlings. AIMS Agric. Food., 4: 854-868.
8. Nurwahyuni, E. and E.T.S. Putra, 2019. The effect of calcium on photosynthetic rate due to ABA and proline behavior of oil palm (*Elaeis guineensis* Jack.) seedlings under drought conditions. J. Sustainable Agric., 34: 31-42.
9. Isah, A.S., E.B. Amans, E.C. Odion and A.A. Yusuf, 2014. Growth rate and yield of two tomato varieties (*Lycopersicum esculentum* Mill.) under green manure and NPK fertilizer rate samaru northern guinea savanna. Int. J. Agron., Vol. 2014. 10.1155/2014/932759.
10. Manurung, A.N.H., Sudradjat and Haryadi, 2015. Optimization Rate of organic and NPK compound fertilizers on second year immature oil palm. Asian J. Appl. Sci., 3: 375-381.
11. Adileksana, C., P. Yudono, B.H. Purwanto and R.B. Wijoyo, 2020. The growth performance of oil palm seedlings in pre-nursery and main nursery stages as a response to the substitution of NPK compound fertilizer and organic fertilizer. Caraka Tani: J. Sustain. Agric., 35: 89-97.
12. Rosenani, A.B., R. Rovica, P.M. Cheah and C.T. Lim, 2016. Growth performance and nutrient uptake of oil palm seedling in prenursery stage as influenced by oil palm waste compost in growing media. Int. J. Agron., Vol. 2016. 10.1155/2016/6930735.
13. Shampazuraini, S., W. SitiAminah, A.G. Husein and A.N. NuzulFahmi, 2016. Effect of different fertilizers on oil palm (*Elaeis guineensis* Jacq.) growth and performance at nursery stage in felda sungai tekam. Int. J. Adv. Res., 4: 1127-1131.
14. Hapsoh, I.R. Dini, Wawan and A.H. Sianipar, 2020. The growth of oil palm seedlings using combination medium of organic oil palm empty fruit bunch and NPK fertilizer at main nursery. J. Trop. Soils, 25: 61-69.
15. Hariyadi, B.W., F. Nizak, I.R. Nurmalasari and Y. Kogoya, 2019. Effect of dose and time of npk fertilizer application on the growth and yield of tomato plants (*Lycopersicum esculentum* mill.) Agric. Sci., 2: 101-111.
16. Adekiya, A.O. and T.M. Agbede, 2009. Growth and yield of tomato (*Lycopersicum esculentum* Mill.) as influenced by poultry manure and NPK fertilizer. Emir. J. Food Agric. 21: 10-20.
17. Falodun, E.J., A.U. Osaigbovo and S.U. Remison, 2011. Effect of palm oil mill effluent and NPK 15:15:15 fertilizer on the growth and yield of soya bean. Bayero J. Pure Appl. Sci., 4: 173-177.
18. Sudrajat, H. Saputra and S. Yahya, 2015. Optimization of NPK compound fertilizer package rate on one year old oil palm (*Elaeis guineensis*, jacq) trees. Int. J. Sci.: Basic Appl. Res., 20: 365-372.
19. Duangpan, S., S. Sujitto and T. Eksomtramage, 2017. Genotypic variation in proline accumulation during sequential drought and rewatering in response to drought preconditioning. Int. J. Agric. Technol., 13: 927-940.
20. Xing, C.H., S.C. Xu, S.H. Bo and L.X. Tao, 2011. Effects of low temperature and drought on the physiological and growth changes in oil palm seedlings. Afr. J. Biotechnol., 10: 2630-2637.
21. Carr, M.K.V., 2011. The water relations and irrigation requirements of oil palm (*Elaeis guineensis*): A review. Exp. Agric., 47: 629-652.
22. Abbas, S.R., S.D. Ahmad, S.M. Sabir and A.H. Shah, 2014. Detection of drought tolerant sugarcane genotypes (*Saccharum officinarum*) using lipid peroxidation, antioxidant activity, glycine-betaine and proline contents. J. Soil Sci. Plant Nutr., 14: 233-243.

23. Hayat, S., Q. Hayat, M.N. Alyemeni, A.S. Wani, J. Pichtel and A. Ahmad, 2012. Role of proline under changing environments: A review. Plant Signal. Behav., 7: 1456-1466.
24. Liang, X., L. Zhang, S.K. Natarajan and D.F. Becker, 2013. Proline mechanisms of stress survival. Antioxid. Redox Signaling, 19: 998-1011.
25. Cao, H.X., C.X. Sun, H.B. Shao and X.T. Lei, 2011. The effect of water stress on the growth and several physiological processes in the leaves as the plant's height, leaf area was generally below the normal rate when compared to the control seedling. Afri. J. Biotechnol., 10: 2630-2637.
26. Mohebi, A., 2019. Effects of superabsorbents on growth and physiological responses of date palm seedling under water deficit conditions. Int. J. Hortic. Sci. Technol., 6: 77-88.
27. Kiyosue, T., Y. Yoshiba, K. Yamaguchi-Shinozaki and K. Shinozaki, 1996. A nuclear gene encoding mitochondrial proline dehydrogenase, an enzyme involved in proline metabolism, is upregulated by proline but downregulated by dehydration in Arabidopsis. Plant Cell, 8: 1323-1335.
28. Dar, M.I., M.I. Naikoo, F. Rehman, F. Naushin and F.A. Khan 2015. Proline accumulation in plants: Roles in stress tolerance and plant development. Springer, New Delhi, India, ISBN: 978-81-322-2616-1 Pages: 170.
29. Putra, E.T.S., Issukindarsyah, Taryono, B.H. Purwanto and D. Indradewa, 2016. Role of boron and silicon in inducing mechanical resistance of oil palm seedlings to drought stress. J. Appl. Sci., 16: 242-251.
30. Mattioli, R., P. Costantino and M. Trovato 2009. Proline accumulation in plants Plant Signaling Behav., 4: 1016-1018.