Journal of Tropical Crop Science Vol. 9 No. 1, February 2022
www.j-tropical-crops.com

RESEARCH ARTICLE

Effectiveness of Various Foliar Fertilizer on the Growth and Performance of Oil Palm (*Elaeis guineensis* Jacq.) Seedlings in Main Nurseries

Yan Sukmawan* and Dewi Riniarti

Estate Crops Department, Politeknik Negeri Lampung, 10 Soekarno-Hatta Street, Rajabasa District, Bandar Lampung City, Lampung Province, Indonesia 35144.

*Corresponding author; email: ysukmawan@polinela.ac.id

Abstract

Fertilizer can be applied through soil and leaves. Fertilizer application through leaves is more effective than soil application due to faster nutrient absorption. This study aims to determine the effectiveness of applying various foliar fertilizer compositions on the growth and performance of oil palm seedlings. The research was conducted from April 2020 to September 2020 at the Oil Palm Nursery Unit at Politeknik Negeri Lampung. A single factor in a completely randomized design with four replications was used in the experiment. The treatment involved nutrients composition of foliar fertilizer consisting of five levels, namely control (no fertilizer), NPK 20-15-15, NPK 27-18-9, NPK 11-8-6, and NPK 27.5-5.5-4.8. Measurement were made on seedling height, stem diameter, number of leaves, leaf greenness, rachis length, and leaflet length. The data were analyzed by means of variance, followed by orthogonal contrast if the result was significantly different. The results showed that the application of foliar fertilizers could increase the growth of seedling height, stem diameter, number of leaves, leaf greenness index, rachis length, and leaflet length. Generally, a foliar fertilizer application gives better results than without a foliar fertilizer application (control). There was no difference in the powder and liquid foliar fertilizer effect on increasing the growth of oil palm seedlings. The formulation of NPK 20-15-15 and NPK 11-8-6 foliar fertilizer had a better effect on the leaf greenness index of oil palm seedlings.

Keywords: foliar fertilizer, oil palm nursery, vegetative growth

Introduction

The production and productivity of oil palm plantations are determined by the quality of seedlings and the technical cultural cultivation technique from the beginning of planting until the plants enter the mature crop phase. The basic problem of low oil palm productivity is the lack of quality and performance of planting material. The determinant of the quality and performance of oil palm seedlings is the nutritional intake provided during the nursery period. Fertilizer treatment in oil palm nurseries is generally provided through the soil in the form of compound fertilizers. Certain conditions can inhibit the uptake of fertilizers that are given through the soil; for example, low soil moisture causes the absorption of fertilizers by the roots to be inhibited (Wang et al., 2018; Xu et al., 2020). On the other hand, the relatively long maintenance period for oil palm seedlings, ranging from 9-12 months, makes maintenance costs high enough so that efforts are needed to shorten the maintenance time without reducing the quality and performance of oil palm seedlings. Fertilizer through leaves can be applied in addition to fertilization through the soil to accelerate plant growth (Muktamar et al., 2017; Niu et al., 2021).

Administering fertilizers through leaves is a technique of applying liquid fertilizer directly to the leaves. Plants can absorb essential nutrients through their leaves (Patil and Chetan, 2018). The absorption of foliar fertilizer occurs through the stomata and leaf epidermis (Butler et al., 2020; Zhu et al., 2020). Foliar fertilizer spraying technique is commonly used for micronutrients. Macronutrients can also be administered via this method if there is insufficient topsoil moisture to support fertilizer uptake. Spraying foliar fertilizers is not to replace the application of

fertilizers through the soil but as an addition. Fertilizers given through the leaves contain both macro- and micronutrients with different concentrations. Fertilizer application through leaves is more effective than through soil because the absorption of leaf nutrients needed for growth occurs faster (Galagi et al., 2018; Joshi et al., 2016; Shahrekizad et al., 2015). Several conditions in the field, such as high rainfall levels, which cause high loss of nutrients from the soil and nutrient deficiency, are the reasons for spraying foliar fertilizers. Leaves can absorb about 90% fertilizer, whereas roots can only absorb about 10% fertilizer (Iswanto, 2002). Nitrogen, phosphorus, and potassium are mobile in plant system so application through the leaves makes it possible to provide these three elements quickly (Das and Avasthe, 2018; Kathpalia and Bhatla, 2018).

Nitrogen deficiency is the most important nutritional problem in oil palm production (Broschat, 2009). Planting media containing organic material derived from plant stems and other wood-derived materials are susceptible to N bonds because this material breaks down (Nikiyuluw et al., 2018). Although P deficiency is generally not a problem in oil palms, it is a severely limiting factor in acid soils in the tropics, where oil palms are grown commercially. Potassium deficiency is by far the most common deficiency in various plants from the family Arecaceae (Broschat, 2009). However, in the nursery phase, potassium deficiency is less common than nitrogen deficiency. Symptoms vary according to species and severity. In many species, the earliest symptoms consist of yellow-orange and necrotic spots on the oldest leaves (Broschat, 2009). Sufficient nutrient content in the soil does not guarantee that oil palm roots in sufficient quantities will absorb these nutrients. Previous studies on various plant commodities showed that application of foliar fertilizers was able to accelerate and increase plant growth. In general, the concentration of foliar fertilizers that produces the best growth on various plants ranges from 0.1-0.4% . The aim of this study was to determine the effectiveness of applying various foliar fertilizer compositions on the growth and performance of oil palm seedlings by comparing seedling height, stem diameter, number of leaves, leaf greenness, rachis length, and leaflet length.

Material and Methods

Experimental Design

The research was conducted from April 2020 to September 2020 at the Oil Palm Nursery Unit of Politeknik Negeri Lampung, Lampung Province, Indonesia. The study site is located at 5° 21' 6.3" S and 105° 13' 40" E. Based on the Agricultural Meteorology Station data of Politeknik Negeri Lampung, the average daily temperature and rainfall during this research were 26.2 °C and 247.77 mm month^{-1}, respectively. The experiment included a single factor in a completely randomized design with four replications. The treatment involved nutrients composition of foliar fertilizer consisting of five levels, namely control (no fertilizer), NPK 20-15-15 (powder), NPK 27-18-9 (powder), NPK 11-8-6 (liquid), and NPK 27.5-5.5-4.8 (liquid). There were 60 seedling samples in the experiment; each experimental unit had four oil palm seedlings measured.

Tools and Materials

The tools used in the study included meters, calipers, leaf area meters CI-202 (CID Bio-Science, USA), SPAD-502 Plus (Konica Minolta, Japan), digital scales, measuring cups, buckets, and hands sprayer. The materials used in the study included DxP oil palm seeds of "Simalungun" variety (IOPRI, Medan) aged 24 weeks after planting, 20-15-15 NPK foliar fertilizer, 27-18-9 NPK foliar fertilizer, 11-8-6 NPK foliar fertilizer, and 27.5-5.5-4.8 NPK foliar fertilizer. Healthy and similar-sized seedlings were selected with an average seedling height of 19.23 ± 1.74, stem diameter of 5.42 ± 0.47, and the number of leaves of 2.00 ± 0.00.

Application of Treatment

Before receiving treatment, oil palm seedlings were arranged in the main nursery with a distance of 70 cm x 70 cm. Oil palm seedlings were arranged into 12 groups and labeled according to treatment. The location for placing the seedlings was on the land of the Oil Palm Nursery Unit. Oil palm plants were sprayed using a hand sprayer that has been filled with foliar fertilizer solution based on the composition of the foliar fertilizer according to the predetermined treatment. Foliar fertilizer solution was made with a concentration of 0.2% and spraying volume was ± 3.5 ml per plant. Foliar fertilizer was sprayed on the top and bottom surface of the leaves every two weeks in the morning when there was no rain.

Measurement and Data Analysis

Plant characteristics, such as seedling height, stem diameter, number of leaves, leaf greenness, rachis length, and leaflet length were recorded. Measurement of the growth of oil palm seedlings was carried out to 60 observation units at 9 month after treatment. The data obtained were analyzed using ANOVA, followed by orthogonal contrast if the result was significantly different, using RStudio. The correlations were

illustrated using the ggpairs function in the GGally R Package (Schloerke et al., 2020).

Result and Discussion

Based on measurement of palm seedlings, foliar fertilizer application promotes the increase in seedling height, stem diameter, and number of leaves over control. The results of further orthogonal contrast tests showed that the height of the seedlings, stem diameter, and number of leaves on the oil palm seedlings treated with foliar fertilizer were significantly larger than those without foliar fertilizer (control) (Table 1). Certain types of foliar fertilizer have no effects on seedling height, stem diameter, and number of leaves (Figure 1). Different foliar fertilizer formulations affect seedling height, stem diameter, and number of leaves. These results show that the application of foliar fertilizer (in powder and liquid form) with high N content effectively enhances the growth of oil palm seedling. Foliar fertilizer is fertilizer in liquids or solids generally dissolved in water and sprayed onto the plants, especially leaves. The foliar fertilizer application is commonly used in horticultural crops, including ornamental and fruit crops. Foliar fertilizer can also be sprayed to plant seedlings. Some types of foliar fertilizers circulating in the market are enriched with micronutrients. The nutrients are entering the leaf through the stomata or by diffusion through the epidermis (Su et al., 2019). This mechanism allows nutrients to enter the plant more effectively and is subsequently utilized by the plant.

The results also show that provision of foliar fertilizer with high nitrogen content can increase the greenness index of leaves and the length of young leaves (Table 1 and Figure 2). The ratio between nitrogen-phosphorus content of 1:1.3 and nitrogen-potassium content of 1:1.3 to 1:1.8 is the composition of nutrients in foliar fertilizers that produces the highest leaf greenness index. The leaf greenness index correlates with the nitrogen levels in the leaves and contributes to photosynthesis. The results of previous studies also showed a high positive correlation between leaf greenness index and leaf chlorophyll concentration (Jhanji and Sekhon, 2018; Neilson et al., 2015). Chlorophyll is a photosynthetic pigment that is important for converting light energy into chemical energy, so leaf chlorophyll content is an essential variable from a physiological perspective. Nitrogen deficiency or water limitation suffered by oil palm seedlings can lead to a low greenness index.

Nitrogen, as well as phosphorus, potassium, and magnesium, are mobile elements. Under conditions of deficiency, the plant can extract N from the oldest leaf in the head and transplant it to a new leaf that is growing (spear leaf) to allow for continued growth. Therefore, nutrient deficiency symptoms occur first on the oldest leaves, and as the deficiency increases, the younger leaves will be affected. Nitrogen stains appear to be characterized by a uniform light green to bright yellowish-green color on the oldest leaves. However, they will usually affect the entire title except for the spear leaf, which is generally slightly greener (Broschat, 2009). When all the mature leaves have run out of mobilizable N, the oil palm's growth will slow down and eventually stop altogether. Severe N deficiency does not cause tissue necrosis. Nitrogen stains can be overcome immediately by fertilizing nitrogen, and the leaves of plants that have rust will turn green again.

Table 1. Growth measurement and orthogonal contrast of foliar fertilizer treatment on oil palm seedlings in main nursery at 9 month after treatment

Treatment	Seedling height (cm)	Stem diameter (mm)	Number of leaves	Leaf greenness index	Rachis length (cm)	Leaflet length (cm)
Control (D_0)	91.17 ± 5.25	76.67 ± 2.06	13.75 ± 0.69	46.13 ± 5.89	45.67 ± 3.16	26.71 ± 1.32
NPK 20-15-15 (D_1)	106.75 ± 5.01	85.68 ± 2.25	17.08 ± 0.83	63.67 ± 6.00	53.54 ± 4.15	30.00 ± 2.13
NPK 27-18-9 (D_2)	103.13 ± 4.63	80.97 ± 5.32	15.67 ± 1.22	54.85 ± 3.15	52.63 ± 3.12	28.71 ± 1.38
NPK 11-8-6 (D_3)	105.08 ± 5.91	84.08 ± 4.13	17.08 ± 0.83	65.03 ± 3.38	51.33 ± 2.92	29.92 ± 1.10
NPK 27.5-5.5-4.8 (D_4)	99.50 ± 5.31	84.18 ± 2.51	16.21 ± 1.13	52.24 ± 2.55	51.00 ± 4.12	26.96 ± 1.39
Orthogonal contrast						
D_0 vs D_1, D_2, D_3, D_4	***	***	***	***	*	*
D_1, D_2 vs D_3, D_4	ns	ns	ns	ns	ns	ns
D_1 vs D_2	ns	ns	ns	**	ns	ns
D_3 vs D_4	ns	ns	ns	**	ns	*

Note: Asterisks indicate significance of contrast as *p < 0.05, **p < 0.01, ***p < 0.001; ns = not significant.

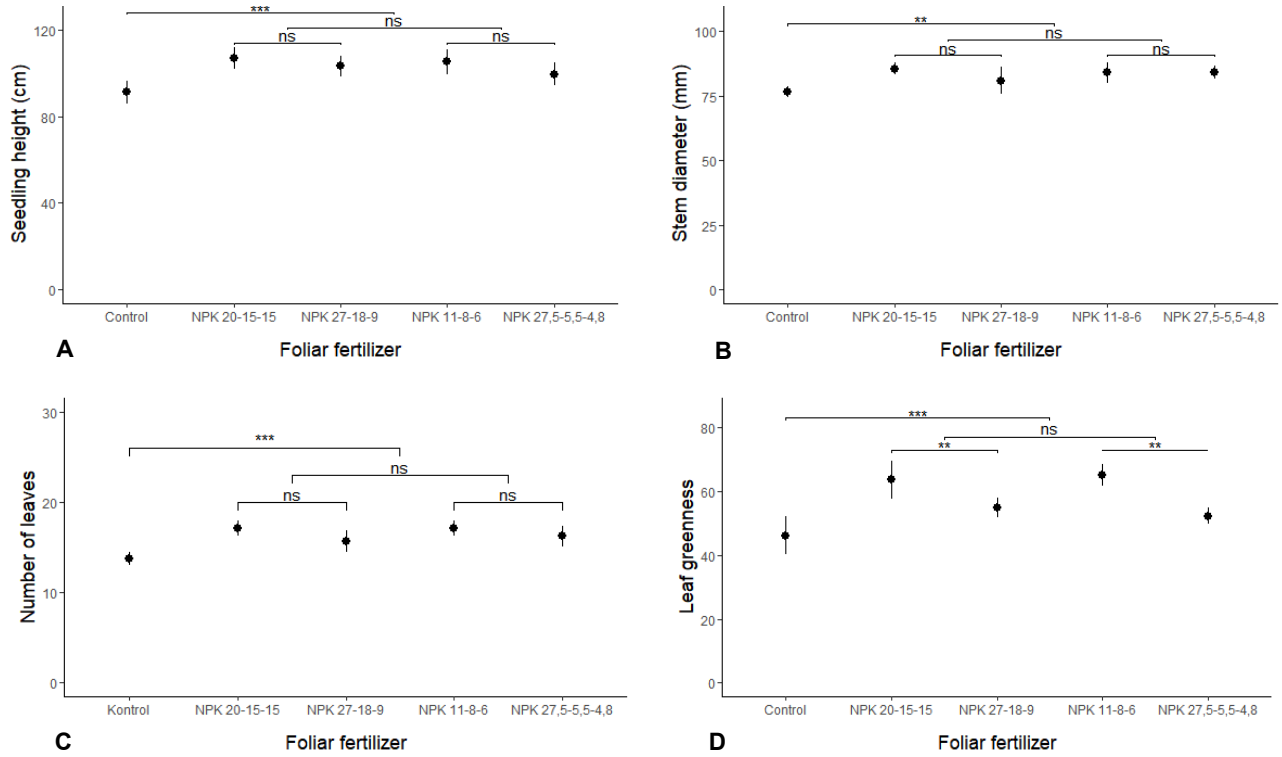

Figure 1. Effect of foliar fertilizer composition and formulation on seedling height (A), stem diameter (B), number of leases (C), and leaf greenness index (D)

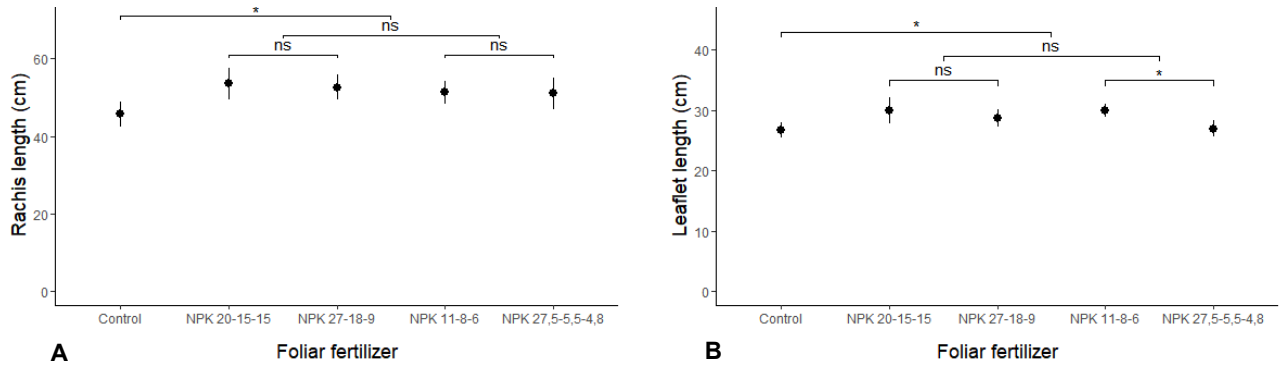

Figure 2. Effect of foliar fertilizer composition and formulation on rachis length (A) and leaflet length (B)

Factors that affect the effectiveness of foliar fertilizer sprays include the physicochemical properties of the formulation, the environment in which the spray is applied, and the characteristics of the plant to which the spray is applied (Fernández and Brown, 2013). The physicochemical properties of spray formulations including molecular size, solubility, pH, surface tension, retention, and dispersion of the formulation play a major role in determining the effectiveness of foliar absorption of fertilizer solution.

The deficiency of phosphorus and potassium nutrients is relatively difficult to identify at the oil palm nursery phase. The earliest symptoms consist of yellow-orange and necrotic spots on the oldest leaves (Broschat, 2009). As deficits develop, necrosis spreads to the edges and ends of the leaves (von Uexkull and Fairhurst, 1991). In some species, spotting does not appear, and necrosis of the leaf tip is the only visible symptom. As with the case of N, K is a very mobile element in the phloem, and the most severe symptoms are on the oldest leaf and towards the end of each affected leaf (Maillard et al., 2015). In other conditions, some Arecaceae plants lacking K show leaflets necrosis only (Broschat, 2009).

The growth and yield of a plant are related to each other. Correlation analysis is needed to determine a relationship between plant growth and yield. Correlation analysis was used to determine the close relationship between the growth and growth components and

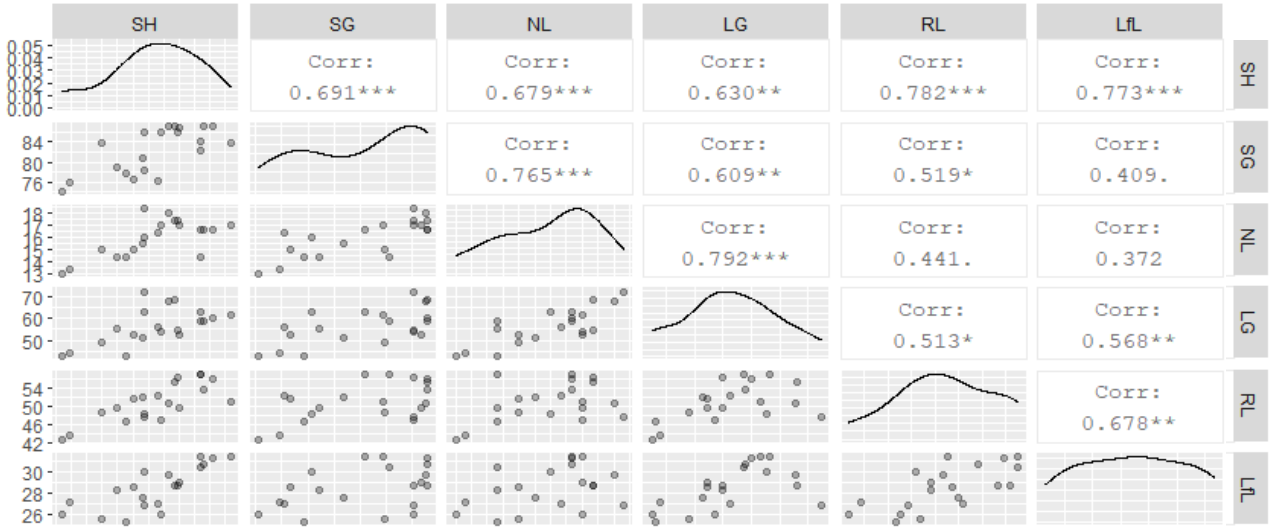

Figure 3. Correlation matrix between six observed variables. Note: SH = seedling height, SG = stem diameter, NL = number of leaves, LG = leaf greenness index, RL = rachis length, LfL = leaflet length. Asterisks indicate significance of the correlations; *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

yield and yield components. Seedling height has a high positive correlation with other observation variables. The high positive correlation was also shown in the measured variables of seedling height, stem diameter, number of leaves, and leaf greenness index. Based on these results, it can be seen that the measured variables of seedling height (R^2 = 0.630-0.782), stem diameter (R^2 = 0.519-0.765), number of leaves (R^2 = 0.792), and leaf greenness index (R^2 = 0.513-0.568) are essential variables of the growth and morphology of oil palm seedlings, especially in fertilization experiment. The results of the correlation analysis shown in Figure 3 indicate that the number of leaves has a very significant positive correlation with the greenness index of the leaves (R^2 = 0.792, $p < 0.001$). Leaves are the primary organ that function in photosynthesis because, in the leaves, there are pigments that play a role in absorbing sunlight. Chlorophyll is a bioactive molecule that receives sunlight and utilizes its energy to synthesize carbon dioxide and water into carbohydrates through photosynthesis.

Oil palm is a nutrient-dense plant and requires a complete and balanced supply of nutrients for optimal plant growth, especially nitrogen (Yadegari et al., 2020). All plants use nitrogen in the form of nitrate and ammonium (Edy et al., 2020). It is the most important factor for the proper growth and development of plants by playing an important role in the biochemical and physiological functions of plants. Nitrogen is the macro element most commonly absorbed by plants under normal conditions in the soil. It enhances the green colour of leaves and is a building block of essential cellular components such as amino acids, proteins and nucleic acids. Approximately 80% of the total cations and anions make the plants absorb nitrate and ammonium, which greatly impact the cation and ion balance involved in regulating cellular pH and the pH of the biosphere (Torres-Olivar et al., 2014; Leghari et al., 2016). For this reason and because their high mobility in the soil, nitrogen is also the most deficient nutrient for most crops. Nitrogen deficiency affects plant growth by reducing photosynthesis leaf area and green leaf longevity (Mu and Chen, 2021). This study indicates that the application of foliar fertilizer effectively increases the vegetative growth of oil palm seedlings, especially seen in the growth performance of the seedlings and greenness of the leaves. Applying foliar fertilizers is recommended to quickly correct the mobile nutrient deficiencies in plants. This action is recommended for oil palm nurseries when there is a deficiency of macronutrients and low rainfall conditions so that fertilization through soil cannot immediately solve the problem.

Conclusion

Foliar fertilizer application enhances the growth and performance of oil palm seedlings. Both powder and liquid foliar fertilizer are equally effective in increasing the growth of oil palm seedlings in terms of seedling height, stem diameter, number of leaves, leaf greenness, rachis length, and leaflet length. Among the different types of foliar fertilizers, NPK 20-15-15 and NPK 11-8-6 have significant effects on the leaf greenness index of oil palm seedlings.

Acknowledgement

This research was funded by DIPA Politeknik Negeri Lampung grant number 193.19/PL15.8/PT/2020.

References

Broschat, T. K. (2009). *Palm nutrition and fertilization. HortTechnology* **19**, 690–694. https://doi.org/10.21273/HORTSCI.19.4.690

Butler, H. J., Martin, F. L., Roberts, M. R., Adams, S., and McAinsh, M. R. (2020). Observation of nutrient uptake at the adaxial surface of leaves of tomato (*Solanum lycopersicum*) using Raman spectroscopy. *Analytical Letters* **53**, 536–562. https://doi.org/10.1080/00032719.2019.1658199

Das, S. K., and Avasthe, R. (2018). Plant nutrition management strategy : a policy for optimum yield. *Acta Scientific Agriculture* **2**, 65–70.

Edy, N., Yelianti, U., Irawan, B., Polle, A., and Pena, R. (2020). Differences in root nitrogen uptake between tropical lowland rainforests and oil palm plantations. *Frontiers in Plant Science*, **11**, 92. https://doi.org/10.3389/fpls.2020.00092

Fernández, V., and Brown, P. H. (2013). From plant surface to plant metabolism: The uncertain fate of foliar-applied nutrients. *Frontiers in Plant Science* **4**, 1–5. https://doi.org/10.3389/fpls.2013.00289

Galagi, S. L., Aiyen, A., and Pasigai, M. A. (2018). Growth and yield of onion (Allium ascalonicum L.) against various concentrations of liquid organic fertilizer. *AGROLAND: The Agricultural Sciences Journal* **4**, 26–34. https://doi.org/10.22487/j24077593.2017.v4.i1.9407

Iswanto, H. (2002). "Petunjuk Perawatan Anggrek." AgroMedia Pustaka, Jakarta.

Jhanji, S., and Sekhon, N. K. (2018). Evaluation of potential of portable chlorophyll meter to quantify chlorophyll and nitrogen contents in leaves of wheat under different field conditions. *Indian Journal of Experimental Biology* **56**, 750–758.

Joshi, N. S., Prabhudesai, S. S., Burondkar, M. M., Gokhale, N. B., Pujari, K. H., and Dhekale, J. S. (2016). Stage-wise nutrient status of leaf and soil of Alphonso mango grown in Ratnagiri district of Maharashtra, India. *Indian Journal of Agricultural Research* **50**, 318–324. https://doi.org/10.18805/ijare.v0iOF.10782

Kathpalia, R., and Bhatla, S. C. (2018). Plant mineral nutrition. In "Plant Physiology, Development and Metabolism" (S. C. Bathla and M. A. Lal, eds.), pp. 37–81. Springer, Singapore.

Leghari, S. J., Wahocho, N. A., Laghari, G. M., Hafeez-Laghari, A., Mustafa-Bhabhan, G., Hussaib-Talpur, K., and Lashari, A. A. (2016). Role of nitrogen for plant growth and development: A review. *Advances in Environmental Biology* **10**, 209-219.

Maillard, A., Diquélou, S., Bilard, V., Laîné, P., Garnica, M., Prudent, M., Garcia-Mina, J., Yvin, J., and Ourry, A. (2015). Leaf mineral nutrient remobilization during leaf senescence and modulation by nutrient deficiency. *Frontier Plant Science* **13**, 1-15. https://doi.org/10.3389/fpls.2015.00317

Mu, X., and Chen, Y. (2021). The physiological response of photosynthesis to nitrogen deficiency. *Plant Physiology and Biochemistry* **158**, 76-82. https://doi.org/10.1016/j.plaphy.2020.11.019

Muktamar, Z., Sudjatmiko, S., Chozin, M., Setyowati, N., and Fahrurrozi. (2017). Sweet corn performance and its major nutrient uptake following application of vermicompost supplemented with liquid organic fertilizer. *International Journal on Advanced Science, Engineering and Information Technology* **7**, 602–608. https://doi.org/10.18517/ijaseit.7.2.1112

Neilson, E. H., Edwards, A. M., Blomstedt, C. K., Berger, B., Møller, B. L., and Gleadow, R. M. (2015). Utilization of a high-throughput shoot imaging system to examine the dynamic phenotypic responses of a C4 cereal crop plant to nitrogen and water deficiency over time. *Journal of Experimental Botany* **66**, 1817–1832. https://doi.org/10.1093/jxb/eru526

Nikiyuluw, V., Soplanit, R., and Siregar, A. (2018). Efisiensi pemberian air dan kompos terhadap mineralisasi NPK pada tanah regosol. *Jurnal Budidaya Pertanian* **14**, 105–122.

Niu, J., Liu, C., Huang, M., Liu, K., and Yan, D. (2021). Effects of foliar fertilization: a review of current status and future perspectives. *Journal of*

Soil Science and Plant Nutrition **21**, 104–118. https://doi.org/10.1007/s42729-020-00346-3

Schloerke, B., Crowley, J., Cook, D., Hofmann, H., Wickham, H., Briatte, F., Marbach, M., Thoen, E., Elberg, A., Larmarange, J., and Toomet, O. (2020). GGally: Extension to "ggplot2." https://ggobi.github.io/ggally, https://github.com/ggobi/ggally

Shahrekizad, M., Ahangar, A. G., and Mir, N. (2015). EDTA-Coated Fe_3O_4 nanoparticles: a novel biocompatible fertilizer for improving agronomic traits of sunflower (*Helianthus annuus*). *Journal of Nanostructures* **5**, 117–127.

Su, Y., Ashworth, V., Kim, C., Adeleye, A. S., Rolshausen, P., Roper, C., White, J., and Jassby, D. (2019). Delivery, uptake, fate, and transport of engineered nanoparticles in plants: A critical review and data analysis. *Environmental Science: Nano* **6**, 2311–2331. https://doi.org/10.1039/c9en00461k

Torres-Olivar, V., Villegas-Torres, O. G., Domínguez-Patiño, M. L., Sotelo-Nava, H., Rodríguez-Martínez, A., Melgoza-Alemán, R. M., and Alia-Tejacal, I. (2014). Role of nitrogen and nutrients in crop nutrition. *Journal of Agricultural Science and Technology* **B4**, 29-37.

Wang, J., Niu, W., Li, Y., and Lv, W. (2018). Subsurface drip irrigation enhances soil nitrogen and phosphorus metabolism in tomato root zones and promotes tomato growth. *Applied Soil Ecology* **124**, 240–251. https://doi.org/10.1016/j.apsoil.2017.11.014

Yadegari, M., Shamshiri, R. R., Mohamed Shariff, A. R., Balasundram, S. K., and Mahns, B. (2020). Using spot-7 for nitrogen fertilizer management in oil palm. *Agriculture* **10**, 133. https://doi.org/10.3390/agriculture10040133

Xu, M., Zhong, Z., Sun, Z., Han, X., Ren, C., and Yang, G. (2020). Soil available phosphorus and moisture drive nutrient resorption patterns in plantations on the Loess Plateau. *Forest Ecology and Management* **461**, 117910. https://doi.org/10.1016/j.foreco.2020.117910

Zhu, J., Li, J., Shen, Y., Liu, S., Zeng, N., Zhan, X., White, J. C., Gardea-Torresdey, J., and Xing, B. (2020). Mechanism of zinc oxide nanoparticle entry into wheat seedling leaves. *Environmental Science: Nano* **7**, 3901–3913. https://doi.org/10.1039/d0en00658k